UNIVERSITEIT GENT

Faculteit Economie en Bedrijfskunde
1999-2000

The Impact of Target Costing on Cost, Quality and Time-to-Market of New Products: Results from Lab Experiments

Dissertation

Submitted at the University of Ghent,
to the Faculty of Economics and Business Administration on October 20, 1999
in Partial Fulfillment of the Requirements for the Degree of Doctor in Applied Economics

by

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Funded by the Intercollegiate Center for Management Science (I.C.M.), Brussels, Belgium

To Pascal and Sarah-Lee,

“They are ill discoverers that think there is no land, when they can see nothing but sea”

- Francis Bacon, 1605, Advancement of Learning -

Acknowledgment

During this long Ph.D. process, many people helped me in one way or another to undertake the research and to present the dissertation as it stands now. Reaching this point would not have been possible without the input and help of many people. I want to express my gratitude to a number of them.

First of all, I want to thank my thesis supervisor Werner Bruggeman. Almost five years ago, he motivated me to start up the Ph.D. process by suggesting this rewarding subject of target costing. He has been an inspiring and encouraging supervisor all the way along, always rising the right questions, while never losing his belief in me to finish this project successfully.

A very special word of thanks also to my foreign supervisor Germain Böer from the Owen Graduate School of Management at Vanderbilt University (Nashville, Tennessee). He turned my stay at Vanderbilt into a very productive year by guiding me through the most valuable doctoral courses. He was like a father to me, always being there when I needed him. He urged me to keep going with disentangling the phenomenon of target costing, always highlighting the progress I had already made. His insightful comments and constructive criticisms on the many versions of my paper have greatly contributed to this final work, for which I am greatly indebted to him.

I am also most grateful to Owen School for their hospitality. In particular, I would like to thank Gary Scudder, director of the Ph.D. program, for accepting me as a foreign student in his program, having confidence in my capabilities. At Vanderbilt, I had the opportunity to learn statistics from teachers as Bruce Cooil, Cliff Huang, Tom Novak and Bahr Weiss. They were invaluable for the progress of my work. Bahr and Tom were incredibly fast in giving email answers to the many problems I encountered in analyzing the data of this study. They all have contributed a lot in the development of this work.

At Vanderbilt I also acquired a taste for experimental research, as the reader will shortly know. I wish to thank professor dr. Joe Lappin (Vanderbilt University), professor dr. ir. Hendrick Van Landeghem (University of Ghent) and my thesis supervisor to let me recruit among their students for the experiments.

Finally at the scientific side, I would like to acknowledge comments on earlier versions of this paper by Frank Selto (University of Colorado, USA), David Otley (Lancaster University, UK), Debra Jeter (Vanderbilt University, USA) and Paul Chaney (Vanderbilt University, USA). Patrick Van Kenhove (University of Ghent, Belgium) has always been available for useful insights and Koenraad Debackere (K.U. Leuven, Belgium) gave me right advice to set up a third experiment. Progress in this work is indebted to all of them.

On the financial side, I want to thank Mr. Dirk Symoens and the Intercollegiate Center for Management Science (I.C.M.) for its generous support. This doctoral research would not have been possible without the I.C.M. fellowship, allowing me to concentrate on research during three years. I.C.M. also created the opportunity to stay one year at Vanderbilt University, which was a unique experience. Furthermore I gratefully acknowledge the support of the DOMO group (Gent, Belgium) for sponsoring the trips of my husband to the US, when I was in Nashville. Without the idea of managing director Mr. Dirk Degrauwe to send Pascal to the US every month for a few days, by assigning him an investment project, I would have suffered even more from our physical separation. I admire him both as a manager and as a person.

Furthermore I thank the University of Ghent for investing in my capabilities as a researcher and a teaching assistant. I also acknowledge the Vlerick Leuven Gent Management School for housing me during my I.C.M. period in Belgium. Both organizations have a stimulating work climate, turning long journeys into most enjoyable days. My colleagues at the university (department of accounting) and at the Vlerick Leuven Gent Management School (department of management control) have always been of big support. Many of them assisted me during the lab experiments. Without their help, it would not have been possible to run the experiments. Thanks for taking the instructions so seriously and for showing interest in my work all the way along. Furthermore, a special word of thanks goes to Heidi Van Doorne and Sandy Devreese. To Heidi, because of her intellectual and practical support. I could not have imagined a better colleague during this last year. To Sandy, because of her moral support during this whole Ph.D. process. She has been my best friend from beginning to end. Her endless words of courage and belief in what I was doing were of undeniable significance.

Another department at the University of Ghent deserves particular attention, i.e. the daycare center at the “Tweekerkenstraat”. Mrs. Goeteyn and her team have made it possible for me to finish this work with an easy mind, because I could be sure of their making happy days for my little daughter.

I save my last expression of thanks for my family. For my parents, because of writing all those faxes during that Vanderbilt year and because of having always been available to take care of Sarah-Lee. Most of all, I am indebted to my husband Pascal. His endless patience, flexibility and permanent love made it possible to engage in this doctoral adventure and to complete it. This doctoral adventure also gave us a special gift. We brought back from Nashville our Sarah-Lee as the most wonderful memory. I owe much to her too. She was always wondering what I needed to do at my “bureautje” (office) at Vlerick and lately at the Sint-Pietersplace, on Saturday and Sunday. Probably not quite understanding that we missed the last two summer holidays, she kept asking me when we all go to “Spain”, which is just an image of spending some time together. That’s why I dedicate this work to my husband and my lovely daughter.

Patricia Everaert

October 20, 1999

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Chapter 1: Research Set-up

1. Introduction

The general research topic of this dissertation can be described as the study of the effectiveness of target costing in designing low cost new products. An introductory chapter explains why and how this research was set up.

In section 2 we discuss the setting of this study within the area of management accounting. Then in section 3 we look at the motivation to conduct the research. Basically, three different areas of literature have guided us in setting up the specific research questions. A first motivation comes from management accounting literature, which describes the need for cost management in highly competitive environments and suggests that target costing is an effective cost management technique. Hence, the testing of the effectiveness of target costing in realizing cost management forms the general research problem of this study. A second motivation comes from R&D management literature, which points to the multiple, conflicting objectives during new product development. This motivated us to include the impact of target costing on the quality level as well as the achieved time-to-market, when studying the effectiveness of target costing during new product development. A third motivation is based on the strategic importance of shortening time-to-market and hence justifies the inclusion of time pressure when studying the effectiveness of target costing. The respective research questions are formulated in section 4. Finally, section 5 examines the structure of the dissertation explaining the research process we chose to answer the research questions.

2. Research Area

2.1 Accounting

This section begins with a definition of accounting, the most general field. Management accounting and accounting for management control are covered in the next two paragraphs, because the latter forms the research area of our study.

The American Accounting Association defines **accounting** as the process of identifying, measuring and communicating economic information to permit informed judgments and decisions by users of the information. Horngren & Foster (1991, 3) state that: "the accounting system is the principal quantitative information system in almost every organization and should provide information for three broad purposes:

(1) *Internal routine reporting to managers* to provide information and to influence behavior regarding cost management and the planning and controlling of operations.

(2) *Internal non-routine, or special reporting* to managers for strategic and tactical decisions on matters such as pricing products or services, choosing which products to emphasize or de-emphasize, investing in equipment, and formulating overall policies and long-range plans.

(3) *External reporting* through financial statements to investors, government authorities, and other outside parties."

Traditionally, **management accounting** is concerned with the first two purposes, i.e. with the provision of routine and non-routine information *to people within the organization*. **Financial accounting** is concerned with the third purpose, providing information *to parties outside the organization* (Horngren, 1975; Horngren, Sundem & Selto, 1993; Drury, 1992). Garrison (1982, 15) adds that management accounting emphasizes relevance and flexibility of data, whereas financial accounting has been oriented more towards the historical aspects of reporting, governed by generally accepted accounting principles, with more emphasis on precision and less emphasis on non-monetary data. According to Horngren, Sundem & Selto (1993, 8) financial accounting is often looked upon as being a cold, objective discipline, whereas management accounting is wrapped up in behavioral ramifications.

2.2 Management Accounting

Management accounting[1] thus involves the routine and non-routine reporting to managers. The American Institute of Management Accountants defines management accounting as the *process of identification, measurement, accumulation, analysis, preparation, interpretation, and communication* of financial information used by the management to plan, evaluate, and control within an organization and to assure appropriate use of and accountability for its resources (Atkinson et al, 1995, 32). Kaplan & Atkinson (1989, 1) are more specific about the two purposes of management accounting, i.e. management accounting is a system that collects, classifies, summarizes, analyses and reports information that will assist managers *in their decision-making and in their control activities*. Similarly, Drury (1992, 17) considers the management accounting system as providing information for

[1] There is some confusion in terminology between **cost accounting** and **management accounting**. Some authors define cost accounting in the same way as management accounting. However, to Horngren & Foster (1991) and Drury (1992) cost accounting is only a part of management accounting. Cost accountants deal exclusively with gathering cost information for stock valuation and the determination of cost of goods sold, to meet the requirements of external reporting. With the increasing use of cost information in decision-making in all functional areas of a business, the role of the cost accountants has expanded to that of management accountants. Montgomery (1979, 15) states that management accountants provide cost data for many more activities than financial accounting. Often, cost information is provided to engineering to assist in product design decisions, to marketing for use in pricing and marketing strategy decisions, to personnel to provide the basis for wage, salary structures and wage negotiations with unions, to operating management for use in the planning and control of current operations, and to top management for use in long-range planning.

management activities such as *decision-making, planning and control.* Management accounting for the first purpose (to assist in decision-making) will here be abbreviated as **accounting for management decisions**, whereas management accounting for the second purpose (to assist in planning and control activities) will be abbreviated as **accounting for management control**[2]. Traditionally, accounting for management decisions handles topics such as product costing, process costing, job order costing, marginal costing, cost-volume-profit analysis, profitability analysis, product-mix analysis, standard costing, variance analysis and investment justification. Although some topics overlap, accounting for management control is more likely to involve topics such as responsibility structure, budgeting, performance measurement, rewarding managerial performance and transfer pricing[3].

This research is situated in the area of accounting for management control, which justifies further elaboration in the next paragraph.

2.3 Accounting for Management Control

As mentioned before, accounting for management control involves the provision of accounting information that assists managers in their planning and control activities. **Planning** is defined by Emmanuel et al. (1990, 14) as the process of setting objectives and the means of their attainment, **control** as the process of ensuring that plans are achieved. Hence, planning activities provide answers to the questions: “What is desired?” and “When and how is it to be accomplished?”, whereas control activities ensure the implementation of those plans and means.

Both planning and control activities are **necessary to achieve management control** in an organization. Anthony & Govindarajan (1995, 8) define management control[4] as the process by which managers influence other members of the organization *to implement the organization’s strategies*[5]. Emmanuel et al. (1990,8) define management control as the process by which managers attempt *to ensure that the organization adapts successfully to its changing environment*, making organization survival the overall objective. Another definition in this way is provided by Lowe (1971, 5):

[2] **Control** is defined here in the broadest sense of the word, including both planning and control activities.

[3] Most **textbooks** in management accounting deal with both accounting for decision-making and accounting for control. See for instance Horngren, Sundem & Selto (1993), Kaplan & Atkinson (1989), Drury (1992), Horngren & Foster (1991), Maher & Deakin (1994). Exceptions are made by Arnold & Hope (1990), who restrict the topics to accounting for management decisions, and by Emmanuel, Otley & Merchant (1990), who deal exclusively with topics in accounting for management control.

[4] Ansari & Bell (1991, 15) define **three forms of control** in organizations, i.e. the symbolic, behavioral and economic form of control. Management control should here be understood as a behavioral one, i.e. to direct behavior of the organization members toward specific desired ends.

[5] It is common to speak of **organization** goals and strategies. Caplan (1966, 500) rightly argues that the organization itself is mindless and, therefore, can have no goals. Hence, organization goals and strategies should here be interpreted as the goals and strategies, set by the dominant members of the organization, i.e. top management.

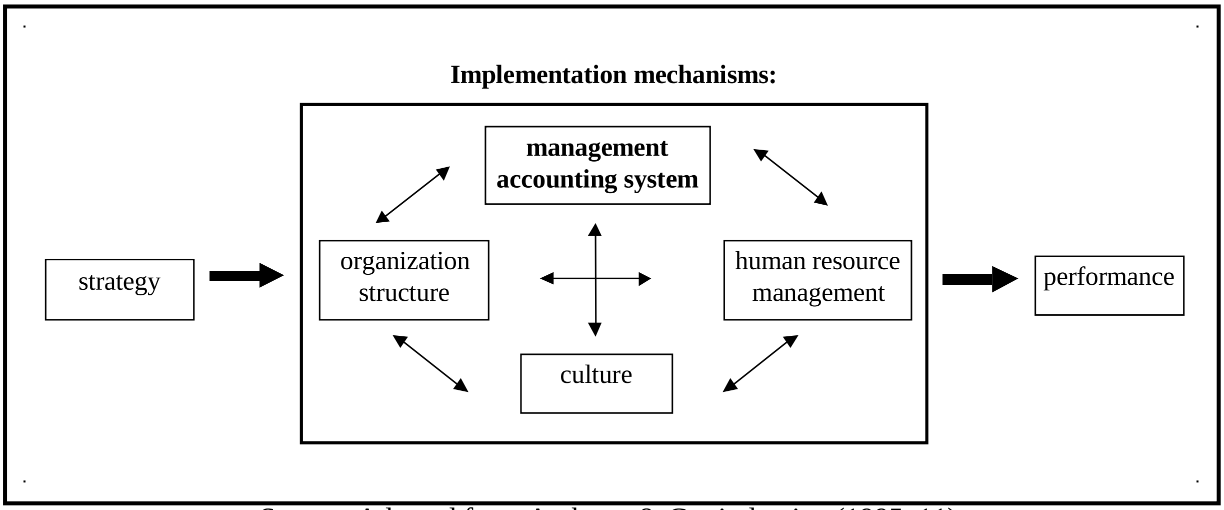
"Management control is a system of organizational information seeking and gathering, accountability and feedback designed to ensure that the enterprise adapts to changes in its substantive environment and that the work behavior of its employees is measured by reference to a set of operational sub-goals (which is conform with overall objectives), so that the discrepancy between the two can be reconciled and corrected for".

To Ansari & Bell (1991, 15) the **major activities in management control** are: "(I) *guiding* behaviors through goals, objectives, missions or standards; (II) *facilitating* behaviors by sharing and communicating information members need about each other's behaviors; (III) *evaluating* behaviors as they occur to ensure they are consistent with desired behaviors; and (IV) *motivating* behaviors by providing the necessary inducements for members to stay within the collective structure."

But ***why* do organizations need management control** to encourage the individuals in the organization to implement the strategies, set by top management? Emmanuel et al. (1990, 110) remark that people may fail to act in an organization's best interest for any of the three basic reasons. The first is *lack of direction*, because people do not always understand what is expected of them. The second reason is *lack of motivation*. Some people know what is expected of them, but are not interested in behaving appropriately because their individual incentives are not adequate to motivate them. The third reason is *lack of abilities*, either abilities innate to all human beings or abilities specific to a particular person. For instance, lack of ability exists when job contents are not designed properly or involve such complex or demanding activities that no human being can be expected to succeed in them.

Consequently, management control is necessary to guard against undesirable actions and to encourage desirable actions leading to the implementation of the strategies and the survival of the firm. A management accounting system of setting objectives, measuring performance and evaluating performance reduces the chances of lack of direction. For instance, by using budgets (profit, revenue or cost) for each sub-unit of the organization or by using operational performance measures such as waste reduction, machine-efficiency, etc. the overall organization goal is quantified and broken down, so that employees know exactly what is expected from them. This lack of direction is a recurring theme in this study. The first and third research question address the problem of comparing the cost behavior of design engineers when vague, unquantified cost objectives are set for a new product under development to the target costing environment, where specific, quantified objectives are set for a new product. Lack of motivation is essentially a behavioral rather than a technical condition and has much to do with linking appropriate rewards[6] to desired performance, so as to encourage the behavior that leads to those desired results. The ideal situation is a situation of perfect **goal congruence,** as mentioned by Anthony & Govindarajan (1995, 10). This means that when employees seek personal goals, they are also helping to attain the organization's goals. The development of optimum compensation plans and other incentives are important considerations in promoting goal congruence. Consequently, for Horngren (1975, 336), the central question to ask about the benefits of a management accounting system (used for control) is whether it encourages managers, when working in their own best interests, to act at the same time in harmony with the overall objectives of the firm.

Figure 1: Framework to realize Management Control



Source: Adapted from Anthony & Govindarajan (1995, 11)

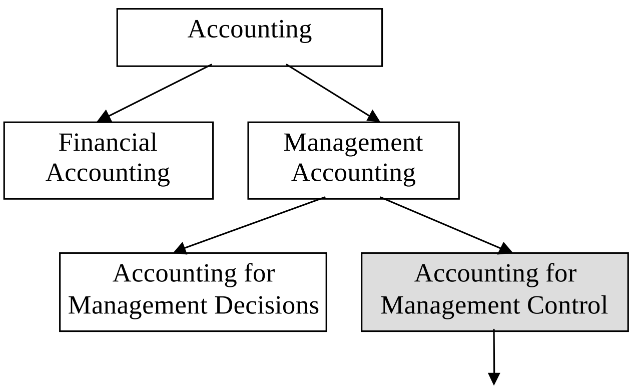
In sum, the **management accounting system** has a **central role** to play in establishing effective management control. As Emmanuel et al. (1990, 7) assert, it is often the only source of quantitative information that combines the results of all activities of the different parts of the enterprise. Nevertheless, an effective management accounting system is just one of the tools managers use to realize management control. (See Figure 1.) Following Anthony & Govindarajan (1995, 11), strategies also get implemented through an adequate *organization structure*, an effective *human resource management* and an appropriate *organization culture*. An adequate organization structure guides the actions of the members by specifying the structure, the roles, the reporting relationships and responsibilities among them, whereas an effective human resource management affects their actions through selection, training, evaluation, promotion, etc. Culture refers to the set of common beliefs, attitudes, and norms and also guides, explicitly or implicitly, the behavior of people in performing

[6] Rewards are just one factor that influences employee **motivation**. A mix of psychological factors, such as the nature of work conditions, individual needs as well as economic factors, influences motivation (e.g. Maslow, 1954; Herzberg et al., 1959; Vroom, 1964). Furthermore, dependent on the managerial approach to motivation, other thoughts dominate regarding the best way to motivate people. Atkinson et al. (1995, 575) point out that the current management accounting systems are based on the human resources model, leaving the scientific management school and the human relations movement behind, by assuming that individuals do not find work objectionable, that they have knowledge to contribute and that they are creative.

their task. Hence, the provision of management accounting information is just a necessary, but not a sufficient condition for effective management control. It is believed, as Emmanuel et al. (1990, 36) state, that the absence of such information, or perhaps worse, the provision of inadequate or misleading information, is a powerful disadvantage to effective organizational functioning.

In conclusion, Figure 2 summarizes this paragraph. This is a study in management accounting, more specifically in accounting for management control. In this area, researchers study how management accounting systems should be designed in order to enable effective management control. The central study theme in this area is the provision of accounting information for management planning and control activities. The main guideline in designing a management accounting system to enable effective management control is the concept of goal congruence, which means that the focus of accounting for management control should be on the motivational impact of a particular accounting system or method. Therefore, accounting for management control has as much to do with influencing human behavior as it has to do with the technical design of information systems.

Figure 2: Accounting for Management Control



What?	The provision of management accounting information to assist managers in *planning* and *control* activities;
Purpose?	to realize *management control*, i.e. to influence employees in the organization to implement the strategies in order to attain the goals of the organization;
How?	by establishing *goal congruence*;
Why?	because employees might have *lack of direction* or *lack of motivation.*

3. Research Justification

3.1 Accounting for Cost Management

In recent years, a new role has emerged for the management accounting system to assist managers in their control activities. **This new role involves the provision of accounting information to influence the members of the organization to realize *cost management*, i.e. to pursue every possible cost reduction opportunity.**

Cost management is understood in different ways in literature. To McIlhattan (1992, M1-1) cost management is the skillful handling or directing of costs. Horngren, Foster & Datar (1997, 28) define cost management as the set of actions that managers take to satisfy customers while continuously reducing and controlling costs. Similarly, Cooper (1995, 91) defines cost management as the creation of pressure to reduce and control costs. In this perspective, Howell & Sakurai (1992, 29) speak of a cost down mentality as a synonym for cost management. Kato (1993, 37) adds that in today's ever-changing environment, pursuing every possible cost reduction opportunity is surely a good strategy, but warns that it is essential to avoid reducing costs without regard for the quality, functions and characteristics of the product, from the customers' point of view. **Hence, cost management requires that managers actively look for cost reduction opportunities, while enhancing or keeping the *value* of the product for the customers at the same level.**

Furthermore, Cooper (1995, 89) argues that cost management needs to include *all aspects* of producing and delivering the product; i.e. the supply of purchased parts, the design of products and the manufacture of these products. So, cost management should be inherent to each stage of a product's life cycle, i.e. during the development, manufacturing, distribution of a new product, and during the service lifetime of a product. Susman (1989, 9) argues that reducing costs at each stage *separately* does not necessarily lead to cost reduction for the product as a *whole*. For instance, reducing costs on testing a new product, might cause much higher costs during the manufacturing stage, due to manufacturing problems. That's why Shields & Young (1991, 39) prefer to use the term "product life cycle cost management", thus stressing the product life cycle content of cost management. **Hence, cost management should focus on reducing the *total* costs of a product, throughout its entire life cycle**[7].

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[7] **Product life cycle** should here be understood as the life cycle of a *product item*, a synonym for stockkeeping unit or product variant. Following Kotler (1997, 430) a product is defined here as a product item or a distinct unit within a brand or product line that is distinguishable by size, price, appearance, or some other attribute. See Kotler (1997, 346) for a discussion of broader definitions of the concept of product life cycle, such as product *categories* (e.g. automobiles), product *forms (e.g. convertibles),* product *brands* (e.g. BMW) and product *items*. Cost management is defined here for the most narrow perspective, i.e. for a product *item* or also called stockkeeping unit.

Furthermore, to Shields & Young (1991, 39) cost management *cannot be limited* to the interests of the *producer alone*, since customers have become more sensitive to costs after purchasing. According to these researchers, today's cost management should not only focus on reducing the costs the *producer* incurs for the product (i.e. what Shields & Young (1991) call the life cycle costs), but should also focus on reducing the costs that consumers incur after purchasing, such as the costs of installation, operation, maintenance, and disposal. Shields & Young (1991, 39) call this total of costs incurred by the producer as well as the consumer, the *whole life cost* of a product. Consequently, Shields & Young (1991, 39) argue that the whole life costs should be the primary focus of cost management[8]. **Summing up**, **cost management can be described as a cost down mentality, i.e. the active and continuous search to reduce the total costs of a product throughout its entire life cycle - for *producer* and *consumer* - but without reducing its value for the customer.**

3.2 The Strategic Importance of Cost Management

Many authors stress that the strategic importance of cost management has drastically increased in recent years due to intense competition**.** According to Cooper & Slagmulder (1997, 108) **customers in highly competitive markets expect that each generation of products presents improvements**. These improvements may include: improved quality, improved functionality or reduced prices. Any of these improvements alone or any combination of them urge a firm to manage its costs to stay profitable. Furthermore, Cooper & Slagmulder (1997, 158) point out that highly competitive markets are characterized by low profit margins, low customer loyalty and low first mover-advantages.

Not only customers ask for cost management, also the intense competition between well matched competitors increases the strategic importance of cost management. Cooper (1995, 10) argues that in competitive markets where competitors are frequently technologically equivalent, that it becomes increasingly difficult to maintain a sustainable competitive advantage. In Japanese competitive markets he found that even before a differentiator can teach its customers about the distinctive advantage of a new product, other firms launch me-too products at even lower prices. In the same way, cost leaders, offering products that are low in price, are leapfrogged by competitors, offering products at the same price but with a higher level of quality and/or more features. This fact leads Cooper (1995, 7) to conclude that in **a world of nonsustainable competitive advantage, a firm that fails to reduce costs as rapidly as its competitors will find its profit margin squeezed and its existence threatened**. So, *all* firms have to manage costs aggressively in order to survive in today's highly competitive markets. Similarly, Kato (1993, 37) argues that while successful Japanese

[8] Yoshikawa et al. (1993, 167) and Susman (1989,9) mention a third component to include in the total costs of a product when aiming for cost management, i.e. the costs caused by the product, but paid by **society**. However, for Susman (1989, 9), cost management from the point of view of producers and consumers should not be contrary to societal interests, since the more governments penalize companies for producing unsafe products or polluting the environment, the more likely companies include these costs in the costs of their products.

companies are all cost conscious companies, they also pursue differentiation strategies. Using the generic strategies of Porter (1980), this means that successful Japanese companies are both cost leaders and product differentiators. Also Monden & Hamada (1991, 16) contend that in highly competitive markets - that are characterized by a shortening of product life cycles, diversification of demand and keen competition, - cost management is indispensable to introduce new products which meet customers' demands at the lowest cost, and to reduce costs of existing products by eliminating wastes. Finally, Cooper (1995, 7) compares the strategic importance of cost management with that of quality management a few years ago and concludes that cost management has to become a discipline practiced by virtually every person in the firm. **Summarizing, in an environment of intense competition, *all* companies need to strive for cost management in order to survive**.

3.3 Downstream Cost Management of Future Products

Traditionally, cost management has focused on reducing costs at the factory level by reducing the cost of producing **current products**. For instance, Kato (1993, 34) mentions that the JIT-production systems, together with the JIT philosophy of waste elimination, have greatly contributed to cost reductions in manufacturing related activities. Computer-integrated manufacturing, vendor certification, total preventive maintenance, statistical process control, etc. are a few other examples of cost reduction methods for existing products (Shields & Young, 1991, 43). This kind of cost management, i.e. cost management aiming for reducing the manufacturing and delivering costs of existing products, is called **cost management of existing products**. Other terms, e.g. introduced by Makido (1989, 3), are *cost control* and *cost maintenance.*

Cost management can also focus on the stages preceding manufacturing, i.e. on the new product development (NPD) stage where **future products** are conceived. Although it varies from company to company, the new product development stage generally includes the idea generation phase, the conceptual design, the detailed design & development, the testing and manufacturing ramp-up phase.[9] During NPD, new product ideas are designed and developed into products that will be manufactured and sold in the future. During NPD, many important decisions are taken that influence the total cost of a future product, such as the selection of material, production method, machines, type of assembling method, the choice between new or existing parts, between making or buying a part, between unique or general purpose packaging, etc. Ulrich & Eppinger (1995, 6) cite the example that the choice between using screws or snap-fits on the cover of a printer can have economic implications of millions

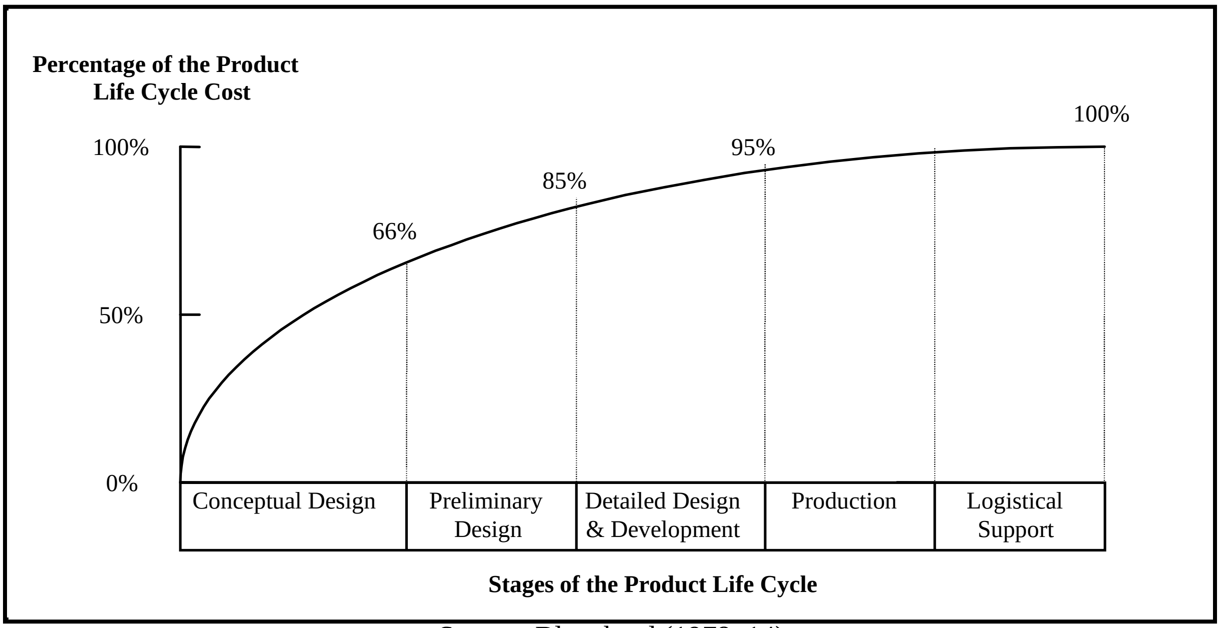
[9] There is no consensus in literature about the **stages and gates** of the new product development process. Cooper & Kleinschmidt (1991, 138) distinguish between the following stages "idea", "preliminary investigation", "detailed investigation", "development", "testing & validation", "full production & market launch". Rosenthal (1992, 21) discusses the phases "idea validation", "conceptual design", "specification and design", "prototype production and testing", "manufacturing ramp-up". Ulrich & Eppinger (1995, 15) define the stages "concept development", "system-level design", "detail design", "testing & refinement" and "production ramp-up".

of dollars. According to these authors, developing a product of even modest complexity may require thousands of such decisions. Thus, cost management during new product development requires that design engineers actively search for cost reductions when taking these decisions in designing and developing a new product. This kind of cost management, i.e. cost management aiming for reducing the total costs of a future product during the new product development stage, is called **cost management of future products**. *Cost reduction* is sometimes used as a synonym for cost management of future products, e.g. by Makido (1989, 3). We however prefer the term cost management of future products to avoid confusion, since both cost management of future products and cost management of existing products have the general purpose of realizing cost reductions.

It is only recently that researchers have come to realize that cost management of *future* products includes many cost reduction opportunities, apart from cost management of *existing* products. Cooper (1995, 91) argues that the most efficient way to keep costs down is to design costs out of a new product, not to try to reduce costs after products have entered production. Similarly, Kato (1993, 35) calls the new product development stage a treasure island for cost reduction opportunities. Indeed, many researchers[10] explain that the life cycle cost (and also the *whole life* cost) of a product significantly depends on decisions made during design and development, which creates much more opportunities for cost management during the design and development stages than during the subsequent production and distribution stages. Blanchard (1978, 14) calculated that up to 95% of the product life cost stems from consequences of decisions made early in the design phase (see Figure 3). This was confirmed by the study of Gietzmann & Inoue (1991). Also Howell & Sakurai (1992, 32) found that by the time design specifications make their way to the accountants, virtually all of the product's cost is locked in. In Hayes' (1981, 63) study a comparison is made between "designing low cost" into a product and "building high quality" into a product. Hayes (1981, 63) argues that building low cost into a product is more efficient than reducing a product's cost afterwards just as building quality in during design is more efficient than considering quality for the first time during mass-production. Finally, Cooper (1995,6) argues that in highly competitive markets, companies have almost no time to reduce costs on existing products due to the short time a product is commercialized and/or due to the maturity of the production technology used. **Summarizing, different studies show that cost management of *future* products during the new product development stage involves far more opportunities for cost reduction than there are for cost management of *existing* products during the manufacturing and subsequent stages, i.e. when the product is fully designed and developed.**

[10] See for instance Gietzmann & Inoue (1991, 53), Howell & Sakurai (1992, 31), Michaels & Wood (1989, 19), Hiromoto (1988, 23), Tanaka (1989, 49), Emore & Ness (1991, 42), Kato (1993, 35), Morgan (1993, 21), Yoshikawa e.a. (1993, 166), Rosenthal (1992, 6), Berliner & Brimson (1988, 140).

Figure 3: Actions affecting the Product Life Cycle Cost



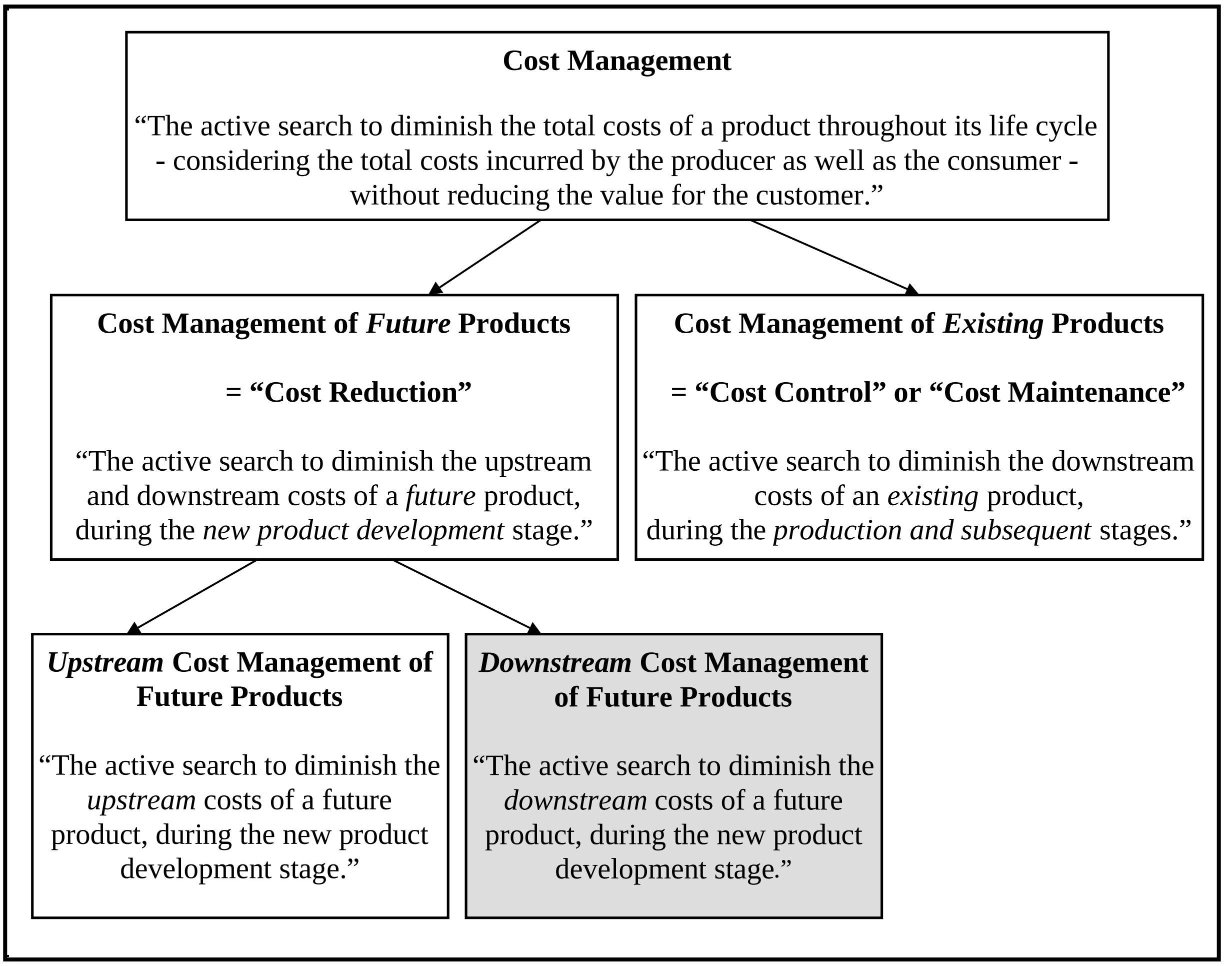
Source: Blanchard (1978, 14)

Furthermore, Shields & Young (1991, 177) point out that it is important to understand that design engineers can affect the total product life cycle cost of a future product in two ways, i.e. by making design and development decisions in such a way that the downstream costs (e.g. manufacturing, logistics, service, operating, etc.) of the future product are reduced, but also by managing the design & development cost itself. Hence, cost management of *future* products can be realized by focusing on ***downstream costs*** (i.e. all costs *from* the start of the manufacturing process) as well as by focusing on ***upstream costs*** (i.e. all costs *before* manufacturing starts, such as the costs of designing, developing, testing[11]). Shields & Young (1994, 177) found by site visits that managing the downstream costs of a future product is much more critical than managing the upstream costs. As one R&D manager puts it: "The key to design engineers is to realize that the development costs they cause are relatively small compared to the downstream costs they cause. The big dollars come later and they are determined by their decisions". In fact, all studies mentioned in the previous paragraph (Blanchard, 1978; Gietzman & Inoue, 1991 and Howell & Sakurai, 1992) refer to *downstream* cost management of future products, i.e. reducing the manufacturing and subsequent life cycle costs by

[11] Studies on **upstream cost management** have traditionally been performed in product development literature. In management accounting, only a few studies are available. Shields & Young (1994), for instance, studied the impact of budget participation, budget tightness, budget changes and incentive systems on the budget consciousness of R&D professionals. Contingency research was provided by Rockness & Shields (1984), studying the importance of input, behavior and output controls and how these vary with task characteristics of the R&D environment. In another study, Rockness & Shields (1988) studied the perceived importance of the R&D budget in relation to the stadia of the management control process (planning, monitoring, evaluating, rewarding), the organizational context and the perceived importance of social control. For a review of studies in product development, we refer to Lin & Vasarhelyi (1980), who classified studies according to organizational factors, behavioral factors, project selection criteria, etc. aiming for an effective planning and control of R&D expenditures. A summary of R&D budgeting practices is also given by Ellis (1988).

designing costs out of a future product during NPD. Of course, cost management of existing products c·n only focus on the downstream costs, since by then the product is fully designed and developed, leaving all upstream costs behind. **Hence, it is only recently that researchers have realized that *downstream* cost management of future products includes many more cost reduction opportunities than cost management of existing products.**

Figure 4: Elements of Cost Management



Summing up, this study is about *downstream* cost management of *future* products. More specifically it is about the provision of accounting information to induce design engineers to realize *downstream* cost management of *future* products. As discussed earlier, cost management of future products can be described as a cost down mentality where design engineers actively look to reduce the costs of a new product throughout its future life cycle - considering the total costs incurred by the producer as well as the consumer - but without reducing the value of the future product for the customer. Cost management of future products can focus on the design and development costs themselves (i.e. the so-called upstream costs) as well as on the manufacturing, logistics, sales and subsequent costs (i.e. the so-called downstream costs). The emphasis here is on *downstream* cost management, because, as suggested by Shields & Young

(1994, 177), the upstream costs design engineers consume are relatively small compared to the downstream costs they cause by their design and development decisions. **Furthermore, according to current literature, downstream cost management of future products provides more opportunities for cost management than postponing cost management activities to the manufacturing stage, when the product already exists.**

Different approaches are suggested to motivate design engineers to aim for downstream cost management of future products. We will only briefly discuss the first two methods and focus on the third method.

3.4 Techniques for Downstream Cost Management of Future Products

3.4.1 Engineering Tools

In the new product development literature different approaches are described, which we have brought together under the heading of engineering tools. Examples[12] are group technology, design for assembly, design for manufacturing, value engineering, quality function deployment, etc. The distinctive feature is that they all start from very simple principles. **Group technology,** for instance, exploits the similarity of parts. Hyer & Wemmerlöv (1984) explain that standardizing and reducing the amount of part numbers, achieved by coding existing parts into a database, leads to lower development costs and lower material costs, but also to indirect cost reduction, due to fewer vendors, smaller purchasing staff, larger purchase volumes and quantity discounts. **Design for X**[13] (DFX) is a general term to describe methodologies aiming for X, where X may correspond to reliability, serviceability (aiming for high mean time between failure and/or low mean time to repair), maintainability, etc. **Design for manufacturing** and **design for assembly** are the most commonly used tools. Ulrich & Eppinger (1995, 182) explain that the design for manufacturing (DFM) methodology focuses on reducing the costs of components, the costs of assembly and the costs of supporting production, by simple rules of thumb. Dewhurst & Boothroyd (1988, 1989) have developed software that modeled the cost of all types of production processes, manual assembly operations and automatic insertion operations. The analysis technique is systematic in its approach by asking simple questions, which allows to make quite an accurate estimation of the assembly time (and hence cost) for each part as well as provides suggestions for improving the ease of assembly. Yoshikawa et al. (1993) describe **value engineering and functional analysis** as an interdisciplinary brainstorming exercise to focus on the functions and the cost of those functions. The purpose is to look either for cheaper ways to produce a future product without reducing the functions of that new product or adding new features without increasing the manufacturing costs.

[12] See Tatikonda & Tatikonda (1994) and Shields & Young (1991,43) for short reviews.
[13] See Huang (1996) for an extensive review.

These are just a few techniques, used during design and development, to aim for downstream cost management of future products. Blanchard (1978, 13) points out that the biggest danger of what we call here the engineering tools is that frequently just one single segment of the product life cycle is being considered, leading to suboptimizations without considering the overall effects on the product's life cycle cost. Nevertheless, these (and other) engineering methods are helpful in finding cost reduction opportunities while designing and developing a future product. **Research on the contribution of these (and other) techniques belongs to the area of R&D management and hence is outside the scope of this study.**

3.4.2 Cost Driver Information: the Activity-based Costing Approach

Activity-based costing (ABC) is a new approach to product costing (Cooper & Kaplan, 1988, 1992). It is based on the following two premises, formulated by Cooper & Kaplan (1991, 269) (1) products create demands for activities and (2) activities (and not products) cause costs. Hence, in an ABC system the activities necessary to produce products are identified, costs are traced to these activities and various cost drivers are used to trace the cost of activities to products. ABC systems are mostly set up to remove much of the distortion in product costing and to gain a better insight into the overhead costs and activities.

Turney (1991, 31) however, explains that the information on activities and cost drivers also facilitates cost reduction, more specifically in four different ways, i.e. by activity reduction, activity elimination, activity selection and activity sharing[14]. Similarly, Cooper & Kaplan (1991, 396) found some firms that use ABC information to influence the behavior of design engineers in order to design new products with lower downstream costs. For instance, in the Tektronix case, Cooper & Turney (1988, 405) describe how the ABC system provides engineers with a list of all parts and of all the material-related overhead cost associated with each part. This information was helpful in the evaluation of designing a new part versus using an existing common part. The ABC information was an incentive to reduce the number of part numbers, but also to increase the proportion of common parts used in the instruments. In the Hewlett-Packard case, Cooper & Turney (1989, 414) describe how and why a new ABC system was developed to support cost management of future products. The objective of the new system was to find the required functionality of a new product with the least expensive design alternative. This was achieved by choosing drivers which were meaningful to product designers such as the number of insertions, the number of test hours, the number of solder points, the number of parts, etc. so that design alternatives could be compared. In the Zytec case,

[14] Turney (1991, 31) defines **activity reduction** as reducing the time or effort required to perform the activity, **activity elimination** as eliminating the activity entirely, **activity selection** as selecting the low-cost alternative from a set of design alternatives and **activity sharing** as making changes that permit the sharing of activities with other products to yield economies of scale.

Cooper and Turney (1990, 416) found that the purpose of the introduced ABC system was to get the engineers think about cost, and not to go for what they called "elegance" every time.

To conclude, research on the use of ABC information to influence design engineers to induce cost management of future products is not extensive. Only a few *case descriptions* can be found in existing literature. In these cases, ABC information is mainly used to design new products that are less costly in terms of indirect manufacturing costs (the so-called overhead costs), since the purpose of an ABC system is to control the indirect costs. Cost reduction through cost-effective material selection[15] for instance, will never be induced from ABC information, since the focus of an ABC system is not on the direct costs. Hence, Blanchard's objection (1978, 13) of focusing on just one segment of the product life cycle (here the indirect costs) also applies to the ABC tool. Furthermore, Spicer (1992, 20) points out that ABC cost driver information focuses only on internal decision making about product and process design. A market perspective on how far to go with cost management of future products is not included in the information provided to design engineers. The target costing approach, discussed next, meets this argument.

3.4.3 Cost Objectives : the Target Costing Approach

The third approach to induce downstream cost management of future products is found in target costing. Kato (1993, 36) defines target costing as an activity which is aimed at reducing the product life cycle costs of future products, while ensuring quality, reliability and other consumer requirements, by examining all possible ideas for cost reduction at the product planning, development and prototyping phase. **Essential is that a cost objective is set for the total product life cycle (or whole life cost) of a new product, before design and development really starts** (Cooper, 1996, 237). This objective is set taking both the market perspective and the profit expectations of the company into account. Indeed, the expected sales price for the future product is estimated based on customer reviews and competitor analysis; the profit margin is determined from the long-term strategic plan. The target cost is then set at the difference between the future sales price and the target profit margin. This global target cost for the future product is then broken down into subtargets for functions, subassemblies and parts. These subtargets are used as strict guidelines for design engineers and parts suppliers. Hence, the target costing system provides design engineers with the cost at which the future product must be manufactured and it provides the maximum purchase prices for the parts supplied by external suppliers in order to survive in a competitive market.

Recently, the Japanese use of target costing systems has been widely studied and reported in English language literature. These studies suggest that by providing target costing information

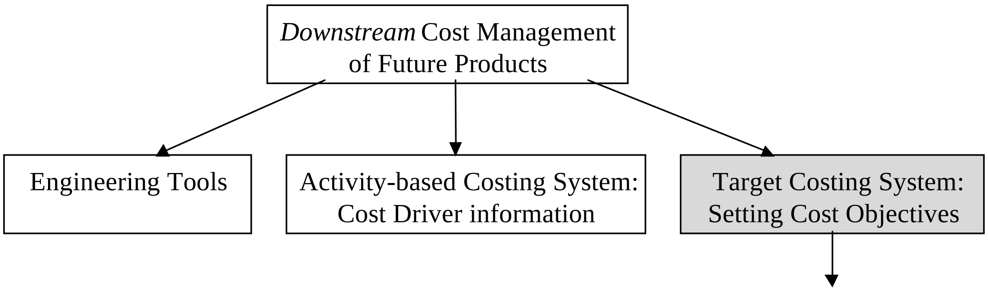
[15] Monden & Hamada (1991, 17) argue that the management of **direct cost** has become extremely important. They quote that the ratio of variable costs to total manufacturing costs has recently increased up to 90% in the car industry and that the ratio of *direct material* costs to total variable costs is about 85 percent in car companies.

to design engineers, downstream cost management of future products is realized. For instance, Cooper (1995, 137) reports that the use of a target costing system appears to be leading to future products that cause lower downstream costs than when design engineers have no specific target cost to achieve and are expected to minimize the downstream cost of the future product. Cooper (1995, 137) suggests that the most likely explanation for this is that designing to a specified low cost appears to create more intense pressure to look for cost reduction opportunities than designing to an unspecified minimum cost. Similarly, Kato, Böer & Chow (1995, 39) argue that the provision of target costing information focuses the attention on the cost implications of design decisions.

The provision of target costing information as a technique to realize downstream cost management of future products has three distinctive advantages compared to the provision of ABC information to induce cost reduction, which explains why current research and practices focus on the target costing approach. *First,* target costing seems to have a strong motivational impact on design engineers to perform downstream cost management of future products. Cooper (1995, 137) argues that what distinguishes target costing from the other techniques is indeed the intensity by which the product is designed to its target cost. By providing clear cost objectives, target costing creates a tremendous pressure for cost reduction. *Second*, the market or external focus of a target costing system justifies how far design engineers need to go with looking for cost reduction opportunities, since the target cost is derived from what the customer is willing to pay for the future product. *Third*, the inclusion of the target profit margin to determine the target cost ensures the profitability of the firm in the short and the long-term. Again, the quantification of the necessary cost reduction objective justifies how intense design engineers need to focus on reducing the cost of a future product through subsequent changes in its design, before the short and long-term profitability is secured.

Summarizing (see Figure 5), the target costing system can be described as a management accounting system, which provides target costing information to assist design engineers to realize downstream cost management of future products in order to survive in highly competitive markets by giving specific cost goals that are derived from market data. The information given is specific, directing the attention on the downstream cost implications of decisions taken regarding the newly designed products. In addition, the target costing information seems to provide a strong motivational impact on design engineers to realize downstream cost management of future products. Consequently the purpose of this study is to *extend the knowledge of the target costing approach* in realizing downstream cost management of future products. Research on the other two mentioned tools, the engineering approach and the activity-based costing approach, falls *outside* the scope of this study.

Figure 5: Techniques for Downstream Cost Management of Future Products



What?	The provision of *target costing information* to assist design engineers;
Purpose ?	to realize *downstream cost management of future products*, in order to survive in highly competitive markets;
How?	by setting *specific cost goals* - derived from market data -;
Why ?	because design engineers might have *lack of direction* or *lack of motivation* in considering the downstream cost implications during new product development.

3.5 Multiple, Conflicting Objectives in New Product Development (NPD)

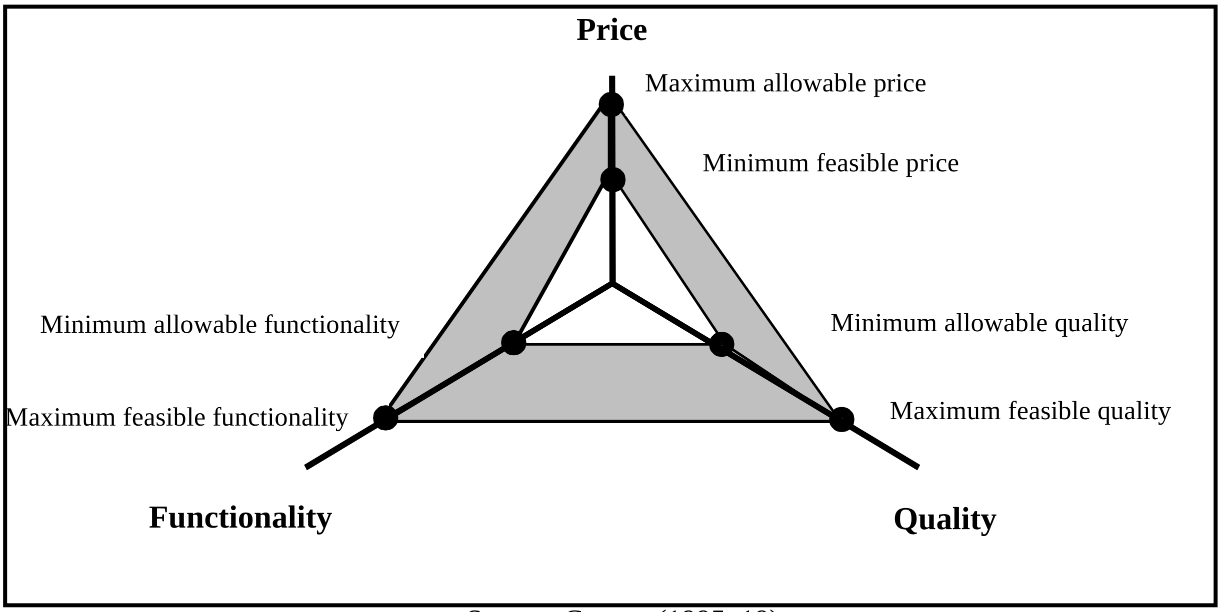
Cost management was defined earlier (see page 7) as the active search to implement cost reduction opportunities, though *without affecting the value of the future product for the customer*. **Indeed, cost is not the one and only factor that management and design engineers need to consider when defining, designing and developing future products**[16]. Kato (1993, 37) argues that it is essential to reduce costs with regard for the quality, the functions and the characteristics of the product from the customers' point of view. We will briefly discuss here two frameworks addressing the different NPD goals while designing and developing future products; the first framework is derived from management accounting literature, the second from R&D management literature.

Cooper (1995, 14) defines three elements that are important to successfully designing and developing a future product, i.e. the cost/price ratio, the quality and the functionality of the future product. These three elements form what he calls the *survival triplet* of a future product. Cooper (1995, 14) defines quality as performance to specifications, while functionality is defined as the specifications of the product. For internal purposes Cooper uses the concept of cost, for external purposes Cooper uses the concept of sales price (which is determined by the market). His reasoning is that sales prices can be disconnected from costs temporarily, but if the firm is to remain profitable in the long run, cost levels must be brought into line with the level of the sales price. Cooper (1995, 14) developed the concept of "survival zones" on the "survival triplet" to stress that a combination of the three objectives is important. A product's *survival zone* (see Figure 6) is established by determining the survival range for each characteristic in the survival triplet. The *survival range* is defined by determining the minimum and maximum values that each characteristic should have for a future product to be successful. The range between the maximum feasible value of functionality that the firm can provide and the minimum acceptable value of functionality that the customer will accept, is for Cooper (1995, 15) the survival range of the characteristic functionality. Similarly, the range between the maximum feasible value of quality that the firm can provide and the minimum acceptable value of quality that the customer will accept, is the survival range of the quality characteristic. Furthermore the survival range of the sales price is the range between the maximum price that the customer will afford on the one hand and the minimum price that the firm will accept on the other hand. The survival zone of a future or current product is obtained by connecting these three maxima and minima. According to Cooper (1995, 18), a future product that falls outside the survival zone will not be successful when launched, because an insufficient number of customers are willing to buy it or because the firm can never realize producing it without inducing significant penalties on the other

[16] We briefly address here the issue of **successful new product development**. Of course, many more variables influence the fact whether a product will be a success or a failure. Barclay (1992), for instance, reviewed literature and found 140 factors associated with new product success. The most important factors had to do with professionalism of management, knowledge of the market, uniqueness/superiority of the new product, coordination between department, and proficiency in technological activities.

characteristics[17]. **Cooper (1995, 30) argues that it is not necessary or even advisable to expend equal effort on all three characteristics of what he calls the survival triplet, i.e. on the cost, functionality and quality of a future product.** To the customers, one characteristic usually dominates the other two. By way of illustration, Cooper & Slagmulder (1997, 38) found that in a market where the customer demands increased functionality, the most important dimension is functionality. In contrast, if the market is price driven, then the critical skill is cost reduction. According to Cooper (1995, 31), many western firms call for highest quality, lowest cost and a first-to-market product, while no firm can reasonably expect to be number one in all three elements, because it would make the company a monopolist with all of its competitors going bankrupted. Cooper (1995, 31) explains that western firms have adopted this “best in all three” approach because they have encountered Japanese competitors who are superior to them in all three elements. To survive they had to improve on all three elements together. In this vision, the key to successful NPD lies in selecting the appropriate rate of improvement for each characteristic.

Figure 6: Cooper’s Framework for Successful NPD: the Survival Triplet



Source: Cooper (1995, 19)

[17] For instance too high functionality will cause quality problems.

The second framework (see Figure 7**) is derived from R&D management literature. In Rosenthal's framework (1992, 52)** ***four*** **elements need to be considered when designing and developing a future product, i.e. the quality of the new product, the time-to-market[18], the unit cost and the development cost[19].** Quality is defined as multidimensional, using the eight dimensions of Garvin (1987, 104), i.e. performance, features, reliability, conformance, durability, serviceability, aesthetics and perceived quality[20]. Time-to-market is defined as "the time from formal allocation of resources to the project until the new product's commercial delivery from volume production is demonstrated to be satisfying its customers". The concept of development cost refers to all costs incurred before manufacturing starts (i.e. what we have called the upstream costs). Unit cost should here be interpreted as the total of all costs incurred from the moment manufacturing starts (i.e. what we called before the downstream costs). According to Rosenthal (1992, 53), the central challenge in new product development is to establish and achieve the mutually compatible time, quality (in its eight dimensions), development and unit cost objectives.

Rosenthal (1992, 70) stresses the ***trade-offs*** **among the multiple objectives in NPD**. Ray (1995, 57) explains that there are six potential trade-offs among the NPD objectives that must be examined and resolved, when translating customers needs into these multiple objectives for the new product, as shown in Figure 8. To illustrate this point, during NPD a lot of time can be spent searching for potential manufacturing problems. This might lead to the achievement of the downstream cost objective and the quality objective for the future product, while the development cost objective and the time-to-market objective are exceeded. Similarly, a low downstream cost objective might be realized by selecting cheaper materials, which in turn might cause a reduced product performance. Thus, aiming for a first objective might cause that a second objective is no longer achieved and vice versa. Also Ulrich & Eppinger (1995, 5) argue that one of the most difficult aspects of NPD is recognizing, understanding and managing the trade-offs among the multiple goals in a way that maximizes the

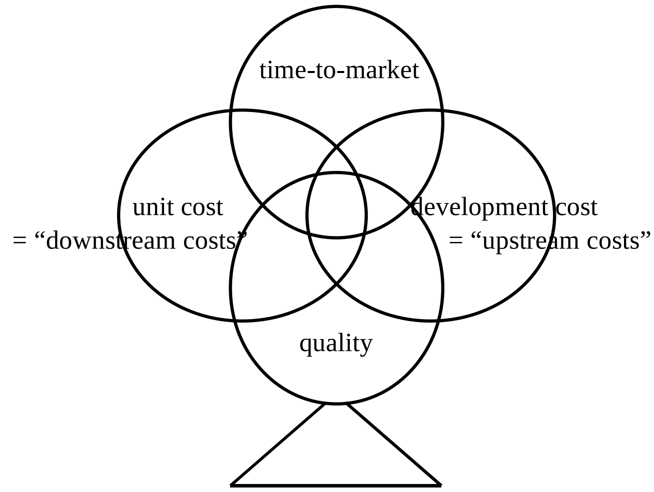
[18] In literature other terms are used for time-to-market, such as **development time, development cycle time, lead time, new product delivery time**.

[19] Ulrich & Eppinger (1995, 3) mention a fifth characteristic of successful product development, i.e. **development capability**, which represents the experience of the team and influences the effectiveness of developing new products.

[20] In **Garvin's** (1987) definition of quality, *performance* refers to a product's primary operating characteristics, *features* refers to the supplementary characteristics of a product and *conformance* refers to meeting the specifications. *Reliability* measures the probability of a product failing over time, while *durability* measures the product life before replacement. *Serviceability* has to do with ease-of-repair, *aesthetics* with the look, the feel, the sound, etc. of a product and *perceived quality* with the subjective reputation of a product. From **Cooper's** (1995, 18) discussion of the survival triplet, it is not so clear which elements of Garvin's (1987) definition are understood by functionality and which by his quality concept. Our feeling, from reading Cooper's cases, is that functionality encompasses the elements performance, features, durability, reliability and aesthetics, while quality corresponds to what Garvin (1987) calls conformance. Seen from that perspective, we conclude that Cooper's definition of functionality is consistent with what is also called "design quality", while Cooper's definition of quality is consistent with what is also called "conformance quality".

success of the product. **Hence, design engineers are expected to achieve not only *multiple* objectives simultaneously, they also are *conflicting* with each other**.

Figure 7: Rosenthal's Framework for Successful NPD: Balancing Multiple Objectives



Source: Rosenthal (1992, 61)

Figure 8: Trade-offs Among the NPD Objectives

	Quality (performance, features, …)	**Time-to-market**	**Development Cost** (upstream costs)	**Product Cost** (downstream costs)
Quality (performance, features, aesthetics, …)		**X**	**X**	**X**
Time-to-market			**X**	**X**
Development Cost (upstream costs)				**X**
Unit Cost (downstream costs)				

Source: Ray (1995, 57)

In summary, the downstream cost level is *just one* important factor that management and design engineers need to consider when defining, designing and developing a future product. Other important objectives such as the quality level of the future product (in any of the eight dimensions) and the projected time-to-market, both driven by competitors' actions and customers' requirements, need to be defined in advance and realized during the NPD process as well. Furthermore, these objectives are *conflicting* with each other, so achieving all of them simultaneously becomes a challenging task. The difference between Cooper's framework and that of Rosenthal is that Cooper (1995) focuses on output variables of the NPD process, i.e. on the functionality, quality and cost level of the future product. Rosenthal (1992) on the other hand, combines objectives that relate to the design and development *process* (i.e. the time-to-market and the development cost level) as well as to the *output* of the process (i.e. the quality and the cost level of the future product). We consider to use the framework and definitions of Rosenthal (1992) to be more valuable because of the inclusion of the element time, the broader definition of the quality concept in its eight dimensions and the separation between the upstream (development) and the downstream (manufacturing) costs.

The purpose of this study is to extend the knowledge on target costing as a way to induce *downstream* cost management of future products. As the NPD objectives are interrelated and conflicting with each other, we will include the impact of target costing on the outcomes of the other NPD objectives. Basically, we will include three of Rosenthal's four NPD objectives, i.e. the *unit cost* (downstream costs), the *quality* level of the future product and the *time-to-market*. The development cost is not taken into account because the focus of our study is on management accounting information to assist design engineers in inducing *downstream* cost management of future products, i.e. on managing "the big dollars that come later" (Shields & Young, 1991, 177). **Consequently, this study aims to extend the knowledge of providing target costing information during NPD on the downstream cost level, the quality level of the future product and the achieved time-to-market.**

3.6 The Strategic Importance of Shortening Time-to-market

While many authors focus on the strategic importance of cost management in highly competitive markets, **another stream of literature stresses the importance of shortening the time-to-market of future products**. Stalk & Hout (1990, 29) argue that *time-based competition* has become an important source of competitive advantage. To them, leading companies in the early 1980s showed the power of this new competitive advantage by compressing the time required to manufacture, to distribute and more importantly, to develop and to introduce new products. **Similarly, Wheelwright & Clark (1992, 4) argue that to succeed, firms must be responsive to changing customer demands and to the moves of their competitors by *shortening the time-to-market* of new products.** The ability to identify opportunities, mount the requisite development effort and bring to market new products quickly is critical to effective competition. Also Smith & Reinertsen (1991, 3), the authors of the bestseller "Developing Products in Half the Time", state that shortening the time-to-market is a tool that no company can afford to ignore if it wants to remain viable in the 1990s.

The basic economic justification for shortening time-to-market, as suggested by Rosenthal (1992, 64), is that much of the potential sales revenues from a new product with a short life cycle will occur between its own product launch date and that of the competitor who follows. Smith & Reinertsen (1991, 3) add that if a product is introduced earlier, it seldom becomes obsolete any sooner, which results in an extended sales life. Furthermore, the earlier a product appears, the better are its prospects for obtaining and retaining a large share of the market. When the underlying technology is moving, a company that develops new products faster, can start late while including the latest technology. Also in target costing literature, the need for shortening time-to-markets is recognized. Cooper (1995, 73) argues that by decreasing time-to-market, a firm is able to accelerate the rate at which new technologies are introduced. Hence it reduces the risk that a firm is left behind by its competitors.

Kato (1993, 42), however, mentions that aiming for a short time-to-market by setting *challenging time-to-market targets*, together with using *target costing* information aiming for downstream cost management of future products, causes a tremendous pressure on design engineers in the Japanese firms he studied. Kato (1993, 42) argues that even if development activities are highly structured and sophisticated support systems[21] are available, much of the creativity involved in developing new products is human-dependent. He concludes that high time pressure in a target costing context creates tension and results in poor performance.

In summarizy, the notion of time-based competition has recently been expanded to the new product development area. Speed-to-market has become a watchword in many industries. As speed-to-market is considered to be vital for a firm to survive, we will include time pressure in

[21] For a review of **planning techniques and support systems** to shorten time-to-market see for instance Smith & Reinertsen (1991), Wheelwright & Clark (1992) and Rosenthal (1992).

this research. Some of the case study researchers in target costing suggest that providing target costing information under severe time pressure does *not* induce the expected outcome of downstream cost management of future products. Thus, this study also aims to extend the knowledge on target costing in terms of contingency factors by including time pressure as a contingency variable.

4. Research Questions

In the previous sections we referred to some researchers who argue that cost management is strategically important to survive in highly competitive markets (Cooper, 1995; Kato, 1993). Furthermore, we came to the conclusion that downstream cost management of *future* products during the new product development (NPD) stage may provide many more opportunities for cost management than focusing on reducing the costs of *existing* products during manufacturing and subsequent stages (Blanchard, 1978). Current research on target costing suggests that target costing is an appropriate method for realizing downstream cost management of future products. In target costing, the provision of target costing information is considered to have a favorable impact on the downstream cost level of a future product (abbreviated further simply to *the cost level*). This will further be illustrated in the chapter on the literature review, where the technique of target costing will be explained more in depth.

Still the favorable impact of target costing on the downstream cost of future products has only been supported by anecdotal evidence (see chapter two). No empirical research has been done to test the impact of target costing on the cost level of future products in a NPD context. Hence, our first research question is about whether *target costing* is a better method in terms of motivating design engineers to induce downstream cost management of future products than when no target costs are set. When no target costs are set, design engineers are expected to minimize the cost level of the future product, what is for us "*non-target costing*". So, the first research question is formulated as follows:

<u>*Research question 1*</u>*:* *Will the downstream cost level of a future product be lower in a target costing than in a non-target costing environment?*

In the previous section we have also quoted researchers (Rosenthal, 1992; Kato, 1993; Cooper, 1995) **who argue that design engineers focus on multiple, conflicting objectives during NPD.** Design engineers need to consider different NPD objectives (quality, time-to-market and cost) simultaneously. In current target costing literature, some of the case study researchers (e.g. Kato, 1993) suggest that the easiest way to attain the target cost is to lower the quality level of the product by lowering the reliability or by reducing some of its functions. Furthermore, other researchers (e.g. Kato, Böer & Chow, 1995) posit that target costing results in longer development periods with a postponed time-to-market. **As will be concluded from chapter two, in current target costing literature no research is available that studies the impact of target costing on the cost level, the quality level and the achieved time-to-market simultaneously.** Because Cooper (1995) and Rosenthal (1992) insist that the *combination* of these elements determines the success of the future product, we include a research question that deals with the impact of target costing on the three combined outcomes (abbreviated further as the *multidimensional NPD performance*). Hence, in research question two, we examine whether design engineers design a totally different product in terms of cost level, quality level and time-to-market in target costing than in non-target costing. Or to put in more specific terms, we seek to understand whether the performance of the NPD task (measured by the cost and quality level of a new product and its achieved time-to-market), is different in a target costing context from that in a non-target costing context. This second research question is formulated as follows:

Research question 2: *Will the multidimensional NPD performance (in terms of the downstream cost level of a future product, the quality level of that future product and the achieved time-to-market) differ between a target costing and a non-target costing context?*

In the previous section, we have also quoted researchers (Stalk & Hout, 1990; Smith & Reinertsen, 1991) who argue that in the current competitive environment being fast on the market with a new product is vital. Current research on target costing (Kato, 1993), however, suggests that extensive time pressure in a target costing context creates tension and results in poor NPD performance. **Yet, no empirical studies have been performed, as far as we know, to study if time pressure (or difficulty of the time-to-market objective) weakens the impact of target costing on the cost level of a future product.** Hence, in the third research question, we seek to explore whether the difference in cost level between target costing and non-target costing depends on the levels of time pressure. This third research question is formulated as follows:

Research Question 3: *Will the difference in downstream cost level between a target costing and a non-target costing context vary between low time pressure and high time pressure?*

This question of time pressure in a target cost setting context has not been analyzed yet in a NPD environment where the outcome of the multiple, conflicting objectives needs to be considered. As we will conclude further from chapter two on the literature review, **no research studies in the field of target costing are available that consider the impact of target costing on multiple NPD performance measures under different levels of time pressure**. Hence, in research question four we seek to investigate whether the impact of target cost setting on the three NPD outcomes (cost, quality and time-to-market) combined, differs across the levels of time pressure. In particular, we are interested to know whether the difference on the multidimensional NPD performance between a target costing and a non-target costing context will be different in a situation of high time pressure from that in a situation of low time pressure. This fourth and final research question is formulated as follows:

<u>Research Question 4</u>: *Will the difference in multidimensional NPD performance (in terms of the downstream cost level of a future product, the quality level of that future product and the achieved time-to-market) between a target costing and a non-target costing context vary between high time pressure and low time pressure?*

Studying these research questions is relevant for a number of reasons:

1. **First, the problem is real**. Existing literature seems to produce convincing evidence that companies in a highly competitive environment have no other choice but to aggressively manage the downstream cost of future products in order to stay on the market. Companies such as Nissan and Sony showed that by setting target costs during NPD, commercially successful products can be launched at low cost levels. Some western firms, however, assert that the creativity of design engineers should not be constrained by cost concerns (Shields & Young, 1994, 176). Design engineers know best how far the cost of a future product can be reduced, as they design the new product (Cooper, 1995, 137).

2. **Second, the above questions are unanswered in target costing literature**. Research question one and three fit into Shields & Young's (1994, 191) general call for more research on determining how design engineers make decisions that affect product life-cycle costs and target costs, a subject which has not been covered since. By including in question two and four the impact of target costing on three NPD outcome variables (quality level, downstream cost level and time-to-market), we meet Cooper's (1995, 82) call for more research on the interlocking roles of these NPD outcomes. Cooper (1995, 82) argues that there is plenty of literature on quality, functionality and costs management practices separately, but only limited studies cover the interlocking roles of the quality level, the downstream cost level and the time-to-market of a future product.

3. **Third, the above questions are unanswered in goal setting literature.** As will be discussed in chapter three on the hypotheses development, the research problem of this study can be considered as a goal setting problem. The first research question might look like a replication of the first core finding of the goal setting theory (goal difficulty/specificity), which asserts that specific and difficult goals lead to a higher level of performance than vague, non-quantitative goals such as "do-your best". (Locke & Latham, 1990, 27). Yet, this study is more than an elaboration of the traditional goal setting studies where just one goal is set and just one sort of task performance is measured to determine if the goal is achieved. In this study, the specific context of the NPD environment demands for a situation of *multiple* goal setting. Just a few goal setting studies (e.g. Ivancevich, 1974, 1976) have focused on multiple goals and multiple performance measures. But, in these existing studies, goals are often causally interrelated in a positive way so that actions

taken to attain one goal help rather than hinder the attainment of the other goals. In the NPD environment, the multiple goals that are set are *conflicting* and have to be achieved simultaneously. Furthermore, in the existing multiple goal setting studies the impact of each of the goals on task performance is measured individually in a univariate way, without considering the interrelation between the different aspects of task performance, as we need to do for answering research question two and four. In addition, only limited research has been done on combining goal setting with time pressure as we will do in order to answer research question three and four of this study. The topics of this study are thus scarcely covered in goal setting literature. Hence, by answering the research questions, we will also meet the call, - posted by Locke & Latham (1990, 54), the fathers of goal setting theory - , for more research on the impact of multiple goals on task performance.

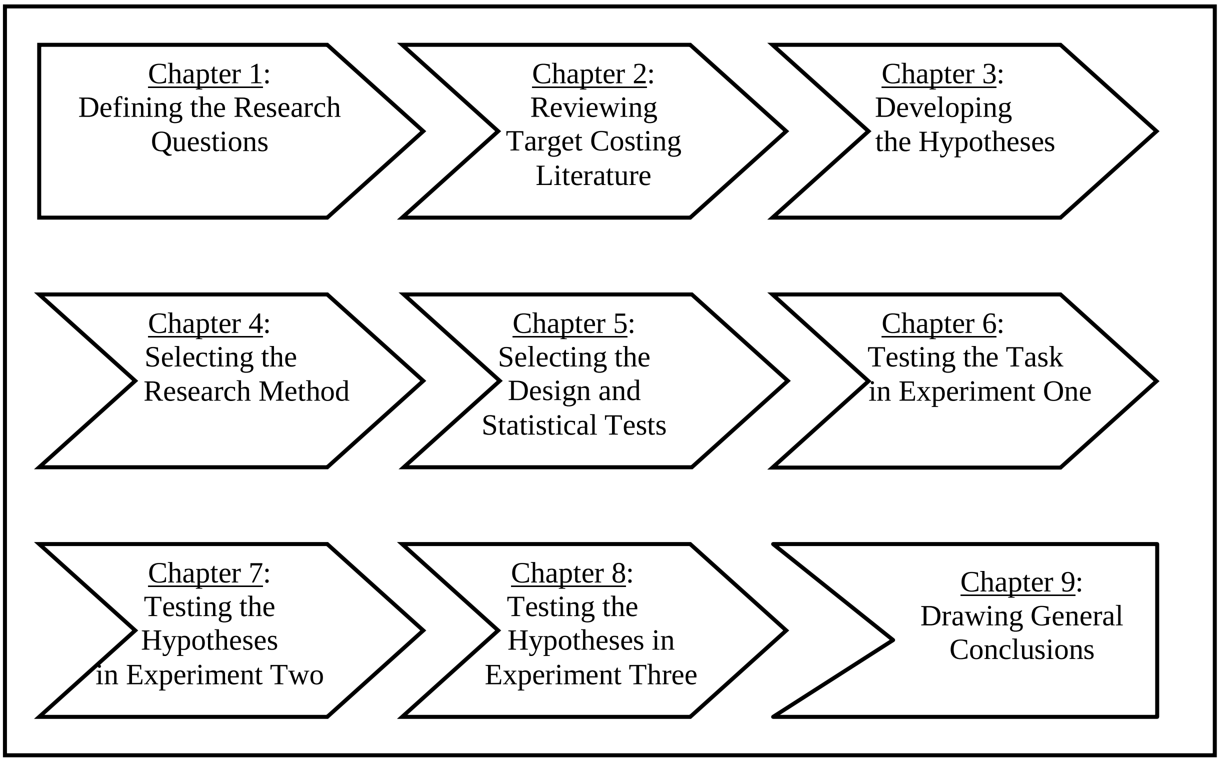
4. **Fourth, answering the research questions will contribute to a broader knowledge of *target costing* in several ways.** *First*, the theory of target costing in terms of its so-called favorable impact on the cost level of future products will be tested empirically in a controlled environment. *Second*, the theory of target costing will be extended by one contingency factor, i.e. time pressure (or time-to-market difficulty). This study can be considered as a first attempt to detect the conditions under which target costing results in effective downstream cost management of future products. *Third*, the research approach to the target costing problem is innovative through the inclusion of the other NPD objectives "quality" (multidimensional) and "time-to-market". The impact of target costing is questioned on the downstream cost level separately, as well as on the multidimensional NPD performance (in terms of the cost level, the quality level and the achieved time-to-market).

5. **Fifth, the research method is novel** since the current knowledge on target costing is almost exclusively based on field study research. In this study the impact of target costing both on the cost level and the other NPD outcomes (quality level and achieved time-to-market) will be tested empirically in a laboratory experiment.

5. Structure of the Dissertation

To answer these four research questions, several steps need to be taken. We begin chapter *two* with a review of literature on target costing, in general terms as well as on the above research questions. In chapter *three* the hypotheses, needed to answer the research questions, will be developed. We will consult mainly two areas in order to construct the hypotheses: studies on target costing and studies on goal setting. In chapter *four* the selection of lab experiments as research method will be addressed. In chapter *five* we will discuss the most appropriate experimental design and the most appropriate statistical tests. In the chapters *six, seven* and *eight* the lab experiments will be described and the results will be analyzed to test the developed hypotheses. Finally, in chapter *nine* we will present general conclusions to this study and notes for further research.

Figure 9: Structure of the Dissertation



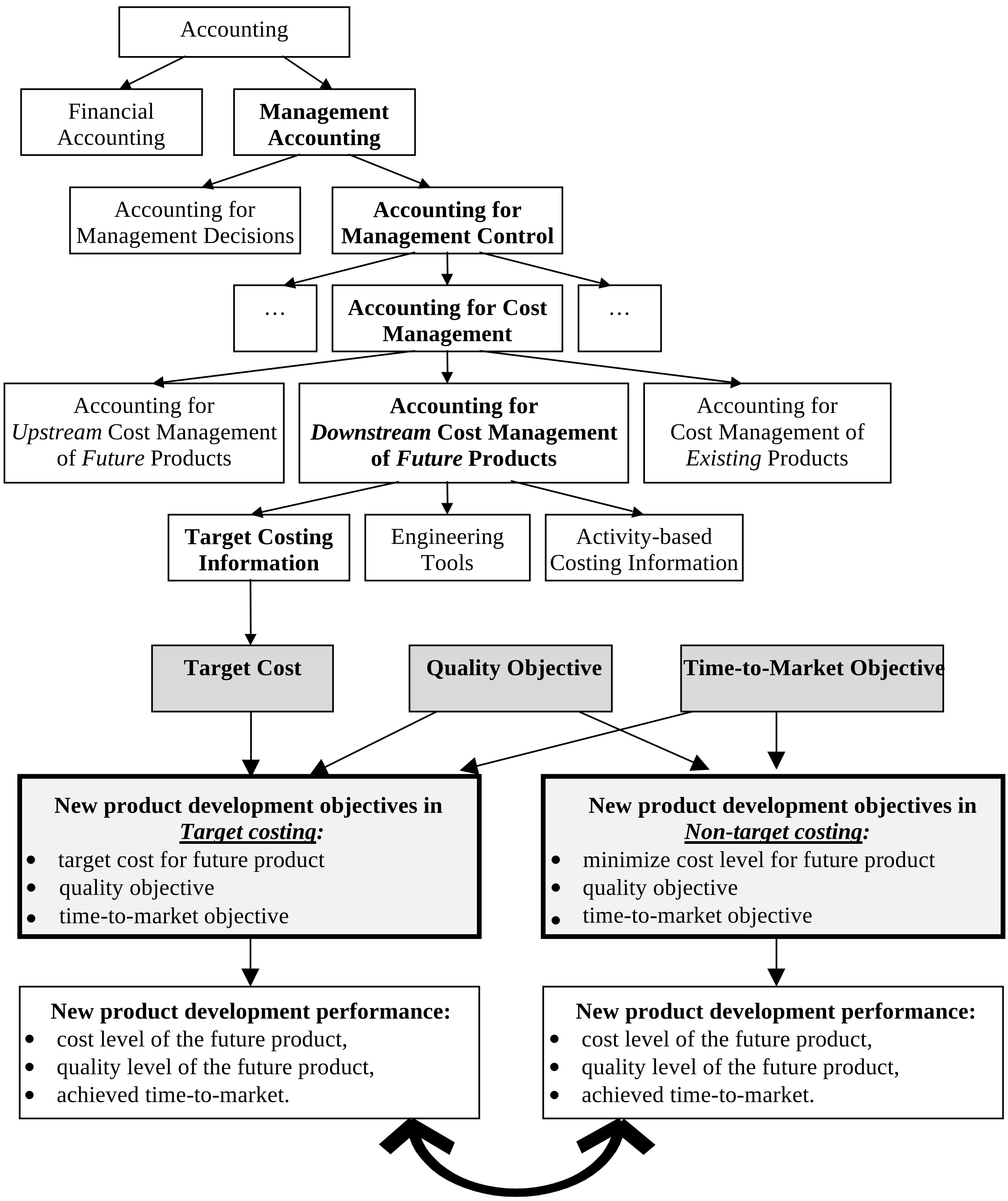
6. Conclusion

This research can essentially be described as behavioral research in the field of *management accounting*. This study is about the provision of cost information in order to influence the behavior of design engineers to realize cost management, necessary to survive in a highly competitive market. A specific form of cost management is aimed for, i.e. *downstream cost management of future products*. This involves reducing the manufacturing and subsequent life cycle costs while a new product is still in the design and development process.

The general research problem can be described as studying the effectiveness of target costing during new product development. We will study the impact of target costing on the cost level of the future product, as well as on the quality level of the future product and the achieved time-to-market. Four specific research questions have been developed. The *first* research question seeks to explore whether the cost level of a future product will be lower when a target cost is set than when no target cost is set and design engineers are expected to minimize the cost level (what we have called "non-target costing"). The *second* research question seeks to investigate whether multidimensional new product development performance (measured by the cost level, the quality level and the achieved time-to-market of the new product) will be different when a target cost is set than when no target cost is set. The *third* research question asks whether the difference in cost level in a target costing and a non-target costing context is dependent on time pressure. Finally, the *fourth* research question asks whether the difference in multidimensional new product development performance (measured by the cost level, the quality level and the achieved time-to-market) between target costing and non-target costing varies as a function of time pressure.

A summary of the research set-up and a short review of the research questions are given in Figure 10, on the next page**.**

Figure 10: Research Set-up



Research Questions:

1. **Will the cost level in target costing be lower than in non-target costing?**
2. **Will the multidimensional NPD performance (cost, quality and time-to-market) in target costing be different than in non-target costing?**
3. **Will the difference in cost level between target costing and non-target costing be different under high time pressure than under low time pressure?**
4. **Will the difference in multidimensional NPD performance (cost, quality and time-to-market) between target costing and non-target costing vary between high and low time pressure?**

Chapter 2: Literature Review on Target Costing

1. Introduction

In this chapter we review literature on target costing. This chapter has mainly two purposes. First, we will address a full description of the target costing process in the sections 2 to 6. Second, we will summarize the research on the effectiveness of target costing, to evaluate the current knowledge on our formulated research questions.

Thus, attention will be given first to the *definition of target costing* in section 2 and 3, since the concept is rather loosely described in current literature. To fill this gap, we will develop *seven typical characteristics* of target costing. In section 4, each of these characteristics is discussed in depth, based on current literature. Next, a short description of the reported *benefits and drawbacks* is provided in section 5. In section 6, we will briefly address the suggested *cost reduction techniques* to achieve the target cost. Last but not least, we will discuss in section 7 the *current state of knowledge* on the research questions, which we have developed earlier in chapter one on page 25.

2. Design-to-Cost

Setting objectives for the cost of a new product is not a brand new practice. Some authors refer to design-to-cost as the precursor of target costing. Indeed, **design-to-cost is an old principle** with its roots in the American Department of Defense. Restrictive budgets led the department of defense to define a maximum amount of costs over the entire life cycle of a to be developed weapon system. Michaels and Wood (1989, XVII) explain that in design-to-cost, cost is elevated to the same level of concern as performance and schedule (time-to-market). Realistic cost goals are established from early trades with performance and time-to-market goals, but not at the expense of the basic function the product is to provide, and never at the expense of the quality of the future product. Blanchard (1978, 12) states that in design-to-cost, the cost of the new product is assumed to be an *active* rather than a *resultant* factor during the design process, which is also one of the basic assumptions of target costing. Furthermore, different design-to-cost systems are described. For instance, Blanchard (1978) and Michaels & Wood (1989) distinguish between "design-to-unit acquisition cost" (where the cost goal includes research and development costs as well as the manufacturing costs), "design-to-unit operation and support cost" (where the cost goal includes only the operation and supports costs) and "design-to-life-cycle cost" (where all cost elements are included in the maximum allowable cost ranging from research and development, manufacturing to operation and support costs). In the few descriptive research studies that are available on design-to-cost, it sounds very much like the target costing method, which will be discussed next. However, according to Yoshikawa et al. (1993, 38) design-to-cost focuses on the internal capabilities of an organization, since the target cost is set at the level which can be achieved with the greatest possible efforts from designers, while target costing has a more external, market-based focus as we will see infra. **Avoiding this discussion of terminology, we will use the term target costing in this study, knowing that it has much ground in common with design-to-cost.**

3. Definitions of Target Costing

Very recently, the target costing system has been described in English language literature. Authors[22] mention that some Japanese firms have a long tradition of using a target costing system. Despite this **long tradition**, we notice only recently the publication of articles dealing with target costing. Kato (1993, 36) explains this contradiction between popularity in practice and non-existence in literature, by pointing out that the effective implementation just started about fifteen years ago in Japan as well and that in general, companies are not very keen on reporting practices of their new product development process.

Before going into definitions, it is important to know that target costing is **not a costing system** like full costing, direct costing or activity-based costing. Target costing is in fact a mistranslation of what is called "*Genka Kikaku*" in Japanese. Brausch (1994, 49) clarifies that the target costing system has not an impact on how costs of products are calculated, but rather affects the way in which costing information, already available, is used. In the early publications, other names were used for target costing systems such as "cost planning" and "cost projection systems".

In literature different definitions are given to target costing. See Table 1 on page 36 for a review. Generally speaking there are two issues in target costing. The first involves the determination of the target cost and the second focuses on achieving the target cost. Depending on the issues stressed, some authors use a *narrow* definition limiting target costing to one of the two processes - determination or achievement -, while others prefer to use a *broad* definition, referring to target costing as both the determination and the achievement of the target cost. Though, several other researchers focus on the *purpose* of target costing, i.e. to reduce the downstream costs of a future product.

Cooper, stressing the process of determining the level of the target cost provides a first narrow definition. Cooper (1995, 135) describes target costing as the structured approach to determine the cost at which a proposed product with specified functionality and quality must be produced in order to generate the desired level of profitability at its anticipated sales price. A *second* class of narrow

[22] Tanaka (1993, 4) mentions a **first practice of target costing** by Toyota around 1965 and Kato (1993, 36) refers to a thirty year history in the Japanese industry.

definitions is provided by Tanaka (1993,4) and Tani et al. (1994, 67), stressing **the process of the attainment of the target cost**. For them, target costing is concerned with simultaneously achieving a target cost along with planning, development and detailed design of new products. *Third,* Makido (1989, 6) and Yoshikawa et al. (1993, 35) assign a broader meaning to target costing by including **both processes, the determination and the achievement of the target cost**. For instance, Yoshikawa et al. (1993, 35) define target costing as the process established to set and support the attainment of cost levels expressed as product costs, which will contribute effectively to the achievement of an organization's planned financial performance. *Finally*, several others, such as Ansari & Bell (1997, 11), Brausch (1994, 45), Fisher (1995, 50), Horvath (1993, 3), Kato (1993, 36), Lee et al. (1994, 183), Monden & Hamada (1991, 16) and Sakurai (1989, 41), focus on the **purpose of target costing** in their definition, i.e. to perform cost reductions while designing and developing a future product in order to realize cost management of future products. For instance, Kato (1993, 36) defines target costing as part of a comprehensive strategic profit management system that focuses on reducing the life-cycle costs of new products while also improving their quality and reliability. Hence, target costing should be distinguished from *kaizen costing*[23], another management accounting process, frequently described as complementary to target costing in Japanese companies. As mentioned before (see 3.1, page 7) cost management can be realized for *future* products as well as for *existing* products. Monden & Hamada (1991, 17) explain that *target* costing focuses on reducing the cost of a *future* product through changes in its design, while *kaizen* costing focuses on reducing the cost of an *existing* product through increased efficiency in the production process.

In the terminology of our first chapter (see 2.2, page 2), target costing is thus part of the management accounting process that collects, classifies, summarizes, analyses and reports a special kind of management accounting information (i.e. target costing information) used to realize a special form of management control (i.e. to induce downstream cost management of future products). **Hence, we define target costing as *the process of determining the target cost for future products early in the new product development process and of supporting the attainment of this target cost during the new product development process, by providing target costing information to motivate design engineers to realize downstream cost management of future products in order to secure product profitability of the new product when being launched.*** This *target costing information*, provided by the *target costing system*, consists mainly of the target sales price, the target profit margin, the target cost for the future product as well as the target costs for different components and/or functions of the product. This target costing information is decided on by top management, based on market information, the company's profit requirements and cost information. Remark that our definition is a broad one, including both the determination and the attainment processes.

[23] See for instance Monden & Lee (1993).

Table 1: Definitions of Target Costing

Narrow	**Process to *determine* the target cost:**
Cooper (1995, 135)	Target costing is a structured approach to determine the cost at which a proposed product with specified functionality and quality must be produced in order to generate the desired level of profitability at the product's anticipated sales price.
Narrow	**Process to support the *attainment* of the target cost:**
Tanaka (1993, 4)	Effort at the planning and development stages to attain a cost target set by management is called target costing, which is carried out mainly by the design divisions.
Tani et al. (1994, 67)	Target costing is concerned with simultaneously achieving a target cost along with planning, development and detailed design of new products by using methods such as value engineering.
Broad	**Process to *determine* and to support the *attainment* of the target cost:**
Makido (1989, 6)	Cost reduction activity at the product planning stage involves two basic processes: extracting the target cost from the profit goal and evaluating the design activity with the intention of achieving the target cost.
Yoshikawa et al. (1993, 35)	Target costing may be defined as the process established to set and support the attainment of cost levels, usually, but not exclusively, expressed as product costs, which will contribute effectively to the achievement of an organization's planned financial performance.
Purpose	**Process to support *cost management* of future products:**
Ansari & Bell (1997, 11)	The target costing process is a system of profit planning and cost management that is price led, customer focused, design centered, and cross-functional. Target costing initiates cost management at the earliest stages of product development and applies it throughout the product life cycle by actively involving the entire value chain.
Brausch (1994, 45)	Target costing is a strategic management tool that seeks to reduce a product's cost over its lifetime. It presumes: interaction between cost accounting and the rest of the firm, a well-executed long-range profit planning, and a commitment to continuous cost reduction.
Cam-I in Horvath (1993, 2)	Target costing is a set of management methods and tools to drive the cost and activity goals in design and planning for new products, to supply a basis for control in the subsequent operations phase and to ensure that those products reach given life cycle profitability targets.
Fisher (1995, 50)	Target costing is a systematic process for reducing product costs that begins in the product planning stage.
Horvath (1993, 3)	Target costing is built on a comprehensive set of cost planning, cost management and cost control instruments which are aimed primarily at the early stages of product and process design in order to influence product cost structures resulting from market-derived requirements. The target costing process requires the cost-orientated coordination of all product-related functions.
Kato (1993, 36) Kato, Böer & Chow (1995, 39)	Target costing is part of a comprehensive strategic profit management system that focuses on reducing the life-cycle costs of new products while also improving their quality and reliability.
Lee, Jacob, Ulinski (1994,183)	Target costing is a market-driven system of cost reduction, focused on managing costs at the development and design stages of a product.

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Monden & Hamada (1991,16)	Target costing is the system to support the cost reduction process in the developing and designing phase of an entirely new model, a full model change or a minor model change.
Sakurai (1989, 41)	Target costing can be defined as a cost management tool for reducing the overall cost of a product over its entire life cycle with the help of the production, engineering, R&D, marketing and accounting departments.
Sakurai (1995, 25)	Target costing is an effective tool for reducing material costs such as materials and parts, but it can also be used for reducing overhead.

However, our definition as well as the mentioned definitions from literature is rather general. None of the existing articles and papers lists the necessary conditions for target costing. Though different characteristics of target costing have been mentioned, some always recurring, while others only now and then (see Brausch (1994), Cooper (1995), Fisher (1995), Kato (1993), Kato, Böer & Chow (1995), Monden & Hamada (1991), Morgan (1993), Sakurai (1989) and Tanaka (1993)).

Based on these descriptions, we developed a set of typical conditions of target costing that will be discussed more in depth in the next paragraphs.

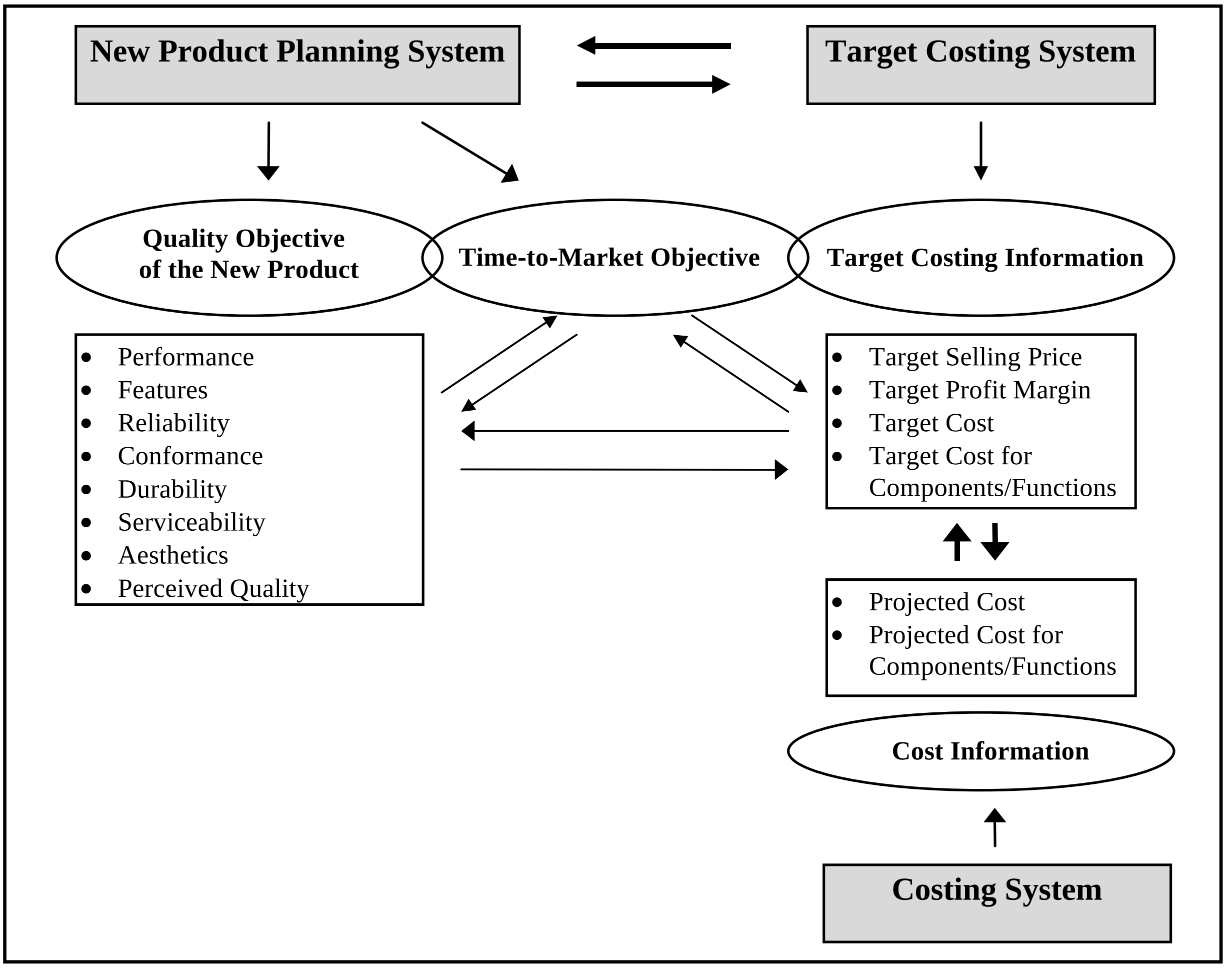
To us, there are *seven typical characteristics* for target costing. These conditions are:

1. **The target sales price is set during product planning, in a market-oriented way.**
2. **The target profit margin is determined during product planning, based on the strategic profit plan.**
3. **The target cost is set before the new product development process (NPD) really starts.**
4. **The target cost is subdivided (into target costs for components, functions, cost items or designers).**
5. **Detailed cost information is provided during NPD to support cost reduction.**
6. **The cost level of the future product is compared with its target cost at different points during NPD.**
7. **A general rule is aimed for that "the target cost can never be exceeded".**

As a concluding remark, we repeat, as discussed before (see 3.5, page 18), that **target costs are not the only elements** that design engineers need to aim for when designing and developing a future product. As mentioned, the quality of the future product in terms of performance, features, reliability, etc. need to be considered as well as the time schedule of the NPD process. It is indeed the combination of the quality of the product, its cost level and the achieved time-to-market that determines (among other elements) the success of the new product. Figure 11 shows the

interrelationship between target costing and new product planning. As shown, all elements influence each other and are mutually intertwined. Figure 11 also shows the link between the target costing system and the costing system of the firm. As will be discussed in the next section, cost information on current products as well as cost estimates on future products provide necessary input during the whole target costing process, both for determining the target cost and achieving it.

Figure 11: Target Costing in relation to New Product Planning and the Costing System



In sum, we define target costing as a management accounting process to aim for downstream cost management of future products. It encompasses the process of determining the target cost as well as the process of supporting the attainment of that target cost during new product development (NPD). Target costing information is provided to motivate design engineers to implement cost reduction ideas (without injuring the quality of the future product or the projected time-to-market) in order to secure the profitability of the future product when it is launched at the market. The most important target costing information is the target cost, which is established based on market data and the company's profit requirement. We also developed seven typical characteristics of target costing, which are discussed one by one in the next sections.

4. Typical Characteristics of Target Costing

4.1 The Target Sales Price is set during Product Planning, in a Market-Oriented Way

Establishing the target sales price is the **starting point** in the target costing process. This implies that the target sales price is decided during product planning**,** when the characteristics of the future product are determined. Cooper & Slagmulder (1997, 94) found that the target sales price is set realistic in companies using target costing, and that the process of setting the target price is taken very thoroughly at most firms. Kato (1993, 38) explains that the **sales price of existing products** or the **price level of competitor's offerings** typically provide an initial starting point for firms using target costing. A higher price point is only justified if the perceived value for the customer is much better than the existing product or competitor's offerings. To illustrate this principle, we quote from the Citizen (watches) and the Topcon (opthalmic instruments) case:

> "Cost-plus pricing was rarely used at Citizen because most products were sold into competitive markets where the competitors had similar product offerings. Occasionally, Citizen would bring out a watch for which there was no direct competitive offering. In these cases, where there was no market price, the selling price was determined using a "to be accepted" market price. This price was determined by market analyses that consisted of an evaluation of the attractiveness of the product and a comparison with other watches and other consumer products". (Cooper, 1994d, 5)

> "Topcon would price its new products near that of competitors' products. However, if management believed that the Topcon product had greater functionality than competitive products, then the price of the Topcon would be higher. If the functionality was perceived to be lower, then the price would be correspondingly lower". (Cooper, 1994e, 6)

Apart from the perceived value by consumers and the price level of competitor products, Kato (1993, 38) mentions **other factors** to consider when setting the sales price, such as the product concept, the characteristics of the anticipated consumers, the product-life cycle, the expected sales quantity and competitors' strategies. Similarly, Ansari & Bell (1997, 32) found that Japanese companies use four key determinants in setting a product's price in a target costing environment, i.e. (1) the consumer needs/wants/tastes related to the product characteristics such as performance, features, conformance, durability, aesthetics, … (2) the customer's willingness to pay for these characteristics, (3) the competitor's product characteristics and its respective prices, and (4) the desired market share for the future product. An illustration of these four elements used to set the price of a new car, can be found in the Nissan case. We quote:

> "The target price for a new car was determined by taking into account a number of internal and external factors. The internal factors included the position of the model in the matrix and the strategic and profitability objectives of top management for that model. The external factors considered included the corporation's image and level of customer loyalty in the model's niche, the expected quality level and functionality of the model compared to competitive offerings, the model's expected market share, and finally, the expected price of competitive models". (Cooper, 1994b, 4)

At Olympus (camera producer), Cooper (1994f, 4) found that the price level of *other* consumer products was also considered as important in deciding on the target sales price of a new camera, since consumer research had shown that many consumers were trying to choose between a compact disc player and a compact camera. So, market research and marketing information systems[24] are extensively used in the process of determining the sales price for a future product.

In sum, pricing a future product under target costing runs counter the well-known belief that managers need to consider the cost of the future product in price setting. Kotler[25] (1997, 502) explains the price setting process from a traditional point of view: The *cost* of the future product sets a floor to the price, the *competitor's prices* and *prices of substitutes* provide an orienting point, while *customer's assessment* of product features establishes the ceiling price. Traditionally, companies resolve the pricing issue by selecting a pricing method that includes one or more of these three elements. **It is clear that target costing contrasts with cost-based pricing methods such as markup pricing (cost-plus pricing) and target-return pricing, since cost issues are not considered as essential under target costing. Or using Kotler's terminology, target costing assumes a perceived-value pricing method.[26]**

[24] Kato (1993, 41) makes a list of six functions and features that **marketing information systems** at least should have in order to support the sales pricing decision. These are: (1) the ability to decompose product functions into sub-functions by various criteria, (2) facilities to convert the value of functions into price, (3) a market research toolbox with various forecasting techniques, (4) a user-friendly interface, (5) a value-price conversion table or database and (6) simulation functions (what-if, goal seeking, sensitivity analysis, what-best).

[25] In marketing, this model for price setting is also called the **three Cs model**.

[26] In target costing literature, another terminology is used for what in marketing is called "perceived-value pricing", i.e. **pricing by functions**. Kato (1993, 38) explains that pricing by functions is based on the belief that a product's price can be decomposed into many elements, each of which reflects the value customers are willing to pay; for instance in the case of automobiles, style, comfort, operability, reliability, quality, attractiveness, etc.

4.2 The Target Profit Margin is determined during Product Planning, based on the Strategic Profit Plan

The second characteristic of a target costing system is the early establishment of the target profit margin during the product planning of the future product. Kato (1993, 40) and Monden & Hamada (1991, 19) state that the target profit margin for a particular future product should be driven by **corporate strategic profit planning**. They explain that the total target profit for a future product should be derived from the medium-term profit plans, reflecting management and business strategies over a period of three to five years. These target profits should then be decomposed into target profits for each product over its expected life cycle. With the estimation of the future sales volumes, the target profit for a future product can be converted to a target profit margin. Kato (1993, 40) admits that it is quite a difficult task to imagine a future product portfolio in today's environment, but adds that without doing this it is impossible to decompose the total target profit into targets for each product. Furthermore, Kato (1993, 40) warns that the procedures to compute target profits should be scientific, rational and agreed, otherwise nobody will accept his/her responsibility for achieving the target profit. Kato, Böer & Chow (1995, 40) found in companies using target costing, that the profit allocation to the various products is an arduous undertaking that consumes many hours of management discussion before top management announces the final allocations.

Cooper (1994b, 5) gives an **illustration** of this critical corporate management activity at the Nissan headquarters in Japan. At Nissan the target margin for a future car is determined by carefully considering the information on the *customer*, the firm's anticipated *product-mix* and its long-term *profit objective*. We quote:

> "Each new model's target margin was established by running simulations of the firm's overall profitability over the next 10 years if it was selling the models identified in the product matrix at expected sales volumes. The simulations started by plotting the actual profit margins of existing products. The desired profitability of planned models was then added and the firm's overall profitability determined over the years at various sales levels. This predicted senior managers compared overall profitability to the firm's long-term profitability objectives set. Once a satisfactory product matrix was established that achieved the firm's profit objective, the target margins for each new model were set. To help minimize the risk that Nissan would not achieve its overall profitability targets, the simulations explored the impact on overall profitability of different price/margin curves for different product mixes. For example, historically higher margins had been earned on higher price vehicles. However, with the reduced product offering and the increased profitability expected, the future curve might be higher. Alternatively, because there was no guarantee that the existing relationship between

> price and margin would remain unchanged, simulations were also run to explore the impact of fundamentally different relationships between sales price and margins." (Cooper, 1994b, 5)

Finally, Horvath (1993, 62) and Makido (1989, 5) describe another method to establish the target profit margin. They argue that as the target price is derived from the market in a first step, the application of a certain **return on sales** seems to be the best way to specify the target profit. To Horvath (1993, 62), return on sales is set by management, based on long-term profit planning and depending on factors like corporate strategy, business sector and competitive situation. To Makido (1989, 5), return on sales (or the target profitability index as he calls it) tends to be based on that of similar existing products.

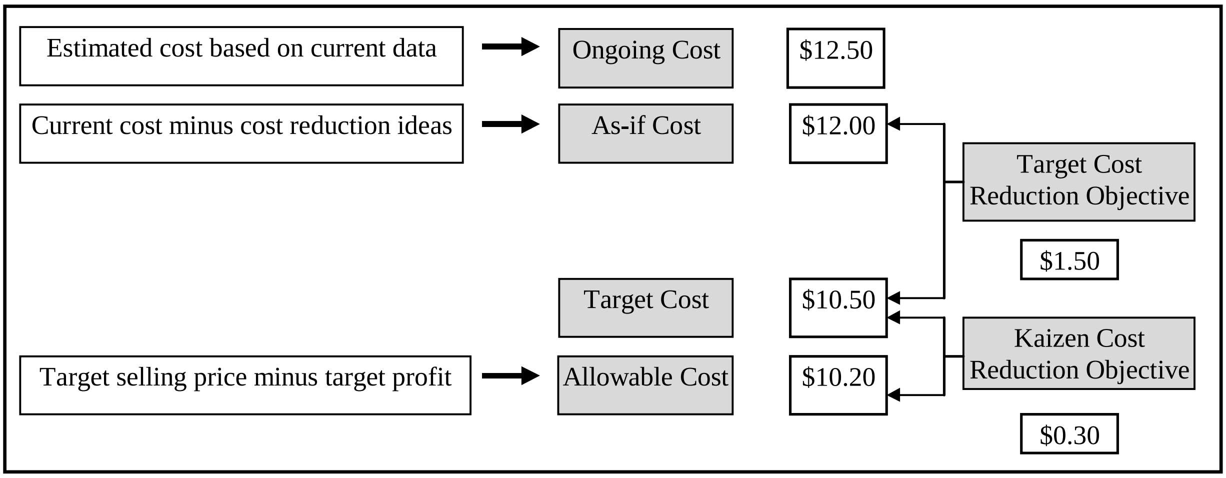
Summarizing, target costing assumes that the target profit margin is set for each new product during the product planning, i.e. before NPD really starts, to ensure the achievement of the firm's long-term profit plan. That's why some authors refer to target costing as a technique for profit management.

4.3 The Target Cost is set before NPD really starts

4.3.1 Different Cost Concepts

The third and most well-known characteristic of the target costing process is that the **target cost is set early in the new product development process**, before design and developing really starts. The decision on the appropriate level of the target cost for the new product to be developed involves a number of calculations. First, the *ongoing cost* is calculated and then the *as-if cost* is estimated. Third, the *allowable cost* is determined and finally the *target cost* is set between the allowable cost and the as-if cost. Each of these cost items will be discussed next. Figure 12 shows the global picture by a numerical example.

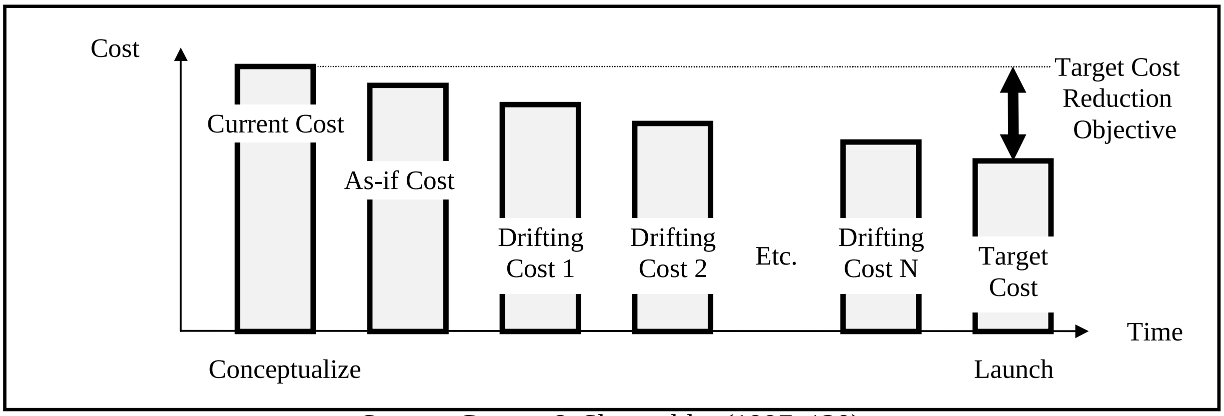
Figure 12: Example of the Cost Concepts in the Target Cost Identification Process



First, the **ongoing cost**, or the drifting cost as Sakurai (1989) calls it, is calculated for a future product. Kato, Böer & Chow (1995, 41) define the ongoing cost as **the best estimate of the future product's cost.** When NPD starts, this best estimate is based on the actual cost of the current product, considering cost-down and cost-up factors. Ansari & Bell (1997, 44) explain that this ongoing cost is also called the drifting cost, since it needs to "drift toward the target cost through successive design iterations during NPD", as shown in Figure 13 on the next page.

Second, the **as-if cost** is calculated. Kato (1993, 41) explains that various ideas for cost reduction might have emerged during NPD or during the manufacturing of current products, but that could not yet be applied to the current products. Hence, the as-if cost represents the cost of making the future product **if the company had implemented all available cost-reduction activities.** As shown in Figure 12, the as-if cost represents in fact a real cost reduction, however, Kato (1993, 41) found that it was unlikely for the Japanese companies he studied, to be sufficient to realize the medium-term profit target, given the market determined sales price.

Figure 13: Calculating the Drifting Cost towards Achieving the Target Cost



Source: Cooper & Slagmulder (1997, 120)

Third, the **allowable cost** is calculated as the difference between the target sales price and the target profit margin. As mentioned before, the target sales price is set based on market information and the target profit margin is strategically determined by top management. The allowable cost represents the cost at which the product must be manufactured in order to gain the target profit margin, when sold at the target sales price. However, Sakurai (1989, 43) clarifies that this allowable cost might not be achievable on the short run and forms in fact **the long-term most strictly cost objective**. Also Cooper & Slagmulder (1997, 106) argue that the allowable cost does not represent the capabilities of the firm and the suppliers; therefore the allowable cost is often unachievable in the short term.

For Cooper & Slagmulder (1997, 8) once the *allowable cost* for a future product is set, the first step in the target costing process is finished, i.e. what they call the "market-driven costing" part of target costing. In their next step, called the "product-level target costing", the *target cost* for the future product is set, while their last step considers dividing the target cost into target costs for components, i.e. what they call the "component-level target costing" part.

4.3.2 Setting the Target Cost for the Future Product between the Allowable Cost and the As-if Cost

Fourth, the **target cost** is set somewhere **between** the **as-if cost** and the **allowable cost**. Different methods are described in literature to set the final target cost. According to the **deductive method,** the target cost is set at the level of the *allowable cost*, i.e. at the *difference between the target sales price and the target profit margin* (see Figure 14 on page 46). This method is most commonly described in existing studies and is also called the subtraction or top-down method, since the target costs are more or less imposed to the new product development team.

The target cost can also be determined by what is called the **adding-up or bottom-up method**. Here, setting the target cost starts within the NPD department itself. Kato (1993, 42) explains that for each subassembly or component the cost is estimated, based on the actual cost of current parts. A cost reduction on each part of the new product is taken into account to get the target for each component of the new product. The total target cost is then obtained by adding up all target costs of the individual parts or subassemblies.

For Kato (1993, 38) it is clear that the **deductive method is superior to the adding-up method**. Kato (1993, 38) argues that though the adding-up method is based on the feasibility test of the proposed value engineering improvements, it is difficult to provide a logical connection with the profit and business plans. Furthermore, in his opinion, innovative ideas for cost reduction seldom emerge with this method. Sakurai (1989,43) on the other hand, argues that a **combination** of the top-down and bottom-up methods leads to the best results. His reasoning is that top management should guard target profits, but at the same time the cooperation of employees is needed to make target costing work.

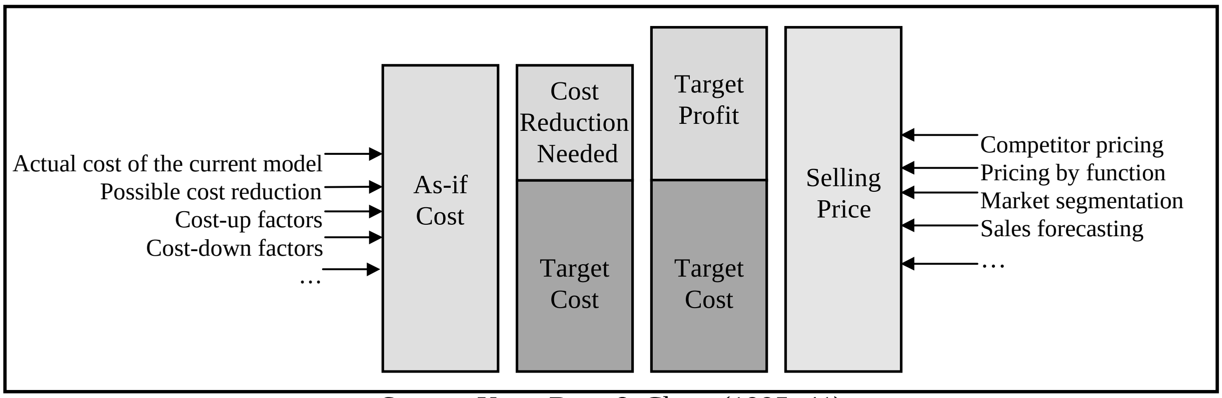
To conclude, determining the level of the final target cost is an important issue. Cooper & Slagmulder (1997, 109) argue that if the target cost is set consistently too low (i.e. too difficult to attain), the work force will be subjected to excessive cost reduction objectives, risking burnout. The discipline of target costing might then be lost, as target costs will frequently be exceeded. On the other hand, if the target cost is set at a level that is too easy to achieve, the firm will loose competitiveness because new products will have excessively high cost levels.

Once the target cost is set, filling the gap between the *as-if cost* and the *target cost* is then the major focus for design engineers. This difference between the as-if cost and the target cost is also called the **target cost-reduction objective**. Indeed, design engineers need to find ways to reduce the cost of the future product with this amount in order to attain the target cost. Filling the gap between the *target cost* and the *allowable cost* is then the objective of the kaizen costing process, during manufacturing. This difference between the target cost and the allowable cost is also called **the kaizen cost-reduction objective**. Cooper & Slagmulder (1997, 110) call it the *strategic cost-reduction challenge*. We quote:

> "It [the strategic cost-reduction challenge] identifies the profit shortfall that will occur because the designers are unable to achieve the allowable cost and signals that the firm is not as efficient as demanded by competitive conditions." (Cooper & Slagmulder, 1997, 110)

Cooper & Slagmulder (1997, 110) explain that in a firm with a well-established and mature target costing system, the strategic cost-reduction challenge will be small or nonexistent and intense pressure will be brought on the design team to reduce it to zero. Furthermore by defining an achievable target cost, management avoids weakening the cardinal rule that the target cost can never be exceeded, as will be discussed further in section 4.7.

Figure 14: Target Cost Computation, following the Top-Down Method



Source: Kato, Böer & Chow (1995, 41)

4.3.3 Factors involved in Setting the Target Cost

When setting target costs for new products, Yoshikawa et al. (1993, 40) argue that general management factors must be taken into consideration such as the *scope* of the target cost and the *cost elements included,* and the *calculation basis* for the target cost.

In terms of the *scope* of the target cost, different parts of the product life cycle of a future product can be taken into account. As mentioned before (see 3.1, page 7), the target cost can be set for the costs the producer incurs, i.e. including R&D costs, manufacturing costs, distribution costs and service costs. However, the target cost can also be set for the costs the consumer incurs, including installation, operating, maintenance and disposal costs. Most of the research done in Japan shows that firms concentrate on the revenue-producing life and more specifically on the manufacturing part of it. For instance, most of the firms Cooper (1994a, 39-69) studied, identified target costs for the manufacturing activities only. Costs for NPD, logistics or service were not included. Also, Fisher (1995, 55) found in his case studies that the focus was on (target) production costs. According to Tanaka (1989, 51), who surveyed 209 Japanese companies using target costing, 100% of the companies set a target cost for the manufacturing activity. Around 41% of the companies set a target cost for the design activity, 37% for the distribution activity and 13% for the user activity of the new product. Similarly, the results of Tani’s et al. (1994, 73) survey of 180 Japanese firms show that 59% of the respondents include target costs for the development stage, 61% for the trial production stage and 69% include logistic activities.

Second, few studies talk about the *cost elements* (e.g. direct costs, overhead costs) that are making part of the target cost. According to Sakurai (1995,25) target costing is an effective tool for reducing *direct costs* such as materials and parts, as well as for reducing *indirect costs* such as overhead costs. Cooper & Slagmulder (1997, 79) found a general focus on the direct costs, while some firms also used so-called rules of thumb to manage the indirect costs, such as reduction of the number of different materials used in a product, reduction of the number of parts across the product line. The survey of Tani et al. (1994, 73) on the adoption of target costing in Japan shows that 99% of the respondents include direct material and labor costs in the target cost. Respectively 81% and 83% of the respondent companies using the target costing process, includes manufacturing overhead costs and depreciation of new equipment in the target cost.

4.3.4 Example

Sakurai (1989, 48) describes an example, based on an actual business application that has been modified for the purpose of the article. **This example illustrates several of the items discussed above**. First, it illustrates that the customer determines the target sales price. Second, it shows that the target profit margin is determined by using a return on sales percentage. Third, it demonstrates how the allowable cost is calculated. Fourth, it shows how the drifting cost is calculated based on current cost information. Fifth, it illustrates how the final target cost is set using the bottom-up method. Sixth, it shows that target cost is set at a level somewhat higher than the allowable cost, but lower than the as-if cost. Seventh, it shows that the difference between the target cost and the allowable cost is considered as a strategic cost reduction objective. Though, in this situation the customer (an industrial firm too) was willing to accept a price increase, which reduced the strategic cost reduction objective (kaizen cost reduction objective) to zero. We quote:

> "XYZ Company received an order for an auto part, product A, from ABC Corporation. The order was for 100 units. According to the proposal from ABC, the *requested price* was ¥143,000 (approximately $1,000) per unit. XYZ's *target return on sales* (ROS) was 20 percent - that is ¥143,000 x 20% = ¥28,600 per unit. Thus, the *allowable cost* is computed as follows: ¥143,000 - ¥28,600 = ¥114,400 per unit. Since the number of orders is 100 units, total allowable cost is ¥114,400 x 100 = ¥11,440,000. Next the *drifting cost* was determined. (…) Engineers determined that the drifting cost was ¥125,000 per unit. This means that the total drifting cost was ¥125,000 x 100 = ¥12,500,000. The next step was to determine the *target cost* for the company. Foremen examined potential production problem areas, item by item, with the help of group leaders. The foremen made every effort to reduce the total drifting cost from ¥12,500,000 down to the allowable cost, ¥11,440,000. Thus, the target cost reduction was computed as, the difference between the two, which is ¥1,060,000. The process of eliminating the difference between the allowable and target cost was accomplished by modifying the drifting cost by means of such engineering tools as value engineering. Steps in this process include: interested groups propose modification of the plans, old figures are replaced with new, lower figures, drifting cost figures are modified, and motivation devices for foremen are devised. (…) By studying other problem areas, XYZ also found that it would be possible to reduce costs by an additional ¥161,000. Thus the total cost reduction achieved at the design stage was as follows: defective units (¥325,000), tooling (¥322,000) and other (¥161,000) equals a total of ¥808,000. Based on these calculations, the target cost was

determined to be ¥11,692,000 (¥12,500,000 - ¥808,000). This figure was approved by top management. However, *this target cost still fell short of the reduction target* by ¥252,000 (¥1,060,000 - ¥808,000). Thus, a cost management accountant explained the results of these cost reduction activities to the sales manager in charge of ABC and asked him to discuss the possibility of a higher price for A. Given all this work and the prospect that A could be produced by XYZ at a reasonable cost, ABC accepted the request to rise the price of A by ¥2,520 ($17) per unit." (Sakurai, 1989, 48-49)

Summing up the third typical characteristic, the target cost is set early in the NPD process. Depending on the method (top-down or bottom-up) the target cost is set taking into account mainly the target sales price and the target profit margin, or considering existing cost reduction ideas on subassemblies and parts of the future product as well.

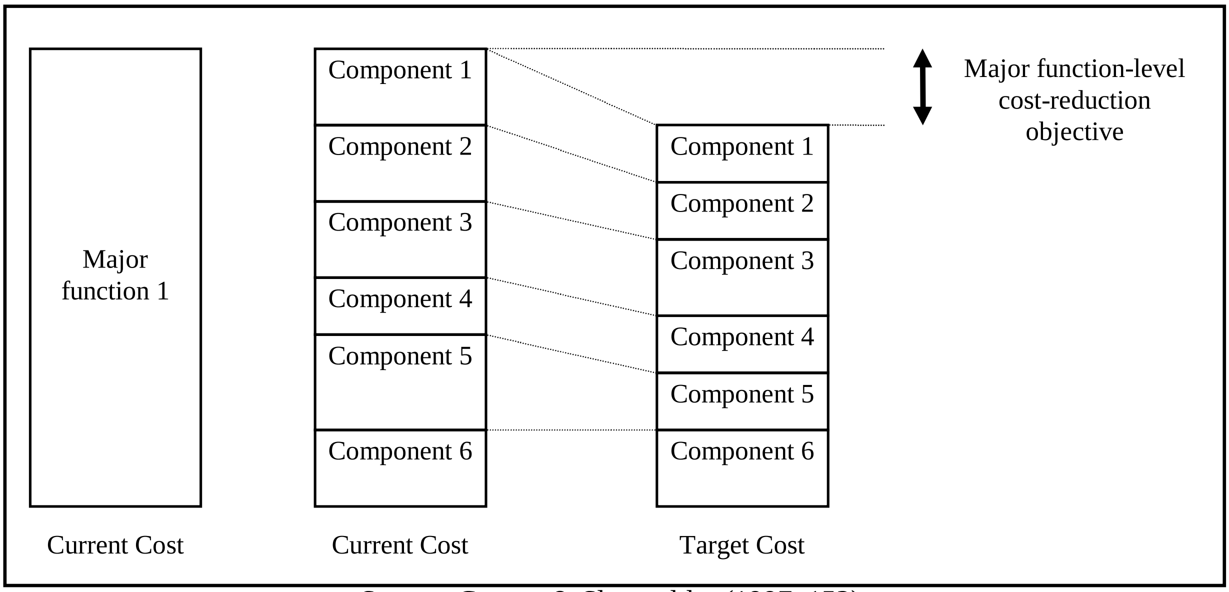
4.4 The Target Cost is subdivided into Target Costs for Components, Functions, Cost Items or Designers

For target costing to work, the target cost for the future product needs to be decomposed in order to have specific targets for designers internally and subcontractors externally. This is the fourth typical characteristic of target costing. Decomposing the target cost to target costs for subassemblies is a difficult issue, since it indirectly determines the necessary cost reduction objectives for the different design teams. According to Tanaka (1993, 9), simply deciding to reduce the estimated cost for each design team by the same x percent is not a good practice. Similarly, Cooper & Chew (1996, 96) argue that is makes no sense to apply cost reduction requirements uniformly across all the components. **Different methods are described in literature, of which the *function-oriented* allocation and the *component* allocation method are the best known.**

In the **function-oriented method,** the target cost is first allocated to the different functions of the future product and then to components. Yoshikawa et al. (1993, 47) explain that the *value of a specific function* as perceived by the *customer* is the main criterion for division of the target cost to functions. We refer to Tanaka (1989, 60) for a detailed illustration of how a target cost is established for each hard and soft function of a "marking pen". In a first step, customer analysis is used to determine the functions and the degree of importance of each function. Target costs are assigned to each function according to these degrees of importance. Then, these target costs are re-allocated to each subassembly, using the degrees of importance of each subassembly to each function. Yoshikawa et al. (1993, 52) add that setting target costs for functions based solely on the customers' viewpoint may overlook certain factors such as technical considerations, meeting safety and other regulations. They argue that although the customers' evaluation should remain dominant, it is often modified to take into account the manufacturer's evaluation before finalizing the target cost for each functional area. According to Cooper & Slagmulder (1997, 151) it is up to the "major function design" teams to decompose the target cost of the major *function* to the *component* level as shown in Figure 15. An example of this composition is provided in the Isuzu case (car manufacturer) by Cooper & Yoshikawa (1994, 5). We quote:

> "As part of the planning stage, the target cost for an entire vehicle in the concept proposal stage was distributed among the vehicle's 8,000 - 10,000 components at the major function or group component levels. Isuzu designers identified approximately 30 major functions per vehicle, including the engine, transmission, cooling system, air conditioning system, and audio system. Group components were the major subassemblies purchased from the firm's suppliers and subcontractors. There were only about 100 such components, yet they amounted to as much as 70%-80% of the manufacturing cost. Group components included the carburetor and starter." (Cooper & Yoshikawa, 1994, 5)

Figure 15: Decomposing the Target Cost of Major Functions to the Component Level



Source: Cooper & Slagmulder (1997, 152)

The second most known allocation method is the **component method**. Here the target cost is allocated to subassemblies, components and parts. Yoshikawa et al. (1993, 47) state that for the subdivision to component blocks, the proportion of the *current cost* of that part in similar existing products is frequently taken into account. Of course, as Cooper & Slagmulder (1997, 150) point out, target costs for components can be set only when the product design has reached the stage at which specific components can be identified. Tanaka (1989, 52) clarifies that the component method is usually applied to new products that are similar in design to previously manufactured products, since the component method is based on historical cost information. For complex, innovative and large-scale products, the functional allocation method is more suitable, since it allows designers as much freedom as possible in using their creative talents to design new or revised products within the target cost guideline. Furthermore, Kato, Böer & Chow (1995, 56) argue that allocating target costs to product characteristics directly satisfy customer requirements, although they found that Toyota and Matsushita, two large Japanese companies, only used the component method. Contrary, based on survey research Tanaka (1989, 53), Tani et al. (1994, 75) and Yoshikawa et al. (1993, 49) found that large Japanese companies using target costing, tend to assign target costs frequently according to the degree of importance of the functional areas, regardless of the historical cost of the components.

Other methods such as the assignment to *cost items* (materials, labor, overhead) and to *designers* are illustrated by Yoshikawa et al. (1993, 54). Monden & Hamada (1991, 22) describe the assignment to *cost items* such as engine, transmission system, chassis, etc. and then into cost items such as material cost, purchased part cost and direct labor cost. Under assignment to *designers*, a target cost is first assigned to a large group of designers working on the same subassembly of the product, then subdivided into a smaller group of components and finally given to individual designers.

Ansari & Bell (1997, 56) argue that in most organizations, departments are responsible for the costs of subassemblies, teams are responsible for the costs of components and designers are responsible for the costs of individual parts. However, Yoshikawa et al. (1993, 54) warn that the more the target cost is subdivided, the greater the restrictions placed on the designers and the less likely that new ideas will emerge.

Summing up, depending on the complexity of the future product, the global target cost should be decomposed into target costs for functions, components, cost items and even for individual designers.

4.5 Detailed Cost Information is provided to support Cost Reduction

The fifth typical characteristic of the target costing process to us, is the provision of detailed cost information. To see the impact of their design decisions on cost and to monitor the progress towards the cost reduction objective, design engineers need to estimate the cost of the future product during design and development. Kato (1993, 41) argues that information systems such as the target costing support system must provide cost information anytime the designers require it, and not only at the so-called milestones in the NPD process. Ansari & Bell (1997, 118) argue that three types of cost data need to be collected to support cost reduction, i.e. feature-cost data, attribute-cost data and function-cost data. The *feature-cost* data is a customer-focused view of costs and provides cost information to features of a product. *Attribute-cost* data provide an engineering view, which relates cost to the major physical attribute of a product. For instance in the aircraft, automobile, heavy machinery and construction industries, information about how costs respond to weight, volume, area, size, density and speed are commonly provided by the target costing system. *Function-cost* data, also an engineering focused view, provides cost information on the major subassemblies of a product.

One famous example of attribute-cost data, mainly used by Japanese companies, is the *cost table*. Yoshikawa et al. (1990, 30) explain that cost tables are large computerized databases, which represent an easily accessible source of information about the effect on product cost of using different productive resources (materials), manufacturing methods, functions and product designs. The cost drivers used in the cost tables include the equipment employed, the type of material used and the main design variable that affects production activities and their cost. A cost table makes it possible to determine for instance the effect on cost of using a particular drilling machine, a particular material and a particular depth of drilling, as shown in the example of Figure 16.

Figure 16: Example of an Approximate Cost Table for Component X (Hypothetical Data in $)

Depth of hole / Type of Material	**3 inches**				**5 inches**				**7 inches**			
	Mat'l	Lab.	OH	Tot.	Mat'l	Lab.	OH	Tot.	Mat'l	Lab.	OH	Tot.
Plastic	5	2	3	10	7	5	5	17	8	7	8	23
Steel	9	2	2	13	10	2	2	14	12	4	5	21
Aluminium	10	2	2	14	11	3	3	17	12	3	4	19

Source: Yoshikawa et al. (1990, 31)

Yoshikawa et al. (1990, 32) discuss different types of cost tables, according to the area in which they are used: approximate cost tables are used for *designing* new products, detailed cost tables are used for *purchasing* activities and for kaizen costing programs during *manufacturing*. Originally, cost tables were developed for purchasing decisions, since it was crucial for purchasing managers to have up-to-date information on the expected costs of subcontracted materials and components. However, the major use of cost tables in target costing now is to estimate future costs at the various stages in the design process. Yoshikawa et al. (1990, 34) explain that if the product is a new motorcycle, the approximate cost table makes it clear that overall costs vary according to the size of the engine. Approximate cost tables based on this criterion may therefore be used at the early stages to estimate cost. When more design decisions are taken, designers use more detailed cost tables to calculate the cost of the various alternative designs. For instance, detailed cost tables provide design engineers with information on how costs will change if a bend in a metal frame is changed by a certain angle, if the capacity of the fuel tank is altered, or if the wheel diameter is modified. Similarly, Tanaka (1993, 11) found at Toyota (cars) that the information sources for calculating the projected cost depend on the product and production decisions already taken. For instance, design engineers are using approximate cost tables to estimate the cost during the first stages of the NPD process, since at that time designers do not know on which lines production will be done. Contrary, in the manufacturing ramp-up stage, when specific production line conditions and capacity utilizations are known, actual cost information is used to take these production facts into account. Finally, Yoshikawa et al. (1990, 35) report that some Japanese companies are now combining their CAD system with their cost tables to make an integrated system to see immediately what effect a proposed change in design will have on the downstream costs of a future product.

Yoshikawa et al. (1990, 35) explain that cost tables are created by the management accountants of the firm and consist of ***direct*** **and** ***indirect*** **manufacturing cost information.** Yoshikawa et al. (1990, 34) estimate that in a Japanese factory of 1,000 employees, three accountants spend full time maintaining cost tables. The widespread availability and use of cost tables in Japan is the result of several decades of experience and work. However, many researchers such as Kato (1993, 41) and Yoshikawa et al. (1990, 36) are convinced that without such information new cost reduction ideas, and the accurate calculation of the cost of a future product are unlikely.

To conclude, one essential condition for target costing to work is the provision of detailed cost information during the design and development of a future product. Detailed cost information is necessary for mainly three reasons: First, to see the impact of design decisions on the cost level of the future product; Second, to support cost reduction ideas and; Third, to estimate the progress towards achieving the target cost.

4.6 The Cost Level of the Future Product is compared with its Target Cost at Different Points during NPD

The sixth characteristic of target costing involves the **comparison** of the estimated cost level of the future product with its target cost at different points during NPD. Different examples are described in literature. Kato, Böer & Chow (1995, 51) found in their case study research that *continuous updating* of projected production costs for the products under development was stressed. Each business followed a formal sequential process in which costs were estimated at certain critical phases in the process. Also Fisher (1995, 54) found that the target cost calculation sheet with the estimated cost and the target cost for each component was formally completed at least *at three different points* during new product development at Matsushita (largest electronics manufacturer in Japan). These milestones were set at the product planning, before ordering the molds (and dies) and just before full-scale production starts. Similarly, Kato, Böer & Chow (1995, 49) found companies using a *standard format* for summarizing cost data on a product moving through development. Team members could refer to this document at any time to see the latest estimates of the cost level. Similarly, Cooper & Slagmulder (1997, 120) found that the *chief engineer* and his *superiors continuously monitor* the progress the design engineers are making toward achieving the cost reduction objective. This monitoring ensures that corrective actions can be taken as early as possible in order to achieve the target cost. Finally, Fisher (1995, 54) remarks that *setting* the target cost and *calculating* the cost is done by separate departments in the organization. At Matsushita, the divisional manager is responsible for setting the target cost, while the chief engineer estimates the cost level.

Summing up, these examples show that monitoring the progress towards the target cost is essential in target costing. Therefore the cost level of the future product needs to be compared to the target cost, either formally at different points, either continuously during new product development.

4.7 Aiming for the General Rule that "The Target Cost can never be Exceeded"

The seventh and last characteristic of target costing involves the policy not to exceed the target cost. Cooper (1995, 137) stresses that the use of a target costing process in Japan is characterized by the intensity with which the rule "the target cost can never be exceeded" is applied. According to Cooper (1995, 137), **without the strict application of such a rule, - he calls it the *cardinal rule* -, target costing typically lose its effectiveness.** Cooper (1995, 138) states that the cardinal rule is necessary to prevent design engineers saying:

"*If we just add this feature, the product will be so much better and only cost a little more*".

The general rule that the target cost can never be increased requires a strong commitment of managers and design engineers to attain the target cost. Kato (1993, 40) states that the western sense of a *target* cost does not necessarily induce *commitment*. Inflation and labor costs increases due to union negotiations are automatically added to a target cost in the western sense. However, in Japanese companies using target costing, agreed target costs are final and they are not expected to change. Also Kato, Böer & Chow (1995, 41) argue that Japanese managers make big efforts to hit the target profit, regardless of how difficult the task may be.

To Cooper & Slagmulder (1997, 122), the general rule that the target cost can never be increased has three consequences. First, *whenever costs increase somewhere in the product during NPD, costs have to be reduced elsewhere by an equivalent amount*. For instance, in the Komatsu case (construction equipment), Cooper (1994c, 4) describes how a more expensive design of the engine, transmission and torque convertor was justified for a future ripper by making the mounting bracket cheaper to produce. We quote from the case:

> "Rippers were used for breaking up hard surfaces while dozers were used for removing loose material. The ripper-mounting bracket enabled the ripper to be attached to the mainframe. The new approach allowed the mounting bracket to be welded, as opposed to bolted, to the mainframe. Welding was cheaper than bolting and the savings equaled the additional cost of adopting the alternative design of the engine, transmission, and torque convertor." (Cooper, 1994c, 4)

Second, *launching a product with a cost above the target is not allowed;* only profitable products are launched. For instance in the Sony case, Cooper (1994c, 4) describes how Sony launches only *by exception* products that do not attain the target cost. We quote:

> "The product planners did not have absolute freedom in relaxing a product's target cost. As a matter of policy, Sony would not sell products at a loss and would not sell them below the

> minimum profit margin established by the appropriate business group's manager." (Cooper, 1994c, 4)

Third, *the transition to manufacturing is managed* carefully to ensure that the target cost is indeed achieved. For instance, in the Nissan case Cooper (1994c, 4) reports:

> "As the vehicle entered production, accounting would monitor all component and assembly costs and if these were not in line with the final target costs, accounting would notify cost design and engineering that the final target costs were not being met. When the target costs were exceeded, additional value engineering was performed to reduce costs back to the target levels." (Cooper, 1994c, 4)

However, Cooper & Slagmulder (1997,124) argue that the general rule can be violated, however only in exceptional cases, determined by strategic considerations. Examples are flagship products that create market awareness of the firm's name and lead to increased sales of other products, or products that use the next generation of technology, or products that play a strategic role in the product line. For instance in the Sony case:

> "The only exceptions to this rule were strategic products, which Sony top management viewed as investments necessary to create or expand markets and which would pay off in the long run." (Cooper, 1994c, 4)

Thus, we developed seven typical characteristics of target costing. The first one involves that the *target sales price* for a future product is set during product planning, based on customer and competitor information. Second, the *target profit margin* of a future product is set beforehand, based on the strategic profit plan. Third, the *target cost* is set before the NPD process really starts. As discussed, the target cost is set at a level somewhere between the allowable cost and the as-if cost, where the allowable cost represents the long-term cost objective, since it is defined as the difference between the target sales price and the target profit margin. Four, the target cost is divided into smaller target costs for *functions or components* in order to have clear cost objectives for *suppliers* and *design engineers*. Five, *detailed cost information* is provided to support cost reduction ideas. Six, *the cost level of the future product* is estimated and compared with the target cost at different points during NPD to monitor the progress towards achieving the target cost. And last but not least, the whole target costing process is sustained by the general rule that *the target cost can never be exceeded*.

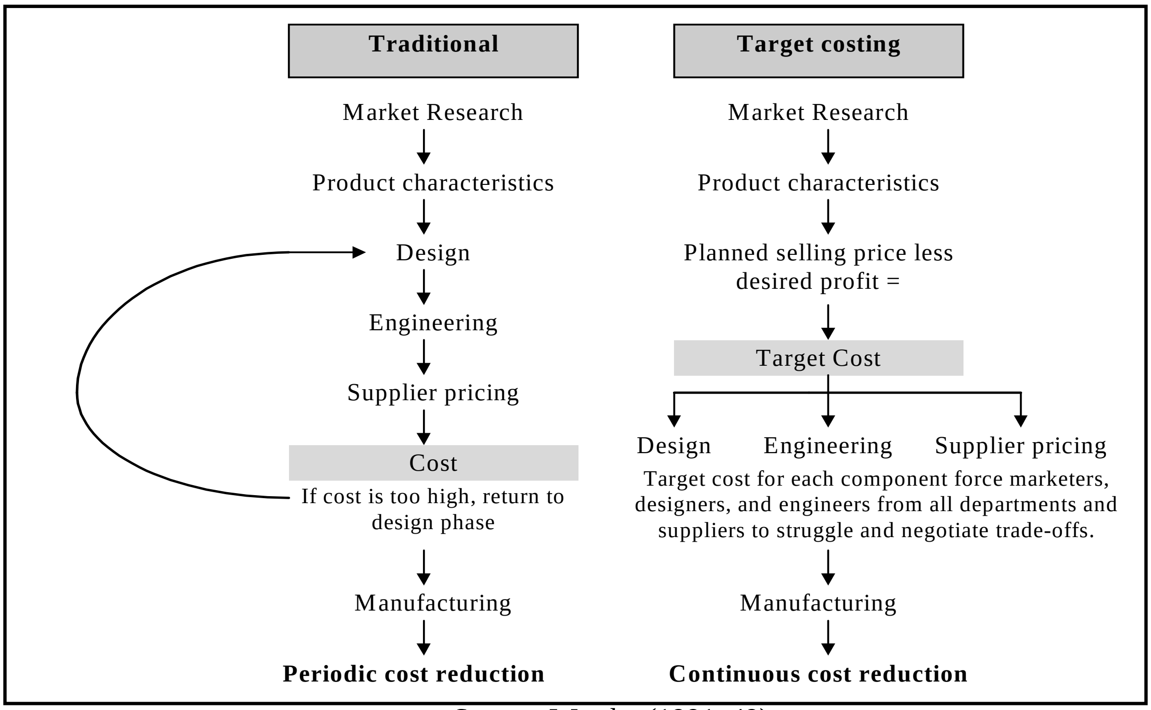
Now we have discussed the definition of target costing and its distinctive characteristics, we are ready for a discussion of the benefits and drawbacks of the use of target costing during new product development. After that section, we will shortly address the mentioned techniques to achieve the target cost, before going into literature on our research topic in target costing (see section 7).

5. Reported Benefits and Drawbacks of Target Costing

In literature, different benefits are attributed to the use of target costing during NPD. Here, we address the most recurring items and refer to Table 2 (see page 60) for a summary of the benefits mentioned by the different field study researchers. Nevertheless, some authors (although less frequently) also refer to some undesirable consequences of target costing during NPD. A summary is provided in Table 3 (see page 62).

First, target costing is future-oriented. Different authors contrast the target costing approach to what they call the traditional western approach or the historical costing approach. According to Worthy (1991,49) western companies more often design the product, then calculate the cost, and finally try to figure out whether it will sell. If the cost is too high, the product goes back to the drawing board for redesign or if no additional time is available the company launches the product and settles for a smaller profit. This traditional western approach is shown in the left part of Figure 17.

Figure 17: Traditional Western Method versus the Target Costing Approach



Source: Worthy (1991, 49)

Fisher (1995, 52) explains that under this traditional western approach cost reduction activities can only start late in the NPD process, whereas companies using a target costing system start with cost reduction from the concept generation phase, hence long before a prototype of the product even exists. Therefore, Cooper (1995, 91) calls target costing a "feedforward" system, whereas the traditional system is a feedback system. Also Brausch (1994, 49) argues that the single largest change in firms, implementing target costing is to stop reporting what products should cost, but instead report what products will cost. This pro-active concentration on a future product's cost allows to *prevent* costs rather than to *reduce* them after the fact. As mentioned before in Table 1 on page 36, the main purpose of target costing is indeed to reduce the cost of future products while still in the NPD process.

Second, the use of target costing ensures **profitability on the short and long run.** Worthy (1991, 51) explains that products that show up as low-margin or unprofitable are quickly dropped. Similarly, ideas for new products whose profitability projections fail to clear certain hurdle rates usually wither away on the accountant's spreadsheet. As mentioned under the seventh characteristic of target costing, the cardinal rule ensures that: "if you cannot meet the target, you cannot launch the product" (Cooper & Chew, 1996, 96). In the past, many leading companies, especially those that led by technical differentiation, could release new products anticipating a future price increase. Cooper & Chew (1996, 89) explain that competitive markets no longer allow a company time to introduce a product and then scale up, because imitators bring me-too products to market so rapidly that first-mover companies have no time to establish brand loyalty, let alone recover their development costs. The importance of target costing in ensuring profitability is also pointed out in Kato, Böer & Chow (1995, 40) by referring to the well-known Ford Thunderbird:

> "The 1988 Ford Thunderbird and its neartwin Mercury Cougar zoomed past their original price and weight targets, so they arrived on the market costing Ford $1,000 more per vehicle than planned. Technical chief Louis Ross says: "That's a lot of money. If you sell 300,000 cars a year, that's $300 million". Astoundingly, Ross says, Ford didn't even discover the true extent of the cost overrun until 15 months after the car was introduced." (Taylor, 1992, 55)

Third, target costing reasons backward from customers' needs and willingness to pay. Cooper & Chew (1996, 88) explain **that target costing focuses the design team on the ultimate customer and on the real opportunities in the market**. They call it "commitment to the customers". If targets cannot be met, the company cannot simply raise the price and launch the product. Cooper & Chew (1995, 97) admit that such discipline may be painful to the people who work on a project, but stress that it sends the important message that the customers come first, and that if the company does not create value for them, a competitor will.

Four, target costing is used at the design stage, **focusing on the cost implications of design decisions.** Tanaka (1993, 10) argues that designers must know how design affects such things as material consumption, yield, machining methods, and line time. Cooper (1995, 137) explains that the intensity by which the product is designed to its target cost is contrary to a situation where the projected cost can be exceeded without penalty. By setting a target cost for a future product, all members of the design team consider the impact on the cost while deciding on design alternatives. As mentioned before, the use of a target costing system prevents design engineers saying: "If we just add this feature, the product will be so much better and only cost a little more" (Cooper, 1995, 138).

Five, **target costing gives a clear, quantitative cost objective to design engineers**. Cooper (1995, 136) argues that target costing is totally different from what he calls the traditional western approach or the cost-plus approach[27]. To him, under the *traditional western approach* the new product's expected profit margin, not the cost level of the future product, becomes the dependent variable when launching a new product. Under this traditional western approach, the profit margin is determined by subtracting its estimated cost from its anticipated sales price (sales price - cost = profit margin). Under the *cost-plus approach*, the product's expected sales price becomes the dependent variable. This means that the sales price is determined by adding the desired profit margin to the expected cost of the product (cost + profit margin = sales price). **Under both approaches product designers have no specified cost objective to achieve. Instead, they are expected to *minimize* the cost of the product as they design it.**

Six, **the use of a target costing system forces management to set the NPD goals early in the NPD process.** As mentioned before in Figure 11, on page 38, setting target costs requires that management decides on the quality of the future product as well as on the time-to-market, based on market research and the company's strategy. For instance, Tanaka (1993, 4) found at Toyota that after a NPD proposal is approved, the development of the new model begins three years before the expected release of the new model and includes all specifications (except styling), the development budget, the development schedule, the retail price and sales targets. Furthermore, setting NPD goals requires making trade-offs between the different characteristics of a future product. Ansari & Bell (1997, 166) state that marketing people are traditionally oriented to sell products and want as much features as possible for a new product, but do not want customers to pay for it. Under target costing, management need to balance cost and features against the customer's ability (or willingness) to pay for all this.

[27] Remember that we call both approaches, the traditional western approach and the cost-plus approach, **a non-target costing approach**. In the experiments, we will refer to this condition as the non-target cost setting, since design engineers are expected to minimize the cost level of the future product.

Table 2: Benefits of Target Costing

Reference	**Benefits of target costing: Target costing**
Ansari & Bell (1997, 63)	• is market driven.
Brausch (1994, 45)	• reduces a product's cost over its lifetime. • stops reporting what products should cost, but instead reports what products will cost.
Cooper (1995, 162)	• outperforms the conventional western and the cost-plus approach because it provides a specified cost reduction target for everyone in the firm to work toward. • creates a tremendous pressure for cost reduction by providing numeral objectives and the commitment to attain them.
Cooper & Chew (1996, 88)	• focuses the design team on the ultimate customer and on real opportunities in the market. • helps prevent senior managers from launching low-margin products that do not generate appropriate returns to the company. • brings the challenge of the marketplace back through the chain of production to product designers. • ensures that development teams will bring profitable products to market not only with the right level of quality and functionality, but also with appropriate prices for the targeted customer segments. • ensures that success with the customers will yield economic success for the company. • forces companies to delineate their product-development goals very precisely and in a single vernacular.
Fisher (1995, 52)	• employees responsible for product design are given the target cost as one of the design specifications of the product. • requires that cost reduction goals are assigned to components in order to achieve the target cost. • does not allow designers to proceed with a design without achieving the target cost reduction at each design point.
Horvath (1993, 3)	• ensures cost management in early product design and development. • provides rationalization of existing products. • is a cost-oriented planning of the production process. • improves the efficiency of indirect activities.
Kato (1993, 36)	• reduces costs at the first stages of product development, while also improving quality and reliability.
Kato, Böer & Chow (1995, 39)	• is future oriented. • focuses designs' attention on the cost implications of design decisions. • helps managers evaluate the profitability of a product before it is produced.
Sakurai (1989, 41)	• reduces the overall cost over its entire life cycle.
Sakurai (1995, 28)	• is an effective tool to reduce direct costs as well as overhead costs.
Tanaka (1993, 10)	• reduces the costs at the design stage. • gives information on the effect of design changes.
Worthy (1991, 49)	• focuses on getting costs out of the product during planning and design. • ensures that low-margin or unprofitable products are quickly dropped.

<u>Nevertheless</u>, some authors also suggest that the use of target costing during NPD can lead to some *undesirable* consequences. Table 3 gives a summary of the drawbacks mentioned in literature - most of them are behavior-oriented. Kato (1993, 43) argues that statistics allow to recognize the dysfunctional effects of target costing in Japanese firms. He compares the long working hours in Japan (2,200 h) with those in Germany (1,450 h) and contrasts the shorter product development periods in Japan, i.e. four years in Japanese automobile companies with six years in the United States, and up to eight years in European specialty car manufacturers. Consequently, to Kato (1993, 42) it is natural that too much time pressure and long working hours creates **job tension** and results in **management fatigue.** Similarly, Kato, Böer & Chow (1995, 50) and Ansari & Bell (1997, 169) found that a constant pressure to meet target costs can cause **management burnout**. Also Monden & Hamada (1991, 29) conclude that target costing may force **unreasonable demands on employees**.

<u>Second</u>, Sakurai (1995, 28) argues that target costing can be severely criticized because of **excessive demands it puts on subcontractors**. Kato, Böer & Chow (1995, 50) state that as major customers like Toyota pass their cost-reduction demands down to suppliers, the suppliers push their suppliers and employees to do more, some of whom are already doing all they can handle. Worthy (1991, 50) calls it the battle of intense negotiation *between* the company and its outside suppliers. To Kato (1993, 42) this excessive demand goes hand in hand with a restricted autonomy of the suppliers.

<u>Third</u>, the use of target costing information might cause **organizational conflicts**. One aspect, mentioned by Fisher (1995, 58), involves the difficulty to decompose the total target cost to target costs of individual components. Worthy (1991, 49) refers to it as the battle *among* the departments, since most of the time different departments are responsible to design parts or subassemblies. Deciding on the component-level target cost means deciding on the effort the different departments will need to do in reducing costs. Organizational conflicts might also arise when design engineers feel that other parts of the organization are getting a free ride while they try to squeeze every penny out of a product, as Ansari & Bell (1997, 170) mention. Kato, Böer & Chow (1995, 49) describe an example of a discussion between the design engineers working incredible hard to reduce costs, and the marketing department apparently caring little about cost. We quote:

> "One design engineer became very angry when he heard that an automobile dealer paid to take pictures of customers with their new cars for a custom calendar: We work incredibly hard with many hours of overtime to reduce the cost of a vehicle by $3, and the marketing people casually spend this amount to make a calendar." (Kato, Böer & Chow, 1995, 50)

<u>Finally</u>, some researchers conclude that the extreme customer focus of target costing might lead to **market confusion**, with too many products, too many options. Kato, Böer & Chow (1995, 50) found that constant attention to customer's desires causes extreme market segmentation. As a result customers get confused by the large number of different products. Kato (1993, 42) argues that the

promotion of giddy and capricious buying attitudes of consumers is one of the severe dysfunctional aspects of target costing. Similarly, Ansari & Bell (1997, 170) state that the uncritically attention to customer requirements cause “feature creep.”

Kato, Böer & Chow (1995, 50) state that Toyota is in the process of revising its target costing system because of some of these problems. Despite the problems caused by the system, Toyota plans to continue using it, because without it the company would lose control over its costs.

Table 3: Dysfunctional Effects of Target Costing

Reference	**Drawbacks of target costing:**
Ansari & Bell (1997, 169)	• Longer development times. • Employee burnout. • Market confusion. • Organizational conflict.
Fisher (1995, 58)	• Discussion on allocating the target cost to individual components.
Kato (1993, 42)	• Too much time pressure and long working hours creates job tension and results in poor performance and management fatigue. • Restricted autonomy of suppliers. • Promotion of giddy and capricious buying attitudes by consumers.
Kato, Böer & Chow (1995, 49)	• Longer development cycles. • Employee burnout (many hours of overtime, tight schedule). • Difficult to trade-off between creating new products and keeping common parts/components. • Market confusion by the large number of different products. • Organizational conflict between designers (cost down) and marketers (cares little about cost).
Monden & Hamada (1991, 29)	• May force unreasonable demands on employees.
Sakurai (1995, 28)	• Excessive demands on subcontractors.
Worthy (1991, 49)	• Battle of intense negotiations between the company and its outside suppliers. • Battle among departments that are responsible for different aspects of the product.

Summarizing, *benefits* as well as *drawbacks* are reported in literature on the use of target costing during new product development. In general, most case study researchers extensively report on the benefits, while the drawbacks are discussed to a less extent. Orientation on the future by feedforward control, ensuring profitability on the short and long run, providing clear cost objectives for designers and suppliers, and focusing on the cost implications of design decisions are just a few of the most frequently mentioned benefits. Though, the use of target costing can also lead to extensive pressure on design engineers and subcontractors, which can raise organizational conflicts and management burnout.

6. Cost Reduction Techniques

Monden & Hamada (1991, 23) conclude that as target costing deals with the development and design of new products, many technical methods of engineering are needed. **In target costing literature, this issue is just *occasionally* addressed, since as Kato (1993, 42) explains, the techniques are not new, but are only reinforced by the target costing philosophy.** Table 4 (see page 65) gives a summary of the methods mentioned by target costing researchers. Here, we address the main items.

To Horvath (1993, 19), **value engineering** (VE) is the most important method in the process of attaining the target cost for companies using target costing. Monden & Hamada (1991, 18) explain that value engineering was first developed in the USA by GE to reduce the purchased parts costs, however without being linked to target profits or target costs. Basically, VE starts from given requirements concerning functions and features of the product and tries to find the best technical solution for realizing those requirements under cost considerations. Yoshikawa et al. (1993, 57) refer to the British Standard definition of value engineering: "VE is a systematic interdisciplinary examination of factors affecting the cost of a product or service in order to devise means of achieving the specified purpose most economically at the required standard of quality and reliability". However, Cooper (1995, 165) stresses that the objective of VE programs in target costing is not to *minimize* the cost of products but to achieve a *specified* level of cost reduction that has been established by the target costing system. For instance, Fisher (1995, 57) found at Matsushita that VE starts with analyzing the performance features of a product to ensure that the part meets the specifications proposed by product planning. Then the value engineering committee focuses on issues such as component functionality, simplification and necessity. Once performance specifications can be met by product design, the committee works on decreasing cost while still meeting the performance targets. According to Sakurai (1989, 44) VE is conducted differently at different companies. For some companies, the purpose is to reduce cost by eliminating waste of time and labor, while for other companies the main purpose is to produce products that suit the needs of customers. For instance, Cooper (1995, 169) found at Isuzu Motors Company, a Japanese truck manufacturer, that VE was used to design products to have the highest value possible, and to ensure that prices paid for purchased parts are low enough to achieve the product's target cost.

Different terms are used, depending on the stage at which the VE activities are performed. Yoshikawa et al. (1993, 58) distinguish between **first look** VE (during design stage) and **second look** VE (during development stage). Kato (1993, 42) also mentions **zero look** VE (during concept-proposal stage). Cooper (1995, 180) even mentions **mini**-value engineering as a simplified approach of VE, applied to small, inexpensive parts such as door locks, mirrors, etc. for an automobile company. Examples of *zero* look VE are found in Cooper & Slagmulder (1997, 134), where zero look value engineering was applied in the development of a special type of transmission system, which combined the higher fuel efficiency of a manual transmission with the convenience of an automatic transmission. An example of *first* look VE is described in the Isuzu case (Cooper & Yoshikawa, 1994, 3) when engineers determined that reducing the time it took for the automobile interior to warm up would be a benefit that users would welcome. So, they found ways to heat the car interior before the engine warmed up. An example of *second* look VE is mentioned in this same Isuzu case, when engineers redesigned the gear, which was positioned between the two front seats and was sometimes annoying occupants, so that it could fold down while the vehicle was stationary. A *full example* of value engineering activities is provided by Yoshikawa et al. (1993, 59) and Tanaka (1989, 56), whereas the Isuzu case of Cooper & Yoshikawa (1994, 13) provides a more descriptive approach.

Another technique frequently mentioned for cost reduction in order to achieve the target cost, is the **tear-down method**. Tear-down, or reverse engineering as mentioned by Worthy (1991, 50), is the method where competitor's products are decomposed and analyzed. Kato, Böer & Chow (1995, 46) report that engineers at Daihatsu (car manufacturer) tear-down the competitor's products to gather information on technologies used and to identify cost reduction possibilities. The researchers found that they have become so skilled that they can estimate competitors' production costs from the information derived. Cooper & Yoshikawa (1994, 7) found eight tear-down approaches at Isuzu Motors Company to analyze competitive products in terms of the materials they contain, the parts they use, the ways they function, the ways they are manufactured and the ways they are assembled. We quote from the Isuzu case:

> "Isuzu's tear-down program contained eight different tear-down methods: dynamic, cost, material, static, process, and matrix tear-down, plus the unit-kilogram price method and the group estimate by tear-down method. The first three methods were designed to reduce the direct manufacturing cost of a vehicle. The next three sought to reduce the investment required to produce vehicles via increased productivity. The last two methods were integrations of tear-down and value engineering techniques. … For example, a windshield washer tank and a radiator surge tank both performed the same fundamental function: holding liquids. Because the tow tanks performed essentially the same function, under the tear-down method they were compared to see if there were ways to make them more efficiently. For example, in some designs the two tanks were combined into a single tank with two compartments". (Cooper & Yoshikawa, 1994, 9)

Cooper (1995, 180) also found companies using the **checklist method** and the **one-day cost reduction meeting**. The checklist method is used to guide design engineers through a list of cost reduction opportunities, whereas the one-day cost reduction meetings are used to improve the efficiency of the entire cost reduction process itself. Finally, Cooper (1995, 152) also mentions the technique of **design analysis**, and defines it as the process of identifying alternate designs for major subassemblies and selecting the appropriate structure of the major subassemblies in new products. A new design alternative is adopted only if it achieves the desired level of performance and cost.

Table 4: Cost Reduction Techniques mentioned in Target Costing Literature

Reference	**Techniques used to attain the target cost:**
Cooper (1995, 150 & 176)	• Design analysis. • Value engineering: zero look, first look, and second look. • Tear-down approaches. • Checklist method. • One day cost reduction meeting. • Mini value engineering.
Cooper & Slagmulder (1997, 126)	• Value engineering. • Design for manufacture and assembly. • Quality function deployment.
Fisher (1995, 57)	• Value engineering: decreasing costs while still meeting the performance targets.
Horvath (1993, 19)	• Value engineering to achieve better cost-benefit relations.
Kato (1993, 42)	• Value engineering in the R&D stage = zero look VE. • Value engineering in the trial production stage = first look VE. • Value engineering in the production stage = second look VE. • Variety reduction: reducing the number of products.
Kato, Böer & Chow (1995, 46)	• Collecting information about new technologies. • Tear-down and evaluate competitors' products. • Learning from experience with current production. • Value engineering studies. • Part commonality.
Monden & Hamada (1991, 18)	• Value engineering: cost reduction activity that involves basic functional changes in the new product development stage. • Value analysis: the cost reduction activity that involves design changes of existing products.
Sakurai (1989, 44)	• Value engineering: to design a product at a lower cost by reviewing the functions needed by the customers.
Tanaka (1993, 10)	• Value engineering: cutting costs while maintaining performance in areas such as material specifications, yield, number of parts, ease of work, man-hours. • Replacing special parts with mass-produced parts.
Worthy (1991, 50)	• Tear-down method (reverse engineering).

Summing up, different methods (see Table 4 above) are mentioned in the current target costing field studies on how design engineers achieve the target cost during new product development. Value engineering and reverse engineering are among the most frequently mentioned techniques.

7. Current State of Research on the Effectiveness of Target Costing

7.1 The Impact of Target Costing on the Cost Level of Future Products

7.1.1 Current State of Knowledge on Research Question One

As discussed in chapter one (page 25), the first research question in our study seeks to investigate whether the use of target costing is a more effective method to induce downstream cost management of future products than when no target costs are provided (what we have called *non-target costing*). In *research question one*, we question whether the downstream[28] cost level of a future product will be *lower* in target costing than in non-target costing.

Based on the **definitions of target costing**, one could reasonably expect a *favorable* impact of the use of target costing during NPD on the cost level of a future product. As mentioned before (see Table 1, on page 36) many authors include the purpose of target costing in their definition, *i.e. to induce cost reduction of future products* (Ansari & Bell, 1997; Brausch, 1994; Horvath, 1993; Kato, 1993; Kato, Böer & Chow, 1995; Lee, Jacob & Ulinski, 1994).

Furthermore, based on **field studies**, Cooper (1995, 137) concludes that target costing results in products with *lower* costs than when no target costs are used. As mentioned in chapter one, non-target costing involves one of two approaches, i.e. the conventional western or the cost-plus approach (Cooper, 1995, 137). In the *conventional western approach*, the future product is developed and then the cost is calculated. The profit margin is then determined as the difference between the target sales price (determined by the market) and the cost. Under the *cost-plus approach*, the cost is first calculated as well as the target profit margin. The selling price is determined last by adding the target profit margin to the product cost, as shown in Figure 18. Cooper (1995, 136) asserts that the main difference between a target costing and a non-target costing environment is that in *target costing* a manufacturing cost objective is *specified*, whereas in *non-target costing* design engineers have *no specified* cost objective to achieve. **In non-target costing, design engineers are expected *to minimize* the cost of the product as they design it.** Cooper (1995, 137) argues that in theory, these non-target cost approaches should outperform target costing, because they set out to minimize a product's cost rather than to reduce it to a specific level. However, in practice, he found that target costing appears to lead to products with lower costs than the non-target costing approaches.

[28] As discussed earlier (see section 3.5, starting on page 18) we want to restrict the impact of target costing to the downstream costs, **leaving out** the impact of target costing on the **development costs**.

Figure 18: Target Costing versus Non-Target Costing

Target Costing:

Target Cost = Target Sales Price - Target Profit Margin

Non-Target Costing:

1. Conventional western Approach:

   Profit Margin = Target Sales Price - Expected Cost

2. Cost-plus Approach:

   Sales Price = Target Profit Margin + Expected Cost

Source: Cooper (1995, 137)

Though, the suggested positive impact of target costing is *exclusively* based on field study research. Only anecdotal evidence is available in current English language literature. We quote a number of examples from those available cases to illustrate our thesis that the evidence provided is *anecdotal*.

In the Olympus Optical Case (a producer of compact cameras), Cooper (1994f, 6-7) describes how by the use of target costing, cost reductions up to 58% of the production costs of an existing model could be realized. We quote:

> "As part of the program to design low-cost products, target costs were set assuming aggressive cost reduction and high quality levels. A target cost system existed prior to 1987 but it was not considered effective. As part of the three-year program to reduce costs, the target cost system was improved and more attention was paid to achieving the targets. Aggressive cost reduction was achieved by applying three rationalization objectives. First, the number of parts in each unit was targeted for reduction. For example, the shutter unit for one class of compact camera was reduced from 105 to 56 pieces, a 47% reduction that led to a *58% decrease in production costs*. Second, expensive, labor-intensive, and mechanical adjustment processes were eliminated whenever possible. Finally, metal and glass components were replaced with cheaper plastic ones. For instance, by replacing metal components that required milling in an SLR body with plastic ones that could be molded, the *SLR body costs were reduced by 28%.* Similarly, replacing three of the glass elements with plastic ones in an eight-element compact camera lens *reduced the lens costs by 29%."* (Cooper, 1994f, 6-7)

In another article, Cooper & Chew (1996, 92) write that by the year 1990, Olympus managers had discovered that the company could generally *reduce its production costs by approximately 35%* across the production life-time of its new products.

At Isuzu (car manufacturer), Cooper & Yoshikawa (1994, 11) describe a cost reduction realization of *2,2 billion Yen*, during a two month period. We quote:

> "With the current downturn we have increased the size of our cost creation teams significantly. The original team contained seven highly trained members. They were called the "brain team": they came up with the ideas and others implemented them. In December 1992, we added 23 new members to the cost creation team. In October of 1993, we added another 22 members to this second team. The two teams have been very active finding ways to reduce costs. In the first two months the team identified savings worth ¥2.2 billion. Their target for the next year is ¥8.4 billion." (Cooper & Yoshikawa, 1994, 11)

Monden & Hamada (1991, 26) report in another automobile company case, a cost reduction of $75 per car. We quote:

> "Just after the oil shock in 1973, the profitability of one automobile model showed a market decrease because of cost increases due to oil. At that time, the plant manager made the following proposals to the top management meeting concerning cost reduction. (i) Establishment of a cost kaizen committee chaired by the plant manager. (ii) Promotion of a company-wide cost reduction program for the specific model. (iii) As substructures to this committee, organization of the three subcommittees. (iv) Establishing a cost reduction goal of ¥10,000 (about $75) per automobile. (v) Expectation that the above goal would be achieved within six months. Through a concerted effect by all departments based on the decisions of the cost kaizen committee, the actual result of the plan was 128% attainment of the goal at the end of six months." (Monden & Hamada, 1991, 26)

Kato, Böer & Chow (1995, 48) found at Matsushita (electronics manufacturer) that the design team realized a cost level of 30% below the current cost of a similar product by the use of target costing. We quote:

> "With the new shaver, however, plant manages realized that cost reduction would have to be formalized, so a cost project management team was established for the new razor. The team was charged with reducing costs to a level *30 percent below the current production cost* for existing products. The team succeeded in reaching this target." (Kato, Böer & Chow, 1995, 48)

Although some of the examples look extreme, they illustrate a favorable impact of target costing on the cost level of future products during NPD.

To conclude, the current field study researchers in target costing report a favorable impact of target costing on the cost level of future products. Though, this evidence is only anecdotal. No empirical research, of which we are aware, has studied target costing in comparison with non-target costing to make conclusions on the *difference in impact* on the downstream cost level of future products. Thus, the current knowledge on target costing does not fully provide an answer to *research question one*. In chapter three, section 2 page 77, hypotheses will be developed to seek an answer in this study on the first research question.

7.1.2 Current State of Knowledge on Research Question Three

As discussed in chapter one (see page 25) the third research question seeks to explore whether the favorable impact of target costing on the cost level differs across the levels of time pressure. In *research question three* we questioned whether the difference in downstream cost level between target costing and non-target costing will vary between low and high time pressure.

This question is *unanswered* in current target costing literature, since none of the published papers in English language literature are combining the issue of target costing with time pressure to discuss its impact on the cost level.

Thus, the knowledge on the impact of target costing on the cost level of the future product in combination with time pressure is still an unexplored area of research in target costing. So, more research is needed to answer research question three asking whether the difference in cost level between target costing and non-target costing varies across the levels of time pressure. In the next chapter, in section 4 on page 90, we will develop hypotheses, trying to make up this lack of knowledge.

7.2 The Impact of Target Costing on Multidimensional NPD Performance of Future Products

7.2.1 Current State of Knowledge on Research Question Two

As remembered from the motivation section in chapter one, we want to measure the impact of target costing on the multidimensional NPD performance. In our study, multidimensional NPD performance is limited to three elements, i.e. the cost level, the quality level of the future product and the achieved time-to-market. Research question two is about the impact of target costing on the combined cost level, quality level and achieved time-to-market, since it is the *combination* of these three elements that determines (among other factors) the success of the future product. As discussed in section 4, page 25, we seek to investigate by r*esearch question two* whether the multidimensional NPD performance will differ between target costing and non-target costing.

In current target costing literature, few research findings are available on the attainment of the other NPD goals. On the **quality** level, some of the case study researchers warn for skipping on quality while aiming for the target cost. Indeed, sacrificing the quality targets may be one easy way to attain the target cost. For instance, Kato (1993, 37) describes that trimming functions or lowering the reliability of products saves costs and hence facilitates to attain the target cost, but warns that such actions inevitably damage future sales. Similarly, Cooper & Slagmulder (1997, 78) found that the required level of functionality and quality must be understood first because the easiest way to remove costs from a product is to reduce its functionality. Though, none of the English language cases describe that such practices of sacrificing quality goals in favor of attaining the target cost are widely accepted in companies using target costing during NPD.

On the **achieved time-to-market**, Ansari & Bell (1997, 169) report that an overemphasis on attaining the target cost can lead to longer product development cycles, and hence delay the product from reaching the market. Again little research on this topic is available, apart from some anecdotes in field studies. For instance, Kato, Böer & Chow (1995, 49) refer to a new product introduction at Matsushita (Japanese electronics manufacturer), where the NPD team was charged with reducing the cost of a future product to a level of 30% below the cost of the existing product. The team succeeded in reaching this target cost, but did so by introducing the product late, which meant that the expected sales were never realized. The authors report that the product was a cost success, but a market failure. Contrary, Cooper & Slagmulder (1997, 181) report that introducing target costing at Olympus cameras (Japanese manufacturer) did not introduce any significant delays into the NPD process. We quote:

> "The target costing process is so integrated into the market analysis and the product development process that most, if not all, the extra work required by the target costing process can be undertaken in parallel". (Cooper & Slagmulder, 1997, 181)

Thus, some anecdotes are available in target costing literature on the quality and the time-to-market issue separate, yet none of the existing cases focus on target costing and its impact on the attainment of several NPD outcomes *together.* More research is needed to answer research question two in order to get a better insight if the use of a target costing has a negative impact on the total NPD performance. In the next chapter, in section 3 (page 86), we will try to contribute to this unsolved issue in target costing by developing hypotheses, which will then be tested in the lab experiments.

7.2.2 Current State of Knowledge on Research Question Four

As discussed in chapter one, on page 25, research question four combines the issues of research question two (multidimensional NPD performance) with the issue of research question three (time pressure). Hence, research question four seeks to explore whether the difference in multidimensional NPD performance between target costing and non-target costing also differs between high and low time pressure.

Only one of the current field study researchers combines time pressure with the expected impact of target costing on the global new product development performance. Kato (1993, 42) argues that even if development activities are highly structured and sophisticated support systems are available, much of the creativity involved in developing new products is human-dependent. He found that too much pressure for shorter time-to-market might no longer produce a creative idea, but creates tension and results in poor performance. Though, from his cases it is not clear what is meant with "poor performance". Yet, no other researcher have studied if the combination of time pressure and target costing is having an unfavorable impact on the development of new products.

Summarizing, very little knowledge is available in current literature on the impact of target costing on the NPD outcomes in combination with time pressure. More research is needed to answer research question four. In the following chapter, in section 5 (see page 94), we will develop hypotheses on this topic and hope to contribute to fill this gap in target costing.

8. Conclusion

Target costing can be defined as *the process of determining the target cost for future products early in the new product development (NPD) process and of supporting the attainment of this target cost during the new product development process*. The target cost represents the maximum cost for the future product, given the quality requirements and the time-to-market objective. This target cost is set early in the NPD process to motivate design engineers to realize downstream cost management of future products in order to secure product profitability of a new product when being launched. Based on current literature, we defined seven typical characteristics that characterize the target costing process. *First*, the target sales price is set early in the NPD process in a market-oriented way. *Second*, the target profit margin is determined during product planning, based on the strategic profit plan. *Third*, the target cost is set before the new product development process really starts. This level of the target cost is set at a level between the allowable cost and the as-if cost. The allowable cost represents the difference between the target sales price and the target profit margin and is externally determined. The as-if cost is usually higher and takes the real attainability of the cost reduction objective into consideration. *Four,* this target cost is then split up into target costs for subassemblies, components or designers. *Five*, detailed cost information is provided during NPD to support cost reduction. *Six*, the cost level of the future product is compared with its target cost at different points during NPD. *Seven*, during the whole target costing process the general rule is aimed for that the target cost can never be exceeded at product launch.

Many benefits of the use of target costing information are reported. In sum, the target costing process enables a future-orientated view on cost management, it secures profitability on the short and the long run, it motivates design engineers to look at the cost implications of design decisions and it establishes an unmistakable cost objective in designing and developing a future product. Though, some drawbacks of target costing are reported as well in current literature, such as extreme pressure to design engineers and subcontractors.

The current *state of knowledge on the research questions* developed earlier in chapter one, is mainly based on field study research. Reviewing literature on the first research question learned that some knowledge is available on the impact of target costing on the cost level of a future product. The current field studies conclude a favorable impact of target costing on the cost level, but provide only anecdotal evidence. Though, no study has focused so far on comparing empirically the cost level in target costing with that in non-target costing, where design engineers are expected to minimize the cost level of the future product. Hence, more research is needed to answer research question one.

On the impact of target costing on the cost level of the future product *across the levels of time pressure*, almost nothing is known in current English language literature. Actually, research question three, asking whether the difference in downstream cost level of a future product between target costing and non-target costing differs across the levels of time pressure has not been answered yet by current research. So more research is needed on question three to broaden our knowledge on target costing among the levels of the contingency factor “time pressure”.

On the impact of target costing *on the other NPD outcomes,* such as the quality level and the achieved time-to-market, little research has been done so far. Some case studies mention an unfavorable impact of target costing on the quality level or on the achieved time-to-market, though these studies all focus on the impact of target costing on each of the outcomes separate. Testing if the NPD performance in terms of the downstream cost level of a future product, the quality level of that future product and the achieved time-to-market is different under target costing than under non-target costing, has not yet been covered in the current research on target costing. So, more research is needed to answer the second research question as well.

Finally, the impact of target costing *on the three NPD outcomes* across the *levels of time pressure* has not been covered yet. Only Kato, one of the most important field study researchers on target costing, raised the thesis that target costing leads to lower performance new products under high time pressure. However, his hypothesis has not been tested empirically before. So, to answer research question four whether the difference between target costing and non-target costing on the cost, quality and time-to-market is dependent on the level of time pressure, more research needs to be done.

Concluding, none of the four research questions have been fully addressed or answered in previous research studies. **All four research questions are unanswered by the current research on target costing.** Thus, proceeding with this study is worth wile. In the next chapter, we will start with developing hypotheses. There after, in chapter four, we will select the appropriate research method and in chapter five we will address the research design and select the proper statistical tests to test the gathered data on the hypotheses. Data gathering or the empirical part of this study is mainly concentrated in the chapters six, seven and eight. The general conclusions of this research study will be summarized in chapter nine.

Chapter 3: Hypotheses Development

1. Introduction

In this chapter, we will develop different hypotheses to study the impact of target costing on the downstream cost level of a future product, the quality level of that future product and the achieved time-to-market. This target costing context is confronted with a so-called non-target costing context, where design engineers are expected to minimize the cost level of the future product. We remember from section 4 on page 25, that this study seeks to answer the following **four research questions**:

1. Will the downstream cost level of a future product be lower in a target costing than in a non-target costing environment?
2. Will the multidimensional NPD performance (in terms of the downstream cost level of a future product, the quality level of that future product and the achieved time-to-market) differ between a target costing and a non-target costing context?
3. Will the difference in downstream cost level between a target costing and a non-target costing context vary between high time pressure and low time pressure?
4. Will the difference in multidimensional NPD performance (in terms of the downstream cost level of a future product, the quality level of that future product and the achieved time-to-market) between a target costing and a non-target costing context vary between high time pressure and low time pressure?

In answering those research questions, we need to consider the broader NPD environment in which target costing and non-target costing takes place. As mentioned before in section 3.5 on page 18 characteristic to the **new product development (NPD) environment** is that:

1. Design engineers face *multiple goals* in their daily task of designing and developing a future product (Rosenthal, 1992; Kato, 1993; Cooper, 1995). In our study the number of goals is limited to three, i.e. for the downstream cost level (or product cost), for the quality level and for the time-to-market (or development time).
2. The multiple goals are *linked* with each other in a *conflicting* sense. This means that the attainment of the one goal might hinder the attainment of the other goal. Indeed, design engineers frequently face trade-offs among the goals (Ulrich & Eppinger, 1995; Ray, 1995). For instance, changing the type of material might have a positive impact on the cost level, but might have a negative impact on the quality level of that future product.

3. The multiple goals need to be attained *simultaneously*. While developing a new product, goals cannot be attained sequentially. First attaining the target cost, then attaining the target quality and then attaining the time-to-market is not possible.

4. *Prioritization* among the multiple goals should be set, because design engineers need to know what objective should be relaxed first when things start to slip beyond the point of full recovery (Rosenthal, 1992; Cooper, 1995).

In the following paragraphs each of the research questions is addressed in a *separate section*. Section 2 (page 77) addresses research question one and compares the impact on the cost level between target costing and non-target costing. Section 3 (page 86) involves research question two and compares the impact on the multidimensional NPD performance. Section 4 (page 90) addresses research question three and compares again the cost level, though now in combination with time pressure. Section 5 (page 94) involves research question four and addresses again the multidimensional NPD performance, though now in combination with time pressure. Research findings from target costing literature as well as from goal setting literature (applied psychology) will be used to develop the hypotheses in seeking an answer to the research questions. A summary of the developed hypotheses will be given in section 6 on page 99.

Since a lot of hypotheses are supported by goal setting theory, we evaluate in section 7 on page 101 the contribution of this theory to the target costing theory.

2. The Impact of Target Costing on the Cost Level of Future Products

2.1 Research Question One

As mentioned in chapter one (page 25) the first research question in our study seeks to investigate whether the use of target costing is a more effective method to induce downstream cost management of future products than when no target costs are provided and design engineers are expected to minimize the cost level of the future products. This first research question was formulated as follows:

Will the downstream cost level of a future product be lower in a target costing than in a non-target costing context?

2.2 Definition of Target Cost Setting (TCS)

As mentioned before in chapter two (see Figure 18, on page 67), the target costing approach can be distinguished from what Cooper (1995, 136) calls the conventional western approach and the cost-plus approach. Under these non-target costing approaches, product designers have *no specific cost objective to achieve*; they are expected to *minimize* the cost of the future product as they design it, given the quality and the time-to-market objective. Contrary, under target costing design engineers have from early on in the design stage, *a clear quantified* target cost for the future product as a whole as well as for its components, in addition to the quality and the time-to-market objective.

Literature review in the previous chapter showed that current field researchers[29] are convinced about the favorable impact of TCS on the cost level of future products. However, only anecdotal evidence is provided[30]. Furthermore, from the previous chapter (page 43) we also know that companies set their target cost for a future product at a level between the as-if cost and the allowable cost. The as-if cost is rather *easy-to-attain* since it is the estimated cost including the existing cost reduction ideas. Following Kato (1993, 41)[31], the allowable cost is rather *difficult-to-attain*, since it is not based on a feasibility check, but defined as the difference between the target sales price (determined by customers) and the target profit margin (determined by the long-term profit plan of the company).

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[29]For instance Sakurai (1989, 41), Monden & Hamada (1991, 16), Brausch (1994, 45), Cooper (1995, 137), Fisher (1995, 50), Kato (1993), Horvath (1993) and Kato, Böer & Chow (1995, 39) describe in their **definition** that the primarily purpose of TCS is to realize cost reduction of future products.

[30] See section 7.1.1 on page 66 for **anecdotes** on extensive cost reductions of future products during NPD, quoted from cases of Cooper (1995), Cooper & Yoshikawa (1994) and Kato, Böer & Chow (1995).

[31] Kato (1993, 41) found that for most of the companies he studied, the **allowable cost** was much lower (read more difficult-to-attain) than the as-if cost.

Thus comparing target costing with non-target costing does not make a point unless we know something about the *difficulty* (attainability) of the target cost[32]. Hence, the discussion of the impact of target costing on the cost of future products should be combined with the discussion at which level the target cost is set, i.e. with the discussion of the difficulty of the target cost. If we want to answer research question one, we need to make assumptions on the difficulty of the target cost level. **In our study, we will consider *two* levels of target cost difficulty, leading to two different types of target costing, i.e. target cost with a difficult-to-attain target cost (i.e. the "*difficult target cost setting*") and target costing with an easy-to-attain target cost (i.e. the "*easy target cost setting*").** Consistent with the definitions of the cost concepts in target costing, in a "difficult target cost setting" the target cost is set at a level much lower than the as-if cost. Similarly, in an "easy target cost setting" the target cost is set at a level near the as-if cost, as shown in the example of Figure 19 on the next page.

To answer research question one now, we need to compare both the "easy target cost setting" and the "difficult target cost setting" with the "non-target cost setting". In this last condition, design engineers receive no target cost but are expected to minimize the cost level of future products. For convenience, we will name those three conditions, the three levels of the "<u>target cost setting</u>" (abbreviated as TCS), as shown in Table 5.

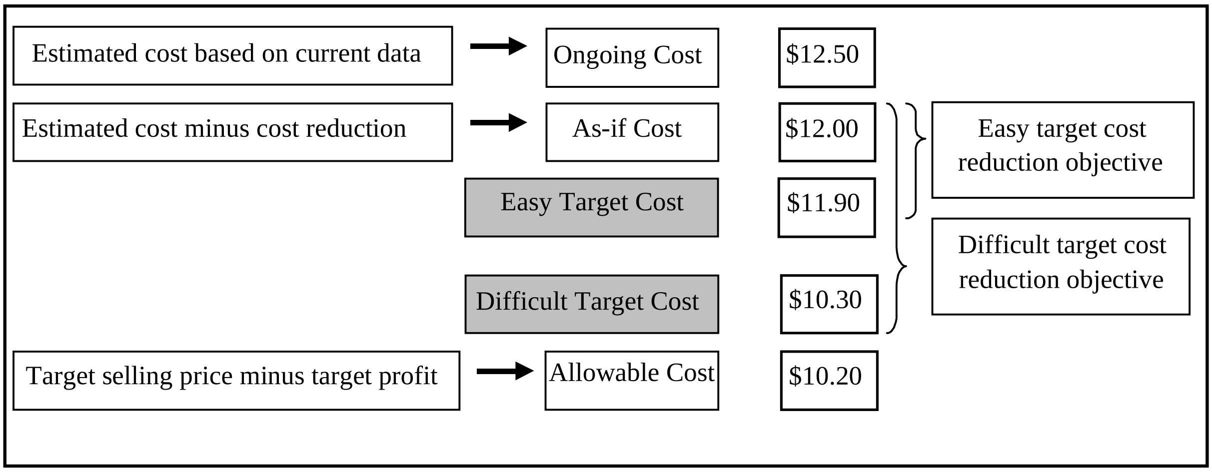
Table 5: Levels of "Target Cost Setting" (TCS) in our Study

Target Cost Setting		
<u>Non-Target Cost Setting</u> **(*Non-TCS*)**	**<u>Easy Target Cost Setting</u>** **(*Easy TCS*)**	**<u>Difficult Target Cost Setting</u>** **(*Difficult TCS*)**
Non-Target Costing: Conventional western Approach or Cost Plus Approach	**Target Costing**	

Hence in the first research question we seek to investigate *whether the cost level of a future product will significantly differ among the three conditions of target cost setting (TCS)*, i.e. among the non-TCS, the easy TCS and the difficult TCS.

[32] Also in goal setting studies researchers never made any assertions about comparing a **specific goal** condition with a **vague goal** condition. Making a goal specific is not improving performance, though making a goal specific with a difficult-to-attain goal level is having a favorable impact on performance, as will be discussed further (Locke, Chah et al., 1989, 270).

Figure 19: Example of an Easy Target Cost Setting and a Difficult Target Cost Setting



2.3 Hypothesis 1: Impact of TCS on Cost

Current field study research on the use of target costing concludes that the target cost is frequently set at a level that is *difficult to attain*, i.e. at a level that approaches more the allowable cost than the as-if cost. Sakurai (1989, 45) and Kato (1993, 36) use the following expression: "the established target cost should be attainable but only attainable with considerable effort." Similarly, Cooper & Slagmulder (1997, 111) found that the target cost is set so that it is "achievable only if the entire organization makes a significant effort to reach it". This conclusion is supported by the results of the survey of Tani et al. (1994, 75), showing that the final target cost is set more towards the allowable cost than towards the as-if cost, as shown in Table 6. Similarly, Tani et al. (1994, 75) asked for the *effort* required to attain the target cost. A value of 1 was given to 'a level attainable with existing technological standards', a value of 4 to 'a level attainable with some effort' and a value of 7 to 'a level that needs considerable innovative ideas'. The mean was 5.04, with a standard deviation of 1.08, making Tani et al. (1994, 75) to conclude that target costs are set at a level which required substantial effort, as perceived by the members of the target costing staff.

Table 6: Results of Tani's Survey (1994) on the Target Cost Level in Japan (n=106)

Level of the Target Cost is equal to the:	Percentage of firms using target costing
Actual cost of similar products:	6%
As-if cost:	18%
Adjustment between the allowable cost and as-if cost:	56%
Allowable cost:	20%

Source: Based on Tani et al. (1994, 75)

Summarizing, target costs seems to be set at levels difficult-to-attain in the companies using target costing. Though, from current research on target costing it is not clear whether the favorable impact of target costing applies to a difficult TCS as well as to an easy TCS. Thus, we need to go to other research areas. Goal setting theory from applied psychology looks promising in helping us to develop hypotheses on target costing, as will be motivated further in section 6 on page 99.

The main premise of **goal setting theory** is that goals are immediate regulators of human action. Locke & Latham (1990, 27) explain that there are two core findings in goal setting theory. The ***first*** **finding** states that (specific) difficult goals[33] lead to a higher level of performance than (specific) easy goals. This first finding is called the goal difficulty effect. The ***second*** **finding** asserts that specific difficult goals lead to a higher level of performance than vague, non-quantitative goals such as "do your best" or no assigned goals[34]. This second finding is called the goal difficulty/specificity effect and is of importance to our study. Four mechanisms are identified by which goals affect performance, explaining this second core finding. First, goals serve as a *directive* function by indicating exactly what acceptable performance consists of and directing the attention away from goal-irrelevant activities. Second, a difficult goal serves as an energizing function by mobilizing the *effort* required for attaining the goal. Carried across time, these two dimensions will also affect a third aspect, i.e. the duration or *persistence* of effort. For instance, Locke (1968, 169) found that a do-best versus a difficult goal group worked at the same pace early in each work period, but the difference between them grew as the work period progressed. Fourth, specific, difficult goals stimulate individuals indirectly to develop effective *task specific strategies* for attaining the goal. (Locke & Latham, 1990, 86-105; Locke & Bryan, 1969b, 35)

In fact our first research question can also be considered as a goal setting problem, i.e. we are comparing a "do-best" goal with a (specific) easy and a (specific) difficult goal situation. However, more than one goal is set in our study. In the NPD context, design engineers face many, conflicting goals for developing a future product, limited to three in our study, i.e. for the cost level of the future product, for the quality level of the future product and for the time-to-market. Hence, we need to look at ***multiple*** **conflicting goal setting studies**. Most of the existing research on goal setting has concentrated on *single* goal setting problems. Locke, Shaw et al. (1981, 127) remark in their review on goal setting research that little attention has been paid to the impact of goal conflict in the current research. Also Austin & Bobko (1985, 291) call multiple goals and conflicts among goals as the two

[33] A **difficult goal** should be distinguished from a **difficult task** or a **complex task**. Goal difficulty refers to the height of the goal level, whereas task difficulty or task complexity refers to the job content itself (Locke & Latham, 1990, 26). Merchant & Manzoni (1989) prefer the term goal achievability instead of goal difficulty, since difficulty is usually operationalized as a probability of achievement.

[34] Participants under "**no goals**" typically try to do as well as they can under a "do-best" goal. Locke, Shaw et al. (1981, 129) did not find any differences in the results of studies for which no goals were assigned and those for which people are explicitly told to do their best.

major unexplored research areas in goal setting. Table 7 on page 85 summarizes the available literature on multiple goal setting. The largest group of research in multiple goal setting is headed by Ivancevich and his colleagues and focuses on multiple goal setting as such[35]. In Ivancevich & McMahon (1982, 363), conflicting goals were set to engineers during NPD for R&D costs, number of quality citations, unexcused overtime hours and a subjective superior's rating on engineering proficiency. The results show that when assigning specific goals to engineers, a significant improvement was found for the R&D costs and the quality measure, while the other two measures did not change. Unfortunately, no information is available in this study on the difficulty of the goal levels. Furthermore, all papers of Ivancevich and colleagues compare performance under multiple goals with a situation where *do-best goals* are set for all performance measures. However, in our research question one only the cost objective is manipulated as do-best, easy and difficult to attain, while the two other goals, i.e. the quality and the time-to-market objective do not change.

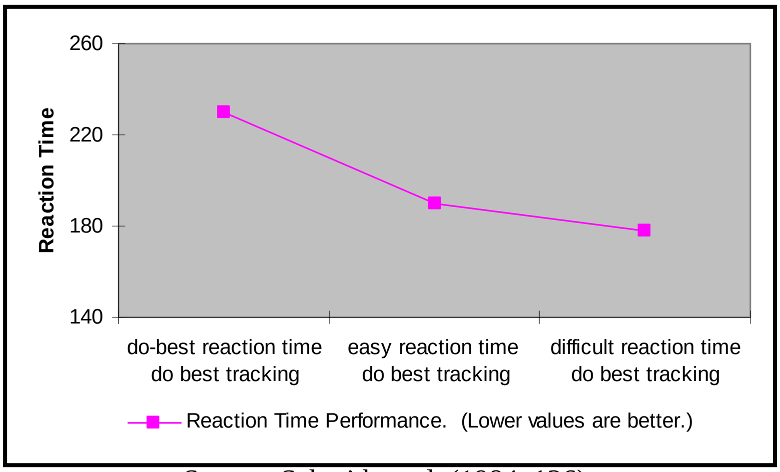
Schmidt et al. (1984) manipulated reaction time and tracking performance in a dual task experiment. In part one of the experiment, both goals were set as a do-best goal. In part two, reaction time goals were set at 20% and 40% improvement over the do-best performance, while the tracking accuracy goal was set at the level as performed under the do-best condition. The results show a significant difference in reaction time performance among the do-best group, the specific-easy (20%) and the specific-difficult (40%) group[36], as shown in Figure 20. In part three of the experiment, tracking performance goals were set at 20% and 40% improvement over the do-best performance, where reaction time goals were set as under the do-best condition. Again, the three groups significantly differed in terms of tracking performance. Also Locke & Latham (1990, 54) conclude that individuals

[35] For instance, **Latham & Kinne** (1974) found in a field study for pulpwood-logging performance, that two of the five performance goals were significantly higher in the group who received training in goal setting than in the control group. **Ivancevich** (1974, 568) did a longitudinal study on the effects of a MBO training of first line supervisors and first line marketing supervisors on the performance of their subordinates. For the operators, goals were set for the quantity of output, the quality, absenteeism and a grievance rate. In plant A, the first three performance measures were significantly better after complete MBO implementation, while in plant B only the first one was better. The grievance rate of the employees deteriorated in both plants. For the salesmen four goals were set, i.e. a market share percentage, a selling cost measure, a sales to visit ratio and a market potential index. All measures, except the selling cost measure, were significantly better in both plants, after the goal setting. **Ivancevich** (1976, 605) found a significant improvement for each of the four performance measures of sales personnel in the group receiving assigned goals, while performance in a control group did not improve. Similarly, for skilled maintenance technicians, **Ivancevich** (1977, 413) found three of the four performance measures significantly better under assigned multiple goal setting than in a control setting. Similarly, **Nemeroff & Cosentino** (1979, 571) defined twelve behaviors (the largest number of goals in goal setting studies so far) to improve the way managers handle performance appraisal interviews with their subordinates. Though the twelve goals did not correspond to the performance measures used after goal setting, performance on interview success, work motivation, satisfaction with the appraisal interview and absenteeism increased significantly for all measures.

[36] In the study of Schmidt et al. (1984, 137) only a significant ANOVA among the three conditions on reaction time is presented, without doing further analyzes on which group differences are responsible for the significant ANOVA. So, it is not clear if the **do-best** condition significantly differs from the **easy** reaction time group in terms of reaction time performance as well as from the **difficult** reaction time group.

can successfully pursue multiple goals and that the two core findings apply to multiple goal setting as well.

Figure 20: Manipulation of Reaction Time Performance under a "Do-Best", Easy and Difficult Reaction Time Goal, in a Two Goal Setting



Source: Schmidt et al. (1984, 136)

Consequently, we expect that in our study, the cost level will significantly differ among the do-best, easy and difficult goal condition. Hence we hypothesize that the cost level will significantly differ among the non-TCS, the easy TCS and the difficult TCS. This first hypothesis is formulated as follows:

<u>Hypothesis 1</u>: *In a three-goal NPD situation, the cost level of a future product will significantly differ among the non-target cost setting (non-TCS), the easy target cost setting (easy TCS) and the difficult target cost setting (difficult TCS).*

2.4 Hypotheses 1a and 1b: Pairwise Comparisons on Cost

Answering research question one requires that we know which conditions do differ in terms of the cost level. Mainly two pairwise comparisons[37] are of interest here: **(1) comparing a *difficult TCS* with a *non-TCS* and (2) comparing an *easy TCS* with a *non-TCS*.**

From the Schmidt et al. study (1984, 136), we know that a difficult goal leads to a better performance than the do-best condition, in a two-goal situation. Similarly, Terborg & Miller (1978, 35) found a better quantity performance when the goal was difficult than in a do-best goal condition, which was

[37] Though a **third comparison** (i.e. comparing the easy TCS with the difficult TCS) is possible as well, in this study we are mainly interested in comparing the target costing with the non-target costing context. According to the first core finding of goal setting, we might expect a lower cost level under the difficult TCS than under the easy TCS as well. See for instance Bassett (1979, 214) and Gilliland & Landis (1992, 676), supporting the first core finding in a *multiple conflicting* goal setting. For support in a single goal setting, we refer to Locke (1968), Latham & Lee (1986), Mento, Steel & Karren (1987, 52), Wood, Mento & Locke (1987, 418) and Locke & Latham (1990, 29). Even when goal levels become *unattainable*, performance still increases, but at a decreasing rate, as shown in Locke (1982, 514) and Locke, Chah et al. (1989, 283).

also found in Audia et al. (1996, 489); both two-goal setting situations. However, in a single goal setting, the number of studies supporting this second core finding is amazing. Locke & Latham (1990, 30) found in 183 out of 201 single goal setting studies a significant effect in favor of specific difficult goals over do-best goals. For other reviews we refer to Mento, Steel & Karren (1987), Wood, Mento & Locke (1987), Locke, Shaw et al. (1981). Even for creative tasks, specific-difficult goals seem to lead to higher performance than do-best goals in a single goal setting. For instance, Latham, Mitchell & Dossett (1978, 169) found a significant better performance under a difficult goal than a do-best goal for highly educated engineers and scientists, who were considered to be already highly motivated prior to the goal setting stimulus.

Hence, as Latham & Lee (1986, 105) assert, the results in single goal setting are overwhelming in favor of difficult goals, compared to "do-best" goals, both in laboratory and field settings, both for quantity and quality performance criteria, and both for individuals and groups. Considering these results with the results of current field studies on target costing suggesting a favorable impact of target costing (knowing that the target cost is set in general at a level not to attain without considerable effort), we can expect that the cost level of a future product will be lower (i.e. better) under a difficult TCS than when design engineers are expected to do their best in minimizing the cost level of the future product in the non-TCS. This leads to the following hypothesis for the first pairwise comparison on the cost level:

<u>Hypothesis 1a</u>: *In a three-goal NPD situation, the cost level of a future product will be significantly lower under the difficult target cost setting (<u>difficult TCS</u>) than under the non-target cost setting (<u>non-TCS</u>).*

The **second comparison** involves comparing the cost level of the future product in an easy TCS with that in a non-TCS. Erez (1990) found hardly a difference in quantity performance between the easy goal and the do-best condition. Contrary, Schmidt et al. (1984) found a better performance on reaction time in the easy goal condition than in the do-best condition, though remember that the goal level was set at 20% improvement over the do-best scores, which can hardly be called easy-to-attain. Also in single goal setting, this question is not addressed as frequently as the previous one. However, some knowledge is available that performance under a "do-best" goal might be better than under an easy goal. For instance, Locke, Mento & Katcher (1978, 275)[38] found that the "do-best" group outperformed the easy goal group ·nd the moderate goal group. Similarly, lower performance under the easy goal than under the "do-best" goal was found by Locke, Chah et al. (1989, 277). Erez & Zidon (1984, 76) set seven goal levels, increasing from very easy-to-attain to very difficult-to-attain and found that the groups with the two most easy goals, had lower performance than the do-best

[38] The **moderate** difficult goal represented a specific goal of 70% of individual performance in an earlier trial session and the **easy** goal group represented a specific goal of 30% of individual performance in an earlier trial session.

group. Even for a moderate difficult goal, Dossett, Latham & Saari (1980, 564) found in their study a lower return of surveys if they asked respondents for a moderate deadline than for the "as soon as possible" deadline. Locke & Latham (1990, 49) clarify that individuals under a do-best group often set their own goals, while individuals reaching an easy goal might stop working. This condition to stop working on the future product when the goal (i.e. the target cost) is reached, is generally present in target costing. Because, Cooper & Slagmulder (1997, 120) conclude, based on case study research, that design engineers receive no incentive for achieving greater cost reductions than those required to achieve the target cost. Thus, the research findings in single goal setting suggest that the so-called favorable impact of target costing on the cost level of a future product might not apply to an easy TCS.

Hence, we hypothesize that setting the target cost at a level that is easy-to-attain will lead to worse performance in terms of the cost level of the future product than when design engineers do not receive a target cost, but are expected to minimize the cost level. Once reached the easy target cost, design engineers have no further stimulus to look for further cost reduction ideas in target costing. This hypothesis for the second pairwise comparison is formulated as follows:

Hypothesis 1b: *In a three-goal NPD situation, the cost level of a future product will be significantly higher under the easy target cost setting (easy TCS) than under the non-target cost setting (non-TCS).*

Summing up, we expect a lower cost level under the difficult TCS than under the non-TCS, though we expect that design engineers will do better in terms of reducing the cost level of the future product in the non-TCS than in the easy TCS, as shown in Figure 21.

Figure 21: Hypotheses 1, 1a and 1b: The Expected Impact of Target Cost Setting on the Cost Level of a Future Product in a Three-Goal NPD Environment

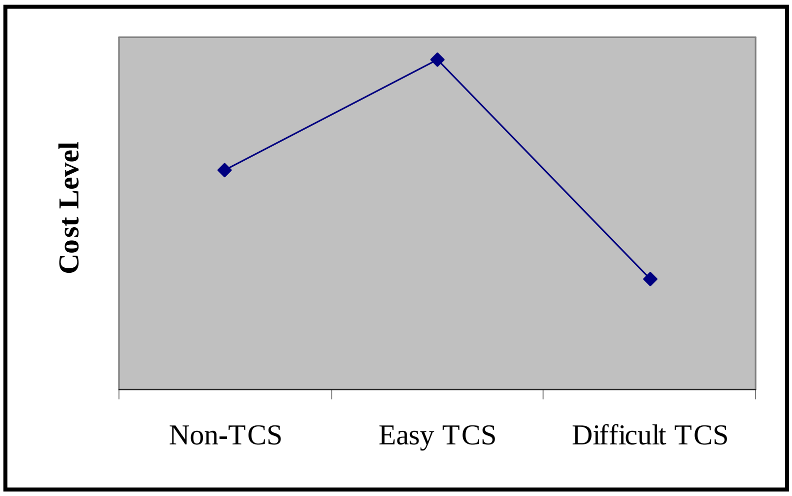


Table 7: Summary of Multiple Goal Setting Studies

Ivancevich (1974, 1976, 1977), Latham & Kinne (1974), Nemeroff & Cosentino (1979), Ivancevich & McMahon (1982)

		Goal 1	
		No goal	Specific
Goal 2	No goal	X	
	Specific		X

Terborg & Miller (1978)

		Quantity Goal	
		Difficult	Do-best
Quality Goal	Difficult		X
	Do-best	X	X

Locke & Bryan (1969a), Bavelas & Lee (1978), Garland (1982)

		Quantity Goal	
		Easy	Difficult
Quality	Do-best	X	X

Schmidt et al. (1984)

		Reaction Time Goal		
		Easy	Difficult	Do-best
Tracking Performance Goal	Easy			X
	Difficult			X
	Do-best	X	X	X

Audia et al. (1996)

		Quantity Goal		
		Progressive	Difficult	Do-best
Quality Goal	Progressive			X
	Difficult			X
	Do-best	X	X	X

Erez, Gopher et al. (1990)

		Quantity goal 1	
		Easy	Difficult
Quantity Goal 2	Easy		X
	Difficult	X	X

Bassett (1979)

		Time Goal	
		Easy	Difficult
Quantity Goal	Easy	X	X
	Difficult	X	X

Erez (1990)

		Quality Goal		
		Do-best	Easy	Difficult
Quantity Goal	Do-best	X		
	Easy		X	
	Difficult			X

Shalley (1991)

		Quality Goal	
		Difficult	Do-best
Quantity Goal	Difficult	X	X
	Do-best	X	X

Gilliland & Landis (1992)

		Quality Goal	
		Easy	Difficult
Quantity Goal	Easy	X	X
	Difficult	X	X

3. The Impact of Target Costing on Multidimensional NPD Performance of Future Products

3.1 Research Question Two

The second research question in our study (see page 25) seeks to investigate the total impact of target costing on the future product, compared to non-target costing. In this study, we consider differences in cost level, in quality level and in time-to-market. This second research question was formulated earlier as:

Will the multidimensional NPD performance (in terms of the cost level, the quality level and the achieved time-to-market) differ between a target costing and a non-target costing context?

3.2 Hypothesis 2: Impact of TCS on Cost, Quality and Time-to-Market

Again, when we compare target costing with non-target costing in terms of the different NPD measures, we need to include the discussion at what level the target cost is set. In answering research question three, we will investigate whether the three NPD measures (cost, quality and time-to-market) are differing among the non-TCS, the easy TCS and the difficult TCS.

As discussed before in literature review[39], most researchers in target costing do not mention any impact of target costing on the quality level of a future product or on the achieved time-to-market. Only Kato (1993, 37) mentions that lowering the quality level of a future product facilitates to attain the target cost. Similarly, Cooper & Slagmulder (1997, 78) mention that the easiest way to remove costs is to reduce its quality level. None of the current case studies addresses that this practice is a matter of course in the firms currently using target costing, though none of the current cases really investigated that issue. Furthermore, there is some evidence available that target costing will delay the time-to-market. For instance Kato, Böer & Chow (1995, 49) found a team succeeding in a cost reduction of 30%, though by introducing the product with a significant delay. Also Ansari & Bell (1997, 169) report that an overemphasis on attaining the target cost leads to longer development time[40]. Hence, from these limited anecdotes, we might expect that target costing will have an unfavorable impact on the quality level and/or the time-to-market, next to the earlier mentioned favorable impact on the cost level. **Or formulated in another way, we expect that design engineers**

[39] See section 7.2.1 on page 70.

[40] Though, this vision is not confirmed by all authors in literature. For instance, Cooper & Slagmulder (1997, 181) explicitly state in one of their cases that **no delayed** time-to-market was realized after implementing target costing.

will create significantly different new products in a target costing than in a non-target costing environment.

Consequently, we hypothesize that the multidimensional NPD performance on a combination of the cost level, the quality level and the achieved time-to-market of a future product will significantly differ among the non-TCS, the easy TCS and the difficult TCS. This hypothesis is formulated as follows:

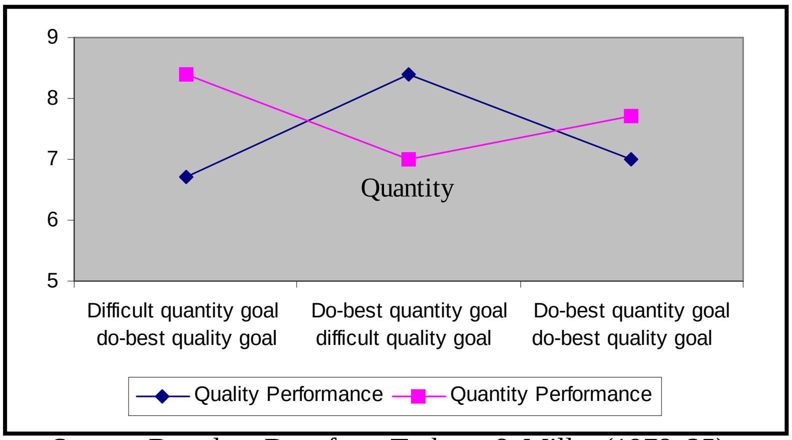
<u>*Hypothesis 2*</u>*:* *In a three-goal NPD situation, a combination of the three new product development measures cost level, quality level and achieved time-to-market will significantly differ among the non-target cost setting (non-TCS), the easy target cost setting (easy TCS) and the difficult target cost setting (difficult TCS).*

3.3 Hypotheses 2a and 2b: Pairwise Comparisons on Cost, Quality and Time-to-Market

We can now question whether the difference in new products between the non-target costing and the target costing environment will apply to both the easy TCS and the difficult TCS. Hence, as mentioned above, mainly two comparisons are of interest in our study: **(1) comparing the differences in new products between the *non-TCS* and the *difficult TCS* and (2) comparing the differences in new products between the *non-TCS* and the *easy TCS*.**

In target costing, this issue of easy and difficult target costs on multiple performance measures has not been addressed. In multiple goal setting, some studies are available on the **first comparison**, i.e. comparing a do-best goal with a difficult goal in terms of two performance measures. For instance, Audia et al. (1996, 488) found in a two-goal setting on quantity and quality goals that changing the *quantity* goal from a do-best goal to a difficult goal, had a negative impact on the quality performance in an assembly task. Also Terborg & Miller (1978) found that the performance on quality decreased when changing from a do-best *quantity* goal condition to a difficult *quantity* goal condition, as shown in Figure 22. Similarly, Shalley (1991, 182) found lower levels of creativity when the other goal was set at a difficult level than at a do-best level. Locke & Bryan (1969a, 62) found in an addition-task experiment that the difficult-goal people attempted more problems, but were making more errors than the easy-goal people did. Bavelas & Lee (1978, 229) found in a creative task that making the quantity goal more difficult resulted in high variances on four quality dimensions with a lower mean value compared to the easy goal condition. Also Garland (1982, 247) found that under a difficult quantity-goal, participants gave more inappropriate and overlapping responses in a creativity task than under the easy quantity goal. **Thus, these studies show that assigning a difficult quantity goal, as compared to assigning a do-best (or easy) quantity goal, improves the performance of that goal, but deteriorates the performance of the other goal**.

Figure 22: Quantity and Quality Performance in Terborg & Miller (1978)



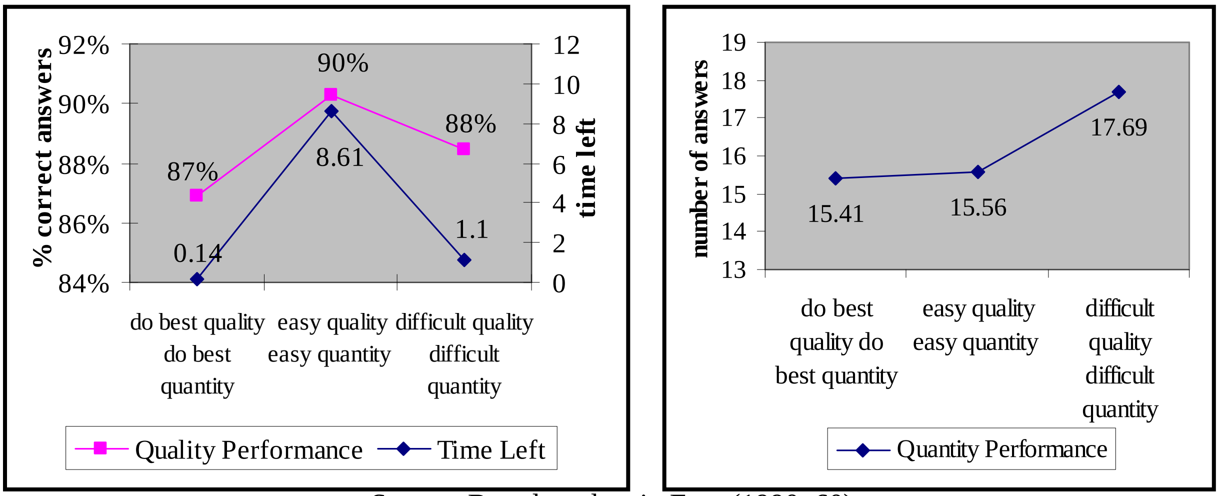
Source: Based on Data from Terborg & Miller (1978, 35)

However, these mentioned studies are all two-goal setting situations, finding a negative impact of a difficult quantity goal on the quality performance. Locke & Latham (1990, 97) explain that lowering quality can be done *conscious* in an attempt to attain a difficult quantity goal or it can be done *unconscious* as a by-product of increasing one's attention to attain the difficult goal. Similarly, Bavelas & Lee (1978, 236) explain that improving performance on the one goal and lowering performance on the other goal is a result of the directing attention effect that comes from the more difficult goal. In our study there are *three goals* in total. Thus, in our study focussing the attention of design engineers on attaining the difficult target cost can have a negative impact on the quality level as well as on the time-to-market. Focusing the attention of design engineers on the difficult target cost can lead to a (conscious or unconscious) lower quality level, as found in the earlier mentioned goal setting studies. Looking for additional cost reduction ideas in order to attain the difficult target cost is more likely to make the total development time longer, as found in Kato, Böer & Chow (1995). Hence, we expect that design engineers will design totally different new products in the non-TCS than in the difficult TCS, leading us to formulate the following hypothesis:

Hypothesis 2a: *In a three-goal NPD situation, a combination of the three NPD measures cost level, quality level and achieved time-to-market will be significantly different between the non-target cost setting (non-TCS) and the difficult target cost setting (difficult TCS).*

Again, on the **second comparison**, comparing an easy goal with a do-best goal, little research has been done so far in a multiple goal setting, as shown in Table 7. Comparing do-best conditions on both quantity and quality with an easy goal on both quantity and quality in the Erez study (1990, 60) did not show a significant difference in quality, though a significant difference in time spent, as shown in Figure 23. Participants in the easy condition were much earlier finished with the task.

Figure 23: Quality, Quantity and Time Performance in Erez (1990)



Source: Based on data in Erez (1990, 60)

Translated to our study, this might suggest that NPD in the easy TCS will result in shorter development times than in the non-TCS, because the former design engineers are finished with cost reduction activities once the target cost is attained. Similar to Erez (1990), we expect no differences in quality level, because the easy-to-attain target cost will not direct the attention away from the quality level as in the difficult TCS. Earlier we expected a significant lower cost level in the non-TCS than in the easy TCS. Thus, we might expect some important differences in new products created in the non-TCS with new products created in the easy TCS in terms of cost level and time spent. Consequently, we hypothesize that the new products will differ between the non-TCS and the easy TCS on a combination of the cost level, the quality level and the achieved time-to-market. This hypothesis is formulated as follows:

<u>Hypothesis 2b</u>: *In a three-goal NPD situation, a combination of the three new product development measures cost level, quality level and achieved time-to-market will significantly differ between the non-target cost setting (<u>non TCS</u>) and the easy target cost setting (<u>easy TCS</u>).*

4. The Impact of Target Costing on the Cost Level of Future Products under Two Conditions of Time Pressure

4.1 Research Question Three

The third research question in this study (see page 25) seeks to investigate whether the favorable impact of target costing on the cost level of future products differs across the levels of time pressure. In fact, this research question asks about the moderating impact of time pressure on the relationship between target costing and the cost level of a future product. This third research question was earlier formulated as follows:

Will the difference in cost level between a target costing and a non-target costing context vary between a situation of low time pressure and high time pressure?

4.2 Definition of Time Pressure (TIME)

As mentioned before in the motivation section (see page 23), shortening time-to-market is considered as strategically important to survive in highly competitive markets. Shortening time-to-market can cause high time pressure for design engineers during the NPD of future products. In our study, we will consider *two* levels of time pressure, i.e. low time pressure and high time pressure. Low time pressure corresponds in our study with a *time-to-market objective* that is *easy-to-attain*. High time pressure corresponds in our study with a *time-to-market objective* that is *difficult-to-attain*. Hence time pressure is here understood in its sense of difficulty of the time-to-market objective. Thus, we will use the terms “time pressure” and “difficulty of the time objective” as synonyms, and abbreviate this second independent variable shortly as ‘TIME’. The two levels of time pressure considered in this study will then be called the easy TIME and the difficult TIME condition, as shown in Table 8.

In answering the third research question, we need to evaluate now the differences in cost level among the three TCS conditions (non-TCS, easy TCS and difficult TCS) under the easy TIME as well as under the difficult TIME. Or stated in another way, we need to investigate whether the differences in cost level among the three conditions of TCS will vary across the two time objectives. Thus this third research question asks about the interaction effect of TCS by TIME on the cost level.

Table 8: Levels of "Time Pressure" (TIME) in our Study

Time Pressure = Difficulty of the Time-to-Market Objective	
Low Time Pressure = **<u>Easy Time-to-Market</u>** (***Easy TIME***)	**High Time Pressure** = **<u>Difficult Time-to-Market</u>** (***Difficult TIME***)

4.3 Hypothesis 3: Impact of 'TCS by TIME' on Cost

As mentioned before in literature review on target costing (see page 69), no findings are available in the current available case descriptions on target costing if the so-called favorable impact of target costing applies to a situation of low time pressure as well as to a situation of high time pressure. Earlier in section 6 of literature review on target costing (see page 63), we described some cost reduction techniques, such as value engineering and tear-down methods that design engineers use during NPD to attain the target cost. More time will be available for such cost reduction activities when the time-to-market objective is set at a level easy-to-attain than when the time-to-market objective is set at a level difficult-to-attain. In this last situation, design engineers perceive not only pressure to attain the target cost, but also to launch the new product on time. Thus, we expect larger differences in cost level among the three levels of target cost setting under the easy time objective than under the difficult time objective. This hypothesis is formulated as follows:

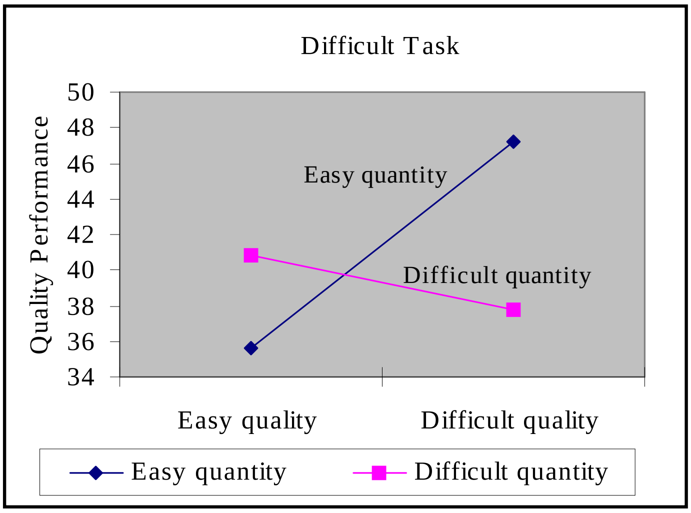
<u>Hypothesis 3</u>: *In a three-goal NPD situation, the impact of target cost setting (non-TCS, easy TCS and difficult TCS) on the cost level of a future product will significantly differ across the two levels of time pressure.*

4.4 Hypotheses 3a and 3b: Interaction Comparisons on Cost

Again, we are further interested in comparing non-target costing with target costing for both the easy TCS and the difficult TCS to investigate whether the interaction effect applies to both conditions. The same two comparisons are of interest: **(1) comparing the cost level between the *non-TCS* and the *difficult TCS* across the two levels of time pressure and (2) comparing the cost level between the *non-TCS* and the *easy TCS* across the two level of time pressure.**

Again these comparisons can be considered as multiple goal setting problems, where goal difficulty is manipulated for two goals simultaneously, i.e. for the time-to-market objective as well as for the target cost. We found two goal setting studies on this interaction effect in a two-goal situation[41]. Bassett (1979, 204) manipulated a quantity and a time goal simultaneously. He found a significant interaction effect between the easy and the difficulty quantity goal across the easy and the difficult time condition. Similarly, Gilliland & Landis (1992, 676) did a lab experiment while manipulating the difficulty on a quality goal and on a quantity goal. For a complex task, a significant interaction effect between quantity and quality-goal difficulty was found. In particular, there was a significant difference in *quality* performance between the easy quality and difficult quality condition when the *quantity* goal was easy, while there was not a significant difference in *quality* performance when the *quantity* goal was difficult, as shown in Figure 24. Hence, only when participants had an easy quantity goal (i.e. had time enough to think about the quality) assigning a difficult quality goal resulted in improved performance for quality. Contrary, under the difficult quantity goal (i.e. when participants had hardly time to think about the quality) assigning a difficult quality goal did not result in improved quality performance.

Figure 24: Interaction Effect in Gilliland & Landis (1992): Quality Performance under an Easy Quantity and under a Difficult Quantity Goal



Source: Gilliland & Landis (1992, 677)

Similarly, we expect in our study that under an *easy* time condition assigning a difficult target cost will improve performance on the cost level, compared to the non-TCS. Contrary, we expect that under a *difficult* time condition assigning a difficult target cost will not improve cost performance significantly, compared to the non-TCS, since design engineers will have hardly time to think about cost reductions. Thus, we expect that the differences in cost level between the non-TCS and the difficult TCS will be larger under the easy time condition than under the difficult time condition,

[41] Remark that these studies both compare a difficult goal with an easy goal, while we are here interested in comparing a **difficult** goal (i.e. the difficult TCS) with a **do-best** goal (i.e. the non-TCS).

resulting in a significant interaction effect. This hypothesis on the first comparison is formulated as follows:

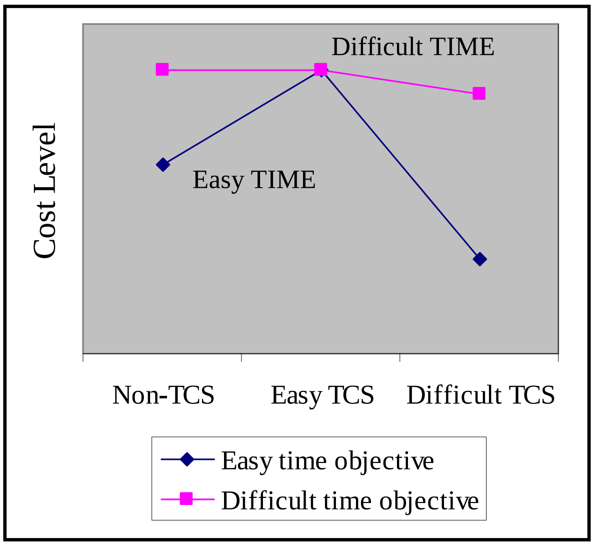
Hypothesis 3a: *In a three-goal NPD situation, the difference in cost level between the non-target cost setting (non-TCS) and the difficult target cost setting (difficult TCS) will significantly differ across the two levels of the time objective.*

Going to the second comparison, we expected in hypothesis 1b a lower cost level under the non-TCS than under the easy TCS, because there are no incentives given in target costing to perform more cost reductions than required to attain the target cost. Similarly as in hypothesis 3a, we expect now that the differences in cost level between the non-TCS and the easy TCS will be larger under the easy time objective, when participants have time to think about cost reduction opportunities in the non-TCS than under the difficult time objective, where the difficult time-to-market objective is speeding up designers in the non-TCS, so that they hardly think about cost reduction activities. This expected interaction effect for the second comparison is formulated in the following way:

Hypothesis 3b: *In a three-goal NPD situation, the difference in cost level between the non-target cost setting (non-TCS) and the easy target cost setting (easy TCS) will significantly differ across the two levels of the time objective.*

Finally, Figure 25 gives a summary of the hypothesized cost level under the three conditions of target cost setting (non-TCS, easy TCS, difficult TCS) for each of the two levels of time pressure (easy TIME, difficult TIME), as results from the developed hypotheses 3, 3a and 3b.

Figure 25: Hypotheses 3, 3a and 3b: The expected Impact of 'TCS by TIME' on the Cost Level of Future Products in a Three-Goal NPD Environment



5. The Impact of Target Costing on Multidimensional NPD Performance under Two Conditions of Time Pressure

5.1 Research Question Four

As mentioned in chapter one (page 25) the fourth research question in our study seeks to investigate whether the impact of target costing on the total future product, compared to non-target costing, also differs as a function of time pressure. Actually, this research question is about the moderating impact of time pressure on the relationship between target costing and the three NPD measures. This fourth research question was formulated before as:

Will the difference in multidimensional NPD performance (in terms of the downstream cost level of a future product, the quality level of that future product and the achieved time-to-market) between a target costing and a non-target costing context vary between low time pressure and high time pressure?

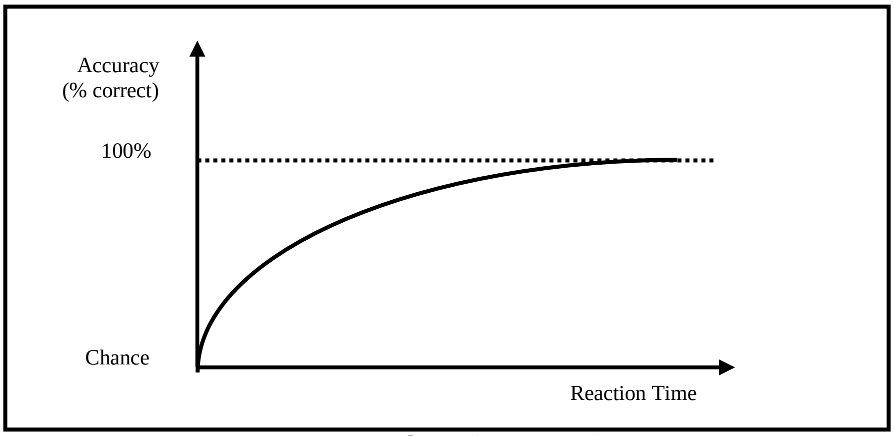
5.2 Hypothesis 4: Impact of 'TCS by TIME' on Cost, Quality and Time-to-Market

We will now consider three target cost settings (non-TCS, easy TCS and difficult TCS) under two conditions of time pressure (easy TIME and difficult TIME). The question to answer now is whether design engineers will design a different future product under the three TCS conditions when time pressure is low than when time pressure is high.

As mentioned before in literature review on target costing (see page 71), just one case study researcher mentions a negative impact of target costing combined with time pressure on the performance of new products. Kato (1993, 42) argues that since much of the creativity involved in developing new products is human-dependent, too much pressure for shortening time-to-market under target costing creates tension and results in poor performance and management fatigue. More than this suggestion is not available in target costing literature. None of the other English language cases on target costing, as far as we know, have included a discussion on an interaction effect of target costing and time pressure on the new products design engineers create.

Thus, we need to look again to other research areas. For speeded performance in general, Wickens (1992, 318) explains that people often make errors and that the relationship between speed and accuracy is an inverse one, as shown in Figure 26. Howell & Kreidler (1963, 43) and Fitts (1966, 853) found that when stressing speed, participants are working faster, but are making more errors. When stressing accuracy, participants are working more slowly, but are making fewer errors. This speed-accuracy trade-off suggests that the difficult time-to-market condition, where design engineers are speeded up in designing the new product, will lead to more design errors with a lower quality level of the future product as a result. Furthermore, combining target costing with time pressure, we can expect larger differences in quality level among the three levels of TCS under the difficult time objective than under the easy time objective.

Figure 26: The Speed-Accuracy Trade-off



Source: Wickens (1992, 320)

Earlier we stated also to expect larger differences in cost level under the easy time than under the difficult time objective, because we hypothesize that design engineers will perform more cost reduction ideas under the easy time (when time is available) than under the difficult time condition. Regarding the time-to-market objective, there are some findings on the impact of the difficulty of the time objective on task completion time. For instance, Bryan and Locke (1967, 265) found in a lab experiment that individuals have the tendency to slow their work pace under an easy time and to increase their work speed under a difficult time objective. This finding is consistent with what is called *Parkinson's Law*, i.e. that people adjust their work speed to the time available. This result was later confirmed by Latham & Locke (1975, 525) in the field and by Christensen-Szalanski (1980, 111) in the lab. Though, before we expected more cost reduction activities under the easy time condition and thus we expect larger differences in time-to-market under the easy time objective than under the difficult time objective. Considering the three NPD measures (cost, quality and time-to-market together), we hypothesize that the difference in new products among the three TCS will depend on the time condition. Thus we expect a significant interaction effect between target cost setting and difficulty of the time-to-market objective on the multidimensional NPD performance**.** This hypothesis is formulated as follows:

<u>*Hypothesis 4*</u>*:* *In a three-goal NPD situation, the impact of target cost setting (non-TCS, easy TCS and difficult TCS) on a combination of the three new product development measures cost level, quality level and achieved time-to-market will significantly differ across the two levels of the time objective.*

5.3 Hypotheses 4a and 4b: Interaction Comparisons on Cost, Quality and Time-to-Market

Again, we are interested in further comparing non-target costing with target costing for both the easy TCS and the difficult TCS to investigate whether the interaction effect applies to both conditions. Hence, the same two comparisons are of interest: **(1) comparing the multidimensional NPD performance between the *non-TCS* and the *difficult TCS* across the two levels of time pressure and (2) comparing the multidimensional NPD performance between the *non-TCS* and the *easy TCS* across the two level of time pressure.**

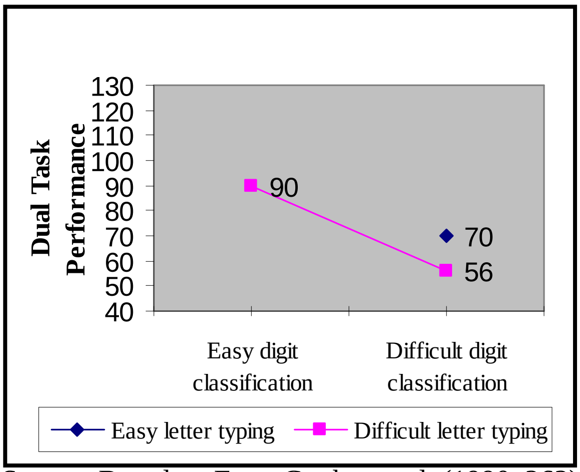
Multiple goal setting studies show that the quality goal is more readily sacrificed for attaining the quantity goal, when two goals are set at a level difficult-to-attain. One of the first studies on multiple goal setting is Stedry & Kay's field experiment (1966, 461) on foremen, receiving productivity goals (two levels) and rework goals (two levels). Support (not confirmation) was found for their hypothesis that if both goals are difficult, participants more often perceive them as impossible than if only one of the two goals is difficult. Consequently, for the two goals being difficult, performance was worse on at least one of the two measures than if only one of the two goals was difficult. Stedry & Kay (1966, 461) explain that people allocate effort to the different goals so as to maximize the expected number of goals attained. Their reasoning is that in the two-goal situation, increasing goal difficulty in an area already receiving effort will increase the effort allocated to the area as well as the expected performance in that area. Beyond a certain point however, further increase in difficulty would drive the area out of the set of those receiving effort. Similar results were found in a dual-task experiment by Erez, Gopher et al. (1990, 249), where *two quantity* goals are assigned, one involving a digit classification quantity and the other a letter typing quantity. Though no analyses were provided on the performance of each goal separate, the dual task performance measure (calculated as a weighted sum) shows the lowest value when both digit classification and letter typing were set at a level difficult-to-attain, as shown in Figure 27[42]. Also Gilliland & Landis (1992, 676) found that participants gave up the less achievable quality goal and allocated their efforts toward the more achievable quantity goal, when both goals were set at a level difficult-to-attain. They explain that for complex tasks, quality may be more easily sacrificed for quantity than the other way around (i.e. sacrifice quantity for quality) when difficult goals are set for both. In general, people are sacrificing the least attainable goal, when achieving both of them becomes very difficult. From the above mentioned studies, we expect that design engineers will more easily sacrifice the quality level of the future product in the difficult TCS, compared to the non-TCS, when the time objective is difficult as well than when the time objective is easy-to-attain. Hence we expect larger differences in quality level between the non-

[42] Only three of the four groups were studied in Erez, Gopher et al. (1990). The condition with both goals easy (digit classification and letter typing) was **not considered** in this study.

TCS and the difficult TCS under the difficult time than under the easy time condition. Earlier we also expected larger differences in cost level between the non-TCS and the difficult TCS. Similar the Erez (1990) study, we do not expect differences in time spent between the non-TCS and the difficult TCS across the two levels of time pressure. Summing up, we hypothesize a significant difference in created products between the non-TCS and difficult TCS, across the two levels of time pressure (because of the quality and cost differences). This hypothesis on the first comparison is formulated as follows:

<u>Hypothesis 4a</u>: *The difference on a combination of the three NPD measures cost level, quality level and achieved time-to-market between the <u>non-TCS</u> and the <u>difficult TCS</u> will significantly vary between the easy and the difficult time objective.*

Figure 27: Interaction Effect of Digit Classification and Letter Typing Difficulty on Dual Task Performance in Erez, Gopher et al. (1990)



Source: Based on Erez, Gopher et al. (1990, 262)

In terms of the second comparison, Erez (1990, 60) also compared a do-best goal condition with an easy goal condition, as shown in Table 7. She found that in the easy goal condition, quality performance is the highest of all conditions and participants have the highest time over. Comparing the "easy quantity - easy quality" condition with the "do-best quantity – do-best quality" condition learned that participants under the easy condition are not sacrificing quality for quantity. We do not expect differences in quality level between the non-TCS and the easy TCS, depending on the levels of time pressure. The results do show however that time left significantly differed among the do-best and the easy goal condition (see Figure 23 on page 89). Earlier we expected that also in target costing, the achieved time-to-market will differ between the non-TCS and the easy TCS, because in the latter condition design engineers can stop with cost reduction activities once the easy target cost is attained. Now, we expect that this difference in achieved time-to-market between the non-TCS and the easy TCS will be more pronounced under the easy time condition than under the difficult time condition. Earlier in hypothesis 3b, we also hypothesized larger differences in cost level under the easy time than under the difficult time-to-market objective.

Summing up, we expect that the differences in created products between the non-TCS and the difficult TCS will differ among the two levels of time pressure (mainly because of the cost and time-to-market differences). This hypothesis on the second comparison is formulated as follows:

Hypothesis 4b: *The difference on a combination of the three NPD cost level, quality level and achieved time-to-market between the non-TCS and the easy TCS will significantly vary between the easy and the difficult time objective.*

6. Summary of the Hypotheses

The formulated hypotheses in the previous paragraphs can be described by what Kirk (1995, 1) calls the *scientific* hypotheses. To test these scientific hypotheses, *statistical* hypotheses need to be formulated as well. **In our research study, these statistical hypotheses do involve each time a comparison between a reduced and a full model.** Table 9 gives an overview of the research questions, as formulated in chapter one, as well as the scientific hypotheses, developed in this chapter, and the statistical hypotheses, needed to test the developed scientific hypotheses. In chapter 5, we will elaborate on the most appropriate statistical tests for each of these developed hypotheses (see summary on page 150 including the test statistics).

Table 9: Overview of the Research Questions, Hypotheses and Model Comparisons

<u>Research question 1</u>:	***Will the cost level of a future product be lower in a target costing than in a non-target costing environment?***
1	In a three-goal NPD situation, the cost level of a future product will significantly differ among the non-TCS, easy TCS and difficult TCS. H_0: Cost = X_0 H_a: Cost = X_0 TCS $_{\text{(non, easy, difficult)}}$
1a	In a three-goal NPD situation, the cost level of a future product will be significantly lower under the difficult TCS than under the non-TCS. H_0: Cost = X_0 H_a: Cost = X_0 TCS $_{\text{(non, difficult)}}$ with $\mu_{\text{(difficult)}} < \mu_{\text{(non)}}$
1b	In a three-goal NPD situation, the cost level of a future product will be significantly higher under the easy TCS than under the non-TCS. H_0: Cost = X_0 H_a: Cost = X_0 TCS $_{\text{(non, easy)}}$ with $\mu_{\text{(non)}} < \mu_{\text{(easy)}}$
<u>Research question 2</u>:	***Will the multidimensional NPD performance (in terms of the downstream cost level of a future product, the quality level of that future product and the achieved time-to-market) differ between a target costing and a non-target costing context?***
2	In a three-goal NPD situation, a combination of the three NPD measures cost level, quality level and achieved time-to-market will significantly differ among the non-TCS, easy TCS and difficult TCS. H_0: Cost Quality Time-to-Market = X_0 H_a: Cost Quality Time-to-Market = X_0 TCS $_{\text{(non, easy, difficult)}}$
2a	In a three-goal NPD situation, a combination of the three NPD measures cost level, quality level and achieved time-to-market will significantly differ between the non-TCS and difficult TCS. H_0: Cost Quality Time-to-Market = X_0 H_a: Cost Quality Time-to-Market = X_0 TCS $_{\text{(non, difficult)}}$

2b	In a three-goal NPD situation, a combination of the three NPD measures cost level, quality level and achieved time-to-market will significantly differ between the non-TCS and easy TCS. H_0: Cost Quality Time-to-Market = X_0 H_a: Cost Quality Time-to-Market = X_0 TCS $_{(non, easy)}$
<u>Research question 3</u>:	***Will the difference in downstream cost level between a target costing and a non-target costing context vary between low time pressure and high time pressure?***
3	In a three-goal NPD situation, the impact of target cost setting (non-TCS, easy TCS and difficult TCS) on the cost level of a future product will significantly differ across the two levels of the time objective. H_0: Cost = X_0 TCS $_{(non, easy, difficult)}$ TIME $_{(easy, difficult)}$ H_a: Cost = X_0 TCS $_{(non, easy, difficult)}$ TIME $_{(easy, difficult)}$ TCS $_{(non, easy, difficult)}$ * TIME $_{(easy, difficult)}$
3a	The difference in cost level between the *non-TCS* and the *difficult TCS* will significantly vary between the easy and the difficult time objective. H_0: Cost = X_0 TCS $_{(non, difficult)}$ TIME $_{(easy, difficult)}$ H_a: Cost = X_0 TCS $_{(non, difficult)}$ TIME $_{(easy, difficult)}$ TCS $_{(non, difficult)}$ * TIME $_{(easy, difficult)}$
3b	The difference in cost level between the *non-TCS* and the *easy TCS* will significantly vary between the easy and the difficult time objective. H_0: Cost = X_0 TCS $_{(non, easy)}$ TIME $_{(easy, difficult)}$ H_a: Cost = X_0 TCS $_{(non, easy)}$ TIME $_{(easy, difficult)}$ TCS $_{(non, easy)}$ * TIME $_{(easy, difficult)}$
<u>Research Question 4</u>:	***Will the difference in multidimensional NPD performance (in terms of the downstream cost level of a future product, the quality level of that future product and the achieved time-to-market) between a target costing and a non-target costing context vary between low time pressure and high time pressure?***
4	In a three-goal NPD situation, the impact of target cost setting (non-TCS, easy TCS and difficult TCS) on a combination of the three NPD measures cost level, quality level and achieved time-to-market will significantly differ across the two levels of the time objective. H_0: Cost Quality Time-to-Market = X_0 TCS $_{(non, easy, difficult)}$ TIME $_{(easy, difficult)}$ H_a: Cost Quality Time-to-Market = X_0 TCS $_{(non, easy, difficult)}$ TIME $_{(easy, difficult)}$ TCS $_{(non, easy, difficult)}$ * TIME $_{(easy, difficult)}$
4a	The difference on a combination of the three NPD measures cost level, quality level and achieved time-to-market between the *non-TCS* and the *difficult TCS* will significantly vary between the easy and the difficult time objective. H_0: Cost Quality Time-to-Market = X_0 TCS $_{(non, difficult)}$ TIME $_{(easy, difficult)}$ H_a: Cost Quality Time-to-Market = X_0 TCS $_{(non, difficult)}$ TIME $_{(easy, difficult)}$ TCS $_{(non, difficult)}$ * TIME $_{(easy, difficult)}$
4b	The difference on a combination of the three NPD measures cost level, quality level and achieved time-to-market between the *non-TCS* and the *easy TCS* will significantly vary between the easy and the difficult time objective. H_0: Cost Quality Time-to-Market = X_0 TCS $_{(non, easy)}$ TIME $_{(easy, difficult)}$ H_a: Cost Quality Time-to-Market = X_0 TCS $_{(non, easy)}$ TIME $_{(easy, difficult)}$ TCS $_{(non, easy)}$ * TIME $_{(easy, difficult)}$

7. Assessment of Goal Setting Theory to Elaborate Knowledge on Target Costing

In the previous sections of this chapter, we used findings of goal setting studies in developing hypotheses on the impact of target cost setting. But why did we use goal setting theory as a way to elaborate the knowledge in target costing? Our motivation involves several factors:

1. *First*, Cooper (1995, 137), one of the main case study researchers in target costing, mentions in one of his articles, that goal setting theory could be a useful model in exploring the relationship between target costing and the downstream cost level of a future product.

2. *Second*, it is not unusual to use models of behavioral sciences in management accounting. Birnberg and Nath (1967, 479) called for efforts to utilize findings from the behavioral sciences in accounting research. For instance, expectancy theory was used by Ronen & Livingstone (1975), Ferris (1977) and Chow (1983) to model budget setting.

3. *Third*, using Baiman's (1982, 154) criteria for evaluating models of human behavior as frameworks for management accounting, current research suggests that goal setting theory meets both criteria of being a "*well-defined*" and "*useful*" model. It is well-defined in the sense that precise and unambiguous implications have been derived from it. To Miner (1984, 300) its usefulness has been highly proven as a framework in organizational behavior. Similarly, Locke, Shaw et al. (1981, 131) conclude that goal setting theory leads to one of the most robust and consistent findings, replicated across a wide variety of tasks, settings, measures, objects, time spans and performance measures. Also Latham & Lee (1986, 105) state that "the results are overwhelming both in laboratory and field settings". Until now few researchers have used it to model individual behavior in management accounting for control purposes. However, Pinder (1984, 169) states that "the evidence thus far indicates that it probably holds more promise as an applied motivational tool for managers than does any other approach."

4. *Four*, goal setting theory is reported to have a high *scientific validity*. Miner (1984, 298) contacted 100 knowledgeable scholars for their opinions on 32 established organizational science theories and found that goal setting theory was rated high on estimated scientific validity. Similar, Mento, Steel & Karren (1987,74) argue: "If there is ever to be a viable candidate from the organizational sciences for elevation to the lofty status of scientific law of nature, then the relationships between goal difficulty, goal difficulty/specificity and task performance are most worthy of serious consideration."

8. Conclusions

This research study focuses on comparing the impact of target costing with non-target costing on the development of future products. However, the target cost can be set at different levels in target costing. If the target cost is set near the as-if cost (i.e. to the cost level if all existing cost reduction ideas are implemented in the new product) the target cost will be easy-to-attain. Contrary, when the target cost is set at a level much lower than the as-if cost, the target cost will be more difficult-to-attain. In comparing target costing with non-target costing, we consider in this study both an easy target cost and a difficult target cost. Consequently, the first independent variable in our study is called "*target cost setting*" (TCS), with three levels, i.e. a non-target cost setting, a difficult target cost setting and an easy target cost setting. The second independent variable in our study is "*time pressure*" (TIME). Time pressure is considered here in the sense of difficulty of the time-to-market objective. Two levels are considered of time pressure, i.e. an easy time-to-market objective (inducing low time pressure) and a difficult time-to-market objective (inducing high time pressure).

The first research question in this study asks whether design engineers create a lower cost new product in target costing than in non-target costing. From the existing case studies on target costing, describing a favorable impact on the cost level, we can expect that the cost level will significantly differ among the non-TCS, the easy TCS and the difficult TCS (hypothesis 1). Existing goal setting studies learn that a difficult goal leads to a higher performance than a do-best condition. Hence we hypothesize a lower cost level under the difficult TCS than under the non-TCS (hypothesis 1b). Contrary, comparing an easy goal with a do-best goal in goal setting studies learns that participants stop once the easy goal is achieved, leading to a better performance under the do-best condition. Thus we hypothesize a higher cost level under the easy TCS than under the non-TCS.

Answering the second research question on the differences in created products between target costing and non-target costing requires that we consider the cost level, the quality level and the achieved time-to-market simultaneously. Goal setting studies on multiple goals learn that trying to attain a difficult goal can lead to a reduced performance on the other goals. Hence, we expect that design engineers will create significantly different products among the three TCS. Or as hypothesized in hypothesis 2, we expect that a combination of the three NPD measures cost level, quality level and achieved time-to-market will significantly differ among the non-TCS, the easy TCS and the difficult TCS. We expect differences in created products when comparing the non-TCS with the difficult TCS (hypothesis 2a) as well as for comparing the non-TCS with the easy TCS (hypothesis 2b).

Furthermore, when we consider the two levels of time pressure, in answering the third research question, we expect larger differences in cost level among the three TCS when the time objective is easy-to-attain than when the time objective is difficult-to-attain. Hence, we expect that the impact of

TCS on the cost level will significantly differ between the two time conditions. Under an easy-to-attain time objective design engineers will have more time available for cost reduction activities, leading to larger differences in cost level between the non-TCS and the difficult TCS under the easy time than under the difficult time objective (hypothesis 3a). Similarly, we expect also larger differences in cost level between the non-TCS and the easy TCS under the easy time than under the difficult time condition (hypothesis 3b).

Finally, to answer research question four we need to consider the differences in created products among the three TCS between the two time conditions. We expect that the combination of a difficult target cost with a difficult time objective will be more detrimental on the three NPD measures than if only the target cost is set at a level difficult-to-attain. Hence, we expect that the impact of TCS on a combination of the three NPD measures cost level, quality level and achieved time-to-market will significantly differ between the easy and the difficult time objective (hypothesis 4). Furthermore, we expect significant differences in new products between the non-TCS and the difficult TCS across the two time conditions, because of larger differences in quality level under the difficult time and larger differences in cost level under the easy time condition (hypothesis 4a). Similarly, we expect significant differences in new products between the non-TCS and the easy-TCS across the two time conditions because of larger differences in cost level and time spent under the easy time condition (hypothesis 4b).

Now we are ready to select the most appropriate research method to test these hypotheses. Motivation of the research method is addressed in the following chapter, chapter 4. The research design and the statistical tests will be discussed in chapter 5. Testing the hypotheses will be addressed in chapters 6, 7 and 8.

Chapter 4: Research Method

1. Introduction

In the previous chapters we discussed literature on target costing and formulated different hypotheses on the impact of target cost setting on the cost level, the quality level and the time-to-market. Mainly three research methods are common in management accounting to investigate this kind of research problem, i.e. field research, survey research and experimental research. We will use the lab experiment as research method to test the impact of target costing. But before discussing why we selected this experimental method of doing research on target costing, we also address the alternative research methods in section 2. The focus is on the type of research question each research method is appropriate for. Then in section 3, we will fully address our motivation to use the lab experiment as research method in this study. In section 4, we will elaborate on the drawbacks of lab experiments to know the limitations of the chosen research method.

2. Research Methods in Accounting for Management Control

2.1 Field Research

Yin (1989, 23) defines field research as "*an empirical inquiry that investigates a contemporary phenomenon within its real-life context, when the boundaries between the phenomenon and context are not clearly evident, and in which multiple sources of evidence are used*". Ferreira & Merchant (1992, 4) further explain that the research problem evolves along with the field observations, and that the presentation of data includes relatively rich (detailed) descriptions of company contexts and practices. By definition, field research calls for intensive amounts of data on a large number of variables, in a small number or a single unit of analysis. Two types of field research are distinguished in literature: a case study and a field study[43]. A *case study* involves the systematic observation of policies, people, processes, etc. within a single company, while a *field study* involves the investigation of two or more organizations. In literature, different strengths and weaknesses are attributed to case studies and field studies, as summarized in Table 10.

[43] Birnberg, Shields & Young (1990, 34) adds a third type of field research, i.e. the **field experiment**, where variables are manipulated within field settings. This third type of field research has much more in common with experimental research and will be further discussed under the heading of experimental research (see page 109).

Table 10: Strengths and Weaknesses of Field Study Research

Strengths	Weaknesses
• **Realism:** Of all research methods, they are closest to real life, by direct and in-depth contact with organizational participants, by interviews and direct observation of activities. [44] [45]	• It is not easy for the experimenter to separate the variables because of **noise** in the communication channel.[44] • Lack of **precision** in the measurement of field variables.[44] • **Sample selection** bias because only organizations that are willing to be studied, can be studied.[49]
• **Unique** approach for studying interesting organizations or interesting practices, even when these practices are ill-defined, ill-structured or non understood.[48] [46]	• **Scientific weak method**, because of its ex post facto character: No variables are manipulated during the study.[44] • Case studies are conducted over **lengthy periods** of time: Things might change during the course of the studies.[47] • Use of **small samples** hinders reliable generalization because of the lack of statistical control over the many relevant variables.[49]
• Presence of data and observations provide a **firm and rich basis** for modeling, theory-building and hypothesis-formation activities.[48]	• Method is **risky**: Field co-operation might not be obtained, co-operation might be lost before the data-collection phase of the study is complete, or no really "new" findings might be discovered.[49] • Difficult to draw **boundaries** around the research subject. [44] [52] • Danger of building a theory, which is overly **complex** or very idiosyncratic.[51]
• Provide a **rich research method**, since the researcher can explore the reasons for lack of support of theory and can enrich the theory with missing parameters. [50] [51]	• Both **response and interpretation biases** of the data.[49] • Researcher **cannot** be regarded as a **neutral independent observer**, because he/she must interpret the phenomena observed.[52]

[44] Kerliner (1973, 405)

[45] Ferreira & Merchant (1992, 4)

[46] Birnberg, Shields & Young (1990, 51)

[47] Otley & Berry (1994, 56)

[48] Kaplan (1986, 445)

[49] Merchant & Ferreira (1992, 25)

[50] Kaplan (1986, 445)

[51] Eisenhardt (1989, 541 & 547)

[52] Scapens (1990, 276)

Field research is appropriate for mainly three purposes: providing description, building hypotheses and testing hypotheses (Ferreira & Merchant, 1992, 11). Scapens[53] (1990, 265) explains that by *descriptive field studies* researchers attempt to illustrate new and innovative practices developed by a few companies. Frequently, there is the implicit assumption that the practices of innovative companies are, in some sense, superior to the practices, used by other companies. Most of Cooper's (1995) field studies on target costing falls into this category of field research.

Hypotheses-building field studies are used to discover significant variables in the field, to discover relations among variables, and to lay the groundwork for later, more systematic and rigorous testing of hypotheses (Kerlinger, 1973, 406; Scapens, 1990, 265). The process of theory building from field studies is particularly appropriate in the early stages of research, for instance, when little is known about a phenomenon, when current perspectives seem inadequate because they have little empirical substantiation or because they conflict with each other (Eisenhardt, 1989, 548).

Testing a theory with field study research is a relatively new approach in management accounting.[54] Testing theories with case study research means that researchers start with relatively strong expectations formed from a review of previous research. The logic of bringing together evidence from different cases is a replication logic rather than a sampling logic, according to Yin (1993, 33). The development of consistent findings over multiple cases is considered as a robust finding, giving support to the theory being tested. If the evidence is not consistent with the formulated hypotheses, most of the researchers then attempt to explore the reasons for the lack of support. Ferreira & Merchant (1992, 12) explain that researchers then modify the theory by including missing parameters or by considering why the theoretical conclusions are contextually dependent. Used in that way, field research provides what is called a *rich* testing method (Kaplan, 1986, 447).

2.2 Survey Research

Birnberg, Shields & Young (1990, 35) describe survey research "*as a standardized approach to collect information from sampling units to make inferences about the population*". Samples of the population are studied to discover the relative incidence, distribution and interrelations of variables (Kerlinger, 1973, 410). The data are collected by mail questionnaire, telephone interview or personal interview. The mail and the telephone survey allow collecting data within a field setting, however without entering the field itself as a researcher. In management accounting, surveys are typically

[53] In fact Scapens (1990, 265) makes a distinction between **five types** of case study research: descriptive, illustrative, experimental, exploratory and explanatory. The first three types are all descriptive in the sense that they describe a current practice, while the last two are used for hypotheses building purposes.

[54] Kaplan (1986, 442) argues that case studies tend to be used **more** for hypotheses-*generation* than for hypotheses-*testing*.

conducted through the mail (Brownell, 1995, 55).[55] A summary of the general strengths and weaknesses of this questionnaire survey research is given in Table 11.

Table 11: Strengths and Weaknesses of Questionnaire Survey Research

Strengths	Weaknesses
• **Wide scope**: a great deal of information can be obtained from a large population.[56]	• **Superficiality**: Survey information does not penetrate very deeply below the surface.[56]
• **Contingency** research: surveys are appropriate to study cross-sectional correlations between (management accounting) phenomena and other phenomena (e.g. decentralization, management style, etc.)[57]	• No variables are **manipulated** during the study.
• **Provide inventory**: A sample can give a remarkably accurate portrait of a community, in terms of its values, attitudes and beliefs, if the survey respondents are representative for the population of interest. [56] [58]	• **Response bias**: The survey interview can lift the respondent out of his/her social context, which can make the results of the survey invalid. [56] • **Non-response bias**: Respondents may not be representative for the population, because people who do cooperate differ in significant ways from those who do not. [58] [59]

Survey research is appropriate for a variety of purposes in management accounting, i.e. for exploration and for theory testing. First, surveys are appropriate for *exploration purposes*. Kirk (1995, 7) states that although surveys cannot establish causality, they can explore, describe, classify and establish relationships among variables. Similarly, Birnberg, Shields & Young (1990, 38) explain that by survey research, the researcher can assess trends in practice. To Kerlinger (1973, 411), the nature of survey research is revealed by the nature of its variables, which can be classified as sociological facts (e.g. income, sex, company size, etc.), opinions, attitudes and behavior. The survey researcher is not primarily interested in the distribution of the sociological facts as such, but more in their relationship to what people think and what they do (Kerlinger, 1973, 411). In that opinion surveys are also appropriate to supplement the qualitative data from field studies, by systematically collecting a large amount of data within a single firm (Birnberg, Shields & Young, 1990, 38).

[55] Brownell (1995, 95) gives two reasons why the **questionnaire has dominated the interview** in management accounting. First, the questionnaire is a low cost means of gathering large volumes of data from remote sources, compared to the much more resource-intensive nature of the interview. Second, Brownell believes that management accountants are in general better trained in questionnaire administration than in interview techniques.

[56] Kerlinger (1973, 411)

[57] Birnberg, Shields & Young (1990, 51)

[58] Kirk (1995, 7)

[59] Birnberg, Shields & Young (1990, 42)

Second, surveys are appropriate *for cross-sectional theory testing*, while using a large sample of firms or individuals (Birnberg, Shields & Young, 1990, 38). In management accounting, the survey is frequently used to answer "when" questions in a contingency type of research. The researcher wants to test in which context variables correlate and in which they do not correlate.

2.3 Experimental Research

In experimental research, the researcher **manipulates** one or more independent variables[60], while carefully **measuring its impact on one or more dependent variables**, and while including controls such as the **random assignment** to the experimental conditions to minimize the effect of nuisance variables (Kirk, 1995, 6). Birnberg, Shields & Young (1990, 35) describe experimental research as "*the manipulation of the independent variables and the observation of their effects on the dependent variables*".

Experimental research can be conducted both **in the lab and in the field.** The difference lies in the setting. A laboratory experiment takes place in a setting which is intended primarily for research, while a field experiment occurs in a natural setting, i.e. a setting which is created for purposes other than research. In both methods, one or more independent variables are manipulated under carefully controlled conditions. Kerlinger (1973, 401) explains that in a lab experiment this is done by isolating the research in a physical situation apart from the routine of ordinary living and by manipulating independent variables under rigorously specified, operationalized and controlled conditions. In the field this is done as carefully as the situation will permit. In management accounting, field experiments are not as common as laboratory experiments. Kaplan (1986, 442) argues that in management accounting field experiments are less likely to occur, because it is *unusual for profit seeking organizations to agree* to a major change in their management accounting system in order to advance the understanding of management accounting phenomena. If an organization is undertaking a change in its management accounting system for its own reasons, the research study is no longer experimental but should be classified as field research. As mentioned, the disadvantage of such a nonexperimental longitudinal study is that the change, for instance to a target costing system, can occur simultaneous with or even be caused by more fundamental changes in the organization's strategy, technology or competitive environment. Hence, the researcher may find it difficult to distinguish impacts caused by changing to target costing from changes occurring in the firm's strategy, environment, etc. Field research does not allow for *time compression* in the way lab experiments do. Ilgen (1986, 261) explains that events spread out over long periods of time can be studied in the lab in much less time. In our study for instance, it can take months (years) in practice to design a future

[60] This characteristic is necessary for inferring **causality** and distinguishes experimental research from field and survey research. In general, three conditions are necessary for A causes Y, i.e. precedence of A to Y, sufficiency of A and necessity of A.

product. Consequently, it will take months before one can measure the impact of the target cost setting on the cost and quality level of the future product. Also, Ilgen (1986, 262) argues that a good field experiment is *more expensive*, while *not* leading to a higher utility than a lab experiment. Finally, Birnberg & Nath (1967, 472) argue that the researcher with hypotheses is better able to test them initially in the laboratory than in the field. In the lab, *few extraneous, unanticipated variables* are likely to occur, that might invalidate or obscure the results of the study. In sum, experimental research in management accounting has more a tradition to be performed in a lab than in a field setting. Also for our study, the mentioned advantages of the lab experiment (time compression, not biasing the results by other simultaneously implemented changes in the new product development process and the few unanticipated variables) make it more attractive than the field experiment. The strengths and weaknesses of laboratory experimental research are summarized in Table 12.

Table 12: Strengths and Weaknesses of Laboratory Experimental Research

Strengths	Weaknesses
• **Manipulation** of one or more independent variables is possible. [61] [62] [63]	• Lack of **external validity**.[63]
• **Control** over nuisance variables by: • *Situational control:* possibility of relatively complete control by isolating the situation from the life around the lab by eliminating the many extraneous influences that may affect the dependent variable.[63] [61] • *Operational* control: High degree of specificity in the operational definitions of the variables under study.[63] • *Controlled* manipulation: Specifying exactly the conditions of the experiment reduces the risk that subjects may respond equivocally and thus introduce random variance into the experimental situation.[63] • *Precise* measurements*:* Precise measurements are made with precision instruments, which makes the results replicable.[63] [61]	• **Artificiality**[64] of the research situation.[63]
• **Random assignment** to treatment.	

[61] Swieringa & Weick (1982, 62)

[62] Birnberg, Shields & Young (1990, 42).

[63] Kerlinger (1973, 398)

[64] Kerlinger (1973, 398) argues that it is difficult to know if **artificiality** is a *weakness* or simply a *neutral* characteristic of a lab experiment. This criticism of artificiality does not come from experimenters, who know that experimental situations are artificial, it comes from individuals lacking an understanding of the purpose of laboratory experiments, according to Kerlinger (1973).

Laboratory experiments are appropriate for mainly two types of research problems in management accounting, i.e. hypotheses building and hypotheses testing. First, lab experiments are used for *hypotheses building* purposes. Kerlinger (1973, 400) explains that experiments attempt to discover relations under "pure" and uncontaminated conditions. He adds that experiments can help in refining theories and hypotheses, in formulating hypotheses related to other experimentally or non-experimentally tested hypotheses and in building theoretical systems.

Second, lab experiments are used for *hypotheses testing* purposes. Birnberg, Shields & Young (1990, 38) state that researchers from a variety of disciplines agree that one important purpose of laboratory experimentation is testing causal relationships. Similarly, Kerlinger (1973, 400) states that experiments are appropriate when the researcher wants to test predictions derived from theory or other research, like in our study. Birnberg and Nath (1967, 473) state: "The laboratory experiment has been and will be a valuable means of testing hypotheses in the earliest stage of any research. Before venturing into any form of field study or survey, the laboratory experiment provides an initial testing ground."

Summarizing, the primary purpose of experimental research is testing causal hypotheses. Secondary, experimental research can also be used for refining hypotheses, by exploring relationships among variables in a so-called uncontaminated environment.

3. Motivation to Choose the Lab Experiment as Research Method

3.1 Different Grounds

Our motivation to use a lab experiment as research method is based on a number of reasons. Kerlinger (1973, 300) argues that the research method should help the investigator *to obtain an answer for the research question* and that the research method should *control variance*. Hence, those two criteria form the first two arguments why we selected the lab experiment as research method in our study. The third argument is based on the framework of Roethlisberger (1977) and involves considering *the stage of scientific inquiry* on target costing. Each of these three arguments is discussed below.

3.2 Ground One: Considering the Research Question

According to Kerlinger's first criterion (1973, 300), research methods are invented to enable the researcher to answer the research question as validly, objectively, accurately and economically as possible. From section 4 on page 25, we remember that our research questions are about testing the impact of target costing on the downstream cost level of a future product, on the quality level of that future product and on the achieved time-to-market.[65]. **Characteristic to our formulated research questions is that they all involve *testing causality*.** The impact of the independent variable target cost setting (with the levels easy TCS, difficult TCS and non-TCS) is questioned on three dependent variables (cost, quality and time-to-market) under two time conditions (easy time and difficult time). Hence, the research method should help us in testing the causal relationships between target costing and the cost level, quality level and achieved time-to-market.

As discussed in the previous section (see page 105 et seq.) hypotheses testing in management accounting can be done using *field research* as well as using *laboratory experimental* research. Both research methods allow to refine the hypotheses along the research process, as we will need to do. **However, both methods each have a distinctive comparative advantage.**

Theory-testing **field research** has a comparative advantage when the topic of inquiry is so complex that the *phenomenon of interest is not readily distinguishable from its contextual conditions, and data are needed about both* (Yin, 1993, 78). Considering the many contextual variables forms an important advantage in contributing to the understanding of the "how" and "why" of the events, over which the

[65] **Research question one** involves testing the favorable impact of target costing on the downstream cost level of a future product. **Research question two** involves testing the impact of target costing on the three NPD measures together, while **research questions three and four** seek to investigate the impact of target costing on the cost level as well as on the three NPD measure, under low and high time pressure.

investigator has no control (Spicer, 1992, 10; Kaplan, 1986, 447). However in our study, being overwhelmed by the many contextual variables in the field is not an advantage, given our research questions. As discussed before, our research questions seek to test the expected favorable and unfavorable impact of target costing, in its purest form, without considering the many contextual variables.

Contrary, lab experiments have a comparative advantage when testing *causal relationships* (Birnberg, Shields & Young, 1990, 51; Zelditch, 1969, 530). Experiments not only provide the opportunity of random assignment to treatment, but also provide the researcher with the opportunity to manipulate the independent variables under controlled conditions. Birnberg and Nath (1967, 473) add that by creating an artificial environment, the relationship between independent and dependent variables can be tested in its purest form, without being hindered from the many nuisance variables that are encountered in the field. Since our research questions are about testing causality on target costing, it is more to choose for lab experiments than for field research. Furthermore, the objective of our study is to test the hypothesized relationships under clearly specified conditions, which we will need to adjust along the research process. In that perspective, we can profit more from the comparative advantage of lab experiments than from the field research method.

Given the comparative advantages of both field research and lab experimental research, we conclude that our research questions can benefit more from testing the causal relations between target costing and the cost level, quality level and time-to-market, in its purest form under the controlled conditions of a lab experimental research method, ignoring the many contextual variables provided by the field research method.

3.3 Ground Two: Controlling Variance

According to Kerlinger's second criterion (1973, 306), the research method should help the researcher in controlling the different types of variance. We quote: "By constructing an efficient research design the investigator attempts (1) to *maximize the variance* of the variable or variables of his/her substantive research hypotheses, (2) to *control the variance of extraneous or "unwanted" variables* that may have an effect on the outcomes, but in which he/she is not interested, and (3) to *minimize the error or random variance*, including so-called errors of measurement."

A strength of lab experimental design is that the possibility of relatively complete control over the variables exists (Birnberg, Shields & Young, 1990, 42). *Maximization of the variance in the dependent variables*, created by the independent variables, is the researcher's most obvious concern in testing causality. The lab experiment is the only research method, where the researcher can vary the strength of the independent variable to determine how much the dependent variables change (Birnberg, Shields & Young, 1990, 42). Manipulating different levels of independent variables (such as the three levels of target cost setting and the two time conditions in our study) are hardly achievable in surveys or field study methods.

Furthermore, lab experiments are scoring high on *controlling extraneous variables*. By random assignment of the subjects to treatments, the groups can be considered statistically equal in all possible ways. To Kerlinger (1973, 310) randomization is the only method of controlling all possible extraneous variables. In our study, many extraneous variables might have an impact on the dependent variables. Degree of feedback on the goal achievements, degree of participation in setting the target costs, achievement of the target cost or time objective in the past, the type of incentive system, degree of peer pressure, … are just a few examples. In a survey research method, it would be hard to include all possible extraneous variables or choose subjects that are as homogeneous as feasible in all possible unwanted variables. The same problem of not knowing to exclude extraneous variables is present in field research as well (Merchant & Simons, 1986, 192). Kaplan (1986, 442) states that the major drawback of field research is that the conclusions can be subject to numerous explanations because the possibility of confounding factors in the entity being studied and the methods by which case study data are collected, aggregated and analyzed.

Finally, the research design should *minimize the error variance* due to random fluctuations. Kerlinger (1973, 311) explains that minimizing error variance can be done by reducing the errors of measurement through controlled conditions and by increase in the reliability of measures. Again, the lab experiment has far more opportunities to control for this third type of variance, by rigorously specified, operationalized and controlled conditions, as Kirk (1995, 6) explains. Though, survey research has the unique advantage to check the validity of survey data by interviewing the same subjects again (Kerlinger, 1973, 417). Minimizing the error variance in field research, is often very difficult to accomplish.

Summarizing, the three forms of control all involve ruling out threats to valid inference making. In general, lab experiments are more appropriate in controlling the three types of variance than the survey or field research method. The objective of our study is to test the favorable impact of target costing on the cost level of a future product, discovered earlier by field researchers. In testing these causal relationships, controlling variance is an important issue. The unique approach of relatively complete control over the variables in a lab experiment forms the second argument why we select the lab experiment as research method.

3.4 Ground Three: Considering the Stage of Scientific Inquiry on Target Costing

The third motivation is related with the stage of current knowledge regarding target costing. Many scholars such as Popper (1959), A. Kaplan (1964) or Simon (1978) attempted to formalize the process of scientific inquiry. R. Kaplan (1986, 433) argues that there is a general agreement among those scholars on a broad set of activities that should be followed to acquire scientific knowledge. He refers to the framework of Roethlisberger (1977) to describe the research process in management accounting. To Roethlisberger (1977, 393), the process of scientific inquiry should be formulated as a "knowledge enterprise", shown in Figure 28.

Figure 28: Model of Scientific Inquiry

Levels	Characteristic Statements	Methods	Products
Analytical knowledge ⇧	General propositions	Creative and inductive leap of imagination	Deductive systems
⇧	Empirical propositions	Operational definitions, rigorous measurement	Statements in the form x varies with y under given conditions
⇧	Elementary concepts	Definition of concepts and variables, elementary measurement	Statements in the form x varies with y
Clinical knowledge ⇧	Conceptual schemes	Classification	Taxonomies
		Observation and interviewing	Descriptive cases and syndromes
Skill ⇧	Knowledge of acquaintance	Practice and reflection	How-to-do-it statements
The phenomena			

Source: Roethlisberger (1977, 393)

According to Roethlisberger (1977, 392), knowledge starts when practitioners develop **skills** in practice to understand a phenomenon and are able to manipulate it to their own advantage. Practice with a phenomenon results in general how-to-do statements. **Clinical knowledge** starts when management scientists enter the field. The aim of clinical research is descriptive, by observing and interviewing practitioners how they are dealing with the phenomenon. Hence, the dominant research method of the clinical knowledge stage is field study research, as Kaplan (1986, 433) explains. At first researchers are mainly interested in the many dimensions of the phenomenon and then the focus is on developing a classification or taxonomy of what appears to be the critical dimension. The start of **analytical knowledge** occurs when the researcher becomes able to measure one or more aspects of the phenomenon. When successful, the researcher first tries to discover a correlation among the variables or phenomena in the sense of x varies with y. In a next stage, the researcher produces empirical propositions, trying to discover if the relationship also holds under different conditions. Kaplan (1986, 437) explains that a totally different research approach is required at this analytical knowledge level than at the clinical knowledge level. We quote: "Empirical propositions require operational definitions, rigorous measurement, experimental designs and sophisticated statistical procedures". The final stage of analytical knowledge is one that may be exceptionally hard to achieve in the social & managerial sciences and seems notably absent in management accounting, according to Kaplan (1986, 439). The goal of this last stage is theory development, showing how a variety of empirical generalizations follow logically from a small number of general propositions under certain conditions.

Considering the development of knowledge on target costing, as described in chapter two, the stage of scientific inquiry on target costing has reached the stage of *clinical* knowledge and is now ready to jump to the *analytical* knowledge level. Since 1965, the Toyota Company uses a sort of target costing process. The knowledge of this skillful practitioner has stayed within a few (mainly) Japanese companies, until researchers have become interested in the phenomenon in the last ten years. Researchers such as Cooper (1995) and Kato (1993) have focused on describing what is going on in those companies using target costing, while Cooper & Slagmulder (1997) tried to make a first classification scheme. However, as mentioned before in chapter two, the concept itself of target costing has not been clearly defined nor have typical characteristics been developed in literature, which seems to be characteristic to research at the clinical knowledge level. Mainly case study research has been used, which seems to be the appropriate method to gather information on the many dimensions of the phenomenon of target costing at this clinical knowledge level.

Recently, formulations in the sense of "the use of target costing results in products with lower downstream costs" have been derived from the descriptive cases. **The purpose of our study is now to elaborate on this relationship, elevating the knowledge from the clinical stage to the analytical stage.** The focus of our study is more *limited* than that of the case studies performed before. We are focusing mainly on the cost impact of the target costing-phenomenon, because the cost impact has been described as one of the most important dimension of target costing (discussed earlier in page 57). Furthermore, we attempted to *define* the concept of target costing (see earlier on page 39) and will *measure* three variables of interest (i.e. the cost level, the quality level and the achieved time-to-market). Furthermore, the purpose of our study is to discover *causal relationships* between the use of target costing and the three variables of interest. Finally, these causal relationships will be examined under *two conditions* of time pressure.

Summing up, by conceptualizing target costing and by using findings on other phenomena (such as goal setting, which is far behind in the analytical knowledge stage) we developed several hypotheses in the previous chapter. Now we want to verify these empirical propositions by an

appropriate research method. Roethlisberger (1977, 392) argues that for each stage of knowledge the appropriate tools and research methods should be used. To him, verifying empirical propositions in the analytical knowledge stage requires an *experimental design* and sophisticated statistics. Consequently, to verify the empirical propositions on target costing Roethlisberger (1977) advises to use an experimental research method. This forms the third argument why we select the lab experiment as research method.

4. Limitations of Lab Experiments

4.1 Internal and External Validity

We will now discuss the limitations of the chosen research method. The limitations of a research method are frequently considered in terms of its threats to internal and external validity. *Internal validity* refers to the validity by which statements can be made about whether there is a causal relationship from one variable to another in the form in which the variables were manipulated (Cook & Campbell, 1979, 38). For instance, when we find a favorable impact of target costing on the cost level, we need to consider whether the direction of causality is from the manipulated TCS or caused by another factor. In section 4.2 we will address possible threats to internal validity in lab experiments and explain how most of these threats will be ruled out in our study. *External validity* refers to whether the results can be generalized to particular persons, settings and times and across types of persons, settings and times (Cook & Campbell, 1979, 71). In section 4.3, we will first explain the meaning of *generalization* in our study. Then we will discuss the two potential threats to external validity, i.e. if we can generalize the findings of the lab setting to the "real" setting and if we can generalize the findings, collected from student-participants to "real" employees.

4.2 Threats to Internal Validity

Cook & Campbell (1979, 56) argue that lab experiments in general are scoring *high* on internal validity, though some specific threats still exist depending on the practical organization of the lab experiment. In our study, ***maturation, testing*** and ***instrumentation*** will not form a threat to internal validity, since all effects are considered as between-subjects effects, avoiding that the same participant is measured twice, i.e. before and after the treatment manipulation. Furthermore, randomization conveniently rules out the threats of ***selection*** and the interaction of ***maturation with selection*** within each experiment. In all three experiments, participants will be assigned randomly to the conditions, making each group on average similar in all extraneous variables within each experiment. Comparing the results across experiment two and experiment three might suffer from selection problems, since we will give participants in experiment two extra credit for participation, while we cannot give extra credit in experiment three, because of different department regulations. Though, as we will see, the results of experiment three, compared to the results of experiment two, are conform the expectations from two other research areas, indicating the high internal validity of our study as well. Furthermore, in experiment one, all participants are Vanderbilt students. In experiment two, all participants are from the fifth year bioengineering (undergraduate level) of the University of Ghent. In experiment three, all participants belong to the second and third year of applied economics (undergraduate level), apart from the 10 master in finance students, who will be assigned proportionally (though also at random) to each condition. Thus in terms of ***history,*** there are differences in patterns of history between participants of experiment one, experiment two and experiment three. However, within each experiment, participants do have an identical global pattern of history across the manipulations and thus the conclusions made within each experiment do not suffer from this threat to internal validity.

Cook & Campbell (1979, 57) admit that "***imitation to treatment***", "***compensatory equalization***", "***compensatory rivalry***" and "***demoralization in groups receiving less desirable treatments***" can form a threat to internal validity even when randomization has been successfully implemented. In our three experiments, there will be *no differences in desirability* between the three TCS treatments (non-TCS, easy TCS and difficult TCS) and the two TIME conditions (easy time versus difficult time). All participants will receive the same experimental material. Furthermore, the probability that participants will *learn of treatment differences is minimal*. As will be discussed later in the chapters six, seven and eight, assignment of participants to the different groups will not be made public. Participants receive an ID number when entering the room and are assigned to one of the three (respectively six and four) conditions of the experiment. All instructions are written, not revealing differences in treatments. The task is individual, though some communication between participants is allowed to keep a relaxed climate. The room will be organized in such a way that participants sitting next to each other receive the same instructions. Thus different instructions will be assigned to different rows in the room (leaving one row in between empty), minimizing the chance that participants will figure out that the research is about testing the impact of different target cost settings. As will follow from the guesses of the purpose of the experiments (see pages 377, 464, 523), we succeeded in this aim. Some participants mention the trade-off between cost and quality, although none of the participants can really figure out the time differences and the differences in difficulty or specificity of the cost objective. Finally, none of the groups are receiving a compensation for being in a less desirable treatment group, since none of the treatments can be considered as less desirable. **To conclude**, we estimate the *imitation of treatments* among the different conditions as almost non-existing, since participants can hardly figure out the information intended for others. *Compensatory equalization* and *demoralization* of respondents receiving less desirable treatments is not threatening internal validity here, since all participants received the same material, while not creating a higher desirable condition. Likewise, *compensatory rivalry* among respondents being in a different treatment group is not an issue to our study, since assignment to conditions will not be made public.

Birnberg, Shields & Young (1990, 43) also mention that internal validity may be threatened by "*demand effects*", "*evaluation apprehension*" and "*expectancy effects*". When participants act in a way that they believe the researcher desires ***demand effects*** occur. In goal setting studies in general, participants usually accept the goals assigned to them and work toward it, even if the goal is unattainable and participants fail to reach it in previous trial sessions. In our study, the goals will not be set at an unattainable level, since pilot studies will be used to determine the goal levels (attainable in respectively 40% and 80% of the cases in the pilot test for the difficult and the easy target cost respectively). Though, it is possible that participants will try harder to attain the difficult target cost and the difficult time objective than design engineers in practice, encountering difficult goals on a day by day basis. ***Evaluation apprehension*** occurs when participants are acting in a way to highlight their personality in terms of intelligence, competence or emotional adjustment. Birnberg, Shields & Young (1990, 47) explain that participants are acting then in an unnatural way to emphasize personal characteristics, while the previous mentioned demand effects occur when participants want to please the researcher. In experiment one, participants are more or less familiar with the researcher, though did not know the researcher's hypotheses in terms of an expected favorable impact of target costing. In both experiment two and three, participants know the researcher as a teacher from one previous session. In all three experiments, there will be no personal contact with the researcher during the experiment. All instructions to the task will be written and anonymity will be secured by the principle of the id number. Thus, evaluation apprehension will be minimal in this study. Finally, the ***expectancy effect*** is caused by the researcher himself/herself because he/she is expecting certain outcomes of the study. In a lab experiment, these effects may be caused by two primary sources, as Birnberg, Shields & Young (1990, 44) explain. One is *the design of the experiment*, which includes the choice of design and variables, their operationalization and measurement, the choice of participants, the kind of incentives offered, etc. We will set up the experiment as objectively as possible. The extensive description of the procedures and the experimental task of the three experiments will help the reader evaluate if we are succeeded or not in resisting the temptation of the expectancy effect. A second source of the expectancy effect is how the *researcher interacts with participants* before and during the experiment, such as emphasizing key areas of instructions or using suggestive body language. In our study, contact between the researcher and the participants will be very formalized. All experimental procedures are explained plenary, using written instructions. A few overhead sheets will be used to explain certain difficult pages. Though, none of these sheets will be on the real manipulations, but rather on the practical organization of the task. Apart from this formal explanation by overhead sheets, there will be no contact between the researcher and the participants during the experiments. Also in the written instruction sheets, the instructions will be presented as objectively as possible, without overstressing certain parts. These instruction sheets are included in the appendices on page 353, 394 and 500 to convince the reader of no expectancy effect.

Summing up, there are almost no threats to internal validity in this study, because of random assignment to treatments, not making the differences in treatment conditions public, formalizing the communication between the researcher and participants by written instruction sheets, keeping anonymity of participants during the task and measuring the impact of manipulations between subjects instead of within subjects. The chosen research method does not show

limitations in terms of internal validity when considering the results within each experiment separate. Though when comparing the results across experiment two and experiment three, history and selection might form a potential threat. Though, as we will see further, the results are conform the expectations from other research areas (page 262), indicating the high internal validity of our study as well.

4.3 Threats to External Validity

4.3.1 Generalizing

As mentioned above, valid inference making can also be intimidated by threats to *external validity*. In general, lab experiments are reported to have more limitations in terms of threats to external validity than threats to internal validity (Kerlinger, 1973, 398). Using the definition of Cook & Campbell (1979, 71), external validity refers to **(1) generalizing the results *to* particular target persons, settings and times and (2) generalizing *across* types of persons, settings and times.** Hence, the external validity of experimental findings depends upon whether background factors (e.g. participants or settings) that are held relatively constant over the cells of an experimental design *interact* in nature with the manipulated variables. If they do so, the relationships observed in experimental data would not be observed if the study was replicated, holding these background factors constant at a different level. Cook & Campbell (1979, 73) argue that the threats to external validity should be formulated as an interaction effect. "*Interaction of setting and treatment*" typically asks whether a causal relationship obtained in a lab environment can be found in a real business environment as well. "*Interaction of selection and treatment*" asks to which categories of persons the found (causal) relationship can be generalized.

The purpose of our study is to generalize the findings to a *specific setting* and to a *specific subpopulation*. Indeed, we want to generalize the findings from the lab experiments to a "real" environment of new product development. Furthermore, we will conduct the experiments with students. So, the purpose is to generalize the causal findings on the "design behavior" of students to the "design behavior" of "real" design engineers. **Thus, the "interaction of setting and treatment" (whether we can generalize the results from the lab to the field) and the "interaction of selection and treatment" (whether we can generalize the results from students to design engineers) need to be discussed as two potential threats to external validity in our study.**

But before going further into each of these threats, we should explain the meaning we give in our study to the term "generalize". Campbell (1986, 270) distinguishes between different meanings, as shown in Table 13. Our preference goes towards alternative three. That is, the fundamental issue in our study is whether the same *conclusion* will result from investigating the use of target cost setting in the laboratory as in the field. So, to us, it is important to consider if the conclusions found in the lab with students would also result from investigating design engineers in their "real" NPD setting. **Hence, the purpose of our study is to generalize the *conclusions* found by studying the behavior of students in a lab environment to the behavior of "real" design engineers in a "real" NPD environment.**

Table 13: Different Meanings to the Term "Generalize"

Generalizing from lab to field means that …
1. Empirical results obtained in the field are *identical* to those obtained in the laboratory.
2. The *direction* of empirical relationships found in the field are the same as those found in the laboratory.
3. The *conclusions* drawn about a specific question are the same for field studies as they are for laboratory studies.
4. The *existence* of a particular phenomenon can be demonstrated in the laboratory as well as in the field.
5. Data from the laboratory can be used to justify or support the *application* of a particular practice or program in an operational setting.

Source: Campbell (1986, 270)

4.3.2 Generalizing from Laboratory to Field Settings

The interaction of setting and treatment is almost always present in lab experiments. The typical argument is: "*You can't generalize from a simple five-minute task performed by college sophomores in a laboratory to the real word*" (Locke, 1986, 3). Some researchers approach this threat deductively and try to create **similarity** between laboratory and real life, by bringing portions of existing organizations into the laboratory setting (Birnberg & Nath, 1967, 473). However, the actors (students versus real people), the relationship between the actors (strangers versus coworkers), the task (simple versus complex), the setting (artificial versus natural) and the time period (two hours versus years) are in general very dissimilar. Hence, Locke (1986, 7) argues that the only way to achieve similarity between laboratory and field settings would be to run a field study in the laboratory, however no other generalization than towards similar field settings could be legitimately made then. Other researchers, such as Swieringa & Weick (1982, 74), reason that there are many **more parallels** between the experimental and the field setting than criticism presumes. For instance, participants in experiments are *apprehensive* about being evaluated, but so are employees in organizations. The relationship between experimenter and participant involve *asymmetrical power*, but the same holds for employees and their superior. Participants in the laboratory seldom know the other participants *intimately*, but the same is true in organizations where personnel transfers are common. Finally, people are *suspicious* of what happens to them in laboratories, but so are employees as they become alerted of hidden agendas, internal politics or possible reorganizations.

Recently, considering **essential/nonessential similarity** between the lab and the field has solved the polemic. Locke's (1986, 7) argument is that only *essential* features of the field settings need to be replicated in the lab. Looking for essential features implies a very different generalization strategy than trying to achieve total representativeness. Finding essential features means not trying to reproduce the total field situation but rather to abstract out of all conceivable situations, those elements which are required as minimum for the phenomenon to occur. Similarly, Zelditch (1969, 532) argues that researchers do not even have to try to "study armies in the laboratory". Instead, they have to embody the same abstract properties and satisfy the same conditions, but only those that are theoretically relevant to the theory. Translated to our study, the essential features of the NPD environment have been described earlier (see page 75) as well as the typical characteristics of target costing (see page 39). **Thus, with respect to the *settings*, essential to our study is the specific form of goal setting (multiple, conflicting goals, simultaneously-to-attain) and the specific type of target costing information that is provided during the task. With respect to the *task*, essential is the high task complexity. Trying to obtain one goal, may hinder the attainment of the other goals, so that it is not obvious at first glance which actions to take. Not a single best outcome of the task should be available, requiring creativity and strategy search from participants. With respect to the *subject*, it is essential that participants try for the different goals, knowing the prioritization among the goals.**

Similarly, Swieringa & Weick (1982, 80) argue that researchers need to distinguish between ***experimental* and *mundane* realism**. In laboratory research, the attempt is not to create tasks and settings which look like natural tasks and settings, but to create tasks and settings which evoke behaviors that unfold in natural tasks and settings. The hallmark of laboratory experimentation is abstraction, that is the deliberate manipulations of one or more crucial variables, the deliberate control of many others and the precise measurement of one or more variables which characterize the behavioral processes of interest. An experiment is realistic if the situation is realistic to the participant, if it involves them, if they are forced to take it seriously, if it has impact on them. This type of realism is referred to as *experimental* realism. Dickhaut et al. (1972, 458) explain that experimental realism refers to the degree of involvement of the participant in the experiment, i.e. that the subject participating in the experiment is aroused and interested rather than bored and detached. A second sense in which an experiment can be said to be realistic is if the events occurring in the laboratory are likely to occur in the real world. In other words, an experiment is realistic if the laboratory events are similar to real-world events. This is called *mundane* realism. Lynch (1982, 231) warns that making an experiment more mundane will not necessary enhance the external validity, because external validity involves the generalizability of cause-effect relationship. Similarly, Swieringa & Weick (1982, 80) believe that the argument of laboratory experiments being artificial (and therefore inducing threats to external validity) is based on the confusion between experimental and mundane realism. **To Swieringa & Weick (1982, 80), if experiments have experimental realism in the sense that laboratory conditions are believed, attended to and taken seriously by participants, there appears to be *little* need to strive for mundane realism.** Even more, the artificiality of the study is a distinctive advantage, when testing causal relationships, as mentioned before. With respect to our study, the choice of the task was in the first place performed to enhance *experimental* realism, in the sense of including only the essential similarity, as discussed above. In our experiments participants will have to make color decisions for a carpet design, while trading-off three goals (cost, attractiveness and time spent). As will be discussed in each of the chapters on the three experiments, the task was taken seriously by the participants and participants were eager to achieve the different goals. The description of the procedures during the experiment as well as the answers to the checkout questions may give an idea to the reader of how successful this study was in creating experimental realism.

Finally, some researchers are addressing the **trade-off between internal and external validity**. Martin (1996, 194) states that the more tightly controlled an experiment is, the less likely conclusions are suffering from threats to internal validity, but the more likely it may suffer from threats to external validity. The purpose of our study is to test causal relationships. As mentioned, the artificial lab environment is more appropriate than the field to validate those causal relationships, which are normally concealed by the sheer mass of extraneous variables in realistic settings. If we have to make a trade-off between internal and external validity, then in this study with the given research objective, it is less important to suffer from threats to external validity than to conduct a study that suffers in many aspects from threats to internal validity.

Summing up, researchers are still divided if the artificiality of the lab environment forms a threat in generalizing the found relationships from the lab to the field setting. Following Locke (1986) we will include the essential features of the NPD environment and of target costing (or non-target costing) in our experimental task[66], though without striving for complete mundane realism. Including the essential features of the real NPD setting will allow us to generalize the findings from the lab to the real setting, removing the treat to external validity.

We conclude this discussion with the central message of Locke's book "Generalizing from Laboratory to Field Settings" (1986). The book focuses on the consistency of results produced in laboratory and field settings, discussed by different scholars in the broad field of organizational behavior. The central message is that: "***Despite the negativism about laboratory research, the data do not support the belief that lab studies produce different results than field studies.***" (Locke, 1986, 276)

[66] As will be discussed in Chapter Six (page 177), the main purpose of the first experiment, the so-called **test experiment**, is to evaluate whether the essential characteristics are correctly operationalized and perceived by participants, before starting with the hypotheses testing.

4.3.3 Generalizing from Students to "Real" Design Engineers

Also on the issue of using students as surrogates for real "business people", there has been **some discussion in literature whether the results found by students can be generalized to real employees.** In early accounting literature, there has been a significant concern for using students as surrogates for other groups (Birnberg, Shields & Young, 1990, 45). For instance, Birnberg & Nath (1968, 40) argue that students may lack the requisite *skills*, prior *experience* or lack some basic *personality traits*, such as efficient handling in stressful situations. However, even when "real" employees participate in research, it is unclear whether the tasks being performed are isomorphic to those performed on a regular basis at work and whether the isomorph evokes the same behaviors (Birnberg, Shields & Young, 1990, 45). So, it is not clear if the so-called experience in practice also helps the practitioner in the laboratory environment. Other researchers, such as Ashton & Kramer (1980,1), limit the generalization to certain types of decision-making tasks. To them, students and real "employees" show sizable discrepancies when studying *attitudes* or *attitudes change*, for instance in their risk-taking attitude towards losing or gaining money. However, studies focusing on *decision-making* and *human-information processing* show considerable similarity in the decisions and the apparent underlying information-processing behavior of students and non-students. Since our study is not on attitudes, but on influencing the behavior of design engineers in designing and developing a future product based on different information cues, the findings of Ashton & Kramer (1980, 1) suggest that students can be adequate surrogates.

Furthermore, a **key consideration** to Birnberg, Shields & Young (1990, 40) is whether students possess the *knowledge*, *motivation* and *other characteristics* to effectively make the decisions required in the study. This is consistent with the earlier mentioned vision of Swieringa & Weick (1982, 80), who call for *experimental* realism of experiments. So, if the task is realistic in a sense that students are involved with it, take it seriously, and have an impact on it, the findings can be generalized from students to "real" employees. As will be discussed further, evaluation of experiment one reveals that students probably did not possess the required knowledge to understand what was meant in the experiment with "creating an attractive carpet for the student bedroom market". We improved the task in the following experiments considerably by including a common reference frame (the so-called interior), examples of previous designs, while also providing immediate feedback on the trial designs. By improving our experimental task, experiment two and three will show far less limitations in terms of external validity than the first experiment, set up to test the feasibility of the task.

In psychology and organizational behavior literature, there is a longer tradition of using students as surrogates for "real" employees. Locke (1986, 276) concludes his review of psychological and organizational behavior literature that there is no way to determine deductively, whether there are critical differences between students and employees; and what types of differences would affect the generalizability of what types of findings. Locke (1986, 5) argues that, after all, *both employees and* *students are human beings*. Many students have worked during the summer term and the great majority will become full-time employees after graduation. Also, many employees once were college students. Furthermore, to him the use of students can have **distinctive advantages** as well, compared to using “real” employees. For instance, Birnberg, Shields & Young (1990, 45) state that students tend to be *more homogeneous* on the extraneous variables, which reduces error variance and increases the power of the statistical tests.

In sum, existing literature does not help us in determining if students and non-students differ in their behavior on designing and developing a future product. We will cope with this possible threat to external validity by making the task realistic in its experimental sense and by teaching students on how to perform the task.

5. Conclusion

In this study the laboratory experiment is used to test the hypotheses on target costing developed in the previous chapter. The lab experiment is just one method of doing research. Though, there are three main reasons why we select the lab experiment as research method here. First, lab experiments have a comparative advantage when causal relationships need to be tested in its purest form, which is the case in our study. Second, lab experiments do have the strength of controlling (experimental, extraneous and error) variance during the research study. The lab experiment is the only research method, where we can objectively vary the difficulty of the target cost and the difficulty of the time objective to determine its impact on the cost level, quality level and achieved time-to-market. Also, controlling extraneous variance is important to our study, since we want to test empirically the so-called favorable impact of target costing on the cost level, which has been detected before in the field. The rigorously specified conditions of the lab environment as well as its artificial environment can help us in minimizing the error and extraneous variance, increasing valid inference making. Third, the stage of scientific inquiry on target costing calls for the development of elementary concepts and empirical propositions, for which a lab experiment is the most appropriate research method.

The general proposition in literature is that lab experiments are scoring high on internal validity, but might suffer from threats to external validity. When using students in a lab environment, as we will do in the experiments of this study, the interaction of “setting and treatment” and the interaction of “selection and treatment” typically form a threat to external validity. However, efforts will be taken to include the essential similarities between the lab and the field setting of a NPD environment as well as to include experimental realism in the task in order to induce participants to be aroused and interested rather than to be bored and detached by the task. Furthermore, we will take care that participants possess the knowledge and motivation to effectively make the design decisions required in the task. By including a description of the detailed procedures in chapters six, seven and eight, we will show that this study does not suffer from threats to external validity. Consequently, the conclusions found in the two main experiments (i.e. experiment two and three) with students in a lab environment can be generalized to “real” design engineers in a “real” NPD environment.

Chapter 5: Research Design and Statistical Tests

1. Introduction

In the first chapter, we described four main research questions (see page 25). In chapter three, we developed different scientific and statistical hypotheses to answer these research questions (see page 99). In the previous chapter, we came to the conclusion that the lab experiment is an adequate research method to test the causal relationships as specified in the hypotheses. In this chapter, we will now address the *specific research design* of the lab experiments as well as the adequate *statistical tests* to examine the hypotheses. More specifically, in the following sections 2 and 3, we motivate the selected research design. In section 4, we shortly present the research design of each lab experiment. In section 5, we outline the required statistics. Discussion of the appropriate univariate analyses is provided in sections 6, while we discuss the multivariate analyses in section 7. A summary of all required tests is provided in section 8 on page 149. Finally, we shortly address the underlying assumptions of the statistical tests at the end of the chapter (see page 152).

2. Potential Research Designs

Different research designs can be set up to test our formulated hypotheses in the lab. Characteristic to our study is that the independent variable "target cost setting" is considered for a non-target cost setting (non-TCS), an easy target cost setting (easy TCS) and a difficult target cost setting (difficult TCS). The second independent variable "difficulty of the time-to-market objective" is considered for an easy time objective (easy TIME) and a difficult time objective (difficult TIME). Thus the first treatment (TCS) has three levels, while the second (TIME) has two levels**. The question is now, how to assign the participants to the six treatments of the experiment.**

Mainly four research designs are possible, as shown in Table 14. We choose for the first presented, i.e. the **completely randomized factorial design (CRF-32)**, as will be motivated in the next section. This CRF-32 design is a *randomized* design, since participants are assigned at random to the treatment levels. It is a *factorial* design, since all levels of the first treatment are considered in combination with all levels of the second treatment. So, each participant is assigned to only one combination and all effects are considered as between-subjects effects. Consequently, there are six groups of participants, who receive each just one treatment combination.

Table 14: Possible Research Designs

Completely Randomized Factorial Design with two treatments (CRF-32):

		Target Cost Setting (TCS)		
		Non-TCS	*Easy TCS*	*Difficult TCS*
Difficulty of the time objective	*Easy TIME*	Group 1	Group 2	Group 3
(TIME)	*Difficult TIME*	Group 4	Group 5	Group 6

Split Plot Factorial Design with three levels and two repeated measures (SPF-3.2):

		Target Cost Setting (TCS)		
		Non-TCS	*Easy TCS*	*Difficult TCS*
Difficulty of the time objective	*Easy TIME*	Group 1	Group 2	Group 3
(TIME)	*Difficult TIME*	Group 1	Group 2	Group 3

Split Plot Factorial Design with two levels and three repeated measures (SPF-2.3):

		Target Cost Setting (TCS)		
		Non-TCS	*Easy TCS*	*Difficult TCS*
Difficulty of the time objective	*Easy TIME*	Group 1	Group 1	Group 1
(TIME)	*Difficult TIME*	Group 2	Group 2	Group 2

Randomized Block Factorial Design with six repeated measures (RBF-23):

		Target Cost Setting (TCS)		
		Non-TCS	*Easy TCS*	*Difficult TCS*
Difficulty of the time objective	*Easy TIME*	Group 1	Group 1	Group 1
(TIME)	*Difficult TIME*	Group 1	Group 1	Group 1

The randomized factorial design differs from the **randomized block factorial design (RBF-32**), presented the last in Table 14**,** where all participants receive all treatment combinations. In the randomized block design, each block is containing one participant, so that a single participant receives 6 different treatments and is observed 6 different times by repeated measures. Contrary to the factorial design, all effects are measured as within-subjects effects and there is basically one group, receiving all the treatment combinations, in a randomized independent order.

Between these two extremes of factorial design and block factorial design lies the **split plot factorial design (SPF)**. The term “split plot” refers to the combination of a between-subjects design with a within-subjects design. In a split plot factorial design with *three levels and two repeated measures* (SPF-3.2), participants are randomly assigned to one of the three TCS, but exposed to both of the

TIME conditions. In a split plot factorial design with *two levels and three repeated measures* (SPF-2.3), participants are exposed to one of the two TIME conditions, but receive consecutively all three TCS manipulations.

The four presented designs mainly differ in terms of a within-subjects versus a between-subjects design. The randomized factorial design is a between-subjects design, in our study with six treatment combinations.

3. Motivation to Choose the Completely Randomized Factorial Design as Research Design

In making the choice between those design possibilities, several factors enter the choice, both from methodological and practical sense. As Kirk (1995, 47) admits, the question on the best design to use is not easily answered. The number of independent variables, the number of participants available for participation and the research questions to answer are just a few of the conditions that influence the selection of the appropriate design (Brown & Melamed, 1990, 5).

In general, a **within-subjects** design is more powerful in keeping individual differences across stimulus levels unchanged, hence enhancing the *precision of the estimate* of the treatment effect (Martin, 1996, 141). Similarly, Schepanski, Tubbs & Grimlund (1992, 139) explain that in a between-subjects design, some part of the difference that is observed among treatment groups may be attributable to differences that existed before the treatments were administered. Though, by assigning participants randomly to the treatments, these initial differences can be minimized. Second, a within-subjects design is having *higher statistical power* relative to a between-subjects designs, because the variance associated with participants is estimated and removed from the error term employed in the statistical tests. Third, within-subjects designs have the advantage of requiring *fewer* participants in total. However, when the time each participant can devote to the experiment is limited, as Schepanski, Tubbs & Grimlund (1992, 139) explain, this advantage no longer counts. For experiment one, we cannot ask students to stay longer than one hour and a half. For experiment two, the official class time takes three hours. For experiment three, the official class time takes two hours, but we can make it two hours and a half, without any problem. Hence, in all three of our experiments the *time limit* is important. Furthermore, within-subjects designs have the disadvantage that a significant *transfer (carryover) effect* can exist between the stimuli because of the learning effect in the participants' behavior. A differential carryover effect might exist as well, because of the effect of a treatment being confounded with the specific treatment conditions to which the participant has been previously exposed in the experiment. For instance, exposing a participant first to a difficult TCS and then to a non-TCS might confound the impact of the non-TCS treatment. Because of the specific target cost under the difficult TCS, participants will have a certain cost level in mind, which they will keep as a reference in trying to minimize the cost level under the non-TCS. Finally, exposing participants to different conditions in a within-subjects design might help them in guessing the hypotheses (*demand effect*). Participants become oversensitized to the independent variables and might help the experimenter by replying in a manner, which the participant perceives that the experimenter desires (Schepanski, Tubbs & Grimlund, 1992, 122). For instance, exposing participants to the three successive target cost setting conditions under the split plot design SPF-2.3 will make it easy to guess the purpose of the experiment, possibly inducing a demand effect.

Concluding, based on the limited time available, the danger of a carryover and a demand effect, it is almost impossible to use a full within-subjects design, like the randomized block factorial design or the split plot design with three repeated measures. Hence, only the completely randomized factorial design (CRF-32) and the split plot factorial design with three levels and two repeated measures (SPF-3.2) prevail. The smaller number of groups of the split plot factorial design than the factorial design makes it attractive. However, Kirk (1995, 514) argues that the split plot is a good design choice if one’s primary interest involves treatment B (within-subjects) and the AB interaction, but a poor choice if one’s primary interest involves A and B. In our study, the primary interest involves the target cost setting, which is treatment A in the wording of Kirk (1995). Our secondary interest involves the interaction effect between the target cost setting and the difficulty of the time objective, hence the AB interaction**. Thus the completely randomized factorial design with all treatments as between-subjects effects is the most appropriate experimental design in our study, given methodological and practical concerns.**

Furthermore, as will be discussed in the practical organization of the lab experiments in the three following chapters, each research design will have the following features:

1. **The research design is completely crossed.** All levels of the target cost setting are combined with all levels of the difficulty of the time objective. None of the factors are nested.

2. **The research design contains only balanced cells.** All of the groups will have equal sample sizes. Both treatments are manipulated variables, allowing organizing the (random) assignment to treatments in such a way that we have an equal number of participants in each cell.

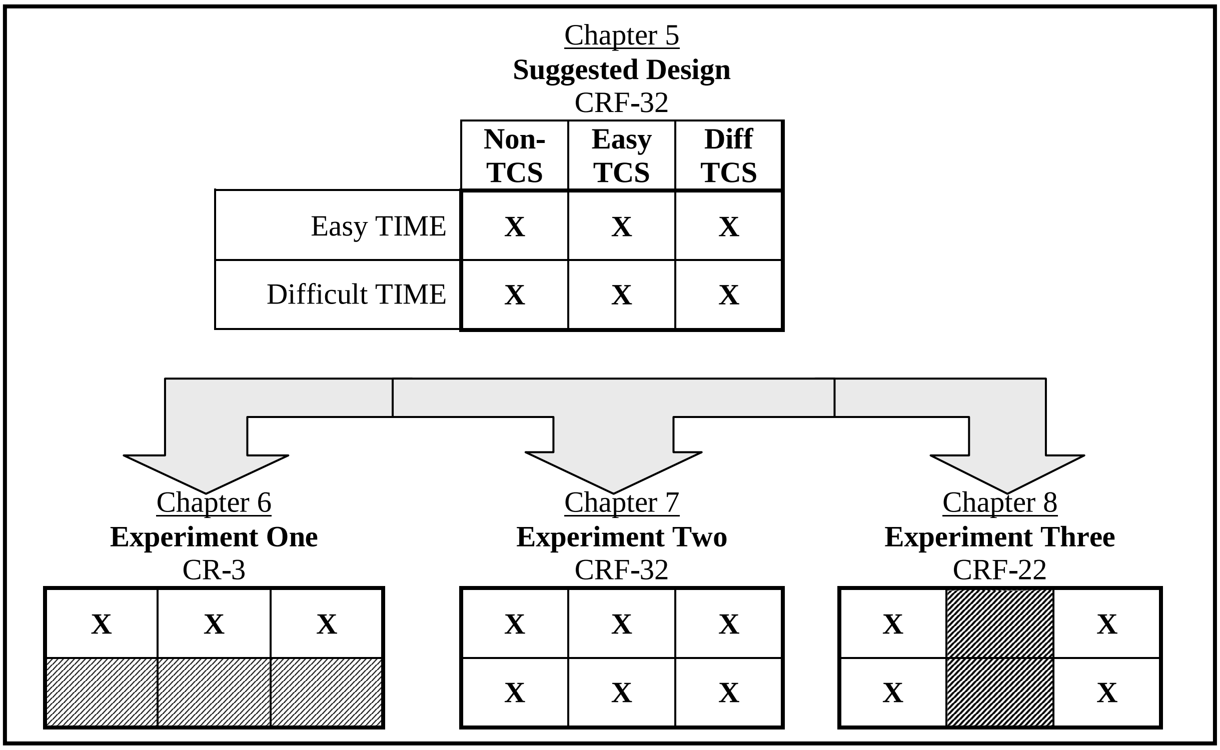
3. **The research design contains only fixed effects.** Here, we are interested in the levels of both variables as specified in the hypotheses. The hypotheses address only three levels of TCS and the two levels of TIME difficulty. We are not interested in additional levels outside the model. So, all contrasts should be seen as fixed effects rather than random effects.

4. Research Design of the Three Lab Experiments

In total, three lab experiments will be set up, as shown in Figure 29. The main purpose of **experiment one** is to test the feasibility of the experimental task. Testing the task mainly involves testing the target cost setting manipulation. Hence a simple completely randomized design with the three levels for TCS will be set up. Only one TIME condition will be manipulated, i.e. the easy time condition. The practical organization as well as the results from experiment one will be described in detail in the following chapter (see page 157).

For the experiments two and three, the earlier suggested design (completely randomized factorial design) will be used. In **experiment two**, the design is complete and contains all 3 by 2 treatment combinations. Experiment two will be further discussed in chapter 7 (see page 181). Because of fewer participants available, the design in **experiment three** will be reduced to a 2 by 2 design. Experiment three will be fully addressed in chapter 8 (see page 267).

Figure 29: Experimental Design of the Three Lab Experiments



In sum, experiment one (chapter 6) will be operationalized as a completely randomized design and can be considered as a test experiment. The conclusions of this dissertation will be mainly based on the results of experiment two (chapter 7) and experiment three (chapter 8); both having the suggested completely randomized factorial design.

5. Statistical Tests to test the Hypotheses

Once the research design is chosen, we are ready to select the most appropriate statistics to test the different hypotheses of this study. Two of the hypotheses - i.e. hypotheses one and three - involve testing the impact of target cost setting on the *single* outcome variable, the cost level. The two other hypotheses - hypotheses two and four - involve testing the impact of target cost setting on *multiple* variables together**. Hence, for hypotheses one and three an *univariate* analysis is necessary, while for the hypotheses two and four a *multivariate* analysis is required. Furthermore, hypotheses one and two involve testing the *main effect* of TCS, while hypotheses three and four involve testing the *interaction effect* of TCS by TIME, as shown in Figure 30.**

In paragraph 6, a short review and the items involved with the univariate tests are discussed. In paragraph 7, the multivariate analysis and its respective tests will be discussed. A summary of the statistical tests, required for each hypothesis is provided in paragraph 8, on page 149.

Figure 30: Overview of the Hypotheses in Statistical Terms

	Main Effect	**Interaction Effect**
Univariate	**Hypothesis 1:** Impact of TCS on the cost level ☛ Section 6.1 and 6.2	**Hypothesis 3:** Impact of TCS * TIME on the cost level ☛ Section 6.3 and 6.4
Multivariate	**Hypothesis 2:** Impact of TCS on the cost level, quality level and time-to-market ☛ Section 7.1 and 7.4	**Hypothesis 4:** Impact of TCS * TIME on the cost level, quality level and time-to-market ☛ Section 7.5 and 7.6

6. Univariate Analyses

6.1 ANOVA for an Univariate Main Effect (Hypothesis 1)

To test the differences in cost level among the three TCS manipulations, as stated in hypothesis 1, we need to perform an analysis of variance. In general, an analysis of variance (ANOVA) is used when two or more group means are compared to see if there are differences among them. Hence, the dependent variable is continuous, while the independent variables are categorical. **The null hypothesis is that all group means on the dependent variable are equal, i.e. that all k groups come from the same population.** Tabachnick & Fidell (1989, 37) explain that an ANOVA is based on a comparison of two estimates of variance, one estimate of variance comes from differences *among scores within each group* (which is considered as error). The second estimate of variance comes from *differences in group means* (which is considered as a reflection of group difference). Hence, the total sum of squared differences (TSS) between the N observed values (scores) and the grand mean[67], can be partitioned into two parts. The sum of squared deviations between each score and its group mean is called the sum of squared differences within groups (ESS) and forms the first part. The second part is the sum of squared differences among groups and represents the sum of squared deviations between each group mean and the grand mean. The ratio of these two sums of squared differences (RSS/ESS) divided by its respective degrees of freedom provides the **F-ratio** to test the null hypothesis of k equal group means.

Three fundamental issues are of concern when performing an ANOVA. The <u>first</u> issue is to test the overall null hypothesis of no differences in the means for the different groups (the so-called omnibus ANOVA test). This *existence* of a difference in the dependent variable among the groups (i.e. the levels of the I.V.) is addressed by comparing the F-ratio to the critical F. This critical F can be obtained from a table with k minus one degrees of freedom for the numerator and N minus k for the denominator at alpha equal to 5%. An F larger than the critical F means a rejection of the null hypothesis, involving that the data show a significant group difference. <u>Second</u>, the *strength* of the relationship can be measured by eta squared. It is a measure that indicates how much of variation in the dependent variable can be reduced by knowing to what group an observation belongs. It is the correlation ratio, computed as the ratio of the sum of squared differences between groups to the total sum of squared differences (RSS/TSS). It is similar to the R^2, the squared multiple correlation coefficient computed in regression analysis. The <u>third</u> issue involves *analyzing the nature of the overall group difference*, i.e. analyzing which groups are responsible for the overall group difference (see next section).

[67] The **grand mean** is the mean of the observations on the dependent variable over all groups.

6.2 Analyzing a significant ANOVA for an Univariate Main Effect (Hypotheses 1a, 1b)

Once the omnibus ANOVA shows a significant group difference, the researcher frequently wants to know which groups are responsible for this significant group difference. In our study, finding a significant difference in cost level among the three TCS groups is not enough. We are mainly interested in comparing the cost level between the non-TCS and the difficult TCS (hypothesis 1a) and comparing the cost level between the non-TCS and the easy TCS (hypothesis 1b). This topic of making comparisons is one of the most vital and controversial within statistics, since the chance of committing a type I-error (erroneous rejecting the null hypothesis that there is no group difference) increases drastically with the number of comparisons made in the same sample. Hence, depending on the purpose, other statistical tests are suggested in literature. The following purposes are distinguished in literature:

1. For a limited number of *a priori* comparisons, orthogonal or non-orthogonal;
2. For *post hoc* exploratory analysis to contrast combinations of groups as well as pairs of means with each other and;
3. For comparing all or a fewer number of *pairs* of means.

In our study, multiple comparisons are understood in the last meaning, since we need to compare pairs of group means. In hypothesis 1a, the cost level of the *difficult* TCS is compared with the *non*-TCS. In hypothesis 1b, the cost level of the *easy* TCS is compared with the *non*-TCS. The contrasts or weights for these two pairwise comparisons are given in Table 15. Of course these pairwise comparisons are not orthogonal[68]. Different tests are discussed in literature for pairwise[69] comparisons, as shown in Table 16. These statistical tests do differ from each other in terms of statistical power (to detect group differences) and control over the type I-error (to prevent from erroneous rejecting a true null hypothesis of no group difference). If a conservative test is adopted, type I-error is controlled, but there will be fewer significant findings and a greater chance to commit a type II-error. On the other hand, more liberal tests will yield more significant differences, but the cost will be a greater type I-error. **Here, we choose *Dunnett's test* to perform the pairwise comparisons**

[68] A simple test can identify if the two comparisons are **orthogonal** (see e.g. Brown & Melamed, 1990, 27). The test involves multiplying the weights of the comparisons for each treatment group and summing these products. When this sum of cross products is zero, the comparisons are orthogonal. For hypothesis 1 the weights are displayed in Table 15. Cross multiplying the weights of comparison one and two sums up to 1. So, these comparisons are not orthogonal.

[69] Klockars & Sax (1986, 41) explain that most of the tests for pairwise comparisons are based on a **q statistic**, i.e. the difference between the group means, divided by the standard error of the mean. For each pairwise comparison this q statistic is calculated. First, the largest difference is evaluated to determine if it reflects more variability than would be expected by chance. Thus, if the value of q is greater than the tabled value, the null hypothesis that all treatments have the same impact on the dependent variable (here cost level) is rejected. Then the test proceeds to evaluate smaller subsets of means.

because of its relative high power to detect a group difference and because of its unique approach to treat one of the groups as a control group. Since we are mainly interested in comparing the non-TCS with both the difficult TCS and the easy TCS separate, this method is the most appropriate and will be used for hypotheses 1a and 1b.

Table 15: Weights for the Pairwise Comparisons of Hypothesis 1a and 1b

	Non-TCS	**Easy TCS**	**Difficult TCS**
H1a: comparison 1	1	0	-1
H1b: comparison 2	1	-1	0

Table 16: Selecting the Most Appropriate Multiple Comparison Test

	Power	**Control over Type I-Error**	**Test Statistic**
A. Limited Number of Comparisons based on a priori Hypotheses (p Hypotheses)			
1. Orthogonal: F-test	High	α experimentwise = 1 - $(1\text{-}0.05)^p$	F
2. Nonorthogonal: Dunn's Test (Bonferroni)	Low	α experimentwise[70] = 5% α per comparison = 5%/p	F
3. Nonorthogonal: Scheffé Test	Low	α experimentwise = 5%	$F' = (k\text{-}1)\ F_{\alpha=0.05}$
B. Exploratory, Post Hoc Comparisons			
1. Scheffé Test	Low	α experimentwise = 5%	$F' = (k\text{-}1)\ F_{\alpha=0.05}$
C. Pairwise Comparisons of Means[71] (k Groups)			
1. Tukey's Honestly Significant Difference Test (HSD)	Lowest	α experimentwise = 5% α per comparison < 5%	q
2. Newman-Keuls Test (N-K)	High	α experimentwise = 5% α per comparison = 5%	q
3. Tukey's Wholly Significant Difference Test (WSD)	Intermediate	α experimentwise = 5% $\alpha_{HSD} < \alpha$ per comparison $< \alpha_{N\text{-}K}$	q
4. Duncan Test	High	α experimentwise = 5% α per comparison = $1\text{-}(1\text{-}0.05)^{k-1}$	q
5. Least Significant Difference Test (LSD)	Highest	α experimentwise = 5% α per comparison > 5%	t
6. Dunnett's Test (with a control group)	**High**	**α experimentwise = 5%** **α per comparison > 5%**	**t**

Source: Based on Klockars & Sax (1986, 7-65)

[70] The **error rate experimentwise or familywise** describes the probability that an experiment involving several comparisons will result in a type I-error on one or more of these comparisons.

[71] Klockars & Sax (1986, 54) stress that for the three conservative methods, i.e. Tukey's HSD, Newman-Keuls and Tukey's WSD, requiring that the overall F-ratio and the q-statistic both be among the most extreme 5% before rejecting the null hypothesis places a **double burden** on the experiment. The F-ratio will be large when several of the groups deviate from the overall average, while the q-statistic depends on the variability of only the two extreme means.

6.3 ANOVA for an Univariate Interaction Effect (Hypothesis 3)

Hypothesis three in our study asks whether the difficulty of the time objective is moderating the impact of TCS on the cost level. Hence, hypothesis three questions the significance of the interaction effect between TCS and time difficulty on the cost level. Again, three fundamental issues are of concern when evaluating an interaction effect: the existence, the size of the effect and the nature of the effect. The first issue of testing the *existence* of an interaction effect can be resolved by conducting an ANOVA, including both the main independent variables and the interaction term. **Inferring that an interaction effect exists in the population involves a comparison of the full model (with the interaction terms) versus the reduced model (with no interaction terms).** The null hypothesis, representing the reduced model, states that the differences in the dependent variable among the treatment levels of variable A in each of the treatment level of variable B are likely to have come from the same sampling distribution of differences among means. Thus the null hypothesis of hypothesis three states that the differences in the cost level among the three TCS in each of the time conditions are drawn from the same distribution of differences among cost level means. A statistically significant **F-ratio** (at alpha equal to 5%) for the interaction term results in a rejection of the null hypothesis, indicating that adding the interaction term is reducing a significant portion of the sum of squared error. Again, the second question of measuring the *strength* of the interaction effect, can be addressed by computing an effect size measure such as **eta squared**, which is the proportion of the variance in the dependent variable that is attributable to the interaction effect. Third, the *nature* of the interaction effect needs to be addressed, which is discussed in the next section.

6.4 Analyzing a Significant ANOVA for an Univariate Interaction Effect (Hypotheses 3a, 3b)

Once a significant interaction effect is found, the researcher frequently wants to know which groups are responsible for this significant interaction effect. In literature, three methods are suggested for determining the nature of an interaction effect (Jaccard et al., 1990, 11). These methods are:

1. Interaction orthogonal contrasts;
2. Interaction comparisons and;
3. Simple main effects.

In our study, we will use both the interaction comparisons and simple main effects to analyze a significant interaction effect in hypothesis three. The first method of orthogonal contrasts is not appropriate in our study, since we are mainly interested to compare the non-TCS with both the easy TCS and the difficult TCS across the levels of time difficulty, which are non-orthogonal comparisons. The method of **interaction comparisons** involves making all possible two by two subtables from the original data and then conducting an ANOVA on each subtable, to evaluate this one degree of freedom interaction effect. In our study, there are 3 by 2 treatments, i.e. six cells. Theoretically, we can thus construct three 2 by 2 subtables, as shown in Table 17. Each time only two TCS conditions are included and the interaction effect is considered with the two TIME conditions. Since this study is about testing the effectiveness of target costing, we are mainly interested in the interaction effect with the TIME condition between the non-TCS and the difficult TCS and between the non-TCS and the easy TCS, as formulated in hypotheses 3a and 3b. Hence, the third subtable, considering the interaction effect of TIME with the easy TCS and the difficult TCS is of less relevance to our study.

Once the interaction effect in a subtable is found significant at $\alpha = 5\%$, we can proceed with the third method, i.e. **simple main effects**. Differences in one of the independent variables are evaluated at each level of the other independent variable. Thus for hypothesis 3a, the difference between the non-TCS and the difficult TCS in terms of cost level is examined for each of the two TIME conditions. Hence, a first t-test examines whether the cost level in the easy TIME condition significantly differs between the non-TCS and the difficult TCS. A second t-test asks whether the cost level in the difficult TIME condition significantly differs between the non-TCS and the difficult TCS. The same procedure will be followed for a significant subtable of hypothesis 3b.

Table 17: Analyzing a Significant Interaction Effect by Interaction Comparisons (Construction of the Three Subtables)

	Original Research Design		
	Non-TCS	Easy TCS	Difficult TCS
Easy TIME	X	X	X
Difficult TIME	X	X	X
	Subtable 1		
	Non-TCS	Easy TCS	Difficult TCS
Easy TIME	X	X	-
Difficult TIME	X	X	-
	Subtable 2		
	Non-TCS	Easy TCS	Difficult TCS
Easy TIME	X	-	X
Difficult TIME	X	-	X
	Subtable 3		
	Non-TCS	Easy TCS	Difficult TCS
Easy TIME	-	X	X
Difficult TIME	-	X	X

Thus, analyzing a significant univariate interaction effect involves two more steps. First, we need to perform interaction comparisons in 2 by 2 subtables. Mainly the first two subtables are of importance here, as formulated in the hypotheses 3a and 3b. Second, significant subtables can be further analyzed using simple main effects. I.e. we will perform t-tests for each TIME condition separate, to detect which pair of TCS differ on the cost level.

7. Multivariate Analyses

7.1 MANOVA for a Multivariate Main Effect (Hypothesis 2)

To test the differences in created new products (measured by the cost level, the quality level and the achieved time-to-market) among the three TCS manipulations, as stated in hypothesis two, we need to perform a multivariate analysis of variance. In a multivariate analysis of variance (MANOVA), all dependent variables are continuous variables, while the independent variables are categorical and represent group membership. A MANOVA tests whether mean differences among groups on a combination of the dependent variables are likely to have occurred by chance. Hence, the null hypothesis here is that the population means for all dependent variables do not differ among the 3 TCS groups. **In fact, a MANOVA asks whether there exist significant differences between groups on a new variable, called the canonical variate.** This canonical variate (or discriminant function) is a linear combination of the original dependent variables that maximally separates the groups. The main distinction with ANOVA is that in a MANOVA the mean differences are evaluated on two or more dependent variables *simultaneously*, while in an ANOVA the mean differences are compared on a *single* dependent variable.

Again three issues are of importance to test group differences. First, the issue of the *existence* of a significant group difference on a combination of dependent variables is of interest. In MANOVA different test statistics can be used. Second, a measure of the *strength* of the association can be discussed. Third, the *nature* of a significant group difference can be analyzed when the researcher wants to know where the significant group difference is coming from. Paragraph 7.3 addresses the first two issues, while paragraph 7.4 is about the third question. But in the next paragraph 7.2, we first motivate why we use a single MANOVA instead of different ANOVAs to test hypothesis two (and hypothesis four).

7.2 A single MANOVA versus multiple ANOVAs for Hypothesis 2

When there are several dependent variables, two types of analyses can be done. Or the researcher conducts a single MANOVA on all dependent variables together or the researcher performs a series of ANOVAs on each dependent variable separate. Tabachnick & Fidell (1989, 372) argue that conducting a MANOVA has a number of advantages over performing a series of ANOVAs. *First*, by measuring several dependent variables instead of only one, the researcher improves the chance of discovering what it is that changes as a result of different treatments and their interactions. Similarly, Bray & Maxwell (1990, 9) argue that in the situation of separate ANOVAs, it is assumed that either the **correlations** between the dependent variables are zero or that the correlations are of no interest. A *second* advantage of MANOVA over a series of ANOVAs is **protection against inflated type I-error** due to multiple tests of likely correlated dependent variables. Manly (1986, 32) explains that with a univariate test at the 5% level, there is a 0.95 probability of a non-significant result when the population means are the same. Hence, if p independent tests are carried out under these conditions then the probability of getting non-significant results is 0.95^p. The probability of at least one significant result is therefore $1 - 0.95^p$. With p equal to three in our study, the probability of at least one significant result by chance alone is $1 - 0.95^3 = 0.14$. Furthermore, with multivariate data, variables are usually not independent, so 0.14 does not quite give the correct probability of at least one significant result by chance alone if variables are tested one by one with univariate F-tests. A *third* advantage of MANOVA is that, under certain conditions, it may **reveal differences not shown in separate ANOVAs.** Bray & Maxwell (1990, 31) explain that only the multivariate test is sensitive to the direction and magnitude of the correlations among the dependent variable. An example is given where the univariate tests yield insignificant group differences on each of the dependent variables, while the multivariate test revealed a significant group difference. However, *next to these advantages*, Tabachnick & Fidell (1989, 372) add that MANOVA is a **far more complicated analysis** than ANOVA. There are several important assumptions to consider, and there is often some ambiguity in interpretation of the effects of independent variables on any single dependent variable.

To Huberty & Morris (1989, 320) the discussion of one single MANOVA or different ANOVAs is non existing, since to them the multivariate and the univariate method address **different research questions**. For Huberty & Morris (1989, 320) multiple *univariate* analyses are appropriate when the outcome variables are conceptually independent, when the research being conducted is exploratory in nature, when all outcome variables under study have been previously studied in univariate contexts so that comparisons are needed. On the other hand, a *multivariate* analysis is needed when the researcher is interested in determining outcome variable subsets that account for group separation, or in determining the relative contribution to group separation of the outcome variables in the final subset or to identify underlying constructs associated with the obtained MANOVA results.

In this study, we will use a single MANOVA to test group differences on a combination of the dependent variables cost level, quality level and achieved time-to-market instead of multiple ANOVAs on each of the variables separate. *First*, we are mainly interested if different target cost settings reveal a significant group difference on the totality of the created new products, i.e. on all three dependent variables together rather than looking at each of them in isolation. *Second*, the dependent variables are not conceptually independent, since design engineers frequently face trade-offs between the three characteristics when designing new products. We cannot capture the outcome of these trade-offs by single ANOVAs.

7.3 Multivariate Test Criterion

Four different test statistics are used in literature to test the multivariate null hypothesis that there are no significant group differences on the canonical variate. The four multivariate test statistics[72] are **Wilks' Lambda, Pillai's Trace, Roy's Greatest Root and Hotelling-Lawley Trace**. Only in the special case of two levels in the independent variable (one degree of freedom between groups) will each of the test criteria result in the same value. Because when there is only one degree of freedom between groups, there is just one possible way to combine the dependent variables to maximally separate the two groups from each other. Similarly, when there is more than one degree of freedom (like in our study) there is more than one way to combine the dependent variables to separate groups. In this case, the F-values are often different but are either significant or nonsignificant. However, not always do the four test statistics lead to the same conclusion.

Bray & Maxwell (1990, 28) state that choosing which test to employ in a MANOVA involves a complex consideration of both *statistical power and robustness*[73]. Tabachnick & Fidell (1989, 398) explain that Wilks' Lambda, Hotelling's Trace and Pillai's Trace pool the statistics from each dimension to test the group difference, while Roy's Greatest Root uses only one dimension. Remember that each way of combining dependent variables is a dimension along which groups might differ. When *one single dimension* is expected in the data, Roy's Greatest Root is the most powerful test. When more than one dimension is expected in the data, with *one dimension more important than the other*, Tabacknick & Fidell (1989, 399) argue that Wilks' Lambda and Hotelling's Trace are the most powerful to detect group differences. When separation of groups is distributed over *different important dimensions,* Pillai's Trace is the most powerful. In terms of **robustness** to the assumption of homogeneity of variance-covariance matrices, Pillai's Trace is said to be more robust than the others are.

In our study, the three dependent variables all measure one aspect of NPD performance of the future product, i.e. the cost level, the quality level and the time-to-market. In hypothesis two, target cost setting is the independent variable with three levels, i.e. a non-TCS, an easy TCS and a difficult TCS. Hence, the maximum number of significant dimensions[74] or canonical variates is two. Since only the target cost setting is manipulated in hypothesis two, it seems realistic to expect one important dimension that highly correlates with the cost level. Because of the inclusion of a time and a quality goal as well, a second dimension is expected, that might highly correlate with the achieved time-to-

[72] See Bray & Maxwell (1990, 27) for the exact **formulas**. Wilks' Lambda is distributed as an F, while Roy's Greatest Root, Hotelling's Trace and Pillai's Trace have an approximate F distribution.

[73] A statistic is said to be **robust**, if violations of its assumptions have little effect on the sampling distribution of the statistic and thus on the type I and type II-errors.

[74] The **maximum number of dimensions** (or canonical variates) is equal to the lowest of the number of independent variables and the number of dependent variables.

market or the quality level of the new product. It is expected that this second dimension will be of less importance than the first. **Consequently, we choose for <u>Wilks' Lambda</u> as the test statistic for hypothesis two,** because there are reasons to expect that one important dimension will show up in the data, next to another dimension of less importance.

Similarly, for *hypothesis four*, there are three treatment levels for the target cost setting manipulation, but also two levels for the difficulty of the time objective. Hence, the MANOVA to test the interaction effect on the NPD performance between TCS and TIME can have at most two significant dimensions. There are reasons to believe that there will be two equally important dimensions, because the target cost condition as well as the difficulty of the TIME objective is manipulated now. **Hence, <u>Pillai's Trace</u> seems to be the most appropriate test for hypothesis four.**

If the researcher has obtained a statistically significant multivariate result, the second step involves measuring the *strength of the association*. For MANOVA the strength of the association is measured by the **squared canonical correlation** (Tabachnick & Fidell, 1989, 389). Again, it represents the variance accounted for by the best linear combination of dependent variables.

7.4 Analyzing a Significant MANOVA for a Multivariate Main Effect (Hypotheses 2a, 2b)

Different approaches are suggested in literature to analyze a significant MANOVA. Bray & Maxwell (1990, 39) state that there is no "right" method for these follow-up analyses. The two most frequently mentioned methods are:

1. Univariate contrasts by different ANOVAs (F-test) on each of the dependent variables and;
2. Multivariate contrasts by pairwise multivariate comparisons (Hotelling's T^2), followed by univariate contrasts (t-tests) on each of the dependent variables, which we will use here.

The <u>first</u> method is to analyze significant group differences on the dependent variables with *different* ANOVAs on each of the dependent variables separately. In particular to our study, this approach suggests a separate ANOVA on the cost level, the quality level and the achieved time-to-market in order to detect on which of the three measures the TCS had an impact. The reader understands that this is not the best approach to our study, since we came earlier to the conclusion in section 7.2 that multiple ANOVAs are not appropriate when the researcher expects interrelations between the dependent variables. Furthermore, Huberty & Morris (1989, 320) argue that conducting a MANOVA as a preliminary to multiple ANOVAs as to control for the type I-error, is seldom appropriate, giving a false feeling of control.

The <u>second</u> approach is to follow a significant overall multivariate result by *pairwise multivariate tests* (Hotelling's T²) and then by *univariate t-tests* on the individual dependent variables (Stevens, 1996, 196). The pairwise multivariate test (Hotelling's T²) is performed to determine which pairs of groups significantly differ on the set of dependent variables. Since we are mainly interested if the new products in totally differ between the non-TCS and the difficult TCS (hypothesis 2a) and differ between the non-TCS and easy TCS (hypothesis 2b), we will use this second approach. To test hypothesis 2a, we need to compare by Hotelling's T² the group centroids between the *non-TCS* and the *difficult TCS*. To test hypothesis 2b, we need to compare the group centroids between the *non-TCS* and the *easy TCS*. To keep the overall type I-error for the set of pairwise multivariate tests under some control, Stevens (1996, 198) suggests to set a relative high overall alpha, for instance at 0.15 and to use the Bonferroni inequality. Since we are mainly interested in comparing the non-TCS with both the difficult and the easy TCS, we only need two comparisons in analyzing a significant MANOVA and can set our overall alpha at 0.10. Hence the two Hotelling's T² tests can then be performed, each at the 0.10/2 = 0.05 level of significance.

For significant multivariate pairs, Stevens (1996, 198) suggests to go further, by performing t-test on each of the dependent variables separate, each at the 0.05 level. The purpose is to determine which of the individual variables are contributing to the significant multivariate pairwise differences. Stevens (1996, 198) argues that this method has fairly good control on type I-error for the first two parts (identify significant multivariate group differences by a MANOVA and significant multivariate pairwise differences by Hotelling's T²), but not as good control for the last part (identifying significant individual variables by t-tests). In particular to our study, analyzing a significant multivariate pairwise comparison requires three different t-tests. As shown in Table 18, a significant Hotelling's T² test comparing a difficult TCS with a non-TCS on the three dependent variables, needs to be analyzed in this last step by three additional t-tests. I.e. the first t-test asks whether there is a significant difference in cost level between the difficult TCS and the non-TCS. The second t-tests asks whether there is a significant difference in quality level between the difficult TCS and the non-TCS, while the third t-test questions a significant difference in achieved time-to-market between the difficult TCS and the non-TCS. This set of three t-tests needs to be performed for each of the multivariate (significant) comparisons, as shown in Table 18.

Summing up, we will use multivariate comparisons and simple main effects to analyze a significant MANOVA for hypothesis two. This so-called second approach in Table 18, is the most appropriate to our study, since we are mainly interested in how the different TCS groups differ on a combination of the dependent variables quality, cost level and achieved time-to-market. Hence to test hypotheses 2a and 2b, we will first perform multivariate pairwise comparisons by Hotelling's T². Then we will further analyze the significant comparisons by t-tests on each of the three dependent variables separately.

Table 18: Two Approaches to Analyze a Significant MANOVA as suggested in Literature

MANOVA hypothesis 2	H_0: Cost Quality Time-to-Market = X0 H_a: Cost Quality Time-to-Market = X0 TCS$_{\text{(difficult, easy, non)}}$
<u>Approach 1</u>:	**Different ANOVAs**
Univariate F-tests:	H_0: Cost = X0 H_a: Cost = X0 TCS$_{\text{(difficult, easy, non)}}$ H_0: Quality = X0 H_a: Quality = X0 TCS$_{\text{(difficult, easy, non)}}$ H_0: Time-to-Market = X0 H_a: Time-to-Market = X0 TCS$_{\text{(difficult, easy, non)}}$
<u>Approach 2</u>:	**Pairwise multivariate comparisons, followed by t-tests**
Multivariate Hotelling's T^2:	H_0: Cost Quality Time-to-Market = X0 H_a: Cost Quality Time-to-Market = X0 TCS$_{\text{(difficult, non)}}$ H_0: Cost Quality Time-to-Market = X0 H_a: Cost Quality Time-to-Market = X0 TCS$_{\text{(easy, non)}}$
Univariate t-tests for each D.V.	For significant pair 1: H_0: Cost = X0 H_a: Cost = X0 TCS$_{\text{(difficult, non)}}$ H_0: Quality = X0 H_a: Quality = X0 TCS$_{\text{(difficult, non)}}$ H_0: Time-to-Market = X0 H_a: Time-to-Market = X0 TCS$_{\text{(difficult, non)}}$ For significant pair 2: H_0: Cost = X0 H_a: Cost = X0 TCS$_{\text{(easy, non)}}$ H_0: Quality = X0 H_a: Quality = X0 TCS$_{\text{(easy, non)}}$ H_0: Time-to-Market = X0 H_a: Time-to-Market = X0 TCS$_{\text{(easy, non)}}$

7.5 MANOVA for a Multivariate Interaction Effect (Hypothesis 4)

To test if the differences in created products (measured by the cost level, the quality level and the achieved time-to-market) among the three TCS manipulations vary as a function of the TIME objective, as formulated in hypothesis four, we need to perform a multivariate analysis of variance.

Again, three fundamental issues are of concern when evaluating a multivariate interaction effect. **First, the issue of the *existence* of an interaction effect is of interest. Second, the *strength* of the interaction effect can be discussed. Third, the *nature* of the interaction effect can be analyzed.** The first two issues are addressed here, while the third issue is discussed in the following section 7.6.

Since we have discussed in the previous paragraphs the multivariate analysis as well as the univariate interaction effect, much of this paragraph will resume of what is discussed earlier. The first issue of testing the *existence* of a multivariate interaction effect can be resolved by conducting a MANOVA on what is called the full model, including both the two independent variables TCS and TIME, as well as the product term TCS * TIME. Inferring that an interaction effect exists in the population involves a comparison of the full model (with the interaction terms) versus the reduced model (with no interaction terms). As mentioned, different statistical tests are available to test for a significant effect in the multivariate case, i.e. Wilks' Lambda, Pillai's Trace, Roy's Greatest Root and Hotelling's Trace. As discussed before in 7.3, on page 143, we expect that there will be two equally important dimensions, because the TCS as well as the TIME objective is manipulated. Pillai's Trace is said to be the most powerful when separation among groups is distributed over equally important dimensions. Consequently we will use **Pillai's Trace** as the multivariate test criterion for the interaction effect of hypothesis four.

The *strength* of the association is measured in MANOVA by the **squared canonical correlation** (Tabachnick & Fidell, 1989, 389). It represents the variance accounted for by the best linear combination of dependent variables.

7.6 Analyzing a Significant MANOVA for a Multivariate Interaction Effect (Hypothesis 4a, 4b)

Once a significant interaction effect is found, the researcher frequently wants to know which groups are responsible for this significant interaction effect, questioning on the *nature* of the interaction effect. In literature, very little is available on analyzing a significant multivariate interaction effect. Mainly two methods can be used:

1. Interaction comparisons by different MANOVAs on subtables, followed by univariate interaction comparisons and univariate simple main effects;
2. Multivariate simple main effects by Hotelling's T^2 tests, followed by univariate simple main effects.

The first method mainly involves comparing the differences in new products between two TCS conditions across the levels of the two TIME conditions. The second method mainly involves comparing the created products between the easy and the difficult TIME condition in each of the three TCS conditions separate. Thus this second method cannot give us information on the differences between the non-TCS and the difficult TCS (or easy TCS) in analyzing the effectiveness of target costing, which can be obtained from the first method. **Hence, the first method of separate multivariate interactions is most appropriate to our study**. As formulated before in hypothesis 4a, we are mainly interested if the created products differ between the non-TCS and the difficult TCS as a function of the TIME objective. As formulated before in hypothesis 4b, we are also interested if the created products differ between the non-TCS and the easy TCS, as a function of the TIME objective. Thus, we will perform different MANOVAs on the subtables, created earlier in Table 17 on page 140.

Next, we can analyze the significant MANOVA subtables by univariate interactions on each of the three dependent variables separately to know which one of the three dependent variables is mainly causing the multivariate interaction effect, as discussed before in paragraph 6.4 on page 138. Similar to the univariate case, we can proceed the analysis then by univariate simple main effects in each of the significant univariate subtables.

Summing up, we will analyze the multivariate interaction effect of hypothesis four by separate MANOVAs on the subtables. For significant subtables, we will proceed the analysis by univariate ANOVAs and simple main effects using different t-tests to find out which group differences and which dependent variables are mainly responsible for the OMNIBUS multivariate interaction effect. In the following paragraph, we make a summary of all suggested statistical tests, that we will use in the following three chapters to test the earlier formulated hypotheses.

8. Summary of the Statistics to Test the Hypotheses

In the previous paragraph different statistical tests are proposed to test the four main hypotheses. A global picture is given in Table 19. A more detailed picture is given in Table 20 on the next page. It gives an overview of the research questions, the scientific and statistical hypotheses, and the statistics, that we need for testing the hypotheses.

Table 19: Summary of the Statistics necessary to test the Hypotheses

Hypothesis 1: Univariate, main effect.	**In a three-goal NPD situation, the cost level will significantly differ among the non-TCS, easy TCS and difficult TCS.**
	1. ANOVA on main effect by F-test. 2. Pairwise comparisons by Dunnett's Test.
Hypothesis 2: Multivariate, main effect.	**In a three-goal NPD situation, a combination of the three NPD measures cost level, quality level and achieved time-to-market will significantly differ among the non-TCS, easy TCS and difficult TCS.**
	1. MANOVA on main effect by Wilks' Lambda. 2. Pairwise multivariate comparisons by Hotelling's T^2. 3. Simple Main Effects by t-tests.
Hypothesis 3: Univariate, interaction.	**In a three-goal NPD situation, the impact of target cost setting (non-TCS, easy TCS and difficult TCS) on the cost level of a future product will significantly differ across the levels of the time objective.**
	1. ANOVA on interaction effect by F -test. 2. Interaction comparisons by ANOVAs on subtables. 3. Simple main effects by t-tests.
Hypothesis 4: Multivariate, interaction.	**In a three-goal NPD situation, the impact of target cost setting (non-TCS, easy TCS and difficult TCS) on a combination of the three NPD measures cost level, quality level and achieved time-to-market will significantly differ across the levels of the time objective.**
	1. MANOVA on interaction effect by Pillai's Trace. 2. Multivariate interaction comparisons by MANOVAs on subtables. 3. Univariate interaction comparisons by ANOVAs on subtables. 4. Simple main effects by t-tests.

Table 20: Overview of the Research Questions, Hypotheses, Model Comparisons and Statistical Tests

<u>Research question 1</u>:	***Will the cost level of a future product be lower in a target costing than in a non-target-costing environment?***
1	In a three-goal NPD situation, the cost level of a future product will significantly differ among the non-TCS, easy TCS and difficult TCS. H_0: Cost = X_0 H_a: Cost = X_0 TCS $_{(non,\ easy,\ difficult)}$ ↳ **ANOVA on main effect: F-test.**
1a	In a three-goal NPD situation, the cost level of a future product will be significantly lower under the difficult TCS than under the non-TCS. H_0: Cost = X_0 H_a: Cost = X_0 TCS $_{(non,\ difficult)}$ with $\mu_{(difficult)} < \mu_{(non)}$ ↳ **Pairwise comparison: Dunnett's test.**
1b	In a three-goal NPD situation, the cost level of a future product will be significantly higher under the easy TCS than under the non-TCS. H_0: Cost = X_0 H_a: Cost = X_0 TCS $_{(non,\ easy)}$ with $\mu_{(non)} < \mu_{(easy)}$ ↳ **Pairwise comparison: Dunnett's test.**
<u>Research question 2</u>:	***Will the multidimensional NPD performance (in terms of the downstream cost level of a future product, the quality level of that future product and the achieved time-to-market) differ between a target costing and a non-target costing context?***
2	In a three-goal NPD situation, a combination of the three NPD measures cost level, quality level and achieved time-to-market will significantly differ among the non-TCS, easy TCS and difficult TCS. H_0: Cost Quality Time-to-Market = X_0 H_a: Cost Quality Time-to-Market = X_0 TCS $_{(non,\ easy,\ difficult)}$ ↳ **MANOVA on main effect: Wilks' Lambda.**
2a	In a three-goal NPD situation, a combination of the three NPD measures cost level, quality level and achieved time-to-market will significantly differ between the non-TCS and difficult TCS. H_0: Cost Quality Time-to-Market = X_0 H_a: Cost Quality Time-to-Market = X_0 TCS $_{(non,\ difficult)}$ ↳ **Pairwise multivariate comparison by Hotelling's T²;** ↳ **Univariate t-tests on each dependent variable.**
2b	In a three-goal NPD situation, a combination of the three NPD measures cost level, quality level and achieved time-to-market will significantly differ between the non-TCS and easy TCS. H_0: Cost Quality Time-to-Market = X_0 H_a: Cost Quality Time-to-Market = X_0 TCS $_{(non,\ easy)}$ ↳ **Pairwise multivariate comparison by Hotelling's T²;** ↳ **Univariate t-tests on each dependent variable.**

<table>
<tr><td colspan="2"><u>Research question 3</u>: Will the difference in downstream cost level between a target costing and a non-target costing context vary between low time pressure and high time pressure?</td></tr>
<tr><td>3</td><td>In a three-goal NPD situation, the impact of target cost setting (non-TCS, easy TCS and difficult TCS) on the cost level of a future product will significantly differ across the two levels of the time objective.

H_0: Cost = X_0 TCS $_{(non, easy, difficult)}$ TIME $_{(easy, difficult)}$
H_a: Cost = X_0 TCS $_{(non, easy, difficult)}$ TIME $_{(easy, difficult)}$ TCS $_{(non, easy, difficult)}$ * TIME $_{(easy, difficult)}$

↳ ANOVA on interaction effect: F-test.</td></tr>
<tr><td>3a</td><td>The difference in cost level between the non-TCS and the difficult TCS will significantly vary between the easy and the difficult time objective.

H_0: Cost = X_0 TCS $_{(non, difficult)}$ TIME $_{(easy, difficult)}$
H_a: Cost = X_0 TCS $_{(non, difficult)}$ TIME $_{(easy, difficult)}$ TCS $_{(non, difficult)}$ * TIME $_{(easy, difficult)}$

↳ ANOVA on interaction effect in subtable 1: F-test;
↳ Simple main effects: t-tests within each time objective.</td></tr>
<tr><td>3b</td><td>The difference in cost level between the non-TCS and the easy TCS will significantly vary between the easy and the difficult time objective.

H_0: Cost = X_0 TCS $_{(non, easy)}$ TIME $_{(easy, difficult)}$
H_a: Cost = X_0 TCS $_{(non, easy)}$ TIME $_{(easy, difficult)}$ TCS $_{(non, easy)}$ * TIME $_{(easy, difficult)}$

↳ ANOVA on interaction effect in subtable 2: F-test;
↳ Simple main effects: t-tests within each time objective.</td></tr>
<tr><td colspan="2"><u>Research Question 4</u>: Will the difference in multidimensional NPD performance (in terms of the downstream cost level of a future product, the quality level of that future product and the achieved time-to-market) between a target costing and a non-target costing context vary between low time pressure and high time pressure?</td></tr>
<tr><td>4</td><td>In a three-goal NPD situation, the impact of target cost setting (non-TCS, easy TCS and difficult TCS) on a combination of the three NPD measures cost level, quality level and achieved time-to-market will significantly differ across the two levels of the time objective.

H_0: Cost Quality Time-to-Market = X_0 TCS $_{(non, easy, difficult)}$ TIME $_{(easy, difficult)}$
H_a: Cost Quality Time-to-Market = X_0 TCS $_{(non, easy, difficult)}$ TIME $_{(easy, difficult)}$ TCS $_{(non, easy, difficult)}$ * TIME $_{(easy, difficult)}$

↳ MANOVA on interaction effect: Pillai's Trace.</td></tr>
<tr><td>4a</td><td>The difference on a combination of the three NPD measures cost level, quality level and achieved time-to-market between the non-TCS and the difficult TCS will significantly vary between the easy and the difficult time objective.

H_0: Cost Quality Time-to-Market = X_0 TCS $_{(non, difficult)}$ TIME $_{(easy, difficult)}$
H_a: Cost Quality Time-to-Market = X_0 TCS $_{(non, difficult)}$ TIME $_{(easy, difficult)}$ TCS $_{(non, difficult)}$ * TIME $_{(easy, difficult)}$

↳ MANOVA on interaction effect in subtable 1: Hotelling's T^2;
↳ ANOVAs on interaction effect in subtable 1: F-test;
↳Simple main effects: t-tests within each time objective.</td></tr>
<tr><td>4b</td><td>The difference on a combination of the three NPD measures cost level, quality level and achieved time-to-market between the non-TCS and the easy TCS will significantly vary between the easy and the difficult time objective.

H_0: Cost Quality Time-to-Market = X_0 TCS $_{(non, easy)}$ TIME $_{(easy, difficult)}$
H_a: Cost Quality Time-to-Market = X_0 TCS $_{(non, easy)}$ TIME $_{(easy, difficult)}$ TCS $_{(non, easy)}$ * TIME $_{(easy, difficult)}$

↳ MANOVA on interaction effect in subtable 1: Hotelling's T^2;
↳ ANOVAs on interaction effect in subtable 1: F-test;
↳ Simple main effects: t-tests within each time objective.</td></tr>
</table>

9. Assumptions of the Statistical Tests

9.1 ANOVA, Multiple Univariate Comparisons and Simple Main Effects

The ANOVA F-test statistic, the multiple comparison q-test and the t-test are all relying on the assumptions of the general linear model (Kirk, 1995, 97). These underlying assumptions are:

1. **Normality**: The observations are drawn from normally distributed populations.
2. **Homoscedasticity:** The variances within the treatment groups are estimates of the same population variance.
3. **Independence**: The observations are statistically independent of one another.

The first criterion assumes **normally distributed** populations, i.e. normally distributed residuals (error terms, disturbances) in each of the treatment combinations. One way to evaluate this assumption is to plot the observed values against the expected values from a normal distribution. SPSS standard provides this normal probability plot as well as the detrended normal plot (observed values versus deviations between observed and expected values from a normal distribution). If the sample is from a normal distribution all the points in the normal probability plot will fall on a straight line. Similarly, in the detrended normal plot all the points will fall symmetrically around the mean of zero with no pattern, within each treatment population. There are also test statistics developed to evaluate the assumption of normality, such as the Kolmogorov-Smirnov (adapted by Lilliefors) and the Shapiro-Wilks' test. With real data, as Toothaker (1993, 57) states, it is very rare that the assumption of normality is met. To Iversen & Norpoth (1987, 92), some of the assumptions can be moderately violated without the results losing theoretical justification. So, the researcher needs to consider the quality of the test statistic in the presence of the violations of the assumptions, i.e. what is called considering the robustness of the test. Based on different research studies, Kirk (1995, 99) concludes that the *F*-statistic and the *t*-statistic are quite robust with respect to violations of the normality assumption. This is particular true when the populations are symmetrical (but not normal) and the number of observations in each cell is equal, but at least 12, which apply to all of our three experiments. Consequently, if the first assumption of normality is not met in our data, the suggested univariate test statistics (see page 149, Table 19) can still be used, without violating valid inference making.

The second assumption is that of **homogeneity of variances,** i.e. that the variances within each treatment population are equal. There are different tests to evaluate this assumption of homoscedasticity, such as Hartley's F_{max} test, Cochran's *C* and Barlett-Box's *F* test statistic (Kirk, 1995, 101). The standard procedure in SPSS is the Levene test, which is not sensitive to departures from normality and which we will use to evaluate the homogeneity of variances in our data. On the robustness of the *F-test* statistic to violations of homoscedasticity, there is some discussion in literature. Kirk (1995, 100) follows Box, who states that the ANOVA F-test is robust with respect to violations of the homogeneity of variance assumption if (1) there is an equal number of observations in each of the treatment levels; (2) the populations are normal; and (3) the ratio of the largest to the smallest variance does not exceed 3. The same care towards violations of the homogeneity of variances is found in literature for the multiple comparison test statistics. Klockars & Sax (1986, 82) argue that the one procedure that is most justifiable for multiple comparisons, when there are heterogeneous variances, is Tukey's HSD as modified by Games and Howell[75]. The suggested Dunnett's test is not recommended, because it cannot control the probability of type I-error under heteroscedasticity. Consequently, if our data show violations to the equality of variances, we will better use the Games and Howell test statistic for making the two pairwise comparisons of hypotheses 1a and 1b.

The third assumption is that of **independence of the residuals**. This assumption is likely to be violated when two or more observations are obtained on each participant, when participants are not randomly sampled, or when participants are not randomly assigned to treatments. Toothaker (1993, 59) argues that if the research design includes randomization of participants to groups and if you avoid obvious dependence in the data, the independence assumption will be met. This third assumption is important, since both the ANOVA *F* and the multiple comparisons test statistics are not robust to violations of the independence assumption (Toothaker, 1993, 59). Careful research design (by assigning participants randomly to treatments) can assure independence of residuals in a study like ours. In each of the three lab experiments, participants will not work in teams, but individually on the assignment, with little communication between peers. Each score for cost, attractiveness and time spent will be measured individually. All participants will be exposed only once to a treatment, no one will participate to more than one experiment; participants in the pilot study will not participate later in one of the real experiments. Finally, communication between participants of the three populations from which we will recruit participants can be assumed to be zero because of different universities or different departments. By the carefully developed experimental procedures, as will be described in the following chapters 6, 7 and 8 (see pages 164, 192, 274), independence of the observations will be realized.

[75] The **Games and Howell** procedure for heterogeneous variances involves two parts. First, the difference between means is divided by a standard error that uses a separate rather than a pooled variance estimate. Second, the computed value of *t* is evaluated against the tabled value using a reduced number of degrees of freedom. (Toothaker, 1993, 62). When Tukey's HSD test is modified by these two formulas, the experimentwise type I-error rates is acceptable close to the 5% stated level, regardless of the heterogeneity of the variances (Klockars & Sax, 1986, 80).

9.2 MANOVA and Multiple Multivariate Comparison

Similarly, for the multivariate test statistics (Wilks' Lambda, Pillai's Trace as well as Hotelling's T^2) we can formulate the following underlying assumptions:

1. **Multivariate normality**: The observations are drawn from *multivariate* normally distributed populations.
2. **Multivariate homoscedasticity**: The *variance-covariance* matrices in each of the treatment groups are estimates of the same population variance-covariance matrix.
3. **Independence**: The observations are statistically independent of one another.

The first assumption accepts that the dependent variables are sampled from **multivariate normally distributed** populations. Unfortunately, none of the statistical packages contains procedures for assessing the degree of departure from multivariate normality. Manly (1986,15) explains that a minimum requirement for a distribution to be multivariate normal is that all the individual variables are normally distributed. Though, if variables are each *univariate* normal, they do not necessarily have a *multivariate* normal distribution. However, it is more likely that the assumption of multivariate normality is met, if all dependent variables are normally distributed (Tabachnick & Fidell, 1989, 79). Furthermore, Bray & Maxwell (1990, 33) summarize that departure from multivariate normality generally has only very slight effects on the type I-error rates. The only exception is Roy's Greatest Root, which may lead to too much type I-errors when one of several groups has a non-normal distribution. As mentioned earlier (see page 149), we will use Wilks' Lambda, Pillai's Trace and Hotelling's T^2 as multivariate test statistics. So, if the data are not drawn from a multivariate normal distribution, the results are still valid, because of the robustness of these suggested tests.

The second assumption of **multivariate homoscedasticity** assumes that the variance-covariance matrices within each treatment group are sampled from the same population variance-covariance matrix. Tabachnick & Fidell (1989, 379) explain that this assumption assures that the different variance-covariance matrices can be pooled to create a single estimate of error. The assumption is twofold. First, the univariate homogeneity of variance assumption must be met for each dependent variable and second, the correlation between any two dependent variables must be the same in each of the treatment groups. A *multivariate* test for the homogeneity of the variance-covariance matrix is provided by Box's *M* test (Tabachnick & Fidell, 1989, 379). The effects of failing to meet the equality of variance-covariance matrices are more complicated than in the univariate case, as Bray & Maxwell (1990, 32) state. When sample sizes are unequal, none of the four multivariate test statistics is robust. When sample sizes are equal, like in our study, all of the multivariate test statistics tend to be robust unless sample sizes are small, or the number of variables is large and the difference in matrices is quite large. Finally, Bray & Maxwell (1990, 32) summarize that with equal sample sizes, Pillai's Trace is much more robust across a wide range of population configurations than any of the other multivariate statistics. Consequently, when finding heterogeneity of variance-covariance matrices in our data, we might better use Pillai's Trace instead of Wilks' Lambda to test the second hypothesis. For testing hypotheses four, Pillai's Trace was already selected as the most appropriate multivariate test criterion (see earlier on page 143).

The third assumption is that of **independence** of the observations. Again, none of the multivariate test statistics is robust towards violations of this independence assumption (Bray & Maxwell, 1990, 33). As mentioned under the univariate assumptions, we will assign participants randomly to treatments and each participant will only be exposed to one treatment. Carefully developed procedures as well as different subpopulations, as will be described in the following chapters when discussing the three lab experiments, assure that independence of the observations are realized.

In sum, before testing the earlier developed hypotheses on the cost level, the quality level and the achieved time-to-market, we need to check the data first to see if the assumptions of normality and homoscedasticity are not violated. If the assumptions are violated, some other tests are more appropriate to test certain hypotheses, as summarized in Table 21.

Table 21: Summary of the Statistics to test the Hypotheses if the Assumptions of the Tests are violated

	Suggested test statistics	**Test Statistics when Violations to *Normality***	**Test Statistics when Violations to *Homoscedasticity***
H1	F-test	F-test	F-test if difference < 3
H1a	Dunnett's Test	Dunnett's Test	Games Howell
H1b	Dunnett's Test	Dunnett's Test	Games Howell
H2	Wilks' Lambda	Wilks' Lambda	Pillai's Trace
H2a	Hotelling's T^2 and t-test	Hotelling's T^2 and t-test	Hotelling's T^2 and t-test
H2b	Hotelling's T^2 and t-test	Hotelling's T^2 and t-test	Hotelling's T^2 and t-test
H3	F-test	F-test	F-test if difference < 3, t-test
H3a	F-test and t-test	F-test and t-test	F-test if difference < 3, t-test
H3b	F-test and t-test	F-test and t-test	F-test if difference < 3, t-test
H4	Pillai's Trace	Pillai's Trace	Pillai's Trace
H4a	Hotelling's T^2, F-test, t-test	Hotelling's T^2, F-test, t-test	Hotelling's T^2, F-test, t-test
H4b	Hotelling's T^2, F-test, t-test	Hotelling's T^2, F-test, t-test	Hotelling's T^2, F-test, t-test

10. Conclusion

In this chapter, we described the research design and the statistics needed to test the different hypotheses, as developed in chapter three. As research design, we choose for the *completely randomized factorial design*. The first independent variable "target cost setting" has three levels, while the second independent variable "difficulty of the time-to-market objective" has two levels. The completely randomized factorial design allows us to randomly assign participants to just one of the six treatments, considering all effects as between subjects.

To test the hypotheses, different test statistics were proposed. Table 19 on page 149 gives a short overview, while Table 20 on page 150 gives a detailed overview. Hypotheses one and three ask for a *univariate* analysis, while hypotheses two and four ask for a *multivariate* analysis. Hypotheses one and two involve testing a *main* effect, while hypotheses three and four involve testing an *interaction* effect. These factors explain why we need for each hypothesis a different test strategy. In sum, the *univariate main* effect of **hypothesis one** will be tested by an ANOVA F-test, while the pairwise comparisons on the cost level will be analyzed using Dunnett's test. The *multivariate main* effect of **hypothesis two** will be tested by a MANOVA, with Wilks' Lambda as test criterion. The pairwise multivariate comparisons on a combination of the three dependent variables will be further analyzed by Hotelling's T^2. Further analyzing the significantly different pairs of TCS, can be done by univariate t-tests for each dependent variable separate. The *univariate interaction* effect of **hypothesis three** will be analyzed by an ANOVA F-test, followed by different F-tests for the interactions of the subtables. The *multivariate interaction* effect of **hypothesis four** will be analyzed by a MANOVA with Pillai's Trace as the test criterion. Hotelling's T^2 tests will be used for analyzing the multivariate interaction effect on the subtables. Analyzing the significant subtables will be done by different ANOVA F-tests on each dependent variable separately and by simple main effects using the t-test statistic.

Though, for these suggested tests statistics is it necessary that the **assumptions** of normality, homoscedasticity and independence are supported by the data. As discussed in the previous paragraphs, some of the test statistics are robust towards violations of the normality and homoscedasticity assumption and can thus still be used. For other test statistics, such as Dunnett or Wilks' Lambda, we will use alternative tests that are less sensitive to departures from the underlying assumptions of homoscedasticity.

Chapter 6: Experiment One

1. Introduction

In the first chapter, we described four main research questions (see page 25). In chapter three, we developed different scientific and statistical hypotheses to answer the research questions (see page 99). In chapter four, we came to the conclusion that the lab experiment is an adequate research method to obtain an answer for the research questions (see page 105). In the previous chapter we decided to use the completely randomized design as research design and we discussed the relevant statistics to test the hypotheses (see page 149). In the following three chapters we will describe the three lab experiments, as shown in Figure 31. In this chapter, we address the first experiment, performed at Vanderbilt University (Nashville, Tennessee, USA). In the next two chapters, we discuss the experiments two and three, performed at the University of Ghent (Belgium).

Figure 31: Overview of the Three Lab Experiments

	Chapter 6 Experiment One CR-3			Chapter 7 Experiment Two CRF-32			Chapter 8 Experiment Three CRF-22		
	Testing the Task			**Testing Hypotheses**			**Testing Hypotheses**		
	Non-TCS	**Easy TCS**	**Diff TCS**	**Non-TCS**	**Easy TCS**	**Diff TCS**	**Non-TCS**	**Easy TCS**	**Diff TCS**
Easy TIME	**X**	**X**	**X**	**X**	**X**	**X**	**X**		**X**
Difficult TIME				**X**	**X**	**X**	**X**		**X**

As shown in Figure 31 and mentioned in the previous chapter, the design of experiment one is **incomplete**. We run in this first experiment only the easy TIME condition, because the main purpose is to test the feasibility of the experimental task. In the following two experiments, both TIME conditions will be included, because those following two experiments are really set up to test the developed hypotheses. Consequently, it is important to recognize that the conclusions of this dissertation are mainly based on the results of **experiment two** (Chapter 7) and **experiment three** (Chapter 8). Though, we decided to include the description and results of experiment one as well in a separate chapter (i.e. this chapter 6), to notify the reader of the **learning process** we lived through to come to the results in Chapter 7 and Chapter 8.

Thus this first experiment can be seen as a ***test* experiment** (and is hence less than perfect), because it is a test in many aspects: i.e.

1. Testing whether the developed task can be set up while realizing *experimental realism* with individuals (students) who had *no education or no experience* with designing.
2. Testing whether the developed task can be used in a *one-shot* lab experiment, with a *short time period*.
3. Testing whether the developed task is considered as a task with three *conflicting* goals, to be attained simultaneously, which is characteristic to the new product development environment.
4. When the preceding three conditions are met, we can test whether our *first hypothesis* is supported by the data, i.e. testing whether the cost level of a future product will significantly differ among the non-TCS, easy TCS and difficult TCS in the hypothesized direction.

Furthermore, this first experiment also provides a **learning experience** to the researcher in administering a lab experiment. Afterwards we will see that this test experiment gave us the opportunity to formulate some important conclusions for setting up the next two experiments, as discussed at the end of the chapter (see page 177).

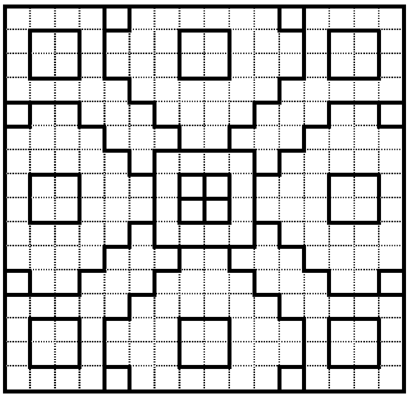
The next pages are organized as follows: The main part of this chapter focuses on describing the organization of the experiment, i.e. the task, the experimental design, the simulated NPD environment, the bonus system, the pilot study, the participants and the procedures. In section 9 the measurement of the variables is shortly addresses, in section 10 the data are screened and in section 11 the first hypothesis is tested. Finally, this chapter ends with exploring the data for attractiveness and with listing the lessons to learn from this first experiment.

2. Task

The idea for the task came from the **carpet industry** and was developed after a series of discussions with the controller of a Belgian textile concern. Hence, the task used in all three experiments shows some resemblance to the job of design engineers in the carpet industry. In the current field studies of Cooper (1995) in Japan, the target costing system has not been described in a textile company[76]. Though, Brausch (1994, 48) reports on target costing used in an American textile company and concludes that the target costing system was well developed and very useful for that company. We quote: "*Because they are in the decorative fabric business, design is a major part of the firm's manufacturing process. The design staff constantly is developing new products with new applications for new markets. The design staff is good, but it never purposely designed for profitability. The target sales price was readily available because the product's perceived value is easily determined based on the "look" of the product*". (Brausch, 1994, 48)

Basically, the purpose of the experimental task was to design a carpet for the student bedroom market. A traditional pattern (6 cm by 6 cm, representing a squared yard) is given, as shown in Figure 32. From the figure, you can see that the pattern of 256 small areas was predefined in a basic pattern of 29 larger areas. Participants were asked to select the appropriate colors for these 29 areas. Colors could be selected from a pallet of 10 basic colors, represented by 9 color pencils and white. By coloring the pattern, participants could easily imagine the carpet they created.

Figure 32: Pattern of the Carpet Designing Task of Experiment One



Furthermore, participants were informed about the cost system, as shown in Table 22. The cost system included the *direct* cost differences between yarn of different colors, but also took into account the higher *indirect* costs when using many colors in a carpet due to higher setup costs of the machines, more material handling costs, more material ordering costs, etc. Especially, there were three groups of colors, having a total cost of $0.10, $0.30 and $0.50 per small area respectively. In a standard setting, machines and employees of the firm could handle five different colors in a rug. Adding an extra color made the total cost per small area $0.20, $0.40 and $0.60 respectively. The levels of these costs were determined, taking into account both realism and ease of calculation. The pattern sheets were constructed in two parts: the standard patterns of the rug on the first half (which students had to color) and the cost calculation table on the second half. In this table participants could easily calculate the cost of their creation during the experiment, providing instant feedback on the cost level of the created rug. An example of this pattern sheet is given in appendix one, on page 364.

Table 22: Cost Calculation System in Experiment One

	Cost per small area *standard* color	Cost per small area *additional* color
	Class A:	Class A+:
White	$0.10	$ 0.20
Black	$0.10	$ 0.20
	Class B:	Class B+:
Yellow	$0.30	$ 0.40
Orange	$0.30	$ 0.40
Sky blue	$0.30	$ 0.40
	Class C:	Class C+:
Red	$ 0.50	$ 0.60
Brown	$ 0.50	$ 0.60
Blue	$ 0.50	$ 0.60
Violet	$ 0.50	$ 0.60
Green	$ 0.50	$ 0.60

Summarizing, the target costing system in the experimental task meets the essential characteristics of target costing, as developed earlier in chapter 2 (see page 37). The *target sales price* and the *target profit margin* is derived during product planning, i.e. before participants start with the design task. The *target cost* is assigned to participants, before they start with the new product development. The target cost is set at the *lowest level*, i.e. for an individual designer, and for the cost items "direct material" and "indirect material-related" costs. *Detailed cost information* is provided during NPD by the table above (see Table 22), supporting cost reduction ideas. The cost level of the design can be *compared with the target cost* anytime during NPD, since participants immediately calculate the cost level below each created design. Participants are instructed not to turn in a design with a cost level higher than the target cost, reflecting the *general rule* that the target cost can never be exceeded.

[76] As will be discussed further in paragraph 4 on page 161, the design task in this simulated textile environment is essentially the same as the design task of design engineers **at Olympus**, a camera-producer, where the target costing system was fully developed and documented by Cooper (1994f).

3. Experimental Design

Three levels of target cost setting are considered, i.e. a non-target cost setting (non-TCS), an easy target cost setting (easy TCS) and a difficult target cost setting (difficult TCS). Participants in the non-TCS are instructed to *design an attractive carpet, trying to minimize the cost of the carpet*. Participants in the easy TCS are instructed to *design an attractive carpet, taking into account a maximum cost of $103*. Participants in the difficult TCS are instructed the same, but with a *maximum cost of $60*.

Just one level of the **time-to-market difficulty** is considered, i.e. an easy time objective (easy TIME) of one hour. Consequently, this first experiment involves a *completely randomized* design CR-3, with one factor, i.e. the target cost setting. This factor has three levels, the non-TCS, the easy TCS and the difficult TCS, as shown in Figure 33. It is a balanced design, since each of the three cells will contain 15 participants.

Figure 33: Completely Randomized Design CR-3 of Experiment One

	Non-TCS	**Easy TCS**	**Difficult TCS**
Easy TIME	Group 1 (n = 15)	Group 2 (n = 15)	Group 3 (n = 15)
Difficult TIME	-	-	-

4. New Product Development Goals

In this study, we simulate in all experiments, a NPD environment with **three conflicting goals** that need to be attained simultaneously. First, there is a **quality** objective, second there is a **cost** objective and third there is a **time** objective. Here the aesthetic value (or the *attractiveness* of the carpet) is used as the dimension of quality (Garvin, 1987). The cost objective is specific in the easy and difficult TCS, while a do-best goal (minimize the cost level) is assigned in the non-TCS. In all conditions, participants receive a specific *time* limit.

As discussed earlier (see page 18), Cooper (1995, 30) advises not to expend equal effort on all three characteristics of the survival triplet, because one characteristic is usually the most important characteristic to the customers. Here, in our experiment **priority** among the three NPD characteristics is given in the following sequence: attractiveness, cost, time. We set attractiveness as the first criterion since we simulate a market where the customer is highly sensitive to the aesthetic value of the product. Consequently, it makes no sense to design a low cost carpet that is not perceived as attractive by the market. We set cost as the second criterion. By giving an additional bonus for low cost designs, we stress that cost is much more important than time. Thus in terms of Cooper's (1995) survival triplet (see page 19 earlier), the aesthetic value dominates the cost and time characteristic of the survival triplet in the NPD environment of our experiments.

Furthermore, in terms of **latitude** (i.e. the range between the minimum allowable and the maximum feasible) on each of the three elements of the survival zone, we simulate an environment where some latitude on aesthetics is allowed throughout the development cycle. But no latitude is accepted for the cost characteristic (because of a given market price) and less latitude is accepted for the time-to-market objective (because of the risk being left behind by competitors).

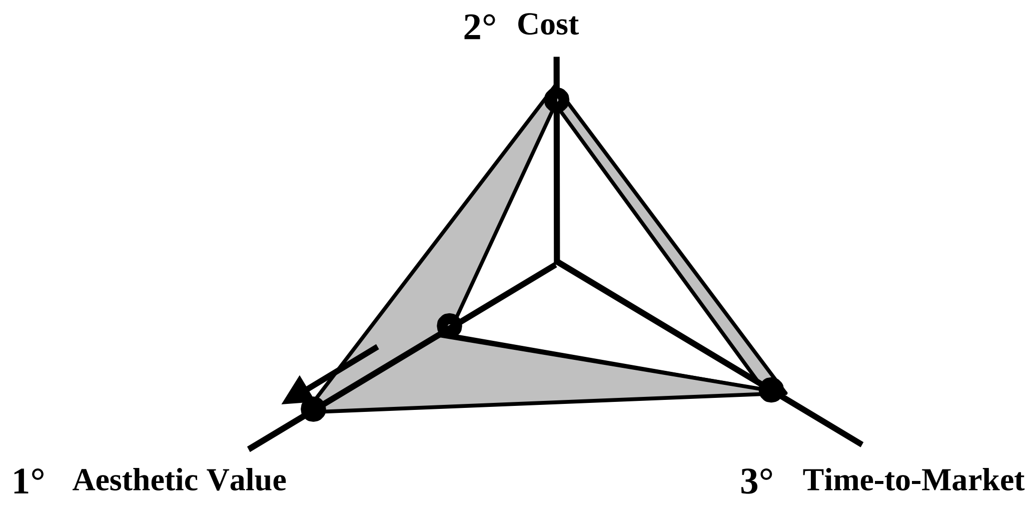
Finally, we simulate an environment of aggressive design, asking for **increased aesthetics** (attractiveness). In the experiment, we instruct participants to go as far as they can in terms of attractiveness, which basically meant that participants should do their best in creating the most attractive carpet. In terms of Cooper's survival triplet, this means that the firm's strategy stresses continuously increasing product functionality[77] (in the sense of aesthetics), as shown in Figure 34.

To set up the experiment, we got inspiration from the Olympus case (Cooper 1994f). **In fact, the simulated NPD environment is identical to the one of Olympus, a Japanese camera producer, where the target costing system seems to work**, as described in Cooper (1994f). Olympus competes almost solely on the functionality it offers at a given price point, since the price is essentially given at the market. The survival zone of a given camera at any moment in time has some latitude on functionality, but almost no latitude on price and time-to-market[78], as shown in Figure 34 (Cooper, 1995, 73). **Hence, the NPD environment to which we want to generalize the results of the experiments is the one with priority given to ever increasing functionality** (in the sense of Cooper, 1995), **with second priority to attaining the target cost and last priority to realizing the time-to-market objective. The latitude on both the cost and the time-to-market objectives are small, compared to the broad latitude on the functionality objective.**

[77] As mentioned earlier in footnote 20 on page 20, there exists some confusion on what is understood under "quality" in the definition of Cooper (1995, 15) when considering his survival triplet. Cooper (1995) would call the **aesthetic value** an aspect of *functionality*, while limiting in his definition quality to the conformity dimension. Under the general accepted definition of Garvin (1987), aesthetic value is considered as one of the eight dimensions of *quality*.

[78] Remark that Cooper (1995) considers "**time-to-market**" also as an element of functionality. To keep only three axes in the survival triplet, we consider time-to-market as the third axes, deleting quality (in the sense of conformance) which is not considered in our study here.

Figure 34: The NPD Goals and the Survival Triplet of Experiment One



5. Bonus System

The incentive system was set up to clarify the **priority** among the three characteristics attractiveness, cost and time-to-market. A bonus of $10 is given to the four most attractive carpets in each of the three groups. Among those four participants with the most attractive carpet, the participants of the two lowest cost creations get an additional bonus of $10[79]. It would be unfair to let participants compete with participants who receive other instructions. Thus, bonus determination occurs in each of the three groups separately.

Actually, both the bonus for an attractive design as well as for a low cost design is based on competition. This **competition based bonus system** was set up to increase the participant's efforts. According to Locke (1968, 179), including competition probably encourages individuals to remain committed to the goals that they might otherwise abandon in the face of fatigue and difficulty.

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[79] These amounts of 4$ on average for one hour and a half **are comparable** to bonuses used in previous studies. For instance, in Terborg & Miller (1978) the maximum amount was $5 for one hour work, in Chow (1983) the average pay was $6 for two one-hour sessions. Birnberg, Shields & Young (1990, 46) argue that incentives are important to *attract* participants and to *motivate* them during the experiment. The critical balance for the researcher is to provide the kinds of incentives that will motivate subjects to become involved in the task and, at the same time, will not bias the results.

6. Pilot Study

The levels of the difficult and the easy TCS of $60 and $103 respectively are based on a rudimental (though seemingly efficient) pilot test. The researcher made ten different designs at different times during a week. The level of the difficult TCS goal was established at $60, attainable in 40% of the cases. The level of the easy TCS was set at $103, attainable in 80% of the cases. These degrees of attainability corresponded to what has been used before in studies on goal setting (Locke & Latham, 1990, 349). Furthermore, as the data will show, 40% of the participants in the non-TCS group made a design with a cost level equal or lower than the difficult target cost of $60. And 80% of the participants in the non-TCS made a design with a cost level equal or lower than the easy target cost of $103. These data of the non-TCS group indicate that the levels of $60 and $103 represent a reasonable range of difficulty, as will be confirmed by the manipulation checks.

7. Participants

The sampling method is a **convenience sample,** using all students who were more or less familiar with the researcher or who took the course "experimental design" of Prof. Lappin. In Appendix One, page 349 the recruitment letter is shown. In this letter, students are told that the study involves testing whether or not different data results in different behavior in decision making. They were informed that the exercise would take no longer than one hour and a half. It was stressed that participation was *voluntary* and that the task involved *no specific skills* or conceivable risk of any kind. Furthermore, they were informed that they had a chance of 13% (2/15) to win a bonus of $10 and a chance of 13% (2/15) to win a bonus of $20, giving a total chance of one to four to earn some money.

Forty-six students participated in this first experiment (see Appendix One, page 351 for the list), of which 11 were undergraduates, 23 graduates and 9 Ph.D.-students at Vanderbilt University (Nashville, Tennessee, USA). These volunteers were females 16 (36%) and males 30 (64%), as shown further in Table 26 on page 172.

8. Procedures

Carefully setting up experimental situations and conditions is a way of controlling the error variance, as Kerlinger (1973, 312) explains. In experiment one, just as in experiment two and three, this was effected by written instructions to participants. **Participants** received an eleven-page written instruction bundle as shown in Appendix One, page 353. The 15 **judges**, that scored the designs afterwards, received a one-page instruction sheet, as shown in Appendix One, page 372.

Students reported to the experimental sessions in groups of three to fifteen. In total there were six sessions, **equal in setting and timing**. Each session took no longer than one hour and a half. This time period was split up in three blocks: 15 minutes for instructions, 60 minutes for the task itself and 15 minutes to answer the post experimental questionnaire. A summary of the procedure is given in Table 23.

Students choose a **numbered card** upon arrival. This number assigned them to one of the three treatment conditions and referred to the numbered seats. For each participant, all the **material** was ready on the table (i.e. the folder with the instruction and pattern sheets, a set of 9 sharpened pencils, a pen and an eraser). One automatic sharpener was available in each session. Then, participants went through the eleven-page **instruction sheets**, page by page, as instructed by the researcher. These written instructions (see Appendix One, page 353) covered comments on practical issues such as the pattern, the colors, the cost of the colors, the cost calculation table, two examples of cost calculation, the objective of the task, the bonus and a one-page summary. In addition to these written instructions, four **overhead sheets** were presented (see Appendix One, page 365). The first slide presented a summary to indicate which topic participants should read at each time. The purpose of the second slide was to make sure that every participant understood what was allowed in terms of merging and splitting predefined fields (page 3 of the instructions). Slides three and four were discussed together to make sure that all participants knew how to calculate the total cost of the rug by using the cost calculation table on the second part of the pattern sheets (explained on the pages 7 and 8 in the instructions). Questions were allowed during this slide presentation. Questions about issues covered in other pages were answered on an individual basis, because of the danger to reveal some of the experimental conditions.

Consequently, students **worked individually** on the task, during 60 minutes at most. When finished, they handed in their most favored design. Before leaving, they completed a very elementary one-page **post experimental survey**, asking general kind of questions, manipulation checks and information to give the researcher some feedback on the task itself.

Total experimental time never exceeded **one hour and a half**. Participants were not allowed to talk, although they were **relaxed**. To keep **anonymity**, the pattern sheets of each participant contained only a preprinted number (equal to that of their pre-numbered card they choose upon arrival). In order to know to whom a bonus should be paid, participants were asked to write their name and phone number (or email address) on that numbered card and put it in an envelope, which was sealed by a volunteer.

These same volunteers (one per session) unsealed the envelope a few weeks later, when the bonus numbers were decided on. Appendix One, page 375 contains an example of the declaration form on the sealed envelope. Bonus **pay** occurred individually, by making an appointment with each participant. Participants received an envelope with the right bonus amount and signed the receipt bonus form, as shown in Appendix One, page 376.

Finally, all participants receive by email a written **feedback report**, a few days after the last session (see Appendix One, page 379).

Table 23: Overview of the Procedures in Experiment One

	Procedure	**Reference to the Instruction Sheets and Overhead Sheets**[80]
1	Each participant chooses one of the **numbered** green cards when arriving.	
2	Participants are take place on the **numbered** seats. The number on the card refers to the number on the seat.	
3	The experimenter is giving a short **welcome** to the group.	
4	Participants **start with reading** the instruction sheets, page by page.	
5	Participants are checking the given **material**.	Page 2
6	Participants are reading the instructions on the **pattern** and the researcher is showing some right and wrong examples on overhead sheet.	Page 3 + Slide 2
7	Participants are reading the instructions on the **colors**.	Page 4
8	Participants are reading the instructions on the **cost system**.	Page 5
9	Participants are reading the instructions on the **cost calculation table**: direct and indirect costs.	Page 6
10	Participants are reading the instructions on a **first example** of the cost calculation table for a design with 4 colors. The researcher explains shortly the example.	Page 7 + slide 3
11	Participants are reading the instructions on a **second example** of the cost calculation table for a design with 6 colors. The researcher explains shortly the example.	Page 8 + slide 4
12	Participants are reading the instructions on the **task**, with the specific target cost setting.	Page 9
13	Participants are reading the instructions on the **bonus system**.	Page 10
14	Participants are reading the instructions that **summarize** all the relevant information for the task.	Page 11
15	Participants are working during 60 minutes (or less) on the **task**.	

[80] See appendix One, page 353 et seq. for the **instruction sheets** to participants and page 365 for the **overhead sheets** used during these instructions to participants.

16	When finished, each participant is **handing in** just one design.	
17	Each participant is completing the post experimental **questionnaire**.	
18	Each participant is writing his/her name (and email address) on the numbered green card.	
19	A volunteer is **sealing** the envelope with the green cards of all participants, to keep anonymity.	
20	In the following days, volunteers are recruited as **judges** at the lobby of the Owen Graduate School of Management. They receive oral explanation of the task and read the one-page instruction sheet.	
21	The researcher is doing the **input** of the cost level, the total score on attractiveness and the time spent into the Excell-spreadsheets to determine the bonus numbers for each group.	
22	The researcher is preparing the **envelopes** with the right amount of money. Bonus receipt forms are completed with the ID numbers.	
23	The same volunteer is **unsealing** the envelope with the green cards.	
24	The researcher is making an appointment with the winners. **Bonus pay** occurs and participants are signing the bonus receipt form.	

9. Measurement of the Variables

9.1 Attractiveness and Cost Level

The two main dependent variables in this experiment are **cost level** and **attractiveness** (quality level). The time spent was not measured, but will be measured in the following two experiments.

The **cost level** is measured as the *total cost* of the created pattern that each participant handed in at the end of the session. As mentioned above, participants were taught how to calculate the cost level of their design by completing the cost calculation table below the created designs.

Attractiveness is measured as the mean score from 15 different judges. These judges were students as well, comparable in terms of age, gender and discipline with the participants of the experiment. None of the judges had participated in the experiment. We asked each of these judges individually to make five different stacks of the designs, ranging from the most preferred designs to the least preferred. We told them that these rugs are designs for a carpet in a student bedroom. See Appendix One, page 372, for the instruction sheet to the judges. The judges could decide themselves about the number of rugs in each batch. The most preferred carpets were given a score of 5, the next batch a score of 4, etc… and a score of 1 for the least preferred batch. Appendix One, page 373 displays the individual scores for each of the judges. A Cronbach's Alpha Reliability Coefficient was calculated for each design to determine the interrater reliability. The Cronbach's Alpha for the scores of the 15 judges was .78 and .82 if the scores from judge K were deleted.

9.2 Other Variables

The one-page post experimental questionnaire (see Appendix One, page 369 et seq.) was mainly set up to give feedback on the experimental task itself. *General kind of questions* included **gender**, **type of student** (MBA, Ph.D.), **discipline** of education (department), **experience with design tasks before** (yes/no) and **guessing the real purpose** of the study. Also a question was included to capture the perception on the *difficulty of the target cost*. Seven more questions were included to give *feedback on the experimental task.* These questions ask if they **liked the task,** if they could **guess the purpose** of the study. Also the **total number** of designs made, the number of designs made **under the target cost** (for easy TCS and difficult TCS), the perception of the **cost level** (for non-TCS) and the perception of the **time difficulty**. Finally, an open-ended question was added where additional **comments** could be given, which are included in Appendix One, page 378. Table 24 gives a summary of the questions included in this post experimental questionnaire.

Table 24: Structure of the (Elementary) Post Experimental Questionnaire of Experiment One

Variable name	Short Description	Measurement Scale	Item n° Non-TCS	Item n° Easy TCS Diff TCS
	General kind of questions:			
GENDER	Male or Female participant	Nominal	9	10
STUDENT	Type of student (undergraduate, MBA, Ph.D., other)	Nominal	1	1
OPTION	Department (Psychology, Economics, Owen, other, spouse)	Nominal	2	2
EXPERIEN	Experience with design tasks before (yes/no)	Nominal	3	3
	Manipulation check:			
COSTDIF	Perception of target cost difficulty, (1-5 scale)	Interval	-	5
	Questions to give feedback on the task:			
PURPOSE	Guessing the purpose of the study (yes/no)	Nominal	8	9
TOTALDES	Total number of designs made	Ratio	7	7
UNDERTAR	Number of designs made under target cost	Ratio	-	8
COSTPERC	Perception of cost level (1-5 scale)	Interval	5	-
TIMEDIF	Perception of difficulty time goal, (1-5 scale)	Interval	6	6
LIKETASK	Did you like the task (1-5 scale)	Interval	4	4
COMMENT	Comments on the exercise	-	10	11

So far, we have discussed the *practical organization* of the first experiment as well as the used *measurement scales* of the variables. From the next section on, we will make the jump to reviewing the "real" data, collected during the experimental task. We will first *screen the data*, and then proceed with *testing hypothesis one*.

10. Data Screening

10.1 Manipulation Checks

Based on the answers on the question about the target cost difficulty in the post experimental questionnaire (see Appendix One, page 369 et seq.), we can check if participants also perceived the target cost more difficult to attain in the difficult TCS than in the easy TCS. Conform the manipulation, the difficult target cost was perceived as more difficult in the difficult TCS (group mean = 2.6) than in the easy TCS (group mean = 1.8), revealing a significant group difference ($F(1,28) = 4.48$, $p = 0.043$), as shown in Table 25. Hence, the manipulation of the target cost difficulty can be considered as successful.

Table 25: ANOVA for the Manipulation Check on Target Cost Difficulty in Experiment One

ANOVA		Sum of Squares	Df	Mean Square	F	Sig.	Eta Squared
Target Cost Difficulty	Between Groups	4.800	1	4.800	4.480	**0.043**	0.138
	Within Groups	30.000	28	1.071			
	Total	34.800	29				

10.2 Accuracy of the Data

The data were entered in SPSS by the researcher. Frequency tables were examined for all variables to ensure no out-of-range numbers. When participants made a mistake in their cost calculation table, the correct total cost was used as the operationalization for the cost level[81]. Making mistakes was independent of the manipulation ($\chi^2 = 1.5$, $p = .47$).

One observation is **deleted** because we doubt if the student took the task seriously. He/she was done after nine minutes. This participant made only one design and gave the weird answer that the time period of one hour was just right to complete the task. All the others took the task seriously and hence the data are the result of participants working on the task to the best of their power.

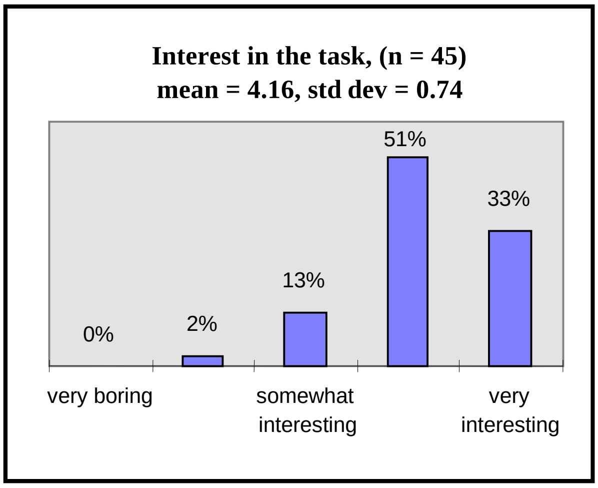
[81] Participants made only minor mistakes in positive as well as in negative sense (mean = \$ .95 compared to the grand mean cost level of \$ 65.73). Using the right or the wrong cost level is **not biasing the results**, since the results of hypothesis 1 are the same with the wrong cost levels ($F(2, 42) = 3.8$, $p = .031$) as with the correct cost levels ($F(2, 42) = 3.9$ $p = .027$). Because of higher accuracy, we will report in the following sections the results using the correct cost levels.

10.3 Descriptive Statistics

For the nominal measured data, the **frequency tables** are shown in Table 26. Most of the participants were male (64%), the largest category were MBA-students (51%), and most of the participants studied at The Owen Graduate School of Management (64%). More than half (64%) did a guess on the purpose of the task. Appendix One, page 377 gives an overview of these guesses. Almost none of the participants, except two, said to have experience with that sort of task before. They both admitted that they had done a rank ordering of the designs in the pilot test. These observations were not deleted because both participants could not guess what the real purpose of the experiment was and because the rank ordering task was totally different from the creation task used here. Furthermore, random assignment to treatment was successfully, since the target costing manipulation was independent of gender, student type, discipline and experience before[82].

Descriptive statistics are given in Table 27 on the next page. From this table, we can see that the cost level varied between $25.60 and $128.00 with a mean of $65.73. The scores for attractiveness ranged between 1.3 and 4.5 with a mean of 2.7. On average, participants made 4 different designs and for those in the easy and difficult TCS, on average, 3 of the created designs were under the given target cost. The time limitation of one hour was perceived as long enough; no one perceived it too short, only two participants checked the answer between "too short" and "just right". In general, participants liked the task, since on the question "did you like the task in the experiment" only one participant checked the answer between "very boring" and "somewhat interesting". All the others found the task "somewhat interesting", "interesting" or "very interesting", as shown in Figure 35.

Figure 35: Frequency Chart for "Interest in the Task" in Experiment One



[82] **None** of the Chi-Square tests **were significant** at $\alpha = 5\%$ (TCS by gender $\chi^2 = 1.4$, p = .51, TCS by student type $\chi^2 = 5.0$, p = .54, TCS by discipline $\chi^2 = 4.4$, p = .82, TCS by experience before $\chi^2 = .10$, p = .59).

Table 26: Frequencies of the Nominal Measured Data in Experiment One

		Frequency	Percent	Valid Percent	Cum Percent
Gender of participant	Female	16	35.6	35.6	35.6
	Male	29	64.4	64.4	100
Student type	Undergraduate	11	24.4	24.4	24.4
	MBA	23	51.1	51.1	75.6
	Ph.D.	9	20.0	20	95.6
	Other	2	4.4	4.4	100
Discipline of education	Psychology	6	13.3	13.3	13.3
	Economics	3	6.7	6.67	20
	Owen	29	64.4	64.4	84.4
	Arts & Science	3	6.7	6.6	91.1
	Other	4	8.9	8.89	100
Experience with designing task	Yes, experience	2	4.4	4.4	4.4
	No, experience	43	95.6	95.6	100
Guessing purpose of exercise	I do a guess on the purpose	29	64.4	64.4	64.4
	I have no idea of the purpose	16	35.6	35.6	100
	Total	45	**100**		

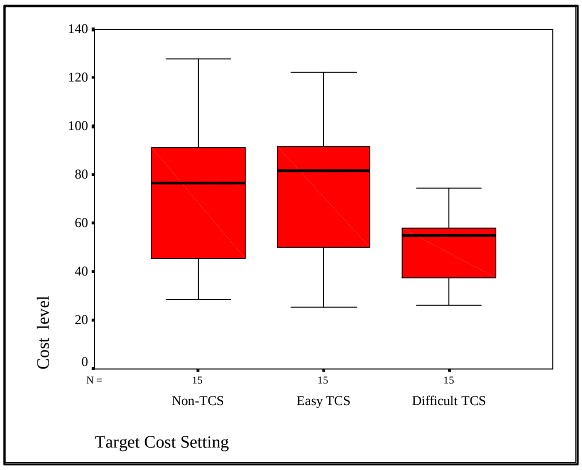
Table 27: Descriptive Statistics for Experiment One

Variable	Label	N	Min	Max	Mean	Std. Dev.	Variance
COST	Cost level	45	25.6	128	65.73	27.8729	776.901
MEANATTR	Attractiveness	45	1.3	4.5	2.7	0.69	0.471
MANICOST	Perception of target cost difficulty	30	1	5	3.80	1.10	1.200
TOTALDES	Number of designs made in total	45	1	9	4.16	2.08	4.316
UNDERTA	Number of designs under target cost	29	0	8	3.31	1.93	3.722
COSTPERC	Perception of cost level in non-TCS	15	1	5	2.87	1.25	1.552
TIMEPERC	Perception of time difficulty	45	2	5	3.38	0.72	0.513
LIKETASK	Interest in the task	45	2	5	4.16	0.74	0.543

10.4 Outliers and Extreme Values

To identify possible **univariate outliers** we made the boxplots for the dependent variable cost level for each TCS, as shown in Figure 36. None of the observations were more than 1.5 box length removed from the 25th and 75th percentile, suggesting the data do not show outliers or extreme values.

Figure 36: Boxplots for the Cost Level in Experiment One



Summarizing, screening the data of experiment one learns that the target cost manipulations were correctly operationalized: the difficult target cost was perceived as more difficult than the easy target cost. Participants were interested in the task and took the task seriously, apart from one participant, for whom we deleted the data in the data set. No outliers were found for the cost level.

11. Testing Hypothesis One

11.1 ANOVA for Hypothesis 1

The first hypothesis asks whether the cost level of a future product will significantly differ among the non-TCS, easy TCS and difficult TCS. From target costing literature, we expect a lower cost level under the difficult TCS than under the non-TCS. The boxplots, as shown in Figure 36, suggest that the cost level of the designs differ among the three TCS. To test hypothesis 1, we need to do the ANOVA F-test, as discussed earlier on page 135. As shown in Table 28, the ANOVA F-test finds a **significant** group difference in cost level (at α = 5%) among the three TCS groups ($F(2,42) = 3.96$, $p = 0.027$). Thus hypothesis 1 is <u>supported</u> by the data, explaining 15.9% of the variance. Though, given the heteroscedasticity of the data for the cost level (Levene test statistic = 4.6, p = .016, ratio of largest to smallest variance = 5.7, thus > 3), we know that this significance level might not be correct, because of a possible discrepancy between the actual type I-error and the nominal significance level.

Table 28: ANOVA on the Cost Level for the three Target Cost Settings in Experiment One

ANOVA		**Sum of Squares**	**Df**	**Mean Square**	**F**	**Sig.**	**Eta Squared**
Cost level	Between Groups	5422.880	2	2711.440	3.960	**0.027***	0.159
	Within Groups	28760.756	42	684.780			
	Total	34183.636	44				
*	This significance level may not be correct, because of heteroscedasticity of the data						

11.2 Pairwise Comparisons for Hypotheses 1a and 1b

Analyzing this significant ANOVA, we are mainly interested in the difference between the non-TCS and the difficult TCS and between the non-TCS and the easy TCS. As discussed earlier, hypothesis 1a expects a lower cost level under the difficult TCS than under the non-TCS. Hypothesis 1b expects a lower cost level under the non-TCS than under the easy TCS. To test these hypotheses 1a and 1b, we proposed earlier (see page 136) to perform pairwise comparisons by Dunnett's test. But because of violations to the homoscedasticity assumption for the cost level here, only the Games-Howell correction of Tukey's HSD test can be done (see page 152). The results of this Games-Howell test are shown in Table 30.

<u>First</u>, the Games-Howell test shows a **significant** group difference in cost level between the difficult TCS and the non-TCS (p = 0.05). From Table 29, we know that the mean cost level in the difficult TCS (group mean = $50.2) is *lower* than in the non-TCS (group mean = $73.6). Since the cost level of

a future product is significantly lower under the difficult TCS than under the non-TCS, the difference is in the hypothesized direction. Consequently, hypothesis 1a is supported by the data[83].

Second, the group difference in cost level between the easy TCS and the non-TCS is **not significant** (p = 1.00). Contrary to what was expected, there is hardly a difference in mean cost level between the easy TCS ($73.4) and the non-TCS condition ($73.6). So, hypothesis 1b is not supported by the data in this first experiment[84].

From Table 29 we also see that the mean cost level in the difficult TCS (group mean = $50.2) is significantly *lower* than in the easy TCS (group mean = $73.4, p = .024), which forms the second explanation of the significant omnibus ANOVA.

Table 29: Group Means on Cost Level for each TCS in Experiment One

	Non-TCS		Easy TCS		Difficult TCS		Total	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Cost level	**73.57**	32.83	**73.41**	28.09	**50.21**	13.69	65.73	27.87

Table 30: Pairwise Comparison on Cost Level for the three TCS by the Games-Howell Test in Experiment One

TCS (I)	TCS (J)	Mean Difference (I-J)	Std. Error	Sig.
Non-TCS	Easy TCS	0.1600	9.555	1.000
	Difficult TCS	23.3667	9.555	**0.050**
Easy TCS	Non-TCS	-0.1600	9.555	1.000
	Difficult TCS	23.2067	9.555	0.024
Difficult TCS	Non-TCS	-23.3667	9.555	0.050
	Easy TCS	-23.2067	9.555	0.024

In sum, the *difficult* TCS and the *non-TCS* do differ from each other in terms of the cost level of the designs. Though, as will be discussed in section 13, these results should be considered with some caution, since the different NPD goals (cost, attractiveness and time) were not considered as conflicting by the participants and no feedback was provided on attainment of the attractiveness goal. Hence, it is not surprising that the cost level is lower under the difficult TCS than under the non-TCS, which is simply a replication of the first core finding of goal setting theory.

[83] Similarly, **Dunnett's Test** finds a significant lower cost level under the difficult TCS than under the non-TCS (p = .017), though we cannot use this result because of the heteroscedasticity of the cost level.

[84] Similarly, **Dunnett's Test** cannot find a significant lower cost level under the non-TCS than under the easy TCS (p = .673), though we cannot use this result because of the heteroscedasticity of the cost level.

12. Further Analyzing the Data Set

Although the data set is rather limited, compared to the next two experiments, the differences in quality levels (i.e. attractiveness) among the three TCS groups can be analyzed. **Hence, is target costing having an unfavorable impact on the attractiveness of the created designs?** As shown in Table 31, the group mean for attractiveness is highest in the non-TCS. Though, the ANOVA F-test cannot detect a significant group difference in attractiveness among the three groups, as shown in Table 32 (F (2, 42) = .5, p = .588). Also the two pairwise comparisons by Dunnett's test do not show a significant difference between the non-TCS and the difficult TCS or between the non-TCS and the easy TCS, as shown in Table 33. Consequently, the created designs do not differ in terms of attractiveness among the three TCS manipulations and in general the use of target costing (difficult or easy) does *not* lead to an unfavorable impact on the attractiveness of the created designs.

Table 31: Group Means on Attractiveness for TCS in Experiment One

	Non-TCS		**Easy TCS**		**Difficult TCS**		**Total**	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Attractiveness	2.83	0.681	2.66	0.622	2.57	0.770	2.69	0.686

Table 32: ANOVA on Attractiveness for TCS in Experiment One

ANOVA		**Sum of Squares**	**Df**	**Mean Square**	**F**	**Sig.**	**Eta Squared**
Attractiveness	Between Groups	0.518	2	0.259	0.538	**0.588**	0.025
	Within Groups	20.209	42	0.481			
	Total	20.727	44				

Table 33: Pairwise Comparison on Attractiveness for TCS by Dunnett's Test in Experiment One

Dependent Variable: Attractiveness				
Dunnett (2-sided)				
(I) TCS	**(J) TCS**	**Mean Difference (I-J)**	**Std. Error**	**Sig.**
Easy TCS	Non-TCS	-0.173	0.253	0.719
Difficult TCS	Non-TCS	-0.258	0.253	0.496

Summarizing, target costing as implemented in the environment of experiment one, has no impact (favorable or unfavorable) on the attractiveness of the created designs. As discussed earlier, the difficult TCS induces a significant lower cost than the non-TCS, though the difficult TCS does not lead to lower attractive new products.

13. Lessons to learn from Experiment One

In the introduction of this chapter, we wrote that the purpose of this first experiment was to test a few items. Let's evaluate now the outcome of the testing purposes.

1. It was possible to set up a design task and to *realize experimental realism* with students who had no education or experience with designing tasks. Participants were interested and really involved with the task.

2. Within a *time period of one hour and a half*, it was possible to explain the task to the participants, to let them work on the creative task during one hour and to fill out the very elementary post experimental questionnaire.

3. Participants were able to combine the three different goals on cost, quality and time. However, we are not sure if this goal setting situation was considered as a situation with multiple, *conflicting* goals by the participants. Although we instructed participants to design a carpet for the student's bedroom, discussion with participants afterwards learned that not all participants understood this in a way to use the more darker (and expensive) colors than the bright (and less expensive) colors. As a result, many of the selected designs contain a lot of bright colors, indicating that the participants did probably not perceive the goal conflict as intended. Also some of the judges really liked the designs with the bright colors, probably not thinking about its purpose for a student bedroom. Thus, participants should be better taught.

4. Since the condition of conflicting goals was not supported in this first experiment, the results of hypothesis one should be interpreted within a three-goal NPD environment, *without* conflicting goals. Similar to the results in earlier multiple goal setting studies[85], the *first hypothesis was supported* by the data. The cost level significantly differed among the three TCS groups. The cost level was lower under the difficult TCS than under non-TCS, while the cost level did not significantly differ between the easy TCS and the non-TCS.

Furthermore, while performing this first experiment, we discovered **some problems** that should be solved, when setting up the following experiments.

1. Instead of asking participants to stop working when the time limit has passed, we better measure the *achieved time-to-market* (time spent), and let participants work as long as they want, though giving a reward when finishing within the time objective. Measuring the time (with a chronometer) that participants worked on the creative task before handing in their selected design, will give us more information on the differences in achieved time-to-market.

[85] See for instance Terborg & Miller (1978), Locke & Bryan (1969a), Bavelas & Lee (1978) and Garland (1982).

2. More *feedback* should be given on *attractiveness* during the task. In this experiment, participants could easily calculate the total cost of the carpet, though they had no idea of the market preferences in the market of student bedroom carpets. Although multiple trials were provided (participants could make as much designs as they wanted), there was no feedback on attractiveness during the task itself, so participants could not react on feedback.

3. For participants there was some uncertainty on what was meant by designing a carpet for a "student bedroom". Though the interrater consistency was rather high among the judges, this uncertainty also applied to the task of the judges, scoring the different designs. In sum, a *common reference frame* was not provided.

4. Similarly, participants were not taught on the *preferences of the market* in student bedroom carpets. No examples were included in the instruction sheets to teach participants on what is exactly understood by creating an "attractive carpet".

5. In this first experiment, we rewarded participants if they realized an attractive and low cost carpet. By this incentive system, we motivated participants both in the easy and the difficult TCS, to create an attractive carpet *at the lowest cost* possible, i.e. even to go further with cost reduction, once the target cost has been reached. In fact, this type of incentive system is not in accordance with target costing. From the available cases on target costing, we know that there is no reward for achieving greater savings than those required to achieve the target cost (Cooper & Slagmulder, 1997, 120). So the bonus system should not be based on *competition* for the cost level in the easy TCS and the difficult TCS, but on the attainment of the target cost.

6. *Manipulation checks* for all manipulations should be included in the post experimental questionnaire, especially to check the perceived cost specificity (non-TCS versus easy TCS and difficult TCS), the perceived cost difficulty (easy TCS versus difficult TCS) and the perceived time difficulty (easy TIME versus difficult TIME). Additionally, we need to check if the priority among the goals is perceived as intended. To check this priority rule, we can for instance measure the (self-reported) energy expended to reach the attractiveness goal and the (self-reported) energy expended to reach the cost goal. Furthermore, from this first experiment, we do not know if all participants were equally motivated by the bonus system. Hence, a self-reported measure on the degree of motivation by the different amounts of bonuses could make it possible to test afterwards for the differences induced by the bonus system. Finally, we can also take advantage of the post experimental questionnaire from an *explorative point of view*, to detect directions for future research on explaining the effectiveness of target costing. Kato (1995) suggests that target costing combined with time pressure results in high job-related tension, hence it would be interesting to include a measure of self-reported tension as well.

14. Conclusions

In the previous paragraphs, we discussed the first experiment, that was run with student-volunteers at Vanderbilt University. A design task was developed, where participants had to decide on the cost level and the attractiveness (or quality level) of a carpet design, within a given time limit. Inspired by the Olympus case in target costing, we gave priority to attractiveness, second to the cost level and third to the time limit. While aiming for an ever increasing quality level (attractiveness), large tolerances were accepted on attractiveness, which explains the operationalization of the attractiveness objective as a do-best goal in the experiment.

The target cost setting was manipulated in the three levels (non-TCS, easy TCS and difficult TCS), while only the easy TIME condition was considered. We choose for this reduced version of the earlier suggested full factorial design, because the main purpose of this first experiment was *to test if the specific characteristics of the NPD environment (multiple, conflicting goals) could be created in a lab environment with student-volunteers*. The results show that participants took the task seriously and were interested in the task. Though, we do not know if participants really perceived a goal conflict in a sense that trying to attain the one goal hindered the attainment of the other goal. Thus, reinforcing the goal conflict is necessary to proceed with this task.

Although we did everything in our power to prepare the experiment fully in detail, still some imperfections occurred. For instance, the bonus system created a less than perfect target costing manipulation, since participants were also rewarded to go even further than the established target cost in this first experiment. Another example is the lack of immediate feedback to participants on the attractiveness of the created designs. Furthermore, participants were not taught on the preferences of the market and probably did not fully understand what was expected from a design to fit within a student bedroom.

In sum, we will go on with the task in a following experiment, to test the developed hypotheses on the effectiveness of target costing during new product development. Though some adjustments will be made to meet the formulated objections.

Chapter 7: Experiment Two

1. Introduction

In the previous chapter, we described our first experiment, which main purpose was to test the feasibility of the task. For that purpose, only the 'target cost setting' was manipulated. Now to test the developed hypotheses, all cells of the completely randomized factorial CRF-32 design will be included, as discussed earlier in chapter five (see page 131). Consequently, the three levels of the target cost setting (non-TCS, easy TCS and difficult TCS) will be combined with the two levels of the difficulty of the time objective (easy TIME and difficult TIME), leading to six different treatments. This 3 by 2 design makes it possible to test all univariate hypotheses as well as all multivariate hypotheses, as developed earlier on page 99.

From the lessons we learned from experiment one, we will **improve the task of experiment two in several aspects** compared to the first experiment:

1. The outcome on all three goals will be measured, i.e. the cost level, the score for attractiveness and the *achieved time-to-market*. By giving participants the choice on how long to work on the task, we can actually measure the time spent.
2. *Immediate feedback* will be provided on *attractiveness* during the task, by bringing the judges into the lab environment. We will keep the principle of multi-trials, so participants have time to react on the feedback of the judges. Only one session will be run, with all participants together instead of the four sessions in experiment one.
3. To reduce the uncertainty of the kind of interior, a picture of a living room interior will be given, within which the new carpet should fit. This interior will give an identical *reference basis* for designers and judges to evaluate the attractiveness of the carpet. The second purpose of this interior is to reinforce the *goal conflict* between attractiveness and cost. The chosen interior will motivate participants to consider more the darker (expensive) colors than the brighter (inexpensive) colors.
4. To teach participants on the *market preferences,* the 10 most attractive and the 10 least attractive designs of experiment one, as perceived by the judges, will be included in the instructions. These market preferences come from the same judges as the ones who will be present during the experiment.
5. The *incentive system* will no longer be based on competition on the *cost level* in the easy and the difficult TCS, as in experiment one. *Goal attainment* will be stressed instead of competing for the lowest cost under the easy TCS and the difficult TCS. Because there are no target costs given

in the non-TCS, we will keep the principle of competing for the lowest cost in the non-TCS group. Similarly, since there are no specific goals set for the aesthetic value of the new carpet, we will keep the competition-based bonus system to stimulate the attractiveness of the carpets, as we did in experiment one. Furthermore since participants can decide when to stop working on the design, a reward will be added for attaining the *time objective*. Consequently, the reward structure takes now into account the three different goals. By varying the amount of money, priority among the three goals will be set.

6. Not only the task is improved, but also the *post experimental questionnaire* will now be fully developed. The first purpose of the post experimental questionnaire is to check the differences in manipulation. Furthermore, by including general questions on age, education, etc. we can evaluate the random assignment to treatment afterwards. Third, other questions will be added such as commitment to attain the target cost (time objective), degree of motivation by the bonus system and perceived job-related tension. Hence, the paragraph on the measurement of the variables (section 10) will be much elaborate here, compared to experiment one.

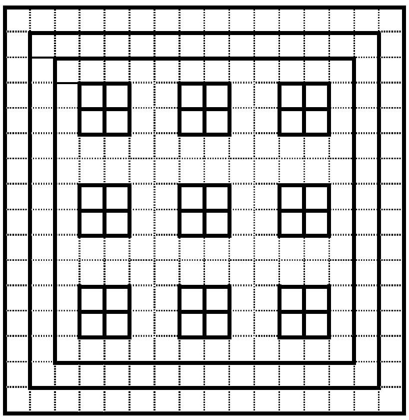
Again some steps need to be taken before we can really start with testing the formulated hypotheses and analyzing the results. Basically, we will take three large steps. First, the *organization* of the experiment is described in detail in the sections 2 to 9. Second in section 10 (page 197), we provide a discussion on the *measurement of the variables*, which is extended because of the enlarged post experimental questionnaire. Third, in section 11 (page 208), we will *screen the data* in terms of manipulation checks, accuracy, descriptives, outliers, normality and homoscedasticity. From then on, we will start with the statistical analyses to *test the hypotheses* in the sections 12 to 15 (page 238). The results are *summarized* in section 16, page 245 and the data set is further explored in section 17, page 247. A *discussion* of the results is provided in paragraph 18 (page 254). This chapter ends with explaining why we need to run another experiment and how we will *change the settings* of that third experiment (see section 19 on page 262).

2. Task

The task is basically the same as in experiment one, **i.e. to design an attractive carpet**. New is that participants receive a picture of a **living room interior** (green sofa, blue curtains and a yellow ground) as shown in Appendix Two, page 427. The purpose of the task is to create a carpet that fits within that kind of interior, for the market of young families with small children. The interior should direct participants more towards the darker colors and make it also easier to evaluate the attractiveness of the carpet, because of the same reference living room. As Swieringa & Weick (1982, 71) argues, finding a good task is often making a trade-off between structure and freedom. By giving the kind of interior, we impose more structure in experiment two than in experiment one. Furthermore, the examples of the 10 most attractive and the 10 least attractive designs of last year (see Appendix Two, page 429), evaluated by the judges within the given living room interior, will help participants to better understand what is meant by creating an attractive design.

Again a basic **pattern** is given, as shown in Figure 37, which is also an element of imposing structure on the experimental task. This basic pattern is different from the one used in experiment one. Here the pattern is more abstract, compared to the more traditional one of experiment one. We changed this pattern from a traditional to an abstract pattern to make a better fit within the given interior. From the figure you can see that the pattern of 256 small areas is predefined in a pattern of 39 larger areas. the task is now to select the appropriate colors for these 39 areas. Again, colors can be selected from a pallet of 10 colors, represented by 9 color pens and white.

Figure 37: Pattern of the Carpet Designing Task of Experiment Two



Furthermore, participants are informed about **the cost system**. Again, the cost system includes the direct cost differences between yarn of different colors, as well as the higher indirect costs when using more than 5 different colors, caused by higher set up costs, more material handling costs, etc. This cost system is summarized in Table 34. Since participants are more familiar with the Belgian currency, the costs per small area are now given in Belgian Franks (contrary to U.S. Dollars in the first experiment for the Vanderbilt participants). The levels of direct and indirect costs are determined taking into account both realism and ease of calculation, as in the first experiment. Furthermore, the Belgian Franc costs are more or less of equal size as the dollar costs of experiment one.

Table 34: Cost Calculation System in Experiment Two

	cost per small square *standard* color	Cost per small square *additional* color
	Class A:	Class A+:
White	3 BEF	6 BEF
Black	3 BEF	6 BEF
	Class B:	Class B+:
Yellow	10 BEF	13 BEF
Orange	10 BEF	13 BEF
Sky blue	10 BEF	13 BEF
Light green	10 BEF	13 BEF
	Class C:	Class C+:
Blue	15 BEF	18 BEF
Brown	15 BEF	18 BEF
Red	15 BEF	18 BEF
Green	15 BEF	18 BEF

Again, the target costing system in the experimental task meets the typical characteristics of target costing, as developed earlier in chapter 2 (see page 37). The *target sales price* and the *target profit margin* is derived during product planning, i.e. before participants start with the design task. The *target cost* is assigned to participants, before they start with the new product development. The target cost is set at the *lowest level*, i.e. for an individual designer, and for the cost items "direct material" and "indirect material-related" costs. *Detailed cost information* is provided during NPD by the table above. The cost level of the design can be *compared with the target cost* anytime during NPD, since participants immediately calculate the cost level below each created design. Participants are instructed not to turn in a design with a cost level higher than the target cost, reflecting the *general rule* that the target cost can never be exceeded.

3. Experimental Design

Three levels of target cost setting are considered, i.e. a non-target cost setting (non-TCS), an easy target cost setting (easy TCS) and a difficult target cost setting (difficult TCS). Participants in the non-TCS are instructed to *design an attractive carpet, trying to minimize the cost of the carpet*. Participants in the easy TCS are instructed to *design an attractive carpet, taking into account the maximum cost of 3.150 BEF*. Participants in the difficult TCS are instructed the same, but with a *maximum cost of 2.750 BEF*. The exact wording for each of the three experimental conditions is given in Figure 39. For the entire set of instruction sheets, we refer to Appendix Two, page 394 et seq.

Two levels of **time-to-market difficulty** are considered, i.e. an easy time objective (easy TIME) and a difficult time objective (difficult TIME). The easy TIME was set at one hour and 45 minutes[86], the difficult TIME at one hour and 15 minutes.

Thus this second experiment involves a **3 by 2 design** or a *completely randomized factorial* design CR-32, with *between* subjects effects, as shown in Figure 38. It is a balanced design, each of the six cells will contain 20 observations.

Figure 38: Completely Randomized Factorial Design CRF-32 of Experiment Two

	Non-TCS	**Easy TCS**	**Difficult TCS**
Easy TIME	Group 1 (n = 20)	Group 2 (n = 20)	Group 3 (n = 20)
Difficult TIME	Group 4 (n = 20)	Group 5 (n = 20)	Group 6 (n = 20)

[86] This easy TIME level of 1 hour and 45 minutes is longer than the easy TIME used in **experiment one** and the easy TIME used in the **pilot study** (1 hour and 30 minutes). Though, we add some time to experiment two, because of immediate feedback from the judges during the task. In peak moments, we estimate that participants will have to wait 10 minutes before they get their design back from the judges, explaining the easy time level of 1 hour and 45 minutes.

Figure 39: Expressions used in the Six Experimental Conditions of Experiment Two

For the non-TCS:
Furthermore, the company uses a cost plus approach to determine the sales price. This means that the cost of the carpet is used as a basis to set the sales price. More specific, the sales price is set at a level equal to the cost of the carpet plus a profit percentage of 20%. Hence, your boss wants you to create an attractive carpet, while trying to *minimize* the cost of that carpet. Your boss is convinced that young families are not prepared to pay a lot of money for their living room carpet. In order to survive in this competitive market of living room carpets, you should come up with an attractive carpet at the lowest cost possible. So, do your best in minimizing the cost level of the design you create.

For the Easy TCS:
Furthermore, the sales price for carpets is determined on the market. For the coming season the market price for a given carpet is estimated at 3.780 BEF. The general manager decided that living room carpets should earn a profit of 630 BEF apiece. Hence, your boss wants you to create an attractive carpet that costs *no more than 3.150 BEF* (i.e. the difference between the estimated market price of 3.780 and the profit margin of 630). Your boss is convinced that young families are not prepared to pay more than the estimated market price of 3.780 BEF. Furthermore, the company needs the profit margin of 630 BEF apiece, in order to survive in the competitive market of living room carpets. So, you should come up with an attractive carpet that costs no more than 3.150 BEF, unless you really think that designing an attractive carpet under that cost is impossible.

For the Difficult TCS:
Furthermore, the sales price for carpets is determined on the market. For the coming season the market price for a given carpet is estimated at 3.300 BEF. The general manager decided that living room carpets should earn a profit of 550 BEF apiece. Hence, your boss wants you to create an attractive carpet that costs *no more than 2.750 BEF* (i.e. the difference between the estimated market price of 3.300 and the profit margin of 550). Your boss is convinced that young families are not prepared to pay more than the estimated market price of 3.300 BEF. Furthermore, the company needs the profit margin of 550 BEF apiece, in order to survive in the competitive market of living room carpets. So, you should come up with an attractive carpet that costs no more than 2.750 BEF, unless you really think that designing an attractive carpet under that cost is impossible.

For the Easy TIME:
Finally, your boss wants you to be finished within *1 hour and 45 minutes*. If you are finished earlier, you should not wait to hand in your design. If you think that designing an attractive carpet in this time period is not possible, you can take some extra time.

For the Difficult TIME:
Finally, your boss wants you to be finished within *1 hour and 15 minutes*. If you are finished earlier, you should not wait to hand in your design. If you think that designing an attractive carpet in this time period is not possible, you can take some extra time.

4. New Product Development Goals

As mentioned in experiment one on page 161, the simulated NPD environment is one with **three** conflicting goals, to be attained simultaneously. First, there is a do-best goal on *attractiveness*. Second there is a specific *cost* goal in the easy and difficult TCS, while there is a do-best goal in the non-TCS. Third, participants have a *time* objective to realize.

As discussed earlier (see page 18), Cooper (1995, 30) advises not to expend equal effort on all three characteristics of the survival triplet, because one characteristic is usually the most important characteristic to the customer. Similar as described in the Olympus case (Cooper 1994f), where the target costing system seems to work effectively, **priority** among the three NPD characteristics is in our experiments given in the following sequence: attractiveness, cost, time. We set attractiveness as the first criterion since we simulate a market where the customer is highly sensitive to the aesthetic value of the product. Consequently, only the most attractive designs will be rewarded. Furthermore, by including a higher bonus for attaining the target cost than for attaining the time objective, we instruct participants that attaining the target cost is more important than attaining the time condition. Thus in terms of Cooper's (1995) survival triplet (see page 19 earlier), the aesthetic value dominates the cost and time characteristic of the survival triplet in the NPD environment of our experiments.

In terms of **latitude** (i.e. the range between the minimum allowable and the maximum feasible value) on each of the three elements of the survival zone, we simulate an environment where some latitude on aesthetics is allowed. But no latitude is accepted for the cost characteristic (because of a given market price) and less latitude is accepted for the time-to-market objective (because of the risk being left behind by competitors).

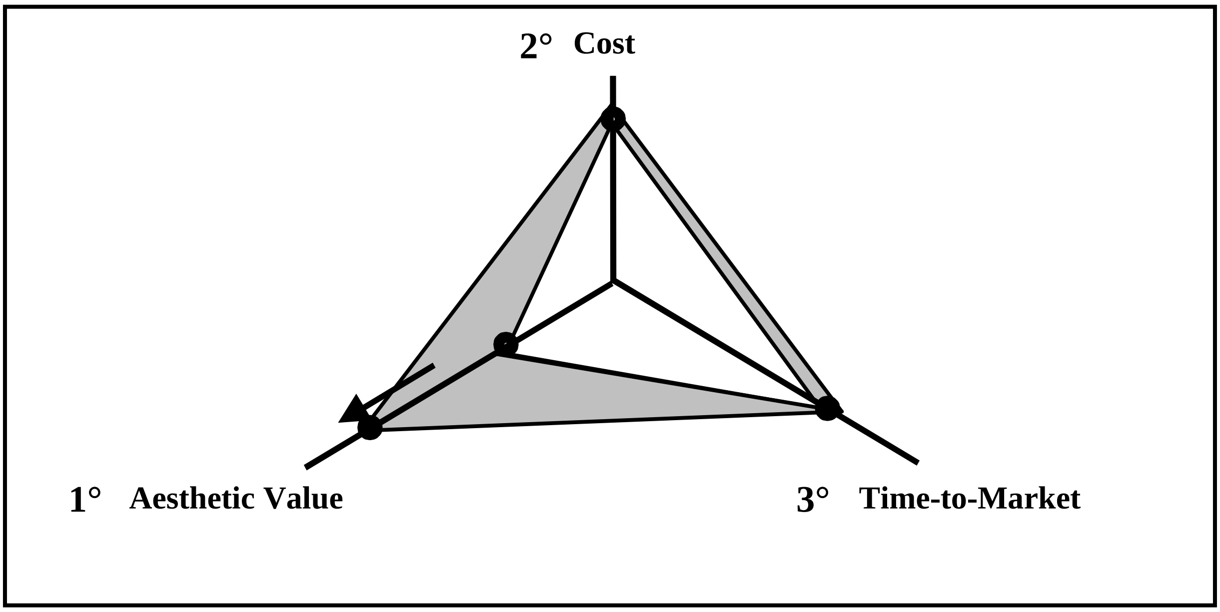
Finally, we simulate a competitive environment, asking for **increased aesthetics** (attractiveness), as in the Olympus Case (Cooper, 1994f). In the experiment, we instruct participants to go as far as they can in creating the most attractive carpet. In terms of Cooper's survival triplet, this means that the firm's strategy stresses continuously increasing product functionality[87] (in the sense of aesthetics), as shown in Figure 40.

Hence, the NPD environment to which we want to generalize the results of the experiments is the one with priority given to the quality level (i.e. aesthetic value), with second priority to attaining the target cost and last priority to realizing the time-to-market objective. The latitude on both

[87] As mentioned earlier in footnote 20 on page 20, there exists some confusion on what is understood under "quality" in the definition of Cooper (1995, 15) when considering his survival triplet. Cooper (1995) would call the **aesthetic value** an aspect of *functionality*, while limiting in his definition quality to the conformity dimension. Contrary, under the general accepted definition of Garvin (1987), aesthetic value is considered as one of the eight dimensions of *quality*.

the cost and the time-to-market objectives are small, compared to the broad latitude on the quality objective.

Figure 40: The NPD Goals and the Survival Triplet in Experiment Two



5. Bonus System

The bonus system perfectly follows the given **prioritie**s among the goals and is improved, compared to the first experiment, in terms of the bonus for cost and time. Similar to the first experiment, the incentive system is first of all based on competition for **attractiveness**, because we want to encourage the designers to create *attractive* carpets. As Locke (1968, 179) states, including competition encourages individuals to the goal that they might otherwise abandon. More specifically, a bonus of 300 BEF is promised to the *five most attractive* designs in each of the six conditions.

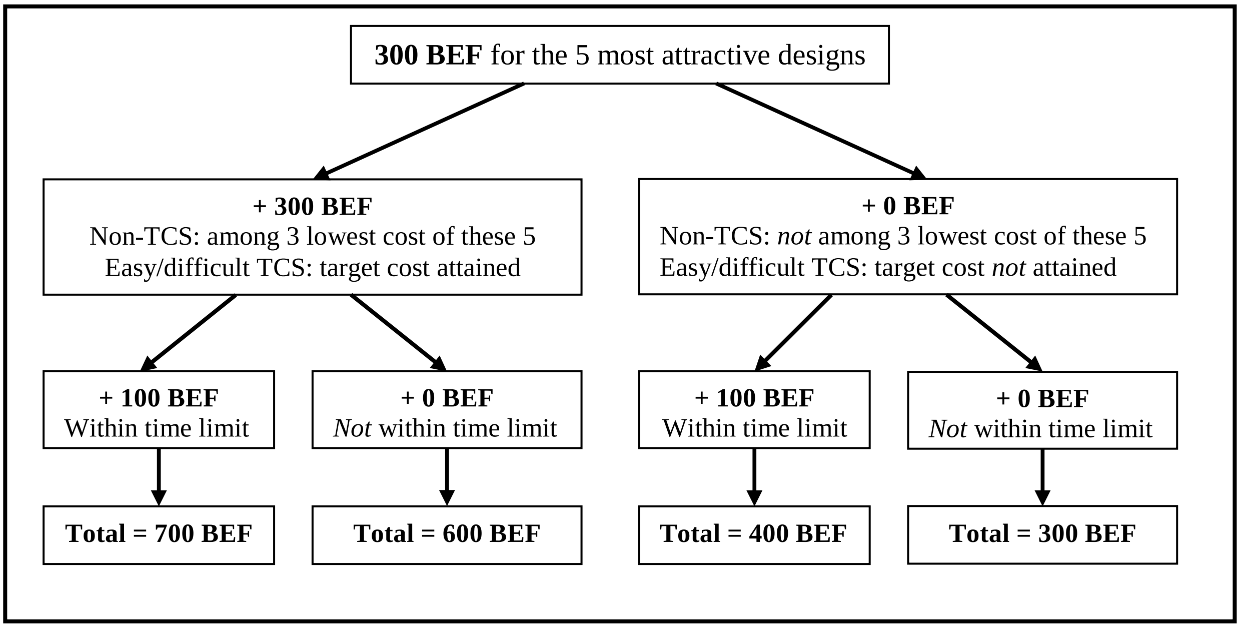
Second for the **cost** goal, in the non-TCS condition an additional bonus of 300 BEF will be given to the *three lowest cost* designs, among those 5 most attractive ones. Contrary to the first experiment, for the easy and the difficult TCS the bonus for cost is not depending on competition, but on the attainment of the target cost. An additional bonus of 300 BEF will be given to participants *who attained* the target cost, among those 5 most attractive ones.

Supplementary to the first experiment, a bonus is now given for attaining the **time** objective. More specifically, an additional bonus of 100 BEF will be given to those 5 most attractive designs, which finished *within the given time* limit.

A summary of this bonus system is given in Figure 41. In fact, 25% of the participants (i.e. 5 of the 20 in each group) will receive a bonus ranging from 300 to 700 BEF. We stress that bonus determination occur in each of the six groups separately, because it would be unfair to let participants compete with participants who received other instructions (e.g. an easier to attain target cost).

Bonus **pay** occurred immediately after the task, i.e. at the end of normal class time. More details of the bonus pay are given in the Appendix Two, page 461. An example of the bonus receipt form is given in Appendix Two, page 463.

Figure 41: Bonus System in Experiment Two



6. Feedback during the Task

Similar to experiment one, participants got immediate feedback on the **cost level** of their creations. The pattern sheets are constructed in two parts: the basic pattern on the first half of the sheet (which participants should color) and the cost calculation table on the second half of the sheet. In this cost calculation table participants could easily calculate the cost of their creations during the experiment, as explained in detail in the instruction sheets. An example of this pattern sheet is given in appendix two, page 426. Reviewing the designs that were not handed in during the first experiment, learned that participants did not always calculate the cost for each of their created designs. It seems that participants are looking for feedback on the cost level, only for those designs that passed their own norms on attractiveness.

Providing immediate feedback on the **attractiveness** of the design is a major improvement of this experiment, compared to the first experiment. Nine judges were present in front of the laboratory and scored the designs (from 1 to 5), considering it within the given living room interior. Assistants brought back and forward the designs from the participants to the jury. For the sake of practical arrangements, we limited the number of feedback possibilities to two. Participants could choose the moment of this feedback possibility, two designs at the same time or each at different time periods. Participants knew the mean scores of the most attractive and the least attractive designs of last season, so they could compare the scores from the judges with these means to see if they are doing well or not. Creating one design took more or less 5 minutes, so there was time available for participants to react on the received feedback. At the end of the exercise, participants handed in one of the scored designs or handed in a new design, which was scored later during "down time" of the judges panel.

Feedback on the progression of **time** was possible as well, by following time progression at the central clock.

7. Pilot Study

The levels of the difficult and easy target cost were based on the outcomes of a pilot study. Since the pattern is different in the second experiment, we cannot use the same levels as in the first experiment. Hence we did a new pilot study with 22 undergraduate students, who will not participate in the real experiment two (or in experiment three).

On February 25, 1999, during official class time of the course "Special topics in Auditing and Management Control" of Dr. Waeytens, **22 undergraduate students** of the fourth year Applied Economics (University Ghent), participated *voluntary*. Just one of the six conditions was tested, i.e. the **non-TCS, easy TIME** condition. Apart from the immediate feedback by the judges, the pilot study was completely similar in setting and material to experiment two. Scores from the judges were provided afterwards and bonus pay occurred within three days after the session. We informed the students that we ran a test version of a larger experimental research study and asked them to give comments on the task. Apart from comments on the explanation of the bonus system in the instruction sheets (which we improved), no other comments were provided.

From this pilot study with just one condition ("*minimizing* the cost level in the easy time condition"), we learned that **40%** of the participants created a carpet with a cost level lower than 2.750 BEF. Similarly, **80%** had a cost lower than 3.150 BEF, as shown in Table 35. These attainability ratios of 40% and 80% are exactly the same ratios as used in the first experiment (see page 164) and are frequently used in goal setting studies (Locke & Latham, 1990, 349). **Thus 2.750 BEF is used as the difficult target cost, and 3.150 BEF is used as the easy target cost in experiment two.**

From this pilot study, we also learned that the cost and attractiveness goal were now perceived as **conflicting**. The correlation between the cost level and attractiveness was significant positive (r = 0.60, p = 0.000), showing that the high cost carpets are in generally the ones with the highest scores for attractiveness.

Table 35: Frequency Table of the Cost Level in the Pilot Study (n = 22) of Experiment Two

Cost Level	Frequency	Percent	Cumulative Percent
1904	1	4.55	4.55
2144	1	4.55	9.09
2196	1	4.55	13.64
2224	1	4.55	18.18
2260	1	4.55	22.73
2560	1	4.55	27.27
2676	2	9.09	36.36
2772	1	4.55	**40.91**
2800	1	4.55	45.45
2856	1	4.55	50.00
2868	1	4.55	54.55
2940	1	4.55	59.09
2950	1	4.55	63.64
2994	1	4.55	68.18
3088	1	4.55	72.73
3120	1	4.55	77.27
3156	1	4.55	**81.82**
3204	1	4.55	86.36
3300	1	4.55	90.91
3388	1	4.55	95.45
3480	1	4.55	100.00
Total	22	100.00	

8. Participants

The sampling method is a **convenience sample,** using all students from the fifth year bioengineering (University Ghent), attending the course "introduction to industrial management" of Professor Dr. Ir. Hendrick Van Landeghem. In total 135 students were enrolled for this course, 120 of them participated voluntary in the experiment. Students were informed of the experiment by a **recruitment letter** (see Appendix Two, page 387) during the class of January 13, 1999. The same letter was posted on the bulletin board to inform students who were absent at that class. The researcher was present as well on January 13, 1999 to clarify the purpose of the experiment and to answer questions. It was stressed that participation was *voluntary*, that the task involved *no specific skills or risks of any kind* and that the purpose was to collect data for *research* purposes. Students participating received *extra credit* for the course "introduction to industrial management". There were no disadvantages for those not participating.

For organizational reasons, students should hand in the **reply form**, either by email, by post, by phone or by fax (see Appendix Two, page 387). A **ground plan** was included to the recruitment letter, since most of the students were not familiar with the location of the Faculty of Economics and Business Administration at the University of Ghent campus. An **additional email message** (see Appendix

Two, page 390) was sent to students who did not returned their reply form within one month, to make sure every students was informed about the experiment.

9. Procedures

Kerlinger (1973, 312) explains that the more uncontrolled the conditions of an experiment are, the more the determinants of error variance can operate. This is one of the reasons for carefully setting up controlled experimental situations and conditions. This is effected, in experiment two by specific and clear instructions to participants, to the judges, to the assistants and to the cashiers.

The task for the participants was explained in a 17-page **written instruction** bundle (see Appendix Two, page 394 et seq.). Additional comments were given on the rather difficult pages by 6 color **overhead sheets** (see Appendix Two, page 440 et seq.). Separate written instructions were provided to the **nine judges** (see page 434 et seq.), to the **four assistants** (see page 431) as well as to the **two cashiers** (see page 432). A summary of all procedures is given in Table 36, on page 194 below.

Students reported all **together** to the experimental session. The session took for no one longer than three hours. This time period was split up in four blocks: 30 minutes for instructions, 120 minutes (at most) for the task itself, 15 minutes to answer the post experimental questionnaire and 15 minutes for bonus pay.

Students receive a **numbered card** upon arrival. This ID number assigned them to one of the six treatment conditions and referred to the numbered desks. For each participant, all the **material** was ready on the desk in a numbered A4-box. This material contained the folder with the instruction and pattern sheets, a set of 9 color pens, a brown envelope, the sealed questionnaire, a blue pen, 2 blue feedback cards, napkins, a plastic bag, the interior, the color copies of the 10 best and 10 worse designs. Each individual material such as the instructions, the patterns, the feedback cards, the brown envelope and the questionnaire was **labeled** with the ID number.

After a short welcome by the experimenter, participants went through the **instruction sheets**, page by page, as instructed by the researcher. These written instructions (see Appendix Two, page 394) covered comments on practical issues such as the pattern, the colors, the cost of the colors, the cost calculation table, the objective of the task, the market information, the judges, the practical organization of the feedback by the judges, the bonus system and a one-page summary. A **practice session** was included as well to familiarize participants with the colors and the cost calculation table.

In addition to these written instructions, six **overhead sheets** were presented (see Appendix Two, page 440). The first slide presented a summary to indicate which should be read now. The purpose of the second, third and fourth slide was to make sure that every participant understood what was allowed in terms of merging and splitting predefined fields (page 3 of the instructions). Slides five and six were discussed to make sure that all participants knew how to calculate the total cost of the rug by using the cost calculation table (explained on the pages 8 and 9 in the instructions). Questions were allowed during this slide presentation. Questions about issues covered in other pages were answered on an individual basis, because of the danger to reveal some of the experimental conditions.

Consequently, students **worked individually** on the task, during 120 minutes at most. They asked for scores of the jury by holding up one of the two blue cards. The assistant responsible for the given row picked the design up and brought it to judge 1 in front of the room. The same assistant brought the scored designs back from judge 9 to the participants.

When finished, they handed in their selected design in the brown envelope. When holding up this brown envelope, the assistant picked it up and wrote the time on it. The cashiers will then later know if the participant was finished within the given time limit. Then participants unsealed the sealed questionnaire folder and completed the questionnaire. Afterwards, they got a free drink and candy bar in the relax room. Bonus numbers were posted on the bulletin board in the relax room and the cashiers started bonus pay from 5.00 PM on (see page 463 for the bonus receipt form). Details on the bonus determination are given in Appendix One, page 461, while the most attractive creations in each group are shown on page 460.

In sum, total experimental time exceeded for no one the three hours, i.e. the normal duration of class time. Furthermore participants were allowed to talk quietly and seemed to be *relaxed*. By including on all personal material only the ID number, *anonymity* was established.

Finally, we add that all participants receive a **feedback** note by email message, a few weeks after the experiment. This feedback report addressed the main purpose of the research study, the hypotheses and the results and explained the bonus system in detail. This feedback attachment is shown in Appendix Two, page 466. The following table shows an overview of all experimental procedures.

Table 36: Overview of the Procedures in Experiment Two[88]

	Procedure	Instruction Sheets
0	The day before the experiment, **judges** 1 to 9 and **assistants** A, B, C and D, **cashiers** X and Y get separate instructions by written instruction sheets. Discussion of it is provided by the researcher.	
1	Each participant receives one of the **numbered cards** when arriving.	
2	Participants are taking place at the **numbered desks**. The ID number on the card refers to the ID number on the box with material.	
3	The experimenter is giving a short **welcome** to the group.	
4	Participants **start** with reading the instruction sheets, page by page.	
5	Participants are checking the given **material**.	Page 2
6	Participants are reading the instructions on the **pattern** and the researcher is showing some right and wrong examples on color overhead sheets.	Page 3 + Slide 2, 3, 4
7	Participants are reading the instructions on the **colors**.	Page 4
8	**Practice** session, part 1: Participants are making one design to familiarize themselves with the pattern.	Page 5
9	Participants are reading the instructions on the **cost system**.	Page 6
10	Participants are reading the instructions on the **cost calculation table**: direct and indirect costs.	Page 7
11	Participants are reading the instructions on a **first example** of the cost calculation table for a design with 5 colors. The researcher shortly explains.	Page 8 + slide 5
12	Participants are reading the instructions on a **second example** of the cost calculation table for a design with 6 colors. The researcher shortly explains.	Page 9 + slide 6
13	**Practice session**, part 2: Participants now fill out the cost calculation table of the design, made earlier.	Page 10
14	**Practice session,** part 3: Participants are checking the cost calculation table of their neighbor to make sure everyone fully understands the cost system.	Page 11
15	Participants are reading the instructions on the **task**, with the specific target cost setting and the specific time objective.	Page 12
16	Participants are reading the instructions on the **market information** (the given interior, the 10 most and the 10 least attractive designs of last year).	Page 13

[88] See appendix Two, page 394 et seq. for the instruction sheets to **participants** and page 440 et seq. for the **overhead sheets** used during these instructions to participants. Instruction sheets for the **judges** 1 to 9 are on page 434, for the **assistants** A, B, C and D on page 431 and for the **cashiers** X and Y on page 432.

17	Participants are reading the instructions about the **judges**.	Page 14
18	Participants are reading the instructions on the **practical issues** on how to get scores from the judges (token system with blue cards, maximum 2 designs).	Page 15
19	Participants are reading the instructions on the **bonus** system.	Page 16
20	Participants are reading the instructions that **summarize** all the relevant information for the task.	Page 17
21	Judges 1 to 9 are **entering** the room and take place in front of the auditorium. They start scoring (individually), while keeping the FIFO principle.	
22	Participants are **working** during 75/105 minutes (or less) on the task.	
23	**Assistants A, B, C and D** are bringing designs from the participants to judge 1. By holding up one of the 2 numbered blue cards, participants let know they have a design to score. Assistants A, B, C and D are taking scored designs from judge 9 back to the assigned participants. The ID number on the designs and on the material box helps assistants finding the right creator.	
24	When **finished**, each participant is putting his/her selected design (just one) in a brown envelope.	
25	Assistants A, B, C and D are picking up the brown envelope and are writing the **time spent** on it.	
26	Each participant is then filling-out the **questionnaire**. When finished, they leave the room with the received ID card.	
27	Participants are getting a **free drink** and candy bar in the relax room, when showing the received ID card.	
28	Cashiers X and Y are making two stacks of the designs: the designs scored before by the judges and the designs not scored before. This last stack is given to judge 1, who keeps track of the **priority rule**: first scoring the designs from participants still in the room; only scoring the designs from participants who left the room during “downtime”.	
29	Cashiers X and Y are doing the **input** of the cost level, the total score on attractiveness and the time spent into the Excell spreadsheets.	
30	Cashiers X and Y are sorting the rows of each of the 6 spreadsheet based on attractiveness, to determine the **five bonus ID’s** in each of the 6 groups. Information on the cost level and time spent helps them in calculating the total bonus for each of those five participants.	
31	Cashiers X and Y are preparing the **envelopes** with the right amount of money. Bonus receipt forms are completed with ID numbers.	

32	Cashiers X and Y are posting the bonus ID's on the **information bulletin board.**	
33	Cashiers X and Y are **paying** the bonus. Participants are signing the receipt.	
34	All participants receive a **written feedback** report by email message, a few weeks after the experiment.	

10. Measurement of the Variables

10.1 Attractiveness, Cost Level and Time Spent

Attractiveness, cost level and time spent are again the three main dependent variables in this experiment. **Attractiveness** is measured as the *mean score* from the judges. Nine judges scored the designs individually from 1 to 5, during the experimental task, given the living room interior (see Appendix Two, page 427). These judges are the same as the judges who did the scoring of the 45 Vanderbilt designs of experiment one to determine the 10 most and the 10 least attractive designs in the given interior. The scores for experiment two are given in appendix two, on page 457. A Cronbach's alpha was calculated for each carpet design to determine the interrater reliability. The coefficient alpha for the scores of these 9 judges was .89, which did not improve if one of the judges was deleted[89].

The **cost level** of the new product is measured as the *total cost* of the created pattern that each participant handed in at the end of the session. During the instructions, participants were taught how to calculate the cost level of the design, by completing the cost calculation table on the second half of the pattern sheets.

Time spent or new product development time is measured as the *interval of time in minutes* between starting and finishing with the design task. All participants started at the same time with designing. When participants were finished and decided which carpet to hand in, they put it in the brown envelope and assistants wrote the time stop on it. The difference between the time start and the time stop gives the score for time spent in experiment two.

In the next ten pages (paragraphs 10.2 to 10.6), we will discuss in detail all measurement scales, used in the post experimental questionnaire. Discussion of the *real data* on cost level, attractiveness and time spent will start from section 11 on page 208.

[89] This **interrater reliability** of .89 with 9 judges is better than the .78 Alpha coefficient with 15 judges in experiment one. Though there are fewer judges in experiment two than in experiment one, the interrater consistency is much higher, probably because of the given interior, allowing for a common frame of reference.

10.2 Manipulation Checks

10.2.1 Manipulation Checks for Target Cost Specificity

Participants in the non-TCS group receive in this study a *vague* cost goal to "minimize the cost level of the carpet". In both the easy TCS and difficult TCS, a *specific* target cost is given of 3.150 BEF and 2.750 BEF respectively. Checking the difference in manipulation between the non-TCS on the one hand and the easy and difficult TCS on the other hand is done by self-reported measures, administered in the **post experimental questionnaire**.

Different scales have been used in literature to check the goal specificity manipulation in lab experiments. For instance, Earley et al. (1987, 109) used two items in their lab study: "How specific was the goal you were given?" (1= not at all specific and 5 = extremely specific) and "How detailed was your goal?" (1 = not at all detailed and 5 = extremely detailed). Earley, Connolly & Ekeren (1989, 26) used only the first item. Winters & Latham (1996, 243) used three items on a 5-point Likert-type scale: "To what extent was the goal for producing schedules vague?", "To what extent was the number of schedules to be completed specified?" and "To what extent was there uncertainty as to the quantity of schedules to be completed?" Shalley (1991, 182) used two items on a 7-point scale (1= strongly disagree, 7 = strongly agree): "I knew how much production was expected of me on this task" and "I had a production goal to meet in this task".

In the same sense, we develop a **two-item** measure on a **5-point Likert-type scale** (1 = absolutely disagree, 5 = absolutely agree): "I knew exactly the acceptable cost of the carpet" and "The instructions of my boss on the acceptable cost of the carpet were rather vague", as shown in Table 37. The answers on the second item will be reversed and then averaged with the answers on the first item to form a global index. The Dutch scales are in Appendix Two, page 446. The Pearson correlation between the two items for the data in experiment two is r = .65, the Cronbach's Alpha coefficient is α = .79, indicating internal consistency.

Table 37: Manipulation Checks for Target Cost Specificity (2 items) in Experiment Two

<u>Cost Specificity, Item 1 (COSTSPE1)</u>				
I knew exactly the acceptable cost of the carpet.				
1	2	3	4	5
absolutely disagree		neutral		absolutely agree
<u>Cost Specificity, item 2 (COSTSPE2)</u>				
The instructions of my boss on the acceptable cost of the carpet were rather vague.				
1	2	3	4	5
absolutely disagree		neutral		absolutely agree

10.2.2 Manipulation Checks for Target Cost Difficulty

In this study, the difficult target cost is set at 2.750 BEF, while the easy target cost is set at 3.150 BEF. Again, questionnaire items will check participants' perception of the difficulty of the target cost.

In lab experiments, different scales have been used to check the goal difficulty manipulation. For instance, Latham & Steele (1983, 410) used: "How difficult was it for you to attain the goal?" Winters & Latham (1996, 244) used two items on a five-point Likert-type scale: "To what extent was the goal set difficult?" and "To what extent was the goal set easy?"

Similarly, we develop a **two-item** measurement scale in this study, "The cost goal of my boss was easy to attain" and "It was difficult to have a cost below the acceptable cost", with answers on a **5-point Likert-Type Scale**, as displayed in Table 38. The answers on the first item will be reversed and averaged with the second item to form a global score. The Dutch scales are in Appendix Two, page 446. The Pearson correlation between the two items for the data in experiment two is r = .70, Cronbach's Alpha α = .82, indicating high consistency.

Table 38: Manipulation Checks for Target Cost Difficulty (2 items) in Experiment Two

<u>Target Cost Difficulty, item 1 (COSTEASY)</u>				
The *cost* goal of my boss was easy to attain.				
1	2	3	4	5
absolutely disagree		neutral		absolutely agree
<u>Target Cost Difficulty, item 2 (COSTDIF)</u>				
It was difficult to have a cost below the acceptable cost.				
1	2	3	4	5
absolutely disagree		neutral		absolutely agree

10.2.3 Manipulation Checks for Difficulty of the Time Objective

The perceived difficulty of the time limit was measured by the following **two items** in the questionnaire: “The time limit was rather short to complete this task” and “The time limit of my boss was easy to attain”, as summarized in Table 39. The answers were scored on a **5-point scale** ranging from 1= absolutely disagree to 5 = absolutely agree. The scores on these two items will be averaged to form a global index. Again, the used Dutch scale is in Appendix Two, page 446. The Pearson correlation between item one and the reverse of item two for the data in experiment two is r = .61, Cronbach’s Alpha α = .76, indicating internal consistency.

Table 39: Manipulations Checks for Difficulty of the Time Objective (2 items) in Experiment Two

Difficulty of Time Objective, item 1 (SHORTTIME):

The time limit was rather short to complete this task.

1	2	3	4	5
absolutely disagree		neutral		absolutely agree

Difficulty of Time Objective, item 2 (TIMEEASY):

The time limit of my boss was easy to attain.

1	2	3	4	5
absolutely disagree		neutral		absolutely agree

10.2.4 Energy Expended on Attractiveness and Energy Expended on Cost

From the pilot study, we know that participants mainly make a trade-off in allocating their energy between creating an attractive carpet and creating a low cost carpet. As goal setting theory asserts, goals influence the allocation of the individual’s energy-related resources to goal performance by influencing the individual’s *effort*, by inducing *persistence* of the effort over time and by directing the individual’s *attention* to the goal. Hence, to check the allocation of energy among the attractiveness and the cost objective, we will measure both, to see if participants perceived the priority among the attractiveness and cost goal (manipulated by the bonus system) as intended.

Earley et al. (1987, 109) measured energy expended, limiting the construct to the effort and persistence component, using the following three items: “I worked at this task without getting tired for ____!” (1 = only a very short time and 5 = a very long time). “How much effort did you expend to work on this task?” (1= little or no effort and 5 = almost all the effort I could). “While working on the task, I found myself working ____.” (1 = not at all hard and 5 = extremely hard).

Here, we develop for each of the two goals a **3-item scale,** including all three elements in measuring the **self-reported energy** expended toward each of the attractiveness and cost goals individually, as shown in Table 40. Each item asks to indicate the effort, the persistence and the attention that participants gave during the task to the attractiveness of the design or to the cost of the design. The Dutch scale is in Appendix Two, page 446. Both three item scales will be averaged to form a global measure. The developed measurement scale has internal consistency, since the reliability measure Cronbach's Alpha is .79 for "energy expended on attractiveness" and .86 for "energy expended on cost" in experiment two.

Table 40: Measurement Scale for Energy Expended on Attractiveness and Energy Expended on Cost in Experiment Two

<u>**Energy to Attractiveness, item 1 (ATTREFFO) and Energy to Cost, item 1 (COSTEFFO)**</u>

How much effort did you provide to create an *attractive* carpet?

How much effort did you provide to bring the *cost* of the carpet down?

1	2	3	4	5
No or rather few	medium	many	high	extremely high

<u>**Energy to Attractiveness, item 2 (ATTRPERS) and Energy to Cost, item 2 (COSTPERS)**</u>

While I was creating the carpet, I worked with ____ persistence to make my design attractive.

I worked with _____ persistence to the *cost* of my design.

1	2	3	4	5
No or rather few	medium	many	high	extremely high

<u>**Energy to Attractiveness, item 3 (ATTRATTE) and Energy to Cost, item 3 (COSTATTE)**</u>

In general, I took much attention to improve the attractiveness of my design.

During the task, I thought that I took much attention to the *cost* of the carpet.

1	2	3	4	5
absolutely disagree		neutral		absolutely agree

10.3 Target Cost Commitment and Time Commitment

In this study, in both the difficult and the easy TCS a **target cost** is assigned to participants. Furthermore, in all groups a **time** objective is assigned as well. To Locke, Latham & Erez (1988, 23) it is virtually axiomatic that if there is no commitment to goals, then goal setting will not work. Consequently, Hollenbeck & Klein (1987, 219) recommend to measure goal commitment in all future studies where specific goals are assigned, even if commitment does not play a central role in the hypotheses tested, like in our study. Gilliland & Landis (1992, 679) measured commitment in a two-goal setting as commitment to both goals together, though advise in discussing the results to use a separate examination of commitment when conflicting goals are set. Consequently, we need to measure in our study **commitment to the target cost** as well as **commitment to the time objective** separately, even more since different priority is set to each of these goals.

The most common used measurement scale for commitment to an assigned goal is the 4-item scale of Hollenbeck, Klein et al. (1989, 953). The response scale associated with these items is a 5-point Likert scale anchored, by strongly agree, strongly disagree. Negative items are recoded so that a high score on the scale is indicative of high goal commitment. We translated this **4-item** scale in Dutch, as shown in Appendix Two, page 446. The English scale is given in Table 41.

Table 41: Measurement Scale for Target Cost Commitment (4 items) and Time Commitment (4 items) in Experiment Two

Target Cost/Time Commitment, item 1 (COSTCOM1 and TIMECOM1)

It was hard to take the *cost (time)* goal of my boss seriously, during the task.

1	2	3	4	5
absolutely disagree		neutral		absolutely agree

Target Cost/Time Commitment, item 2 (COSTCOM2 and TIMECOM2)

It was unrealistic for me to expect to reach the *cost (time)* goal of my boss.

1	2	3	4	5
absolutely disagree		neutral		absolutely agree

Target Cost/Time Commitment, item 3 (COSTCOM3 and TIMECOM3)

It was quite likely that the *cost (time)* goal may need to be revised, depending on how things went.

1	2	3	4	5
absolutely disagree		neutral		absolutely agree

Target Cost/Time Commitment, item 4 (COSTCOM4 and TIMECOM4)

Quite frankly, I did not care if I achieved the *cost (time)* goal or not.

1	2	3	4	5
absolutely disagree		neutral		absolutely agree

Coefficient Cronbach Alpha reliability for the data of experiment one is .56 for “target cost commitment” and .37 for “time commitment”, which is both rather low compared to the Alpha of .71 in the study of Hollenbeck, Klein et al. (1989, 953). In our study, both for commitment to the target cost as well as for commitment to the time objective, the developed scale seems to capture more than one dimension, as shown in Table 42. Deleting item four increases Cronbach’s Alpha to .65 for target cost commitment and to .58 for time commitment. Running an explorative factor analysis on each of the four items, reveals just one main dimension for target cost commitment (though with low factor loadings on item four) but two dimensions for time commitment, as shown in Table 43. In fact, these last factor loadings are consistent with the findings of DeShon & Landis (1997, 114), who claim that in complex tasks the Hollenbeck-scale (like we used in experiment two) captures two different dimensions. Items 1, 2 and 3 (dimension 1) are measuring the “likelihood of goal achievement” and have much more to do with the expectancies of goal achievement than with abandoning or not assigned goals. Item 4 captures the "real" goal commitment construct[90]. Consequently, we will only consider the answers on the fourth item, when doing further analyses on target cost commitment and time commitment. For more details on this Hollenbeck-scale debate, we refer to the studies of Tubbs & Dahl, 1991; Tubbs, 1993; Wright et al., 1994; Deshon & Landis, 1997.

Table 42: Reliability Coefficients Cronbach's Alpha for Target Cost Commitment and Time Commitment in Experiment Two

		Alpha if Item Deleted			Alpha if Item Deleted
Target Cost Commitment, item 1		0.537	Time Commitment, item 1		0.123
Target Cost Commitment, item 2		0.357	Time Commitment, item 2		0.247
Target Cost Commitment, item 3		0.401	Time Commitment, item 3		0.239
Target Cost Commitment, item 4		0.647	Time Commitment, item 4		0.576
Alpha for 4 items	.563		Alpha for 4 items	.367	

Table 43: Factor Loadings (unrotated) for the Explorative Factor Analysis on the Four items of Target Cost Commitment and Time Commitment in Experiment two

Target Cost Commitment		Time Commitment		
Component Matrix with 1 component extracted		Component Matrix with 2 components extracted		
	Component		Component	
	1		1	2
Target Cost Commitment, item 2	0.85	Time Commitment, item 3	0.80	-0.18
Target Cost Commitment, item 3	0.82	Time Commitment, item 2	0.75	-0.18
Target Cost Commitment, item 1	0.57	Time Commitment, item 1	0.66	0.46
Target Cost Commitment, item 4	0.39	Time Commitment, item 4	-0.02	0.91

10.4 Job-Related Tension caused by Goal Conflict

A self-reported measure was included in the questionnaire to measure to which extent the conflicting goals raised job-related tension for the participants during the task. Field researchers such as Kato (1993) report on design engineers complaining about extensive tension under target costing during new product development.

A frequently used measure of job-related tension is the 15-item scale of Kahn et al. (1964, 424) or the 30-item scale of Rizzo, House & Lirtzman (1970, 156), though both are too extensive and too general for this study. Jaworski & Young (1992, 35) developed a three-item scale, similar in spirit to the one of Rizzo, but adapted to a situation of performance evaluation. These three items are: "I experience tension in my job"; "I experience job tension during performance evaluations" and "If I don't attain

[90] DeSohn & Landis (1997, 106) explain that **real goal commitment** refers to the degree to which the individual considers the goal to be important and is determined to reach it by expending effort over time and being unwilling to abandon or lower the goal when confronted with setbacks or negative feedback.

my performance goals, I feel sense", each time scored on a 5-point scale, ranging from "never" to "always".

Inspired by Jaworsky & Young (1992), we develop a **three-item scale**, focusing on the tension because of the conflicting goals. The three items will be scored on a 5-point Likert-type scale ranging from absolutely disagree (5) to absolutely agree (1), as shown in Table 44. The Dutch scale is in Appendix Two, page 446. The answers on the third item will be reversed and averaged with the other items to form a global index on self-reported job-related tension.

For the data of experiment two, the Cronbach's Alpha is equal to .59, comparable to the Alpha of .60 in the Jaworski & Young (1992) study.

Table 44: Measurement Scale for Self-Reported Job-Related Tension (3 items) in Experiment Two

Self-Reported Tension, item 1 (TENSION1):

During the task, I was rather tensed because I thought I would never find the ideal design.

1	2	3	4	5
absolutely disagree		neutral		absolutely agree

Self-Reported Tension, item 2 (TENSION2):

Looking for an attractive and cheap carpet made me rather tensed during the exercise.

1	2	3	4	5
absolutely disagree		neutral		absolutely agree

Self-Reported Tension, item 3 (TENSION3):

I felt rather comfortable when aiming for the different goals during the exercise.

1	2	3	4	5
absolutely disagree		neutral		absolutely agree

10.5 Motivation by the Bonus System

From discussion with participants in the pilot study, we also learned that there was disagreement among the students if they were motivated or not by the bonus system. In the post experimental questionnaire of experiment two, we will included three items to measure the degree to which participants are motivated by each of the three bonuses (300 BEF, 300 BEF and 100 BEF). Again, this is a self-reported measure. The English language scales are given in Table 45 below. The Dutch scale is in Appendix Two, page 446. The data of experiment two show a Cronbach's Alpha coefficient of .92, indicating that the degree of self-reported motivation is consistent over each of the three bonuses. So, the answers on the three scales can be averaged to form the global index of self-reported motivation by the bonus system, though the items will be used separately as well.

Table 45: Measurement Scale for Degree of Motivation by the Bonus System (3 items) in Experiment Two

<u>Motivation by the Bonus System, item 1 (BONUS1)</u>

By a possible bonus of 300 BEF, I was strongly motivated to create an attractive carpet.

1	2	3	4	5
absolutely disagree		neutral		absolutely agree

<u>Motivation by the Bonus System, item 2 (BONUS2)</u>

By a possible bonus of 300 BEF, I was strongly motivated to create an attractive carpet that had a low cost as well.

1	2	3	4	5
absolutely disagree		neutral		absolutely agree

<u>Motivation by the Bonus System, item 3 (BONUS3)</u>

By a possible bonus of 100 BEF, I was strongly motivated to make an attractive carpet, within the time limit.

1	2	3	4	5
absolutely disagree		neutral		absolutely agree

10.6 Other variables

Identical to the first experiment, other variables will be measured as well in the post experimental questionnaire (see Appendix Two, page 446 for the used Dutch measurement scales, see page 451 for the English scales). *General kinds of questions include* the **age** of the participant, **gender**, **discipline** of education (study option within bioengineering) and **experience with design tasks before** (yes/no).

Seven more questions will be included to give *feedback on the experimental task.* These questions ask if participants **understood the task** after reading the instruction sheets, if they would **participate again** even without extra credit, if they **liked the task** and if they could **guess the real purpose** of the study. A review of the Dutch answers on the guesses of the purpose of the study is given in Appendix Two, on page 464. Also the **total number** of designs made, the importance they gave to the **scores of the jury**, and their perception on the **length** of the questionnaire is added.

Finally, a summary of all questions included in the post experimental questionnaire is given on the next pages, in Table 46. For the full questionnaire in Dutch, we refer to Appendix Two, page 446 et seq. The full questionnaire in English is in Appendix Two, page 451 et seq.

Table 46: Structure of the Post Experimental Questionnaire of Experiment Two[91]

Variable name	Short Description	Measurement Scale	Item n° Non-TCS	Item n° Easy TCS Diff TCS
	General kind of questions:			
AGE	Age of participant	Ratio	1	1
GENDER	Male or Female participant	Nominal	2	2
OPTION	Discipline of education (option chemicals, environment, cell & gene, other)	Nominal	3	3
EXPERIEN	Experience with design tasks before (yes/no)	Nominal	4	4
	Questions to give feedback on the task:			
PURPOSE	Guessing the purpose of the study (yes/no)	Nominal	5	5
UNDERSTA	Understanding the task after reading the instructions	Nominal	6	6
AGAIN	Participate again, without extra credit	Nominal	7	7
LIKETASK	Did you like the task (1-5 scale)	Interval	11	11
QUESTION	Perception of length of questionnaire (1-5 scale)	Interval	31	37
TOTALDES	Total number of designs made	Ratio	8	8
JURYIMPO	Importance to scores of the jury (1-5 scale)	Interval	12	12
	Manipulation checks:			
COSTSPE1	Cost specificity, item 1 (1-5 scale)	Interval	15	15
COSTSPE2	Cost specificity, item 2 (1-5 scale)	Interval	24	28
COSTEASY	Target cost difficulty, item 1 (1-5 scale)	Interval	-	30
COSTDIFF	Target cost difficulty, item 2 (1-5 scale)	Interval	-	34
SHORTTIM	Time difficulty, item 1 (1-5 scale)	Interval	16	16
TIMEEASY	Time difficulty, item 2 (1-5 scale)	Interval	25	29
ATTREFFO	Energy expended on attractiveness, item 1 (1-5 scale)	Interval	9	9
ATTRPERS	Energy expended on attractiveness, item 2 (1-5 scale)	Interval	14	14
ATTRATTE	Energy expended on attractiveness, item 3 (1-5 scale)	Interval	30	36
COSTEFFO	Energy expended on cost, item 1 (1-5 scale)	Interval	10	10
COSTPERS	Energy expended on cost, item 2 (1-5 scale)	Interval	13	13
COSTATTE	Energy expended on cost, item 3 (1-5 scale)	Interval	19	20

[91] For the **full questionnaire**, see Appendix Two, page 446 for the Dutch version and page 451 for the translation in English.

	Commitment to the target cost:			
COSTCOM1	Target cost commitment, item 1 (1-5 scale)	Interval	-	17
COSTCOM2	Target cost commitment, item 2 (1-5 scale)	Interval	-	22
COSTCOM3	Target cost commitment, item 3 (1-5 scale)	Interval	-	24
COSTCOM4	Target cost commitment, item 4 (1-5 scale)	Interval	-	27
	Commitment to the time objective:			
TIMECOM1	Time commitment, item 1 (1-5 scale)	Interval	18	19
TIMECOM2	Time commitment, item 2 (1-5 scale)	Interval	20	21
TIMECOM3	Time commitment, item 3 (1-5 scale)	Interval	21	23
TIMECOM4	Time commitment, item 4 (1-5 scale)	Interval	23	26
	Job-related tension:			
TENSION1	Tension because of goal conflict, item 1 (1-5 scale)	Interval	17	18
TENSION2	Tension because of goal conflict, item 2 (1-5 scale)	Interval	22	25
TENSION3	Tension because of goal conflict, item 3 (1-5 scale)	Interval	29	35
	Motivation by bonus system:			
BONUS1	Motivated by bonus for attractiveness (1-5 scale)	Interval	26	31
BONUS2	Motivated by bonus for low cost design (1-5 scale)	Interval	27	32
BONUS3	Motivated by bonus for attaining time objective (1-5 scale)	Interval	28	33

So far, we have discussed the *practical organization* of experiment two as well as the used *measurement scales* of the variables. From the next section on, we will make the jump to reviewing the "real" data, collected during and after the experimental task. We will first *screen* the data, to verify if we can proceed with hypotheses testing. Different issues will be discussed, such as the results of the manipulation checks, the accuracy of the data, descriptive statistics, checking for outliers, normality and homoscedasticity of the main variables. A summary of the data screening process is provided in section 11.6 on page 223. Then, we will progress towards testing the hypotheses.

11. Data Screening

11.1 Results of the Manipulation Checks

Before testing the hypotheses, we will first analyze if the manipulations of target cost setting and time difficulty were successfully operationalized in the experiment. Since the TCS included an aspect of cost specificity as well of cost difficulty, we need to check on both elements. Thus, in total three aspects need to be checked, i.e. the perception on *target cost specificity*, the perception on *target cost difficulty* and the perception on *time difficulty*, as discussed earlier on page 198.

The mean score on **target cost specificity** is significantly different between the non-TCS on the one hand (mean = 2.3) and the easy and difficult TCS conditions on the other hand (mean = 4.4), indicating that the target cost in the easy TCS and difficult TCS was perceived as much *more* specific than the minimizing cost objective in the non-TCS (F (1, 118) = 143.2, p = 0.000 in Table 47 below).

The perception on the **difficulty of the target cost** was significantly different between the easy and the difficult TCS (F (1, 78) = 15.8, p = 0.000). Conform the manipulation, the difficult target cost was perceived as more difficult (mean = 2.8) than the easy TCS (mean = 1.8), as shown in Table 47 below.

The **difficulty of the TIME objective** was perceived as significantly different between the easy TIME and the difficult TIME condition (F (1, 118) = 7.8, p = 0.006). The mean score on the time difficulty index was 1.6 for the easy TIME, while 2.1 for the difficult TIME condition (see Table 47).

Table 47: ANOVA's for the Manipulation Checks on Target Cost *Specificity*, Target Cost *Difficulty* and *Time* Difficulty in Experiment Two

ANOVA		**Sum of Squares**	**Df**	**Mean Square**	**F**	**Sig.**
Specificity of cost objective (1-5)	Between Groups	112.067	1	112.067	143.222	**0.000**
	Within Groups	92.331	118	0.782		
	Total	204.398	119			
ANOVA		**Sum of Squares**	**Df**	**Mean Square**	**F**	**Sig.**
Target cost difficulty (1-5)	Between Groups	21.013	1	21.013	15.778	**0.000**
	Within Groups	103.875	78	1.332		
	Total	124.888	79			
ANOVA		**Sum of Squares**	**Df**	**Mean Square**	**F**	**Sig.**
Difficulty of the time objective (1-5)	Between Groups	6.533	1	6.533	7.870	**0.006**
	Within Groups	97.958	118	0.830		
	Total	104.492	119			

In sum, the results reveal that both manipulations, i.e. the target cost setting and the time difficulty, were successfully implemented.

Furthermore, we need to check if participants (across all manipulations) understood the type of new product development environment in terms of **priority among the attractiveness and cost goal**. In general, the mean for energy on attractiveness (3.15) was higher than for energy on cost (2.23). Individually considered, 70% of all participants expended more energy on improving the attractiveness than on reducing the cost level of the design, while 18% expended equal effort, as shown in Table 48. Only 15 participants (12%) expended more energy on cost than on attractiveness. Higher or lower energy on cost was independent of the TCS manipulation ($\chi^2 = 1.7$, $p = .782$) or the TCS by TIME difficulty manipulation ($\chi^2 = 6.1$, $p = .806$). The paired samples t-test reveals that participants reported significantly higher energy expended on attractiveness than on cost ($t = 8.7$, $p = .000$), as shown in Table 49. **Hence, priority among attractiveness and cost was understood in the way as intended.** We admit that we did not check in experiment two if the time objective was perceived as the least important objective, which we will do in the third experiment.

Table 48: Relative Difference between Energy Expended on Attractiveness and Energy Expended on Cost in Experiment Two

Difference		**Frequency**	**Percent**	**Cumulative Percent**
< 0:	more energy on cost	15	12.50%	12.50%
= 0:	equal energy on attractiveness and cost	22	18.33%	18.33%
> 0:	more energy on attractiveness	83	69.17%	100.00%
	Total	120	100.00%	

Table 49: Paired Sample t-Test between Energy Expended on Attractiveness and Energy Expended on Cost in Experiment Two

Paired Differences			95% Confidence Interval of the Difference				
Mean	**Std. Deviation**	**Std. Error Mean**	**Lower**	**Upper**	**t**	**Df**	**Sig. (1-tailed)**
0.917	1.151	0.105	0.709	1.125	8.725	119	**0.000**

11.2 Accuracy of the Data

The data were entered in SPSS by the experimenter and ran over with a student-secretary. Frequency tables were examined for all variables to make sure there were no out-of-range numbers. When participants made mistakes in the cost calculation table (in 6.7 % of the cases), the right total cost is used as the operationalization for the cost level[92]. These mistakes were all minor, in positive as well as in negative sense (mean of absolute values = 160, compared to the grand mean for cost level of 2635) and independent of the manipulations (χ^2 = 9.0, p = .11). None of the mistakes induced a wrong perception about the attainment of the target cost.

One observation is **missing scores** for attractiveness, cost level and time spent. This participant with id number 57 left the room without handing in his/her selected design, though he/she filled-out the questionnaire. Deleting this case will make our design no longer balanced, giving 19 observations in the difficult TCS, easy TIME condition in stead of 20 for all the other conditions. To maintain a balanced design with 20 observations in each group, we replaced the missing values for attractiveness, cost level and time spent for this ID number 57 with the *group means* (difficult TCS, easy TIME). Following Tabachnick & Fidell (1989, 64), this procedure is a good compromise since it is not as conservative as inserting the overall mean value and not as liberal as inserting a well-educated guess of the researcher (such as selecting one of the tryout designs in the folder of ID number 57).

Rarely participants **forgot** (or refused) **to answer** some items of the post experimental **questionnaire**. In total we are missing 12 item scores on the questionnaire, coming from 11 different participants, randomly spread out over the whole sample and over the different questions. For questions with multi-items (7 of the 12 missing are in this category), we calculate the average based on the non-missing data items only. For variables with just one item in the questionnaire (5 of the 12 missing are in this category), we will simply delete these cases, when running analyses on these specific variables.

[92] By using the correct cost level we did **not bias the results**, since all conclusions of the hypotheses give exactly the same results with the wrong cost levels as with the correct ones. In the main text, we will report the results with the correct cost levels, because of higher accuracy. To show the similarity of the conclusions, we report here shortly the results with the wrong cost levels. Hypothesis 1: F (2, 117) = .53, p = .590 instead of p = .635 with the correct cost levels, leading to the same conclusion. Hypothesis 2: Pillai's Trace p = .001, which is the same as the one who will be reported further on and thus leading to the same conclusion. The two pairwise comparisons show the same p-values for Hotelling's T^2, p = .002 and p = .000 and p = .231 with the same p-values for the univariate follow-up t-tests, leading to the same conclusions. Hypothesis 3: F (2, 114) = 2.3, p = .10 instead of p = .098, leading to the same conclusion of marginal significance. For interaction comparison one, we have now F (1, 76) = 4.6, p = .035 instead of p = .027. For interaction comparison two, we find with the wrong cost data F (1, 76) = 1.7, p = .191 instead of p = .206. For interaction comparison three, the F-test is F (1, 76) = .49, p = .489 instead of p = .416. Follow-up analyses for interaction comparison one under the easy time condition gives p = .053 instead of the reported p = .046. Under the difficult time condition, p = .326 instead of p = .281 with the correct cost data. All results of this hypothesis 3 are thus the same as the ones who will be reported further on. Hypothesis 4: Pillai's Trace gives p = .257 instead of the reported p = .244. Hotelling's T^2 for the first interaction comparison gives p = .074 instead of the reported p = .067. Hotelling's T^2 for the second interaction comparison gives p = .416 instead of the reported p = .432. Hotelling's T^2 for the third interaction comparison gives p = .754 instead of the reported p = .714. **Hence, all conclusions really remain the same and it doesn't matter for the results which one of the two operationalizations of the cost level we use.**

11.3 Descriptive Statistics

The **frequency tables** for the nominal measured data are given in Table 50. Of the 120 participants, 72 were male (60%). Most of them had no experience with design tasks (88%). Less than half (40%) did a guess on the purpose of the task. Appendix Two, page 464 gives an overview of these guesses in Dutch. All 120 participants understood the task after reading the instruction pages. And even if no extra credit points were given, 42% of the participants would participate again. Furthermore, random assignment to treatment was successfully implemented. Participants were randomly spread out over the six conditions in terms of gender, discipline and experience with design tasks before. None of the Chi-Square tests are significant at $\alpha = 5\%$.[93]

Descriptive statistics for the interval and ratio measured variables are shown in Table 51. *Attractiveness* ranged between 1 and 4.3, with a mean of 2.75. The *cost level* varied between 1300 BEF and 3805 BEF, with a mean of 2635 BEF. *Time spent* varied between 40 and 95 minutes, with a mean of 68 minutes.

Energy expended to improve attractiveness had a mean of 3.15, while *energy expended* on cost had a grand mean of 2.23, both ranging from 1 to 5. Participants reported their *target cost commitment* and their *time commitment* to respectively 3.24 and 3.11 on average, also ranging between 1 and 5. The scores for *job-related tension* ranged between 1 and 4, indicating that no one perceived tension as extremely high. The mean of job-related tension was 1.96. Motivation by the *bonus system* ranged from 1 to 5 with a mean of 3.04.

Participants disagreed in the importance they took to the scores of the jury. The answers ranged between 1 and 5, with a mean of 2.48. Interest in the task had a mean of 3.34, ranging from 1 to 5. Most participants, i.e. 81% found the task "interesting", "rather fun" or "fun", as shown in Figure 42. The length of the questionnaire was perceived as just right (3), rather long (4) or too long (5), with a mean of 3.84. On average participants were 22.5 years old. The number of designs made had a mean of 6, with a minimum of 2 and a maximum of 15.

[93] The **Chi-Square tests** give the following results: Treatment by gender $\chi^2 = 5.417$, p = 0.367; treatment by discipline of education $\chi^2 = 7.917$, p = 0.161; $\chi^2 = 1.617$, p = 0.899.

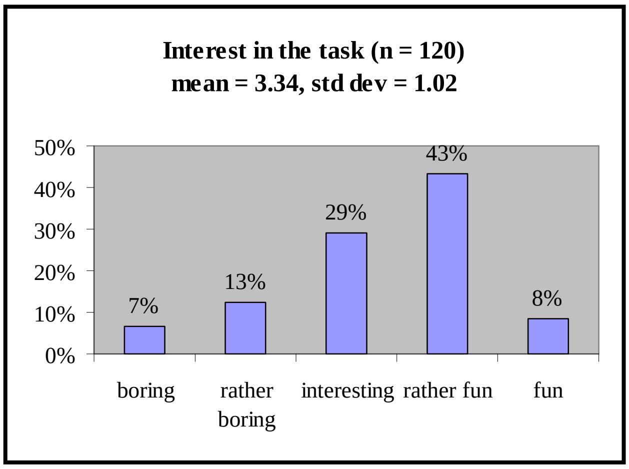
Table 50: Frequency Tables for the Nominal Measured Data in Experiment Two

		Frequency	Percent	Valid Percent	Cum. Percent
Gender	Male	72	60	60	60
	Female	48	40	40	100
Discipline of education	5th Year, option chemicals	48	40	40	40
	5th Year, option environment	55	45.8	45.8	85.8
	5th Year, option cell & gene	14	11.7	11.7	97.5
	5th Year, other	3	2.5	2.5	100
Experience with designing task	Yes experience	14	11.7	11.7	11.7
	No experience	106	88.3	88.3	100
Guessing purpose of exercise	I do a guess on the purpose	48	40	40	40
	I have no idea of the purpose	72	60	60	100
Understanding of the task	Yes, I did understand task	120	100	100	100
	No, I did not understand task	0	0	0	0
I'll participate again (without extra credit)	Yes, I participate again	51	42.5	42.8	42.8
	No, I do not participate again	68	56.7	57.1	100
	System Missing	1	0.8		
	Total	120	100		

Table 51: Descriptive statistics for Experiment Two

Variable	Label	N	Min	Max	Mean	Std. Dev.	Variance
MEANATTR	Attractiveness (scored on 5)	120	1	4.33	2.75	0.80	0.64
COST	Cost Level	120	1300	3805	2635.1	507.2	257246.3
TIME	Time spent in minutes	120	40	95	67.8	11.7	135.8
ENERGYAT	Energy expended on attractiveness (1-5)	120	1	5	3.15	0.81	0.66
ENERGYCO	Energy expended on cost (1-5)	120	1	5	2.23	0.98	0.96
COSTCOM	Target cost commitment (1-5)	80	1	5	3.24	1.45	2.11
TIMECOM	Time commitment (1-5)	120	1	5	3.11	1.51	2.27
TENSION	Tension because of goal conflict (1-5)	120	1	4	1.96	0.80	0.65
BONUS	Motivation by the bonus system (1-5)	120	1	5	3.04	1.33	1.77
JURYIMPO	Importance to jury scores (1-5)	120	1	5	2.48	1.11	1.23
LIKETASK	Interest in the task (1-5)	120	1	5	3.34	1.02	1.05
QUESTION	Length of the questionnaire (1-5)	118	3	5	3.84	0.78	0.61
AGE	Age of participant	120	21	27	22.5	0.81	.65
TOTALDES	Number of designs made in total	118	2	15	5.87	2.81	7.92

Figure 42: Frequency Chart for "Interest in the Task" in Experiment Two



11.4 Outliers and Extreme Values

To identify possible **univariate outliers** and extreme values, we need to make the boxplots for the dependent variable cost level. Following Tabachnick & Fidell (1989, 67) outliers are sought separately within each group. Hence for the main effect, we need to consider the three groups of TCS, for the interaction effects, we need to consider six groups (i.e. the 3 TCS by 2 TIME conditions).

Let's *first* consider the outliers for the three TCS groups for the cost level, as shown in the first graph of Figure 43. Three cases are more than 1.5 box length removed from the 25th percentile. Cases 92 and 99 are in the easy TCS and case 48 in the difficult TCS. *Secondly* for the interaction effect on the cost level, we need to consider the boxplot for each of the six groups. As shown in the second graph of Figure 43, nine cases in total show up as outliers. Checking the cost calculation table convinced us that these cost data were correctly entered in SPSS.

To identify possible **multivariate outliers**, we computed the Mahalanobis distance[94] for cost level, attractiveness and time spent, in separate runs for each group (Tabachnick & Fidell, 1989, 69). *First*, for the three TCS groups, two multivariate outliers were identified (cases 80 and 99), as shown in the first graph of Figure 44. Table 53 gives a description of these cases in terms of cost level, attractiveness and time spent. It is the combination of these three dependent variables that makes a case a multivariate outlier. Indeed, both cases 80 and 99 made a design with a rather low cost, received a rather low score for attractiveness and spent rather low time on it. From the data we don't know if these participants did not bother to perform the task well or just had no ability to perform better. *Secondly*, when looking at the outliers for the interaction effect, calculating the Mahalanobis

[94] The **Mahalanobis** distance is the distance of an observation from the centroid of the remaining observations. The centroid is the point created by the means of all the variables. If an observation has an unusual combination of scores, the Mahalanobis distance of that observation from the rest is significant.

distances in each of the 6 groups, we just found one multivariate outlier, i.e. case 80, as shown in the second graph of Figure 44. As summarized in Table 52, case 99 and 80 are outliers both from a univariate as well as multivariate perspective.

We decided **not to delete** any of these univariate or multivariate outliers, since the data were accurately sampled following rigorously the procedures of lab experiment two, as described earlier. Though, we did all analyses with and without outliers. For the hypotheses one and two, the significance levels are more or less the same when we delete the outliers or when we include the outliers. For hypotheses three and four, deleting the outlier cases from the sample makes the outcome of the statistical tests more significant, as will be reported further on. Marginally significant differences become then significant differences at $\alpha = 5\%$, but leading to the same conclusions.

Table 52: Outlier Case Numbers in Experiment Two

Hypotheses	**Condition**	**Univariate Outliers (for Cost Level)**	**Multivariate Outliers (for Cost Level, Attract. and Time Spent)**
H1 and H2	Non-TCS	-	80
	Easy TCS	92, 99	99
	Difficult TCS	48	-
H3 and H4	Non-TCS, Easy TIME	-	-
	Easy TCS, Easy TIME	-	-
	Difficult TCS, Easy TIME	45, 48	-
	Non-TCS, Difficult TIME	80	80
	Easy TCS, Difficult TIME	92, 99	-
	Difficult TCS, Difficult TIME	105, 111, 117, 118	-

Table 53: Describing the Multivariate Outliers of Experiment Two

	Condition		**Cost Level**	**Attractiveness**	**Time Spent**
H2	Non-TCS	Case 80	1328	1.44	58
	Group Mean		**2574**	**3.12**	**66**
	Easy TCS	Case 99	1368	2.00	44
	Group Mean		**2678**	**2.49**	**66**
H4	Easy TCS, Difficult TIME	Case 80	1328	1.44	58
	Group Mean		**2748**	**3.05**	**61**

Figure 43: Boxplots for the Cost Level in each TCS group (H1) and in each 'TCS by TIME' Group (H3) in Experiment Two

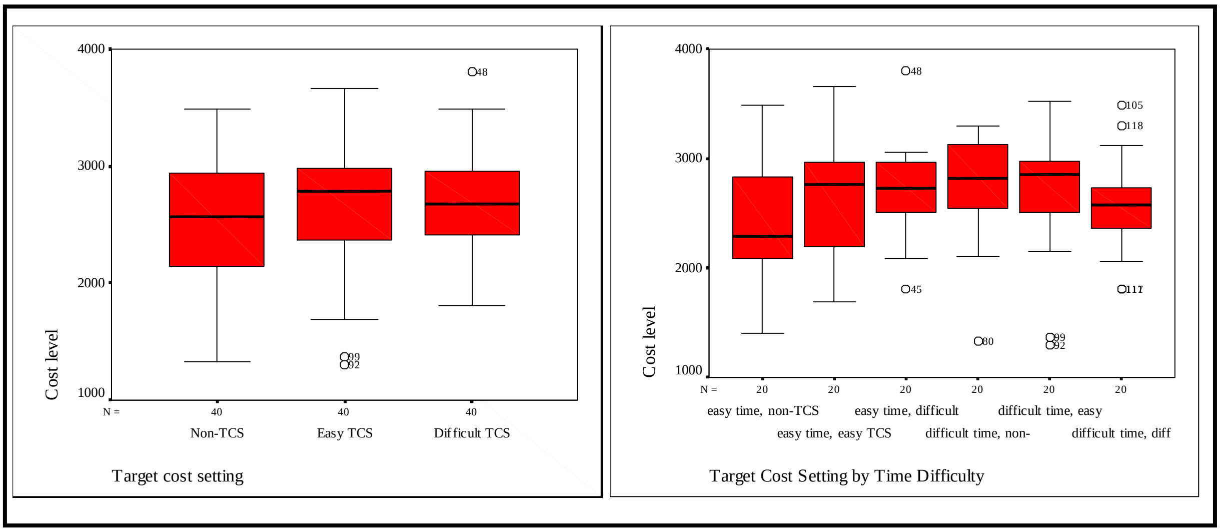
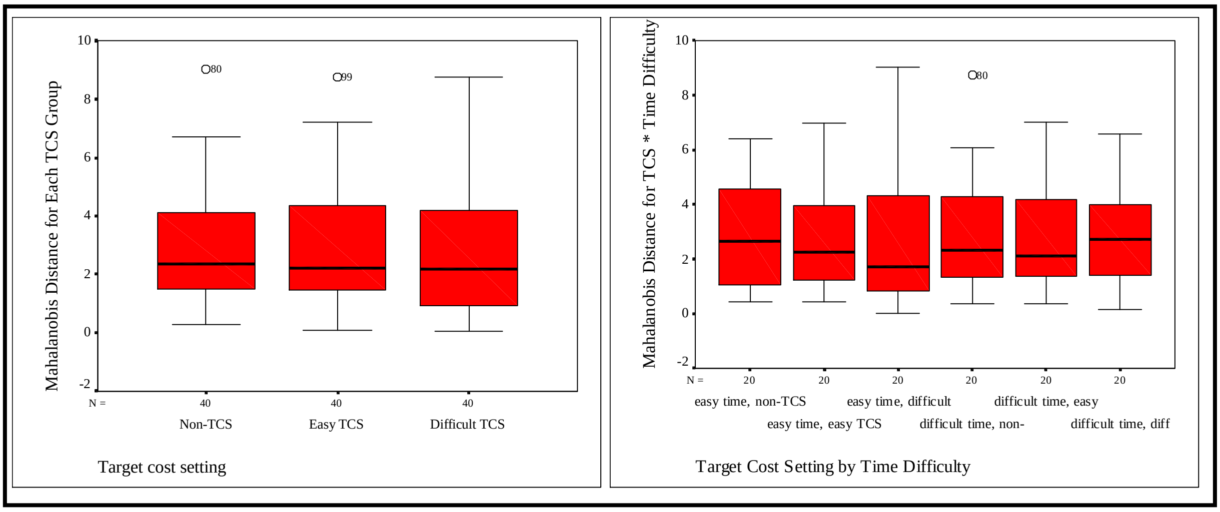


Figure 44: Boxplots for the Mahalanobis Distance (based on Cost Level, Attractiveness and Time Spent) in each TCS Group (H2) and each 'TCS by TIME' Group (H4)



11.5 Checking the Assumptions of Normality and Homoscedasticity

11.5.1 Checking the Assumptions to test Hypothesis One (Univariate, Main Effect)

To check the assumption of *normally* distributed populations we made the normal probability plot and the detrended normal plots for the **cost level** in each of the TCS conditions, as shown in Figure 45 on page 220. In the normal probability plots almost all points fall on the straight line. In the detrended normal plots, there is no pattern and the points cluster around the horizontal line, suggesting normality. Indeed, both the Kolmogorov-Smirnov and Shapiro-Wilks' test can *not* reject the null hypotheses of normality for any of the three TCS groups at $\alpha = 5\%$, as shown in Table 54 on page 218.

To check the assumption of *homogeneity* of variances, the Levene test statistic was performed. As shown in Table 55 on page 219, the Levene test cannot reject the null hypothesis of homoscedasticity among the TCS groups for the cost level ($p = 0.19$). **Hence, both the assumptions of normality and homoscedasticity are met for the cost level in each TCS group. So we can use the F-test and the suggested multiple comparison test to test the hypotheses 1, 1a and 1b.**

11.5.2 Checking the Assumptions to test Hypothesis Three (Univariate, Interaction Effect)

For the interaction effect of the TCS by TIME manipulation in hypothesis three, we can see in the detrended normal plot of Figure 45 (page 220) a pattern for the non-TCS, difficult TIME and for the easy TCS, difficult TIME condition. Based on the Kolmogorov-Smirnov test in Table 54 (page 218), the assumption of normally distributed data is violated for these conditons (Shapiro-Wilks' $p = .035$, $.042$ respectively). As mentioned earlier on page 152, it is very rare that the assumption of normality is met with real data (Toothaker, 1993, 57). Furthermore, as discussed earlier on page 152, the F-test and t-test statistic are quite robust towards violations of normality.

To check the assumption of *homogeneity of variances*, the Levene test statistic was performed on the cost level, for the interaction effect, as shown in Table 54. The homogeneity assumption can be supported for each of the six groups, since the Levene test statistic cannot reject the null hypothesis of equal variances ($p = 0.69$). Hence, the assumption of homogeneity is met for the cost level. **In sum, we can use the suggested F and t-test statistics to test the hypotheses 3, 3a and 3b.**

11.5.3 Checking the Assumptions to test Hypothesis Two (Multivariate, Main Effect)

Doing multivariate analysis, like the MANOVA for hypothesis two, requires *multivariate normally* distributed populations. As mentioned before, SPSS (as well as other statistical packages) does not provide in a test statistic to accept or reject the hypothesis of multivariate normality. As mentioned in chapter 5, page 154, it is more likely that the assumption of *multivariate* normality is met, if all dependent variables are *univariate* normally distributed. From the first six plots of Figure 45 (page 220) and Figure 46 (page 221) we can see that attractiveness and cost level are normally distributed in each TCS. For the variable time spent in Figure 47 (page 222), there is a problem in the difficult TCS. Also the Kolmogorov-Smirnov test of Table 54 (page 218) rejects the null hypothesis of normality for time spent in this difficult TCS condition (p = 0.001). Since one of the three variables is not *univariate* normally distributed, it is likely to assume that the *multivariate normality* assumption is violated for the TCS manipulation. To test hypotheses 2, 2a and 2b we suggested earlier to use Wilks' Lambda, Hotelling's T^2 and the t-test. Following Bray & Maxwell (1990), as discussed before on page 154, these test statistics are all robust to violations of normality.

For the *multivariate homoscedasticity*, two assumptions need to be checked. First, the univariate homogeneity of variance assumption must be met for each dependent variable and second the correlation between any two dependent variables must be the same in each of the treatment groups. The dependent variables attractiveness and cost level have homogeneous variances in each of the three TCS, as shown in Table 55 (page 219). Though, time spent is not homoscedastic (Levene test statistic p = 0.045). Second, the correlation between any two dependent variables is equal in each of the three groups, since Box's M test (p = 0.219) cannot reject the null hypothesis of homogeneity of variance-covariance matrices (see Table 56). **Thus, the first condition for multivariate homoscedasticity is not met in this experiment leading to a violation of the multivariate homoscedasticity assumption. Hotelling's T^2 and the t-test statistic can be used without major problems to test hypotheses 2a, 2b. But it would be better to use Pillai's Trace instead of the suggested Wilks' Lambda to test hypothesis 2, as discussed in the chapter 5 on page 154.**

11.5.4 Checking the Assumptions to test Hypothesis Four (Multivariate, Interaction Effect)

For the interaction between the TCS and TIME manipulation, none of the three variables attractiveness, cost level and time spent is univariate normally distributed, as shown in Figure 45, Figure 46, and Figure 47. The Shapiro-Wilks' test and the Kolmogorov-Smirnov tests give p-values of .035, .042, .024, .020 and .015 for some of the 'TCS by TIME' groups, indicating that the null hypothesis of normality should be rejected when testing for the interaction effect. Hence, it is likely that also the *multivariate normality* assumption is violated. As discussed earlier on page 154, departure from multivariate normality has only slight effects on the type I-error (Bray & Maxwell, 1990). Hence, Pillai's Trace, Hotelling's T^2, the F and t-test are still recommended to test hypotheses 4, 4a and 4b.

To evaluate the *multivariate homoscedasticity*, two assumptions need to be checked. The first condition of univariate homoscedasticity is supported, since all three variables cost level, attractiveness and time spent do have equal variances in each of the 6 groups, as indicated in Table 55 (page 219). Furthermore, Box's M-test confirms the assumption of equality of variance-covariance matrices among the six groups (p = .563). Both conditions are met, thus the assumption of homoscedasticity is not violated for the multivariate interaction effect. **Hence, we can use the suggested multivariate tests Pillai's Trace and Hotelling's T^2 to test hypotheses 4, 4a and 4b. Follow-up univariate analyses will be done by the suggested F and t-tests.**

Table 54: Tests of Normality for Experiment Two

Tests of Normality for Target Cost Setting							
		Kolmogorov-Smirnov[a]			**Shapiro-Wilks**		
		Statistic	**Df**	**Sig.**	**Statistic**	**Df**	**Sig.**
Cost level	Non-TCS	0.081	40	0.200	0.963	40	0.348
	Easy TCS	0.130	40	0.085	0.945	40	0.080
	Difficult TCS	0.093	40	0.200	0.972	40	0.515
Attractiveness	Non-TCS	0.122	40	0.138	0.947	40	0.089
	Easy TCS	0.131	40	0.080	0.960	40	0.284
	Difficult TCS	0.135	40	0.064	0.940	40	0.051
Time spent	Non-TCS	0.068	40	0.200	0.979	40	0.715
	Easy TCS	0.105	40	0.200	0.971	40	0.474
	Difficult TCS	0.189	40	**0.001**	0.946	40	0.085
Tests of Normality for Target Cost Setting * Time Difficulty							
Cost level	Non-TCS, Easy Time	0.147	20	0.200	0.956	20	0.468
	Easy TCS, Easy Time	0.148	20	0.200	0.950	20	0.412
	Difficult TCS, Easy Time	0.166	20	0.150	0.943	20	0.337
	Non-TCS, Difficult Time	0.135	20	0.200	0.894	20	**0.035**
	Easy TCS, Difficult Time	0.157	20	0.200	0.899	20	**0.042**
	Difficult TCS, Difficult Time	0.163	20	0.173	0.962	20	0.564
Attractiveness	Non-TCS, Easy Time	0.158	20	0.200	0.887	20	**0.024**
	Easy TCS, Easy Time	0.177	20	0.103	0.954	20	0.444
	Difficult TCS, Easy Time	0.134	20	0.200	0.944	20	0.342
	Non-TCS, Difficult Time	0.113	20	0.200	0.957	20	0.482
	Easy TCS, Difficult Time	0.177	20	0.102	0.924	20	0.139
	Difficult TCS, Difficult Time	0.143	20	0.200	0.931	20	0.208
Time spent	Non-TCS, Easy Time	0.122	20	0.200	0.963	20	0.588
	Easy TCS, Easy Time	0.139	20	0.200	0.946	20	0.366
	Difficult TCS, Easy Time	0.174	20	0.116	0.934	20	0.239
	Non-TCS, Difficult Time	0.162	20	0.180	0.932	20	0.220
	Easy TCS, Difficult Time	0.187	20	0.066	0.884	20	**0.020**
	Difficult TCS, Difficult Time	0.216	20	**0.015**	0.934	20	0.242
a Lilliefors Significance Correction							

Table 55: Testing Homogeneity of Variances in Experiment Two

Test of Homogeneity of Variances for Target Cost Setting				
	Levene Statistic	**Df1**	**Df2**	**Sig.**
Cost Level	1.666	2	117	0.193
Attractiveness	2.490	2	117	0.087
Time spent	3.175	2	117	**0.045**
Test of Homogeneity of Variances for Target Cost Setting * Difficulty of the Time Objective				
	Levene Statistic	**Df1**	**Df2**	**Sig.**
Cost Level	0.614	5	114	0.690
Attractiveness	1.538	5	114	0.184
Time spent	1.852	5	114	0.108

Table 56: Box's M Test for Equality of Covariance Matrices for the Dependent Variables Cost Level, Attractiveness and Time Spent in Experiment Two

Box's Test of Equality of Covariance Matrices for Target Cost Setting				
Box's M	**F**	**Df1**	**Df2**	**Sig.**
16.032	1.286	12	66339	**0.219**
Box's Test of Equality of Covariance Matrices for Target Cost Setting * Difficulty of the Time Objective				
Box's M	**F**	**Df1**	**Df2**	**Sig.**
30.184	0.938	30	29370.068	**0.563**

Figure 45: Normal Probability Plots and Detrended Normal Plots for *Cost Level* for each TCS and Detrended Normal Plots for each 'TCS by TIME' Group in Experiment Two

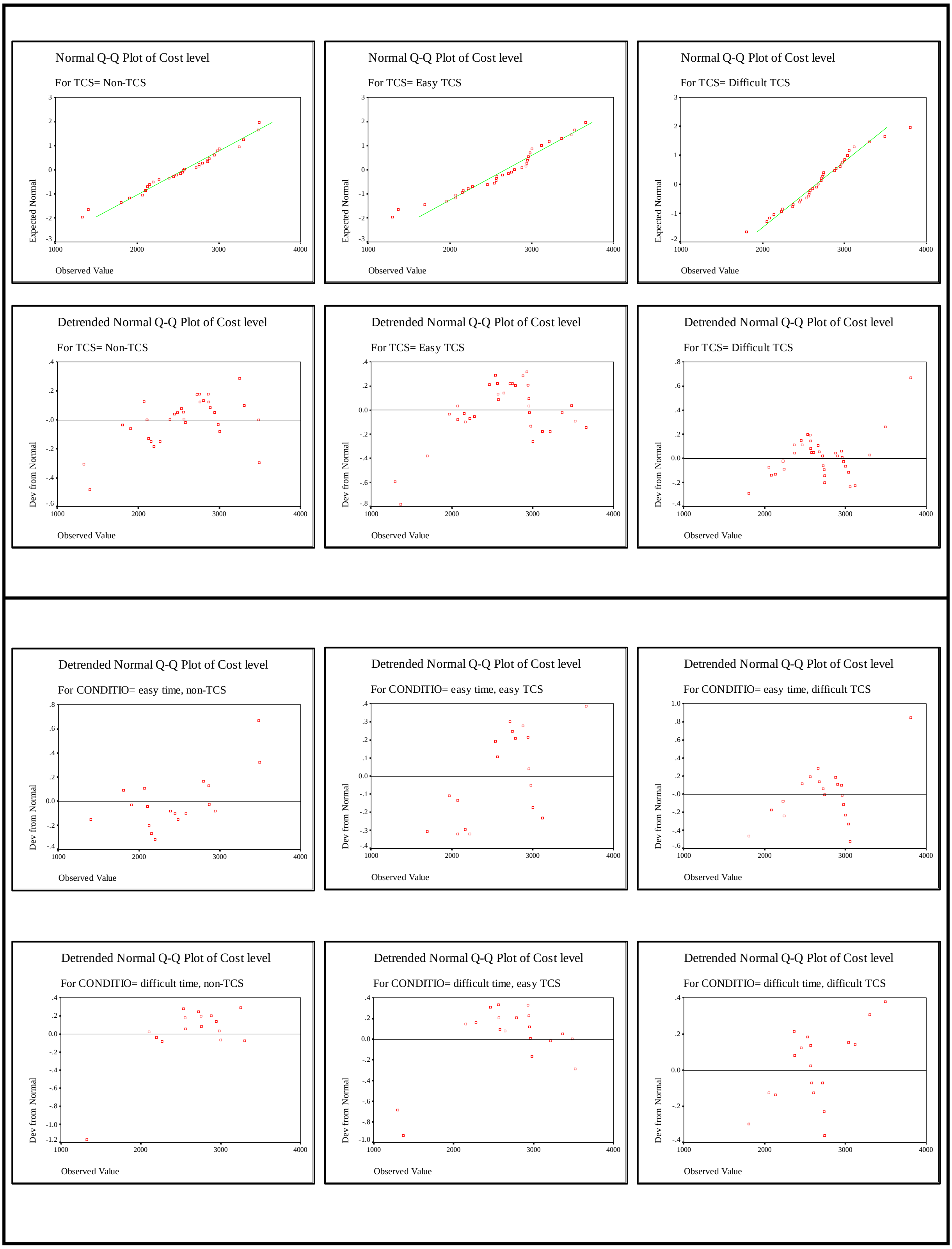


Figure 46: Normal Probability Plots and Detrended Normal Plots for *Attractiveness* for each TCS and Detrended Normal Plots for each 'TCS by TIME' Group in Experiment Two

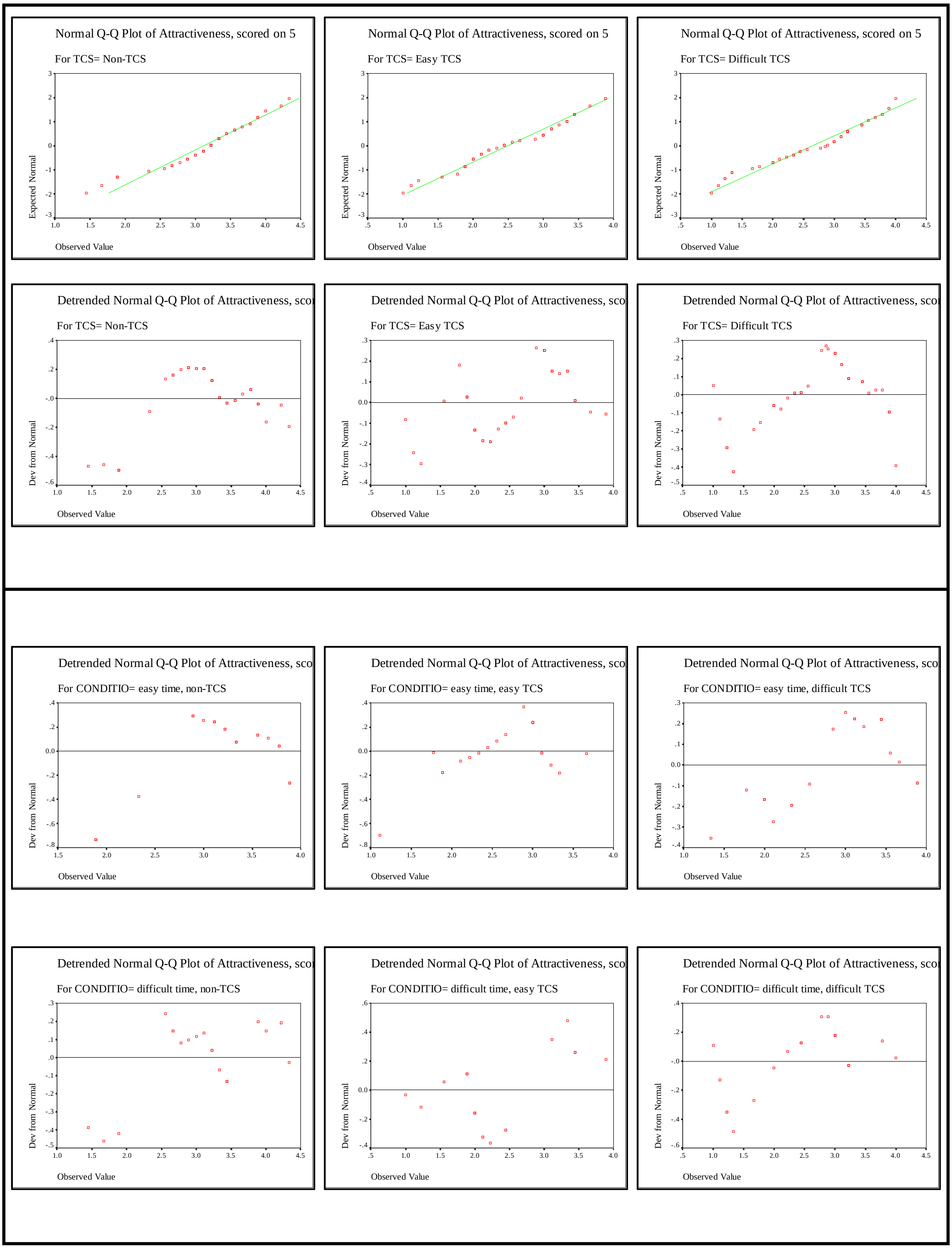
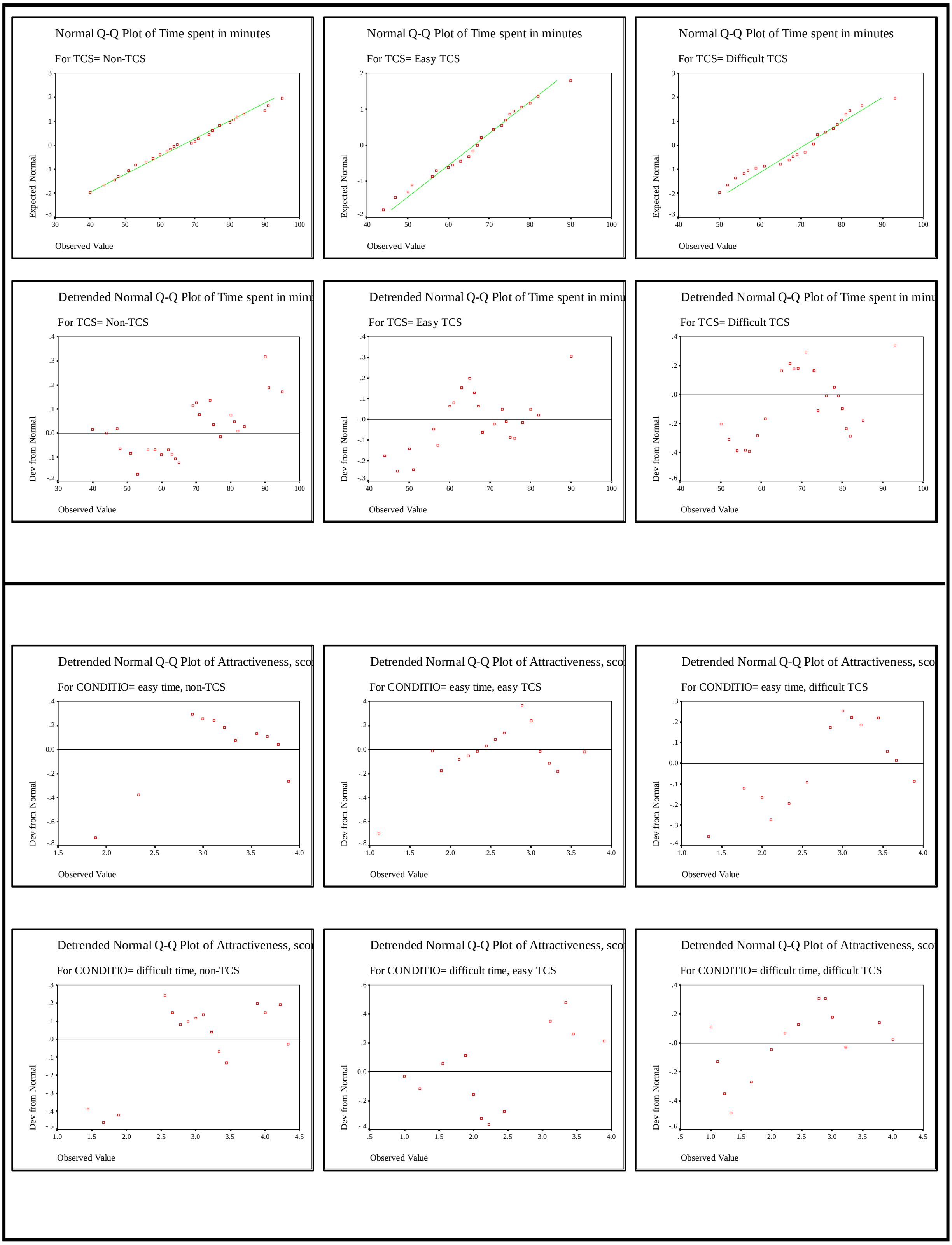


Figure 47: Normal Probability Plots and Detrended Normal Plots for *Time Spent* for each TCS and Detrended Normal Plots for each 'TCS by TIME' Group in Experiment Two



11.6 Conclusions of the Data Screening

In the previous sections we screened the data to make sure that we can progress with testing the hypotheses on the collected data. Table 57 summarizes the conclusions of this data screening process.

Table 57: Conclusions of the Data Screening in Experiment Two

Action	Conclusion
<u>Manipulation checks</u>: • For target cost specificity: • For target cost difficulty: • For time difficulty: • Priority rule :	 • Perceived as intended. • Perceived as intended. • Perceived as intended. • Perceived as intended.
<u>Accuracy of the data</u>: • One missing score for cost level, attractiveness and time spent:	 • Replace missing score by group mean to keep balanced cells.
<u>Outliers</u>: • Univariate outliers: • Multivariate outliers:	 • Include outliers in the analysis. • Include outliers in the analysis.
<u>Normality</u>: • H1: Univariate for TCS in the cost level: • H3: Univariate for TCS * TIME in the cost level: • H2: Multivariate for TCS in the cost level, attractiveness and time spent: • H4: Multivariate for TCS * TIME in the cost level, attractiveness and time spent:	 • Assumption supported. • Assumption violated, but F-test and t-test are robust. • Assumption violated, but Hotelling's T^2 and t-test are robust. • Assumption violated, but Hotelling's T^2, F-test and t-test are robust.
<u>Homoscedasticity</u>: • H1: Univariate for TCS in the cost level: • H3: Univariate for TCS * TIME in the cost level: • H2: Multivariate for TCS in the cost level, attractiveness and time spent: • H4: Multivariate for TCS * TIME in the cost level, attractiveness and time spent:	 • Assumption supported. • Assumption supported. • Assumption not supported: Better use Pillai's Trace instead of Wilks' Lambda. Hotelling's T^2 and T-test are robust. • Assumption supported.

In sum, the manipulations were correctly operationalized, the data are correctly entered and the data support the assumptions associated with the test statistics. **Consequently, in the next paragraphs we will start with testing the hypotheses. Each of the four hypotheses is addressed in a separate section (from section 12 to section 15). Afterwards, we provide a summary table in paragraph 16 on page 245.**

12. Testing Hypothesis One

12.1 ANOVA for Hypothesis 1

As discussed earlier in chapter three, we expect that the target cost setting manipulation will have an impact on the cost level of the created designs. From target costing literature, we expect that the cost level will be lower under the difficult TCS than under the non-TCS. From previous goal setting studies, we expect that the cost level will be lower under the non-TCS than under the easy TCS. Consequently:

In hypothesis 1, we hypothesized that in a three-goal NPD situation, the *cost level* of a future product will significantly differ among the non-TCS, the easy TCS and the difficult TCS.

In order to test the hypothesized group difference on cost level, we need to do an ANOVA F-test, as discussed on page 135. Contrary to the expectations, the ANOVA F-test does not find a significant group difference in cost level among the three target cost settings (F (2, 117 = 0.46, p = 0.634), as shown in Table 58. We cannot reject the null hypothesis of equal cost levels among the three groups. Thus the data do **not support** hypothesis 1 of a significant difference in cost level among the non-TCS, the easy TCS and the difficult TCS. As displayed in Table 59 and Figure 48, the group means in cost level hardly differ among the three TCS.

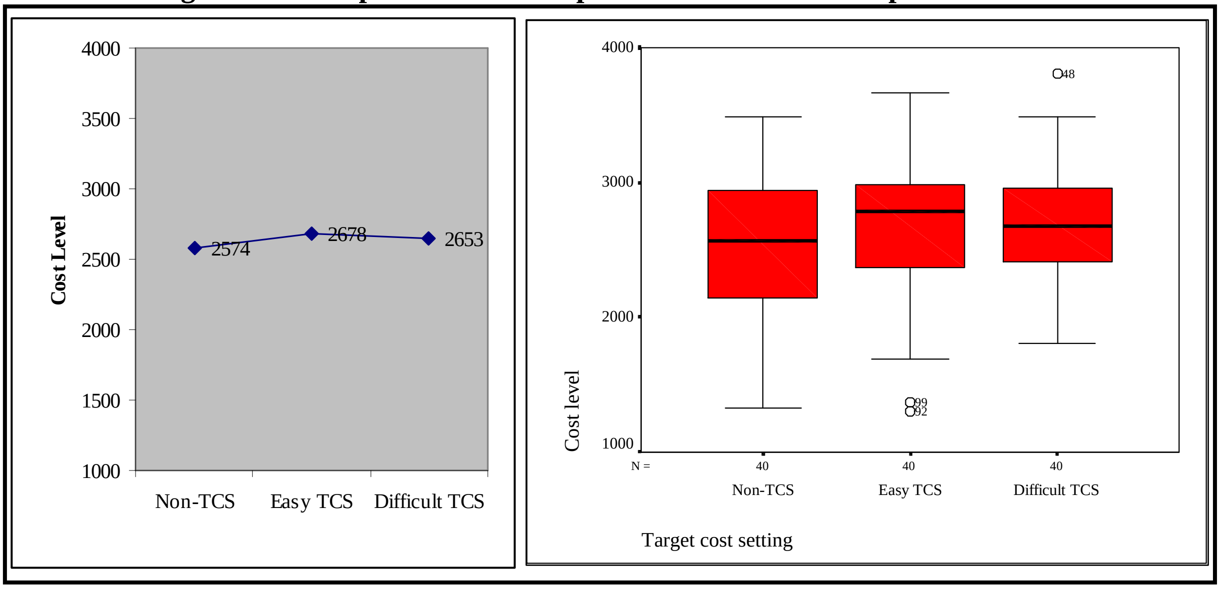
Table 58: ANOVA for TCS on Cost Level to test Hypothesis 1 in Experiment Two

ANOVA		**Sum of Squares**	**Df**	**Mean Square**	**F**	**Sig.**	**Eta Sq.**
Cost Level	Between Groups	236837.267	2	118418.633	0.456	**0.635**	.008
	Within Groups	30375474.325	117	259619.439			
	Total	30612311.592	119				

Table 59: Group Means on Cost Level in Experiment Two

	Non-TCS	**Easy TCS**	**Difficult TCS**	**Total**
Mean	**2574**	**2678**	**2653**	2635.1
N	40	40	40	120
Std. Deviation	547.0	537.5	436.7	507.2

Figure 48: Group Means and Boxplots on Cost Level in Experiment Two



12.2 Pairwise Comparisons for Hypotheses 1a and 1b

Although the omnibus ANOVA is not significant, we are still allowed to perform the two suggested pairwise comparisons to test hypothesis 1a and 1b, as discussed earlier on page 136.

In hypothesis 1a, we hypothesized that the cost level of a future product will be significantly *lower* under the difficult TCS than under the non-TCS. The results of Dunnett's test are shown in Table 60. Hypothesis 1a is not supported by the data and we cannot reject the null hypothesis of equal group means in cost level (p = 0.884). Thus we should accept the alternative hypothesis that there is not a significant difference in cost level between the non-TCS and the difficult TCS.

In hypothesis 1b, we hypothesized that the cost level of a future product will be significantly *higher* under the easy TCS than under the non-TCS. This hypothesis 1b can not be supported by the data, since Dunnett's test does not detect a significant higher cost level under the easy TCS than under the non-TCS (p = 0.286).

Table 60: Pairwise Comparisons by Dunnett's Test for hypotheses 1a and 1b in Experiment Two

Dependent Variable: Cost Level				
Difficult TCS < Non-TCS (1-sided)				
(I) TCS	(J) TCS	Mean Difference (I-J)	Std. Error	Sig.
Difficult TCS	Non-TCS	79.150	113.934	**0.884**
Easy TCS > Non-TCS (1-sided)				
(I) TCS	(J) TCS	Mean Difference (I-J)	Std. Error	Sig.
Easy TCS	Non-TCS	104.250	113.934	**0.286**

In sum, none of the three TCS groups (non-TCS, easy TCS and difficult TCS) differ significantly in terms of the *cost level* of the created designs. Unexpectedly, the TCS manipulation, though perceived as significantly different by the participants (see page 208), had no significant impact on the cost level of the created designs. Thus the so-called *favorable* impact of target costing on the cost level was *not* supported.

13. Testing Hypothesis Two

13.1 MANOVA for Hypothesis 2

As discussed earlier in chapter three, we expect that the TCS manipulation will have an impact on the type of new products that participants create during new product development. A lower attractiveness level and a longer time spent under the difficult TCS are the most frequently mentioned outcomes, found in previous goal setting studies.

In hypothesis two, we hypothesize that a combination of the cost level, quality level (i.e. attractiveness) and achieved time-to-market (i.e. time spent) will significantly differ among the non-TCS, easy TCS and difficult TCS.

To test this multivariate hypothesis, we need to do a MANOVA on the three dependent variables cost level, attractiveness and time spent for TCS[95]. As discussed before in chapter 5 (see page 143), Wilks' Lambda is the most appropriate test criterion here, though, because of the violation of the homoscedasticity assumption (see page 217) it is better to use Pillai's Trace as the multivariate test criterion for this second hypothesis (see page 154). As shown in Table 61, Pillai's Trace detects a **significant difference** in group centroids among the three TCS conditions on a combination of the three dependent variables cost level, attractiveness and time spent ($p = 0.001$). So, the null hypothesis of equal group centroids should be rejected (at alpha 5%) and the data support hypothesis 2. This means that TCS indeed had an impact on the created new products, when considering all three characteristics (cost, attractiveness and time spent) together.

Before analyzing which of the three TCS groups differ from each other (see next paragraph) we can look at the **canonical variates**, i.e. the new identified dimensions that maximally separate the three groups. Table 62 shows that only the first canonical variate is significant ($p = 0.001$), accounting for 15.9% of the total variance. From the third part of this table, we learn that this first canonical variate is highly positive correlated with attractiveness ($r = .798$), while time spent is highly positive correlated with the second (insignificant) dimension ($r = .98$). We can label this first canonical variate the "**creativity**" factor. Designs with a high score for attractiveness are scoring high on this identified

[95] Barlett's test of sphericity is **significant** (approx. $\chi^2 = 2016.7$, df = 5, p = .000), indicating a multivariate analysis should be used.

"creativity" factor. When comparing the group means for TCS on this "creativity" factor, as shown in the last part of Table 62, we see that relative to the other two groups, the non-TCS is having the highest group mean on this "creativity" factor. The easy TCS group is having the lowest group mean. Also the group mean of the difficult TCS is closer to the easy TCS than to the non-TCS, which suggests that relative to the non-TCS both the easy and the difficult TCS are scoring worse in terms of the creativity of the new designs made, as shown in Figure 49 on the next page.

In sum, the three TCS manipulations led to significant different new products in terms of the variables cost level, attractiveness and time spent. In the next paragraph, we will consider two by two comparisons to explain which specific groups are responsible for the overall multivariate group difference.

Table 61: MANOVA for TCS on Cost level, Attractiveness and Time Spent to test Hypothesis 2 in Experiment Two

Effect	**Test criterion**	**Value**	**F**	**Hypothesis Df**	**Error Df**	**Sig.**
TCS	Pillai's Trace	0.188	4.015	6	232	**0.001**
	Wilks' Lambda	0.816	4.090	6	230	0.001
	Hotelling's Trace	0.219	4.163	6	228	0.001
	Roy's Largest Root	0.189	7.320	3	116	0.000

Table 62: Multivariate Statistics to interpret the Results of Hypothesis Two

Eigenvalues

Function	Eigenvalue	% of Variance	Cumulative %	Canonical Correlation	Sq. Canonical Correlation
1	0.189	86.397	86.397	0.399	0.159
2	0.030	13.603	100	0.170	0.029

Wilks' Lambda

Test of Function(s)	Wilks' Lambda	Chi-square	Df	Sig.
1 through 2	0.816	23.519	6	0.001
2	0.971	3.407	2	0.182

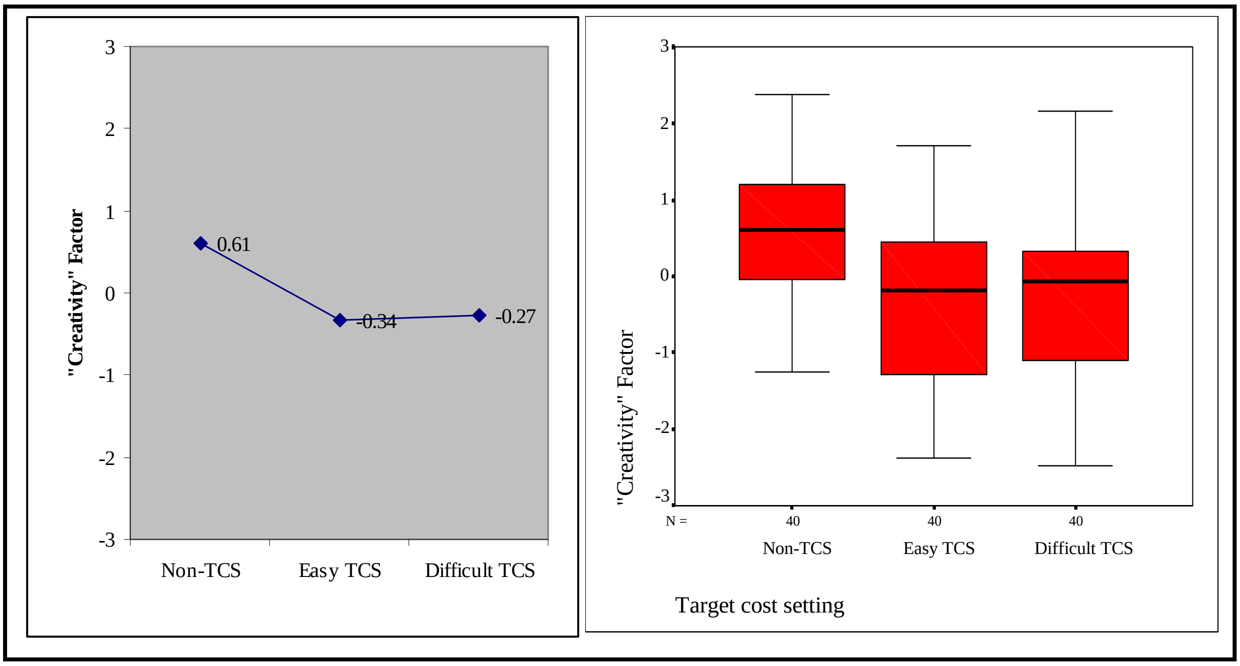
Structure Matrix: Correlation between Canonical Variate (Function) and D.V.

	Function 1	Function 2
	"Creativity" factor	
Attractiveness	**0.798**	0.357
Cost level	-0.200	-0.088
Time spent	-0.197	0.980

Functions at Group Centroids

	Function 1	Function 2
	"Creativity" factor	
Non-TCS	0.606	-0.015
Easy TCS	-0.335	-0.201
Difficult TCS	-0.271	0.216

Figure 49: Group Means and Boxplots on Canonical Variate 1 (H2), labeled the "Creativity" Factor in Experiment Two



13.2 Pairwise Comparisons for Hypotheses 2a and 2b

As discussed in chapter 5, page 144, breaking down a significant MANOVA involves two steps. The first step is to perform all pairwise multivariate comparisons by Hotelling's T^2 to see which groups do differ from each other on a combination of the dependent variables cost level, attractiveness and time spent. The second step involves univariate comparisons, which is addressed in the next paragraph. As discussed before, we are mainly interested in comparing the non-TCS with the difficult TCS (hypothesis 2a) and in comparing the non-TCS with the easy TCS (hypothesis 2b).

In hypothesis 2a, we hypothesized that a combination of the cost level, attractiveness and time spent will significantly differ between the *non-TCS* and the *difficult TCS*. As shown in Table 63, Hotelling's T^2 detects a **significant difference** in group centroids between the non-TCS and the difficult TCS ($p = 0.002$). Hence the null hypothesis of equal group centroids should be rejected and the data support our hypothesis 2a. Thus, the overall significant MANOVA can partly be explained by the difference between the non-TCS and the difficult TCS, what could be expected from Figure 49.

Looking at the canonical variate in Table 64, now explaining 17.4% of the total variance, we see that this significant canonical variate again highly correlates with attractiveness ($r = .668$), but also negatively correlates with time spent ($r = -.435$). We can label this canonical variate as the "**quick creativity**" factor. The group means on this "quick creativity" factor learn that designs under the non-TCS are scoring better on average on this "quick creativity" factor than designs under the difficult

TCS (see Table 64), which will be later confirmed by the univariate t-tests on attractiveness and time spent (see paragraph 13.3).

In hypothesis 2b, we hypothesized that a combination of the cost level, attractiveness and time spent will significantly differ between the *non-TCS* and the *easy TCS*. As shown in Table 63, Hotelling's T² also detects a **significant group difference** for the second comparison on a combination of the three dependent variables ($p = 0.000$). Hence the null hypothesis of equal group centroids should be rejected and the data support our hypothesis 2b. Thus, the overall significant MANOVA can also be explained by the difference between the non-TCS and the easy TCS.

The canonical variate now explains 21.8% of the total variance, as shown in Table 65. Only attractiveness is highly correlated ($r = .84$) with the new identified dimension, which we can again label the "**creativity**" factor. The groups means on this canonical variate, as shown in the last part of Table 65, indicate that on average designs made in the non-TCS are scoring better on this "creativity" factor than designs made under the easy TCS.

Thus, both pairwise comparisons produce significant results. **Participants create a different new product, if they receive a non-TCS manipulation compared to a difficult TCS manipulation. Similarly, participants create a different new product, if they receive a non-TCS manipulation compared to an easy TCS manipulation.** The third comparison in Table 63, though not relevant to our research questions, shows that the new products do not significantly differ between the easy and the difficult TCS. Hence, not the difficulty of the target cost, but rather the specificity of the cost goal is causing a difference in created products. In the next paragraph, we will switch from the multivariate to the univariate case to further explain on what specific characteristics the created new products differ in those two significant comparisons.

Table 63: Hotelling's T² to test Hypotheses 2a and 2b in Experiment Two

Hotelling's T²				
Effect	**F**	**Hypothesis Df**	**Error Df**	**Sig.**
Non-TCS versus Difficult TCS	5.348	3	76	**0.002**
Non-TCS versus Easy TCS	7.062	3	76	**0.000**
Easy TCS versus Difficult TCS	1.464	3	76	0.231

Table 64: Multivariate Statistics to interpret the Results of Hypothesis 2a in Experiment Two

Eigenvalues					
Function	Eigenvalue	% of Variance	Cumulative %	Canonical Correlation	Sq. Canonical Correlation
1	0.211	100	100	0.418	0.174

Structure Matrix: Correlation between Canonical Variate (Function) and D.V.

	"Quick creativity" factor
Attractiveness	**0.668**
Time spent	**-0.435**
Cost level	-0.176

Functions at Group Centroids

	"Quick creativity" factor
Non-TCS	0.454
Difficult TCS	-0.454

Table 65: Multivariate Statistics to interpret the Results of Hypothesis 2b in Experiment Two

Eigenvalues					
Function	Eigenvalue	% of Variance	Cumulative %	Canonical Correlation	Sq. Canonical Correlation
1	0.279	100	100	0.467	0.218

Structure Matrix: Correlation between Canonical Variate (Function) and D.V.

	"Creativity" Factor
Attractiveness	**0.844**
Cost level	-0.184
Time spent	-0.002

Functions at Group Centroids

	"Creativity" Factor
Non-TCS	0.521
Difficult TCS	-0.521

13.3 Simple Main Effects to further Analyze the Supported H2a and H2b

To further analyze the two significant multivariate group differences between the non-TCS and the difficult TCS and between the non-TCS and the easy TCS, we now perform **univariate t-tests** on each of the three dependent variables separate, as discussed earlier on page 144 et seq.

Table 66 compares the ***non-TCS*** with the ***difficult TCS*** on each of the three dependent variables to analyze the supported hypothesis 2a. First, from paragraph 12.2 we know that the **cost level** does not differ between the non-TCS and the difficult TCS (p = .477). Second, based on the t-test for **attractiveness**, we can reject (at α = 5%) the null hypothesis of equal group means on attractiveness (p = .008). From Table 68 and Figure 50 we can see that the group mean on attractiveness is much higher for the non-TCS (mean = 3.12) than for the difficult TCS (mean = 2.65). Third, there is a marginally significant difference for **time spent** (p = .082). Participants in the non-TCS (group mean = 66) are using less time than participants in the difficult TCS (group mean = 70). Both the lower attractiveness and the higher time spent explain why designs under the difficult TCS score worse on the so-called "quick creativity" factor in the previous paragraph.

To further analyze the supported multivariate difference between the ***non-TCS*** **and the** ***easy TCS*** (hypothesis 2b), we made three t-test on each of the three variables cost level, attractiveness and time spent separate, as shown in Table 67. First, from paragraph 12.2 we know that the **cost level** does not differ (p = .393). Second, there is a significant group difference detected for **attractiveness** (p = .000). The group means in Table 68 learn that participants under the non-TCS created much more attractive new designs than participants under the easy TCS. Third, there was no significant difference detected in **time spent** between the non-TCS and the easy TCS. Hence the significant lower scores for attractiveness under the easy TCS explain why designs under the easy TCS score worse on the so-called "creativity" factors in the previous paragraph.

Table 66: Multiple Univariate t-Tests to further analyze the supported H2a in Experiment Two

t-test for Equality of Means between the ***Non-TCS*** and the ***Difficult*** **TCS**					
	t	**Df**	**Sig. (2-tailed)**	**Mean Difference**	**Std. Error Difference**
Cost Level	-0.715	78	0.477	-79.150	110.670
Attractiveness	2.710	78	**0.008**	0.470	0.174
Time Spent	-1.764	78	**0.082**	-4.600	2.608

Table 67: Multiple Univariate t-Tests to further analyze the supported H2b in Experiment Two

t-test for Equality of Means between the ***Non-TCS*** and the ***Easy*** **TCS**					
	t	**Df**	**Sig. (2-tailed)**	**Mean Difference**	**Std. Error Difference**
Cost Level	-0.860	78	0.393	-104.250	121.263
Attractiveness	3.935	78	**0.000**	0.622	0.158
Time Spent	-0.009	78	0.993	-0.025	2.776

Table 68: Descriptives in each TCS Group for Cost Level, Attractiveness and Time Spent in Experiment Two

Target Cost Setting		Non-TCS	Easy TCS	Difficult TCS	Total
Cost level	Mean	2574	2678	2653	2635
	N	40	40	40	120
	Std. Deviation	547.0	537.5	436.7	507.2
Attractiveness	Mean	**3.12**	**2.49**	**2.65**	2.75
	N	40	40	40	120
	Std. Deviation	0.69	0.73	0.86	0.80
Time spent	Mean	**66.3**	66.3	**70.9**	67.8
	N	40	40	40	120
	Std. Deviation	13.4	11.3	9.6	11.7

Figure 50: Group Means and Boxplots on Attractiveness in Experiment Two

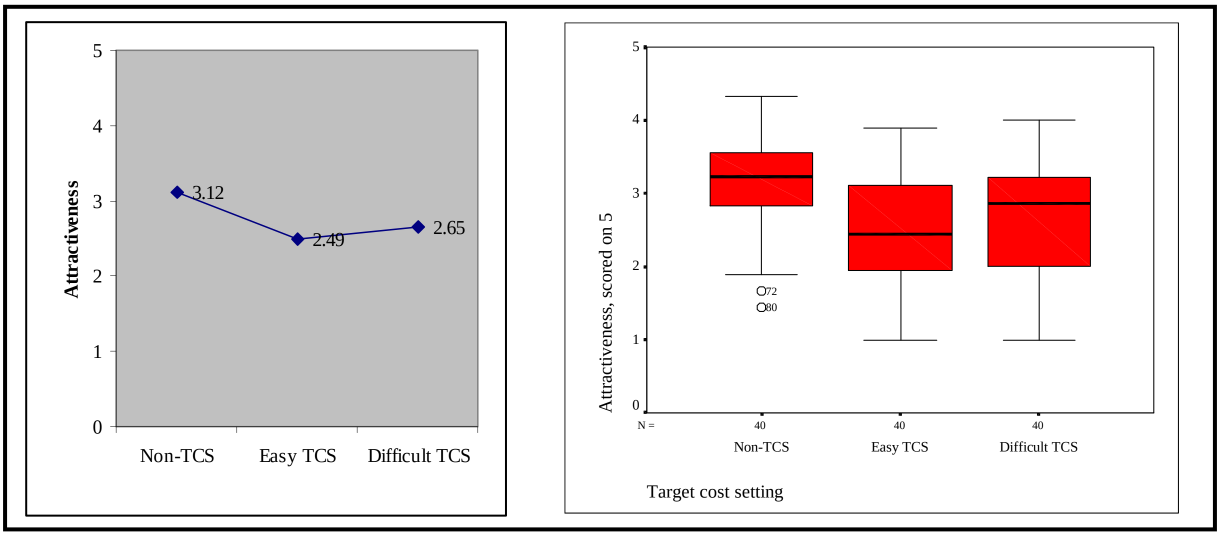
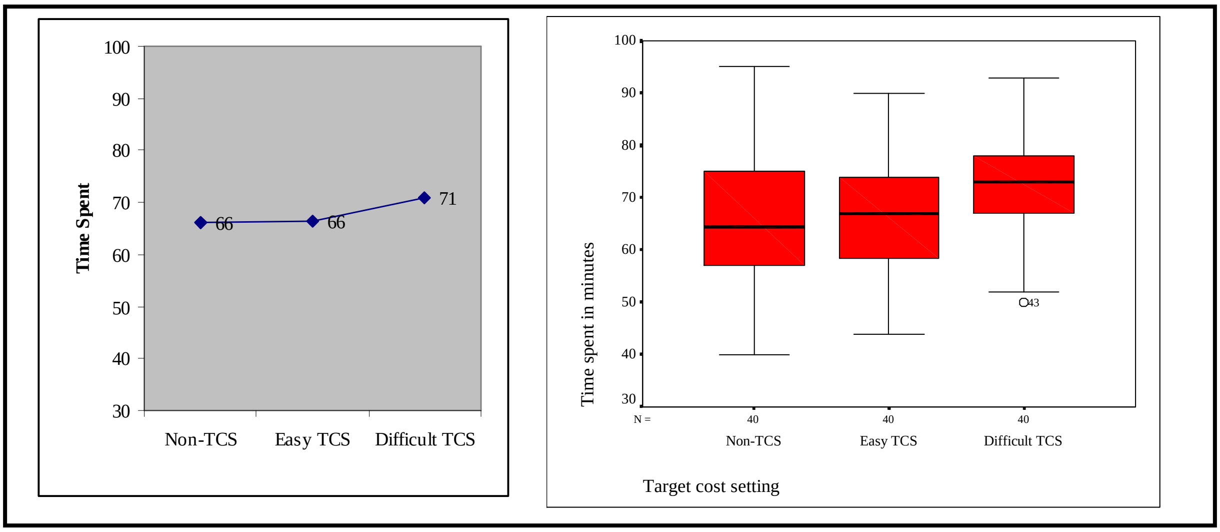


Figure 51: Group Means and Boxplots on Time Spent in Experiment Two



In sum, the difference in group centroids between the *non-TCS* and the *difficult TCS* can be explained by a significant difference in attractiveness and a marginally significant difference in time spent. The difference in group centroids between the *non-TCS* and the *easy TCS* can be explained by a significant group difference in attractiveness.

So far we can conclude that target costing had in experiment two only a *negative* impact on the new products that designers create. More specifically, there was a *negative* impact of setting a difficult target cost on the *attractiveness* of the designs as well as on the *time spent*, both compared to the non-TCS. Furthermore, the *negative* impact on the *attractiveness* of the designs was also found under the easy TCS, again compared to the non-TCS situation.

14. Testing Hypothesis Three

14.1 ANOVA for Hypothesis 3

As discussed in chapter three, we expect a significant interaction effect between the TCS and the TIME manipulation on the cost level of the new products. In general, we expect that the differences in cost level among the TCS manipulations will be larger under the easy TIME than under the difficult TIME condition, because participants have more time available for cost reduction activities in the easy TIME condition. Consequently:

In hypothesis three, we hypothesized that the impact of target cost setting (non-TCS, easy TCS, difficult TCS) on the cost level will significantly differ across the two levels of the time objective.

To test this univariate interaction effect, we need to run an ANOVA, as discussed earlier on page 138. Taking the whole data set, the interaction effect is **marginally significant** (F (2,114) = 3.4, p = 0.098), accounting for 4 % of the variance, as shown in Table 69. Thus the data marginally support hypothesis three. Though, when we delete the 9 outliers as identified earlier in section 11.4, the interaction effect is **significant** (F (2, 105) = 4.06, p = 0.02) at α = 5 %, accounting for 7.2 % of the total variance, suggesting we should go on with the analysis. The group means (and standard deviations) of the cost level for each of the six cells are displayed in Table 70 and presented in Figure 52. As expected, the largest differences between the three TCS are found in the easy TIME condition, while the means in the difficult TIME condition are less different.

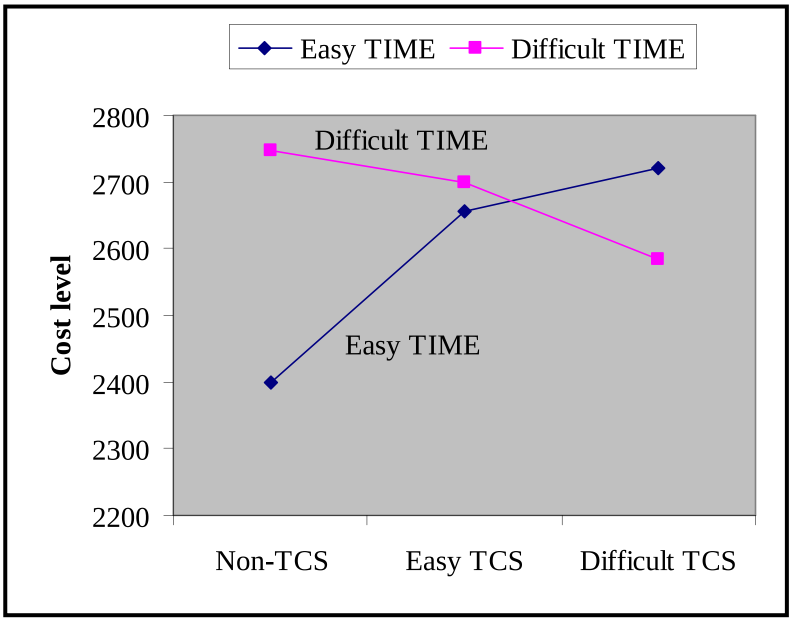
Table 69: ANOVA for 'TCS by TIME' on the Cost Level to test Hypothesis 3 in Experiment Two

Dependent Variable: Cost level (*all data*)						
Source	**Sum of Squares**	**Df**	**Mean Square**	**F**	**Sig.**	**Eta Squared**
TCS	236837.267	2	118418.633	0.466	0.629	0.008
Difficulty of Time Objective	216835.008	1	216835.008	0.854	0.357	0.007
TCS * TIME	1204829.067	2	602414.533	2.372	**0.098**	**0.040**
Error	28953810.250	114	253980.792			
Total	863867823.000	120				
Dependent Variable: Cost level (*without outliers*)						
Source	**Sum of Squares**	**Df**	**Mean Square**	**F**	**Sig.**	**Eta Squared**
TCS	420522.9	2	210261.4	1.219	0.300	0.023
Difficulty of Time Objective	727145.2	1	727145.2	4.215	0.043	0.039
TCS * TIME	1400733.7	2	700366.8	4.060	**0.020**	**0.072**
Error	18113960.5	105	172513.9			
Total	811231442.0	111				

Table 70: Group Means (and Standard Deviations) of Cost Level for each of the Six Cells in Experiment Two

	Target Cost Setting (n = 120)			
Difficulty of Time Objective	**Non-TCS**	**Easy TCS**	**Difficult TCS**	**Total**
Easy TIME	**2400** (547)	**2657** (489)	**2722** (431)	2593 (503)
Difficult TIME	**2748** (501)	**2700** (595)	**2585** (443)	2678 (512)
Total	2574 (547)	2678 (536)	2653 (437)	2635 (507)

Figure 52: Interaction Effect between 'TCS and TIME' on the Cost Level in Experiment Two



14.2 Interaction Comparisons and Simple Main Effects for Hypotheses 3a and 3b

As discussed in chapter 5 (page 138) analyzing a (marginally) significant univariate interaction effect involves two steps. First we need to consider the interaction effect in 2 by 2 subtables. For each significant subtable, we can then progress the analysis in a second step by comparing the group means on the cost level for each of the 2 TIME conditions separate. Mainly two subtables are of importance to our study, i.e. comparing the *non-TCS* and the *difficult TCS* across the two TIME conditions; and comparing the *non-TCS* and the *easy TCS* across the two TIME conditions. For both subtables, we expect larger differences under the easy TIME than under the difficult TIME condition. The hypothesis for this first subtable is formulated as follows:

In <u>hypothesis 3a</u> we hypothesized that the difference in cost level between the *non-TCS* and the *difficult TCS* will significantly vary between the easy and the difficult TIME condition. As shown in Table 71, the ANOVA F-test is significant (F (1, 76) = 5.06, p = .027 and p = .004 without outliers) and the data support a significant interaction effect for the first subtable. The group means in Table 70 indicate that the difference in cost level between the non-TCS and the difficult TCS is larger under the easy TIME than under the difficult TIME condition, as expected. When further analyzing this significant interaction effect by simple main effects in Table 72, we find a significant difference in cost level in the *easy* TIME condition between the non-TCS and the difficult TCS (p = .046). Contrary, in the *difficult* TIME condition, the t-test does not detect a significant difference in cost level between the non-TCS and the difficult TCS (p = .281). Even more, under the *easy* TIME condition, the direction of the difference is in the *opposite* direction as one could expect from target costing and goal setting literature. The cost level is significantly *lower* under the non-TCS (group mean = 2400) than under the difficult TCS (group mean = 2657) in this easy TIME condition, as shown before in Figure 52.

Looking now at the second subtable, we hypothesized in hypothesis 3b that the difference in cost level between the *non-TCS* and the *easy TCS* will significantly differ between the easy and the difficult TIME condition. As mentioned, we expect larger differences in cost level under the easy TIME than under the difficult TIME condition. As shown in Table 71, this hypothesis is not supported by the data, since the F-test cannot detect a significant interaction effect (F (1,76) = 1.6, p = .206). Thus participants in the non-TCS were not doing significantly better in terms of creating a low cost carpet compared to the easy TCS, if they had an easy TIME than if they had fewer time available under the difficult TIME condition.

Thus the (marginally) significant interaction effect of TCS (non-TCS, easy TCS and difficult TCS) by the TIME objective (easy TIME and difficult TIME) can mainly be explained by the difference in cost level between the *non-TCS* and the *difficult TCS* across the two TIME conditions. Only this first interaction comparison was significant. Under the easy TIME condition, the cost level was significantly *lower* under the non-TCS than under the difficult TCS, contrary to the expectations from target costing. Under the difficult TIME condition, there was no significant difference detected in cost level among the non-TCS and difficult TCS.

Table 71: Interaction Comparisons to test Hypotheses 3a and 3b in Experiment Two

Interaction Comparison 1: Non-TCS versus Difficult TCS						
Source	**Sum of Squares**	**Df**	**Mean Square**	**F**	**Sig.**	**Eta Squared**
TCS	125294.450	1	125294.450	0.538	0.466	0.007
Difficulty of TIME Objective	223661.250	1	223661.250	0.960	0.330	0.012
TCS * TIME	1179036.800	1	1179036.800	5.061	**0.027**	0.062
Error	17704073.300	76	232948.333			
Interaction Comparison 2: Non-TCS versus Easy TCS						
Source	**Sum of Squares**	**Df**	**Mean Square**	**F**	**Sig.**	**Eta Squared**
TCS	217361.250	1	217361.250	0.761	0.386	0.010
Difficulty of TIME Objective	768712.050	1	768712.050	2.692	0.105	0.034
TCS * TIME	465125.000	1	465125.000	1.629	0.206	0.021
Error	21705678.900	76	285601.038			
Interaction Comparison 3: Easy TCS versus Difficult TCS						
Source	**Sum of Squares**	**Df**	**Mean Square**	**F**	**Sig.**	**Eta Squared**
TCS	12600.200	1	12600.200	0.052	0.821	0.001
Difficulty of TIME Objective	43711.250	1	43711.250	0.180	0.673	0.002
TCS * TIME	163081.800	1	163081.800	0.670	0.416	0.009
Error	18497868.300	76	243393.004			

Table 72: Simple Main Effects to further analyze the Significant Hypothesis 3a in Experiment Two

t-test for Equality of Means (Non-TCS vs. Difficult TCS) in the *Easy TIME* condition					
	t	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
Cost level	-2.068	38	**0.046**	-321.950	155.703
t-test for Equality of Means (Non-TCS vs. Difficult TCS) in the *Difficult TIME* condition					
	t	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
Cost level	1.095	38	0.281	163.650	149.487

Consequently, we should partly modify our finding of "*no impact of target costing on the cost level*" (see earlier in hypothesis 1). In the easy TIME condition, participants created a *lower* cost new product under the non-TCS than under the difficult TCS. Hence in an easy TIME condition, setting a difficult target cost is leading to a *higher* cost level of a future product, compared to the non-TCS. In the difficult TIME condition, the earlier finding of no impact of TCS on the cost level still holds.

15. Testing Hypothesis Four

15.1 MANOVA for Hypothesis 4

As discussed in chapter three, we expect a significant multivariate interaction effect between the TCS and the time difficulty manipulation on a combination of the cost level, the attractiveness of the new product and the time spent to create it. We expect larger differences in new product characteristics among the TCS conditions under the difficult TIME than under the easy TIME objective, because participants might skip more on one of the goals when both the target cost and the time objective become difficult to attain. Thus:

In hypothesis 4, we hypothesized that the impact of target cost setting (non-TCS, easy TCS, difficult TCS) on a combination of the three NPD measures cost level, attractiveness and time spent will significantly differ across the levels of the time objective.

Again, we need to do a MANOVA on the three dependent variables cost level, attractiveness and time spent, but now for the interaction effect between TCS and TIME[96]. As discussed earlier (see page 146), we selected Pillai's Trace as multivariate test criterion, because we expect more than one important dimension here. As shown in Table 73, Pillai's Trace does not detect a significant interaction effect (p = .244). The effect of TCS on the three NPD measures does not vary as a function of the time objective. Thus the data do not support hypothesis 4.

Table 73: MANOVA for 'CS by TIME' on Cost level, Attractiveness and Time Spent to test Hypothesis 4 in Experiment Two

Effect	Test criterion	Value	F	Hypothesis df	Error df	Sig.
TCS	Pillai's Trace	0.194	4.038	6	226	0.001
	Wilks' Lambda	0.812	4.110	6	224	0.001
	Hotelling's Trace	0.226	4.180	6	222	0.001
	Roy's Largest Root	0.193	7.275	3	113	0.000
TIME	Pillai's Trace	0.085	3.456	3	112	0.019
	Wilks' Lambda	0.915	3.456	3	112	0.019
	Hotelling's Trace	0.093	3.456	3	112	0.019
	Roy's Largest Root	0.093	3.456	3	112	0.019
TCS * TIME	Pillai's Trace	0.068	1.331	6	226	0.244
	Wilks' Lambda	0.932	1.343	6	224	0.239
	Hotelling's Trace	0.073	1.354	6	222	0.234
	Roy's Largest Root	0.073	2.740	3	113	0.047

[96] Barlett's test of sphericity is **significant** (approx. χ^2= 1965.9, df = 5, p = .000), indicating a multivariate analysis should be used.

Thus, the difference in created new products among the three TCS does not significantly vary as a function of the TIME condition.

15.2 Interaction Comparisons for Hypotheses 4a and 4b

Though the omnibus multivariate interaction effect is insignificant, we can still proceed with the multivariate interaction comparisons (subtables). As mentioned in chapter three, we are mainly interested in two subtables. The first subtable compares the non-TCS with the difficult TCS across the two time levels (hypothesis 4a). The second subtable compares the non-TCS with the easy TCS across the two time levels (hypothesis 4b). Thus:

In hypothesis 4a, we hypothesized that the difference in created new products (measured as a combination of the three NPD measures cost level, attractiveness and time spent) between the *non-TCS* and the *difficult TCS* will significantly vary between the easy and the difficult TIME condition. As shown in Table 74, Hotelling's T^2 detects a marginally significant multivariate interaction effect (p = .064). Thus, the difference in created products between participants who received a non-TCS manipulation and participants who received a difficult TCS marginally varies across the two TIME conditions. Though, if we delete the one outlier (case 80), as identified before on page 291, the interaction effect becomes significant at α = 5% (p = .027), suggesting we need to further analyze the differences by univariate interaction comparisons in the next section .

Though we will first compare the group means on the canonical variate, explaining 9.3 % of the total variance. This canonical variate is highly negative correlated with cost (r = -.80) and highly positive correlated with time spent (r = .64), representing what we might call the "**cost reduction activity"** factor. Participants scoring high on this cost reduction activity factor, designed a low cost carpet, but used a long time to create the carpet. The group means on this "cost reduction activity" factor (see third part of Table 75) show that participants in the easy TIME condition are scoring higher in terms of cost reduction activities in the non-TCS (group mean = .737) than in the difficult TCS (group mean = .486). Contrary, in the difficult TIME condition, participants are scoring higher in terms of cost reduction activities in the difficult TCS (group mean = .654) than in the non-TCS (group mean = -.115). Interesting is that the difference between the two TCS is larger under the difficult TIME condition than under the easy TIME condition, explaining the marginally significant interaction effect, as shown in Figure 53.

Looking at the second subtable, we hypothesized in hypothesis 4b that the difference in created new products (measured as a combination of the three NPD measures cost level, attractiveness and time spent) between the *non-TCS* and the *easy TCS* will significantly vary between the easy and the difficult TIME condition. The data do not support this multivariate interaction effect, since Hotelling's T^2 is not significant (p = .432) in Table 74. This hypothesis is not supported by the data.

Thus the difference in created new products between the non-TCS and the easy TCS does not vary as a function of the TIME condition.

Thus, the interaction effect between TCS and difficulty of the time objective is only significant in the non-TCS and the difficult TCS.

Table 74: Multivariate Interaction Comparisons to test Hypotheses 4a and 4b in Experiment Two

Interaction Comparison 1: *Non*-TCS versus *Difficult* TCS				
Effect by Hotelling's T^2	**F**	**Hypothesis Df**	**Error Df**	**Sig.**
Target Cost Setting	5.265	3	74	0.002
Difficulty of Time Objective	2.651	3	74	0.055
TCS * TIME	2.525	3	74	**0.064**
Interaction Comparison 2: *Non*-TCS versus *Easy* TCS				
Effect by Hotelling's T^2	**F**	**Hypothesis Df**	**Error Df**	**Sig.**
Target Cost Setting	7.015	3	74	0.000
Difficulty of Time Objective	3.579	3	74	0.018
TCS * TIME	0.927	3	74	0.432
Interaction Comparison 3: *Easy* TCS versus *Difficult* TCS				
Effect by Hotelling's T^2	**F**	**Hypothesis Df**	**Error Df**	**Sig.**
Target Cost Setting	1.482	3	74	0.226
Difficulty of Time Objective	1.429	3	74	0.241
TCS * TIME	0.455	3	74	0.714

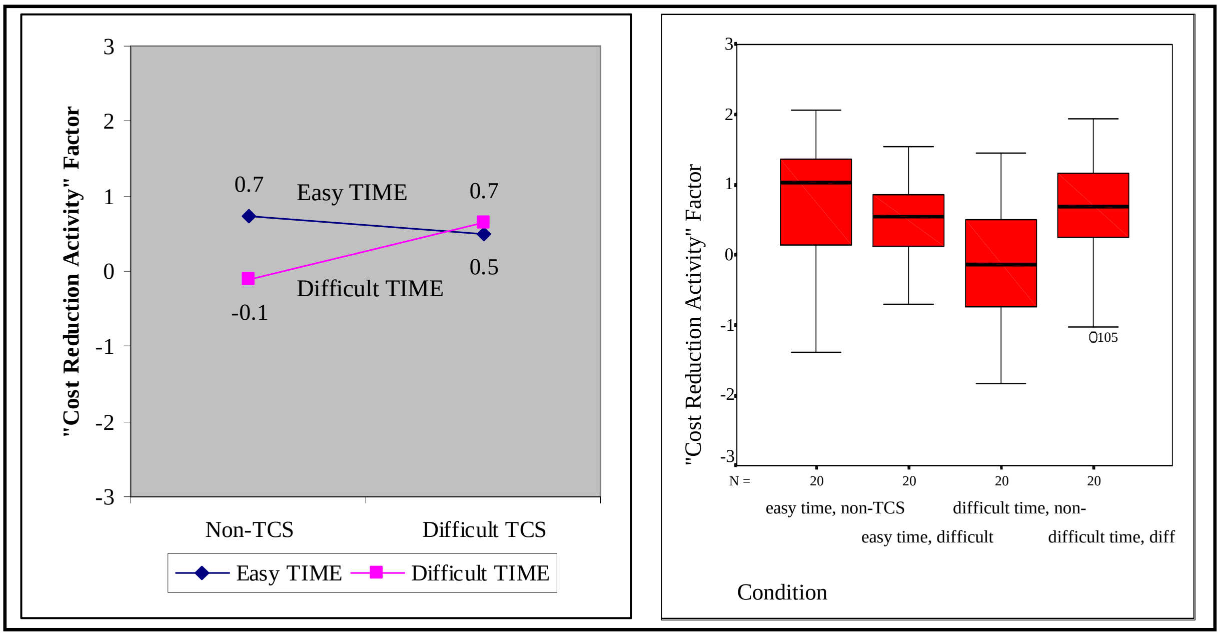
Table 75: More Multivariate Statistics to Interpret the Results of Hypothesis 4a in Experiment Two

Eigenvalues					
Function	Eigenvalue	% of Variance	Cumulative %	Can. Correlation	Sq. Can. Cor.
1	0.102	100	100	0.305	0.093

Structure Matrix: Correlation between Canonical Variate (Function) and D.V.	
	Function 1
	"Cost Reduction Activity" Factor
Cost Level	-0.807
Attractiveness	-0.293
Time Spent	0.642

Functions at Group Centroids ("Cost Reduction Activity" Factor)		
	Non-TCS	Difficult TCS
Easy TIME	0.737	0.486
Difficult TIME	-0.115	0.654

Figure 53: Group Means and Boxplots on the Canonical Variate (H4a), labeled the "Cost Reduction Activity" Factor in Experiment Two



15.3 Univariate Interaction Comparisons and Simple Main Effects to Further Analyze the Supported H4a

Only hypothesis 4a was supported, indicating that the difference in new products between the non-TCS and the difficult TCS differed across the two time conditions. As discussed in chapter five (page 147), analyzing a multivariate interaction effect involves two more steps. First, we will evaluate the interaction effect on each of the three dependent variables separate in a univariate analyses. Significant ANOVAs will then be further analyzed by simple main effects, using t-tests.

The three F-tests for the univariate interaction effect on cost level, attractiveness and time spent are shown in Table 76. The ANOVA F-test detects a **significant** interaction effect on the **cost level** (F (1, 76) = 5.061, p = .027). As discussed under hypothesis 3a, only in the easy TIME condition is the cost level significantly lower in the non-TCS than in the difficult TCS (t = -2.068, p = .046). Second, there is there is **no significant** interaction effect detected on **attractiveness** (F (1, 76) = .667, p = .417). Finally, there is a marginally **significant** interaction effect detected on **time spent** (F (1, 76) = 3.207, p = .077), as shown in Table 76. The difference in time spent between the non-TCS and the difficult TCS is larger under the difficult TIME condition than under the easy TIME condition. Indeed the time spent significantly differs between the non-TCS and the difficult TCS in the difficult TIME condition (t = -2.866, p = .007) while the time spent does not significantly differ between the non-TCS and the difficult TCS in the easy TIME condition (t = -.026, p = .980), as shown in Table 77. The group means on time spent are shown in Table 78 and learn that under the difficult TIME condition, the time spent is higher in the difficult TCS (group mean = 70) than in the non-TCS (group mean = 61).

Hence, setting a difficult target cost is having a negative impact on the time spent compared to the non-TCS, but only under a difficult TIME condition.

Putting all pieces together, we can now explain the multivariate interaction effect of hypothesis 4a. Under the **easy TIME condition** we found more cost reduction activities under the non-TCS than under the difficult TCS. These performed cost reduction activities led indeed to new products with a significant lower cost under the non-TCS compared to the difficult TCS, but participants did not require significantly more time to create these low cost designs. Contrary, under the **difficult TIME condition**, we found more cost reduction activities under the difficult TCS than under the non-TCS. However, these performed cost reduction activities led not to new products with a significant lower cost level compared to the non-TCS (though the group mean is lower under the difficult TCS than under the non-TCS), but participants used significantly more time to create these designs under the difficult TCS.

Table 76: Univariate Interaction Comparisons by F-tests to Further analyze the Supported H4a in Experiment Two

Dependent Variable: Cost Level						
Source	**Sum of Squares**	**Df**	**Mean Square**	**F**	**Sig.**	**Eta Sq.**
TCS	125294.450	1	125294.450	0.538	0.466	0.007
Difficulty of Time Objective	223661.250	1	223661.250	0.960	0.330	0.012
TCS * TIME	1179036.800	1	1179036.800	5.061	**0.027**	0.062
Error	17704073.300	76	232948.333			
Dependent Variable: Attractiveness						
Source	**Sum of Squares**	**Df**	**Mean Square**	**F**	**Sig.**	**Eta Sq.**
TCS	4.426	1	4.426	7.459	0.008	0.089
Difficulty of Time Objective	1.502	1	1.502	2.531	0.116	0.032
TCS * TIME	0.396	1	0.396	0.667	0.417	0.009
Error	45.093	76	0.593			
Dependent Variable: Time Spent						
Source	**Sum of Squares**	**Df**	**Mean Square**	**F**	**Sig.**	**Eta Sq.**
TCS	423.200	1	423.200	3.351	0.071	0.042
Difficulty of Time Objective	605.000	1	605.000	4.790	0.032	0.059
TCS * TIME	405.000	1	405.000	3.207	**0.077**	0.040
Error	9598.600	76	126.297			

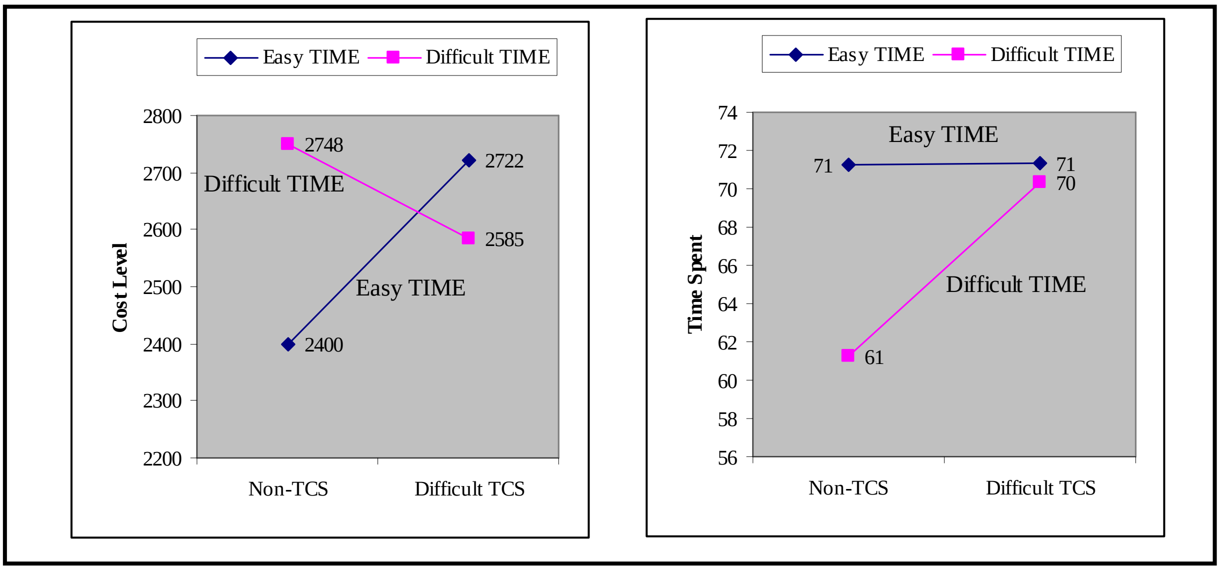
Table 77: Simple Main Effects to further analyze the Significant and Marginally Significant Interaction Effect for Cost Level and Time Spent in Experiment Two

t-test for Equality of Means (Non-TCS vs. Difficult TCS) in the ***Easy TIME*** condition					
	t	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
Cost level	-2.068	38	**0.046**	-321.950	155.703
Time Spent	-0.026	38	0.980	-0.100	3.896
t-test for Equality of Means (Non-TCS vs. Difficult TCS) in the *Difficult TIME* condition					
	t	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
Cost level	1.095	38	0.281	163.650	149.487
Time Spent	-2.866	38	**0.007**	-9.100	3.175

Table 78: Group Means (Standard Deviation) on Cost Level, Attractiveness and Time Spent in Experiment Two

Cost Level	**Non-TCS**	**Easy TCS**	**Difficult TCS**	Total
Easy TIME	**2400** (547)	2656 (489)	**2722** (431)	2593 (503)
Difficult TIME	**2748** (501)	2700 (595)	**2585** (443)	2678 (512)
Total	2574 (547)	2678 (536)	2653 (437)	2635 (507)
Attractiveness	**Non-TCS**	**Easy TCS**	**Difficult TCS**	Total
Easy TIME	3.2 (0.6)	2.6 (0.6)	2.9 (0.8)	2.9 (0.7)
Difficult TIME	3.1 (0.8)	2.4 (0.8)	2.4 (0.9)	2.6 (0.9)
Total	3.1 (0.7)	2.5 (0.7)	2.6 (0.9)	2.8 (0.8)
Time Spent	**Non-TCS**	**Easy TCS**	**Difficult TCS**	**Total**
Easy TIME	**71** (14)	68 (13)	**71** (10)	70 (12)
Difficult TIME	**61** (11)	64 (10)	**70** (9)	65 (10)
Total	66 (13)	66 (11)	71 (10)	68 (12)

Figure 54: Group Means on Cost Level and Time Spent for the Interaction of 'TCS by TIME' in Experiment Two



Thus, when considering only the non-TCS and the difficult TCS the data reveal a marginally significant multivariate interaction effect. When further analyzing this multivariate interaction effect, we found that under the *easy TIME condition*, new products differed between the non-TCS and difficult TCS mainly in terms of the cost level. Participants in the difficult TCS were creating designs with a significantly *higher* cost level, compared to the non-TCS. In the *difficult TIME condition*, new products differed between the non-TCS and the difficult TCS mainly in terms of the time spent. Participants under the difficult TCS were using significantly more time to design the new product, compared to the non-TCS. In sum, <u>in the easy TIME condition</u>, setting a difficult target cost resulted in an unfavorable impact on the *cost level*, compared to the non-TCS. <u>In the difficult TIME condition</u>, setting a difficult target cost resulted in an unfavorable impact on the *time spent*, compared to the non-TCS.

16. Summary of the Hypotheses Testing in Experiment Two

In the previous paragraphs, we tested the different hypotheses by univariate as well as multivariate tests. We summarize the results in Table 79 below.

Table 79: Summary of the Hypotheses Testing in Experiment Two

Hypotheses		Results
H1:	**Univariate main effect:**	Not supported.
H1a:	Lower cost level under difficult TCS than under non-TCS.	Not supported.
H1b:	Higher cost level under easy TCS than under non-TCS.	Not Supported.
H2:	**Multivariate main effect:**	Supported.
H2a:	New products significantly differ between non-TCS and difficult TCS.	Supported. Mainly explained by: • Lower attractiveness under difficult TCS than under non-TCS. • Marginal higher time spent under difficult TCS than under non-TCS.
H2b:	New products significantly differ between non-TCS and easy TCS.	Supported. Mainly explained by: • Lower attractiveness under easy TCS than under non-TCS.
H3:	**Univariate interaction effect:**	Supported.
H3a:	Difference in cost level between the non-TCS and difficult TCS is dependent on the time objective.	Supported. Mainly explained by: • For *easy* TIME: Lower cost level under non-TCS than under difficult TCS.
H3b:	Difference in cost level between the non-TCS and easy TCS is dependent on the time objective.	Not supported.
H4:	**Multivariate interaction effect:**	Not supported.
H4a:	Difference in new products between the non-TCS and the difficult TCS is dependent on time objective.	Marginally supported. Mainly explained by: • For *easy* TIME: Lower cost level under non-TCS than under difficult TCS. • For *difficult* TIME: Lower time spent under non-TCS than under difficult TCS.
H4b:	Difference in new products between the non-TCS and the easy TCS is dependent on time objective.	Not supported.

Three large conclusions can be drawn from the hypotheses testing in our second experiment.

***<u>First</u>*, target cost setting is not leading to a significant impact on the cost level of the created designs.** Contrary to the expectations from literature, a difficult TCS is not leading to new products with a significantly lower cost level than the non-TCS. Even more, under the easy TIME condition, the difficult TCS is having an unfavorable impact on the cost level compared to the non-TCS.

***<u>Second</u>*, target costing (either an easy TCS or a difficult TCS) is having an unfavorable impact on the quality level of the new products.** New designs created under the easy and difficult TCS received significantly lower scores for attractiveness than designs created under the non-TCS.

***<u>Third</u>*, target costing (only the difficult TCS) is having an unfavorable impact on the time spent to create new products under a difficult TIME condition**. Under a difficult time objective, participants spent much more time under the difficult TCS than under the non-TCS.

Each of these conclusions will be discussed in detail from page 254 on, where we will try to find explanations by going back to other research studies. **But before probing for explanations, we will look at the data of the post experimental questionnaire to make sure that the found results are not caused by another reason than the target cost setting or the time difficulty manipulation**. First, we will address the failure to detect a difference in cost level among the TCS manipulation. Second, we will focus on the unfavorable impact of target costing (easy TCS and difficult TCS) on the quality level. Third, we will address the unfavorable impact on the time spent under the difficult TCS, difficult TIME condition.

17. Further Exploring the Data Set in Experiment Two

17.1 Exploring the Failure to Support an Impact of Target Cost Setting on the Cost Level (Hypothesis 1)

We will analyze the measured data in the post experimental questionnaire to find out if the **failure to support a favorable impact of target costing on the cost level** can be explained by a lack of commitment, general discouragement by the bonus system or few energy expended on the cost objective under the easy and difficult TCS, compared to the non-TCS.

One main cause of a negative result frequently found in previous goal setting studies is **lack of *commitment*** to the imposed goal (Locke & Latham, 1990, 31). Difficult goals lead only to better performance than do-best goals, if participants are committed to attain that specific difficult goal (Erez & Zidon, 1984). In our study, the easy TCS and the difficult TCS both contain participants that were rather high committed and participants that were rather low committed to attain the target cost. But, as shown in Table 80, the mean cost level does not significantly differ in the difficult TCS among participants of the top third, middle third and bottom third group of target cost commitment ($F (2, 37) = 1.711$, $p = .195$). Also in the easy TCS, there is no significant difference in cost level among the three categories of target cost commitment ($F (2, 37) = .265$, $p = .769$). Furthermore, if we compare the cost level of only the highly committed participants under the difficult TCS with the non-TCS, there is still no favorable impact of target costing on the cost level ($F (1, 54) = .002$, $p = .961$). Also, the mean cost level of only the highly committed participants under the easy TCS does not significantly differ from the mean cost level under the non-TCS ($F (1, 56) = .290$, $p = .592$). Summarizing, even if we take only highly committed participants, there is still no significant difference in cost level among the three conditions. **Hence, the failure to support hypothesis 1 can *not* be explained by a lack of target cost commitment. Even for highly committed participants the cost level does not differ between the non-TCS and the difficult TCS (or easy TCS).**

Table 80: Means on Cost Level across Target Cost Commitment in Experiment Two

	Cost Level	**Non-TCS**	**Easy TCS**	**Difficult TCS**
Low committed to attain the target cost (1-2)	Mean Cost Level N		2765 13	2833 13
Moderate committed to attain the target cost (3)	Mean Cost Level N		2605 9	2545 11
High committed to attain the target cost (4-5)	Mean Cost Level N		**2652** 18	**2581** 16
Total	Mean Cost Level N	**2574** 40	**2678** 40	**2653** 40

Second, the failure to support a favorable impact of target costing on the cost level might be caused by unequal levels of ***motivation by the bonus system*** among the three TCS conditions. From the descriptive statistics on page 212, we know that participants indeed differ in terms of their self-reported degree of motivation by the bonus system. More specifically, not all participants reported to be highly motivated by the bonus system to attain the target cost. Can the failure to detect a significant group difference on cost be caused because not all participants were highly motivated by the bonus for cost? The answer is no. First of all, the degree of self-reported motivation does not differ among the three TCS manipulations, suggesting that the differences in motivation are not going together with the TCS manipulation (F (2, 116) = 1.754, p = .178). Furthermore, if we limit the sample to only those participants who reported to be highly motivated by the additional bonus of 300 BEF to attain the target cost (or to create a low cost carpet), again there is no significant difference in cost level among the 3 TCS groups (F (2, 39) = .16, p = .851). Also, the degree of motivation by the bonus for cost is not moderating the relationship between target cost setting and the cost level, as shown in Table 81 (F (4, 110) = .872, p = .483). Finally, considering motivation by the bonus system as a covariate in the relationship between TCS and cost level is not revealing a significant impact of target costing on the cost level (F (2, 115) = .523, p = .594). **Hence, the failure to support hypothesis 1 can *not* be explained by the fact that participants were differently motivated by the bonus system for cost among the three TCS conditions. TCS is having no impact on the cost level, even if we limit the sample to only the highly motivated participants (to attain the bonus) and even if we statistically control for a possible impact of self-reported motivation by the bonus system to the cost level.**

Third, we might question whether the failure to detect a group difference on cost could be explained by a lack of ***energy expended on the cost objective*** in the easy and difficult TCS. As mentioned before, priority was in the first place given to create an attractive carpet. Participants did not expend higher energy on cost under the non-TCS than under the easy or difficult TCS (F (2, 117) = 1.354, p = .262). Again limiting the sample to only those participants who report to have expended high energy on the cost objective does not show a significant impact on the cost level of the difficult TCS or easy TCS compared to the non-TCS (F (2, 20) = 1.5, p = .232). When we recode the variable "energy to cost" into three categories, there is no significant interaction effect detected with TCS on the cost level, as shown in Table 81 (F (4, 111) = .869, p = .458). However, this table shows that there is a main effect of "energy expended on cost" on the cost level of the created designs (F (2, 111) = 4.585, p = .012). Indeed, across all manipulations, energy expended on cost is negatively correlated with the cost level of the new design (r = -.268, p = .003) indicating that a higher self-reported energy expended on the cost objective goes together with a lower cost design. But, if we treat "energy expended on cost" as a covariate in the relationship between TCS and the cost level, the TCS manipulation still does not induce a significant difference in cost level, as shown in the last part of Table 81 (F (2, 116) = .505, p = .605). **Hence, the failure to support hypothesis 1 can *not* be explained by the energy expended on the cost objective during the design task. In general, a high energy expended on cost results in a lower cost design, though the target cost setting manipulation is not having an impact on the energy participants expended on the cost objective during the task. Furthermore, the TCS manipulation cannot explain a further difference in cost level, when statistically controlling for the impact of energy expended on the cost level.**

Table 81: The Impact of TCS on the Cost Level, with Moderators and Covariates in Experiment Two

Dependent Variable: Cost Level					
ANOVA	**Type III Sum of Squares**	**Df**	**Mean Square**	**F**	**Sig.**
TCS	403814.736	2	201907.368	0.756	0.472
Motivation by bonus for cost	133368.856	2	66684.428	0.250	0.779
TCS * Motivation by bonus	931323.523	4	232830.881	0.872	**0.483**
Error	29359934.292	110	266908.494		
Total	857211423.000	119			
ANCOVA	**Type III Sum of Squares**	**Df**	**Mean Square**	**F**	**Sig.**
Motivation by bonus for cost	87441.173	1	87441.173	0.332	0.566
TCS	275214.437	2	137607.219	0.523	**0.594**
Error	30282548.777	115	263326.511		
Total	857211423.000	119			
ANOVA	**Type III Sum of Squares**	**Df**	**Mean Square**	**F**	**Sig.**
TCS	311925.942	2	155962.971	0.638	0.531
Energy expended on cost	2243058.623	2	1121529.312	4.585	0.012
TCS * Energy expended on cost	850755.106	4	212688.777	0.869	**0.485**
Error	27153825.355	111	244629.057		
Total	863867823.000	120			
ANCOVA	**Type III Sum of Squares**	**Df**	**Mean Square**	**F**	**Sig.**
Energy expended on cost	2207212.058	1	2207212.058	9.090	0.003
TCS	245442.614	2	122721.307	0.505	**0.605**
Error	28168262.267	116	242829.847		
Total	863867823.000	120			

Concluding, *commitment, motivation to work on the cost objective* or *effort expended on the cost objective* can <u>not</u> explain the failure to detect a difference in cost level among the non-TCS, easy TCS and difficult TCS. In the section of the discussion of the results (see page 254), we will go back to literature and formulate some alternative explanations for this first finding.

17.2 Exploring the unfavorable Impact of Target Costing on the Quality Level (Hypothesis 2)

Can the **unfavorable impact of target costing on the attractiveness level** be explained by another reason than the TCS manipulation, such as a lower degree of motivation by the bonus system, a lower energy expended on attractiveness or higher self-reported job-related tension in the easy and difficult TCS?

Are participants ***more motivated by the bonus system*** for attractiveness under the non-TCS than under the easy or difficult TCS? The answer is no. Analyzing the self-reported motivation by the bonus system, we can conclude that motivation by the bonus for attractiveness was not significant different among the three TCS groups (F (2, 117) = 1.791, p = .171). Across all manipulations, being highly motivated by the bonus for attractiveness is having a positive impact on the attractiveness of the created designs (F (4, 115) = 2.6, p = .04). But if we limit the sample to only those participants who report to be highly motivated by the bonus for attractiveness, the attractiveness level is still higher under the non-TCS (mean = 3.2) than under the easy TCS (mean = 2.6) and difficult TCS (mean = 2.7); (F (2, 83) = 6.07, p = .003). Similarly, for participants who report to be low motivated by the bonus system to create an attractive carpet, the differences in attractiveness are still (marginally) significant and in the same direction (F (2, 31) = 2.8, p = .074). Furthermore, the unfavorable impact of target costing on the attractiveness of the designs still holds, even after statistically controlling for the impact of the degree of motivation by the bonus system, as shown in Table 82 (F (2, 116) = 9.1, p = .000). **Hence, the unfavorable impact of target costing on the attractiveness level can *not* be explained by different degrees of motivation created by the bonus system in the non-TCS than in the easy or difficult TCS.**

Second, are participants ***expending a higher level of energy to the attractiveness objective*** in the non-TCS than in the easy TCS or difficult TCS? Again the answer is no. Energy expended on attractiveness does not significantly differ among the non-TCS, easy TCS and difficult TCS (F (2, 117) = 2.346, p = .100)[97]. Across all manipulations, energy expended on attractiveness is highly positive correlated with the attractiveness level of the design (r = .254, p = .005), indicating that a higher energy expended on the attractiveness of the design also corresponds with a high attractive design. Limiting the sample to only those participants who report to have expended high energy on the attractiveness of their design, still shows an unfavorable impact of the easy TCS (group mean = 2.7) and the difficult TCS (group mean = 2.7) compared to the non-TCS (group mean = 3.2); (F (2, 80) = 4.5, p = .014) . The same conclusion applies to the limited sample of only those participants who report to have expended rather low energy on the attractiveness of the designs (F (2, 34) = 3.7, p =

.035). Finally, if we take out statistically the impact of "energy expended on attractiveness" on the attractiveness levels of the created designs in an ANCOVA analysis, target costing (easy and difficult TCS) still has an unfavorable impact on the attractiveness level, as shown in Table 82 (F (2, 116) = 7.8, p = .001). **Hence, participants are not expending lower energy on the attractiveness component of the design task under the easy and difficult TCS, compared to the non-TCS. The TCS manipulation still has an unfavorable impact on the attractiveness level, when statistically controlling for the impact of energy expended on attractiveness.**

Third, is there a higher level of ***job-related tension*** perceived under the easy TCS and difficult TCS than under the non-TCS, resulting in worse performance? Again the answer is no. Job-related tension does not significantly differ among the three TCS conditions (F (2, 117) = 1.4, p = .245). Furthermore across all manipulations, self-reported tension is not significantly correlated with the attractiveness level of the created designs (r = -.045, p = .622). Consequently, the unfavorable impact of target costing on the attractiveness of the new designs still prevails when statistically controlling for the impact of job-related tension, as shown in Table 82 (F (2, 116) = 7.2, p = .001**). Hence, the unfavorable impact of target costing on the attractiveness cannot be explained by higher levels of job-related tension under the difficult TCS or the easy TCS, compared to the non-TCS.**

Table 82: The Impact of TCS on Attractiveness with Covariates in Experiment Two

Dependent Variable: Attractiveness					
ANCOVA	**Type III Sum of Squares**	**Df**	**Mean Square**	**F**	**Sig.**
Self-reported motivation by bonus for attractiveness	4.078	1	4.078	7.441	0.007
TCS	9.953	2	4.977	9.080	**0.000**
Error	63.578	116	0.548		
Total	985.197	120			
ANCOVA	**Type III Sum of Squares**	**Df**	**Mean Square**	**F**	**Sig.**
Energy expended on attractiveness	4.895	1	4.895	9.047	0.003
TCS	8.392	2	4.196	7.756	**0.001**
Error	62.761	116	0.541		
Total	985.197	120			
ANCOVA	**Type III Sum of Squares**	**Df**	**Mean Square**	**F**	**Sig.**
Self-reported job-related tension	0.120	1	0.120	0.206	0.650
TCS	8.383	2	4.191	7.199	**0.001**
Error	67.536	116	0.582		
Total	985.197	120			

[97] This almost marginally significant result can mainly be explained by the differences between the **easy TCS** and the **difficult TCS**. Doing pairwise comparisons, Tukey's HSD test shows only a (marginally) higher energy expended on attractiveness in the difficult TCS than in the easy TCS (p = .086).

Concluding, *motivation* by the bonus system, *energy expended* on the attractiveness of the design and self-reported *tension* cannot explain why participants created both under the easy TCS and difficult TCS designs which scored significantly lower in terms of attractiveness than designs created under the non-TCS.

17.3 Exploring the unfavorable Impact of the Difficult TCS on Time Spent under the Difficult Time Condition (Hypothesis 4)

Can the unfavorable impact of the difficult TCS on the time spent in the difficult TIME condition be explained by another reason than the TCS manipulation, such as a lower commitment to achieve the time limit, a lower degree of motivation by the bonus for finishing within the time limit or a higher level of self-reported tension?

Are participants ***more committed to attain the time limit*** under the non-TCS than under the difficult TCS? The answer is no. As shown in Table 83, the t-test cannot detect a significant difference in commitment to the time objective between the non-TCS (group mean = 2.9) and the difficult TCS (group mean = 3.65); (t = 1.67, p = .10). Also considering the two TCS groups together, a higher time commitment does not goes together with a lower time spent (r = .139, p = .391). **Hence, the unfavorable impact of the difficult TCS on the time spent cannot be explained by a lower commitment to the time objective under the difficult TCS.**

Second, are participants ***more motivated by the bonus*** for achieving the time limit under the non-TCS than participants under the difficult TCS, in that difficult TIME condition? The answer is no. Again the self-reported motivation by the bonus system for finishing within the time limit does not show a significant difference between the non-TCS and the difficult TCS (see Table 83, t = -1.15, p = .26). In general, a higher degree of motivation is not leading to a significant lower time spent (r = .069, p = .673). **Hence, the unfavorable impact of the difficult TCS on the time spent cannot be explained by a lower degree of motivations by the bonus system under the difficult TCS.**

Third, is there a higher level of ***self-reported tension*** perceived under the difficult TCS than under the non-TCS, resulting in more time spent? The answer is no. As shown in Table 83, job-related tension is not differing between the non-TCS and the difficult TCS (t =-.97, p = .34) and job-related tension is not significantly correlated with the time spent (r = .237, p = .14). **Hence, the significant difference in time spent, cannot be explained by perceived tension.**

Table 83: Differences in Group Means between the Non-TCS and the Difficult TCS under the Difficult TIME Condition in Experiment Two

t-test for Equality of Means between the Non-TCS and Difficult TCS, under the difficult TIME				
	t	**Df**	**Sig. (2-tailed)**	**Mean Difference**
Commitment to the time objective	-1.673	38	0.103	-0.750
Motivation by the bonus for time	-1.153	38	0.256	-0.500
Self-reported job-related tension	-0.970	38	0.338	-0.250

Concluding, *commitment* to attain the time objective, *self-reported motivation* by the bonus system and *self-reported tension* cannot explain why participants used significantly more time under the difficult TCS than under the non-TCS, when the TIME condition was set at a level difficult to attain.

Thus, further exploring the data set did *not* reveal explanations for the three main findings in the second experiment. In the next paragraphs, we proceed with the discussion of the results. First in section 18.1, we address the failure to support the favorable impact of target costing as found in hypothesis 1 and 3. In section 18.2, we focus on the unfavorable impact of target costing on the quality level, as found in hypothesis 2. Finally, in section 18.3 we discuss the unfavorable impact of target costing on the time spent, as found in hypotheses 2 and 4. Discussing of these results will lead to a revised setting of experiment three, discussed at the end of this chapter in section 19 on page 262.

18. Discussion of the Results

18.1 Failure to support an Impact of Target Costing on the Cost Level (Hypothesis 1) and even an Unfavorable Impact of the Difficult TCS under the Easy Time Condition (Hypothesis 3)

The results on the first hypothesis show that target costing did not induce cost reduction behavior when designing a future product in the NPD environment of experiment two. **Contrary to the expectations from target costing literature, we did not found a significant difference in cost level of the new products among the three TCS manipulations**. Assigning a difficult target cost to participants did not result in a significant lower cost design than giving the objective to "minimize the cost level of the future product" in the non-TCS. From the manipulation checks, we know that participants perceived the TCS manipulation as intended, though the created carpet designs did not result in a significant difference in cost level among the non-TCS, easy TCS or difficult TCS.

Furthermore, when we consider the results of hypothesis 3, target costing has even an unfavorable impact on the cost level of a future product in one time condition. The data support a significant interaction effect between the TCS and the difficulty of the time objective. This significant interaction effect can mainly be explained by the difference between the non-TCS and the difficult TCS. We found that the difference in cost level between the non-TCS and the difficult TCS was significant under the easy time condition, while it was not significant under the difficult time condition. In that easy time condition, the mean cost level for the non-TCS was significantly lower than the mean cost level for the difficult TCS. Hence contrary to the expectations from target costing literature, the difficult TCS results in new products with significantly higher cost levels (i.e. worse performance) compared to the non-TCS, when participants receive much time (i.e. under the easy TIME condition). **Thus in general, target costing (difficult TCS) is *not* leading to lower cost products, compared to the non-TCS condition where participants are expected to "do their best in minimizing the cost level of the new product". In the easy time condition, the difficult TCS is even leading to new products with a *higher* cost level, compared to the non-TCS, which is totally unexpected, because target costing systems are essentially set up to lead to lower cost products.**

How can it be explained that target costing is not working in this second experiment? Why does our result contrast so sharply with the existing goal setting literature as a whole, asserting that specific difficult goals enhance performance? A <u>first</u> explanation can be found in goal setting studies, referring to the moderating impact of **task complexity** in the relationship between goals and performance (Campbell, 1988, 40). Based on a meta-analysis, Wood, Mento & Locke (1987, 421) found that the positive performance effects of specific and difficult goals versus do-best goals are decreasing as task complexity increases[98]. In general, designing and developing new products is defined as a high complex task (Wood, Mento & Locke, 1987, 418). Also the carpet designing task in this study can be considered as a complex task, since the task meets all four attributes of complexity in Wood's definition. Wood (1986, 43) states that a task is complex to the degree to which it posses (1) multiple strategies to arrive at the desired goals, (2) multiple goals, (3) conflicting interdependencies between the strategies leading to the goals, and (4) uncertain links among the strategies and the goals. Creating an attractive carpet in our study, while not exceeding the target cost, within the given time limit involves multiple goals, which is attainable through several different strategies. Furthermore, conflicting interdependence exist among the desired goals and it is uncertain beforehand which strategy will result in an attractive, low cost carpet. Hence, the complexity of the task in our study might have caused that participants did not develop the suitable task strategies to reach the specific cost goal, explaining why there was no difference in cost level among the difficult TCS, the easy TCS and the non-TCS.

Though, the high task complexity of our study cannot explain why participants under the non-TCS, easy TIME *outperformed* participants under the difficult TCS, easy TIME in terms of the cost level as found in the third hypothesis. Hence a <u>second</u> explanation need to be explored. A few papers in goal setting have thusfar tried to formulate the boundaries beyond which goal setting will not work or may even be harmful. Huber (1985) found that for a **heuristic task**, performance is *worse* when a difficult rather than a do-your best goal is set, just as in our study. Individuals performing a maze task were less effective if they had a specific, difficult rather than a general goal for how quickly to find the way out of a computer maze. Similarly, Earley, Connolly & Ekegren (1989, 26) found that performance was consistently better in the "do your best" condition than in a specific easy or specific difficult goal condition for a stock market prediction task, where a **large number of strategies** were available.

Huber (1985, 492) argues that his task differed from prior goal setting studies in the type of solution (algorithmic or heuristic) that was required to solve the task. Heuristic problems are more difficult than algorithmic because it is first necessary to discover which operations are relevant to the solution. Second, for heuristic problems there may be no single way of solving the problem to guarantee success. Third, there is ambiguity about how to go about solving the problem. Designing a new product in practice involves that the paths to the solutions are not well mapped out or straightforward in advance and that design engineers first have to think about how to approach the development

[98] Locke & Latham (1990, 260) explain this reduced effect on performance for high complex tasks by referring to the fact that "for simple tasks the effort induced by the goals leads relatively directly to task performance. In more **complex tasks**, the effort does not necessary pay off so directly. One must decide where and how to allocate effort. In more complex tasks, the plans, tactics, and strategies used by the individual play a larger role in task performance than they do in simpler tasks where the number of different strategies is more limited and are generally known to all performers."

process. Hence designing and developing a new product requires rather a heuristic than an algorithmic approach. Also the experimental task of experiment two can be considered as a heuristic task. Participants had to select first the most appropriate colors to fit within the interior and then allocate these colors to the right areas. No single best strategy and no single best carpet design was available. Many participants colored first a few designs, then calculated the cost of those designs that passed their own norms of attractiveness and finally consulted the jury. Others created quickly a few carpets without thinking on the cost issues to get an idea of the judges early in the process. Still others tried to copy some of the examples of successful designs of the previous year. Participants realizing a breakthrough (attractive, but low cost carpet) recognized that it was critical to choose the right color for the background area, since deciding on the background color (because of the highest number of small areas) essentially determined the total cost of the carpet.

Similarly Earley, Connolly & Ekegren (1989, 26) argued that their task differed from prior goal setting studies in the number of strategies available to solve the task. They found that specific difficult goals enhance strategy search. Though, when very large numbers of possible strategies are available, merely searching through them offers little hope in quickly finding the best one. They showed empirically that at least part of the poorer performance in the difficult goal condition (compared to the "do-best" condition) is attributable to shifting strategies more often under the difficult goal than under the "do-best" condition. This more frequent changing of strategies was later confirmed by Mone & Shalley (1995, 257). Thus, Earley, Connolly & Ekegren (1989, 25) conclude that for certain types of tasks specific-difficult goals may harm performance, because difficult goal participants seem to choose **less than optimal strategies**. Such tasks will be those in which (1) performance is primarily a function of strategy rather than of task effort, (2) there are many available strategies, (3) the optimal strategy is neither obvious nor readily identified and (4) little opportunity exists to go back and retry a strategy. At least the first three conditions were present in our study and are obvious characteristic to the new product development environment where "novelty" of the daily job and "strategic multiplicity" are likely to occur**. In sum, our experiment match in several aspects with both the Huber (1985) and Earley, Connolly & Ekeren study (1989). The heuristic task characteristics of developing a new product as well as the multiplicity of available strategies might explain why the cost level in the non-TCS resulted in a lower cost level (i.e. better performance) than in the difficult TCS.**

Still, it is not clear from these studies why in our study the non-TCS outperformed the difficult TCS <u>only</u> under the easy time condition and not under the difficult time condition. One explanation is that participants worked extensively on cost reduction, only when they had time enough and were not misdirected by a difficult target cost on how to approach the heuristic task. For complex tasks in general, the development of suitable strategies is necessary before a significant performance effect emerges because individuals need to learn which task strategies are effective (Chesney & Locke, 1991, 420; Smith et al., 1990, 130). As mentioned before, in our task it was essential to select the right background color, because it determined to a large extent the total cost level of the design. Only participants having a long time available, might have found this appropriate strategy. And, as will be discussed in section 18.3, participants spent significantly less time under the "non-TCS, difficult TIME" condition, explaining why the non-TCS did *not* result in significantly lower cost designs in that difficult TIME condition, compared to the difficult TCS. Furthermore, also from the point of view of the innovation literature, it is not surprising that in our study the least restrictive condition, i.e. the "non-TCS easy TIME" condition induced new products with the highest degree of innovation (here the highest scores for attractiveness and the lowest scores for cost level). A condition of slack (no time and budget constraints such as in our non-TCS, easy time condition) is found more supportive in generating high innovative products than a situation of tight control (time constraints and cost constraints). Abernathy (1978) calls it the dilemma between innovation and efficiency. Based on empirical data from the automobile industry he came to the conclusion that the conditions that support a high level of efficiency are entirely different from those that support a high rate of innovation. Similarly, Quinn (1985, 73) states that for innovation, accepting the essential chaos of development is necessary, unencumbered by formal plans or pert charts that would limit the range of imaginations. In such an environment of unrestricted chaos, timeliness (hence the easy time objective in our study) and flexibility to attack opportunities not at first perceived (hence the non-TCS in our study) are crucial. Also Iansiti (1995, 44) found that a more flexible organization of NPD was associated with higher system performance (i.e. the most fundamental characteristics of the product). Hence the unfavorable impact of the "difficult TCS easy TIME" condition can also be explained by the less favorable innovative environment, compared to the "non-TCS easy TIME" condition. **Concluding, participants created lower cost products under the non-TCS than under the difficult TCS, probably because they received far less restrictions on their creative behavior. This occurred only in the easy TIME condition, because only when much time was available participants found the appropriate strategy to create a low cost, high attractive carpet under this so-called less restrictive environment of the non-TCS.**

18.2 Unfavorable Impact of Target Costing on the Quality Level (Hypothesis 2)

The use of target costing during NPD had a significant impact on the type of new products the designers created, as found in hypothesis two. The differences in created new products were most pronounced between the non-TCS and the difficult TCS and between the non-TCS and the easy TCS. **Hence, giving a target cost to participants led them create totally different new products than when no target cost was given**. Analyzing the differences in created new products *between the non-TCS and the difficult TCS*, we found that new products under the difficult TCS were scoring worse in terms of attractiveness. Furthermore, designers under the difficult TCS needed more time to create the designs. Though when considering both time conditions separate (see next paragraph), the unfavorable impact of the difficult TCS was only found under the difficult TIME condition. Analyzing the differences in created new products *between the non-TCS and the easy TCS*, we also found that new products created under the easy TCS were scoring worse in terms of attractiveness. Thus, from hypothesis two we can conclude that the use of target costs during NPD resulted in an unfavorable impact on the attractiveness of the created new products. Giving a specific target cost, - easy or difficult, it doesn't matter -, is resulting in less attractive new products than asking participants to do their best on minimizing the cost level. From the previous section, we also know that assigning a target cost (easy or difficult) was not resulting in a favorable impact on the cost level. **Concluding, target costing (either in an easy TCS or a difficult TCS) is not beneficial for the development of new products in an environment as simulated in experiment two.**

How can it be explained that target costing (difficult TCS as well as easy TCS) is having such a negative impact on the attractiveness of the designs in this second experiment? As mentioned in chapter three, some of the field study researchers in target costing mention that **sacrificing** the quality may be one easy way to attain a difficult target cost (Kato, 1993; Cooper & Slagmulder, 1997). Though in our study, the unfavorable impact is also found under the easy TCS, suggesting that something else is going on. Is our result then in conformity with the existing goal setting literature on multiple conflicting goals? Partly, because previous goal setting studies (Terborg & Miller, 1978; Schmidt et al., 1984, Shalley, 1991; Audia et al., 1996) also found that assigning a *difficult* goal compared to assigning a do-best goal, improves the performance of that goal, but deteriorates the performance of the other do-best goal. Schmidt et al. (1984, 138) found the same deteriorating effect for an *easy* goal as well, though to a less extent as for the difficult goal. The improvement of the specific goal performance is achieved each time at the cost of the do-best goal performance. In these studies the do-best goal is presumed to have a **lower priority**, because of a lack of feedback during the task or because of the unspecific goal instruction (Schmidt et al., 1984, 138). However in our study, participants received immediate feedback on the attractiveness goal by the scores of the jury. Furthermore in our study, attractiveness was set (and perceived) as the most important goal and participants expended more energy to the attractiveness than to the cost goal (see page 208). Hence, the explanation of lower priority and no feedback cannot be followed in our study. Furthermore, in our study the specific goal performance (i.e. cost level) did *not* improve when shifting the cost objective from the non-TCS to the easy TCS or difficult TCS, as in the previous mentioned studies. Thus, traditional goal setting studies are not fully providing an explanation.

Let's considering again the Huber (1985) study, where the difficult and the easy goal had an unfavorable impact on performance. In his heuristic task experiment, the poor performance of the difficult goal group was also associated with the use of a **dysfunctional performance strategy**. Goal setting assumes that a specific, difficult goal activates strategy search. There is however no general requirement that increased strategy search will lead to improved performance. Huber (1985, 501) argued that goal setting **misdirects** strategy search in heuristic tasks, since participants in the difficult goal condition overused the peeking function in a way to minimize the number of moves. The dysfunctional performance strategy might explain why participants in the easy TCS as well as the difficult TCS created less attractive carpets, compared to the non-TCS in our study. Being focused by the maximum allowable cost of the carpet, participants might have selected only the cheapest colors in their carpets (black, white, orange, sky blue, light green), though these colors did not fit into the given interior with bleu curtains and a yellow ground. Once limiting the creativity to only these colors, participants could never find an attractive carpet. Hence the restriction of the target cost might have misdirected their attention in the strategy search. This misdirected search did lead to less attractive carpets, but not to significantly lower cost designs.

Again, we can refer to the **innovation** literature, where the distinction between **radical** and **incremental** innovation has produced important insights. Radical and incremental innovations can be seen as both extremes of a continuum. An incremental innovation introduces relatively minor changes to the existing product or manufacturing process, such as cost-reduced versions of an existing product, add-ons or enhancements to an existing production process (Wheelwright & Clark, 1992, 93). A radical innovation in contrast, is based on a different set of engineering and scientific principles, containing a high level of new knowledge (Henderson & Clark, 1990, 9). Wheelwright & Clark (1992, 93) argue that for incremental innovation, such as in derivatives, hybrids and enhancement projects, less creativity is required. More radical innovations such as next generation (platform) projects or breakthrough projects, require more creativity, greater degree of freedom and more time (Burgelman et al., 1996, 662). **Looking carefully at the design task of experiment two, we can state that the required innovation is more than just an incremental one[99]. Although the basic design was given, participants still had many degrees of freedom in selecting the appropriate colors. The examples of earlier generations of products (the so-called market preferences as shown in Appendix Two, page 429) did not help participants to determine quickly which colors the market really preferred in the given interior. In these examples all 10 colors were used, hence not guiding the choice on which colors to use. Following Wheelwright & Clark (1992, 93) we might name experiment two a NPD environment calling for "*next generation*" new products.**

Furthermore, the innovation literature states that radical and incremental innovations require quite different organizational capabilities (Dewar & Dutton, 1986; Ettlie et al., 1984). Utterback (1996, 230) states that for more radical innovations, traditional organizational controls must be loose. Abernathy (1978, 173) concludes that a high degree of radical product innovation is inconsistent with a policy that seeks to reduce costs substantially. Furthermore, Utterback & Abernathy's (1975, 644) dynamic model of product and process innovation anticipates extensive cost reductions only when

[99] We are indebted to Prof. Dr. Koenraad Debackere for this remark.

product designs are stable and product innovation is incremental. Hence, it is not surprising that in our study, where a more radical innovation was required for the new product, assigning a target cost (easy or difficult) is imposing some limitations on the creativity of participants and is resulting in new products with much lower levels of attractiveness than when participants receive fewer restrictions in designing the new product under the non-TCS. Hence our results confirm the general belief among scientists and engineers working in R&D laboratories, as Shields & Young (1994, 176) report, that "their creativity should not be constrained by cost concerns" or as Hertenstein & Platt (1998, 52) report "that setting strict cost targets may curtail the very creativity required to achieve the best product".

Summarizing, the heuristic task of our study might have misdirected the attention of participants under the easy TCS and difficult TCS, leading to less attractive carpets compared to the non-TCS. Furthermore, the experimental task required from participants more than just an incremental change of the presented designs of last year. For the development of such type of new products (so-called next generation new products), imposing control on the behavior of design engineers is having a detrimental impact on the degree of innovation in new products. Target costing restricts the creativity of design engineers, explaining why the created designs are less attractive (read less innovative) under the easy TCS and difficult TCS than under the non-TCS. Consequently, in an environment where a more radical innovation is required such as for next generation new products, the use of target costing is not beneficial.

18.3 Unfavorable Impact of Target Costing (Difficult TCS) on the Time Spent under the Difficult Time Condition (Hypothesis 4)

Considering the interaction effect between the TCS and the TIME manipulation, the results of hypothesis four show that in general the difference in new products among the three TCS conditions is not dependent on the TIME condition (easy TIME versus difficult TIME). **Though, when considering only the non-TCS and the difficult TCS, we found a (marginally) significant multivariate interaction effect.** In the easy TIME condition, participants created a *higher* cost carpet under the difficult TCS than under the non-TCS, suggesting an unfavorable impact of the difficult TCS on the cost level as discussed before in section 18.1. In the difficult TIME condition, participants used *more* time to design a new product under the difficult TCS than under the non-TCS, inducing again an unfavorable impact of target costing on the time spent. Hence, the use of a difficult TCS had in both TIME conditions a negative impact on the new product, apart from the general unfavorable impact of target costing on the attractiveness of the design, as discussed in the previous paragraph.

Is the negative impact of target costing on the time spent conform the expectations from current literature on **target costing**? Yes, some authors (Kato, Böer & Chow, 1995) suggest an extended time-to-market when using target costing during NPD. But from the results on hypothesis four, we know that the extended time spent under the difficult TCS was only confirmed under the difficult TIME condition and not under the easy TIME condition. How can it be explained that the difference in time spent with the non-TCS is <u>only</u> significant <u>under the difficult TIME objective</u> and not under the easy TIME objective? Considering the group means in Table 78, we see that under the easy TIME condition, both the non-TCS and the difficult TCS used the same amount of time (71 minutes). Hence, for the easy TIME condition **Parkinson's law** is applying to both the non-TCS and the difficult TCS. People adjust their work speed to the time available and thus use more time under an easy TIME condition than under a difficult TIME condition (Bryan & Locke, 1967, 260). However in our study, Parkinson's law does not apply to the difficult TIME condition for both the non-TCS and the difficult TCS. The difficult time condition forced participants of the *non-TCS* to speed up with the task, leading to a significantly lower time spent (61 minutes under the difficult time compared to 71 minutes under the easy time; $t = 2.1$, $p = .016$). Contrary, the difficult time condition could not force participants of the *difficult TCS* to speed up with the task, not leading to a lower time spent (70 minutes under the difficult time compared to 71 minutes under the easy time; $t = .326$, $p = .746$).

Is the significant interaction effect conform the expectations from previous goal setting studies? Yes, as discussed before in chapter three participants give up the less achievable goal and allocate their efforts towards the more achievable goal, when both goals are set at a level difficult to attain (Erez, Gopher et al., 1990; Erez, 1990; Gilliland & Landis, 1992). Actually, in our study, the time goal was the most achievable goal, but participants received instructions by the bonus system on the priority of each goal. Conform the instructions, **participants gave up the least important goal**, i.e. the time objective, when both the target cost and the time objective was set at a level difficult to attain. When only the target cost was set at a level difficult to attain and the time objective was easy to attain, participants did not spent significantly more time under the difficult TCS than under the non-TCS.

Summarizing, under the *difficult* TIME condition participants of the difficult TCS spent more time on designing a future product than participants of the non-TCS. Though, this higher time spent in the difficult TCS did not result in significantly lower cost designs, as discussed before. Conform to multiple goal setting studies, when two goals become difficult to attain, people skip on the least important goal, which is the time goal in our study. Furthermore, the difference in time spent between the difficult TCS and the non-TCS was not significant under the *easy* TIME condition. The explanation is that participants under the non-TCS spent also a long time on the design task, conform Parkinson's law. From the previous paragraph, we also know that this high time spent of participants under the non-TCS, easy TIME condition resulted in designs with a significantly lower cost level.

19. Changing the Settings of the following Experiment from Next Generation to Derivative kind of New Products

The failure to find a significant difference in cost level among the three TCS and the unfavorable impact of both the easy and the difficult TCS on the attractiveness of the designs, gave us some food for thought on the degree of required innovation in the simulated NPD environment of experiment two. The high degrees of freedom in color selection and the limited guidance from the designs of last season asked for a radical innovation when creating the new designs. The task was more than just a few incremental changes to the designs of last year, which leads us to call the type of new products in experiment two "next generation products" (Wheelwright & Clark, 1992).

This framework of Wheelwright & Clark (1992, 92) actually distinguishes among three types of new products (for commercial purposes): (1) derivatives (enhancements or hybrids), (2) next generations (or platforms) and (3) breakthroughs, as shown in Figure 55[100]. In this framework a two-dimensional diagram defines individual NPD projects according to the degree of change in the product and the manufacturing process. Derivatives involve just incremental changes to existing products and thus require few creativity. Next generations involve more radial changes to existing products and/or processes and thus ask for higher levels of creativity. Breakthroughs require the most radical innovations, both in terms of product and processes. **Actually, in experiment two we investigated target costing for the development of *next generation* type of new products.** The results of experiment two show that target costing is not appropriate for the development of next generation new products. **Hence, we will set up a third experiment and change the settings to *derivative* kind of new products (asking for a less radical innovation). It would be interested to investigate whether the earlier formulated hypotheses on the impact of target costing are supported for this type of new product development environment.**

There are mainly three reasons why we change to *derivative* new products in experiment three[101] and why we expect that the earlier formulated hypotheses (see chapter 3) will hold for derivatives.

1. First, from the **innovation literature** we know that efficiency and incremental innovations can occur simultaneously. In longitudinal research, the highest levels of cost reduction were found when product innovations were incremental, such as in derivatives (Utterback & Abernathy, 1975,

[100] Remark that this framework of Wheelwright & Clark (1992) was originally set up to see if an organization is getting the most out of its development resources. Though, here we can use it to visualize the differences between new products requiring **more incremental** versus **more radical** types of innovations, as simulated in experiment three versus experiment two.

[101] Breakthroughs will **not** be considered in this study.

644). Furthermore, derivatives typically require less creativity than the development of next generation new products, probably allowing more restrictions in terms of target costs without resulting in less favorable new products (Burgelman et al. , 1996, 662).

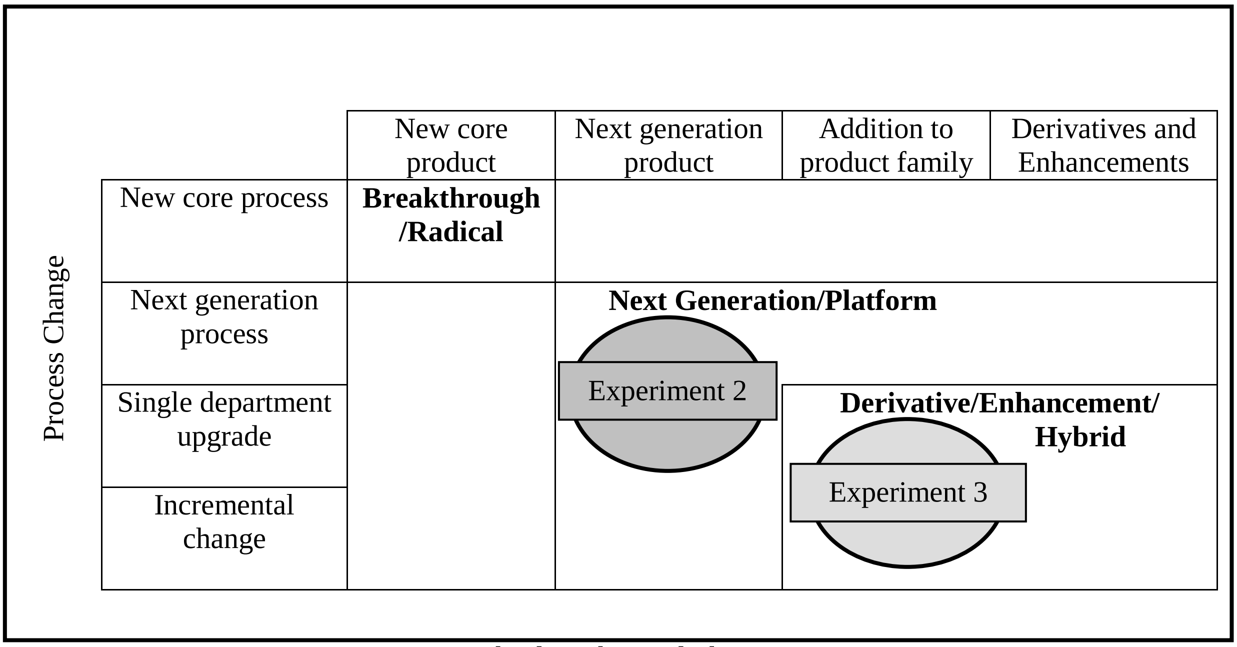
2. Second, in **goal setting**, Earley, Connolly & Ekegren (1989, 32) argue that one way to overcome the debilitating effect of specific, difficult goals in complex tasks when multiple strategies are available (such as in experiment two, as discussed earlier) is to provide some help in strategy development. Earley (1985, 490) found that giving employees information about task strategies compensated for the detrimental impact of the difficult goals for complex tasks. Similarly, Kanfer & Ackerman (1989) found that once initial learning has taken place on the suitable task strategies, the introduction of specific, challenging goals can improve performance.

3. Last, but not least, when going back to **target costing literature**, we found some authors arguing that target costing is more appropriate for incremental than for radical changes in new products. Cooper & Slagmulder (1997, 177) mention that target costing is most difficult to apply to revolutionary products. Though they refer to different reasons than the one suggested in the innovative and goal setting literature above. We quote: “Target sales prices are often difficult to establish because the value to the customer of the new product is difficult to estimate. Also, because the firm has never applied the technology in its products, historical cost information is not available. Finally, more new suppliers are typically involved.” (Cooper & Slagmulder, 1997, 177). Though in our second experiment no “uncertainty of the cost estimates or sales prices” was provided. Furthermore, Ansari & Bell (1997, 169) suggest that there are three ways to reduce the likelihood of adverse behavioral consequences of target costing during NPD; i.e. use employee participation in setting targets, create slack in the target costs and focus on continuous improvement rather than on radical changes. Finally, the limited survey research in Japan shows that target costing is extensively used by companies offering products with short product life cycles and regular model changes (Sakurai, 1989, 41; Morgan, 1993, 20; Fisher, 1995, 50). Industries such as the automotive industry, electronics, machinery and precision equipment show high adoption levels of target costing (Kato, Böer, & Chow, 1995, 40; Tani et al., 1994, 70), which are typical industries with a high rate of incremental product changes. Thus, from the anecdotal evidence in target costing literature we can hypothesize that target costing will have a favorable impact on the cost level for a derivative kind of future new product.

Concluding, the three streams of literature converge that the found unfavorable impact of target costing on the cost level and the quality level are less likely to occur for derivative new products. The incremental type of innovation requires less creativity of the designers, because they can start working from an existing product. In terms of goal setting literature, providing guidance in strategy development (by good examples of existing products) is expected to compensate for enhanced strategy search under the difficult goal condition for complex tasks. Also the target costing environment provides some anecdotal evidence that target costing is more appropriate for incremental product changes than for radical new products.

Thus, the unexpected results of experiment two, together with the above mentioned could-be explanations, are pushing us to change the settings of the following experiment. As shown in Figure 55, we will change the kind of expected new products from "next generations" in experiment two to "derivatives" in experiment three. As mentioned in chapter 4 (see page 111), a second purpose of lab experiments, apart from testing hypotheses, is to refine theories by building hypotheses based on the results found in the controlled environment of the lab. This is exactly what we are doing now.

Figure 55: Types of New Product Development Projects



Source: Wheelwright & Clark, 1992, 93

20. Conclusions

Apart from some improvements, the task of this second experiment was the same as in the first experiment, i.e. to design an attractive low cost carpet within the time limit. Three levels of TCS were considered, i.e. the non-TCS, the easy TCS and the difficult TCS. Both time conditions were considered, i.e. an easy TIME and a difficult TIME objective. This 3 by 2 factorial design was completely randomized with only between subjects effects. Again new product development goals were formulated for the cost, the quality and the time spent, with high emphasis on attractiveness, then on cost and finally on the attainment of the time objective. This priority among the three goals was established by the different amounts of bonuses. Feedback was provided on all three elements (attractiveness, cost and time). In total, 120 bioengineering-students participated, i.e. 20 participants in each of the six cells. Strict procedures were set up to guide participants, judges, assistants and cashiers during the experimental task.

A post experimental questionnaire was included, mainly to check if the manipulations were perceived as intended. The results show that target cost specificity, target cost difficulty and difficulty of the time objective were perceived as intended. Participants reported a higher energy on the attractiveness than on the cost objective, indicating that the manipulation on the priority of the goals was succeeded.

The results show that TCS is not leading to a significant impact on the cost level of the created designs, as hypothesized in hypothesis one. Contrary to the expectations from target costing literature, a difficult TCS is not leading to new products with a significantly lower cost level than the non-TCS. Similarly, the easy TCS is not leading to new products with a significantly higher cost level than the non-TCS.

The created new products significantly differed from each other among the three levels of TCS. The difference in created products is mainly caused by different levels on attractiveness. Target costing (either an easy TCS or a difficult TCS) is having an unfavorable impact on the attractiveness levels of the new products. New designs created under the easy and difficult TCS received significantly lower scores for attractiveness from the judges than designs created under the non-TCS, although there were no differences in the cost level of these designs.

Considering the impact of TCS on the cost level in each of the two time conditions, a significant interaction effect between the non-TCS and the difficult TCS across the two time objectives was supported. Under the easy TIME condition, the difficult TCS is having an unfavorable impact on the cost level compared to the non-TCS. Thus contrary to the expectations, the “non-TCS easy time” condition resulted in significantly *lower* cost designs (read better designs) than the “difficult TCS easy time” condition.

The multivariate interaction effect of TCS and the time objective was only supported between the non-TCS and the difficult TCS. Hence, the difference in created new products between the non-TCS and the difficult TCS significantly differed among the two time conditions. More specifically, under the difficult time condition, the difficult TCS is having an unfavorable impact on the time spent compared to the non-TCS. Under the easy time condition, as mentioned, the difficult TCS is having an unfavorable impact on the cost level compared to the non-TCS.

Concluding, target costing (either easy TCS or difficult TCS) was not beneficial in inducing a lower cost level. Instead, both the easy TCS and the difficult TCS resulted in new products with significantly lower quality levels. Totally unexpected, the difficult TCS lead even to significantly higher cost new products under the *easy* time condition, compared to the non-TCS. As expected from goal setting, the difficult TCS lead to significant higher time spent under the *difficult* time condition compared to the non-TCS, because of two goals set at a level difficult-to-attain in that "difficult TCS difficult TIME" condition. One explanation why our results contrast so sharply with current literature on target costing is that target costing might not be appropriate for all types of new products. In this second experiment, we simulated in fact a more radical than incremental innovation, leading us to call the NPD environment of experiment two one requiring the development of next generation new products. In the following experiment, the settings will be changed to the development of derivative new products, requiring only incremental innovations, to study if the expected favorable impact of target costing on the cost level can be supported for this kind of NPD environment.

Chapter 8: Experiment Three

1. Introduction

In the previous chapter, we described the second experiment, which included three levels of target cost setting (non, easy and difficult) and two levels of time difficulty (easy and difficult). Because of less available participants in this third experiment, we cannot assign participants to each of the six cells and thus need to consider a more efficient use of participants. From the results of experiment two we know that the main differences are found between the non-TCS and the difficult TCS. Hence we decided to include those two levels of TCS, i.e. the non-TCS and the difficult TCS, while not manipulating the easy TCS. Similar to experiment two, we will consider the two TIME conditions. Consequently, the design in experiment three is a completely randomized factorial **2 by 2 design** with four in stead of six cells, compared to experiment two.

The main difference with experiment two is the **change of the type of new products to create**. The results in the previous chapter learned that target costing was not appropriate for the development of next generation products. Hence the main purpose of experiment three is to test the impact of target cost setting for the development of derivative new products, requiring a less radical innovation, as discussed at the end of the previous chapter (page 262).

Thus, we can state that **experiment three varies from experiment two** in the following two ways:

1. Only two levels of target cost setting are included. The *easy TCS* manipulation is *deleted*. Only the non-TCS and the difficult TCS manipulation are included in experiment three, for both the easy and the difficult time condition, leading to a 2 by 2 factorial design.

2. The type of new product development is changed from one with *next generations* to one requiring *derivative* kind of new products. We will operationalize this revised setting by changing the examples of the most attractive designs of last season (the so-called market preferences). By limiting the number of colors in these examples to 5 (instead of all 10 in experiment two), we facilitate the innovation process by giving more guidance on which strategy to use in selecting the appropriate colors. Hence, by reducing the degrees of freedom, we require less creativity from the participants in selecting the appropriate colors for the given interior, since participants can now really start from these earlier versions to create the new design.

Furthermore, some minor changes will be made compared to experiment two, though not changing the task fundamentally.

1. *Bonus pay* will not occur immediate after the experimental task, but 10 minutes before the next class, because total available class time is smaller here than in experiment two.
2. We will delete the *practice session* on the cost calculation table in experiment three, since most participants suggested in experiment two to delete that part. This will save us another ten minutes in the total experimental time.
3. We will add a question in the post experimental questionnaire to ask for the *strategy* that participants took during the experimental task in realizing the conflicting goals, to check if participants worked conform the given priority rule of the three conflicting goals. Target cost commitment and time commitment will no longer be included in the questionnaire.

This chapter is organized analogously to the previous chapter. Before we start with testing the formulated hypotheses and analyzing the results, we first address the *organization* of the experiment in the sections 2 to 9. Then, we provide a discussion on the *measurement of the variables*, in section 10 (see page 278). Since most of the variables are measured in the same way as in experiment two, we will frequently refer to the previous chapter in that section. Third, we will *screen the data* in section 11 to check the manipulations and the accuracy of the data, to identify possible outliers and to check the normality and homoscedasticity assumption (see page 285). From then on, we will start with the statistical analyses to *test the hypotheses* in sections 12 to 15. A summary of the results is provided in section 16 (page 317) and the results are further *discussed* in section 18 (page 328).

2. Task

The task is completely identical to the task of experiment two, i.e. **to design an attractive carpet** for the market of young families with small children. The same living room **interior** (see Appendix Two, page 427) will be distributed as well to guide the creators. The same abstract **pattern** is used as in experiment two (see Figure 56). Participants need to select colors for the 39 larger areas. Colors can be selected from a pallet of 10 colors, represented by 9 color pens and white. The same color pens are used as in experiment two. Again, participants can practice and create as much designs as they want.

Again, participants are informed about the **cost system**. The cost system is exactly the same as the one in experiment two, summarized in Table 84. Thus, the cost system represents direct cost differences between yarn of different colors and addresses indirect cost differences when using more than the standard number (5) of colors. The currency is again Belgian Francs because we use Belgian participants in experiment three.

Figure 56: Pattern of the Carpet Designing Task of Experiment Three

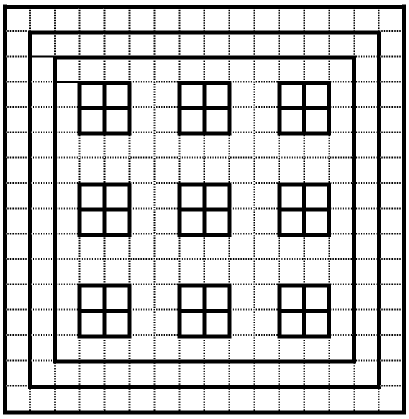


Table 84: Cost Calculation System in Experiment Three (Summarized Version)

	Cost per small square *standard* color	Cost per small square *additional* color
White, Black	Class A: 3 BEF	Class A+: 6 BEF
Yellow, Orange, Sky blue, Light green	Class B: 10 BEF	Class B+: 13 BEF
Blue, Brown, Red, Green	Class C: 15 BEF	Class C+: 18 BEF

3. Experimental Design

Two levels of target cost setting are considered in this third experiment, i.e. a non-target cost setting (non-TCS) and a difficult target cost setting (difficult TCS). Participants in the non-TCS are instructed to *design an attractive carpet, trying to minimize the cost of the carpet.* Participants in the difficult TCS are instructed to *design an attractive carpet, taking into account the maximum cost of 2.750 BEF*. This level of the difficult TCS is the same as in experiment two. The exact wording for each of the experimental conditions is given in Figure 58 on the next page. For the entire set of instruction sheets, we refer to Appendix Three, page 480 et seq.

Two levels of the **difficulty of the time-to-market objective** are considered, i.e. an easy time objective (easy TIME) and a difficult time objective (difficult TIME). The easy TIME was set at one hour and 45 minutes, the difficult TIME at one hour and 15 minutes. These levels are exactly the same as in experiment two.

Summarizing, this third experiment involves a **2 by 2 design** or a *completely randomized factorial* design CRF-22, with *between* subjects effects, as shown in Figure 57. As discussed later, the design is balanced, with each of the four cells containing 16 observations.

Figure 57: Completely Randomized Factorial Design CRF-22 of Experiment Three

	Non-TCS	**Difficult TCS**
Easy TIME	Group 1 (n = 16)	Group 2 (n = 16)
Difficult TIME	Group 3 (n = 16)	Group 4 (n = 16)

Figure 58: Expression used in the Four Experimental Conditions of Experiment Three

For the non-TCS:
Furthermore, the company uses a cost plus approach to determine the sales price. This means that the cost of the carpet is used as a basis to set the sales price. More specific, the sales price is set at a level equal to the cost of the carpet plus a profit percentage of 20%. Hence, your boss wants you to create an attractive carpet, while trying to *minimize* the cost of that carpet. Your boss is convinced that young families are not prepared to pay a lot of money for their living room carpet. In order to survive in this competitive market of living room carpets, you should come up with an attractive carpet at the lowest cost possible. So, do your best in minimizing the cost level of the design you create.

For the Difficult TCS:
Furthermore, the sales price for carpets is determined on the market. For the coming season the market price for a given carpet is estimated at 3.300 BEF. The general manager decided that living room carpets should earn a profit of 550 BEF apiece. Hence, your boss wants you to create an attractive carpet that costs *no more than 2.750 BEF* (i.e. the difference between the estimated market price of 3.300 and the profit margin of 550). Your boss is convinced that young families are not prepared to pay more than the estimated market price of 3.300 BEF. Furthermore, the company needs the profit margin of 550 BEF apiece, in order to survive in the competitive market of living room carpets. So, you should come up with an attractive carpet that costs no more than 2.750 BEF, unless you really think that designing an attractive carpet under that cost is impossible.

For the Easy TIME:
Finally, your boss wants you to be finished within *1 hour and 45 minutes*. If you are finished earlier, you should not wait to hand in your design. If you think that designing an attractive carpet in this time period is not possible, you can take some extra time.

For the Difficult TIME:
Finally, your boss wants you to be finished within *1 hour and 15 minutes*. If you are finished earlier, you should not wait to hand in your design. If you think that designing an attractive carpet in this time period is not possible, you can take some extra time.

4. Derivative New Products

As mentioned in the introduction, the main difference between the second and the third experiment is a different degree of required innovation to create the new products. Compared to experiment two, the task in experiment three is requiring **only incremental innovations**. Hence the new products to create are now *derivatives* instead of the next generation products in experiment two. First, we reduce the number of examples of the most attractive designs of last season from 10 to 8, to make it clear which colors fit within the given interior. Second, in these 8 most attractive designs (see Appendix Three, page 501), only five colors are used, i.e. yellow, green, blue, light blue and white, which all perfectly fit within the given interior (according to the judges panel). Although the basic pattern was totally different, it was so obvious from the examples that only those five colors fit within the given interior, with a dominance of yellow. Thus, we reduce the degrees of freedom in terms of the selection of the colors in experiment three, requiring less creativity and making it clear which strategy to select in creating an attractive, low cost carpet.

5. New Product Development Goals

Similar to experiment one and two, this experiment simulates a NPD environment with **three conflicting goals, to be attained simultaneously**. There is a do-best goal on *attractiveness*. There is a specific goal for *cost* in the difficult TCS and a do-best goal for cost in the non-TCS. Finally, there is a specific goal for development *time*.

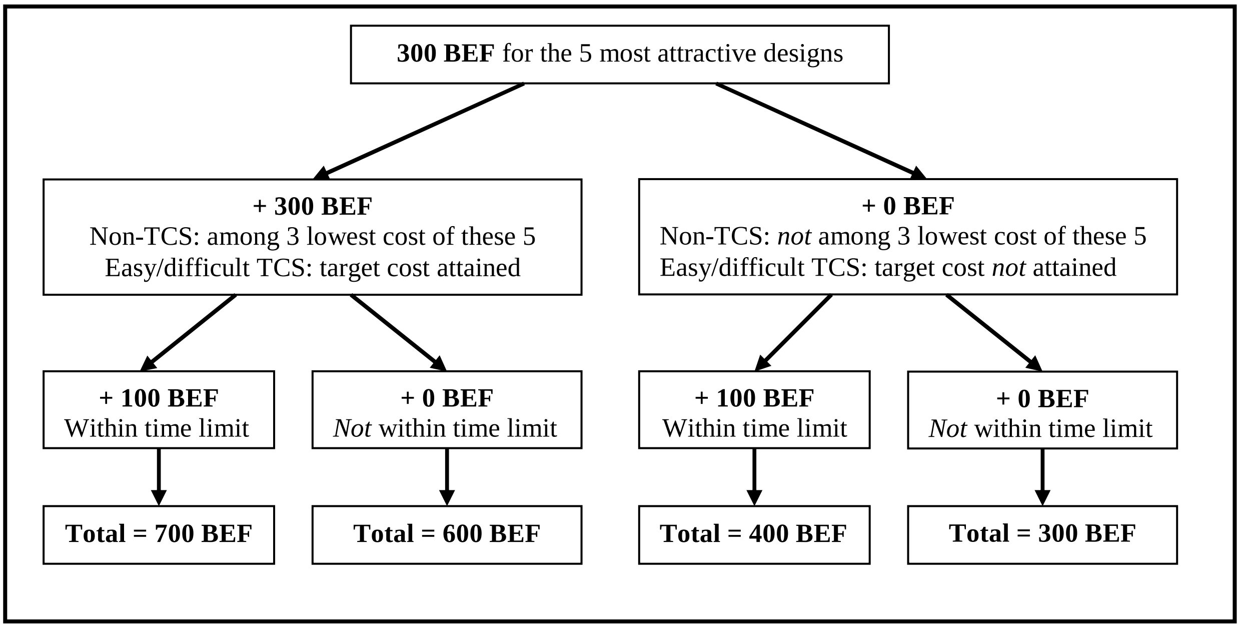
Again there is a clear **priority** within each of these conflicting goals, operationalized by the bonus system. Attractiveness is set as the most important goal, then cost and then time. Earlier on page 188, we graphed this kind of the survival triplet, asking for ever-increasing attractiveness.

6. Bonus System

The bonus system is identical to the one used in experiment two. Summing up, for **attractiveness** there is a competition based bonus system (300 BEF for each of the 5 most attractive designs in each group). In the non-TCS, there is also a competition based bonus system for **cost** (an additional 300 BEF for the 3 lowest in cost among the 5 most attractive ones). For the difficult TCS, the bonus for cost is dependent on not exceeding the target cost (an additional 300 BEF for those who did not exceed the target cost among those 5 most attractive ones). For the **time** objective, the bonus is dependent on finishing within the given time limit (an additional 100 BEF for those among the 5 most attractive ones finishing within the time limit). We reproduce the summary in Figure 59.

Contrary to experiment two, **bonus pay** occurs not immediately after the task, but at the beginning of the next class. Since total class time is 2 hours and a half, there is hardly time to input the three relevant measures into the spreadsheet to determine the bonus numbers before the end of the promised period of two hours and a half. The morning after the experiment, bonus numbers are posted on the bulleting board. Specific time and date arrangements are set to the convenience of participants to pay the bonuses. More details of the numbers receiving a bonus are given in Appendix Three, page 521. An example of the bonus receipt form used during bonus pay is shown in Appendix Three, on page 522.

Figure 59: Bonus System in Experiment Three



7. Feedback during the Task

The three forms of feedback are identical to the three forms of feedback used in experiment two.

First, participants get immediate feedback on the **cost level** of their creations. In the cost calculation table on each pattern sheet participants can easily calculate the cost of their creations during the experiment, as explained in detail in the instruction sheets. An example of such a pattern sheet is given in Appendix Three, page 500.

Second, participants can ask for **scores of the judges** for two of their created designs. Eight judges will be present in front of the room to score the designs (from 1 to 5), referring to the given living room interior. Assistants bring back and forward the designs from the participants to the jury. Participants knew the mean scores of the eight most attractive and the ten least attractive designs of last season, so they can compare the scores from the judges with these scores to see if they are doing well or not. Creating one design took more or less 5 minutes time, so there was plenty of time available for participants to react on the received feedback. At the end of the exercise, participants hand in one of the scored designs or a new design, which is then scored later during "down time" of the judges panel.

Third, feedback on the progression of **time** is possible as well. All participants start at the same time and the researcher asks to write this start time on the last page of the instruction sheets.

8. Participants

The sampling method is again a **convenience sample,** using all students from the second and third year of Economics (University Ghent) and students of Master in Financial Management (Vlerick Leuven Gent Management School). Students were informed of the experiment by a **recruitment letter** (see Appendix Three, page 473) during the class of April 21, 1999. The same letter was posted on the bulletin board to inform students who were absent at that class. It was stressed that participation was *voluntary*, that the task involved *no specific skills or risks of any kind* and that the purpose was to collect data for *research* purposes. There were no disadvantages for those not participating. For organizational reasons, students should hand in the **reply form** (attached to the recruitment letter), either by email, by post, by phone or by fax.

In total **65 participants participated voluntary** (see Appendix Three, page 475 for the list), of which 10 were master students. We used random assignment to treatments for the Economics students, while the 10 master students were randomly assigned equally over the four conditions[102].

9. Procedures

Again experiment three was carefully set up to minimize that determinants of error variance operate. Written instructions were provided to participants as well as to the 11 experimenters. The task for the participants was explained in a 14-page **written instruction** bundle (see Appendix Three, page 480 et seq.). Additional comments were given on the rather difficult pages by the same 5 color **overhead sheets** as experiment two (see Appendix Two, page 440 et seq.). Separate written instructions were provided to the **eight judges** (see page 434 et seq.) and to the **three assistants** (see page 431).

Students reported **together** to the experimental session. The session took for no one longer than two hours and a half. This time period was split up in four blocks: 30 minutes for instructions, 105 minutes (at most) for the task itself and 15 minutes to answer the post experimental questionnaire.

Random assignment to treatments was realized by choosing a **numbered card** upon arrival. This ID number assigned them to one of the four treatment conditions (numbered seats). Ten dedicated numbers (2, 2, 3 and 3 students in the four groups) were reserved for the master students. All **material**[103] was ready on the desk in a numbered A4-box, as in experiment two. Each individual

[102] Ability for instance is one of the **extraneous variables** which we do not measure in the experiment. There are methods available to control for this and other extraneous variables, as Kerlinger (1973, 309) explains, such as randomization and matching. We thus control for extraneous differences among participants by randomization the undergraduate participants to the four treatments and by matching the master participants equally among all four conditions, i.e. assigning two students at random to each condition.

[103] Similar to experiment two, this **material** contained the folder with the instruction and pattern sheets, a set of 9 color pens, a brown envelope, the sealed questionnaire, a blue pen, 2 blue feedback cards, the interior, the color copies of the 8 best and 10 worse designs of last season.

material such as the instructions, the patterns, the feedback cards, the brown envelope and the questionnaire was **labeled** with the ID number.

After a short welcome by the experimenter, participants went through the **instruction sheets**, page by page, as instructed by the researcher. These written instructions (see Appendix Two, page 394) covered comments on practical issues, on the task, on the judges, on the market information and on the bonus information, as summarized in Table 85. In addition to these written instructions, six **overhead sheets** were presented (see Appendix Two, page 440) to explain what was allowed in terms of merging and splitting predefined fields and to explain the cost calculation table.

Consequently, students **worked individually** on the task. They asked for scores of the jury by holding up one of the two blue cards. The assistant responsible for the given row picked up the design and brought it to judge 1 in front of the room. The same assistant brought the scored designs back from judge 8 to the participants. When finished, participants handed in their selected design in the brown envelope. When holding up this brown envelope, the assistant collected the envelope and wrote the time on it. Then participants unsealed the sealed questionnaire to complete it. Afterwards, they got a free drink and candy bar. **Bonus pay** occurred a few minutes before the next class. See Appendix Three, page 521 for the bonus details and page 522 for an example of the bonus receipt.

Thus, we summarize that participants worked *quietly and relaxed* on the task. By choosing an ID card, *random assignment* was established and by including on all personal material the ID number, *anonymity* was established as well.

Finally, we can add that all participants received a week after the experiment a **written feedback** note by email message, addressing the purpose of the experiment, explaining the bonus system and discussing the main results. This short feedback note is shown in Appendix Three, page 525.

Table 85: Overview of the Procedures in Experiment Three[104]

	Procedure	**Instruction Sheets**
0	The day before the experiment, **judges** 1 to 8 and **assistants** A, B and C get separate instructions by written instruction sheets. Discussion of it is provided by the experimenter.	
1	Each participant receives one of the **numbered cards** when arriving.	
2	Participants are taking place on the **numbered seats**. The ID number on the card refers to the ID number on the box with material.	
3	The experimenter is giving a short **welcome** to the group.	

[104] See appendix Three, page 480 et seq. for the **instruction** sheets to **participants** and page 440 et seq. for the **overhead** sheets used during these instructions to **participants**. Instruction sheets for the **judges** 1 to 8 are on page 434, and for the **assistants** on page 431.

4	Participants **start** with reading the instruction sheets, page by page.	
5	Participants are checking the given **material**.	Page 2
6	Participants are reading the instructions on the **pattern** and the researcher is showing some right and wrong examples on color overhead sheets.	Page 3 + Slide 2, 3, 4
7	Participants are reading the instructions on the **colors**.	Page 4
8	Participants are reading the instructions on the **cost system**.	Page 5
9	Participants are reading the instructions on the **cost calculation table**: direct and indirect costs.	Page 6
10	Participants are reading the instructions on a **first example** of the cost calculation table for a design with 5 colors. The researcher shortly explains.	Page 7 + slide 5
11	Participants are reading the instructions on a **second example** of the cost calculation table for a design with 6 colors. The researcher shortly explains.	Page 8 + slide 6
12	Participants are reading the instructions on the **task**, with the specific target cost setting and the specific time objective.	Page 9
13	Participants are reading the instructions on the **market information** (the given interior, the 8 most and the 10 least attractive designs of last year).	Page 10
14	Participants are reading the instructions about the **judges**.	Page 11
15	Participants are reading the instructions on the **practical issues** on how to get scores from the judges (token system with blue cards, maximum 2 designs).	Page 12
16	Participants are reading the instructions on the **bonus** system.	Page 13
17	Participants are reading the instructions that **summarize** all the relevant information for the task.	Page 14
18	Judges 1 to 8 are **entering** the room and take place in front of the auditorium. They start scoring (individually), while keeping the FIFO principle.	
19	Participants are **working** during 75/105 minutes (or less) on the task.	
20	**Assistants A, B and C** are bringing designs from the participants to judge 1. By holding up one of the 2 numbered blue cards, participants let know they have a design to score. Assistants A, B and C are taking scored designs from judge 8 back to the assigned participants. The ID number on the designs and on the material box helps assistants finding the right creator.	
21	When **finished**, each participant is putting his/her selected design (just one) in a brown envelope.	
22	Assistants A, B and C are picking up the brown envelope and are writing the **time spent** on it.	
23	Each participant is then filling-out the **questionnaire**.	

24	When finished, participants leave the room and take a **free drink** and candy bar.	
25	The experimenter is making two stacks of the designs: the designs scored before by the judges and the designs not scored before. This last stack is given to judge 1, who keeps track of the **priority rule**: first scoring the designs from participants still in the room; only scoring the designs from participants who left the room during "downtime".	
26	When all participants finished, the researcher is doing the **input** of the three main dependent variables into the Excell spreadsheets. She is then sorting the rows of each of the 6 spreadsheet based on attractiveness, **to determine the five bonus ID's** in each of the 6 groups. Information on the cost level and time spent helps her in calculating the total bonus for each of those five participants.	
28	The researcher is preparing the **envelopes** with the right amount of money. Bonus receipt forms are completed with ID numbers.	
29	The morning after the experiment, the researcher is posting the bonus ID's on the **information bulletin board.**	
30	Just before next class, the researcher is **paying** the bonus. Participants sign the receipt form.	
31	All participants receive a **written feedback** report by email message, a few weeks after the experiment.	

10. Measurement of the Variables

10.1 Attractiveness, Cost Level and Time Spent

The cost levels of the design, the attractiveness score of the design and the time spent to create the design are again the three main dependent variables in this experiment. These three main dependent variables are **measured identical** as in experiment two.

Attractiveness is measured as the *mean of all scores* received by the judges. Eight judges scored the designs individually from 1 to 5 during the experimental task, using the same living room interior as the participants (see Appendix Two, page 427). These eight judges were the same judges as the judges who did the scoring in experiment two and who did the scoring of the designs to determine the 10 best designs. The individual scores given to the 65 participants are shown in Appendix Three, on page 517. The Cronbach's Alpha for the scores of the 8 judges was $\alpha = .92$ and did not improve if one of the judges was deleted, suggesting internal consistency. This Alpha score is comparable to the $\alpha = .89$ of experiment two.

The **cost level** of the future product is measured as the *total cost* of the created carpet that each participant handed in at the end of the session. Again, participants were taught in the instruction sheets how to fill out the cost calculation table to determine the total cost.

Time spent during NPD is measured as the *time period* between starting time and finishing time. All participants started at the same time with the experimental task, but stopped at different times during the official class time. When finished, participants put their design in the brown envelope and assistants wrote the "time stop" on it. The time spent is calculated in minutes.

10.2 Manipulation Checks

10.2.1 Manipulation Checks for Target Cost Specificity

The non-TCS received a *vague* cost goal, i.e. "to minimize the cost level of the carpet". The difficult TCS received a *specific* target cost, i.e. to "design a carpet with a maximum cost of 2.750 BEF". Checking if participants perceived the cost objective as more specific under the difficult TCS than under the non-TCS was done by the ***same*** **two questionnaire items as in experiment two** (see page 198). These two items with a 5-point Likert-Type Scale (1= absolutely disagree, …, 5 = absolutely agree) are: "*I knew exactly the acceptable cost of the carpet*" and "*The instructions of my boss on the acceptable cost of the carpet were rather vague*." Answers on the first item were reversed and averaged with answers on the second item to form a global score. The Pearson correlation between the two items was r = .51, Cronbach's Alpha $\alpha = .67$, which is lower than $\alpha = .79$ of experiment two.

10.2.2 Manipulation Checks for Target Cost Difficulty

In this third experiment, only one specific TCS was included, i.e. the difficult TCS. Though, we included the **same questionnaire items** as in experiment two (see page 199), to get an idea of the perception of the difficulty of the target cost by the participants. The two items are: "*The cost goal of my boss was easy to attain*" and "*It was difficult to have a cost below the acceptable cost*." A global score was formed for each participant by averaging the first with the reversed of the second item. Pearson correlation was $r = .77$, while the Cronbach's Coefficient was $\alpha = .87$, somewhat higher than $\alpha = .82$ of experiment two.

10.2.3 Manipulation Checks for Difficulty of the Time Objective

The *same* two items were included as in experiment two (cf. page 200) to check if the difference in time difficulty was also perceived by participants. The items are, with answers on a 5-point Likert type of scale: "*The time limit was rather short to complete this task*" and "*The time limit of my boss was easy to attain*". The scores on the first and the reversed second item were averaged to form a global index. The Pearson correlation between the items was $r = .64$. Cronbach's Alpha was $\alpha = .78$, which is comparable to $\alpha = .76$ of experiment two.

10.2.4 Manipulation Checks for Priority among the Conflicting Goals

The *same* scale was used as in experiment two to measure the "energy expended on the attractiveness of the design" and the "energy expended on the cost objective" to determine if participants worked most extensively on the attractiveness goal than on the cost goal. The 3 items include issues of effort, persistence and attention, as discussed earlier on page 200. The answers on these three items were averaged to form a global measure. Cronbach's Alpha was $\alpha = .69$ for energy expended on attractiveness and $\alpha = .83$ for energy expended on cost, comparable to $\alpha = .79$ and $\alpha = .86$ in experiment two respectively.

These two measures can only tell us something about the trade-off between the attractiveness and the cost level of the carpet, leaving out the time objective. To address the relative importance of each of the three goals, we develop now a new measurement scale. Each of the three goals is assigned to the description "I found it important" and "I found it less important". Combining these two descriptions for each of the three goals results in eight different strategies, as shown in Table 86. We asked participants to rank order these eight different strategies. With the given rank ordering scores, we will run a conjoint analysis[105] to determine the relative importance of each of the three goals.

Table 86: Measurement Scale for Strategies Implemented in Experiment Three

Please indicate to which extent you followed the strategies below when designing your carpet. You can score them from 8 to 1.
8 = Most relevant 1= Least relevant

8 Strategies	**Your score**
It thought it was important to create a carpet with a *low cost (*not to exceed the cost objective of my boss). It thought it was important *not to exceed* the time limit of my boss. It thought it was important to create an *attractive* carpet.	…………
It thought it was important to create a carpet with a *low cost* (not to exceed the cost objective of my boss). It thought it was *not so bad* to exceed the time limit of my boss. It thought it was important to create an *attractive* carpet.	…………
It thought it was *not so important* to create a carpet with a low cost (that exceeded the cost objective of my boss). It thought it was important *not to exceed* the time limit of my boss. It thought it was important to create an *attractive* carpet.	…………
It thought it was *not so important* to create a carpet with a low cost (that exceeded the cost objective of my boss). It thought it was *not so bad* to exceed the time limit of my boss. It thought it was important to create an *attractive* carpet.	…………
It thought it was *not so important* to create a carpet with a low cost (that exceeded the cost objective of my boss). It thought it was important *not to exceed* the time limit of my boss. It thought it was *not* so important to create an attractive carpet.	…………
It thought it was important to create a carpet with a *low cost* (not to exceed the cost objective of my boss). It thought it was *not so bad* to exceed the time limit of my boss. It thought it was *not* so important to create an attractive carpet.	…………
It thought it was *not so important* to create a carpet with a low cost (that exceeded the cost objective of my boss). It thought it was *not so bad* to exceed the time limit of my boss. It thought it was *not* so important to create an attractive carpet.	…………
It thought it was important to create a carpet with a *low cost* (not to exceed the cost objective of my boss). It thought it was important *not to exceed* the time limit of my boss. It thought it was *not* so important to create an attractive carpet.	…………

[105] The purpose of the **conjoint analysis** is to determine what participants found important when creating the new product. Hence in this conjoint analysis the three goals are the attributes, while “high importance” and “low importance” are the levels of the attributes. The purpose of the conjoint analysis is to estimate the so-called utility scores for each of the two levels for the three goals and to calculate the relative importance of each goal (attribute). The utility score can be described as the mean centered average score of an attribute level. The importance scores are computed by taking the utility range for a particular attribute and dividing it by the sum of all utility ranges.

10.3 Job-Related Tension caused by Goal Conflict

Again the *same* self-reported measure was used as in experiment two, as discussed earlier on page 203. We developed three items similar in spirit to the one of Jaworski & Young (1992). These items with answers on a 5-point Likert type of scale are: "*I was rather tensed because I thought I would never find the ideal design*"; "*Looking for an attractive an cheap carpet made me rather tensed during the exercise*" and "*I felt rather comfortable when aiming for the different goals during the exercise*". Cronbach's Alpha was .76, which is higher than α = .60 in the Jaworski & Young (1992) study and the α = .59 of experiment two. The answers on the third item were reversed and then averaged with the answers on the first two items to form a global score for job-related tension.

10.4 Motivation by the Bonus System

The *same* self-reported measure was used as developed for experiment two (cf. page 204). The three items to measure the degree to which participants were motivated by each of the three bonuses are: "*By a possible bonus of 300 BEF, I was strongly motivated to create an attractive carpet*"; "*By a possible bonus of 300 BEF, I was strongly motivated to create an attractive carpet that had a low cost as well*"; "*By a possible bonus of 100 BEF, I was strongly motivated to make an attractive carpet, within the time limit*".

The data of experiment three showed a Cronbach's Alpha of .82, which is lower than α = .92 of experiment two. Again, the answers were averaged for each participant over these three items to form a global index for the degree of self-reported motivation, though each of the items will be used separately as well.

10.5 Other Variables

The same *general kind of questions* were included, such as the **age** of the participant, **gender**, **discipline** of education, **experience** with design tasks before and **guessing** the real purpose of the study. A review of the Dutch answers on the different guesses on the purpose of the study is given in Appendix Three, page 523.

Seven more questions are included to give *feedback on the experimental task*. These questions ask if participants **understood the task** after reading the instruction sheets and if they **liked the task.** Also the **total number** of designs made, the importance they gave to the **scores of the jury**, and their perception on the **length** of the questionnaire was added.

Because of the inclusion of other market information now (cf. most attractive designs of last year, using the same 5 colors) we add a question on what participants think about the **relevance of these examples** when creating the new product.

10.6 Differences with Experiment Two

Summing up the differences with experiment two in the post experimental questionnaire, the major change is that we added one large question on the "*strategies*" participants took during the NPD, to check the priority rule among the three conflicting goals, as discussed in paragraph 10.2.4 above. Some minor changes were made as well, such as **deleting** the question on "*would you like to participate again*" and **adding** a question on the "*relevance of the examples of last year's collection*". Two other questions were **deleted** as well, i.e. "*commitment to the target cost*" and "*commitment to the time objective*". As remembered from the discussion in paragraph 10.3, page 201, more than one dimension did show up in both four-item scales, translated from Hollenbeck, Klein et al. (1989).

Finally, a **summary** of the structure of the post experimental questionnaire is given in Table 87. For the entire questionnaire in Dutch, we refer to Appendix Three, page 506 et seq. The entire questionnaire in English is given in Appendix Three, on page 511 et seq.

Table 87: Structure of the Post Experimental Questionnaire of Experiment Three[106]

Variable name	Short Description	Measurement Scale	Item n° Non-TCS	Item n° Diff TCS
	General kind of questions:			
AGE	Age of participant	Ratio	1	1
GENDER	Male or Female participant	Nominal	2	2
OPTION	Discipline of education (2nd Year Economics, 2nd Year Economics, option TBK, 3rd Year Economics, Master in Finance)	Nominal	3	3
EXPERIEN	Experience with design tasks before (yes/no)	Nominal	4	4
	Questions to give feedback on the task:			
PURPOSE	Guessing the purpose of the study (yes/no)	Nominal	5	5
UNDERSTA	Understanding the task after reading instructions (yes/no)	Nominal	6	6
TOTALDES	Total number of designs made	Ratio	7	7
FEEDBACK	Relevance of designs last year (1-5 scale)	Interval	8	8
JURYIMPO	Importance to scores of the jury (1-5 scale)	Interval	12	12
LIKETASK	Did you like the task (1-5 scale)	Interval	11	11
QUESTION	Perception length of questionnaire (1-5 scale)	Interval	28	30
	Manipulation checks:			
COSTSPE1	Cost specificity, item 1 (1-5 scale)	Interval	15	15
COSTSPE2	Cost specificity, item 2 (1-5 scale)	Interval	20	20
COSTEASY	Target cost difficulty, item 1 (1-5 scale)	Interval	-	22
COSTDIFF	Target cost difficulty, item 2 (1-5 scale)	Interval	-	26
SHORTTIM	Time difficulty, item 1 (1-5 scale)	Interval	16	16
TIMEEASY	Time difficulty, item 2 (1-5 scale)	Interval	21	21
ATTREFFO	Energy expended on attractiveness, item 1 (1-5 scale)	Interval	9	9
ATTRPERS	Energy expended on attractiveness, item 2 (1-5 scale)	Interval	14	14
ATTRATTE	Energy expended on attractiveness, item 3 (1-5 scale)	Interval	26	28
COSTEFFO	Energy expended on cost, item 1 (1-5 scale)	Interval	10	10
COSTPERS	Energy expended on cost, item 2 (1-5 scale)	Interval	13	13
COSTATTE	Energy expended on cost, item 3 (1-5 scale)	Interval	18	18

[106] For the **full questionnaire in Dutch**, we refer to page 506 et seq. For the **entire questionnaire in English**, we refer to page 511 et seq.

	Manipulation checks (strategies): (1-8 scale)			
CARD1	High importance to attractiveness, high importance to cost, high importance to time.	Interval	27	29
CARD2	High importance to attractiveness, high importance to cost, low importance to time.	Interval	27	29
CARD3	High importance to attractiveness, low importance to cost, high importance to time.	Interval	27	29
CARD4	High importance to attractiveness, low importance to cost, low importance to time.	Interval	27	29
CARD5	Low importance to attractiveness, low importance to cost, high importance to time.	Interval	27	29
CARD6	Low importance to attractiveness, high importance to cost, low importance to time.	Interval	27	29
CARD7	Low importance to attractiveness, low importance to cost, low importance to time.	Interval	27	29
CARD8	Low importance to attractiveness, high importance to cost, high importance to time.	Interval	27	29
	Job-related tension:			
TENSION1	Tension because of goal conflict, item 1 (1-5 scale)	Interval	17	17
TENSION2	Tension because of goal conflict, item 2 (1-5 scale)	Interval	19	19
TENSION3	Tension because of goal conflict, item 3 (1-5 scale)	Interval	25	27
	Motivation by bonus system:			
BONUS1	Motivated by bonus for attractiveness (1-5 scale)	Interval	22	23
BONUS2	Motivated by bonus for low cost design (1-5 scale)	Interval	23	24
BONUS3	Motivated by bonus for attaining time objective (1-5 scale)	Interval	24	25

So far, we have discussed the *practical organization* of experiment three as well as the used *measurement scales*. From the next section on, we will make the jump to reviewing the "real" data, collected during and after the experimental task. We will first *screen* the data, to verify if we can proceed with hypotheses testing. Different issues will be discussed, such as the results of the manipulation checks, the accuracy of the data, descriptive statistics, checking for outliers, normality and homoscedasticity of the main variables. A summary of the data screening process is provided in section 11.6 on page 301. Then, we will progress towards testing the hypotheses.

11. Data Screening

11.1 Results of the Manipulation Checks

We will now analyze if participants in the experiment also perceived the manipulation of *target cost specificity* (non-TCS versus difficult TCS) and the manipulation of *time difficulty* (easy TIME versus difficult TIME). Furthermore, we need to check if the *difficult target* cost was really perceived as difficult to attain. As discussed earlier on page 278, questionnaire items were administered in the post experimental questionnaire to capture these perceived differences.

The mean scores on **target cost specificity** is significantly different between the non-TCS (mean = 2.6) and the difficult TCS conditions (mean = 4.2), indicating that the target cost in the difficult TCS was perceived as much *more* specific than the minimizing cost objective in the non-TCS (F (1, 62) = 50.4, p = 0.000), as shown in Table 88.

Here in experiment three, we do have only one group with a specific target cost, i.e. the difficult TCS. So, it is not possible to compare the perception of the **difficulty of the target cost** in that difficult TCS with another group. Though, we do have means on this same measurement scale from experiment two in a difficult and in an easy TCS. As discussed in the previous chapter, the mean on the manipulation check for target cost difficulty in the difficult TCS in experiment two (mean = 2.8) significantly differed from the mean in the easy TCS in experiment two (mean = 1.8). If we compare now these means of experiment two (mean difficult TCS = 2.8 and mean easy TCS = 1.8) with the mean on the manipulation check for target cost difficulty in experiment three (mean = 3.1), we can conclude that the difficult TCS was indeed perceived as difficult to attain in experiment three (F (1,70) = 27.0, p = 0.000), as shown in Table 88.

The **difficulty of the time objective** was perceived significantly different between the easy TIME and the difficult TIME condition (F (1, 62) = 5.7, p = 0.020), as shown in Table 88. The mean score on the time difficulty index was 1.7 for the easy TIME, while 2.3 for the difficult TIME condition, indicating that the difficult TIME was indeed perceived as more difficult to attain than the easy TIME.

In sum, both manipulations, i.e. the target cost setting and the time difficulty were successfully.

Table 88: ANOVA's for the Manipulation Checks on Target Cost *Specificity*, Target Cost *Difficulty* and Time *Difficulty* in Experiment Three

ANOVA		Sum of Squares	Df	Mean Square	F	Sig.
Specificity of cost objective (1-5)	Between Groups	41.441	1	41.441	50.387	**0.000**
	Within Groups	50.992	62	0.822		
	Total	92.434	63			
ANOVA		**Sum of Squares**	**Df**	**Mean Square**	**F**	**Sig.**
Difficulty of the target cost (1-5)	Between Groups	32.400	1	32.400	27.008	0.000
	Within Groups	83.975	70	1.200		
	Total	116.375	71			
ANOVA		**Sum of Squares**	**Df**	**Mean Square**	**F**	**Sig.**
Difficulty of the time objective (1-5)	Between Groups	4.516	1	4.516	5.660	**0.020**
	Within Groups	49.469	62	0.798		
	Total	53.984	63			

Furthermore, we need to check if participants (across all manipulations) understood the type of new product development environment in terms of **priority among the attractiveness, cost goal and time objective**. Similar to experiment two, the mean for energy expended on attractiveness (3.55) was higher than for energy expended on cost (2.60). Individually considered, 80% of all participants reported to have expended more energy on improving the attractiveness than on reducing the cost level of the design, while 5% expended equal effort, as shown in Table 89. Only 10 participants (15%) expended more energy on cost than on attractiveness (of which 8 came from the difficult TCS and 2 from the non-TCS. In general, participants reported significantly higher energy expended on attractiveness than on cost since the paired samples t-test reveals a significant difference ($t = 6.9$, $p = .000$), as shown in Table 90. Furthermore, the results of the **conjoint analysis** on the scores of the 8 strategies show that participants found it most important to create an attractive carpet (a relative importance of 50%), as shown in Table 91. The importance on the cost goal (i.e. not to extend the target cost or to create a low cost carpet) is found on the second place with a relative importance of 29%. The goal to which participants attached least importance was the time goal, with a relative importance of 21%. These priority among the goals conform to the manipulation on the new product development goals. **Hence based on the results of both manipulation checks, we can state that priority among attractiveness, cost and time was understood in the way as intended.**

Table 89: Relative Difference between Energy Expended on Attractiveness and Energy Expended on Cost in Experiment Three

Difference		Frequency	Percent	Cumulative Percent
< 0:	more energy on cost	10	15.63%	15.63%
= 0:	equal energy to attractiveness and cost	3	4.69%	20.31%
> 0:	more energy to attractiveness	51	79.69%	100%
	Total	64	100%	

Table 90: Paired Sample t-Test between Energy Expended on Attractiveness and Energy Expended on Cost in Experiment Three

Paired Differences			95% Confidence Interval of the Difference				
Mean	**Std. Deviation**	**Std. Error Mean**	**Lower**	**Upper**	**t**	**Df**	**Sig. (1-tailed)**
0.948	1.103	0.138	0.672	1.224	6.872	63	0.000

Table 91: Results Conjoint Analysis to Check Priority among the Three Goals in Experiment Three

Averaged Importance	Utility	Attribute (Goal)	Factor
		ATTRACTIVENESS	Importance to attractiveness
50.49	1.408		*High* importance
	-1.408		*Low* Importance
		COST	Importance to cost
28.77	0.654		*High* importance
	-0.654		*Low* importance
		TIME	Importance to time
20.74	0.531		*High* importance
	-0.531		*Low* importance
	4.486	CONSTANT	
Pearson's R = 0.997	Significance = .0000		

11.2 Accuracy of the Data

The data were entered in SPSS by the researcher and checked by another person. Furthermore, examination of the frequency tables for all variables did not reveal out-of-range data. When participants made mistakes in the calculation of the total cost (in 15% of the cases)[107], the right total cost was used as the operationalization for the cost level. Though, these mistakes were all minor in positive as well as in negative sense (mean = 75 compared to the grand mean for cost level of 2725) and independent of the manipulation (χ^2= .47, p = .93). None of the mistakes induced a difference in thinking about attaining the target cost or not[108].

There were **no missing data** for the three main dependent variables **attractiveness, cost level and time spent**. A few participants forgot (or refused) to answer some items of the **post experimental questionnaire**. In total we have three missing answers for the perception of the length of the questionnaire (QUESTION), which was placed on the last page of the questionnaire. Five participants did not answer or answered incompletely the question on the used strategies (CARD1 to CARD8), which was indeed the hardest question to answer. There was no pattern for these missing data, since they were evenly distributed among all four conditions. We will simply ignore these cases when analyzing these variables with missing data, though keep them in the sample for all other observations.

The experimental design was set up to have an **equal number of observations** in each of the four groups (cells)[109]. Though, three participants did not show up at the experiment, causing unequal numbers. In total we had 65 observations, with 17 in the first cell (non-TCS, easy TIME) and 16 in each of the other three cells. The simplest strategy to keep a balanced-cell design is to randomly *delete* here one case from the first cell. As Tabachnick & Fidell (1989, 49) explain, deletion of a few cases is a good choice, if an unequal number of cases is due to random loss of a few subjects in an

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[107] The percentage of participants who made a **mistake** in calculating the cost level was higher in experiment three (15%) than in experiment two (6.7%). Though the instruction sheets and cost calculation tables were identical. But in experiment three the practice session on the cost calculation table was not inserted, because participants found this practice session rather stupid in experiment two.

[108] By using the correct cost level we did **not bias the results**, since all conclusions of the hypotheses give the same results with the wrong cost levels as with the correct ones. In the main text, we will report the results with the correct cost levels, because of higher accuracy. To show the similarity of the conclusions, we report here shortly the results with the wrong cost levels. Hypothesis 1: F (1, 62) = 9.7, p = .003 instead of p = .002 with the correct cost levels, leading to the same conclusion. Hypothesis 2: Hotelling's T^2 p = .005, which is the same as the one who will be reported further on and thus leading to the same conclusion. Hypothesis 3: F (1, 60) = 4.0, p = .05 instead of p = .081, leading to the same conclusion. In the easy time condition, the one-tailed t-test has a p = .0005 instead of p = .001. In the difficult time condition the one-tailed t-test reveals a p = .203 instead of p = .132. All results of this hypothesis 3 lead to the same conclusions as the ones who will be reported further on. Hypothesis 4: Hotelling's T^2 gives p = .023 instead of the reported p = .030. The univariate interaction effect on cost level is significant (p = .05) instead of the reported p = .081. The differences in cost remain significant in the easy time condition, p = .001 instead of the reported p = .002, while the differences in time spent in the difficult time condition do evidently not change. **Hence, all conclusions really remain the same**.

[109] As Tabachnick & Fidell (1989, 48) explain in factorial designs (like our study) **unequal sample sizes** in each cell create difficulty in computation and ambiguity of the results. Hypotheses about main effects and interactions are no longer independent and sum of squares are no longer additive.

experimental design originally set up for equal n. Thus, we deleted randomly one observation from the non-TCS, easy TIME group. We took the last observation of this first cell (id number 17), which came from the participant arriving as last person in the room. So, we will analyze the data as if that person did not show up.

11.3 Descriptive Statistics

The **frequency tables** for the nominal measured data are given in Table 92. Of the 64 participants, 39 were male (61%). Similar to experiment two, most of them had no experience with design tasks (84%). More than half (58%) did a guess on the purpose of the task. Appendix Three, page 523 gives an overview of these guesses in Dutch. All 64 participants understood the task after reading the instruction pages. Furthermore, random assignment to treatment was successfully implemented. The manipulation was independent of participant's gender, discipline of education and experience with design tasks before[110].

Table 92: Frequency Tables for the Nominal Measured Data in Experiment Three

		Frequency	Percent	Valid Percent	Cum Percent
Gender	Male	39	61	61	61
	Female	25	39	39	100
Discipline of education	2nd Year Economics	33	52	52	52
	2nd Year Economics, option TBK	12	19	19	70
	3rd Year Economics	4	6	6	77
	Master in Financial Management	10	16	16	92
	Other (IAJ, ...)	5	8	8	100
Experience with designing task	Yes experience	10	16	16	16
	No experience	54	84	84	100
Guessing purpose of exercise	I do a guess on the purpose	37	58	58	58
	I have no idea of the purpose	27	42	42	100
Understanding of task	Yes, I did understand the task	64	100	100	100
	No, I do not understood the task	0	0	0	100
	Total	64	100		

Descriptive statistics for the interval and ratio measured variables are shown in Table 93. The *cost level* varied between 1352 BEF and 3580 BEF, with a mean of 2724 BEF. *Attractiveness* ranged between 1 and 4.1, with a mean of 2.80. *Time spent* varied between 47 and 109 minutes, with a mean of 72 minutes.

[110] The **Chi-Square** tests give the following results: Treatment by gender χ^2= 1.772, p = 0.621; treatment by discipline of education χ^2= 1.189, p = 0.756; treatment by experience before χ^2= 2.370, p = 0.499.

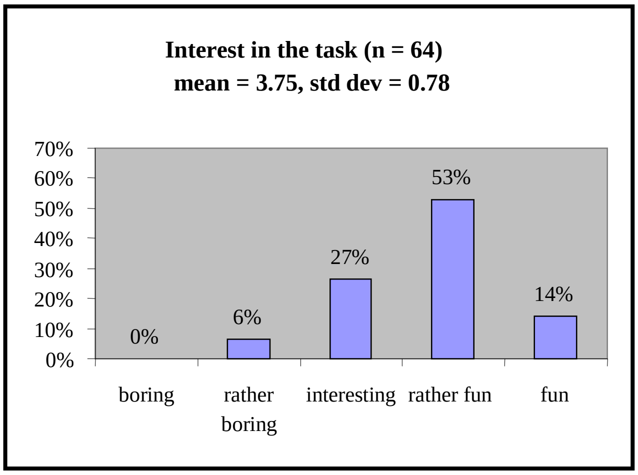
Energy expended on attractiveness had a mean of 3.55, while *energy expended* on cost had a mean of 2.60. The scores for *job-related tension* because of goal conflict ranged between 1 and 4.3, with a mean of 2.56. Motivation by the *bonus system* ranged from 1 to 5 with a mean of 3.66.

Participants disagreed in the importance they took to the *scores of the jury*. The answers ranged between 1 and 5, with a mean of 3.11. *Interest in the task* had a mean of 3.75, ranging from 1 to 5. The frequency chart in Figure 60 shows that 94 % of the participants found the task "interesting", "rather fun" or "fun". No-one found the task "very boring". The *length of the questionnaire* was perceived as rather short (2), just right (3) and rather long (4), with a mean of 3.21. On average participants were 20 years old. The *number of designs* made had a mean of 7, with a minimum of 2 and a maximum of 14, comparable to experiment two.

Table 93: Descriptive Statistics for Experiment Three

Variable	Label	N	Min	Max	Mean	Std. Dev.	Variance
COST	Cost Level	64	1352	3580	2724	367	134563
MEANATTR	Attractiveness (scored on 5)	64	1	4.13	2.80	0.84	0.70
TIME	Time spent in minutes	64	47	109	72	14	201
ENERGYAT	Energy expended on attractiveness (1-5)	64	2.33	4.67	3.55	0.61	0.38
ENERGYCO	Energy expended on cost (1-5)	64	1	4.33	2.60	0.90	0.81
TENSION	Tension because of goal conflict (1-5)	64	1	4.33	2.56	0.99	0.98
BONUS	Motivation by the bonus system (1-5)	64	1	5	3.66	0.91	0.82
JURYIMPO	Importance to jury scores (1-5)	64	1	5	3.11	1.10	1.21
FEEDBACK	Relevance market information (1-5)	64	1	5	3.97	0.89	0.79
LIKETASK	Interest in the task (1-5)	64	2	5	3.75	0.78	0.60
QUESTION	Length of the questionnaire (1-5)	61	2	4	3.21	0.52	0.27
AGE	Age of participant	64	18	24	20.30	1.52	2.31
TOTALDES	Number of designs made in total	64	2	14	7.25	3.06	9.37

Figure 60: Frequency Chart for "Interest in the Task" in Experiment Three



11.4 Outliers and Extreme Values

To identify possible **univariate outliers** and extreme values **for the cost level,** we made the boxplots for the cost level in the two TCS conditions. As shown in the first graph of Figure 61, four outliers are identified and one extreme case is found (shown with an asterisk). In the non-TCS case 40 is more than 1.5 box length removed from the 25th percentile and case 44 is more than 1.5 box length removed from the 75th percentile. Similar in the difficult TCS, cases 60 and 63 are more than 1.5 box length removed from the 75th percentile. The outlier, case 18 is more than 3 box lengths lower than the 25th percentile.

To find the **univariate outliers** for the **interaction effect** (TCS by TIME difficulty) four boxplots on the cost level were made. The same univariate outliers are found, i.e cases 18, 44, 60 and 63. As shown in the second graph of Figure 61.

To graph the **multivariate outliers**, we computed the Mahalanobis distance for cost level, attractiveness and time spent, in two runs for each TCS, as described in Tabachnick & Fidell (1989, 69). As shown in the first graph of Figure 62, two multivariate outliers were identified (cases 8, 16) and two multivariate extreme values were identified (cases 18 and 40). Table 95 gives a description of these cases in terms of cost level, attractiveness and time spent, compared to the group means. Though the two multivariate extreme values did show up univariately as well, it is the combination of the three variables that makes a case a multivariate outlier. For instance, case 8 has a rather low score for attractiveness, but used a lot of time compared to the group mean. Case 16 on the other hand had a rather high score for attractiveness, while also using a lot of time, compared to the group mean. The extreme values for case 18 and 40 came from the low score for cost, the low score for attractiveness and the low score for time spent. From this data, we don't know if these students quit too early with the task or if they just had no ability to perform better on the task.

To find the **multivariate outliers** for the **interaction effect**, we calculated the Mahalanobis distance separate for each of the four conditions. The second graph of Figure 62 shows that more or less the same cases were identified, i.e. case 18 and 43 as outlier and case 40 and 44 as extreme values. Table 95 shows again why these cases are far off the other observations on the three combined dependent variables.

A summary of all identified univariate and multivariate outliers and extreme values are given in Table 94. Similar to experiment two, we decide **not to delete** these outliers and extreme values for testing the hypotheses, because the data were accurately gathered from participants following rigorously the earlier described procedures. Hence for all hypotheses, we will use the total group of 64 observations. Though, we ran all hypotheses testing without the respective outliers as well and came to the same conclusions as the ones that will be reported in the following sections. Only for hypothesis 3a, we found a non-significant result when deleting the outliers, as will be discussed later on.

Table 94: Case Numbers of the Outliers and Extreme Values (*) in Experiment Three

Hypotheses	Condition	Univariate Outliers (for Cost Level)	Multivariate Outliers (for Cost Level, Attract. and Time Spent)
H1 and H2	Non-TCS	40, 44	8, 16, 40*
	Difficult TCS	18*, 60, 63	18*
H3 and H4	Non-TCS, Easy TIME	-	-
	Difficult TCS, Easy TIME	18	18
	Non-TCS, Difficult TIME	44	40*, 43, 44*
	Difficult TCS, Difficult TIME	60, 63	-

Table 95: Describing the Multivariate Outliers and Extreme Values (*) for Experiment Three

	Condition		Cost Level	Attractiveness	Time Spent
H2	Non-TCS	Case 8	2768	1.38	109
		Case 16	2800	3.75	103
		Case 40*	1904	1.00	64
		Group Mean	**2863**	**2.72**	**70**
	Difficult TCS	Case 18*	1352	2.00	64
		Group Mean	**2584**	**2.86**	**73**
H4	Difficult TCS, Easy TIME	Case 18	1368	2.00	64
		Group Mean	**2530**	**2.75**	**76**
	Non-TCS, Difficult TIME	Case 40*	1904	1.00	64
		Case 43	3000	3.00	72
		Case 44*	3580	1.63	70
		Group Mean	**2768**	**2.98**	**59**

Figure 61: Boxplots for the Cost Level in each TCS Group (H1) and in each 'TCS by TIME' Group (H3) in Experiment Three

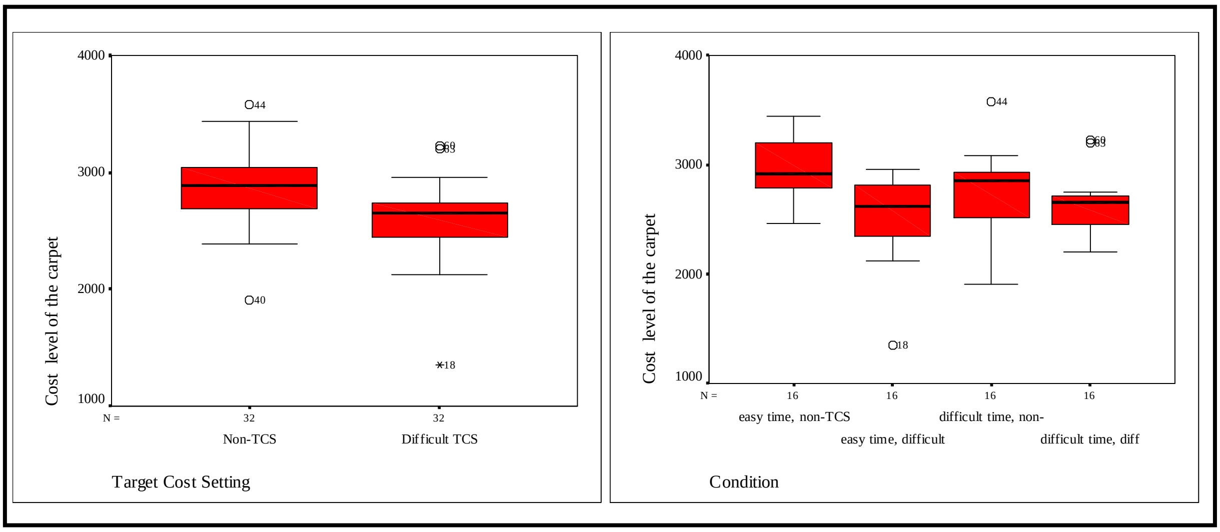
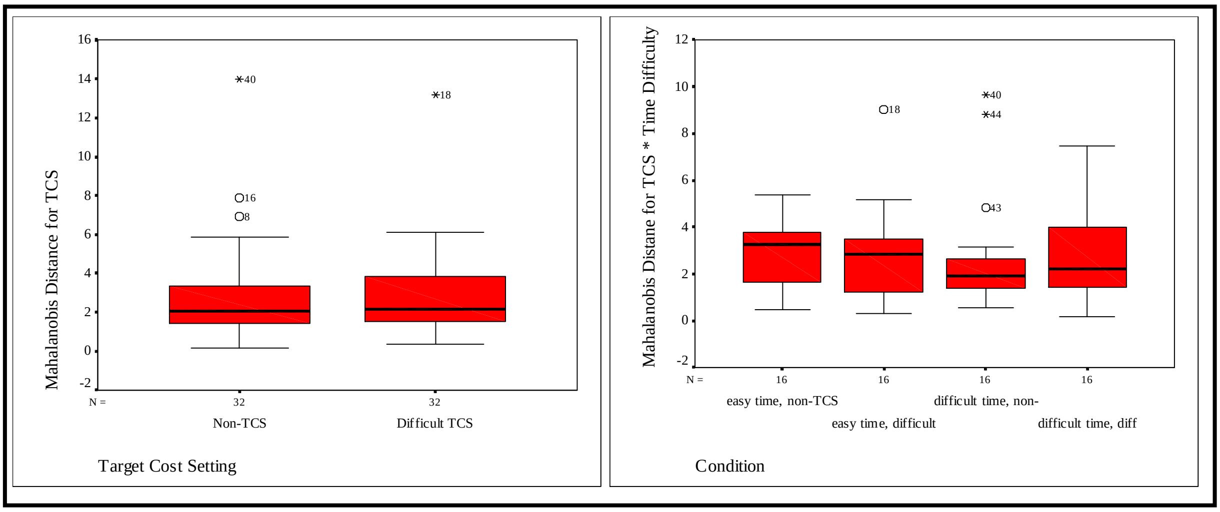


Figure 62: Boxplots for the Mahalanobis Distance (based on Cost Level, Attractiveness and Time Spent) in each TCS (H2) and in each 'TCS by TIME' Group (H4)



11.5 Checking the Assumptions of Normality and Homoscedasticity

11.5.1 Checking the Assumptions to test Hypothesis One (Univariate, Main Effect)

To check the assumption of *normally* distributed populations we made the normal probability plots and the detrended normal plots for the **cost level** in each of the TCS conditions, as shown in Figure 63 (page 298). In the normal probability plots almost all points fall on the straight line. In the detrended normal plots, there is a slight pattern for the difficult TCS. The Kolmogorov-Smirnov test can *not* reject the null hypotheses of normality for both TCS groups at $\alpha = .05$, while Shapiro-Wilks' does reject the null hypothesis of normality in the difficult TCS ($p = .016$), as shown in Table 96. Thus the data for cost level do not support the normality assumption. As mentioned earlier on page 152, the F and t-statistic are quite robust with respect to violations of the normality assumption, particular when the number of observations is equal in each cell, but at least 12, which is both the case here in our experiment three.

To check the assumption of *homogeneity* of variances, the Levene test statistic was performed. As shown in Table 97, the Levene test cannot reject the null hypothesis of homoscedasticity among the TCS for cost level ($p = 0.931$). Hence, the assumption of homoscedasticity is met for the cost level in both TCS groups**. In sum, we can use the suggested F and t-test to test hypothesis 1a.**

11.5.2 Checking the Assumptions to test Hypothesis Three (Univariate, Interaction Effect)

To check the assumption of normally distributed populations we made the detrended normal plots for the cost level in each of the four groups in the last four graphs of Figure 63 (page 298). The points do not cluster around the horizontal line for the "difficult TCS easy TIME" condition, what is confirmed by the Shapiro-Wilks' test ($p = .012$) in Table 96 (page 296). Based on the Kolmogorov-Smirnov test in Table 96, the assumption of normally distributed data is also violated for the "difficult TCS difficult TIME" condition ($p = .043$). Thus the normality assumption is violated for hypothesis three. But as mentioned earlier on page 152, the F and t-test statistic are quite robust towards violations of normality (Kirk, 1995, 99).

To check the assumption of *homogeneity of variances*, the Levene test statistic was performed on cost level, for the interaction effect. The homogeneity assumption can be supported for each of the four groups, because the Levene test statistic cannot reject the null hypothesis of equal variances ($p = 0.622$). Hence, the assumption of homogeneity is met. **In sum, we can use the suggested F-test and t-test statistics to test hypothesis 3a.**

11.5.3 Checking the Assumptions to test Hypothesis Two (Multivariate, Main Effect)

Doing multivariate analysis, like the MANOVA for hypothesis two requires *multivariate normally* distributed populations. We cannot rely on a statistical test to accept or reject the hypothesis of multivariate normality. Though, as mentioned in chapter 5, page 154, it is more likely that the assumption of *multivariate* normality is met, if all dependent variables are *univariate* normally distributed. From paragraph 11.5.1, we know that there are deviations from normality for the cost level. For attractiveness, the first four graphs of Figure 64 (page 299) do show some deviation from the straight line. Both the Kolmogorov-Smirnov ($p = .002$) and the Shapiro-Wilks' test ($p = .010$) reject the null hypothesis of normality for the difficult TCS, as shown in Table 96. For the variable time spent, in the normal probability plot all points fall on the straight line, while in the detrended normal plots all points cluster evenly around the horizontal line for both TCS groups. This is confirmed by the Kolmogorov-Smirnov and the Shapiro-Wilks' test of Table 96, which cannot reject the null hypothesis in both TCS groups. But since two of the three variables are not *univariate* normally distributed in all conditions, we can conclude that the *multivariate normality* assumption is violated. To test hypotheses 2a, we suggested earlier to use Hotelling's T^2. Following Bray & Maxwell (1990), as discussed before on page 154, this multivariate test statistic is robust to violations of normality.

For the *multivariate homoscedasticity*, two assumptions need to be checked. First, the univariate homogeneity of variance assumption must be met for each dependent variable and second the covariance matrices must be the same in each of the treatment groups. First, all three dependent variables cost level, attractiveness and time spent have homogeneous variances (at $\alpha = .05$) in each of the three TCS, as shown in the first part of Table 97. Second, the correlation between any two dependent variables is assumed to be equal in each of the three groups. Box's M test ($p = 0.339$) cannot reject the null hypothesis of homogeneity of variance-covariance matrices (see Table 98). **In sum, the suggested test criteria Hotelling's T^2 and the univariate t-test can thus be used to test hypothesis 2a.**

11.5.4 Checking the Assumptions to test Hypothesis Four (Multivariate, Interaction Effect)

For the interaction effect, we made only the detrended normal probability plots in the last four graphs of Figure 63 (cost level), Figure 64 (attractiveness) and Figure 65 (time spent). The Kolmogorov-Smirnov test and Shapiro-Wilks' test suggest deviations from normality for the cost level in the "difficult TCS easy TIME" ($p = .012$) and in the "difficult TCS difficult TIME" condition ($p = .043$). This last condition of "difficult TCS difficult TIME" also shows deviations from normality for attractiveness ($p = .004$ and $p = .010$). For the variable time spent, each of the four groups is normally distributed. Because we found deviations from normality in two of the four conditions for two of the three variables, we can conclude that the *multivariate normality* assumption is violated. As discussed earlier on page 154, literature assures that departure from multivariate normality has only slight effects on the type I-error in multivariate tests (Bray & Maxwell, 1990). Thus, we can still use the multivariate Hotelling's T^2 to test hypothesis 4a and the univariate F and t-test to further analyze the results of hypothesis 4a.

To test the assumption of *multivariate homoscedasticity*, we first need to look at the variances of each variable separate. As shown in the second part of Table 97, the three variables cost level, attractiveness and time spent do have equal variances in each of the four groups (no significant Levene test). Furthermore, Box's M-test confirms the assumption of equality of covariance matrices for the multivariate interaction effect, as shown in the second part of Table 98 (p = .145). Thus, the assumption of multivariate homoscedasticity is met for the interaction effect in experiment three. **In sum, we can use the suggested multivariate Hotelling's T^2 and the suggested F and t-test to test hypothesis 4a**.

Table 96: Tests of Normality for Experiment Three

Tests of Normality for Target Cost Setting							
		Kolmogorov-Smirnov*			**Shapiro-Wilks**		
		Statistic	**Df**	**Sig.**	**Statistic**	**Df**	**Sig.**
Cost level	Non-TCS	0.116	32	0.200	0.972	32	0.597
	Difficult TCS	0.144	32	0.089	0.910	32	**0.016**
Attractiveness	Non-TCS	0.124	32	0.200	0.942	32	0.113
	Difficult TCS	0.204	32	**0.002**	0.903	32	**0.010**
Time spent	Non-TCS	0.143	32	0.096	0.935	32	0.071
	Difficult TCS	0.106	32	0.200	0.974	32	0.669
Tests of Normality for Target Cost Setting * Difficulty of Time Objective							
Cost level	Non-TCS, Easy TIME	0.136	16	0.200	0.965	16	0.720
	Difficult TCS, Easy TIME	0.156	16	0.200	0.848	16	**0.012**
	Non-TCS, Difficult TIME	0.141	16	0.200	0.941	16	0.408
	Difficult TCS, Difficult TIME	0.217	16	**0.043**	0.888	16	0.053
Attractiveness	Non-TCS, Easy TIME	0.103	16	0.200	0.949	16	0.478
	Difficult TCS, Easy TIME	0.175	16	0.200	0.944	16	0.427
	Non-TCS, Difficult TIME	0.195	16	0.107	0.872	16	0.032
	Difficult TCS, Difficult TIME	0.263	16	**0.004**	0.845	16	**0.010**
Time spent	Non-TCS, Easy TIME	0.118	16	0.200	0.978	16	0.924
	Difficult TCS, Easy TIME	0.140	16	0.200	0.916	16	0.190
	Non-TCS, Difficult TIME	0.173	16	0.200	0.958	16	0.596
	Difficult TCS, Difficult TIME	0.186	16	0.140	0.927	16	0.281
* Lilliefors Significance Correction							

Table 97: Testing Homogeneity of Variances in Experiment Three

Test of Homogeneity of Variances for Target Cost Setting				
	Levene Statistic	**Df1**	**Df2**	**Sig.**
Cost Level	0.008	1	62	0.931
Attractiveness	0.299	1	62	0.587
Time spent	3.713	1	62	0.059
Test of Homogeneity of Variances for Target Cost Setting * Difficulty of Time Objective				
	Levene Statistic	**Df1**	**Df2**	**Sig.**
Cost Level	0.592	3	60	0.622
Attractiveness	0.117	3	60	0.950
Time spent	2.464	3	60	0.071

Table 98: Box's M Test for Equality of Covariance Matrices for the Dependent Variables Cost Level, Attractiveness and Time Spent in Experiment Three

Box's Test of Equality of Covariance Matrices for Target Cost Setting				
Box's M	**F**	**Df1**	**Df2**	**Sig.**
7.182	1.134	6	27850.868	0.339
Box's Test of Equality of Covariance Matrices for TCS * Difficulty of Time Objective				
Box's M	**F**	**Df1**	**Df2**	**Sig.**
26.785	1.352	18	12721.472	0.145

Figure 63: Normal Probability Plots and Detrended Normal Plots for *Cost Level* in each TCS and Detrended Normal Plots in each 'TCS by TIME' Group in Experiment Three

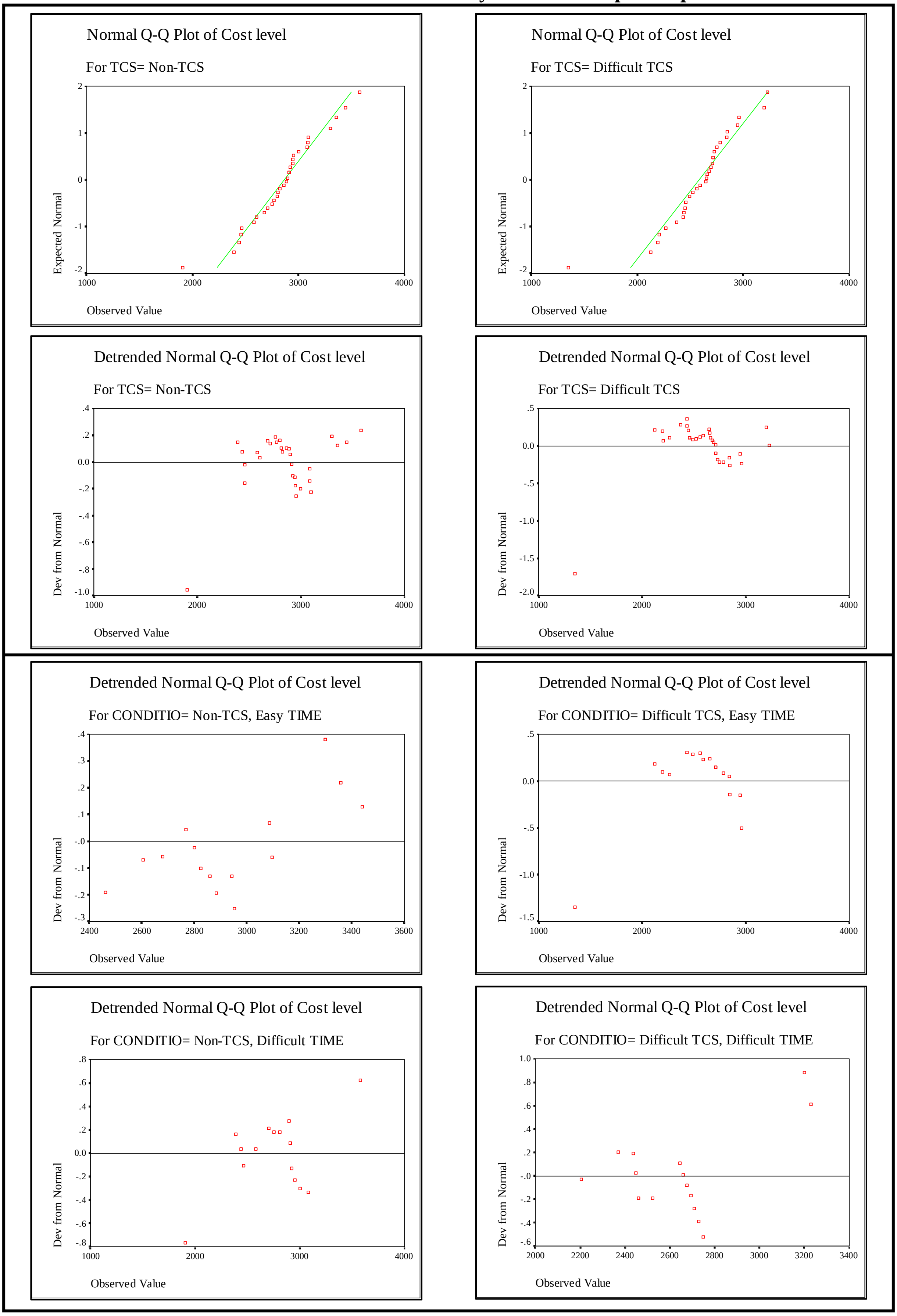


Figure 64: Normal Probability Plots and Detrended Normal Plots for *Attractiveness* in each TCS and Detrended Normal Plots in each 'TCS by TIME' Group in Experiment Three

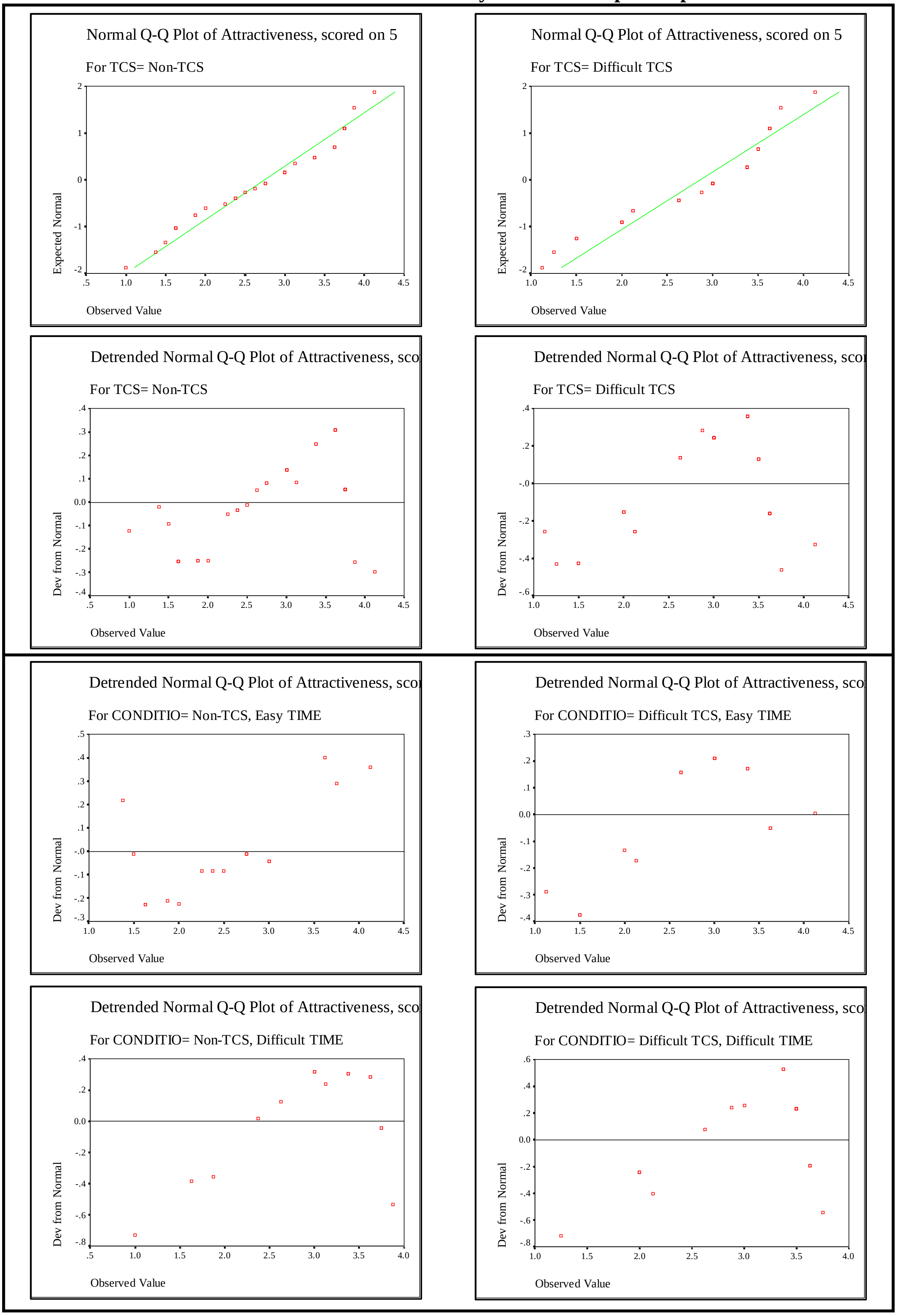
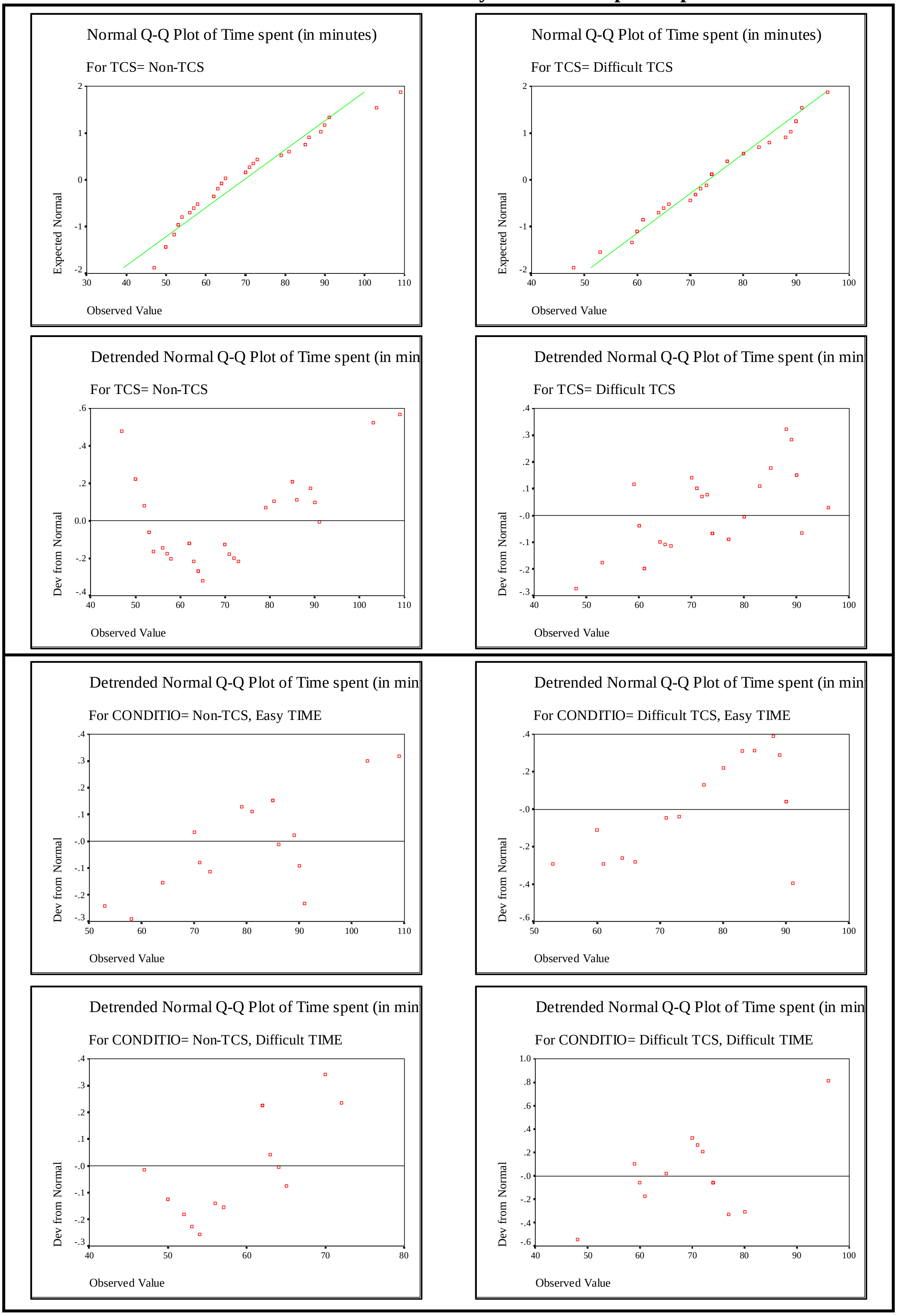


Figure 65: Normal Probability Plots and Detrended Normal Plots for *Time Spent* in each TCS and Detrended Normal Plots in each 'TCS by TIME' Group in Experiment Three



11.6 Conclusions of the Data Screening

In the previous sections we screened the data to make sure that we can progress with testing the hypotheses on the collected data. Table 99 summarizes the conclusions of this process.

Table 99: Conclusions of the Data Screening in Experiment Three

Action	Conclusion
Manipulation checks:	
• For target cost specificity:	• Perceived as intended.
• For target cost difficulty:	• Perceived as intended.
• For time difficulty:	• Perceived as intended.
• For priority rule:	• Perceived as intended.
Accuracy of the data:	
• Unbalanced cells because of 17 observations in non-TCS, easy TIME condition:	• Delete last observation of this group to keep balanced cells (n = 16 in each cell).
Outliers:	
• Univariate outliers:	• Include outliers in the analysis.
• Multivariate outliers:	• Include outliers in the analysis.
Normality:	
• H1: Univariate for TCS in the cost level:	• Assumption violated, but F and t-test are robust.
• H3: Univariate for TCS * TIME in the cost level:	• Assumption violated but F and t-test are robust.
• H2: Multivariate for TCS in the cost level, attractiveness and time spent:	• Assumption violated, but Hotelling's T^2 and t-test are robust.
• H4: Multivariate for TCS * TIME in the cost level, attractiveness and time spent:	• Assumption violated, but Hotelling's T^2, F and t-test are robust.
Homoscedasticity:	
• H1: Univariate for TCS in the cost level:	• Assumption supported.
• H3: Univariate for TCS * TIME in the cost level:	• Assumption supported.
• H2: Multivariate for TCS in the cost level, attractiveness and time spent:	• Assumption supported.
• H4: Multivariate for TCS * TIME in the cost level, attractiveness and time spent:	• Assumption supported.

Summing up, we are now sure that the data are correctly entered, that the manipulations are correctly operationalized and understood by the participants and that the data support the assumptions associated with the test statistics. Consequently, in the next paragraphs we will start with testing the hypotheses. Each of the four hypotheses is addressed in a separate section (from paragraph 12 to paragraph 15). Afterwards, we provide a summary table in paragraph 16 (see page 317).

12. Testing Hypothesis One

12.1 ANOVA for Hypothesis 1a

From target costing, we expect that the TCS manipulation will have an impact on the cost level of the created designs. In this third experiment, we just consider two TCS conditions (the non-TCS and the difficult TCS), hence we can proceed immediately to hypothesis 1a. As discussed earlier in chapter three, we expect a significant lower cost level under the difficult TCS. Thus the hypothesized direction is a favorable impact of target costing on the cost level. Or as formulated before:

Hypothesis 1a hypothesizes that the cost level of a future product will be significantly lower under the difficult TCS than under the non-TCS.

As shown in Table 100, the group difference in cost level between the non-TCS and the difficult TCS is significant at α = 5% ($F (1, 62) = 10.8$, $p = 0.002$), explaining 14.8% of the total variance. From the group means of Table 101 and from Figure 66 we learn that the cost level in the difficult TCS (group mean = 2584) is lower than the cost level in the non-TCS condition (group mean = 2864), what is confirmed by the one-tailed t-test in Table 102 ($t = 3.3$, $p = .001$). Thus hypothesis 1a is now supported by the data.

Table 100: ANOVA for TCS on Cost Level to test Hypothesis 1 in Experiment Three

ANOVA		Sum of Squares	Df	Mean Square	F	Sig.	Eta Sq.
Cost Level	Between Groups	1257201.563	1	1257201.563	10.795	**0.002**	**0.148**
	Within Groups	7220290.875	62	116456.304			
	Total	8477492.438	63				

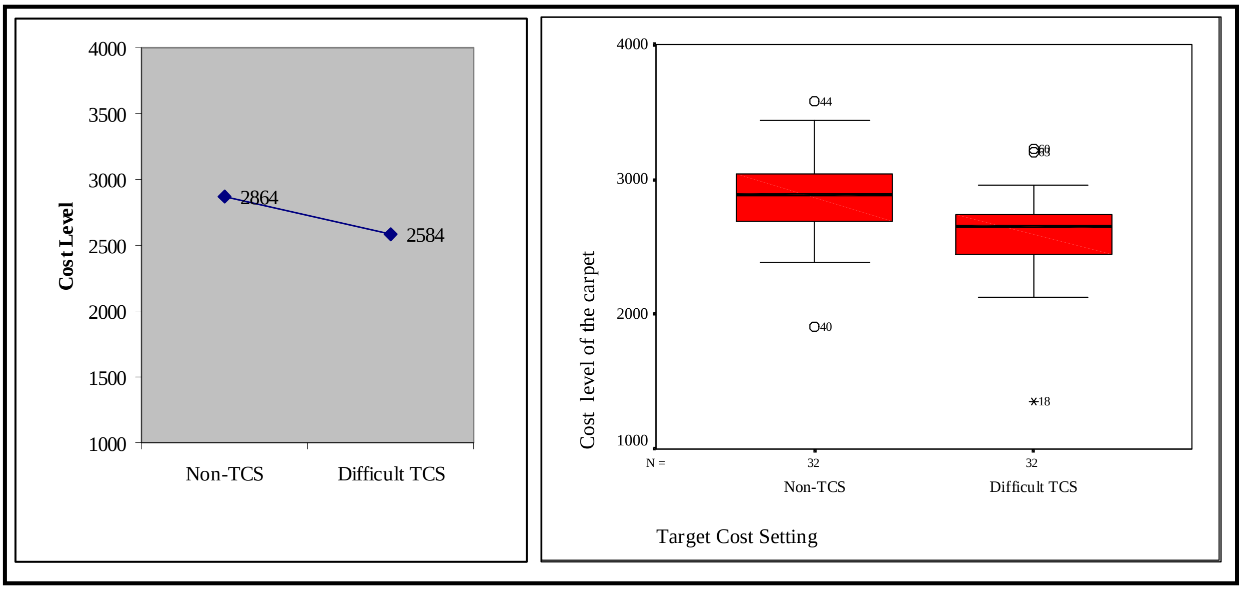
Table 101: Group Means on Cost Level in Experiment Three

	Non-TCS	Difficult TCS	Total
Mean	**2864**	**2584**	2723.7
N	32	32	64
Std. Deviation	339.0	343.5	366.8

Table 102: T-Test for Hypothesis 1a in Experiment Three

t-test for Equality of Means between non-TCS and difficult TCS					
	t	Df	Sig. (1-tailed)	Mean Difference	Std. Error Difference
Cost Level	3.286	62	**0.001**	280.313	85.314

Figure 66: Group Means and Boxplots on Cost Level in Experiment Three



Thus, the designs under the non-TCS and the difficult TCS significantly differ in terms of the cost level. Contrary to the second experiment, but conform the expectations from target costing, the mean cost level of new products created in the difficult TCS is significantly *lower* than the mean cost level of new products created in the non-TCS.

13. Testing Hypothesis Two

13.1 MANOVA for Hypotheses 2a

As discussed in chapter three, we expect that the TCS manipulation will have an impact on the type of new products that design engineers create during new product development. A lower attractiveness level and a longer time spent under the difficult TCS are among the expectations. Thus:

In hypothesis 2a, we hypothesize that a combination of the cost level, quality level (i.e. attractiveness) and achieved time-to-market (i. e. time spent) will significantly differ between the *non-TCS* and *difficult TCS*.

To test this multivariate hypothesis[111], we need to compare the non-TCS with the difficult TCS by a Hotelling's T^2. As shown in Table 103, Hotelling's T^2 detects a **significant** group difference between the two TCS conditions on a combination of the three dependent variables cost level, attractiveness and time spent (p = 0.005). The null hypothesis of equal group centroids should be rejected (at alpha 5%) and the data support hypothesis 2a. Consequently, designers created a different future product in the non-TCS than in the difficult TCS, when considering the three characteristics cost, attractiveness and time spent.

Table 103: Hotelling's T² to test Hypothesis 2a in Experiment Three

Hotelling's T²				
Effect	**F**	**Hypothesis Df**	**Error Df**	**Sig.**
Non-TCS vs Difficult TCS	4.811	3	60	**0.005**

Before analyzing in which of the three characteristics the future products differ (see next paragraph), we first look at the **canonical variate** or the new identified dimension that significantly separates the two TCS on a combination of the cost level, attractiveness and time spent. Table 104 shows that this canonical variate accounts for 19,4% of the total variance. From the third part of this table, we see that this canonical variate is highly negatively correlated with the cost level (r = -.851). We can label this canonical variate as the **"low cost" factor**. Designs with a low score for cost level, are performing better (thus scoring higher) on this "low cost" factor. When comparing the group means for TCS on this "low cost" factor, as shown in the last part of Table 104, we see that designs from the *non-TCS* are scoring relatively worse in terms of "low cost" designs, while designs from the *difficult*

[111] Barlett's test of sphericity is **significant** (approx. χ^2= 924.4, df = 5, p = .000), indicating a multivariate analysis should be used.

TCS are scoring relatively better in terms of “low cost” designs. The group means on the identified “low cost” factor (as well as the dispersion within the groups) is shown in Figure 67 on the next page.

Table 104: More Multivariate Statistics to Interpret the Results of Hypothesis 2a in Experiment Three

Eigenvalues

Function	Eigenvalue	% of Variance	Cumulative %	Canonical Correlation	Sq. Canonical Correlation
1	0.241	100	100	0.440	0.194

Wilks' Lambda

Test of Function	Wilks' Lambda	Chi-square	Df	Sig.
1	0.806	13.042	3	0.005

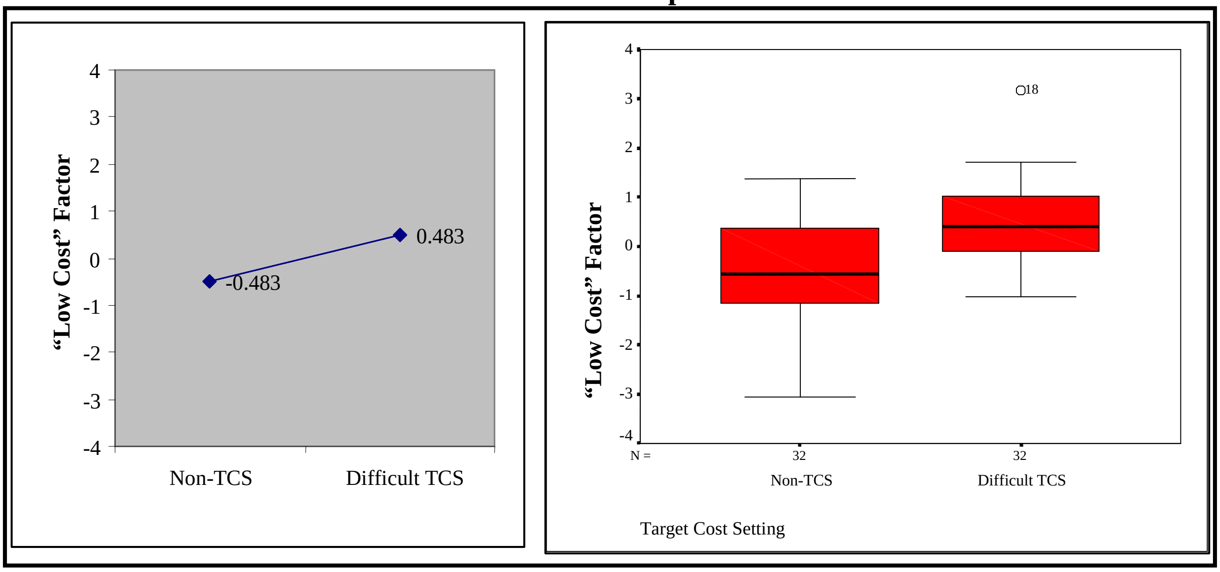
Structure Matrix: Correlation between Canonical Variate (Function) and D.V.

	Function 1
	“Low Cost” Factor
Cost Level	-0.851
Time Spent	0.284
Attractiveness	0.144

Functions at Group Centroids

	“Low Cost” Factor
Non-TCS	-0.483
Difficult TCS	0.483

Figure 67: Group Means and Boxplots on the Canonical Variate (H2a), labeled the “Low Cost” Factor in Experiment Three



In sum, new products created in the non-TCS and in the difficult TCS significantly differ in terms of the combined characteristics cost, attractiveness and time spent. More specifically, the created carpets differ significantly in terms of the “low cost” factor. Designers created more lower cost carpets under the difficult TCS than under the non-TCS, explaining the significant

univariate group difference on the cost level in the first hypothesis. In the next paragraph we will compare the created designs in the non-TCS with the designs in the difficult TCS, but now on each of the dependent variables cost, attractiveness and time spent separately.

13.2 Simple Main Effects to further Analyze the Supported H2a

To further analyze the significant multivariate group difference between the non-TCS and the difficult TCS, we now perform univariate t-tests on each of the dependent variables separate, as discussed before on page 144 and as shown in Table 105 below. As discussed before when testing the first hypothesis, the **cost level** significantly differs between the non-TCS and the difficult TCS (t = 3.3, p = .002). Furthermore for the second dependent variable **attractiveness**, there is no significant difference detected between the non-TCS and the difficult TCS (t = -.55, p = .58). As shown in Table 106, the group mean for attractiveness is 2.75 for the non-TCS, which hardly differs from the group mean of 2.86 for the difficult TCS. Also for the third dependent variable **time spent** the t-test (t = -1.1, p = .277) does not capture a significant difference between the non-TCS and the difficult TCS[112]. The group mean on time spent is 70 minutes for the non-TCS and 73 minutes for the difficult TCS, as shown in Table 106. In sum, the attractiveness of the designs and the time spent to create those designs is not significantly different when creating new products in the difficult TCS than in the non-TCS, as shown in Figure 68 and Figure 69.

Table 105: Univariate t-Tests for Cost Level, Attractiveness and Time Spent, Experiment Three

t-test for Equality of Means between Non-TCS and Difficult TCS					
	t	**Df**	**Sig. (2-tailed)**	**Mean Difference**	**Std. Error Difference**
Cost Level	3.286	62	**0.002**	280.313	85.314
Attractiveness	-0.555	62	0.581	-0.117	0.211
Time Spent	-1.096	62	0.277	-3.875	3.536

Table 106: Descriptives in Each TCS for Cost Level, Attractiveness and Time Spent in Experiment Three

		Non-TCS	**Difficult TCS**	**Total**
Cost level	Mean (n = 32)	**2864**	**2584**	2724
	Std. Deviation	339	343	367
Attractiveness	Mean (n = 32)	**2.75**	**2.86**	2.80
	Std. Deviation	0.87	0.81	0.84
Time Spent	Mean (n = 32)	**70**	**73**	72
	Std. Deviation	16	12	14

[112] However, when **deleting the four multivariate outliers** (cases 8, 16, 40 and 18) the univariate difference in time spent between the non-TCS and the difficult TCS becomes marginally **significant** (t = -1.9, p = .054). The group mean of 67 minutes in the non-TCS is significantly lower (p = .027) than the group mean of 74 minutes in the difficult TCS.

Figure 68: Group Means and Boxplots on Attractiveness in Experiment Three

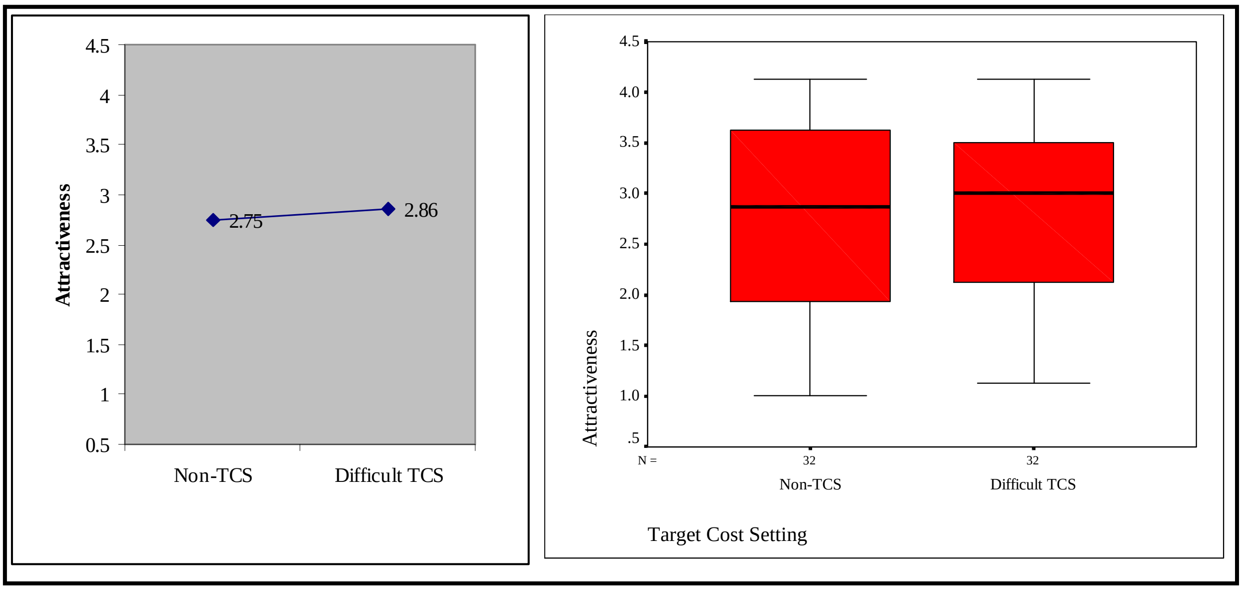
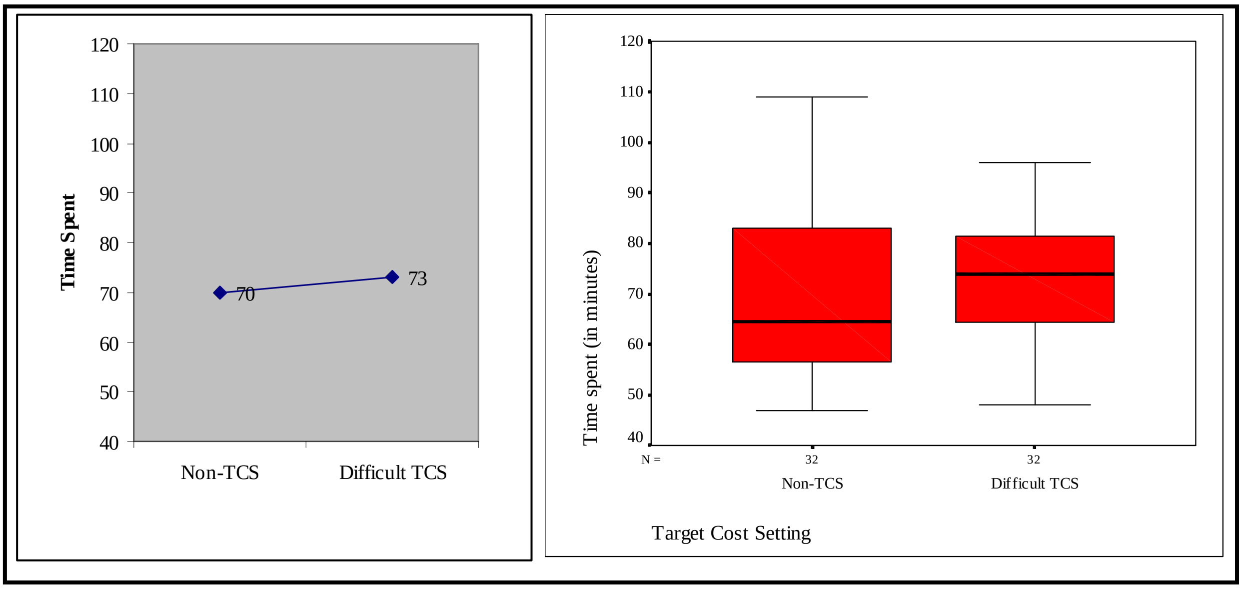


Figure 69: Group Means and Boxplots on Time Spent in Experiment Three



Analyzing the multivariate significant difference by univariate analyses on each dependent variable, we found that designs differed significantly in terms of *cost level* between the non-TCS and the difficult TCS. The group means in *time spent* suggest that participants used more time in the difficult TCS than in the non-TCS, though this difference was not significant. Furthermore, in terms of *attractiveness* there was no significant difference between the two TCS manipulations. Contrary to experiment two, giving a difficult target cost to designers is now reducing the cost level, without reducing the attractiveness of the new product nor increasing the time spent to create it. Though this last conclusion will be revised when considering the two time conditions separate in hypothesis four.

14. Testing Hypothesis Three

14.1 ANOVA and Simple Main Effects for Hypothesis 3a

As discussed in chapter three, we expect a significant interaction effect between the non-TCS and the difficult TCS across the two time levels (easy TIME and difficult TIME). We expect a larger difference in cost level between the two TCS under the easy TIME condition than under the difficult TIME condition. Or as formulated before:

Hypothesis 3a hypothesizes that the difference in cost level between the non-TCS and the difficult TCS will significantly vary between the easy and the difficult TIME condition.

To test this univariate interaction effect, we need to run an ANOVA, as discussed earlier on page 138. As indicated in Table 107, the interaction effect is **marginally significant** (F (1, 60) = 3.1, p = 0.081), accounting for 5 % of the variance. Hence the data marginally support hypothesis three[113]. The group means in Table 108 suggest that differences in cost level are larger under the easy TIME than under the difficult TIME. Indeed, when we progress towards the simple main effects, as shown in Table 109, the t-test detects a significant difference in cost level between the non-TCS and the difficult TCS in the *easy* TIME condition (t = 3.5, p = .001). Furthermore, the means are in the hypothesized direction. The mean cost level under the difficult TCS is 2530, which is lower than the mean cost level of 2960 under the non-TCS. For the *difficult* TIME condition, the t-test does not detect a significant difference in cost level between the non-TCS and the difficult TCS (t = 1.1, p = .132). Although, the direction of the means shows a favorable impact of the difficult TCS on the cost level, the group difference is not significant[114]. Thus, participants who had a difficult TIME condition did not create a significant lower cost carpet in the difficult TCS than in the non-TCS.

Table 107: ANOVA for 'TCS by TIME' to test Hypothesis 3a in Experiment Three

Dependent Variable: Cost level						
Source	**Sum of Squares**	**Df**	**Mean Square**	**F**	**Sig.**	Eta Squared
TCS	1257201.563	1	1257202	11.039	0.002	0.155
Difficulty Time Objective	28985.063	1	28985.06	0.255	0.616	0.004
TCS * Time Difficulty	357903.063	1	357903.1	3.143	**0.081**	0.050
Error	6833402.750	60	113890			
Total	483248908.000	64				

[113] When deleting **outlier case** 44, the F-test becomes significant (F (1, 59) = 4.7, p = .034). When deleting all 4 outlier cases, the F-test is no longer significant (F (1, 56) = 1.99, p = .164).

[114] When deleting all 4 **outlier cases**, also under the difficult TIME condition is the cost level significantly lower (t = 1.7, p = .05) under the difficult TCS (group mean = 2554) than under the non-TCS (group mean = 2713).

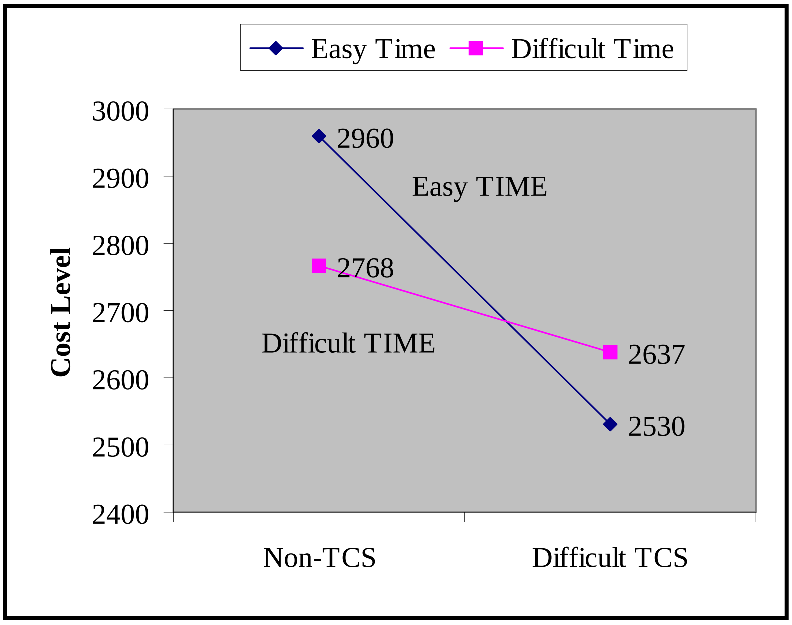
Table 108: Group Means (Standard Deviations) on Cost Level for each of the Four Cells in Experiment Three

	Target Cost Setting		
Difficulty of the Time Objective	**Non-TCS**	**Difficult TCS**	**Total**
Easy TIME	**2960** (283)	**2530** (405)	2745 (407)
Difficult TIME	**2768** (371)	**2637** (272)	2702 (327)
Total	2864 (339)	2584 (343)	2724 (367)

Table 109: Simple Main Effects by t-Tests to further analyze Hypothesis 3a in Experiment Three

	t-test for Equality of Means (Non-TCS vs. Difficult TCS) under the *easy* TIME				
	t	**Df**	**Sig. (1-tailed)**	**Mean Difference**	**Std. Error Difference**
Cost level	3.481	30	**0.001**	429.875	123.498
	t-test for Equality of Means (Easy vs. Difficult TIME) under the *difficult* TIME				
	t	**Df**	**Sig. (1-tailed)**	**Mean Difference**	**Std. Error Difference**
Cost level	1.137	30	0.132	130.750	114.981

Figure 70: Interaction Effect between 'TCS and TIME' on the Cost Level in Experiment Three



Summing up, the impact of TCS (non-TCS, difficult TCS) on the cost level marginally differs across the two levels of time difficulty. Similar to experiment two, this marginally significant interaction effect can mainly be explained by a larger difference in cost level under the easy TIME than under the difficult TIME condition, as shown in Figure 70. Only in the easy TIME condition is a significant difference in cost level between the non-TCS and the difficult TCS detected.

In this *easy* time condition, the cost level is found significantly *lower* under the difficult TCS than under the non-TCS, conform target costing literature. Contrary, under the *difficult* TIME condition, the data do not show a significant difference in cost level between the non-TCS and the difficult TCS.

Consequently, we should partly modify our finding of a *favorable impact of target costing on the cost level* (see earlier hypothesis 1). The favorable impact of target costing on the cost level was only supported if participants received an easy-to-attain time objective, i.e. under the easy TIME condition. Under the difficult TIME condition, there was no impact of setting a difficult TCS on the cost level, compared to the non-TCS.

15. Testing Hypothesis Four

15.1 MANOVA for Hypothesis 4a

As discussed in chapter three, we expect that the differences in new products between the non-TCS and the difficult TCS will depend on the time condition. We expect more unfavorable impacts of target costing under the difficult TIME condition (because of two difficult-to-attain goals) than under the easy TIME condition. Or as formulated before:

In hypothesis 4a, we hypothesized that the difference on a combination of the three NPD measures cost level, attractiveness and time spent between the *non-TCS* and the *difficult TCS* will significantly vary between the easy and the difficult time objective.

To test this hypothesis, we need to do a MANOVA[115] on the three dependent variables cost level, attractiveness and time spent, but now for the interaction effect between TCS and TIME (as discussed earlier on page 146). As shown in Table 110, Hotelling's T^2 detects a **significant** interaction effect ($p = .030$). The effect of TCS on the three NPD measures does vary as a function of time difficulty and the data support hypothesis 4a. Consequently, designers created a different future product (in terms of cost, attractiveness and time spent) under the non-TCS than under the difficult TCS, depending on the TIME objective they received.

Table 110: MANOVA for TCS * Time Difficulty on Cost level, Attractiveness and Time Spent to test Hypothesis 4a in Experiment Three

Effect by Hotelling's T^2	Value	F	Hypothesis Df	Error Df	Sig.
TCS	0.198	4.777	3	58	0.005
Difficulty of the Time Objective	0.269	7.101	3	58	0.000
TCS * Time Difficulty	0.141	3.186	3	58	**0.030**

Before explaining where this significant interaction effect comes from (see next paragraph), we can look at the canonical variate (or the new identified dimension that maximally separates the groups) in Table 111. The canonical variate now explains 14% of the total variance and is negatively correlated with time spent ($r = -.862$) and negatively correlated with the cost level ($r = -.564$). We can label this canonical variate the "**efficiency**" factor. Participants using few time for designing a new carpet and creating a carpet with a rather low cost are scoring high on this "efficiency" factor. Participants, who used a lot of time to create a carpet that has furthermore a rather high cost, are scoring low in terms of the "efficiency" factor. The group means on this "efficiency" factor are shown in the fourth part of Table 111. Relative to the other groups, the "non-TCS easy TIME" condition is having the *lowest* mean in terms of "efficiency". Thus participants receiving a lot of time and receiving no cost constraints are designing least efficiently new products in terms of time spent and cost level. The "non-TCS difficult TIME" condition is having the *highest* mean on this "efficiency" factor, suggesting that these participants created most efficiently new products in terms of time spent and cost level. Looking at the interaction effect, Figure 71 shows that under the difficult TIME condition, participants created more efficiently in the non-TCS than in the difficult TCS condition. Contrary, under the easy TIME condition, participants created more efficiently in the difficult TCS than in the non-TCS.

Table 111: More Multivariate Statistics to Interpret the Results of Hypothesis 4a in Experiment Three

Eigenvalues					
Function	Eigenvalue	% of Variance	Cumulative %	Canonical Correlation	Sq. Canonical Correlation
1	0.165	100	100	0.376	**0.141**
Wilks' Lambda					
Roots	Wilks Lambda.	F	Hypoth. DF	Error DF	Sig.
1	0.859	3.186	3	58	**0.030**

Structure Matrix: Correlation between Canonical Variate (Function) and D.V.

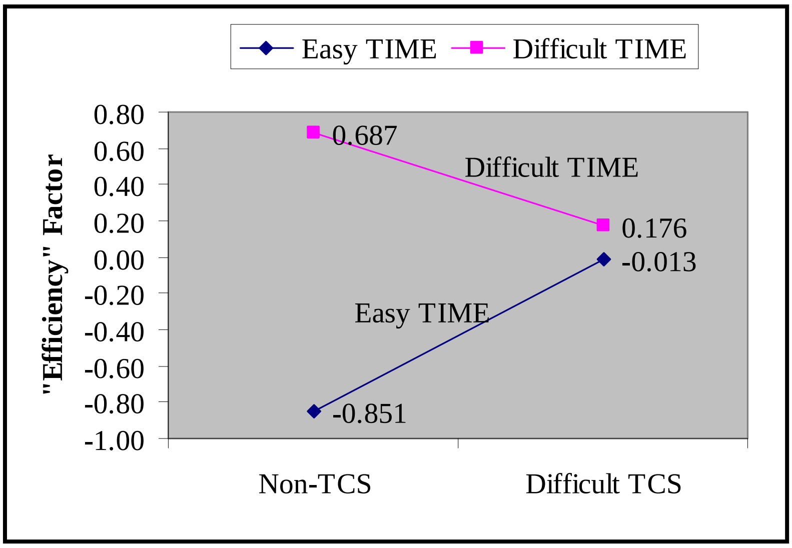
	Function 1
	"Efficiency" Factor
Time Spent	**-0.862**
Cost Level	**-0.564**
Attractiveness	0.190

Function 1 ("Efficiency" Factor) at Group Centroids

	Non-TCS	Difficult TCS
Easy Time	-0.851	-0.013
Difficult Time	.687	0.176

[115] Barlett's test of sphericity is **significant** (approx. χ^2= 909.7, df = 5, p = .000), indicating a multivariate analysis should be used.

Figure 71: Group Means on Canonical Variate 1 (H4), labeled the "Efficiency" Factor in Experiment Three



In sum, the differences in future products between the TCS groups (in terms of cost level, attractiveness and time spent) significantly differed as a function of the TIME condition. More specifically, there was a significant interaction effect detected on what has been called the "efficiency" factor.

15.2 Univariate Interaction Comparisons and Simple Main Effects to analyze the supported H4a

To further analyze where this significant multivariate interaction effect of hypothesis 4a comes from, we suggested earlier (see page 147) to use univariate interaction comparisons and simple main effects. First, we will evaluate the interaction effect on each of the three dependent variables separate by an ANOVA. Second, significant ANOVAs will be further analyzed by simple main effects (using t-tests).

The three F-tests for the univariate interaction effect on cost level, attractiveness and time spent are shown in Table 112. The ANOVA F-test detects a marginally **significant** interaction effect on the **cost level** (F (1, 60) = 3.1, p = .081). As discussed under hypothesis 3a, only in the easy TIME condition is the cost level significantly lower in the difficult TCS than in the non-TCS (t = 3.5, p = .002). There is no difference in cost level detected under the difficult TIME condition (t = 1.1, p = .264). Second, there is **no significant** interaction effect detected on **attractiveness** (F (1, 60) = .358, p = .552). Finally, there is a **significant** interaction effect detected on **time spent** (F (1, 60) = 7.3, p = .009). The difference in time spent between the non-TCS and the difficult TCS is larger under the difficult TIME condition than under the easy TIME condition. Doing the simple main effects by t-tests learns that time spent significantly differs between the non-TCS and the difficult TCS in the difficult TIME condition (t = -3.6, p = .001), while time spent does not significantly differ between the non-TCS (group mean = 80) and the difficult TCS (group mean = 76) in the easy TIME condition (t = .8, p = .409), as shown in Table 113. The group means on time spent, shown in Table 114, learn that under the difficult TIME condition, time spent is higher in the difficult TCS (group mean = 71) than in the non-TCS (group mean = 59). Hence, setting a difficult target cost is having a negative impact on the time spent compared to the non-TCS, but only under a difficult TIME condition.

Thus, in the *easy* TIME condition, the created designs differed in cost level between the non-TCS and the difficult TCS. In this easy TIME condition designs did not differed from each other in terms of attractiveness or time spent. In the *difficult* TIME condition, not the cost level but time spent significantly differed between the non-TCS and the difficult TCS. In this difficult TIME condition designs differed not in terms of cost level or attractiveness.

Table 112: Univariate Interactions by F-tests to Further analyze the Supported H4a in Experiment Three

Dependent Variable: Cost Level						
Source	**Sum of Squares**	**Df**	**Mean Square**	**F**	**Sig.**	**Eta Sq.**
TCS	1257201.563	1	1257201.563	11.039	0.002	0.155
Difficulty of Time Objective	28985.063	1	28985.063	0.255	0.616	0.004
TCS * TIME	357903.063	1	357903.063	3.143	**0.081**	0.050
Error	6833402.750	60	113890.046			
Dependent Variable: Attractiveness						
Source	**Sum of Squares**	**Df**	**Mean Square**	**F**	**Sig.**	**Eta Sq.**
TCS	0.220	1	0.220	0.314	0.577	0.005
Difficulty of Time Objective	1.978	1	1.978	2.828	0.098	0.045
TCS * TIME	0.250	1	0.250	0.358	0.552	0.006
Error	41.955	60	0.699			
Dependent Variable: Time Spent						
Source	**Sum of Squares**	**Df**	**Mean Square**	**F**	**Sig.**	**Eta Sq.**
TCS	240.250	1	240.250	1.725	0.194	0.028
Difficulty of Time Objective	3025.000	1	3025.000	21.719	0.000	0.266
TCS * TIME	1024.000	1	1024.000	7.352	**0.009**	0.109
Error	8356.750	60	139.279			

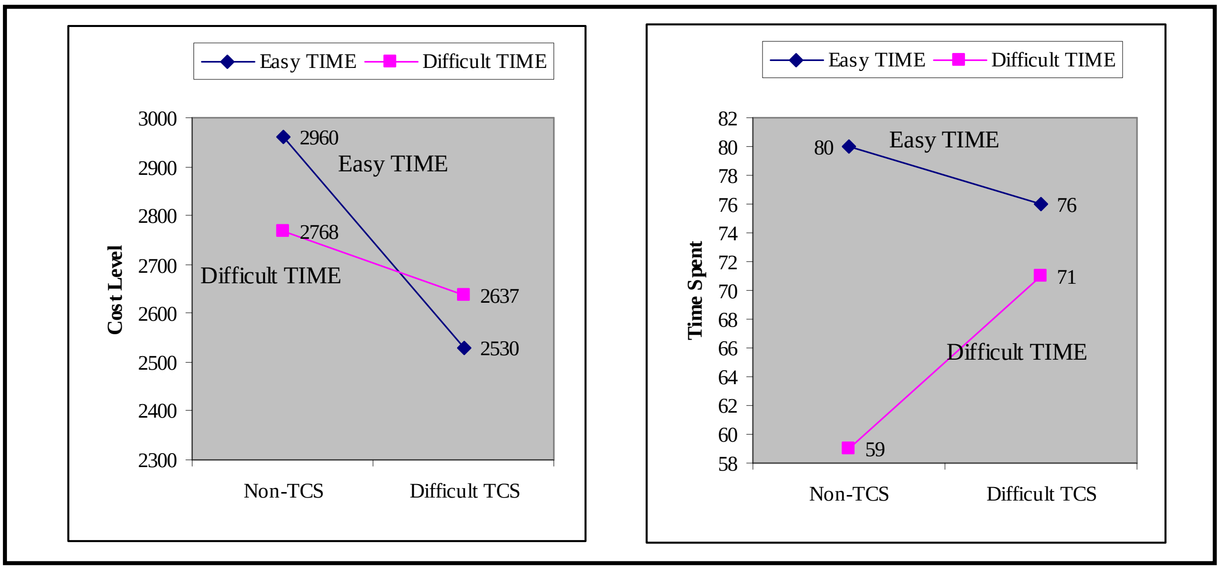
Table 113: Simple Main Effects to further analyze the Marginally Significant and Significant Interaction Effect for Cost Level and Time Spent in Experiment Three

	t	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
t-test for Equality of Means (Non-TCS vs. Difficult TCS) under *Easy TIME*					
Cost level	3.481	30	**0.002**	429.875	123.498
Time Spent	0.838	30	0.409	4.125	4.924
t-test for Equality of Means (Non-TCS vs. Difficult TCS) under *Difficult TIME*					
	t	**Df**	**Sig. (2-tailed)**	**Mean Difference**	**Std. Error Difference**
Cost level	1.137	30	0.264	130.750	114.981
Time Spent	-3.652	30	**0.001**	-11.875	3.252

Table 114: Group Means (Standard Deviation) on Cost Level, Attractiveness and Time Spent in Experiment Three

Cost Level	**Non-TCS**	**Difficult TCS**	**Total**
Easy TIME	**2960** (283)	**2530** (405)	2745 (407)
Difficult TIME	2768 (371)	2637 (272)	2702 (327)
Total	2864 (339)	2584 (343)	2724 (367)
Attractiveness	**Non-TCS**	**Difficult TCS**	**Total**
Easy TIME	2.5 (0.8)	2.8 (0.9)	2.6 (0.9)
Difficult TIME	3.0 (0.9)	3.0 (0.8)	3.0 (0.8)
Total	2.7 (0.9)	2.9 (0.8)	2.8 (0.8)
Time Spent	**Non-TCS**	**Difficult TCS**	**Total**
Easy TIME	80 (15)	76 (13)	78 (14)
Difficult TIME	**59** (7)	**71** (11)	65 (11)
Total	70 (16)	73 (12)	72 (14)

Figure 72: Univariate Interaction Effect on Cost Level and Time Spent in Experiment Three



Summing up the results of hypothesis 4a, we can say that the created new products indeed differed among the non-TCS and difficult TCS as a function of the TIME condition. As remembered from Figure 71 on page 313, the difficult TCS led to more "efficient" new products in the easy TIME condition, while the difficult TCS led to less "efficient" new products in the difficult TIME condition, both compared to the non-TCS. Why is target costing leading to more "efficient" new products in the easy TIME condition and to less "efficient" new products in the difficult TIME condition? Well, in the easy TIME condition, the difficult TCS manipulation is leading to new products with a *lower cost* than in the non-TCS. New products are more "efficient" under the difficult TCS because of the favorable impact of target costing on the cost level of the future products and no unfavorable impact on time spent. Thus in the easy TIME condition target costing had only a *favorable* impact on the *cost level*.

Contrary in the difficult TIME condition designers *spent more time* to develop the new products under the difficult TCS than under the non-TCS. New products are less "efficient" under the difficult TCS because of the unfavorable impact of target costing on the time spent and no favorable impact on the cost level. Thus, in the difficult TIME condition target costing had only an *unfavorable* impact on *time spent*.

16. Summary of the Hypotheses Testing in Experiment Three

In the previous paragraphs, we tested the different hypotheses by univariate as well as multivariate tests. We summarize the results in Table 115 below:

Table 115: Summary of the Hypotheses Testing in Experiment Three

Hypotheses	Results
H1: Univariate main effect: H1a: Lower cost level under difficult TCS than under non-TCS.	 Supported.
H2: Multivariate main effect: H2a: New products significantly differ between non-TCS and difficult TCS.	 Supported. Mainly explained by: • Lower cost level under difficult TCS than under non-TCS.
H3: Univariate interaction effect: H3a: Difference in cost level between the non-TCS and difficult TCS is dependent on the time objective.	 Marginally Supported. Mainly explained by: • For *easy* TIME: Lower cost level under difficult TCS than under non-TCS.
H4: Multivariate interaction effect: H4a: Difference in new products between the non-TCS and the difficult TCS is dependent on time objective.	 Supported. Mainly explained by: • For *easy* TIME: Lower cost level under difficult TCS than under non-TCS. • For *difficult* TIME: Higher time spent under difficult TCS than under non-TCS.

Three large conclusions can be drawn from this third experiment.

***First*, target cost setting is now leading to a significant impact on the cost level of the created designs, without causing an unfavorable impact on the quality level of the new products.** Conform the expectations from target costing literature, the difficult TCS manipulation is leading to new products with a significantly lower cost level than under the non-TCS manipulation.

***<u>Second</u>*, when considering the two TIME conditions separate, the favorable impact of target costing on the cost level can only be supported under the easy TIME condition**. Under the difficult TIME condition, the cost level is not significantly lower in the difficult TCS than in the non-TCS.

***<u>Third</u>*, under the difficult TIME condition, participants spent more time in the difficult TCS than in the non-TCS to create the new product.** Thus similar to experiment two, target costing has an unfavorable impact on time spent, compared to the non-TCS, though only under the difficult TIME condition.

Each of these conclusions will be discussed in detail from page 328 on. **But before discussing the results, we will look at the data of the post experimental questionnaire (energy expended on cost, energy expended on attractiveness, tension and motivation by bonus) to investigate whether they can explain the found relationships.** First, we will address the favorable impact of target costing on the cost level. Second, we will focus on the failure to detect a favorable impact on the cost level in the difficult TIME condition. Third, we will address the unfavorable impact of target costing on the time spent in the difficult TIME condition.

17. Further Exploring the Data Set in Experiment Three

17.1 Exploring the Favorable Impact of Target Costing (Difficult TCS) on the Cost Level (Hypothesis 1)

We will now analyze the measured data of the post experimental questionnaire to find out if the favorable impact of target costing on the cost level can be explained by another factor than the TCS manipulation, such as a higher degree of motivation by the bonus system, a higher energy expended on cost or a lower energy expended on attractiveness in the difficult TCS compared to the non-TCS.

Is the favorable impact of target costing on the cost level in the difficult TCS, compared to the non-TCS, caused by a *higher motivation by the bonus* by participants in the difficult TCS? The answer is no. The degree of self-reported motivation by the additional bonus for cost is though differing between the two TCS groups (F (1, 62) = 4.307, p = .042), with a higher mean for the difficult TCS than for the non-TCS[116]. Participants in the difficult TCS might have reported to be higher motivated by the amount of 300 BEF, because they were more certain about attaining that bonus of 300 BEF (i.e. when the cost level did not exceed the target cost). Contrary, participants in the non-TCS got more uncertainty about receiving that bonus. Their bonus for low cost depends on the cost level of the other participants as well and thus report to be lower motivated by the amount of 300 BEF. Though, if we consider the motivation by the additional bonus for cost as a covariate in the relationship between TCS and cost level, there is still a favorable impact of target costing on the cost level (F (1, 61) = 7.587, p = .008), as shown in Table 116. **Hence the favorable impact of target costing cannot solely be explained by a higher degree of motivation by the bonus for cost between the non-TCS and the difficult TCS.**

Can the favorable impact of target costing on the cost level be explained by a higher self-reported *energy to work on the cost objective* in the difficult TCS than in the non-TCS? The answer is no. Participants did not report higher energy expended on cost in the difficult TCS than in the non-TCS (F (1, 62) = 2.090, p = .153). Across all manipulation, the energy expended on cost is not significantly correlated with the cost level of the new design (r = -.144, p = .258). Hence, the ANCOVA still finds a favorable impact of target costing on the cost level with energy to cost as the covariate, as shown in Table 116 (F (1, 61) = 9.614, p = .003). **Thus, the favorable impact of target costing is not going together with a higher energy expended on the cost objective in the difficult TCS, compared to the non-TCS.**

[116] If we consider the self-reported motivation by the complete bonus system, there is **no significant** difference between the non-TCS and the difficult TCS (F (1, 62) = 1.55, p = .218).

Can the favorable impact of target costing on the cost level be explained by a lower self-reported *energy to work on the attractiveness* of the new designs in the difficult TCS than in the non-TCS? The answer is no. Participants did not report a lower energy on attractiveness in the difficult TCS than in the non-TCS (F (1, 62) = 1.345, p = .251). Furthermore, if we consider energy to attractiveness as a covariate in the relationship between TCS and the cost level, the favorable impact of target costing on the cost level still exists, as shown in Table 116 (F (1, 61) = 11.445, p = .001). **Thus, the favorable impact of target costing cannot be explained by a lower energy expended on the attractiveness of the new designs in comparison with the non-TCS.**

Table 116: The Impact of Target Cost Setting on the Cost Level with Covariates in Experiment Three

Dependent Variable: Cost Level					
ANCOVA	**Type III Sum of Squares**	**Df**	**Mean Square**	**F**	**Sig.**
Self-reported motivation by bonus for cost	415018.871	1	415018.871	3.720	0.058
TCS	846462.643	1	846462.643	7.587	**0.008**
Error	6805272.004	61	111561.836		
Total	483248908.000	64			
ANCOVA	**Type III Sum of Squares**	**Df**	**Mean Square**	**F**	**Sig.**
Energy expended on cost	48086.255	1	48086.255	0.409	0.525
TCS	1130413.144	1	1130413.144	9.614	**0.003**
Error	7172204.620	61	117577.125		
Total	483248908.000	64			
ANCOVA	**Type III Sum of Squares**	**Df**	**Mean Square**	**F**	**Sig.**
Energy expended on attractiveness	101472.066	1	101472.066	0.869	0.355
TCS	1335633.719	1	1335633.719	11.445	**0.001**
Error	7118818.809	61	116701.948		
Total	483248908.000	64			

Concluding, *differences in motivation* to work on the cost objective (caused by the bonus system), differences in *effort expended on the cost objective* and differences in *effort expended on the attractiveness objective* do not explain the favorable impact of target costing on the cost level. Controlling for these impacts, the TCS manipulation is still leading to a significant difference in cost level.

17.2 Exploring the Failure to find a significant Impact of the Difficult TCS on the Cost Level under the Difficult Time Condition (Hypothesis 3)

The favorable impact of target costing on the cost level could only be supported in the easy TIME condition and not in the difficult TIME condition, causing a marginally significant interaction effect of TCS by TIME on the cost level. Can this interaction effect be explained by a difference in self-reported motivation by the bonus for cost, by a difference in energy expended on the cost objective, by a difference in energy expended on the attractiveness objective or by a difference in self-reported tension across the two time conditions? On each of these questions, the answer is no.

The *degree of self-reported motivation* by the additional bonus for cost does not show a significant interaction effect for TCS by TIME ($F(1, 60) = .053$, $p = .819$), as shown in Table 117. Limiting the sample to the difficult TIME condition, the degree of motivation by the bonus for cost is still higher in the difficult TCS than in the non-TCS ($t = -1.775$, $p = .043$). But treating self-reported motivation by the bonus system as a covariate, the same (marginal) significant interaction effect ($F(1, 59) = 3.5$, $p = .066$) is found showing only a favorable impact of target costing under the easy TIME condition and not under the difficult TIME condition.

Similarly, the *energy expended on the cost objective* does not show a significant interaction effect for the TCS by TIME manipulation ($F(1, 60) = .171$, $p = .680$), as shown in Table 117. If we limit the sample to the difficult TIME condition, there is no significant difference detected in energy expended on the cost objective between the non-TCS and the difficult TCS ($t = -1.3$, $p = .191$). Also in the easy TIME condition, the self-reported energy to work on the cost objective was not higher under the difficult TCS than under the non-TCS ($t = -.697$, $p = .491$).

Similarly, the *energy expended on the attractiveness* of the designs does not show a significant interaction effect for the TCS by TIME manipulation ($F(1, 60) = .385$, $p = .537$), as shown in Table 117. Limiting the sample to the difficult time condition, does not reveal a significant difference in energy expended on attractiveness between the non-TCS and the difficult TCS ($t = 1.657$, $p = .108$).

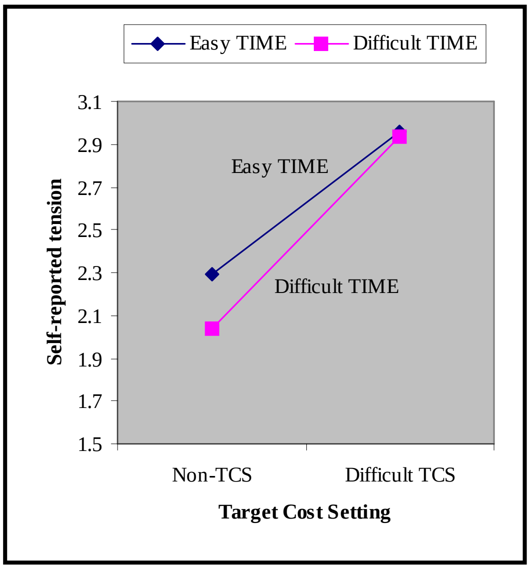
Finally, *self-reported tension* does not significantly differ between the non-TCS and the difficult TCS across the two time conditions ($F(1, 60) = .244$, $p = .623$). Limiting now the sample to the difficult TIME condition shows a significant difference in self-reported tension between the difficult TCS and the non-TCS ($t = -2.8$, $p = .01$). But this significant difference is also found in the easy TIME condition ($t = -2.0$, $p = .05$). For both time conditions, we find a higher self-reported tension under the difficult TCS (group mean = 2.9) than under the non-TCS (group mean = 2.2), as shown in Table 117 and in Figure 73. The difference in self-reported tension is thus not caused by the TIME manipulation, but by the TCS manipulation. Consequently, treating tension as a covariate, the same (marginal) significant interaction effect ($F(1, 59) = 3.04$, $p = .068$) is found showing only a favorable impact of target costing under the easy TIME and not under the difficult TIME condition. Thus, differences in self-reported tension cannot explain why target costing is not leading to a favorable impact on the cost level in the difficult TIME condition and leading to a favorable impact on the cost level in the easy TIME condition.

Hence, degree of *motivation by the bonus* for cost, *energy expended on the cost objective, energy expended on attractiveness* and *self-reported tension* do not explain why the favorable impact of target costing only applies to the easy TIME condition and not to the difficult TIME condition.

Table 117: Interaction Effect of 'TCS by TIME' on Motivation by the Bonus System, Energy expended on Cost, Energy Expended on Attractiveness and Self-Reported Tension

ANOVA for *self-reported motivation by bonus for cost*	**Type III Sum of Squares**	**Df**	**Mean Square**	**F**	**Sig.**
TCS	5.063	1	5.063	4.263	0.043
Difficulty of TIME Objective	1.563	1	1.563	1.316	0.256
TCS * TIME	0.063	1	0.063	0.053	**0.819**
Error	71.250	60	1.188		
Total	876.000	64			
ANOVA for *energy expended on cost*	**Type III Sum of Squares**	**Df**	**Mean Square**	**F**	**Sig.**
TCS	1.668	1	1.668	2.035	0.159
Difficulty of TIME Objective	0.141	1	0.141	0.171	0.680
TCS * TIME	0.141	1	0.141	0.171	**0.680**
Error	49.201	60	0.820		
Total	483.444	64			
ANOVA for *energy expended on attractiveness*	**Type III Sum of Squares**	**Df**	**Mean Square**	**F**	**Sig.**
TCS	0.502	1	0.502	1.374	0.246
Difficulty of TIME Objective	1.085	1	1.085	2.971	0.090
TCS * TIME	0.141	1	0.141	0.385	**0.537**
Error	21.910	60	0.365		
Total	828.778	64			
ANOVA for *self-reported tension*	**Type III Sum of Squares**	**Df**	**Mean Square**	**F**	**Sig.**
TCS	9.766	1	9.766	11.324	**0.001**
Difficulty of TIME Objective	0.293	1	0.293	0.340	0.562
TCS * TIME	0.210	1	0.210	0.244	**0.623**
Error	51.743	60	0.862		
Total	480.556	64			
ANOVA for *self-reported motivation by bonus for time goal*	**Type III Sum of Squares**	**Df**	**Mean Square**	**F**	**Sig.**
TCS	0.563	1	0.563	0.452	0.504
Difficulty of TIME Objective	0.563	1	0.563	0.452	0.504
TCS * TIME	1.563	1	1.563	1.254	**0.267**
Error	74.750	60	1.246		
Total	904.000	64			

Figure 73: Self-Reported Tension in Experiment Three



17.3 Exploring the Unfavorable Impact of the Difficult TCS on Time Spent under the Difficult Time Condition (Hypothesis 4)

Earlier, we saw that the difficult TCS has only an unfavorable impact on the time spent in the difficult TIME condition and not in the easy TIME condition, resulting in a significant interaction effect on time spent. Can this unfavorable impact be explained by another reason than the TCS by TIME manipulation, such as a lower degree of motivation by the bonus for finishing within the time limit or a higher level of self-reported tension? The answer is no.

Are participants *differently motivated by the bonus* for achieving the time limit in the non-TCS than in the difficult TCS, across the two levels of the TIME condition? The self-reported motivation by the bonus system for finishing within the time limit does not show a significant interaction effect between the non-TCS and the difficult TCS (F (1, 60) = 1.254, p = .267), as shown in Table 117. When we consider only the difficult time condition, participants in the difficult TCS did not report a significantly higher motivation by the bonus for time achievement (t = -.307, p = .761). Hence, the unfavorable impact of the difficult TCS on the time spent cannot be explained by a lower degree of motivation by the bonus system under the difficult TCS, compared to the non-TCS.

Second, as mentioned above, there is a higher *self-reported tension* perceived in the difficult TCS than in the non-TCS. Though this difference is independent of the time objective as shown earlier in Table 117 and Figure 73. Furthermore, if we treat tension as a covariate in the relationship between TCS and time spent, the interaction effect of TCS by TIME is still significant (F(1, 59) = 7.3, p = .009), as shown in Table 118. Hence, the significant difference in time spent in the difficult TIME condition between the non-TCS and the difficult TCS cannot be explained by a higher tension under the difficult TIME condition.

Table 118: The Impact of TCS on Time Spent with Tension as Covariate in Experiment Three

Dependent Variable: Time Spent					
ANCOVA	**Type III Sum of Squares**	**Df**	**Mean Square**	**F**	**Sig.**
Self-reported tension	1197.646	1	1197.646	9.870	0.003
TCS	0.182	1	0.182	0.002	0.969
Difficulty of TIME objective	2729.656	1	2729.656	22.496	0.000
TCS * TIME	884.149	1	884.149	7.286	**0.009**
Error	7159.104	59	121.341		
Total	339830.000	64			

Concluding, *self-reported motivation* by the bonus system and *self-reported tension* cannot explain why participants used significantly more time under the difficult TCS than under the non-TCS, when the TIME condition was set at a level difficult-to-attain.

However, when we look at the *number of designs made* and at the *importance participants took to the examples of last season* (remember the existing products), we can explain where the difference in time spent comes from. The difference in number of designs made during the NPD process between the non-TCS and the difficult TCS significantly differs across the two time levels (F (1, 60) = 5.5, p = .022), as shown in Table 119. Similarly, the difference in importance participants took to the designs of last year between the non-TCS and the difficult TCS also significantly differs across the 2 time objectives (F (1, 60) = 4.5, p = .039), as shown in Table 119. Thus, when considering both variables in the analysis as covariates, the interaction effect of TCS by TIME on time spent is no longer significant (F (1, 58) = 1.9, p = .168).[117]

More specifically, **<u>under the difficult TIME condition</u>**, participants made a significantly lower number of designs in the non-TCS than in the difficult TCS (t = -.1,7, p = .05). Furthermore, under that difficult TIME condition, participants took significantly more importance to the designs of last season in the non-TCS than in the difficult TCS (t = 2.1, p = .021). Thus, participants in the “non-TCS difficult TIME” condition used only 59 minutes to create the final design by using a very specific strategy, i.e. starting from the examples of last year, while trying only a few number of designs (6 on average). Contrary, participants in the “difficult TCS difficult TIME” condition needed to consider the target cost as well. These participants took less importance to the examples of last year and tried

[117]When considering both variables in the analysis as covariates for the **cost level**, the interaction effect of TCS by TIME on cost is still (marginal) significant (F (1, 58) = 3.5, p = .066), indicating that the differences in cost level is mainly caused by other factors than the number of trial designs and the importance to the designs of last season.

out a significant higher number of designs, resulting in a significantly higher time spent. Though, this longer design process did not result in significantly lower cost designs, as found in hypothesis 3.

Also in the **easy TIME condition**, the number of designs made and the importance to the existing products reveals the strategy that participants used to approach the design task. In the "non-TCS easy TIME" condition, participants did not start from the examples of last year and experimented a lot by creating a high number of different designs (8.5 on average). Because of the long time available, these participants used a less efficient strategy, i.e. experimenting without taking high attention to the most attractive designs of the previous season. Contrary, participants in the "difficult TCS easy TIME" condition, made a lower number of designs ($t = 1.6$, $p = .055$), as shown in Table 120. Since total time spent did not differ from those in the non-TCS, this indicated that participants worked longer on each design. Though, their attention to the designs of last year was low as well and not significantly different from the non-TCS ($t = -.858$, $p = .199$). Target costing prevented these participants from experimenting at random, and focused their attention to the cost implications by working longer on each trial design. This resulted in designs with a significantly lower cost level, as discussed in hypothesis 3.

To conclude, the significant interaction effect on time spent can mainly be explained by the different strategy participants took in creating a low cost, attractive design as shown in Figure 74 and Figure 75. Under the *difficult* time condition, the difficult TCS forced participants to look not only at the examples of last year, but also to consider the cost implications of the color selection. This strategy resulted in a higher number of trial designs and a reduced focus on the existing products (designs last year), leading to a higher time spent but not to a lower cost level, compared to the non-TCS. Under the *easy* time condition, participants in the difficult TCS did not experiment as much as participants in the non-TCS, who created at random new designs without considering the existing products. In the difficult TCS, participants created a fewer number of designs, though not resulting in a significantly lower time spent, because these participants worked longer on each design, probably thinking extensively on the cost level of their designs. This strategy also resulted in significantly lower cost designs.

Table 119: Interaction Effect of TCS by TIME on "Number of Designs made" and "Importance to Designs last Year" in Experiment Three

ANOVA for *number of designs made*	**Type III Sum of Squares**	**Df**	**Mean Square**	**F**	**Sig.**
TCS	0.250	1	0.250	0.028	0.868
Difficulty of TIME Objective	6.250	1	6.250	0.702	0.406
TCS * TIME	49.000	1	49.000	5.500	**0.022**
Error	534.500	60	8.908		
Total	3954.000	64			
ANOVA for *importance to designs last year*	**Type III Sum of Squares**	**Df**	**Mean Square**	**F**	**Sig.**
TCS	0.563	1	0.563	0.818	0.369
Difficulty of TIME Objective	5.063	1	5.063	7.364	0.009
TCS * TIME	3.063	1	3.063	4.455	**0.039**
Error	41.250	60	0.688		
Total	1058.000	64			

Table 120: Simple Main Effects to further analyze the Significant Interaction Effect for "Number of Designs made" and "Relevance to Designs of last Season" in Experiment Three

t-test for Equality of Means (Non-TCS vs. Difficult TCS) under *Easy TIME*					
	t	**Df**	**Sig. (1-tailed)**	**Mean Difference**	**Std. Error Difference**
Number of Designs	1.645	30	**0.055**	1.875	1.140
Relevance previous designs	-0.858	30	0.199	-0.250	0.291
t-test for Equality of Means (Non-TCS vs. Difficult TCS) under *Difficult TIME*					
	t	**Df**	**Sig. (1-tailed)**	**Mean Difference**	**Std. Error Difference**
Number of Designs	-1.687	30	**0.051**	-1.625	0.963
Relevance previous designs	2.119	30	**0.021**	0.625	0.295

Figure 74: Interaction Effect of 'TCS by TIME' on "*Number of Designs made*" and "*Relevance of Designs Last Year*" in Experiment Three

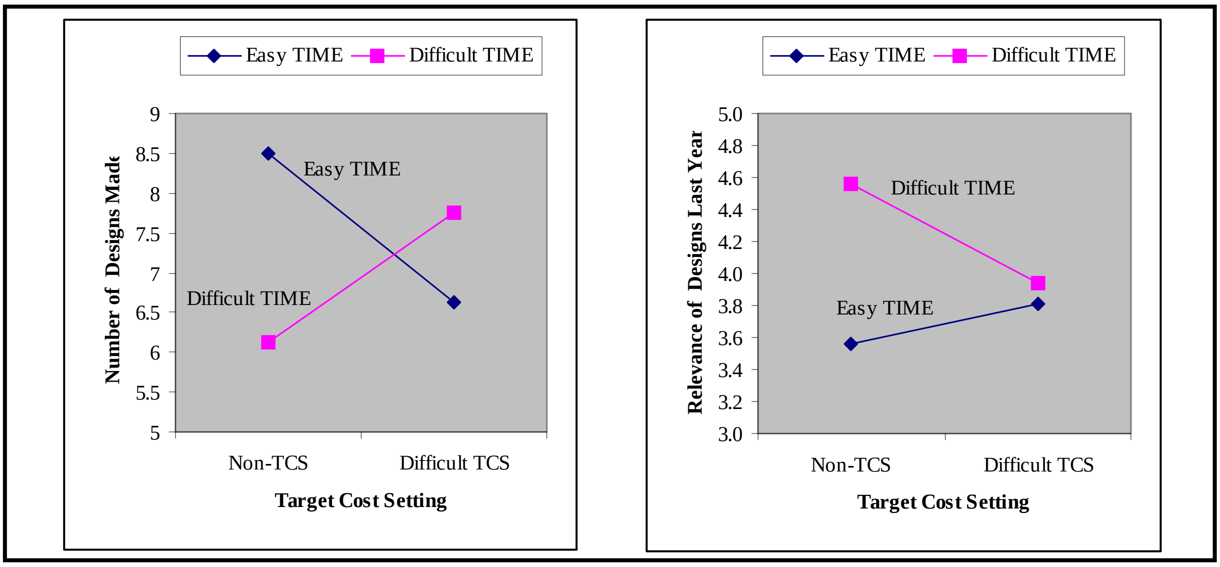
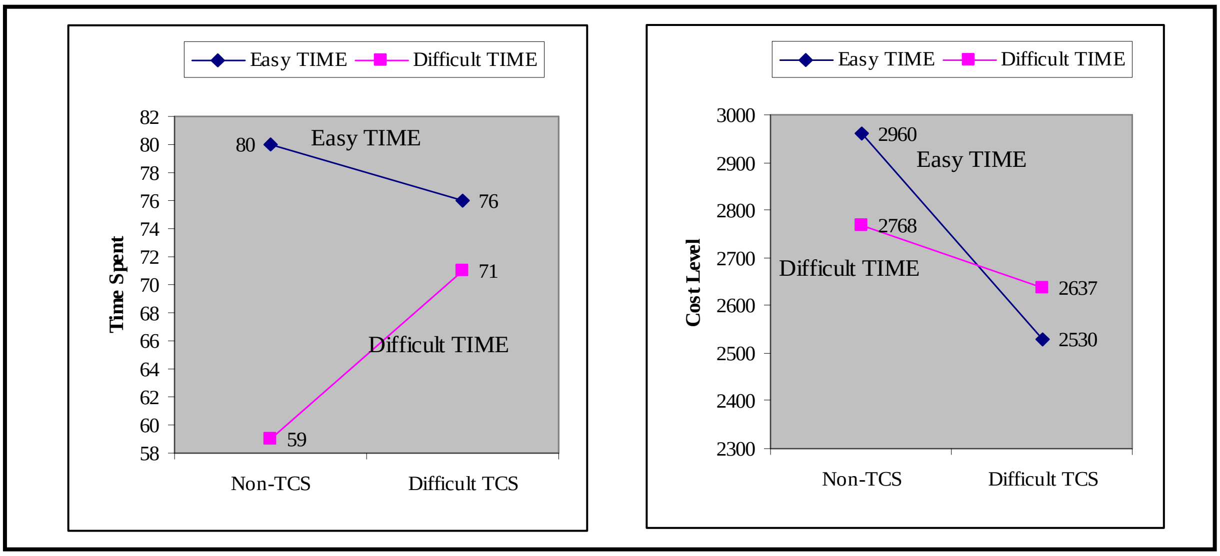


Figure 75: Interaction Effect of 'TCS by TIME' on *Time Spent* and *Cost Level* in Experiment Three



Thus, further exploring the data set did reveal some explanations for the interaction effect on time spent (fourth hypothesis). In the next paragraphs, we proceed with the discussion of the results. First in section 18.1, we address the favorable impact of target costing as found in hypothesis 1 for both time conditions and in hypothesis 3 only for the easy TIME condition. In section 18.2, we focus on the no impact of target costing on the quality level as found in hypothesis 2. Finally, in section 18.3 we discuss the unfavorable impact of target costing on the time spent, as found in hypothesis 4.

18. Discussion of the Results

18.1 Favorable Impact of Target Costing on the Cost Level (Hypothesis 1) but only under the Easy Time Condition (Hypothesis 3)

The results of the first hypothesis show that the cost level was significantly lower under the difficult TCS than under the non-TCS. **Assigning a difficult target cost to participants did result in a significant *lower* cost design than giving the objective to "minimize the cost level of the future product".** Thus in the new product environment of experiment three the expectations from current field research on target costing are now empirically supported.

Contrary to experiment two, only incremental innovation was required in this third experiment because of the clear examples of most attractive designs of last season. The results support the hypothesis, as posted earlier in section 19 on page 262, that target costing is more appropriate for the development of derivative kind of new products than for next generation new products (Cooper & Slagmulder, 1997, 177; Ansari & Bell, 1997, 169). The current results are also in conformity with the expectations from previous goal setting studies. By providing more specific examples of the most attractive designs of last year, we provided some help in developing an optimal strategy to approach the design task. As formulated at the end of the previous chapter, this increased information is expected to compensate for the detrimental impact of difficult goals in complex heuristic tasks (Earley, 1985, 490; Earley, Connoley & Ekeren, 1989, 32). Indeed, participants did now develop suitable task strategies in the difficult TCS to reach the target cost, which resulted in a significantly lower cost level under the difficult TCS than under the non-TCS. The results are also conform to the earlier mentioned innovation studies that cost reductions are possible (only) during the development of derivative kind of new products (Utterback & Abernathy, 1975, 644).

However, when we consider the two TIME conditions separate, the picture becomes somewhat different. The results of hypothesis three show a (marginally) significant interaction effect of TCS by TIME on the cost level. The difference in cost levels between the non-TCS and the difficult TCS is larger under the easy time objective than under the difficult time objective. In particular, the favorable impact of target costing on the cost level is only significant in the easy TIME condition. Though the mean cost levels are in the right direction under the difficult TIME condition as well (2768 for non-TCS versus 2637 for difficult TCS), the differences are not significant. **From these results, we can state that the favorable impact of using a difficult target cost (compared to a minimizing cost objective) was only supported when participants had no time pressure, i.e. when an easy-to-attain time objective was imposed.**

Thus similar to experiment two, the differences in cost level are only significant under the easy TIME condition. Participants work extensively on reducing the cost level of their designs, only when they receive time enough. As mentioned before, for complex tasks in general, it might take some time before a significant performance effect emerges because individuals need to learn which task strategies are effective (Chesney & Locke, 1991, 420; Smith et al., 1990, 130). But remember that in experiment two, target costing (difficult TCS) was leading to new products with significantly *higher* cost levels, whereas in this environment of derivative kind of new products, target costing (difficult TCS) is leading to new products with significantly *lower* cost levels, compared to non-target costing.

To conclude, contrary to experiment two but conform the expectations from target costing, participants created *lower* cost products under the difficult TCS than under the non-TCS. Though, when considering the two time conditions separate, the favorable impact of target costing could *only* be supported in the easy TIME condition.

18.2 No unfavorable Impact of Target Costing (Difficult TCS) on the Quality Level (Hypothesis 2)

The use of target costing during NPD had a significant impact on the type of new products designers created, as found in hypothesis 2. Similar to experiment two, **giving a difficult target cost to participants led them to create totally different new products than when no target cost was given.** But considering the differences, the new products now only differ in terms of the cost level between the non-TCS and the difficult TCS. Participants under the difficult TCS did more what we called cost reduction activities, leading to significantly lower cost products, as discussed above. **Contrary to experiment two, participants did not create new products with significantly lower levels of attractiveness. Also there are no significant differences found in time spent between the non-TCS and the difficult TCS**. Thus, from hypothesis two we can conclude that the use of a difficult target cost during NPD did *not* result in an unfavorable impact on the new products, as we found earlier in the NPD environment of experiment two. **Concluding, target costing (difficult TCS) is now beneficial for the development of future products, in the NPD environment as simulated in experiment three.**

Why is the quality level not sacrificed now as an easy way to attain the difficult target cost, as found in our second experiment? First of all, changing the NPD environment from next generation to derivative kind of new products no longer misdirects strategy search of participants. From the examples it is now obvious that selecting only the cheapest colors (black, white, orange, sky bleu and light green) is not a good strategy, because it can never lead to an attractive design within the given interior. This increased information *prevented* participants in the difficult TCS from selecting a *dysfunctional performance strategy* (Huber, 1985; Earley, Connoley & Ekeren, 1989). In a way, our result on this second hypothesis is identical to the results of Erez & Arad (1986), who found that the trade-off relationship between performance quantity and quality can be affected by cognitive-motivational factors. Participants who had more information on how to perform the task were less likely to reduce quality for an increase in quantity than the less informed subjects. Furthermore, our study differs from the previous mentioned multiple goal setting studies (Terborg & Miller, 1978; Schmidt et al., 1984; Shalley, 1991; Audia et al., 1996) where quality (defined as a do-best goal) is sacrificed for a difficult quantity goal by the fact that the do-best quality goal (attractiveness) in our study is communicated and also perceived (see page 285) as the *most important goal*. Feedback was provided on attractiveness during the task avoiding that participants implicitly attached fewer attention to this do-best goal. Though as will be discussed later, time spent (communicated as the least important goal) is sacrificed in our study when both the time and the cost objective are set at a level difficult-to-attain, which was also the case in experiment two.

Summarizing, the heuristic task of our study is no longer misdirecting the attention of participants under the difficult TCS, because of the increased information on how to approach the design task. In terms of the innovation literature, experiment three requires only an incremental change to the most attractive designs of last season. For the development of such types of new products (so-called derivatives), imposing control on the behavior of design engineers is not having an detrimental impact on the quality level (attractiveness) of the future product nor on the time-to-market (time spent). Thus, the use of target costing during the development of derivatives is now beneficial. Though, we will see that this last conclusion is not totally true when we consider the two time conditions separate in the next section.

18.3 Unfavorable Impact of Target Costing (Difficult TCS) on the Time Spent under the Difficult Time Condition (Hypothesis 4)

Again, the picture becomes somewhat different, when we consider the two TIME conditions. **The significant multivariate interaction effect of hypothesis four indicates that the differences in new products between the non-TCS and the difficult TCS are also depending on the received TIME objective.** Under the <u>easy</u> TIME condition, participants created significantly lower cost products under the difficult TCS than under the non-TCS, as discussed before in section 18.1. Under the <u>difficult</u> TIME condition, participants used significantly more time under the difficult TCS than under the non-TCS, though this increase in time spent did not lead to significantly lower cost products as discussed before in section 18.1. **Thus the cost reduction activities in the difficult time condition lead to considerable more time spent, without a significant decrease in cost level, compared to the non-TCS. While in the easy time condition, the cost reduction activities lead to a significant lower cost, without a significant increase in time spent, compared to the non-TCS**.

Similar to experiment two, we find here a negative impact of target costing on the time spent, only under the difficult time condition. As mentioned in chapter three, some authors suggest an extended time-to-market when using target costing during NPD (Kato, Böer & Chow, 1995). But how can be explained that this difference in time spent, compared to the non-TCS, is only significant under the difficult time objective and not under the easy time objective? Considering the group means in Figure 75 on page 327, we see that under the easy TIME condition, both the non-TCS and the difficult TCS are using approximately the same amount of time (80 minutes for non-TCS and 76 minutes for difficult TCS). Though, under the difficult TIME condition, the group mean of the non-TCS is only 59 minutes versus 71 minutes in the difficult TCS. Thus again, it seems that **Parkinson's law** is working for the non-TCS, but not for the difficult TCS. In particular, as discussed in section 17.3 on page 252, participants in the "non-TCS easy TIME" condition used a less than efficient strategy in designing the new product. They experimented a lot by a high number of trial designs, while not giving high attention to the examples of last year[118], and thus adjusting their speed to the long time available as Parkinson's law prescribes (Bryan & Locke, 1967, 260). Contrary, the difficult TIME condition forces participants to speed up with the task. In the "non-TCS difficult TIME" condition, participants created a low number of trial designs, while considering extensively the designs of last season and hence used the lowest time spent of all four conditions. However, in the "difficult TCS difficult TIME" condition, the target costing system force participants to consider the cost implications of their design decisions as well, leading to a higher number of trial designs than the non-TCS, explaining why these participants used a significant higher time spent than the non-TCS. Though, this higher time spent is not leading to significantly lower cost designs compared to the non-TCS, as mentioned above.

These results are also conform to previous **goal setting studies**. Participants give up the least attainable goal and allocate their efforts toward the other goals, when two goals are set at a level difficult to attain (Erez, Gopher et al., 1990; Erez, 1990; Gilliland & Landis, 1992). Though, in our study, the time objective was the easiest to attain goal, but we communicated it as the *least* important of the three goals (see bonus system). Hence, participants gave up in our study the least important goal, when the cost goal and the time goal were both set at a level difficult-to-attain.

Summarizing, under the *difficult* TIME condition participants of the difficult TCS spent more time on designing a future product than participants of the non-TCS, which is similar to experiment two. Though this higher time spent in the difficult TCS did not result in significantly lower cost designs compared to the non-TCS. Furthermore, under the *easy* TIME condition, participants does not spent more time in the difficult TCS than in the non-TCS,

[118] Actually in this "non-TCS, easy TIME" condition, we find exactly what Shields & Young (1994, 178) heard during site visits from an accounting saying: "**scientists are like a kid in a candy store, they can't spend enough**" or here "they can't experiment enough". Also Cooper (1995, 138) mentions that design engineers frequently say: "**If we just add this feature, the product will be so much better** (and cost only a little more)" or here "if we just try one more design, the new product might look so much nicer".

similar to experiment two. Though, contrary to experiment two, this difficult TCS is now leading to significantly lower cost products, compared to the non-TCS.

19. Conclusion

One major change was performed in this third experiment, compared to the second experiment. The simulated new product development environment was changed from a next generation to a derivative kind of new product development environment. Apart from this major change, the task of this third experiment was exactly the same as in the second experiment, i.e. to design an attractive low cost carpet within the time limit. Though, only two levels of TCS were considered, i.e. the non-TCS and the difficult TCS. Similar to the previous experiment, two time conditions were included, i.e. an easy TIME and a difficult TIME objective. This 2 by 2 factorial design was completely randomized with only between subjects effects. Again, new product development goals were formulated for the quality, the cost and the time spent, with priority in the given sequence. This priority among the three goals was established by the different amounts of bonuses. Feedback was provided on all three elements (attractiveness, cost and time). In total, 64 economics-students participated, i.e. 16 participants in each of the four cells. Strict procedures were set up to guide participants, judges, and assistants during the experimental task.

The same post experimental questionnaire was included as in experiment two, to check if the manipulations were perceived as intended. The results show that target cost specificity, target cost difficulty and difficulty of the time objective were perceived as intended. Participants reported a higher energy on the attractiveness than on the cost objective, indicating that the manipulation on the priority of the goals was succeeded. Furthermore, the conjoint analysis on the 8 formulated strategies also learned that participants worked during the task according to the given priority rule.

We changed the settings of this third experiment to a derivative kind of NPD environment, requiring less creativity and thus a lower degree of radical innovation. By giving more appropriate examples of the most attractive designs of last year (using only 5 of the 10 colors and thus decreasing the degrees of freedom), we actually helped participants in their strategy search to create an attractive, low cost carpet.

The results are conform the hypothesis that target costing is appropriate for the development of derivative kind of new products (or incremental product changes). The results of hypothesis one show a lower cost level in the difficult TCS than in the non-TCS, conform the expectations of target costing literature.

Furthermore, the created products significantly differed from each other between the non-TCS and the difficult TCS. But, contrary to experiment two, target costing is *not* having an unfavorable impact on the attractiveness level of the new products or on the time spent. The only significant difference in new products between the non-TCS and the difficult TCS was found in the cost level.

Considering the impact of TCS on the cost level in each of the two time conditions, a significant interaction effect between the non-TCS and the difficult TCS across the two time objectives was found. Under the easy TIME condition, the difficult TCS is having a favorable impact on the cost level compared to the non-TCS, contrary to experiment two where the difficult TCS was having an unfavorable impact on the cost level compared to the non-TCS. Though in this experiment three, the favorable impact on the cost level compared to the non-TCS could not be supported under the difficult TIME. This leads us to conclude that for the development of derivative new products, target costing is only leading to “lower cost” new products under the easy TIME condition.

The multivariate interaction effect of TCS by TIME was supported as well. Hence, the difference in created new products between the non-TCS and the difficult TCS significantly differed among the two time conditions. Similar to experiment two, target costing had an unfavorable impact on the time spent in the difficult TIME condition, compared to the non-TCS. This unfavorable impact on the time spent was not supported in the easy TIME condition. Furthermore, as mentioned above, in that easy TIME condition, the difficult TCS was having a favorable impact on the cost level compared to the non-TCS.

Concluding, target costing (the difficult TCS) is beneficial in inducing a lower cost level for the development of derivative type of new products, though only under an easy TIME condition. Under a difficult TIME objective, target costing did not result in lower cost levels, although designers spent significantly more time to create the new product than designers in the non-TCS, difficult time condition. Furthermore, target costing is not having a detrimental impact on the quality level as found in experiment two. Thus considering all elements, for the development of derivative kind of new products target costing is only beneficial when design engineers face no time pressure, such as when an easy-to-attain time-to-market objective is set.

Chapter 9: General Conclusions

1. Introduction

This study investigated the favorable and unfavorable impact of target costing on the development of new products. Three elements were considered i.e. the *cost level* of the future product (i.e. the product cost at which the new product can be produced during manufacturing), the *quality level* of the future product and the *achieved time-to-market* (i.e. the time that designers spent from idea generation to product introduction).

One main characteristic of target costing is that early in the new product development stage (NPD) a clear limit is set on the maximum acceptable cost of the future product to be developed (the so-called target cost). This target cost is derived taking into account both the company's profit requirement and the customers' willingness to pay for the product. Though, if the target cost is set at a level much lower than the current cost of existing products, design engineers need to find extensive cost reduction ideas to reach this difficult-to-attain target cost. When the target cost is set only slightly below the current cost level of existing products, design engineers will cope a much easier-to-attain target cost.

This study compared a NPD environment where design engineers (1) face **no target cost** (the non-TCS), (2) face an **easy target cost** (easy TCS) and (3) face a **difficult target cost** (the difficult TCS). First of all, the cost level of new products is compared among these three target cost setting conditions. Though, the cost level is not the one and only factor that design engineers need to consider when designing and developing new products. In this study, the quality level of the future product and the time-to-market were included as well. So, this study also investigated the differences in created products among the three mentioned target cost settings. The differences in created products were analyzed here in terms of *the cost level, the quality level and the achieved time-to-market*. Furthermore, since speed-to-market has become extremely important in the current competitive environment, our study combined the three target cost settings with **two time conditions**, i.e. one where design engineers face an easy time-to-market objective (inducing low time pressure) and one where design engineers face a difficult time-to-market objective (inducing high time pressure).

This concluding chapter is organized as follows. The findings of this study are summarized in section 2, the assumptions are discussed in section 3 and the limitations are admitted in section 4. Section 5 addresses the academic contributions, section 6 focuses on the managerial implications and in section 7 some directions for future research are given.

2. Findings of the Study

The first finding of this study is that **target costing is *not always* leading to a lower cost of future products compared to the non-TCS**, i.e. the NPD environment where design engineers face no target costs but are expected to minimize the cost level of the future product. Based on anecdotal evidence from field research, current target costing literature asserts that target costing is having a favorable impact on the cost level. Though we could only confirm this favorable impact for the development of *derivative* kind of new products where design engineers face a difficult target cost (difficult TCS). For the development of *next generation* new products, which require more than just incremental changes to existing products, the cost level was not significantly different between the non-TCS, the easy TCS and the difficult TCS. Thus for the development of these next generation new products, giving a difficult target cost is not leading to lower cost products compared to the non-TCS; also giving an easy target cost is not leading to new products with a higher cost level compared to the non-TCS. This is in line with innovation and goal setting literature that target costing is only working for the development of derivative kind of new products, where no radical innovation but only incremental innovation is required and where information on existing products is assisting design engineers in how to achieve the low target cost.

The second finding of this study is that the **impact of target costing on the cost level depends on the time pressure design engineers get.** When we consider the impact of target costing under the easy and the difficult time objective separately, the favorable impact of target costing on the development of *derivative* new products could only be confirmed under the easy time objective, i.e. when design engineers perceive low time pressure. When design engineers perceive high time pressure, even for the development of derivative new products, target costing had no favorable impact on the cost level, compared to non-TCS. Hence, the advantage of continuing innovation from existing products is only relevant, when design engineers receive no sharp time objective. For the development of *next generation* new products however, target costing (difficult TCS) was even having an unfavorable impact on the cost level, in the easy time objective. Thus when design engineers perceive low time pressure during the development of next generation type of new products, giving no target cost is leading to *lower* cost products than setting a difficult target cost. Hence, for the development of next generation products, - which asks for higher creativity of design engineers than for derivatives -, the condition with the least restrictions in terms of cost and time is leading to new products with the lowest cost levels. This last finding of lower cost new products under non-target costing than under target costing is totally contrary to the current case descriptions in target costing. Though, findings in innovation and goal setting literature support the conclusion that target costing is leading to worse results also in terms of the cost level when high creativity is required for the development of products.

The difficult target cost places restrictions on the creative behavior and is misdirecting the attention of design engineers in selecting the appropriate design strategy.

The third finding of this study is that **target costing has an impact on the new products design engineers create**. The created products (next generation as well as derivatives) differed significantly between the non-TCS and the difficult TCS, but also between the non-TCS and the easy TCS. For the development of *next generation* kind of new products the differences are most pronounced in terms of the **quality level**. New products under an easy TCS and under a difficult TCS score significantly *lower* in terms of quality level than new products created under a non-TCS. We cannot say that the quality level was sacrificed for attaining the difficult target cost as found in previous goal setting studies, since the negative impact of target costing on the quality level applies to both the easy and the difficult TCS. Hence, target costing is not only misdirecting strategy search but is also imposing limitations on the creativity of design engineers in designing a high quality product. For the development of *derivative* type of new products, target costing is also leading to totally different new products than when no target costs are given. However, the main difference in products between the non-TCS and the difficult TCS lies in the **cost level**. The difficult TCS is leading to new products with a lower cost level, while not reducing the quality level or delaying the time-to-market. This result confirms the expectations from target costing literature. Considering again the available cases on target costing, we can conclude that target costing is mainly described in companies producing automobiles, electronics, machinery, etc., i.e. in industries knowing a high rate of incremental product changes, which also explains why we found a favorable impact of target costing on created products only for derivatives.

The fourth conclusion of this study is that the **impact of target costing on created new products also depends on the time-to-market objective**. At least, this result is found for comparing non-target costing with a difficult target cost setting. For both the derivatives and next generation new products, design engineers spent more time in the difficult TCS than in the non-TCS to create the new product under a difficult time objective, whereas there was no significant difference in time spent under the easy time objective. For both derivatives and next generation new products, the additional cost reduction activities in target costing (difficult TCS) increased the development time, but did not result in significant lower cost new products, as discussed before. Concluding, target costing has an unfavorable impact on the time-to-market, when design engineers face both a difficult target cost and a difficult time-to-market objective. The difficult time-to-market can speed up design engineers in the non-TCS, while the difficult target cost forces design engineers to consider the cost implication of their design decisions as well, leading to a higher number of trial designs.

General conclusion is that target costing is not always recommended during NPD. Our study shows that target costing has a favorable impact on the total new product only if design engineers need to develop derivative kind of new products (adding a few changes to existing

products) and if the time-to-market objective is set at a level easy-to-attain. In that situation, setting a difficult target cost is leading to a lower cost of new products, without an impact on the quality level and without a delay in time-to-market compared to non-target costing. The use of target costing (easy or difficult) is not at all beneficial for the development of next generation kind of new products, because of its detrimental impact on the quality level.

These conclusions were found considering different assumptions, as discussed next.

3. Assumptions of the Study

3.1 Three Multiple, Conflicting NPD Objectives, Simultaneously-to-Attained

Characteristic to the NPD environment is that multiple, conflicting objectives are set for developing a new product. Furthermore, all goals need to be attained simultaneously, in extremis at the moment of product launch. In our study on target costing in the NPD environment, we limit the number of conflicting goals to three: i.e. for the cost level, for the quality level and for the time-to-market.

3.2 No Objective for Development Cost

No objective is considered for the development cost in our study. The development budget is traditionally the fourth NPD objective in practice (Rosenthal, 1992). Though in our study we only considered a target cost for the total manufacturing cost, excluding the impact of target costing on the research and development costs.

3.3 Prioritization among the Three NPD Objectives

The results of this study apply to companies, where the quality level of the future product is the most important characteristic for customers. The NPD strategy assumed in this study is one giving priority to the quality level of a new product, then on attaining the cost objective and finally on attaining the time-to-market objective. The detrimental impact of target costing on the quality level for the development of next generation new products should be considered in this perspective. Also the least importance of the time objective might explain why design engineers relax the time-to-market objective when receiving a difficult target cost and a difficult time-to-market objective, when full recovery of all objectives seems to be impossible.

3.4 Aesthetics as an Aspect of Quality

In this study, we selected aesthetics as an aspect of quality, though knowing that the quality of a new product can be described in many dimensions (performance, features, reliability, conformance, durability, serviceability, aesthetics and perceived quality). Especially for the reliability, durability and conformance dimension, it is difficult to measure the quality level and to give immediate feedback to design engineers about the quality level attained, as Bassett (1979) points out. Avoiding the discussion that feedback on quality will always lag feedback on cost performance because of the difficulty to notice a failure, we assumed in this study a quality dimension which makes immediate feedback more or less possible (such as the aesthetic value of a product). Hence, the conclusions of this study on quality can be easily generalized to all elements of what Anderson & Sedatole (1998) call "design quality", referring to the intrinsic fit between a product's design specification and the customer's preferences. Generalizing the results to "conformance quality", referring to how consistently the product is manufactured to stated design specifications, is more difficult.

3.5 Immediate Feedback on all Three NPD Goals

Feedback or knowledge of the results is a necessary condition for goal setting to work (Erez, 1977). As mentioned above, we assumed that design engineers have knowledge of the results, allowing them to track the progress towards attaining each of the three goals.

3.6 Goal-Contingent Bonus System

We assumed a goal contingent reward system for each of the three goals. In general, three types of monetary reward system can be used for design engineers, i.e. a *fixed* salary, a *linear system* (such as percentage on sales) and a *bonus* system (base salary plus bonus for attaining an objective). The latter is called a *goal*-contingent compensation form. The results of our study are found in a reward system where achievement of each of the three goals is simultaneously rewarded. Furthermore, in this study no incentives are assumed for design engineers going further than the target cost or having finished the development of the new product earlier than specified in the time-to-market objective.

3.7 Environment of High Task Complexity

This study assumed an environment of high task complexity. The NPD environment is in general described as highly complex, because it is characterized by trade-offs, dynamics, details and time pressure (Ulrich & Eppinger, 1995; Wood, Mento & Locke, 1987). This highly complex new product environment, the effort of design engineers does not necessary pay off so directly. One must decide where and how to allocate effort. The plans, tactics, and strategies used by the engineer play a larger role in this environment than they do in simpler tasks where the number of different strategies is more limited and are generally known to all performers. Our study tried to capture this high complexity and the findings evidently apply only to such an environment.

4. Limitations of the Study

First, since we used the lab experiment as research method, the general limitation of the **artificiality of the lab environment** applies to our study as well. This uncontaminated and controlled environment of the lab forms its main strength in terms of realizing control, but is also its major weakness in terms of generalization of the results. Despite our attempt to bring the essential features of the field setting into the lab environment and by creating realism in its experimental sense, we cannot guarantee that no biases occurred because of the artificiality of this research situation. Though, generalizing the conclusions of this study, found by students in the lab environment to design engineers in the real NPD environment, can be done within the conditions specified in the previous paragraph.

Secondly, some threats to internal validity might have biased our findings. Although we ruled out in each experiment many threats of internal validity by random assignment to treatment and by formalizing contact between researcher (or judges) and participant, some distortions might exist **in comparing the results *across* the experiments**. For each of the three experiments a different sampling population was used (because of organizational reasons). Hence, part of the differences in results between experiment two (the next generation type of new products) and experiment three (the derivative kind of new products) could be caused by the differences between bioengineering students (experiment two) and economics students (experiment three). Although participants in both experiments perceived the manipulations as intended and both attached the biggest importance to the attractiveness part of the task, other variables omitted in the experiments (such as personality variables or history issues) could have accounted for the differences in impact on the new products between experiment two and three. We recognize this problem, although the evidence found in innovation and goal setting literature led us to conclude that the differences in outcomes are caused by the differences in required innovation and not by different groups of students.

5. Academic Contribution

<u>First</u>, this study extends the knowledge on target costing in several ways. Until now the concept was rather loosely defined. From our point of view, the formulation of the typical characteristics of target costing might advance a better understanding among researchers of what is meant by target costing. Furthermore, until now the favorable impact of target costing on the cost level has only been supported by anecdotal evidence. In our study, the favorable impact of target costing on the cost level of future products is **empirically tested** in the controlled environment of the lab. Moreover, our study can also be distinguished from previous research on target costing, by our unique approach to consider the **difficulty of the target cost** as well. Our results show that making a distinction between target costing with an easy-to-attain target cost and target costing with a difficult-to-attain target cost makes sense when considering the effectiveness of target costing in terms of created new products. Furthermore, by simulating a new product environment with three objectives (i.e. for cost, quality and time-to-market), and by measuring the outcomes on these three objectives, we meet Cooper's (1995) call for more research on the interlocking roles of the NPD objectives. As far as we know, this is the first study that considers the impact of target costing on the three elements **cost, quality and time-to-market** simultaneously. Last, but not least, our study is elaborating the theory on target costing with two contingency factors, i.e. time pressure and the type of innovation required in new products. From current literature, we had no idea of the effectiveness of target costing in combination with **time pressure**. The results do show however, that the impact of target costing differs between an easy and a difficult time-to-market objective. Furthermore, in discussing the favorable and unfavorable impact of target costing during the development of new products, it was crucial to make a distinction in the **type of innovation** required for the new products to be developed. Our result learns that the discussion on the effectiveness of target costing is meaningless without considering the differences between a NPD calling for an incremental and a NPD calling for a radical type of innovation. The current knowledge on target costing is probably mainly based on companies using target costs for the development of derivative type of new products. Combining the discussion on the effectiveness of target costing in realizing cost management with the type of new products (derivatives versus next generation new products) is essential to further our knowledge on target costing.

<u>Second</u>, this study is one of the first to investigate the phenomenon of target costing in a lab environment. Current research on target costing was exclusively based on field and (limited) survey research. By showing that the essential characteristics of the complex area of new product development can be brought into the lab environment, where the researcher has control to the degree of manipulation of the independent variables (such as the difficulty of the target cost, the difficulty of the time-to-market objective, type of required innovation, etc.) we hope to inspire other researchers as well to go on with this unusual research method in target costing to further explore this rich phenomenon.

<u>Third</u>, this study also contributes indirectly to goal setting. A multiple goal setting was operationalized with three, conflicting goals. As far as we know, no other goal setting studies have combined the second core finding with two levels of time pressure, comparing a difficult (easy) goal with a do-best goal under two levels of time pressure. Furthermore, our study can be distinguished from previous multiple goal setting studies, by the clear prioritization among the three conflicting goals. Past research shows that people sacrifice the least attainable goal for attaining the most easily attainable goal, while our study shows that people can act in accordance to the given prioritization, probably because of the immediate feedback on all goals and because of the adequate reward system. Finally, this study can be added to the studies of Huber (1985) and Earley, Connolly & Ekegren (1989) exploring the boundaries beyond which goal setting is not working or even is harmful. The task in this study can be seen as another example of a complex heuristic task, which can be approached by a high number of task strategies. However, typical to our task is also that people face multiple, conflicting goals. Further research should determine if only this last condition, as well as the combination with a heuristic task causes invalidation of the second core finding of goal setting theory. Furthermore, this study also adds evidence to the statement of Earley (1985) that the debilitating effect of specific, difficult goals in heuristic tasks can be overcome by providing adequate information on strategy development.

6. Managerial Implications

First, the managerial implication of this study is that the general recommendation to use target costing, as a way to survive in a competitive environment, should be used with caution. The general conclusion of our study is that target costing is *not* without harm for all possible new product developments. Our study shows that target costing has only a favorable impact on the total new product if design engineers can develop *derivative kind of new products* (requiring incremental innovation such as a small product change to existing products, upgrades, add-ons, etc.) on condition that design engineers can afford *to work relaxed* because the projected time-to-market objective seems to be set in a realistic way. In that situation, setting a difficult target cost is leading to lower cost new products, without leading to a negative impact on the quality level or a delay in time-to-market. Setting no target costs in that situation is leading to random experimenting of design engineers, leading to a high number of trial designs, though with a higher cost level than in target costing. This is what Cooper (1995, 138) meant by quoting design engineers as follows: "*If we just add this feature, the product will be so much better and only cost a little more*".

However, if design engineers perceive *high time pressure*, because of a sharp time-to-market objective, the use of target costing is not recommended. Giving a difficult target cost to design engineers is not leading to a cost advantage in the new products, while design engineers will spent much more time in developing the new products. In that situation of time pressure for the development of derivatives, management should have confidence in the creative power of the design team and should not expend effort on defining and setting cost objectives, since the difficult time-to-market objective will focus designers on the product to be developed. This last conclusion also suggests to avoid setting two difficult conflicting goals.

Furthermore, the use of target costing is not at all beneficial for the development of *next generation* kind of new products, where design engineers encounter many degrees of freedom and need to implement a more radical oriented innovation in the new product, distinguishing it from predecessor-products. Setting a target cost (either difficult or easy) is leading in that situation to new products with lower quality levels than if design engineers receive no cost objective but are instructed to minimize the cost level of the future product. Moreover, when design engineers *can work relaxed*, setting a difficult target cost is even leading to higher cost new products. When design engineers perceive *more time pressure*, setting a difficult target cost is leading again to a longer development process, while not resulting in lower cost levels of new products.

Table 121 summarizes these recommendations, though we stress that these recommendations only apply for a NPD where the quality of the product is having first priority, superior to attaining the cost or the time-to-market objective.

Table 121: Summarized Impact of Target Costing, compared to setting no Target Costs

	Development of *Derivative* New Products	
	Target Cost is *easy*-to-attain	**Target Cost is *difficult*-to-attain**
***Low* Time Pressure**	*not included in this study*	Target Costing is appropriate: ☺ Lower cost new products 😐 No difference in quality 😐 No difference in time-to-market
***High* Time Pressure**	*not included in this study*	Target Costing is <u>not</u> appropriate: ☹ Delayed time-to-market 😐 No difference in cost level 😐 No difference in quality
	Development of *Next Generation* New Products	
	Target Cost is *easy*-to-attain	**Target Cost is *difficult*-to-attain**
***Low* Time Pressure**	Target Costing is <u>not</u> appropriate: ☹ Lower quality new products 😐 No difference in cost level 😐 No difference in time-to-market	Target Costing is <u>not</u> appropriate: ☹ Lower quality new products ☹Higher cost new products 😐 No difference in time-to-market
***High* Time Pressure**	Target Costing is <u>not</u> appropriate: ☹ Lower quality new products 😐 No difference in cost level 😐 No difference in time-to-market	Target Costing is <u>not</u> appropriate: ☹ Lower quality new products ☹ Delayed time-to-market 😐 No difference in cost level

Second, this study provides a first understanding of the paradox between literature and practitioners whether to impose cost restrictions to the behavior of design engineers. On the one hand, researchers in target costing assert that target costs are necessary to manage the cost level of future products aggressively in order to survive in highly competitive markets. On the other hand there is the general belief of many western design engineers that their creativity should not be constrained by cost objectives during NPD, because they know best how far to go with cost reductions (Shields & Young, 1994; Hertenstein & Platt, 1998). We might have solved this inconsistency by putting each of those statements in its right perspective. For the development of derivative kind of new products, requiring rather incremental innovation, the practice of using target costing is beneficial during NPD, such as in our third experiment and as illustrated in the many cases on target costing. Though, for the development of next generation type of new products, requiring a more radical innovation and asking for more creativity of design engineers, the best products are indeed found under the least restrictive environment, i.e. when no target costs are set.

7. Directions for Future Research

This research was just a start in studying the effectiveness of target costing in developing new products. The opportunities for research in the area of target costing are numerous. We can only mention a few hereafter.

First, as the results of the second and third experiment revealed a new dimension to the discussion on the effectiveness of target costing in developing new products, it would be interesting to replicate this study in a single lab experiment, testing the three independent variables "target cost setting", "time pressure" and "type of new products" simultaneously in a 3 by 2 by 2 design.

Second, the results show that the unfavorable impact of target costing on the development of next generation new products is dependent on the *difficulty* of the target cost as well. Hence, it would be interesting to investigate whether the distinction between an easy and a difficult target cost also determines the impact of target costing on the development of the derivative type of new products, which could not be included in our third experiment because of shortage of participants. Also field research could focus on this distinction in describing the impact of target costing on the cost level.

Third, our study just focuses on one type of "survival triplet". Not elaborating the number of NPD goals, we might be interested in using *another priority* among the quality, the cost and the time objective. Is the detrimental impact of target costing in the next generation experiment caused by the fact that the quality level of the new product was set as the highest priority? If we set the cost level as the most important characteristic of the new product, could we confirm the result of no impact of target costing and/or a negative impact on quality and development time? Furthermore, it could be a promising direction to investigate a broader latitude on time-to-market as well, for instance by defining both the quality and the time-to-market objective as a do-best condition.

<u>Fourth</u>, more research needs to be done on exploring the *boundary conditions* of target costing in inducing cost management of future products. In our study, we started investigating the impact of "difficulty of the target cost", "time pressure" and "type of new products" (or type of required innovation). Though, other factors such as the "number of goals to achieve", "degree of goal conflict", "rewarding structure", "new product development budget", etc. might be worthwhile studying in the lab as well as in the field.

<u>Five</u>, although it was no explicit objective of our study, we found a higher *job-related tension* under target costing, independent of time pressure. An interesting direction for future research could be to develop a more extensive scale to measure the differences in job-related tension to explore its relationship with the impact of target costing. We found also that people used totally *different task strategies* to approach the design problem under target costing than under non-target costing. More research on the impact of target costing (in combination with other objectives such as time-to-market) on the suitability of the different task strategies of design engineers, might provide some more insight on how design engineers make design decisions that affect product life-cycle costs, as posted before by Shields & Young (1994).

8. Conclusion

This study found that target costing influences the behavior of design engineers in designing and developing new products. The impact of target costing on the new product's cost level, quality level and time-to-market is dependent on the difficulty of the target cost, the time pressure during new product development and the type of innovation required in the new product.

Appendix 1: Experiment One
(Vanderbilt University, April 12, 1996)

1. Recruitment Letter of Experiment One

To: All Vanderbilt Students and spouses
From: Patricia Everaert
Subject: Data Collection for Research in Management

Interested in helping me with data collection for testing a hypothesis of my doctoral dissertation? The purpose of the research is to test if different data leads to different behavior in decision making.

I am looking for 45 volunteers to do an easy task, requiring no special skills, no effort and it involves no conceivable risk of any kind.

The whole exercise will take no longer than one hour and a half. During the first 15 minutes I will explain the task, then you have one hour time to do the small task and then I will ask you to answer a small questionnaire of one page. Your "performance" on this task and the answers on the questionnaire will stay anonymous.

Participation is voluntary, refusal to participate will involve no penalty, and as a participant you might discontinue participation at any time during the exercise without penalty.

Six participants will get a bonus of $10.00 each, six other participants a bonus of $20.00 each.
This experiment is supervised by professor Böer of The Owen Graduate School of Management and by professor Lappin of the Psychology Department, Vanderbilt University.

As a participant, you will have access to the (anonymous) results.

If you have questions, you can call me at 421-1991 or send me an email message.

Thanks for your cooperation.

Patricia Everaert
Visiting Scholar at Owen
Email: everaepc@ctrvax.vanderbilt.edu
Phone: 421-1991

1/2

Please, sign up if you are willing to participate:

1. Friday April 12, 1996 from 8.30 AM to 10.00 AM, Wilson Hall, room 120
2. Friday April 12, 1996 from 11.00 AM to 12.30 PM, Owen School, room 126
3. Friday April 12, 1996 from 4.00 PM to 5.30 PM, Owen School, room 126
4. Friday April 19, 1996 from 8.30 AM to 10.00 AM, Wilson Hall, room 120
5. Friday April 19, 1996 from 4.00 PM to 5.30 PM, Owen School, room 126
6. Thursday May 16, 1996 from 1.00 PM to 2.30 PM, Owen School, room 126

Name: ....

Phone: ....

Email: ....

2/2

2. List of Participants of Experiment One

	Last Name	First Name	Signed-up	Participated (Yes/No)
1	Acevedo	Carlos	Yes	Yes
2	Baur	McKay	Yes	No
3	Benujin	Lao	Yes	Yes
4	Blanchette	Valerie	Yes	Yes
5	Brossard	Hubert	Yes	Yes
6	Chatterjee	Patrali	Yes	Yes
7	Cliff	Karissa	Yes	Yes
8	Corbet	Charles	Yes	Yes
9	Delgado	Manuel	Yes	Yes
10	Dewar	Heather	Yes	Yes
11	Drannan	Danny	Yes	Yes
12	Egle	Anders	Yes	Yes
13	Erickson	Taylor	Yes	Yes
14	Figueiro	Isabel	Yes	Yes
15	Fisher	Tami	Yes	No
16	Frederickson	Taylor	Yes	Yes
17	Gomez	Louis-Fernando	Yes	Yes
18	Gsching	Silke	Yes	Yes
19	Guardiola	Jose	Yes	Yes
20	Hauri	Sepp	Yes	Yes
21	Henderson	Douglas	Yes	Yes
22	Hill	Craig	Yes	Yes
23	Hollinger	Chris	Yes	Yes
24	Janosik	J.J.	Yes	Yes
25	Klunzinger	Lynn	Yes	Yes
26	Laiuellen	Denis	Yes	Yes
27	Lakshmanan	Shiva	Yes	Yes
28	Lazareva	Elena	Yes	Yes
29	Lutz	Kristy	Yes	Yes

30	Massuda	Gina	Yes	Yes
31	McCarthy	Brandon	Yes	Yes
32	Michel	Sabine	Yes	Yes
33	Narasimhan	Anand	Yes	Yes
34	Narasimhan's wife	Anand	Yes	Yes
35	Pillsbury	Steve	Yes	Yes
36	Rauch	Stephanie	Yes	Yes
37	Salinas	Cote	Yes	Yes
38	Sedks	Omar	Yes	Yes
39	Sircely	Bryan	Yes	Yes
40	Sonu	Bhalla	Yes	Yes
41	Stefanov	Stefan	Yes	Yes
42	Trigueros	Alvaro	Yes	Yes
43	Varkis	Sajeev	Yes	Yes
44	Wang	Yiwen	Yes	Yes
45	Waterson	Andrew	Yes	Yes
46	Watson	Mary	Yes	Yes
47	Williamson	Mary	Yes	Yes
			Total	*45*

3. Instruction Sheets to Participants of Experiment One

Instruction Sheets

Thank you so much for your cooperation. If I can do something to help you, please let me know.

Patricia Everaert

1/11

Some Practical Comments

You received:

1. a card with your number
2. a set of 9 color pencils
3. an eraser
4. a pen
5. 2 bundles of paper:

    this instruction sheet bundle and
    a bundle with patterns

Please check now.

Remark: You might or might not have received the same instructions for the exercise as your neighbor. So don't compare your task with the task of your neighbor!

Please wait before reading the next page!

2/11

Pattern

From now on, you are carpet designers.

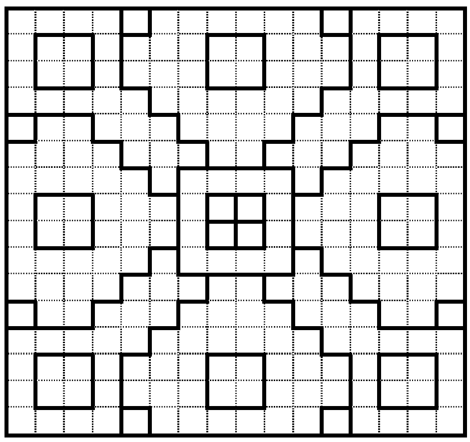
Your task is to design a carpet for the market of student's bedrooms (like dormitories). Your boss decided on the type of design, but you have to decide on the colors of the carpet. You find this basic design in the second half of this page. For your information, this pattern represents more or less a squared yard.

Make sure you see the difference between the small area's and the fields surrounded by the dark lines. Take a look at that design now. How many small areas did you count? How many dark line fields did you find?

Since your boss decided already on the type of design, you can only use a different color within each dark line field. You CAN NOT use different colors within the same dark line field. If you want to make neighbor areas in the same color, you can. You can decide to make your color choice symmetric (i.e. equal size "dark line fields" in the same color), but this is NOT a requirement.

The instructor will show a good and a bad example on slides.

If you still have questions after these examples, ask her.



There are 16 * 16 small areas, i.e. 256 in total.

There are 29 dark line fields:	4 dark line fields of 30 small areas =	120 small areas
	4 dark line fields of 20 small areas =	80 small areas
	1 dark line field of 12 small areas =	12 small areas
	8 dark line fields of 4 small areas =	32 small areas
	12 dark line fields of 1 small area =	12 small areas
	29 dark line fields in total =	256 small areas

Please wait before reading the next page!

3/11

Colors

You received a set of 9 color pencils:

blue,
orange,
green,
brown,
yellow,
black,
sky blue,
red and
violet.

If you leave an area blank, this means you use the color white.

So in total you can decide between 10 different colors, i.e. the 9 color pencils and white.

Make sure you know the difference between blue, sky blue and violet.

You can use as many of these colors as you want, but you CAN NOT combine colors, since these are the 10 colors we have in yarn. They look the same in reality as the color pencils you are using now.

Please, use only these pencils to color the designs. Don't use the pen as a color.

Please wait before reading the next page!

4/11

Costs: Page 1

As design engineer, you know of course a lot about the cost of the carpets you create.

You know that the cost of a carpet is mainly determined
1) by the sort of colors you use and
2) by the number of colors you use.

You know that there exists 3 categories of colors: the neutral colors, the bright colors and the dark colors. Yarn in neutral colors are the least expensive, yarn in light colors are more expensive and yarn in dark colors are the most expensive.

These 3 classes of colors are:

Class A: Neutral colors:
white
black

Class B: Light colors:
yellow
orange
sky blue

Class C: Dark colors:
blue
violet
brown
red
green

Please wait before reading the next page!

5/11

Costs: Page 2

You also know that the machines have a standard setting of 5 colors. These are called the standard colors. You can decide yourself which colors you will use as standard colors. If you use an additional color (i.e. a sixth, a seventh, an eight, a ninth or a tenth color), the machines will have to be set up more times, making this additional color more expensive.

Make sure you understand the following table. The cost of the colored yarn is given for each small area:

	cost per small area standard color	cost per small area additional color
	Class A:	Class A+:
White	$0.10	$ 0.20
Black	$0.10	$ 0.20
	Class B:	Class B+:
Yellow	$0.30	$ 0.40
Orange	$0.30	$ 0.40
Sky blue	$0.30	$ 0.40
	Class C:	Class C+:
Red	$ 0.50	$ 0.60
Brown	$ 0.50	$ 0.60
Blue	$ 0.50	$ 0.60
Violet	$ 0.50	$ 0.60
Green	$ 0.50	$ 0.60

Lets have a look at a few examples now.

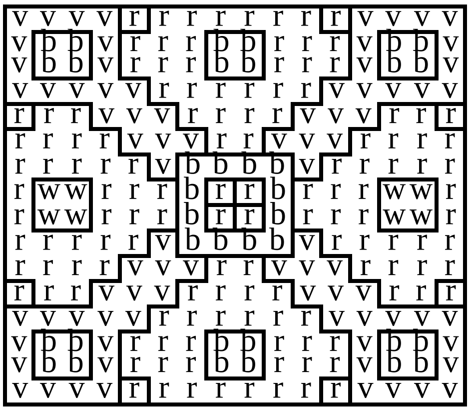
If you have questions after those examples, please ask your instructor.

Please wait before reading the next page!

6/11

Costs: Page 3

Example 1:



r = red, b = blue, w = white, v = violet

color	type	cost	total	color	type	cost	Total
30:red	C	30 * 0.50	= 15.00	1: red	C	1 * 0.5	= 0.50
30: red	C	30 * 0.50	= 15.00	1: red	C	1 * 0.5	= 0.50
30: red	C	30 * 0.50	= 15.00	1: red	C	1 * 0.5	= 0.50
30: red	C	30 * 0.50	= 15.00	1: red	C	1 * 0.5	= 0.50
20: violet	C	20 * 0.50	= 10.00	1: red	C	1 * 0.5	= 0.50
20: violet	C	20 * 0.50	= 10.00	1: red	C	1 * 0.5	= 0.50
20: violet	C	20 * 0.50	= 10.00	1: red	C	1 * 0.5	= 0.50
20: violet	C	20 * 0.50	= 10.00	1: red	C	1 * 0.5	= 0.50
12: blue	C	12 * 0.50	= 6.00	1: red	C	1 * 0.5	= 0.50
4: white	A	4 * 0.10	= 0.40	1: red	C	1 * 0.5	= 0.50
4: white	A	4 * 0.10	= 0.40	1: red	C	1 * 0.5	= 0.50
4: bleu	C	4 * 0.50	= 2.00	1: red	C	1 * 0.5	= 0.50
4: blue	C	4 * 0.50	= 2.00				6
4: blue	C	4 * 0.50	= 2.00				
4: blue	C	4 * 0.50	= 2.00				
4: blue	C	4 * 0.50	= 2.00				
4: blue	C	4 * 0.50	= 2.00				
			118.8				118.8 + 6
							124.8

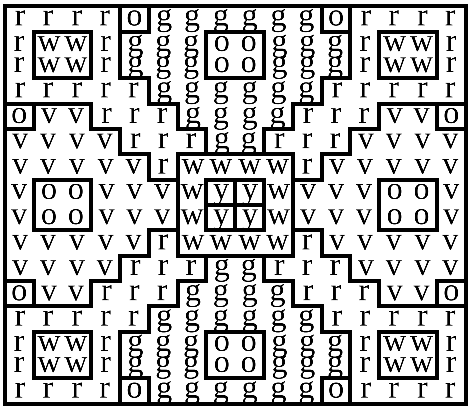
We are using here 4 colors. So there are no additional costs (no A+, no B+, no C+).
All costs per small area are coming from the second column of the cost table of the previous page.

Please wait before reading the next page!

7/11

Costs: Page 4

Example 2:



r = red, g = green, v = violet, o = orange, w = white, y = yellow

color	type	cost	total	color	type	cost	Total
30:green	C	30 * 0.50	= 15.00	1: orange	B	1 * 0.3	= 0.30
30: green	C	30 * 0.50	= 15.00	1: orange	B	1 * 0.3	= 0.30
30: violet	C	30 * 0.50	= 15.00	1: orange	B	1 * 0.3	= 0.30
30: violet	C	30 * 0.50	= 15.00	1: orange	B	1 * 0.3	= 0.30
20: red	C	20 * 0.50	= 10.00	1: orange	B	1 * 0.3	= 0.30
20: red	C	20 * 0.50	= 10.00	1: orange	B	1 * 0.3	= 0.30
20: red	C	20 * 0.50	= 10.00	1: orange	B	1 * 0.3	= 0.30
20: red	C	20 * 0.50	= 10.00	1: orange	B	1 * 0.3	= 0.30
12: white	A	12 * 0.10	= 1.20	1: yellow	B+	1 * 0.4	= 0.40
4: white	A	4 * 0.10	= 0.40	1: yellow	B+	1 * 0.4	= 0.40
4: white	A	4 * 0.10	= 0.40	1: yellow	B+	1 * 0.4	= 0.40
4: white	A	4 * 0.10	= 0.40	1: yellow	B+	1 * 0.4	= 0.40
4: white	A	4 * 0.10	= 0.40				4
4: orange	B	4 * 0.30	= 1.20				
4: orange	B	4 * 0.30	= 1.20				
4: orange	B	4 * 0.30	= 1.20				
4: orange	B	4 * 0.30	= 1.20				
			107.6				107.6 + 4
							111.6

We are using here 6 colors: 5 standard colors and one additional color.
Remark that the color with the least total number of small areas (here yellow) should be chosen as the additional color (indicated by a B+ in stead of a regular B).

Please wait before reading the next page!

8/11

Task

You will have 1 hour to create the most attractive carpet. You can start as many copies of the basic design as you want, but at the end of the exercise, i.e. after 60 minutes, you have to decide which carpet is the most attractive according to your OWN opinion.

Since we are going to show your colored design to another student population (the market), make sure your pattern is not looking dirty and make sure you are not writing anything above the horizontal line. On that line, we will cut your design in 2 parts: the pattern part and the cost part. The so-called market will only see the design itself without your cost calculation.

Remember you have to design a carpet for a student's bedroom (dormitory) and remember that the pattern is more or less 1 squared yard.

[Group 1: Non-Target Cost Setting]
However there is more ....
Your boss wants you to create an attractive carpet, while trying to minimize the cost of that carpet. I.e. your boss thinks that the market for student bedroom carpets is not willing to pay a lot of money. Based on market research, he/she thinks that the company can only survive in this market segment of student bedroom carpets if you come up with an attractive carpet with the lowest cost possible.
To summarize, you should turn in the most attractive carpet ACCORDING TO YOUR OWN NORMS, but that has the lowest cost possible. So, you made several carpets that you really like, you should turn in that carpet with the lowest cost.

[Group 2: Easy Target Cost Setting]
However there is more ....
Last's year top model had a total cost of $103. Your boss wants you to create an attractive carpet for this year that costs no more than this amount of $103. I.e. your boss thinks that the market for student bedroom carpets is not willing to pay a lot of money. Based on market research, he/she thinks that the company can only survive in the market segment of student bedroom carpets if you come up with an attractive carpet with a total cost of $103 or less.
So, you should turn in a carpet that is the most attractive ACCORDING TO YOUR OWN NORMS but that has a cost not higher than $103, unless you really think that designing an attractive carpet under that price is impossible.

[Group 3:Difficult Target Cost Setting]
However there is more ....
Last's year top model had a total cost of $60. Your boss wants you to create an attractive carpet for this year that costs no more than this amount of $60. I.e. your boss thinks that the market for student bedroom carpets is not willing to pay a lot of money. Based on market research, he thinks that the company can only survive in the market segment of student bedroom carpets if you come up with an attractive carpet with a total cost of $60 or less.
So, you should turn in a carpet that is the most attractive ACCORDING TO YOUR OWN NORMS but that has a cost not higher than $60, unless you really think that designing a attractive carpet under that price is impossible. *9/11*

Bonus

In total there are 15 design engineers in your firm. They might or might not be in the same room as you are now. But they are all Vanderbilt Students (or spouses), who volunteered in this experiment and who have absolutely no experience in designing carpets. There should be no difference in ability to create carpets between you all.

In the next week, all 15 carpets (i.e. one of each person) will be showed to another group of 15 students. They will give a score from 1 to 5 to your carpet. Based on these scores, the computer will calculate the overall score of all 15 designs.

The designers of the 4 most attractive carpets receive a bonus of $10.00.

Among those 4 best ranked, the 2 carpet designers of the carpet with the lowest cost will get an additional bonus of $10.00.

If all 4 designs would have a carpet with the same cost, then all 4 will receive this additional bonus.

You have to believe us, that we will pay you the bonus (at last) in the week of May 20th, 1996.

We are not interested in who made the carpets, until this very last moment when we have to pay you your bonus. We don’t want to know who the designer of each carpet is until then and we don’t want to give your name to the persons rank ordering the carpets. So we made it anonymous with the number you get.

You received a card with a number on it. This number was assigned to you at random.
We ask you to write your name on this card. An envelope will go around and you can put your card in it. This envelope will be closed until the 4 best designs are selected by another group of 15 students, as mentioned above. Your instructor will ask a volunteer to place her/his signature on the seal. This same person will also be contacted when the best designs are selected to open this same envelope and to confirm that the seal has not been broken. For reasons of safety, we will save this envelope till that moment.

It might be interesting to know for us what is the best way to reach you before May 20th, 1996. So, write now your name and phone number (address or email address) on that card and put it in the envelope.
If you have questions, please ask your instructor now.

Please wait before reading the next page!

10/11

Summary

Let's briefly summarize your task.

1. You are carpet designers and can use 10 different colors in your design: 9 pencils and white. Do not combine these pencils to get a new color.

2. Remember to use one color within the dark line fields.

3. **[Group 1: Non-Target Cost Setting:]** Your boss asks you to design a carpet for student bedrooms at a minimal possible cost.

   [Group 2: Easy Target Cost Setting:] Your boss asks you to design a carpet for student bedrooms that cost not more than $103.00.

   [Group 3: Difficult Target Cost Setting:] Your boss asks you to design a carpet for student bedrooms that cost not more than $60.00.

4. The 4 most attractive creations out of the 15 get a bonus of $10.00. The 2 carpets among those 4 with the lowest cost, get an additional bonus of $10.00, making their total bonus $20.00 in total.

5. You have 60 minutes time and can create as much carpets as you want, but at the end you should select the most attractive carpet according to your own norms, by taking the cost restriction of your boss into account. Make sure this carpet is a fully colored pattern (except for the white areas). You can keep your "non selected" designs if you want.

Here goes the cost table again.

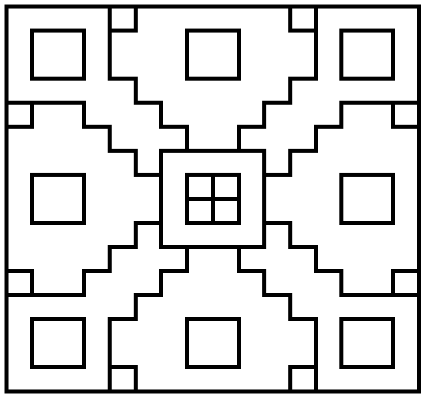
	cost per small area standard color	cost per small area additional color
	Class A:	Class A+:
White	$0.10	$0.20
Black	$0.10	$0.20
	Class B:	Class B+:
Yellow	$0.30	$0.40
Orange	$0.30	$0.40
Sky blue	$0.30	$0.40
	Class C:	Class C+:
Red	$ 0.50	$0.60
Brown	$ 0.50	$0.60
Blue	$ 0.50	$0.60
Violet	$ 0.50	$0.60
Green	$ 0.50	$0.60

You can start with the design task now. Good luck designer!

11/11

4. Pattern Sheet of Experiment One

ID_Number



ID_Number

color	type	cost	total
30:		30 *	=
30:		30 *	=
30:		30 *	=
30:		30 *	=
20:		20 *	=
20:		20 *	=
20:		20 *	=
20:		20 *	=
12:		12 *	=
4:		4 *	=
4:		4 *	=
4:		4 *	=
4:		4 *	=
4:		4 *	=
4:		4 *	=
4:		4 *	=
4:		4 *	=

color	type	cost	total
1:		1 *	=
1:		1 *	=
1:		1 *	=
1:		1 *	=
1:		1 *	=
1:		1 *	=
1:		1 *	=
1:		1 *	=
1:		1 *	=
1:		1 *	=
1:		1 *	=
1:		1 *	=

1/1

5. Overhead Sheets for the Instructions of Experiment One

Overhead Sheet 1

Page 2: Some practical comments

Page 3: Pattern

Page 4: Colors

Page 5: Costs: Page 1

Page 6: Costs: Page 2

Page 7: Costs: Page 3

Page 8: Costs: Page 4

Page 9: Task

Page 10: Bonus

Page 11: Summary

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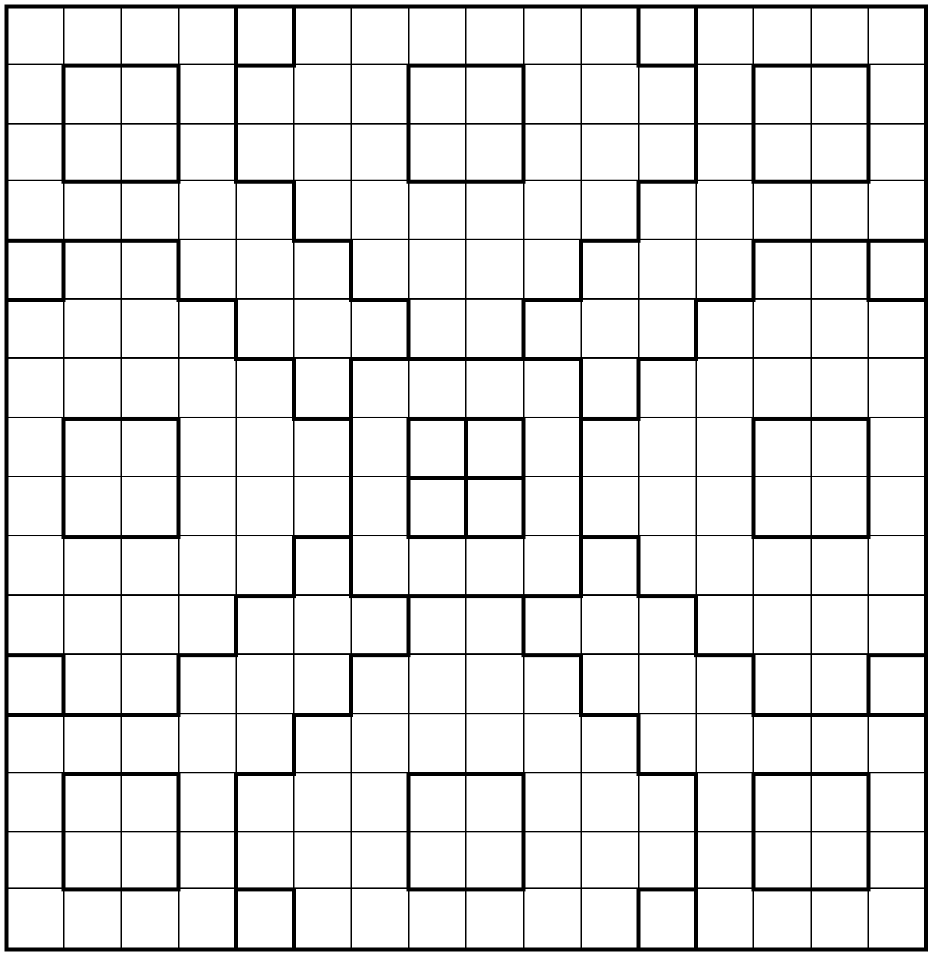
Overhead Sheet 2



2/4

Overhead Sheet 3

v	v	v	v	r	r	r	r	r	r	r	r	v	v	v	v
v	b	b	v	r	r	r	b	b	r	r	r	v	b	b	v
v	b	b	v	r	r	r	b	b	r	r	r	v	b	b	v
v	v	v	v	v	r	r	r	r	r	r	v	v	v	v	v
r	r	r	v	v	v	r	r	r	r	v	v	v	r	r	r
r	r	r	r	v	v	v	r	r	v	v	v	r	r	r	r
r	r	r	r	r	v	b	b	b	b	v	r	r	r	r	r
r	w	w	r	r	r	b	r	r	b	r	r	r	w	w	r
r	w	w	r	r	r	b	r	r	b	r	r	r	w	w	r
r	r	r	r	r	v	b	b	b	b	v	r	r	r	r	r
r	r	r	r	v	v	v	r	r	v	v	v	r	r	r	r
r	r	r	v	v	v	r	r	r	r	v	v	v	r	r	r
v	v	v	v	v	r	r	r	r	r	r	v	v	v	v	v
v	b	b	v	r	r	r	b	b	r	r	r	v	b	b	v
v	b	b	v	r	r	r	b	b	r	r	r	v	b	b	v
v	v	v	v	r	r	r	r	r	r	r	r	v	v	v	v

r = red, b = blue, w = white, v = violet

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Overhead Sheet 4

r	r	r	r	o	g	g	g	g	g	g	o	r	r	r	r
r	w	w	r	g	g	g	o	o	g	g	g	r	w	w	r
r	w	w	r	g	g	g	o	o	g	g	g	r	w	w	r
r	r	r	r	r	g	g	g	g	g	g	r	r	r	r	r
o	v	v	r	r	r	g	g	g	g	r	r	r	v	v	o
v	v	v	v	r	r	r	g	g	r	r	r	v	v	v	v
v	v	v	v	v	r	w	w	w	w	r	v	v	v	v	v
v	o	o	v	v	v	w	y	y	w	v	v	v	o	o	v
v	o	o	v	v	v	w	y	y	w	v	v	v	o	o	v
v	v	v	v	v	r	w	w	w	w	r	v	v	v	v	v
v	v	v	v	r	r	r	g	g	r	r	r	v	v	v	v
o	v	v	r	r	r	g	g	g	g	r	r	r	v	v	o
r	r	r	r	r	g	g	g	g	g	g	r	r	r	r	r
r	w	w	r	g	g	g	o	o	g	g	g	r	w	w	r
r	w	w	r	g	g	g	o	o	g	g	g	r	w	w	r
r	r	r	r	o	g	g	g	g	g	g	o	r	r	r	r

r = red, g = green, v = violet, o = orange, w = white,
y = yellow

4/4

6. Post Experimental Questionnaire of Experiment One

Group 1:Non-Target Cost Setting

Checkout Questionnaire

Before you leave, could you answer some general questions. These answers will not be analyzed on an individual basis. Nobody will know your answers on these questions, only general results will be concluded.

1. I am a
   - ▫ undergraduate student
   - ▫ MBA student
   - ▫ Ph.D. student
   - ▫ other, please specify: ....

2. My department or school is:
   - ▫ Psychology Department
   - ▫ Economics Department
   - ▫ Owen Graduate School of Management
   - ▫ other, please specify: ....
   - ▫ I am a spouse

3. Have you had experience with this sort of task, before?
   - ▫ yes, please specify: ....
   - ▫ no

4. Did you like the task in this exercise?

very interesting		somewhat interesting		very boring
▫	▫	▫	▫	▫

5. How do you think about the cost of your final selected carpet?

extremely low cost		low cost		rather high cost
▫	▫	▫	▫	▫

6. How do you feel about the time period of 1 hour to fulfill this task?

too long		just right		too short
▫	▫	▫	▫	▫

7. How many designs did you made in total (more or less)? ....

8. Can you guess what the real purpose of this exercise was?
   Please specify:...

9. Gender (optional)
   - ▫ female
   - ▫ male

10. Do you have other comments on this exercise? Please write below or on other side.

1/1

Group 2: Easy Target Cost Setting

Checkout Questionnaire

Before you leave, could you answer some general questions. These answers will not be analyzed on an individual basis. Nobody will know your answers on these questions, only general results will be concluded.

1. I am a
   - ▫ undergraduate student
   - ▫ MBA student
   - ▫ Ph.D. student
   - ▫ other, please specify: ....

2. My department or school is:
   - ▫ Psychology Department
   - ▫ Economics Department
   - ▫ Owen Graduate School of Management
   - ▫ other, please specify: ....
   - ▫ I am a spouse

3. Have you had experience with this sort of task, before?
   - ▫ yes, please specify: ....
   - ▫ no

4. Did you like the task in this exercise?

very interesting — somewhat interesting — very boring

▫ ▫ ▫ ▫ ▫

5. Was the maximum cost of $103.00 (established by your boss) hard to attain?

extremely hard	really hard	hard	easy	really easy
▫	▫	▫	▫	▫

6. How do you feel about the time period of 1 hour to fulfill this task?

too long — just right — too short

▫ ▫ ▫ ▫ ▫

7. How many designs did you made in total (more or less)? ....

8. Do you remember how many of these designs were below the maximum cost? ....

9. Can you guess what the real purpose of this exercise was?
   Please specify:..

10. Gender (optional)
    - ▫ female ▫ male

11. Do you have other comments on this exercise? Please write below or on other side.

1/1

Group 3: Difficult Target Cost Setting

Checkout Questionnaire

Before you leave, could you answer some general questions. These answers will not be analyzed on an individual basis. Nobody will know your answers on these questions, only general results will be concluded.

1. I am a
   - ▫ undergraduate student
   - ▫ MBA student
   - ▫ Ph.D. student
   - ▫ other, please specify: ....

2. My department or school is:
   - ▫ Psychology Department
   - ▫ Economics Department
   - ▫ Owen Graduate School of Management
   - ▫ other, please specify: ....
   - ▫ I am a spouse

3. Have you had experience with this sort of task, before?
   - ▫ yes, please specify: ....
   - ▫ no

4. Did you like the task in this exercise?

very interesting		somewhat interesting		very boring
▫	▫	▫	▫	▫

5. Was the maximum cost of $60.00 (established by your boss) hard to attain?

extremely hard	really hard	hard	easy	really easy
▫	▫	▫	▫	▫

6. How do you feel about the time period of 1 hour to fulfill this task?

too long		just right		too short
▫	▫	▫	▫	▫

7. How many designs did you made in total (more or less)? ....

8. Do you remember how many of these designs were below the maximum cost? ....

9. Can you guess what the real purpose of this exercise was?
   Please specify:..

10. Gender (optional)
    ▫ female ▫ male

11. Do you have other comments on this exercise? Please write below or on other side.

1/1

7. Instruction Sheet for the Judges of Experiment One

Thanks for Your Cooperation!

This rank order task is part of an experiment in cost management. Fourty five students have each made a design for a bedroom carpet. In order to determine what the market of students think about their creations, I ask you to make 5 different groups of those 45 carpets:

group 1: your most preferred carpets for a student bedroom (dormitory)
group 2:
group 3:
group 4:
group 5: your least preferred carpets for a student bedroom (dormitory)

Keep in mind you select designs for student's bedrooms (like for a dormitory)!
You can decide yourself how many carpets you assign to each of the 5 groups.

The best strategy to do this task is to make first 3 groups: the ones you "really like", the "don't knows" and the ones you "really don't like". Overlook your selection and go back to end up with 5 groups. You can switch back and forwards as many (and as long) as you want. There is no time constraint, so take your time.

The bonus of the 45 students "creators" depends on your selection, try to do it seriously. Nobody will know your selection. Your name on this sheet is not matched with your selection!! You can stop with this task, if you feel you should do so.

May I ask you to date and sign the following:
I, ... declare that I have read the instructions above and that I understand the rank order task. I also declare that I did the task seriously, without knowledge of the names or id numbers of the students "creators", who made the carpets in the first place.

Date: .... Signature: ....

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8. Scores of the Judges for "Attractiveness" in Experiment One

	Scores from 1 to 5 from the 15 Judges																
ID	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**	**N**	**O**	**Total Score**	**Mean Score**
1	5	2	2	4	2	2	2	1	1	2	4	2	4	3	1	37	2.47
2	5	5	1	4	2	1	2	1	1	4	5	5	3	2	3	44	2.93
3	5	5	3	4	2	2	3	1	1	5	5	3	5	5	3	52	3.47
4	2	5	2	2	3	3	1	1	5	5	4	5	4	4	2	48	3.20
5	4	3	1	1	3	3	5	1	3	5	5	2	4	1	3	44	2.93
6	2	3	2	3	2	4	4	1	2	5	5	4	3	4	2	46	3.07
7	2	4	1	2	2	3	2	1	1	3	5	2	4	3	1	36	2.40
8	2	2	2	1	2	4	1	3	1	1	3	3	1	2	1	29	1.93
9	4	3	1	3	3	2	1	1	1	1	5	1	2	1	2	31	2.07
10	1	2	1	1	3	3	1	1	3	5	1	3	1	2	2	30	2.00
11	5	3	2	4	1	4	2	5	1	3	4	1	5	3	2	45	3.00
12	2	2	1	1	1	1	1	1	1	4	5	4	5	1	3	33	2.20
13	3	1	5	1	5	4	1	5	1	2	1	2	4	2	5	42	2.80
14	5	4	1	3	1	2	3	3	1	3	4	3	5	2	3	43	2.87
15	3	2	4	5	4	5	1	5	5	5	1	4	5	5	5	59	3.93
16	2	4	2	3	2	5	3	1	3	4	4	3	3	4	1	44	2.93
17	1	3	1	1	2	1	2	1	1	1	5	1	2	1	2	25	1.67
18	5	4	1	4	3	2	5	2	5	5	5	5	5	1	3	55	3.67
19	2	3	4	2	2	3	3	2	1	1	3	2	1	1	1	31	2.07
20	3	4	4	5	5	5	1	5	5	5	1	5	2	5	4	59	3.93
21	4	1	4	4	3	3	1	1	1	1	4	1	1	4	1	34	2.27
22	3	1	5	5	4	5	1	4	2	5	3	4	3	3	4	52	3.47
23	2	4	2	5	1	4	1	2	1	3	2	5	2	4	1	39	2.60
24	2	4	2	3	2	3	1	1	1	2	4	2	3	2	1	33	2.20
25	2	3	1	1	1	1	2	1	2	5	5	4	4	1	2	35	2.33
26	4	1	1	1	1	1	1	3	1	1	1	1	4	1	3	25	1.67
27	3	4	3	2	2	5	5	1	4	5	4	5	3	5	2	53	3.53
28	5	4	3	5	1	4	3	3	4	1	3	4	4	4	2	50	3.33
29	1	3	1	1	3	1	3	4	2	2	4	3	3	1	3	35	2.33
30	3	2	4	2	3	5	1	3	3	5	1	5	2	5	2	46	3.07
32	3	4	2	5	4	5	1	3	3	5	1	5	1	5	3	50	3.33
33	3	3	3	4	1	3	3	3	2	4	2	4	4	3	2	44	2.93
34	4	2	1	1	2	5	1	1	1	1	5	1	5	1	1	32	2.13
35	2	3	3	1	2	4	2	3	1	1	3	4	2	3	1	35	2.33
36	1	2	1	1	2	1	2	1	1	2	1	1	1	1	1	19	1.27
37	3	2	3	3	4	3	3	2	1	1	2	2	2	5	2	38	2.53
38	2	2	1	1	2	2	2	1	1	2	5	1	1	1	1	25	1.67
39	3	3	3	2	1	4	2	2	1	4	4	4	1	3	2	39	2.60
40	2	3	2	3	2	3	1	1	1	3	5	1	3	4	1	35	2.33
41	2	2	3	3	3	2	1	2	1	1	2	2	2	2	1	29	1.93
42	5	2	4	5	1	3	5	5	4	4	4	2	3	1	3	51	3.40
43	4	2	3	1	3	5	1	4	1	1	3	4	5	2	2	41	2.73
44	5	3	5	5	4	5	4	3	5	5	4	5	5	5	4	67	4.47
45	4	5	1	2	3	4	1	1	1	1	4	5	1	1	1	35	2.33
46	3	2	4	2	5	4	1	4	2	1	1	2	2	2	4	39	2.60

9. Details of the Bonus Pay in Experiment One

Non-Target Cost Setting				
ID Number	**Mean Score for Attractiveness**	**Cost Level**	**Within 2 lowest cost**	**Total Bonus**
15	3.93	$ 43.20	Yes	$ 20.00
27	3.53	$ 61.60	No	$ 10.00
3	3.47	$ 96.00	No	$ 10.00
11	3.00	$ 25.60	Yes	$ 20.00
Easy Target Cost Setting				
ID Number	**Mean Score for Attractiveness**	**Cost Level**	**Within 2 lowest cost**	**Total Bonus**
20	3.93	$ 44.00	Yes	$ 20.00
18	3.67	$ 128.00	No	$ 10.00
22	3.47	$ 47.20	No	$ 10.00
28	3.33	$ 28.80	Yes	$ 20.00
Difficult Target Cost Setting				
ID Number	**Mean Score for Attractiveness**	**Cost Level**	**Within 2 lowest cost**	**Total Bonus**
44	4.47	$ 56.80	No	$ 10.00
42	3.40	$ 48.00	No	$ 10.00
32	3.33	$ 40.80	Yes	$ 20.00
33	2.93	$ 34.40	Yes	$ 20.00

10. Declaration of the Sealed Envelope in Experiment One

Declaration of Sealed Envelope

I, ... declare that the envelope was still sealed with my name on the seal before I opened it.

I declared that I opened the envelope on .... (date) and found the following names on the green ID cards.

Bonus of $ 20.00:

11 ....

15 ....

20 ....

28 ....

32 ....

33 ....

Bonus of $ 10.00:

3 ....

27 ....

22 ....

18 ....

42 ....

44 ....

Signature: ....

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11. Receipt Form for the Bonus in Experiment One

Bonus $20.00 Receipt

I, ... declare that I had the id number **11** in the experiment done on Friday April 12, 1996 from 11.00-12.30 in room 126, at Owen School of Management, Vanderbilt University, Nashville, Tennessee.

I also declare that I received an envelope with $20.00 from Patricia Everaert on .... (date), because I made a design that was selected as one of the 4 most attractive of all 15 designs made by participants assigned to the experimental group and because my design was one of the 2 cheapest within those 4.
(All 15 participants of the experimental group received the same instructions. Another 15 students of Owen Graduate School did the rank order task in order to decide on the most attractive carpets.)

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12. Guessing Real Purpose of Experiment One

Answers on the Question: "Can you guess what the real purpose of this exercise was?"

ID Number	Non-Target Cost Setting, Easy Time
2	To see if cost had an effect on design choice and color choice.
10	Acceptance of burden.
12	No.
14	To see if cost and design preferences go hand in hand.
16	Relationship of contrast in colors and different colors of attractiveness.
18	See if you choose cheap colors even if they are not the prettiest.
20	No.
24	Market strategy.
26	No idea.
28	How color can affect space and appreciation.
30	Clueless.
	Easy Target Cost Setting, Easy Time
5	No.
7	Nope.
9	To effectively use the tastes of the customer under their budget.
11	Incentive utilization.
13	To test if cost burden affect creativity or the choice of colors.
15	Trade-off between cost minimization and artistic value.
17	To test decision making skills.
19	Might be for purpose of showing how much "material" cost influences the total cost. But might be anything else. I mean in two neutral colors, the cost was $ 25, when I replaced one to class B, the cost increase twice.
21	Maybe marketing.
9	No, I have no clue.
25	Production/Marketing.
27	To see if we can minimize costs before products are made.
29	To evaluate how subjects perceive the different components of the task.
	Difficult Target Cost Setting, Easy Time
32	No.
33	To test spatial perception abilities.
34	To see how I balance the different criteria/restrictions.
35	Reduce or control costs of design.
36	Trade-off between cost and abilities.
37	Balance out artistic expression versus real world business variables such as cost of producing.
38	How a target cost affects performance/quality.
39	Test ability/willingness/ likelihood of cost restriction adherence.
40	No.
41	No idea.
42	Low cost producer.

13. Comments by the Participants of Experiment One

Answers on the Question: "Do you have other comments on this exercise?"

ID Number	Non-Target Cost Setting, Easy Time
4	Very well organized.
8	Good luck.
16	Hard for me to imagine how multiple squares will look like together once the carpet is laid. I personally don't like the asymmetrical nature of the design – too jagged for my test.
18	I enjoyed this. Wishing you good luck with your dissertation.
22	I really like my design.
26	The time went by really fast.
	Easy Target Cost Setting, Easy Time
3	Great idea for the experiment.
23	A fun and worthwhile experiment.
25	Computerize it. Changing two colors can mean redoing the whole carpet.
	Difficult Target Cost Setting, Easy Time
36	Could have been done on line, with a computer. The task is not user friendly.
43	Provide pencil sharpener. [Note from the researcher: One sharpener was provided for the whole group, but you might not have noticed.]
44	What colors students like might depend upon school's colors.

14. Written Feedback to the Participants of Experiment One

To: All 45 participants of the experiment
From: Patricia Everaert (everaepc@ctrvax.vanderbilt.edu)
Re: Feedback on the experiment

0. Thanks

Thank you so much for participating. You all did a great job. Thank you! This is a summary of the results. If you want the full paper, please ask me.

1. Three Different Groups

There were three different sets of instructions. People with an odd number (under 30) were assigned to the experimental group 1, people with an id number >31 were assigned to the experimental group 2 and people with an even number (under 30) were assigned to the control group.

2. Bonus

You probably remember from the instructions sheets that I promised a bonus of $10.00, if your carpet was selected as one of the 4 most attractive of the 15 carpets designed by participants who received the same instructions as you. Furthermore, I promised an additional bonus of $10.00 to the 2 cheapest designs among those 4.

In order to decide on the 4 most attractive carpets in each group, another 15 students did a scoring task with the following results:

Control group: 4 most attractive perceived carpets for a student bedroom

18	**cost = 128**	**bonus = $10.00**
20	**cost = 44**	**bonus = $20.00**
22	**cost = 47.2**	**bonus = $10.00**
28	**cost = 28.8**	**bonus = $20.00**

Experimental group 1: 4 most attractive perceived carpets for a student bedroom

3	**cost = 96.0**	**bonus = $10.00**
11	**cost = 25.6**	**bonus = $20.00**
15	**cost = 43.2**	**bonus = $20.00**
27	**cost = 61.6**	**bonus = $10.00**

Experimental group 2: 4 most attractive perceived carpets for a student bedroom

32	**cost = 40.8**	**bonus = $20.00**
33	**cost = 34.4**	**bonus = $20.00**
42	**cost = 48.0**	**bonus = $10.00**
44	**cost = 56.8**	**bonus = $10.00**

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3. Purpose of the Experiment

The purpose of this experiment is to test if Cooper's statement that working with a hard specified cost target (versus an easy specified costs target versus an unspecified vague cost objective) leads to better cost performance of design engineers. Cooper argues that designing to a specified low cost appears to create more intense pressure to reduce costs than designing to an unspecified minimum cost. The experimental group 1 received the task to design the most attractive carpet without having a cost higher than $103.00. The experimental group 2 received the task to design the most attractive carpet without having a cost higher than $60.00, i.e. a much more difficult cost objective. The control group received the task to design the most attractive carpet while trying to minimize the cost of it.

4. Hypotheses and Results

1. It was hypothesized that each category of students had the same ability to create carpets in terms of costs and attractiveness. For instance, undergraduates are not doing better (or worse) than MBA's or Ph.D.-students, there is no difference between female and males; there is no significant difference between students of Owen School, the Psychology Department, the Economics Department or Arts & Science students. This hypothesis was not approved. Females seems to be better in terms of perceived attractiveness ($p = 0.014$) and also undergraduates are doing better, though not significant in terms of perceived attractiveness ($p = 0.076$).

2. There is a significant group difference between the 3 groups (easy cost goal vs. difficult cost goal vs. unspecified cost goal) on cost performance. The dependent variable "cost performance" was quantified by the calculated cost of the designs. This hypothesis was confirmed by the data ($p=0.027$).

Variable	Value	Label	Mean	Std Dev	Cases
		entire population	65.7311	27.8729	45
CONDITION	1	easy target cost condition	73.4133	28.0949	15
CONDITION	2	non-target cost condition	73.5733	32.8266	15
CONDITION	3	difficult target cost condition	50.2067	13.6905	15

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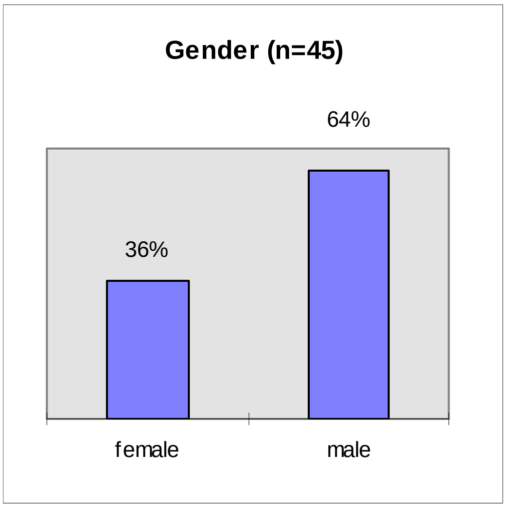
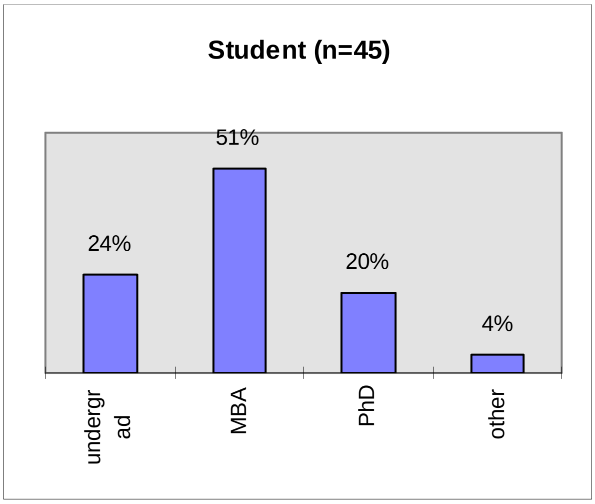
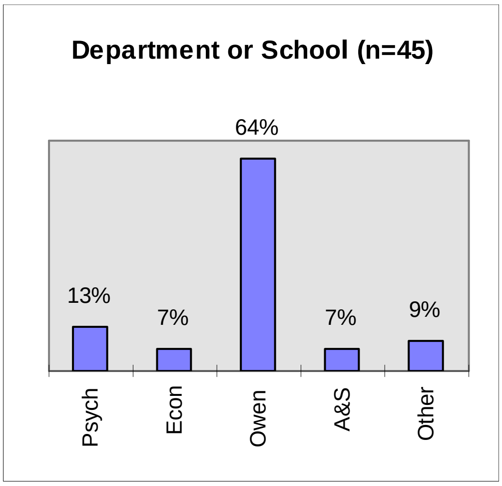
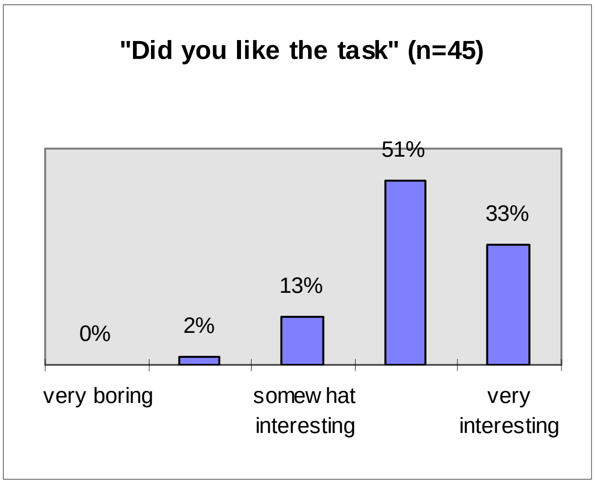
5. Descriptive Statistics

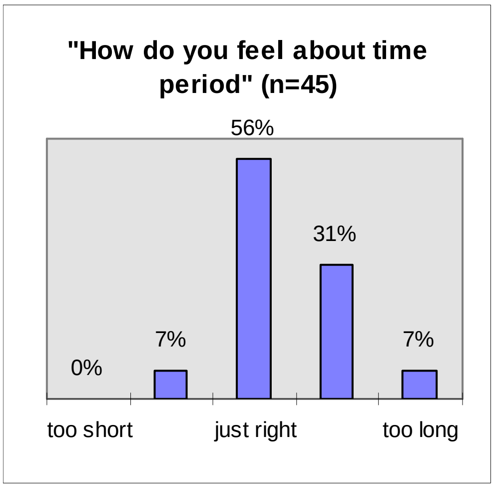


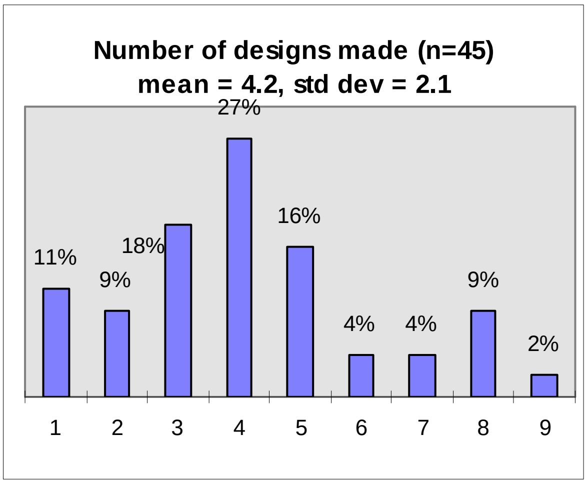


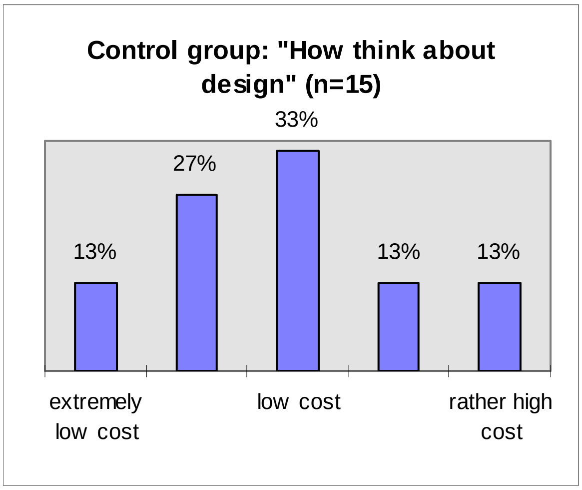


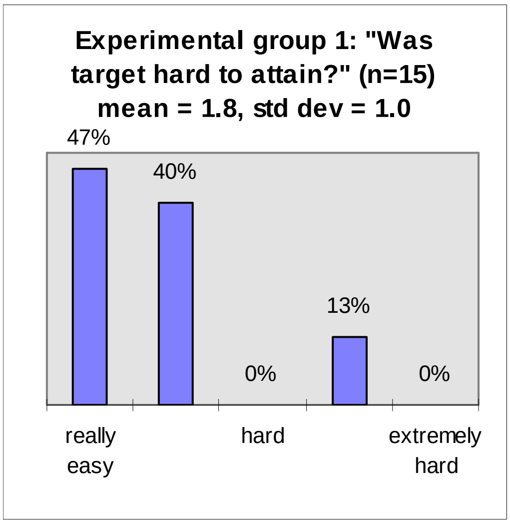


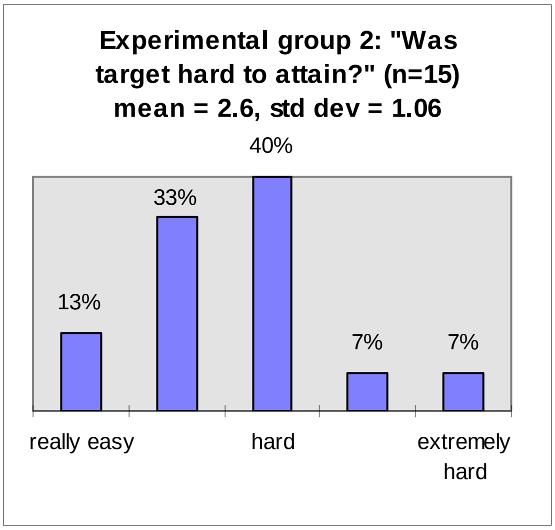
3/5


"How do you feel about time period" (n=45)
0%
7%
56%
31%
7%
too short
just right
too long

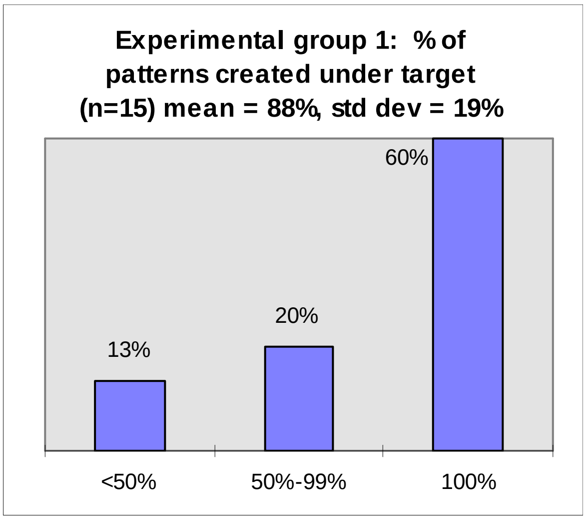

Number of designs made (n=45)
mean = 4.2, std dev = 2.1
11%
9%
18%
27%
16%
4%
4%
9%
2%
1
2
3
4
5
6
7
8
9

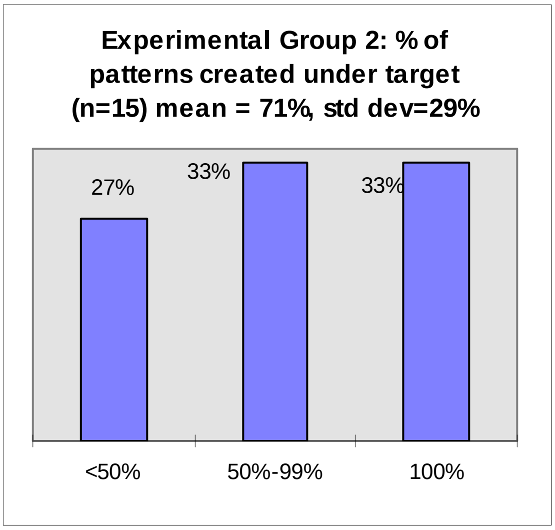

Control group: "How think about design" (n=15)
13%
27%
33%
13%
13%
extremely low cost
low cost
rather high cost

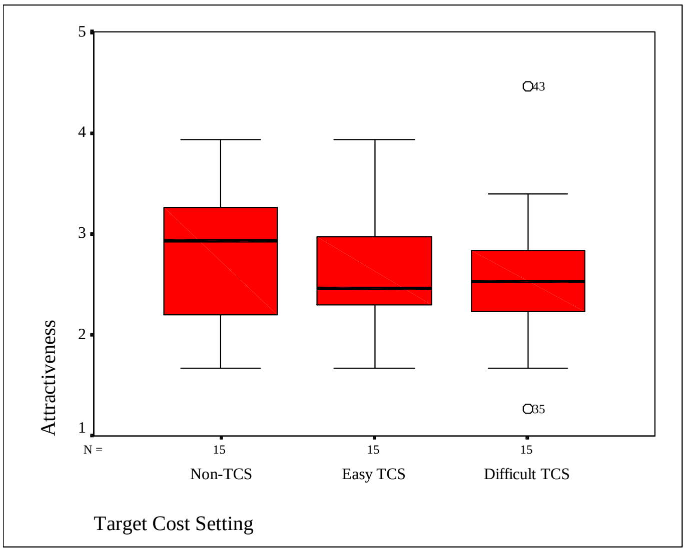

Experimental group 1: "Was target hard to attain?" (n=15)
mean = 1.8, std dev = 1.0
47%
40%
0%
13%
0%
really easy
hard
extremely hard

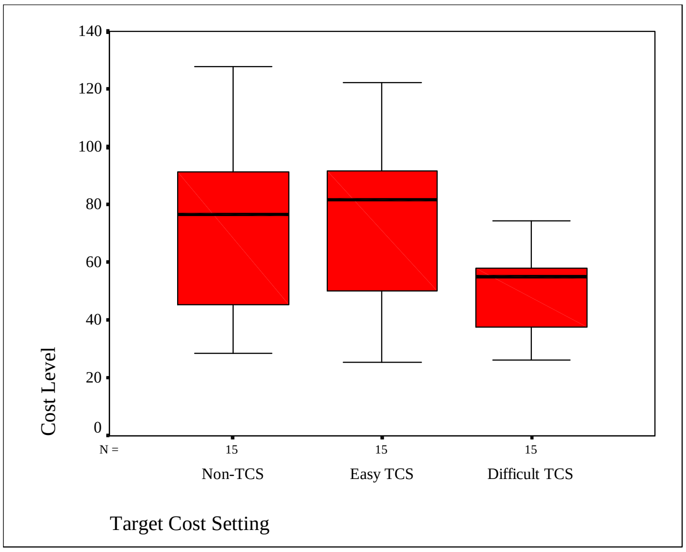

Experimental group 2: "Was target hard to attain?" (n=15)
mean = 2.6, std dev = 1.06
13%
33%
40%
7%
7%
really easy
hard
extremely hard

4/5


Experimental group 1: % of patterns created under target (n=15) mean = 88%, std dev = 19%
13%
20%
60%
<50%
50%-99%
100%


Experimental Group 2: % of patterns created under target (n=15) mean = 71%, std dev=29%
27%
33%
33%
<50%
50%-99%
100%


Attractiveness
5
4
3
2
1
43
35
N =
15
15
15
Non-TCS
Easy TCS
Difficult TCS
Target Cost Setting


Cost Level
140
120
100
80
60
40
20
0
N =
15
15
15
Non-TCS
Easy TCS
Difficult TCS
Target Cost Setting

5/5

Appendix 2: Experiment Two
(University of Ghent, March 11, 1999)

1. Recruitment Letter of Experiment Two (in Dutch)

U

Gent, 13/01/1999

Betreft: Laatste sessie van het vak "Inleiding tot het Industrieel Beheer"

Aan de studenten 3de proef bio-ingenieur,

De studenten 3de proef bio-ingenieur krijgen de mogelijkheid om deel te nemen aan een laatste vrijblijvende sessie in het kader van de cursus "Inleiding tot het Industrieel Beheer". Deze laatste sessie gaat door op:

Datum:	Donderdag 11 maart 1999
Tijdstip:	van 14.00 uur stipt tot 17.00 uur
Plaats:	Auditorium I, Faculteit Economie, Hoveniersberg 4, 9000 Gent. *Hoveniersberg is het steegje in de Sint-Pietersnieuwstraat, schuin over Blandijn.* Zie schets op 3/3.

De deelname aan deze laatste sessie is *niet* verplicht. Studenten die deelnemen aan deze laatste sessie krijgen als *beloning* voor hun aanwezigheid, één extra punt (op 20) bij de eindscore voor het vak "inleiding tot het industrieel beheer". Enkele voorbeelden:

- Student X scoort op het schriftelijk examen 7 op 20. Student X was aanwezig op de laatste sessie, dus zijn/haar eindscore voor het vak "inleiding tot het industrieel beheer" zal 8 op 20 bedragen. Indien hij/zij niet aanwezig was op de laatste sessie, zal zijn/haar score 7 op 20 blijven.
- Student Y scoort op het schriftelijk examen 11 op 20. Student Y was aanwezig op de laatste sessie, dus zijn/haar eindscore voor het vak "Inleiding tot het industrieel beheer" zal 12 op 20 bedragen. Indien hij/zij niet aanwezig was op de laatste sessie, zal zijn/haar score 11 op 20 blijven.
- Student Z scoort op het schriftelijk examen 19,5 op 20. Student Z was aanwezig op de laatste sessie, dus zijn/haar eindscore voor het vak "Inleiding tot het industrieel beheer" zal 20 op 20 bedragen. Indien hij/zij niet aanwezig was op de laatste sessie, zal zijn/haar score 19,5 op 20 blijven.

Studenten die niet deelnemen aan deze laatste sessie, zullen op geen enkele manier een nadelige invloed ondervinden. Het schriftelijk examen zal *niet* handelen over de inhoud van deze laatste sessie.

Het doel van deze laatste sessie is om aan de hand van een eenvoudige oefening, data te verzamelen voor onderzoeksdoeleinden. De resultaten ervan zullen op een later tijdstip worden meegedeeld. De oefening vraagt *geen* speciale kennis of talenten van de deelnemende studenten. Studenten kunnen zich *niet* op deze sessie voorbereiden. De inhoud van de cursus moet dus nog *niet* in detail zijn gekend tegen deze laatste sessie.

Studenten die verhinderd zijn op deze datum, maar er toch op staan om deel te nemen, gelieve contact op te nemen met Kurt Persoons (kurt.persoons@rug.ac.be).

Om praktische en organisatorische redenen, hadden we graag geweten of we op uw aanwezigheid kunnen rekenen. Daarom vragen wij u om ons bijgaand inschrijvingsformulier zo spoedig mogelijk te willen terug bezorgen. Indien u nog vragen hebt over deze laatste sessie, kunt u steeds terecht bij *Kurt Persoons* (09/264 55 04) of bij *Patricia Everaert* (09/264 35 00).

Vriendelijke groeten,

Prof. Dr. Ir. H. Van Landeghem

Kurt Persoons
kurt.persoons@rug.ac.be

Patricia Everaert
patricia.everaert@rug.ac.be

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3de proef bio-ingenieurs

Invulformulier laatste sessie bij het vak

"Inleiding tot het industrieel beheer"

Prof. Dr. Ir. Hendrick Van Landeghem

Academiejaar 1998-1999

Betreft:	Laatste sessie "inleiding tot het industrieel beheer"
Datum:	Donderdag 11 maart 1999
Tijdstip:	van 14.00 uur stipt tot 17.00 uur
Plaats:	Auditorium I, Faculteit Economie, Hoveniersberg 4, 9000 Gent. *Hoveniersberg is het steegje in de Sint-Pietersnieuwstraat, schuin over Blandijn.*

Naam: ....

☐ Zal niet aanwezig zijn op de laatste sessie van het vak "Inleiding tot het industrieel beheer", op donderdag 11 maart 1999, van 14 uur tot 17 uur.

☐ Zal aanwezig zijn op de laatste sessie van het vak "Inleiding tot het industrieel beheer", op donderdag 11 maart 1999, van 14 uur tot 17 uur.

Om eventuele wijzigingen van datum, tijdstip of lokaal door te geven, vragen wij u ook volgende gegevens te vervolledigen, zodat wij u op tijd kunnen verwittigen:

Mijn adres: ....

....

Mijn telefoon (eventueel van thuis):...

....

Mijn e-mail adres (indien u dit één keer per week raadpleegt):

....

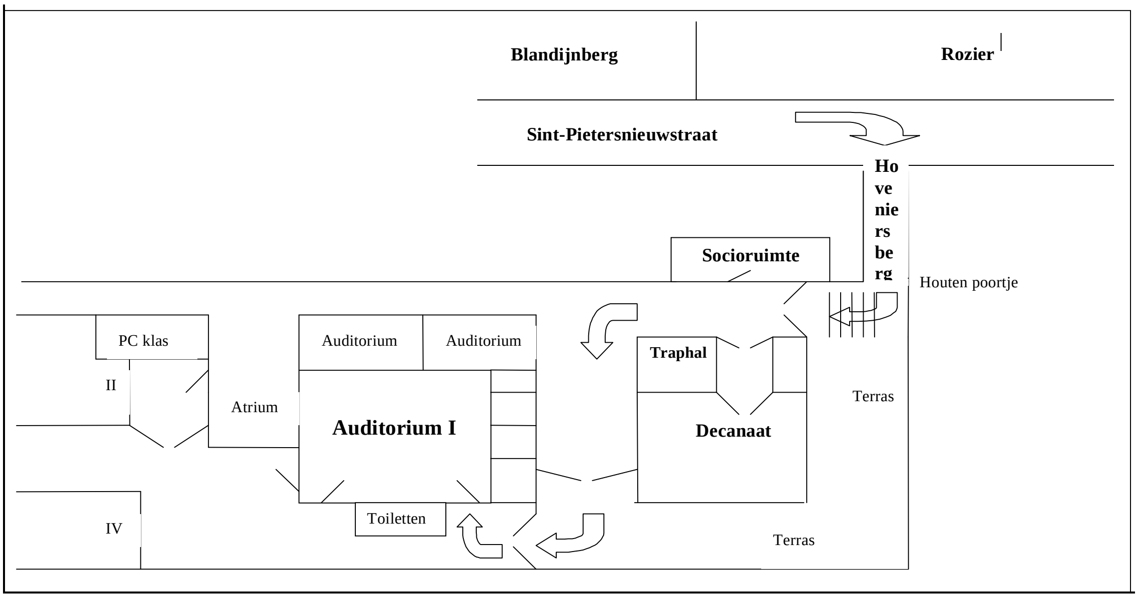
Af te geven aan of terug te sturen voor 31 januari 1999 aan:

Kurt Persoons

Vakgroep Technische Bedrijfsvoering
Technologiepark – Zwijnaarde 9, 9052 Zwijnaarde
Telefoonnummer: 09/264 55 04
Faxnummer: 09/264 58 47

2/3

Wegbeschrijving naar de Faculteit Economie en Bedrijfskunde, Auditorium I Hoveniersberg 4, 9000 Gent



Indien u nog vragen hebt over de locatie van deze laatste sessie "inleiding tot het industrieel beheer", dan kunt u steeds terecht bij Patricia Everaert op het telefoonnummer 09/264 35 00 of via e-mail: patricia.everaert@rug.ac.be

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2. Reminder Message by Email for Experiment Two (in Dutch)

From: Patricia Everaert
Sent: Saturday February 27, 1999; 21.19 h.
So: 'sven.blomme@rug.ac.be'; 'jeroen.debuck@rug.ac.be'; 'barbara.hendrickx@rug.ac.be'; 'erik.meers@rug.ac.be'; 'laurens.theunis@rug.ac.be'; 'bart.vandroogenbroeck@rug.ac.be'; 'thomas.vanleeuwen@rug.ac.be'; 'wim.vanwassenhove@rug.ac.be'; 'tim.verresen@rug.ac.be'; 'wim.ballaux@rug.ac.be'; 'joke.claeys@rug.ac.be'; 'bart.goethals@rug.ac.be'; 'pieter.plets@rug.ac.be'; 'davy.vandewalle@rug.ac.be'; 'ludwig.buts@rug.ac.be'; 'sofie.cabooter@rug.ac.be'; 'pieter.cabus@rug.ac.be'; 'gregory.cloquet@rug.ac.be'; 'benny.dauwe@rug.ac.be'; 'nick.dedecker@rug.ac.be'; 'wim.demare@rug.ac.be'; 'christof.depauw@rug.ac.be'; 'iris.desutter@rug.ac.be'; 'koen.dewinne@rug.ac.be'; 'jan.mestdagh@rug.ac.be'; 'joris.roels@rug.ac.be'; 'bart.schrever@rug.ac.be'; 'Sofie.vanbruyssel@rug.ac.be'; 'anouk.vandemeulebroecke@rug.ac.be'; 'joriska.vanhaelewyn@rug.ac.be'; 'steven.vantieghem@rug.ac.be'; 'tom.verbrugge@rug.ac.be'; 'peter.vermeire@rug.ac.be'; 'tim.verslycke@rug.ac.be'; 'diederik.rousseau@rug.ac.be'; 'sacha.diaine@rug.ac.be'
Subject: Laatste sessie industrieel beheer op 11/03/99

Beste,
Er is een laatste sessie gepland van het vak inleiding tot het industrieel beheer van prof. Dr. H. Van Landeghem op donderdag 11 maart 1999, van 14.00 u – 17.00 uur, in Auditorium I van de Faculteit Economie en Bedrijfskunde (Hoveniersberg 4, 9000 Gent).

Dit is een totaal vrijblijvende sessie, gezien er op dat moment een oefening zal worden gegeven door Patricia Everaert om data te verzamelen voor onderzoeksdoeleinden. Deelname is dus niet verplicht en wie niet deelneemt zal op geen enkele manier een nadelige invloed ondervinden. Het schriftelijk examen zal dan ook niet handelen over de inhoud van deze sessie op 11 maart. Allicht hebt u van uw medestudenten vernomen dat er een beloning voor deelname wordt voorzien.

Tot nog toe hebben wij van u geen bevestiging ontvangen. Betekent dit dat wij hieruit mogen afleiden dat u niet zal aanwezig zijn op deze laatste sessie? Uit praktische en organisatorische redenen moeten we dit zeker vooraf weten.

Nogmaals, u mag zich zeker niet verplicht voelen om deel te nemen. Als u echter wel zult aanwezig zijn, kunt u dan “replyen” op deze mail naar patricia.everaert@rug.ac.be, zodat we voor u een stoel kunnen reserveren?

Vriendelijke groeten,

Patricia Everaert
University of Ghent, Faculty of Economics and Business Administration
Hoveniersberg 4, 9000 Gent
Phone: 32 (0)9 264 35 00
Fax: 32 (0)9 264 35 00
E-mail: patricia.everaert@rug.ac.be

1/1

3. List of Participants of Experiment Two

	Last Name	First Name	Answer on Reply Form (Yes/ No)	Participated (Yes/No)
Cell & Gene Bioengineering				
1	Blomme	Sven	No reply form returned	-
2	De Buck	Jeroen	No	-
3	De Waele	Katrien	Yes	Yes
4	Dooms	Stefania	Yes	Yes
5	Goossens	Steven	Yes	Yes
6	Heirman	Ans	Yes	Yes
7	Hendrickx	Barbara	Yes	Yes
8	Meers	Erik	No reply form returned	-
9	Schoonooghe	Steve	Yes	Yes
10	Tanghe	Miek	Cancelled	-
11	Theunis	Laurens	No reply form returned	-
12	Van den Plas	Dave	Yes	Yes
13	Vanderdonck	Eric	Yes	Yes
14	Vandermeersch	Erik	Yes	Yes
15	Van Droogenbroeck	Bart	No reply form returned	-
16	Vanhercke	Thomas	Yes	Yes
17	Vanholme	Bartel	Yes	Yes
18	Van Leeuwen	Thomas	No	-
19	Van Wassenhove	Wim	No reply form returned	-
20	Verdurme	Annelies	Yes	Yes
21	Vermeersch	Marieke	Yes	Yes
22	Verresen	Tim	Yes	Yes
			Total	*14*
Chemical Bioengineering				
1	Ballaux	Wim	Yes	Yes
2	Bernaert	Herwig	Yes	Yes
3	Bosteels	Dirk	Yes	Yes
4	Bultynck	Bart	Yes	Yes
5	Cantaert	Ruben	Yes	Yes
6	Claerebout	Isabelle	Yes	Yes
7	Claeys	Joke	Yes	Yes
8	Cocquyt	Jan	Yes	Yes
9	Colpaet	Jeroen	Yes	Yes
10	De Caluwé	Katleen	Yes	Yes
11	De Clippeleir	Claudia	Yes	Yes
12	De Praeter	Caroline	Yes	Yes
13	De Rudder	Tom	Yes	Yes
14	De Wilde	Jurgen	Yes	Yes
15	Dhaenens	Kristof	Yes	Yes
16	Diaine	Sacha	No reply form returned	Yes
17	Eeckman	Hélène	Yes	Yes
18	Florizoone	Stanny	Yes	Yes
19	Foubert	Imogen	Yes	Yes
20	Goethals	Bart	Yes	Yes
21	Kerkaert	Inge	Yes	Yes
22	Kochuyt	Valérie	Yes	Yes
23	Lasure	Muriel	Yes	Yes

24	Laureyn	Inge	Yes	Yes
25	Ledeganck	An	Yes	Yes
26	Mehuys	Sophie	Yes	Yes
27	Mortier	Frédéric	Yes	Yes
28	Notebaert	Eveline	Yes	Yes
29	Philips	Ben	Yes	Yes
30	Plets	Pieter	Yes	Yes
31	Rammeloo	Thomas	Yes	Yes
32	Taelman	Charlotte	Yes	Yes
33	Taverniers	Isabel	Yes	Yes
34	Van Daele	Karin	Yes	Yes
35	Van den Berghe	Erika	Yes	Yes
36	Van De Voorde	Marc	Yes	Yes
37	Vandewaetere	Bart	Yes	Yes
38	Van de Walle	Davy	Yes	Yes
39	Van Hauteghem	Inge	Yes	Yes
40	Van Herck	Jan	Yes	Yes
41	Van Hoecke	Veerle	Yes	Yes
42	Van Royen	Geert	Yes	Yes
43	Vansteenkiste	Leen	Yes	Yes
44	Van Strydonck	Kristel	Yes	Yes
45	Vermeirssen	Vanessa	Yes	Yes
46	Vermeulen	Stéphane	Yes	Yes
47	Veulemans	Roselinde	Yes	Yes
48	Wymeersch	Jens	Yes	Yes
			Total	*48*
			Cumulative Total	*62*
Environment Bioengineering				
1	Accoe	Frederik	Yes	Yes
2	Bekaert	Maarten	Yes	Yes
3	Bols	Jan	Yes	Yes
4	Bossuyt	Bart	Yes	Yes
5	Buts	Ludwig	Yes	Yes
6	Cabooter	Sofie	No	-
7	Cabus	Pieter	Yes	Yes
8	Claeys	Christophe	Yes	Yes
9	Cloquet	Gregory	No	-
10	Cools	Eva	Yes	-
11	Dauwe	Benny	Yes	Yes
12	Debaillie	Frederik	Yes	Yes
13	Debusscher	Diedert	Yes	Yes
14	De Decker	Nick	No reply form returned	-
15	Defoer	Nele	Yes	Yes
16	DeKeyser	Jeroen	No reply form returned	-
17	Demaré	Wim	No reply form returned	Yes
18	Demeestere	Kristof	Yes	Yes
19	De Pauw	Christof	No reply form returned	-
20	Derudder	Maarten	Yes	Yes
21	De Schamphelaere	Karel	Yes	Yes
22	De Sutter	Iris	Yes	Yes
23	De Visscher	Karel	Yes	Yes
24	De Winne	Koen	Yes	-
25	Dumont	Koenraad	Yes	Yes
26	Duville	Katty	Yes	Yes

27	Geuens	Sam	Yes	Yes
28	Goossens	Yves	Yes	Yes
29	Haegeman	Yves	No reply form returned	-
30	Haustraete	Kathy	Yes	Yes
31	Heirwegh	Nathalie	Yes	Yes
32	Hellinck	Nathan	Yes	Yes
33	Huyghebaert	Bram	Yes	Yes
34	Jacquet	Patrick	Yes	Yes
35	Mestdagh	Jan	Yes	Yes
36	Moerman	Olivier	Yes	Yes
37	Nollet	Hendrik	Yes	Yes
38	Nopens	Ingmar	Yes	Yes
39	Raes	Steven	Yes	Yes
40	Roels	Joris	No reply form returned	-
41	Roels	Tine	Yes	Yes
42	Roggeman	Els	Yes	Yes
43	Rousseau	Diederik	No reply form returned	-
44	Sabbe	Sara	Yes	Yes
45	Saey	Karen	Yes	Yes
46	Schippers	Michael	Yes	Yes
47	Schrever	Bart	Yes	-
48	Seghers	Dave	Yes	Yes
49	Tavernier	Daphné	Yes	Yes
50	Tuymans	Annick	Yes	Yes
51	Van Bruyssel	Sofie	Yes	Yes
52	Van Campenhout	Karen	Yes	Yes
53	Van de Meulebroecke	Anouk	No reply form returned	-
54	Van den Abeele	Liesbet	Yes	Yes
55	Van den Daele	Gerd	Yes	Yes
56	Van Eeckhout	Hilde	Yes	Yes
57	Vanhaelewyn	Joriska	No reply form returned	-
58	Van Meirhaehe	Eveline	Yes	Yes
59	Van Renterghem	Steven	Yes	Yes
60	Van Renterghem	Timothy	Yes	Yes
61	Vantieghem	Steven	No reply form returned	Yes
62	Verbrugge	Tom	Yes	Yes
63	Verdonck	Frederik	Yes	Yes
64	Vermeire	Peter	No	-
65	Verslycke	Tim	Yes	Yes
66	Verstichel	Steve	Yes	Yes
67	Vyvey	Daphne	Yes	Yes
68	Wollaert	Eva	Yes	Yes
69	Wouters	Laurent	Yes	Yes
			Total	*55*
			Cumulative Total	*117*
Bioengineering: Other than Cell & Gene, Chemical or Environmental				
1	Jolie	Katleen	No	-
2	Lippens	Wim	Yes	Yes
3	Meyns	Bart	Yes	Yes
4	Anonymous	Anonymous	No reply form returned	Yes
			Total	*3*
			Cumulative Total	*120*

4. Instruction Sheets to Participants of Experiment Two

Instruction sheets

Please wait before reading the next page!

1/17

Some practical comments

You received when entering the room:

1. a card with your number.

On your desk there should be a box with the following items:

2. 1 folder that is open and that contains:

    these instruction sheets and

    a bundle of patterns,

3. 1 folder that is closed and that contains a questionnaire ("vragenlijst"),
4. some napkins to keep your hands clean,
5. a plastic bag to put dirty napkins in,
6. a ballpoint,
7. a set of 9 color pens,
8. a colored picture of a living room interior,
9. two small cards in blue with your number on it,
10. an open envelope.

Please *check now* if you have all these items in your box.

Remark 1: These instruction sheets belong to *you* during the whole exercise. You can make notes on these sheets, if you want.

Remark 2: You might or might not have received the same instructions for the exercise as your neighbor. So don't compare *your* task with the task of your *neighbor*!

Remark 3: This exercise is *voluntary*. You can stop with this exercise, if you feel you should do so.

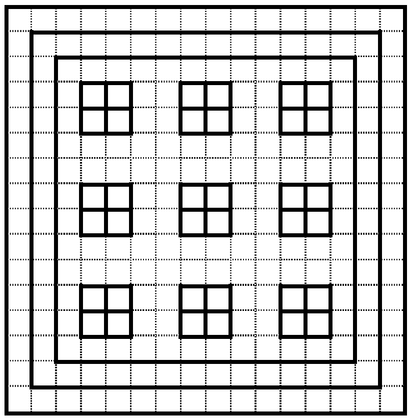
Please wait before reading the next page!

2/17

Pattern

From now on, you are carpet designers. Your task is to design a carpet for a *living room* for the market of young families, with small children. Your boss decided on the type of design, but you have to decide on the colors of the carpet. You find this basic design in the middle of the page. This pattern represents a square of two by two meters.

Make sure you see the difference between the *small squares* and the *predefined fields* of small squares. As you can see, some of the small squares belong together, because a bold line surrounds them. Take a look at that design now.



There are 16 * 16 small squares, i.e. 256 in total.

Outside border:	1 predefined field of 60 small squares =	60 small squares
Inside border:	1 predefined field of 52 small squares =	52 small squares
Background:	1 predefined field of 108 small squares =	108 small squares
Singles:	36 predefined fields of 1 small square =	36 small squares
	39 predefined fields in total	256 small squares

Since your boss decided already on the type of design, you can only use a different color within each predefined field. You can not use *different* colors within the same predefined field. If you want to make neighbor fields in the same color, you can. So, merging fields is allowed, but splitting a predefined field is not allowed. The instructor will show two good and one bad example on slide. If you still have questions after these examples, ask her.

Please wait before reading the next page!

3/17

Colors

You received a set of 9 color pens:

blue,
sky blue,
green,
light green,
yellow,
orange,
red,
brown,
black.

If you leave a square blank, this means you use the color white.

So in total you can decide between *10 different colors*, i.e. the 9 color pens and white.

Make sure you know the difference between:

- *blue* and *sky blue*,
- *green* and *light green*.

You can use as many of these colors as you want, but you *cannot combine* colors, since these are the 10 colors we have in yarn. They look the same in reality as the color pens you are using now.

Please, use only these color pens to color the designs. Don't use the ballpoint as a color.

Please wait before reading the next page!

4/17

Example

Now, you can make *one* design to familiarize yourself with the pattern and the color pens. The purpose is to make an *attractive* carpet for a living room, for the market of young families with small children.

Please use the *first sheet* of the bundle of patterns enclosed. On that first sheet there is a diagonal text saying: "example to clarify the instructions". Do *not* start with the other sheets, since you will need them later on. The second part of this pattern sheet has a table. We will discuss later what the purpose of this table is. Right now, you should only color the pattern on the upper part of this example sheet.

You can start now and you will have more or less four minutes time.

Please wait before reading the next page!

5/17

Costs: Page 1

As design engineer, you know of course a lot about the cost of the carpets you create.

You know that the cost of a carpet is mainly determined

1) by the *sort* of colors you use and
2) by the *number* of colors you use.

You know that there exist 3 categories of colors: the *neutral* colors, the *bright* colors and the *dark* colors. Yarns in neutral colors are the least expensive, yarns in bright colors are more expensive and yarns in dark colors are the most expensive.

These 3 classes of colors are:

Class A: Neutral colors:

white
black

Class B: Bright colors:

yellow
orange
sky blue
light green

Class C: Dark colors:

blue
brown
red
green.

Please wait before reading the next page!

6/17

Costs: Page 2

You also know that the machines have *a standard setting of 5 colors*. These are called the standard colors. You can decide yourself which colors you will use as standard colors. If you use an additional color (i.e. a sixth, a seventh, an eight, a ninth or a tenth color), the machines will have to be set up more times, making this additional color more expensive.

Make sure you understand the following table. The cost of the colored yarn is given for each small square:

	Cost per small square *standard* color	cost per small square *additional* color
	Class A:	Class A+:
White	3	6
Black	3	6
	Class B:	Class B+:
Yellow	10	13
Orange	10	13
Sky blue	10	13
Light green	10	13
	Class C:	Class C+:
Blue	15	18
Brown	15	18
Red	15	18
Green	15	18

Lets have a look at a few examples now.

If you have questions after those examples, please ask your instructor.

Please wait before reading the next page!

7/17

Costs: Page 3

Example 1:

R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
R	B	B	B	B	B	B	B	B	B	B	B	B	B	B	R
R	B	B	B	B	B	B	B	B	B	B	B	B	B	B	R
R	B	B	G	G	B	B	Y	Y	B	B	G	G	B	B	R
R	B	B	G	G	B	B	Y	Y	B	B	G	G	B	B	R
R	B	B	B	B	B	B	B	B	B	B	B	B	B	B	R
R	B	B	B	B	B	B	B	B	B	B	B	B	B	B	R
R	B	B	Y	Y	B	B	W	W	B	B	Y	Y	B	B	R
R	B	B	Y	Y	B	B	W	W	B	B	Y	Y	B	B	R
R	B	B	B	B	B	B	B	B	B	B	B	B	B	B	R
R	B	B	B	B	B	B	B	B	B	B	B	B	B	B	R
R	B	B	G	G	B	B	Y	Y	B	B	G	G	B	B	R
R	B	B	G	G	B	B	Y	Y	B	B	G	G	B	B	R
R	B	B	B	B	B	B	B	B	B	B	B	B	B	B	R
R	B	B	B	B	B	B	B	B	B	B	B	B	B	B	R
R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R

R = Red, B = Blue, G = Green, Y = Yellow, W = White

Color Issues	Color	Type	Cost per small square	*Number*	Total Cost
Outside border:	Red	C	15	60	900
Inside border:	Blue	C	15	52	780
Background:	Blue	C	15	108	1.620
Singles:	White	A or ~~A+~~	3	4	12
	Black	A or A+	-	-	-
1	Yellow	B or ~~B+~~	10	16	160
2	Orange	B or B+	-	-	
3	Sky Blue	B or B+	-	-	
4	Light Green	B or B+	-	-	
5	Blue	C or C+	-	-	
	Brown	C or C+	-	-	
	Red	C or C+	-	-	
	Green	C or ~~C+~~	15	16	240
			Check Total	256 ☑	**3.712**

We are using here 5 colors. So there are no additional costs (no A+, no B+, no C+).

All costs per small square are coming from the second column of the cost table of the previous page.

Please wait before reading the next page!

8/17

Costs: Page 4

Example 2:

B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B
B	G	G	G	G	G	G	G	G	G	G	G	G	G	G	B
B	G	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	G	B
B	G	Y	B	B	Y	Y	W	R	Y	Y	B	B	Y	G	B
B	G	Y	B	B	Y	Y	R	W	Y	Y	B	B	Y	G	B
B	G	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	G	B
B	G	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	G	B
B	G	Y	R	W	Y	Y	L	L	Y	Y	W	R	Y	G	B
B	G	Y	W	R	Y	Y	L	L	Y	Y	R	W	Y	G	B
B	G	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	G	B
B	G	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	G	B
B	G	Y	B	B	Y	Y	W	R	Y	Y	B	B	Y	G	B
B	G	Y	B	B	Y	Y	R	W	Y	Y	B	B	Y	G	B
B	G	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	G	B
B	G	G	G	G	G	G	G	G	G	G	G	G	G	G	B
B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B

B = Brown, G = Green, Y = Yellow, R = Red, W = White, L = Light green

Color Issues	Color	Type	Cost per small square	*Number*	Total Cost
Outside border:	Brown	C	15	60	900
Inside border:	Green	C	15	52	780
Background:	Yellow	B	10	108	1.080
Singles:	White	A or A+	3	8	24
	Black	A or A+		-	
1	Yellow	B or B+		-	
2	Orange	B or B+		-	
3	Sky Blue	B or B+		-	
4	Light Green	B or B+	13	4	52
5	Blue	C or C+		-	
6	Brown	C or C+	15	16	240
	Red	C or C+	15	8	120
	Green	C or C+		-	
			Check Total	256 ☑	**3.196**

We are using here 6 colors: 5 standard colors and one additional color.

Remark that the color with the least total number of small squares (here 4 small squares in light green) should be chosen as the additional color (indicated by a B+ in stead of a regular B).

If you have questions on these tables, please ask now to your instructor!

Please wait before reading the next page!

9/17

Example

Now, take back the pattern you colored earlier. This was the sheet with the diagonal text saying: "*example to clarify the instructions*".

Now, try to fill-out the cost calculation on the *second* part of this example sheet. Of course, you can go back to the previous pages.

You can start now and you will have more or less two minutes time.

Please wait before reading the next page!

10/17

Checking the Example

Now you will switch your example sheet with the example sheet of your neighbor. Switch with the neighbor that is sitting close to you.

Look at the design of your neighbor and check the cost calculation of your neighbor.

If you notice mistakes, please discuss it with your neighbor and ask your instructor if you need more clarification.

When finished, return the example sheet back to your neighbor.

Remark: You will check the calculation of your neighbor only once, just to make sure that everyone understands how to fill out the cost calculation table.

Please, wait before reading the next page!

11/17

Task

[Non-TCS, Easy TIME]

The task involves creating an *attractive* carpet for a living room, for the market of young families with small children. You can color as many copies of the basic design as you want, but at the end of the exercise, you have to decide which carpet you will hand in. Your boss only wants *one* colored design.

Since your boss is going to show your colored design to judges (representing the market), make sure your pattern is not looking dirty and make sure you are *not* writing anything above the horizontal line. On that line, we will fold your sheet in two parts: the pattern part and the cost part. The judges will only see the pattern part, without your cost part.

Furthermore, the company uses a cost plus approach to determine the sales price. This means that the cost of the carpet is used as a basis to set the sales price. More specific, the sales price is set at a level equal to the cost of the carpet plus a profit percentage of 20%. Hence, your boss wants you to create an attractive carpet, while trying to *minimize* the cost of that carpet. Your boss is convinced that young families are not prepared to pay a lot of money for their living room carpet. In order to survive in this competitive market of living room carpets, you *should* come up with an attractive carpet at the *lowest cost* possible. So, do your best in minimizing the cost level of the design you create.

Finally, your boss wants you to be finished *within 1 hour and 45 minutes*. If you are finished earlier, you should not wait to hand in your design. If you think that designing an attractive carpet in this time period is not possible, you can take some extra time.

Please wait before reading the next page!

12/17

Task

[Easy TCS, Easy TIME]

The task involves creating an *attractive* carpet for a living room, for the market of young families with small children. You can color as many copies of the basic design as you want, but at the end of the exercise, you have to decide which carpet you will hand in. Your boss only wants *one* colored design.

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Furthermore, the sales price for carpets is determined on the market. For the coming season the market price for a given carpet is estimated at 3.780 BEF. The general manager decided that living room carpets should earn a profit of 630 BEF apiece. Hence, your boss wants you to create an attractive carpet that costs *no more than 3.150 BEF* (i.e. the difference between the estimated market price of 3.780 and the profit margin of 630). Your boss is convinced that young families are not prepared to pay more than the estimated market price of 3.780 BEF. Furthermore, the company needs the profit margin of 630 BEF apiece, in order to survive in the competitive market of living room carpets. So, you *should* come up with an attractive carpet that costs no more than 3.150 BEF, unless you really think that designing an attractive carpet under that cost is impossible.

Finally, your boss wants you to be finished *within 1 hour and 45 minutes*. If you are finished earlier, you should not wait to hand in your design. If you think that designing an attractive carpet in this time period is not possible, you can take some extra time.

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12/17

Task

[Difficult TCS, Easy TIME]

The task involves creating an *attractive* carpet for a living room, for the market of young families with small children. You can color as many copies of the basic design as you want, but at the end of the exercise, you have to decide which carpet you will hand in. Your boss only wants *one* colored design.

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12/17

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12/17

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[Difficult TCS, Difficult TIME]

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Please wait before reading the next page!

12/17

Market Information

To help you with the kind of style, your boss already selected the *interior* where the collection of designs of this year should fit in. A picture of that interior is enclosed. We cut a frame out of the yellow ground, so you can easily place your colored design behind this interior page, to see if your design is an attractive one for this kind of interior. Can you see how it works? Please do not make notes on that picture.

Furthermore, your boss also has some market data available on what the market liked and disliked during the previous season. The 10 *most attractive* designs are given as well as the 10 *least attractive* designs, as perceived by the market (judges). The judges used the same interior as you have now.

Remark that *light green* was not one of the colors of last season. So, in these 20 designs you will not find light green as a color. It is our new color for this year. In the previous season, we had *violet* ("paars"), but your boss deleted violet as a color for this season.

As you will see, the basic design of last season was totally different from the one of this year. The creators are 45 students from another university. They had no experience in designing. These students were using the same colors (apart from light green and violet) as you have now. Slight differences in colors between your color pens and the colors on these pages can be caused by the color copy machine we used to multiply these pages. All judges used earlier the original designs to give a score.

Please do not write on these pages with the 10 most attractive and the 10 least attractive designs.

If you have questions, please ask your instructor!

13/17

Judges

Most of the judges, who did the scoring of the designs earlier, are also present now. Today there are _________ judges present. They will score your design as 1, 2, 3, 4 or 5. The *higher* the score, the *more* they like the design, as indicated in the following table.

	Score
Very attractive	5
Rather attractive	4
Something in between	3
Rather non-attractive	2
Not at all attractive	1

Each of the judges will score *individually* and they will do it according to their *own norms*.

Let's assume that there are 10 judges and that each of these 10 judges gave the following scores:

Judge 1	Judge 2	Judge 3	Judge 4	Judge 5	Judge 6	Judge 7	Judge 8	Judge 9	Judge 10	Total sum
5	4	5	4	3	4	5	4	3	4	?

To come to a global score on attractiveness, you can calculate the *mean*. Hence, you make the sum of all scores and you divide this sum by the number of judges. In this example, the sum is 41 and the mean is 41/10 = 4,1.

Since, there are ______ judges today, you will get _____ scores from the judges and you should divide the total of these scores by _______.

Please wait before reading the next page !

14/17

Organization of the Feedback by the Judges

To get scores from the judges (representing the market), your boss set up some rules:

- If you want scores of the judges for a given design, you should *fold your pattern sheet* in the *correct way*. First, fold the page in two on the horizontal line. One part shows the design and the other part shows the cost. Right? Secondly, fold the cost part in two again, so the judges cannot see the cost information. Your instructor will show an example. After this example, try to fold the *example design* you made earlier.
- A *courier* will walk around. If you have a design ready to score, hold up one of the blue cards. He/she will come to you as soon as possible to bring your design to the judges in front of the room.
- Put your design *upside down* in the box of the courier. You put it upside down, so your neighbor cannot see your design.
- Give the *blue card* to the courier.
- Since you are having only two blue cards, you can use the judges *only two times*, to give you some feedback on what the market likes. You can give two designs together or you can give them at different times. Please remark that you are *not obligated* to use the judges during the task.
- Make sure you remember the design you gave to the judges, since it might take 20 minutes before you will get your design back.

If you have questions on this, please ask your instructor!

15/17

Bonus

[Non-TCS, Easy TIME]

In total there are 20 design engineers in your firm. They are all students (3de proef bio-ingenieur), who volunteered in this experiment and who received the same information as you have now. There should be no difference in ability to create carpets between you all.

You will hand in *one* created carpet. This design might or might not have received scores from the judges yet. If it did not receive scores from the judges, the judges will score it at the end of the afternoon.

The designers of the *5 most attractive* carpets of your group of 20 will receive a bonus of 300 BEF. Among those 5 most attractive carpets, the 3 carpets with the *lowest cost* will get an additional bonus of 300 BEF. This means that 3 persons will receive a bonus of 600 BEF because their design is one of the 5 most attractive and because their design is one of the 3 lowest cost designs of those 5 most attractive designs. Similarly, 2 persons will get a bonus of 300 BEF, because their design is one of the 5 most attractive, though not belonging to the 3 (of those five) with the lowest cost.

An additional bonus of 100 BEF is provided for those 5 most attractive carpets, if the designer was finished *within the time limit* of 1 hour and 45 minutes.

We will pay you your bonus *today*, at the end of the session, at 17.00 hour. Look at the examples in the following table to see if you understand how the bonus system works.

Identity Number	Mean score	Total cost of the carpet (these figures are *not* realistic)	Time spent	Bonus
15	3,8	10.000	1 hour 20 minutes	300 + 0 + 100 = 400
23	3,7	9.000 2°	1 hour 15 minutes	300 + 300 + 100 = 700
2	3,3	11.000	1 hour 55 minutes	300 + 0 + 0 = 300
8	3,2	7.000 1°	1 hour 45 minutes	300 + 300 + 100 = 700
14	3,1	9.500 3°	2 hour 00 minutes	300 + 300 + 0 = 600
31	2,9	7.000	1 hour 10 minutes	0

Why is number 31 not getting a bonus? Because he/she was not within the 5 most attractive of his/her group of 20 design engineers.

If you have questions on the bonus determination, please ask your instructor now!

Please wait before reading the next page!

16/17

Bonus

[Easy TCS, Easy TIME]

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15	3,8	3.300	1 hour 20 minutes	300 + 0 + 100 = 400
23	3,7	2.940	1 hour 15 minutes	300 + 300 + 100 = 700
2	3,3	3.840	1 hour 55 minutes	300 + 0 + 0 = 300
8	3,2	3.088	1 hour 45 minutes	300 + 300 + 100 = 700
14	3,1	2.868	2 hour 00 minutes	300 + 300 + 0 = 600
31	2,9	2.560	1 hour 10 minutes	0

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16/17

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8	3,2	2.676	1 hour 45 minutes	300 + 300 + 100 = 700
14	3,1	2.560	2 hour 00 minutes	300 + 300 + 0 = 600
31	2,9	2.224	1 hour 10 minutes	0

Why is number 31 not getting a bonus? Because he/she was not within the 5 most attractive of his/her group of 20 design engineers.

If you have questions on the bonus determination, please ask your instructor now!

Please wait before reading the next page !

16/17

Bonus

[Non-TCS, Difficult TIME]

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Why is number 31 not getting a bonus? Because he/she was not within the 5 most attractive of his/her group of 20 design engineers.

If you have questions on the bonus determination, please ask your instructor! *16/17*

Bonus

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16/17

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[Difficult TCS, Difficult TIME]

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16/17

Summary [Non-TCS, Easy TIME]

Let's briefly summarize your task.

1. You are a carpet designer and can use 10 different colors in your design: 9 color pens and white. Do not combine these pens to get a new color.
2. Remember to use one color within the predefined fields. You are not allowed to split predefined fields, but you are allowed to merge those fields.
3. Your boss asks you to design an attractive carpet for a living room, within a given interior, while trying to minimize the cost. You can consult the market (judges) two times, if you want.
4. Your boss thinks that you will be finished within 1 hour and 45 minutes. If you are finished earlier, do not hesitate to hand in your creation. If you want some more time, you can take it.
5. The 5 most attractive creations out of the 20 in your group will get a bonus of 300 BEF. The 3 carpets with the lowest cost among those 5 most attractive will get an additional bonus of 300 BEF, making their total bonus 600 BEF. Furthermore, all 5 most attractive creations that were finished within 1 hour and 45 minutes get a supplementary bonus of 100 BEF.
6. Here goes the cost table again.

	cost per small square *standard* color	Cost per small square *Additional* color
	Class A:	Class A+:
White	3	6
Black	3	6
	Class B:	Class B+:
Yellow	10	13
Orange	10	13
Sky blue	10	13
Light green	10	13
	Class C:	Class C+:
Blue	15	18
Brown	15	18
Red	15	18
Green	15	18

7. You can create as much carpets as you want, but your boss needs only one. If you are finished, put your selection in the brown envelope. Make sure this carpet is a fully colored pattern (except for the white squares). Indicate on the envelope if the judges already scored your selected design (yes or no). Hold this envelope *up* and your instructor will come to pick it up and she/he will write the time spent on it. Then (and only then) you can open the sealed folder. There is a questionnaire of four pages in it. This questionnaire will take more or less 10 minutes to fill out. We started at ….. hour. Good luck designer! *17/17*

Summary [Easy TCS, Easy TIME]

Let's briefly summarize your task.

1. You are a carpet designer and can use 10 different colors in your design: 9 color pens and white. Do not combine these pens to get a new color.

2. Remember to use one color within the predefined fields. You are not allowed to split predefined fields, but you are allowed to merge those fields.

3. Your boss asks you to design an attractive carpet for a living room (see interior), and which costs no more than 3.150 BEF. You can consult the market (judges) two times, if you want.

4. Your boss thinks that you will be finished within 1 hour and 45 minutes. If you are finished earlier, do not hesitate to hand in your creation. If you want some more time, you can take it.

5. The 5 most attractive creations out of the 20 in your group will get a bonus of 300 BEF. The carpets among those 5 with a cost level equal to or lower than 3.150 BEF will get an additional bonus of 300 BEF, making their total bonus 600 BEF. Furthermore, all 5 most attractive creations that were finished within 1 hour and 45 minutes get a supplementary bonus of 100 BEF.

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Black	3	6
	Class B:	Class B+:
Yellow	10	13
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Sky blue	10	13
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	Class C:	Class C+:
Blue	15	18
Brown	15	18
Red	15	18
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Summary [Difficult TCS, Easy TIME]

Let's briefly summarize your task.

1. You are a carpet designer and can use 10 different colors in your design: 9 color pens and white. Do not combine these pens to get a new color.
2. Remember to use one color within the predefined fields. You are not allowed to split predefined fields, but you are allowed to merge those fields.
3. Your boss asks you to design an attractive carpet for a living room (see interior), and which costs no more than 2.750 BEF. You can consult the market (judges) two times, if you want.
4. Your boss thinks that you will be finished within 1 hour and 45 minutes. If you are finished earlier, do not hesitate to hand in your creation. If you want some more time, you can take it.
5. The 5 most attractive creations out of the 20 in your group will get a bonus of 300 BEF. The carpets among those 5 with a cost level equal to or lower than 2.750 BEF will get an additional bonus of 300 BEF, making their total bonus 600 BEF. Furthermore, all 5 most attractive creations that were finished within 1 hour and 45 minutes get a supplementary bonus of 100 BEF.
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Black	3	6
	Class B:	Class B+:
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Orange	10	13
Sky blue	10	13
Light green	10	13
	Class C:	Class C+:
Blue	15	18
Brown	15	18
Red	15	18
Green	15	18

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Summary [Non-TCS, Difficult TIME]

Let's briefly summarize your task.

1. You are a carpet designer and can use 10 different colors in your design: 9 color pens and white. Do not combine these pens to get a new color.

2. Remember to use one color within the predefined fields. You are not allowed to split predefined fields, but you are allowed to merge those fields.

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	Class B:	Class B+:
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Orange	10	13
Sky blue	10	13
Light green	10	13
	Class C:	Class C+:
Blue	15	18
Brown	15	18
Red	15	18
Green	15	18

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Red	15	18
Green	15	18

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Summary [Difficult TCS, Difficult TIME]

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1. You are a carpet designer and can use 10 different colors in your design: 9 color pens and white. Do not combine these pens to get a new color.
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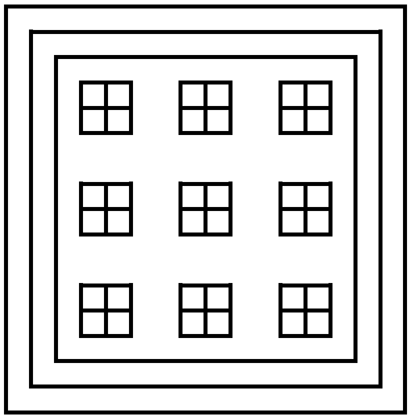
5. Pattern Sheet of Experiment Two

«ID_Number»



«ID_Number»

Color Issues	**Color**	**Type**	**Cost per small area**	***Number***	**Total Cost**
Outside border:				60	
Inside border:				52	
Background:				108	
Singles:	White	A or A+			
	Black	A or A+			
	Yellow	B or B+			
	Orange	B or B+			
	Sky Blue	B or B+			
	Light Green	B or B+			
	Blue	C or C+			
	Brown	C or C+			
	Red	C or C+			
	Green	C or C+			
			Check Total	256 ☐	

1/1

6. Colored Picture of a Living Room Interior, distributed in Experiment Two

☞ **The Living Room Interior is inserted on the next page !**

7. Market Information distributed in Experiment Two

☞ **Inserted on the next two pages:**

- **Ten *Most Attractive* Designs of Last Year, as perceived by the Market (Judges)**
- **Ten *Least Attractive* Designs of Last Year, as perceived by the Market (Judges)**

8. Instruction Sheet for the Assistants of Experiment Two

Summary of the Instructions given to the Assistants

- Each assistant A, B, C and D (Marijke, Christophe, Tom and Patricia) is responsible for a given number of rows.
- Make sure your watch is set equal to the one of Christophe.
- First *task* of the assistants is to bring designs to the jury members and to take scored designs back to the participants.
- Second *task* is to write down the time on the envelope when participants are finished.
- Sandy is "*jury-in*", Heidi is "*jury-out*". Heidi is making stacks of the scored designs for the three assistants separately. Please, take only those designs of your dedicated rows!
- Token system: Each participant might ask for scores on maximum 2 designs (together or separate). Participants give a blue card to assistant when asking for scores of the jury. Assistants are giving designs to jury 1 (Sandy). Blue cards can be put in a box under Sandy's table.
- *FIFO* principle: Keep designs in the order of first in, first out.
- Bring the scored designs back to the participants as soon as possible!
- When finished with the design, participants will show you their white envelope. You take the envelope, write the time on it. Collect the envelopes in a box under Sandy's seat.
- **DO NOT FORGET TO WRITE DOWN THE TIME, PLEASE !**
- Sandy will take care of the *priority rule* between designs from participants in the room and from participants who left the auditorium (i.e. the white envelope).
- Participants can only open the folder with the questionnaire, when handed in the white envelope.
- When finished, participants can leave everything in their box on the table, except the white card with their ID number.
- When finished, participants go to the relax room to get a free drink and a candy (when showing their white card).

1/1

9. Instruction Sheets for the Cashiers of Experiment Two

Summary of the Instructions given to the Cashiers

1. The first task of the cashiers X and Y is to *write down* the id numbers of participants who did not show up.
2. The second task of the cashiers is to *check* the closed envelope with 20 000 BEF for the bonus pay.
3. The third task is to calculate the *total score* for attractiveness, based on the 9 individual scores of the jury members.
4. The fourth task is to *input* the total score for attractiveness, the cost and the time in the Excell spreadsheet. The Excell file is already set up, so the only cells that are missing are these three scores for each participant. A separate sheet is set up for each of the six groups.
5. The fifth task is to *sort* the fields within each group, based on the total score for attractiveness.
6. Then *print* each of these six sheets to determine the bonus id numbers.
7. Copy the bonus fields from the Excell spreadsheet to the Word document to *display* them on the blackboard in the relax room. Marijke will help you with posing these six sheets.
8. Then prepare the *envelopes* with the right amount of money and write the ID number in front of it.
9. You can start now with *paying* the bonuses in the meeting room.
10. Make sure each “winning” participant is checking the money and is signing a *receipt form*.

1/2

Summary of the Bonus System

There are six groups and each group is having a different bonus system, as shown in the table.

	Nrs. 1-22	**Nrs. 23-44**	**Nrs. 45-66**
Bonus	• 300 for 5 most attractive • 300 for 3 lowest costs • 100 if within time limit of 1 hour, 45 min	• 300 for 5 most attractive • 300 if cost ⦸ 3.150 • 100 if within time limit of 1 hour, 45 min	• 300 for 5 most attractive • 300 if costs ⦸ 2.750 • 100 if within time limit of 1 hour, 45 min
	Nrs. 67-88	**Nrs. 89-110**	**Nrs. 111-134**
Bonus	• 300 for 5 most attractive • 300 for 3 lowest costs • 100 if within time limit of 1 hour, 15 min	• 300 for 5 most attractive • 300 if costs ⦸ 3.150 • 100 if within time limit of 1 hour, 15 min	• 300 for 5 most attractive • 300 if costs ⦸ 2.750 • 100 if within time limit of 1 hour, 15 min

2/2

10. Instruction Sheets for the Judges of Experiment Two

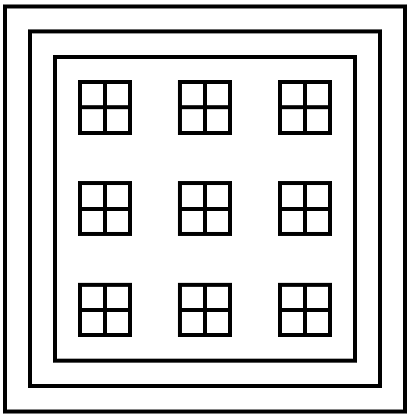
Practical Instructions to the Jury

- All juries are expected at 14.30 h in the room next to auditorium I. The task will last till 17.15 h (in the worse case).
- Instruction sheets for the members of the jury will be on the table.
- Jury members will be in front of the blackboard, looking at the participants.
- Token system: Each participant might ask for scores on maximum 2 designs (together or separate). Participants give a blue card to assistant when asking for scores of the jury.
- *FIFO* principle: Keep designs in the order of first in, first out.
- Sandy is "*jury-in*", Heidi is "*jury-out*". Heidi is making stacks of the scored designs for the three assistants.
- Sandy takes care of the *priority rule* between designs from participants in the room and from participants who left the auditorium.
- Each member of the jury should give scores *independently*, referring to the own norms !

1/6

Task of the Participants

We told the participants to design a carpet for a *living room* for the market of young families, with small children. Their boss decided on the type of design, but they have to decide on the colors of the carpet. You find this basic design in the middle of the page. This pattern represents a square of two by two meters. Since their boss decided already on the type of design, they can only use a different color within each predefined field.



They received a set of 9 color pens: blue, sky blue, green, light green, yellow, orange, red, brown, black. If they leave a square blank, this means they are using the color white.

They can use as many of these colors as they want, but they *can not combine* colors, since these are the 10 colors the company holds in yarns for living room carpets. These colors look more or less the same in reality as on the paper.

2/6

Market Information

To help them with the kind of style, their boss already selected the *interior* where the collection of designs of this year should fit in. A picture of that interior is enclosed. We cut a frame out of the yellow ground, so you can easily place the colored design behind this interior page, to see if the design is an attractive one for this kind of interior. Can you see how it works?

Furthermore, we also gave to the participants what you all together liked and disliked of the previous season (remember the 45 other patterns from Vanderbilt students). Participants received these 10 *most attractive* designs as well as these 10 *least attractive* designs.

Remark that *light green* was not one of the colors of last season. So, in these 20 designs you will not find light green as a color. It is our new color for this year. In the previous season, they had *violet* (“paars”), but this color is deleted now.

As you will see, the basic design of last season was totally different from the one of this year. Slight differences in colors between the colors of the participants now and the colors on those pages can be caused by the color copy machine we used to multiply these pages.

3/6

Task of the Judges

Most of the judges, who did the scoring of the designs earlier, are also present now. Today you are with _________ judges. You will score the design of the participants with a score of 1, 2, 3, 4 or 5. The *higher* the score, the *more* you like the design, as indicated in the following table.

	Score
Very attractive	5
Rather attractive	4
Something in between	3
Rather non-attractive	2
Not at all attractive	1

You should score *individually* and according to your *own norms*. Do not look at the scores of the other judges before giving your own score. Last time you were all pretty consistent, so do not hesitate on the scoring ability of yourself!

Participants will fold their pattern sheet in a special way, so you can only see the pattern and you cannot see the scores of your colleagues. Please, write your score (*clearly*) on the back of the pattern.

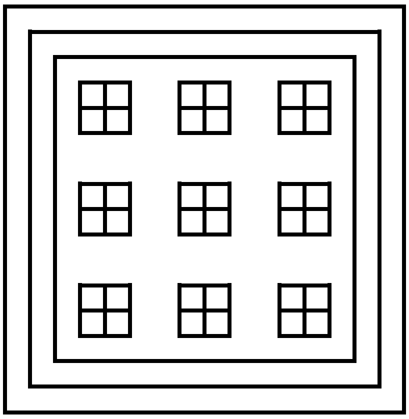
A *courier* will walk around. He/she will bring the designs to the judges (jury-in box). Please hold this FIFO principle while you are scoring. Another courier will bring the designs back to the participants (jury-out box). If you keep the same rank order of designs (the FIFO-principle), all participants will have to wait equally and it will be easier to bring the designs back to the participants.

During the whole afternoon, participants can ask for scores of the judges, only for 2 designs (together or individually).

4/6

Example of the Pattern Sheet

«ID_Number»



«ID_Number»

Color Issues	**Color**	**Type**	**Cost per small area**	***Number***	**Total Cost**
Outside border:				60	
Inside border:				52	
Background:				108	
Singles:	White	A or A+			
	Black	A or A+			
	Yellow	B or B+			
	Orange	B or B+			
	Sky Blue	B or B+			
	Light Green	B or B+			
	Blue	C or C+			
	Brown	C or C+			
	Red	C or C+			
	Green	C or C+			
			Check Total	256 ☐	

5/6

Bonus to the Participants

Participants will hand in *one* created carpet. This design might or might not have received scores from the judges yet. If it did not receive scores from the judges, you will score them at the end of the afternoon.

Please take the scoring task seriously, since the bonus of the participants is dependent on the total of all your scores. The designers of the *5 most attractive* carpets in each group of 20 persons will receive a bonus of 300 BEF. They can receive an additional bonus, if they complete the task within a given time limit. So, do not judge longer than necessary to give your score.

Thanks again for your cooperation!

6/6

11. Overhead Sheets used during the Instructions to Participants in Experiment Two

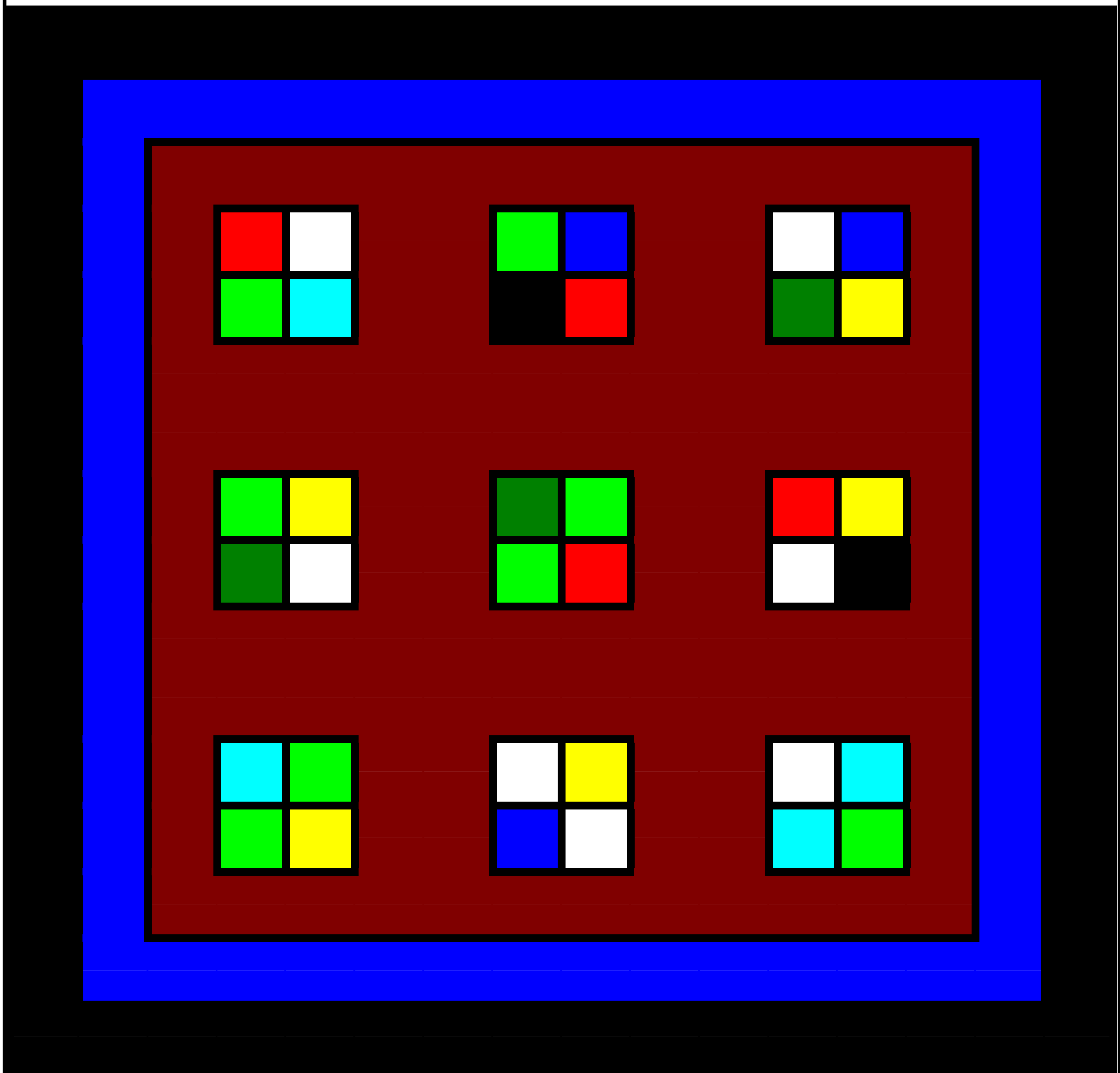
Overhead Sheet 1

- **Some practical comments**
- **Pattern**
- **Colors**
- **Example**
- **Costs: Page 1**
- **Costs: Page 2**
- **Costs: Page 3**
- **Costs: Page 4**
- **Example**
- **Checking the example**
- **Task**
- **Market information**
- **Judges**
- **Organization of the Feedback by the Judges**
- **Bonus**
- **Summary**

1/6

Overhead Sheet 2

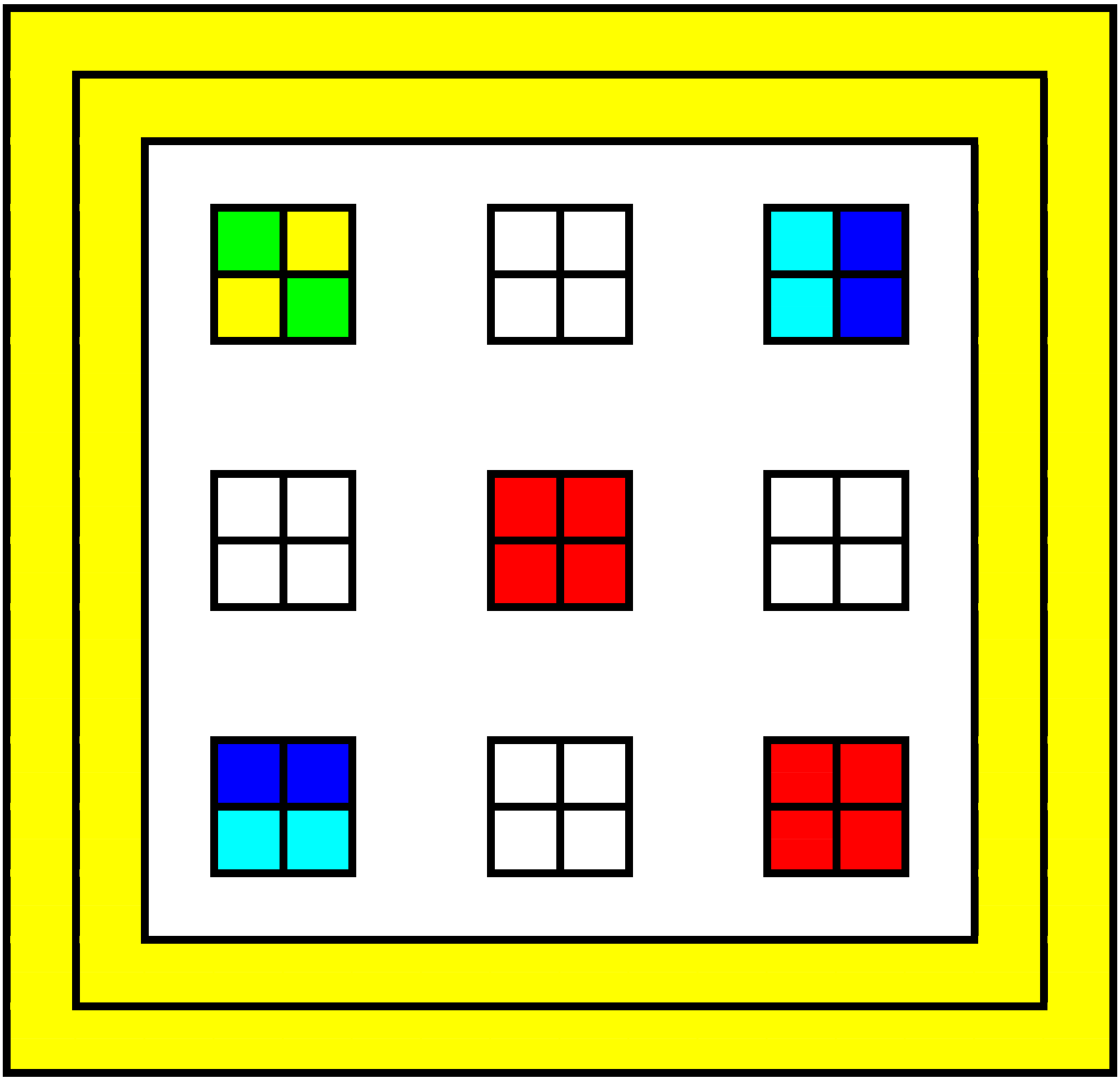
Example 1



2/6

Overhead Sheet 3

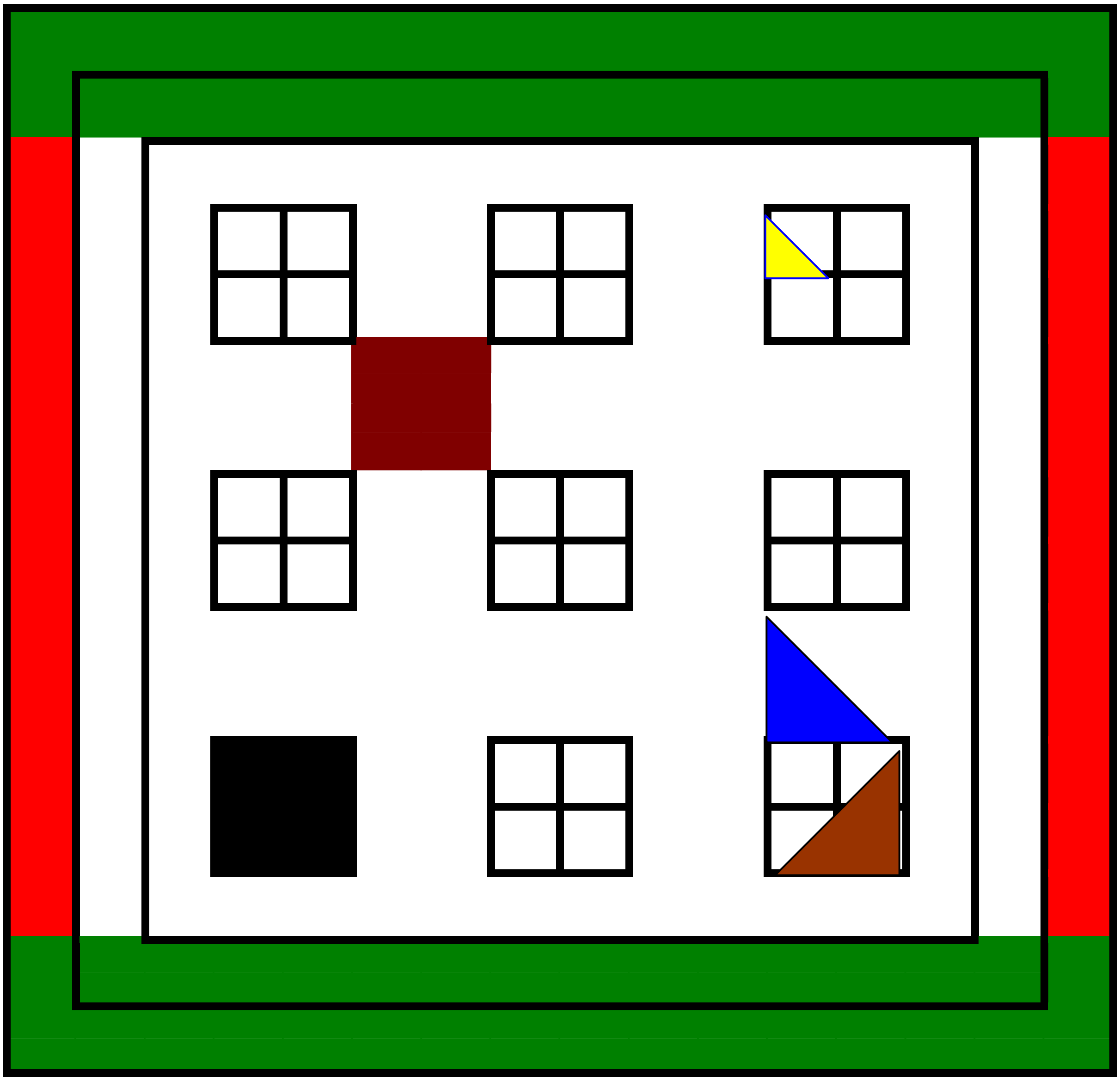
Example 2



3/6

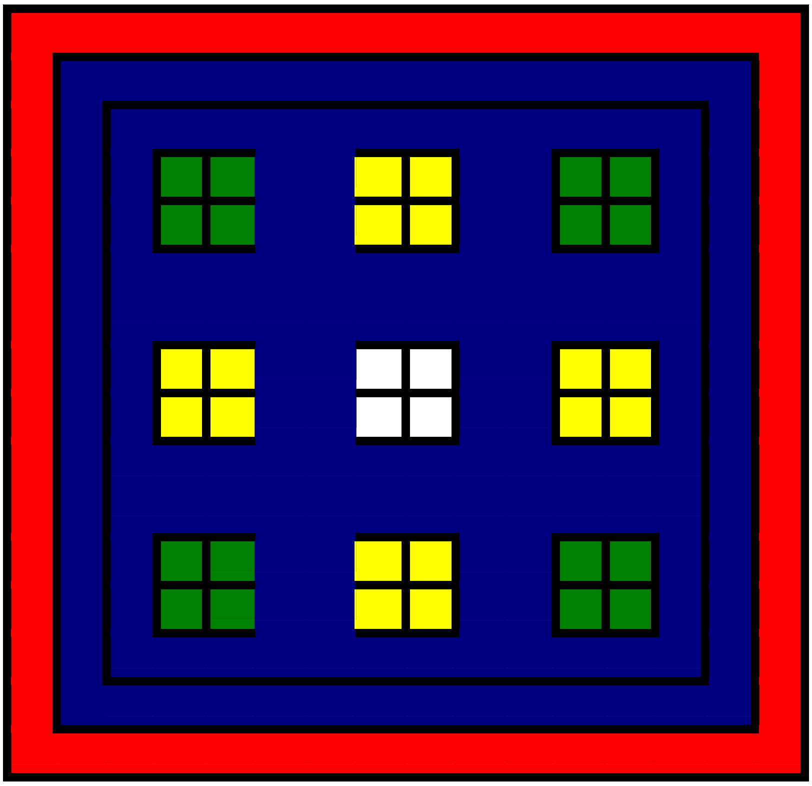
Overhead Sheet 4

Example 3



4/6

Overhead Sheet 5



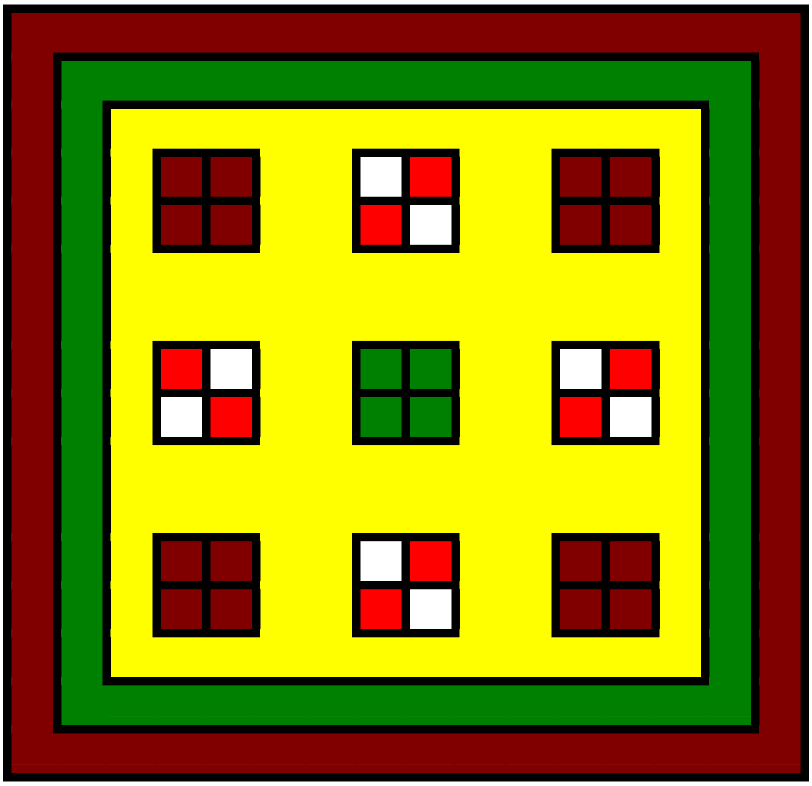
R = Red, B = Blue, G = Green, Y = Yellow, W = White

Color Issues	Color	Type	Cost per small square	*Number*	Total Cost
Outside border:	Red	C	15	60	900
Inside border:	Blue	C	15	52	780
Background:	Blue	C	15	108	1.620
Singles:	White	A or A+	3	4	12
	Black	A or A+	-	-	-
	Yellow	B or B+	10	16	160
1	Orange	B or B+	-	-	
2	Sky Blue	B or B+	-	-	
3	Light Green	B or B+	-	-	
4	Blue	C or C+	-	-	
5	Brown	C or C+	-	-	
	Red	C or C+	-	-	
	Green	C or C+	15	16	240
			Check Total	256 ☑	3.712

We are using here 5 colors. So there are no additional costs (no A+, no B+, no C+).

5/6

Overhead Sheet 6



B = Brown, G = Green, Y = Yellow, R = Red, W = White, L = Light green

Color Issues	Color	Type	Cost per small square	*Number*	Total Cost
Outside border:	**Brown**	**C**	**15**	**60**	**900**
Inside border:	**Green**	**C**	**15**	**52**	**780**
Background:	**Yellow**	**B**	**10**	**108**	**1.080**
Singles:	**White**	**A or A+**	**3**	**8**	**24**
	Black	**A or A+**		**-**	
1	**Yellow**	**B or B+**		**-**	
2	**Orange**	**B or B+**		**-**	
3	**Sky Blue**	**B or B+**		**-**	
4	**Light Green**	**B or B+**	**13**	**4**	**52**
5	**Blue**	**C or C+**		**-**	
6	**Brown**	**C or C+**	**15**	**16**	**240**
	Red	**C or C+**	**15**	**8**	**120**
	Green	**C or C+**		**-**	
			Check Total	**256 ☑**	**3.196**

6/6

12. Post Experimental Questionnaire Experiment Two (in Dutch)

Variable Names Were Added

Vragenlijst ID_Number»

Zou je nog even deze vragen kunnen beantwoorden? De antwoorden zullen niet op een individuele basis worden gebruikt. Niemand zal dan ook inzage krijgen in jouw antwoorden. Enkel algemene conclusies voor de totale groep zullen worden gemaakt.

1. Mijn leeftijd is (**AGE**): ....

2. Geslacht (**GENDER**):

   1 ☐ Mannelijk
   2 ☐ Vrouwelijk

3. Mijn richting is (**OPTION**):

   1 ☐ Scheikunde
   2 ☐ Milieutechnologie
   3 ☐ Cel- en genbiotechnologie
   4 ☐ Andere

4. Heb je in het verleden al eens ontwerptaken uitgevoerd? (**EXPERIEN**)

   1 ☐ Ja namelijk: ....
   ....
   2 ☐ Neen

5. Kan je raden wat we met deze oefening wilden onderzoeken? (**PURPOSE**)

   1 ☐ Ja namelijk: ....
   ....
   2 ☐ Neen

6. Verstond je de taak voldoende om ze goed te kunnen uitvoeren, na het lezen van de instructie-bladzijden? (**UNDERSTA**)

   1 ☐ Ja
   2 ☐ Neen
   Suggesties tot verbeteringen: ....
   ....

7. Als we deze oefening nog eens zouden herhalen (zonder extra punt), zou je dan opnieuw deelnemen? (**AGAIN**)

   1 ☐ Ja
   2 ☐ Neen
   Bijkomende commentaar: ....
   ....

8. Hoeveel volledige designs heb je in totaal gemaakt? (**TOTALDES**)

   ☐ ....

1/5

9. Hoeveel inspanning heb je geleverd tijdens de oefening om een attractief (mooi) tapijt te creëren? (**ATTREFFO**)

1	2	3	4	5
☐	☐	☐	☐	☐
Geen of weinig	middelmatig	veel	heel veel	extreem veel

10. Hoeveel inspanning heb je geleverd tijdens de oefening om de *kost* van het tapijt naar beneden te halen? (**COSTEFFO**)

1	2	3	4	5
☐	☐	☐	☐	☐
Geen of weinig	middelmatig	veel	heel veel	extreem veel

11. In het algemeen beschouwd, vond ik deze oefening _________.(**LIKETASK**)

1	2	3	4	5
☐	☐	☐	☐	☐
Saai	nogal saai	gewoon	eerder leuk	leuk

12. Ik hechtte ______ belang aan de scores van de juryleden bij de finale keuze van mijn ontwerp. (**JURYIMPO**)

1	2	3	4	5
☐	☐	☐	☐	☐
Geen of weinig	middelmatig	veel	heel veel	extreem veel

13. Ik werkte aan de *kosten* van mijn ontwerp, met _________ doorzettingsvermogen. (**COSTPERS**)

1	2	3	4	5
☐	☐	☐	☐	☐
Geen of weinig	middelmatig	veel	heel veel	extreem veel

14. Tijdens het ontwerpen, legde ik _________ doorzettingsvermogen aan de dag om het tapijt er *aantrekkelijk* te doen uitzien. (**ATTRPERS**)

1	2	3	4	5
☐	☐	☐	☐	☐
Geen of weinig	middelmatig	veel	heel veel	extreem veel

15. Ik wist precies hoe hoog de toelaatbare kost van het te ontwerpen tapijt mocht zijn. (**COSTSPE1**)

1	2	3	4	5
☐	☐	☐	☐	☐
absoluut niet akkoord		neutraal		absoluut akkoord

16. De tijdslimiet was eerder kort om deze taak uit te voeren. (**SHORTTIM**)

1	2	3	4	5
☐	☐	☐	☐	☐
absoluut niet akkoord		neutraal		absoluut akkoord

2/5

17. Tijdens de taak was het moeilijk om de *kosten*doelstelling, zoals opgelegd door mijn baas, ernstig op te vatten. [Easy and Difficult Target Cost Setting] (**COSTCOM1**)

1	2	3	4	5
☐	☐	☐	☐	☐
absoluut niet akkoord		neutraal		absoluut akkoord

18. Tijdens het uitvoeren van de oefening, was ik nogal gespannen omdat ik dacht dat ik het ideale ontwerp nooit zou vinden. (**TENSION1**)

1	2	3	4	5
☐	☐	☐	☐	☐
absoluut niet akkoord		neutraal		absoluut akkoord

19. Tijdens de taak was het moeilijk om de tijdslimiet van mijn baas “au serieux” te nemen. (**TIMECOM1**)

1	2	3	4	5
☐	☐	☐	☐	☐
absoluut niet akkoord		neutraal		absoluut akkoord

20. Tijdens de taak vond ik van mezelf dat ik heel veel aandacht besteedde aan de totale kostprijs van het tapijt. (**COSTATTE**)

1	2	3	4	5
☐	☐	☐	☐	☐
absoluut niet akkoord		neutraal		absoluut akkoord

21. Ik vond het tijdens de taak helemaal niet realistisch dat ik de *tijds*limiet van mijn baas zou halen. (**TIMECOM2**)

1	2	3	4	5
☐	☐	☐	☐	☐
absoluut niet akkoord		neutraal		absoluut akkoord

22. Ik vond het tijdens de taak helemaal niet realistisch dat ik de *kosten*doelstelling van mijn baas zou halen. [Easy and Difficult Target Cost Setting] (**COSTCOM2**)

1	2	3	4	5
☐	☐	☐	☐	☐
absoluut niet akkoord		neutraal		absoluut akkoord

23. Ik vond dat de *tijds*limiet moest worden herzien door mijn baas, afhankelijk van de vooruitgang die ik maakte met de taak. (**TIMECOM3**)

1	2	3	4	5
☐	☐	☐	☐	☐
absoluut niet akkoord		neutraal		absoluut akkoord

24. Ik vond dat de *kosten*doelstelling moest worden herzien door mijn baas, afhankelijk van de vooruitgang die ik maakte in het realiseren van de kostendoelstelling. [Easy and Difficult Target Cost Setting] (**COSTCOM3**)

1	2	3	4	5
☐	☐	☐	☐	☐
absoluut niet akkoord		neutraal		absoluut akkoord

3/5

25. Het zoeken naar een attractief *en* goedkoop tapijt binnen de tijdslimiet leidde bij mij tot nogal wat spanning tijdens de oefening. (**TENSION2**)

1	2	3	4	5
☐	☐	☐	☐	☐
absoluut niet akkoord		neutraal		absoluut akkoord

26. Eerlijk gezegd, ik trok het mij niet aan tijdens de oefening of ik de *tijds*limiet zou halen of niet. (**TIMECOM4**)

1	2	3	4	5
☐	☐	☐	☐	☐
absoluut niet akkoord		neutraal		absoluut akkoord

27. Eerlijk gezegd, ik trok het mij niet aan tijdens de oefening of ik de *kosten*doelstelling zou halen of niet. [Easy and Difficult Target Cost Setting] (**COSTCOM4**)

1	2	3	4	5
☐	☐	☐	☐	☐
absoluut niet akkoord		neutraal		absoluut akkoord

28. De instructies van mijn baas in verband met de toelaatbare kost van het te ontwerpen tapijt waren eerder vaag. (**COSTSPE2**)

1	2	3	4	5
☐	☐	☐	☐	☐
absoluut niet akkoord		neutraal		absoluut akkoord

29. De *tijds*doelstelling van mijn baas was makkelijk haalbaar. (**TIMEEASY**)

1	2	3	4	5
☐	☐	☐	☐	☐
absoluut niet akkoord		neutraal		absoluut akkoord

30. De *kosten*doelstelling van mijn baas was makkelijk haalbaar. [Easy and Difficult Target Cost Setting] (**COSTEASY**)

1	2	3	4	5
☐	☐	☐	☐	☐
absoluut niet akkoord		neutraal		absoluut akkoord

31. Door een mogelijke bonus van 300 BEF was ik sterk gemotiveerd om een aantrekkelijk tapijt te maken. (**BONUS1**)

1	2	3	4	5
☐	☐	☐	☐	☐
absoluut niet akkoord		neutraal		absoluut akkoord

32. Door een mogelijke bonus van 300 BEF was ik sterk gemotiveerd om een aantrekkelijk tapijt te maken, dat *bovendien* zo weinig mogelijk kostte. (**BONUS2**)

1	2	3	4	5
☐	☐	☐	☐	☐
absoluut niet akkoord		neutraal		absoluut akkoord

4/5

33. Door een mogelijke bonus van 100 BEF was ik sterk gemotiveerd om een aantrekkelijk tapijt te maken, *binnen* de tijdslimiet. (**BONUS3**)

1	2	3	4	5
☐	☐	☐	☐	☐
absoluut niet akkoord		neutraal		absoluut akkoord

34. Het was moeilijk om de kost van het te ontwerpen tapijt onder de toelaatbare kost te krijgen. [Easy and Difficult Target Cost Setting] (**COSTDIF**)

1	2	3	4	5
☐	☐	☐	☐	☐
absoluut niet akkoord		neutraal		absoluut akkoord

35. Ik voelde me relatief op mijn gemak bij het streven naar de verschillende doelstellingen van mijn baas tijdens de oefening. (**TENSION3**)

1	2	3	4	5
☐	☐	☐	☐	☐
absoluut niet akkoord		neutraal		absoluut akkoord

36. In het algemeen, besteedde ik heel veel aandacht om de attractiviteit van mijn ontwerp te verbeteren. (**ATTRATTE**)

1	2	3	4	5
☐	☐	☐	☐	☐
absoluut niet akkoord		neutraal		absoluut akkoord

37. Ik vond deze vragenlijst: (**QUESTION**)

1	2	3	4	5
☐	☐	☐	☐	☐
te kort	eerder kort	juist goed	eerder lang	te lang

38. Ik zou nog de volgende opmerkingen willen maken over deze oefening: (**COMMENT**)

....

....

....

Hartelijk dank voor je medewerking! Laat nu alles in de doos liggen, laat de doos op je bank staan en verlaat de zaal. Zorg er wel voor dat je het *witte kaartje* met je nummer meeneemt. Tegen vertoon van dit kaartje, kan je in de socio-ruimte (gratis) een drankje en een snoep krijgen. De bonus zal betaald worden rond 17.00 uur. De bonus nummers zullen uitgehangen worden in de socio-ruimte. Als je *niet* wil wachten tot 17.00 uur, schrijf dan je naam en e-mail adres op het witte kaartje en geef het af in de socio-ruimte. Indien je een bonus verdiende, contacteren we jou in de loop van volgende week om een tijdstip af te spreken, waarop wij je je bonus kunnen overhandigen.

5/5

13. Post Experimental Questionnaire Experiment Two (in English)

Variable Labels, Names and Headings were Added[119]

General Kind of Questions

Age (AGE)

1. My age is: ....

Gender (GENDER)

2. Gender:

   1 ☐ Male
   2 ☐ Female

Discipline of Education (OPTION)

3. My discipline of Education is:

   1 ☐ Bioengineering, option Chemicals
   2 ☐ Bioengineering, option Environment
   3 ☐ Bioengineering, option Cell & Gene
   4 ☐ Bioengineering, Other

Experience with Design Tasks (EXPERIEN)

4. Have you had experience with designing tasks before?

   1 ☐ Yes Please specify: ....
   ....
   2 ☐ No

Guessing the Real Purpose of the Task (PURPOSE)

5. Can you guess what the real purpose of the exercise is?

   1 ☐ Yes Please specify: ....
   ....
   2 ☐ No

1/6

[119] The 2 questions on **target cost difficulty** are only presented to the easy and the difficult TCS groups. Similarly, the 4 items on **target cost commitment** are only administered in the questionnaire for the easy and the difficult TCS. Questions 17, 19, 21, 22, 23, 24, 26, 27, 28, 29, 30 and 35 are **reverse scaled** for data analysis purposes.

Questions to give Feedback on the Task

Understanding of the Task (UNDERSTA)

6. Did you fully understand the task, after reading the instruction sheets?

1 ☐ Yes
2 ☐ No
Suggestions for improvements: ....
....

Participate again (AGAIN)

7. If we organize this task again in the future, would you participate again (without extra credit)?

1 ☐ Yes
2 ☐ No
Comments: ....
....

Total Number of Designs Made (TOTALDES)

8. How many designs did you made in total?

☐ ....

Perception of the Task (LIKETASK)

11. In general, I found this exercise __________.

1	2	3	4	5
☐	☐	☐	☐	☐
boring	rather boring	interesting	rather fun	fun

Importance to the Scores of the Jury (JURYIMPO)

12. I took ______ account of the scores of the jury.

1	2	3	4	5
☐	☐	☐	☐	☐
No or rather few	medium	many	high	extremely high

Perception of the Length of Questionnaire (QUESTION)

37. This questionnaire was:

1	2	3	4	5
☐	☐	☐	☐	☐
too short	rather short	just right	rather long	too long

General Comments on the exercise (COMMENT)

38. Do you have other comments on this exercise? Please write below:

....
....
....

2/6

Manipulation Checks

Manipulation Checks for Target Cost Specificity (COSTSPE1, COSTSPE2)

15. I knew exactly the acceptable cost of the carpet. (COSTSPE1)

1	2	3	4	5
☐	☐	☐	☐	☐
absolutely disagree		neutral		absolutely agree

28. The instructions of my boss on the acceptable cost of the carpet were rather vague. (COSTSPE2)

1	2	3	4	5
☐	☐	☐	☐	☐
absolutely disagree		neutral		absolutely agree

Manipulation Checks for Target Cost Difficulty (COSTEASY, COSTDIF)

Only for Easy and Difficult Target Cost Setting

30. The *cost* goal of my boss was easy to attain. (COSTEASY)

1	2	3	4	5
☐	☐	☐	☐	☐
absolutely disagree		neutral		absolutely agree

34. It was difficult to have a cost below the acceptable cost. (COSTDIF)

1	2	3	4	5
☐	☐	☐	☐	☐
absolutely disagree		neutral		absolutely agree

Manipulation checks for Difficulty of Time Objective (SHORTTIM, TIMEEASY)

16. The time limit was rather short to complete this task. (SHORTTIM)

1	2	3	4	5
☐	☐	☐	☐	☐
absolutely disagree		neutral		absolutely agree

29. De time limit of my boss was easy to attain. (TIMEEASY)

1	2	3	4	5
☐	☐	☐	☐	☐
absolutely disagree		neutral		absolutely agree

3/6

Energy Expended on Attractiveness and on Cost

Energy Expended on Attractiveness (ATTREFFO, ATTRPERS, ATTRATTE)

9. How much effort did you provide to create an *attractive* carpet? (ATTREFFO)

1	2	3	4	5
☐	☐	☐	☐	☐
No or rather few	medium	many	high	extremely high

14. While I was creating the carpet, I worked with _________ persistence to make my design *attractive*. (ATTRPERS)

1	2	3	4	5
☐	☐	☐	☐	☐
No or rather few	medium	many	high	extremely high

36. In general, I took much attention to improve the attractiveness of my design. (ATTRATTE)

1	2	3	4	5
☐	☐	☐	☐	☐
absolutely disagree		neutral		absolutely agree

Energy Expended on Cost (COSTEFFO, COSTPERS, COSTATTE)

10. How much effort did you provide to bring the cost of the carpet down? (COSTEFFO)

1	2	3	4	5
☐	☐	☐	☐	☐
No or rather few	medium	many	high	extremely high

13. I worked with _________ persistence to the cost of my design. (COSTPERS)

1	2	3	4	5
☐	☐	☐	☐	☐
No or rather few	medium	many	high	extremely high

20. During the task, I thought that I took much attention to the cost of the carpet. (COSTATTE)

1	2	3	4	5
☐	☐	☐	☐	☐
absolutely disagree		neutral		absolutely agree

4/6

Cost Commitment and Time Commitment

<u>Cost commitment, 4 items (COSTCOM1, COSTCOM2, COSTCOM3, COSTCOM4)</u>

Only for Easy and Difficult Target Cost Setting

17. It was hard to take the *cost* goal of my boss seriously, during the task. (COSTCOM1)

1	2	3	4	5
☐	☐	☐	☐	☐
absolutely disagree		neutral		absolutely agree

22. It was unrealistic for me to expect to reach the *cost* goal of my boss. (COSTCOM2)

1	2	3	4	5
☐	☐	☐	☐	☐
absolutely disagree		neutral		absolutely agree

24. It was quite likely that the *cost* goal may need to be revised, depending on how things went. (COSTCOM3)

1	2	3	4	5
☐	☐	☐	☐	☐
absolutely disagree		neutral		absolutely agree

27. Quite frankly, I did not care if I achieved the *cost* goal or not. (COSTCOM4)

1	2	3	4	5
☐	☐	☐	☐	☐
absolutely disagree		neutral		absolutely agree

<u>Time Commitment, 4 items (TIMECOM1, TIMECOM2, TIMECOM3, TIMECOM4)</u>

19. During the task, it was difficult to take the *time* limit of my boss seriously. (TIMECOM1)

1	2	3	4	5
☐	☐	☐	☐	☐
absolutely disagree		neutral		absolutely agree

21. It was was unrealistic for my to expect to reach the *time* goal of my boss. (TIMECOM2)

1	2	3	4	5
☐	☐	☐	☐	☐
absolutely disagree		neutral		absolutely agree

23. It was quite likely that the *time* limit may needed to be revised, depending on how things went. (TIMECOM3)

1	2	3	4	5
☐	☐	☐	☐	☐
absolutely disagree		neutral		absolutely agree

26. Quite frankly, I did not care if I achieved the time goal or not. (TIMECOM4)

1	2	3	4	5
☐	☐	☐	☐	☐
absolutely disagree		neutral		absolutely agree

5/6

Tension (Self-Reported) and Motivation by the Bonus System

Tension because of Goal Conflict, 3 items (TENSION1, TENSION2, TENSION3)

18. During the task, I was rather tensed because I thought I would never find the ideal design. (TENSION1)

1	2	3	4	5
☐	☐	☐	☐	☐
absolutely disagree		neutral		absolutely agree

25. Looking for an attractive and cheap carpet made me rather tensed during the exercise. (TENSION2)

1	2	3	4	5
☐	☐	☐	☐	☐
absolutely disagree		neutral		absolutely agree

35. I felt rather comfortable when aiming for the different goals during the exercise. (TENSION3)

1	2	3	4	5
☐	☐	☐	☐	☐
absolutely disagree		neutral		absolutely agree

Motivation by bonus system (BONUS1, BONUS2, BONUS3)

31. By a possible bonus of 300 BEF, I was strongly motivated to create an attractive carpet. (BONUS1)

1	2	3	4	5
☐	☐	☐	☐	☐
absolutely disagree		neutral		absolutely agree

32. By a possible bonus of 300 BEF, I was strongly motivated to create an attractive carpet that had a low cost as well. (BONUS2)

1	2	3	4	5
☐	☐	☐	☐	☐
absolutely disagree		neutral		absolutely agree

33. By a possible bonus of 100 BEF, I was strongly motivated to make an attractive carpet, within the time limit. (BONUS3)

1	2	3	4	5
☐	☐	☐	☐	☐
absolutely disagree		neutral		absolutely agree

6/6

14. Scores of the Judges for "Attractiveness" in Experiment Two

	Scores from 1 to 5 from the 9 judges										
ID Number	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**Total Score**	**Mean Score**
1	2	2	2	4	4	4	5	3	3	29	3.22
2	4	3	3	4	3	4	2	3	3	29	3.22
3	5	3	4	4	4	5	2	4	3	34	3.78
4	2	2	3	4	2	3	4	4	4	28	3.11
5	4	4	4	4	3	3	2	3	3	30	3.33
6	2	2	2	1	2	2	2	3	1	17	1.89
7	3	4	5	3	4	3	3	2	3	30	3.33
8	2	2	2	2	2	2	1	2	2	17	1.89
9	5	4	4	3	4	3	3	3	3	32	3.56
10	5	4	4	5	4	5	2	3	3	35	3.89
11	4	3	2	4	2	3	3	5	4	30	3.33
12	5	3	4	4	4	5	2	3	3	33	3.67
13	4	5	5	5	3	4	2	4	2	34	3.78
14	5	3	3	3	3	5	4	3	3	32	3.56
15	5	4	3	4	4	5	3	3	4	35	3.89
16	4	3	2	2	3	3	4	2	3	26	2.89
17	2	4	4	3	4	3	2	2	2	26	2.89
18	4	3	3	4	4	3	2	2	3	28	3.11
19	3	3	1	3	4	4	4	2	3	27	3.00
20	1	2	3	2	1	3	3	3	3	21	2.33
23	3	4	4	4	5	3	3	4	3	33	3.67
24	3	2	3	3	2	3	2	2	2	22	2.44
25	2	3	3	3	4	2	3	2	4	26	2.89
26	1	1	1	1	1	2	1	1	1	10	1.11
27	2	2	3	2	2	2	3	4	3	23	2.56
28	1	2	3	2	2	2	2	2	3	19	2.11
29	3	3	3	3	4	3	2	3	3	27	3.00
30	2	5	2	5	4	4	4	2	2	30	3.33
31	3	1	3	2	4	3	2	3	3	24	2.67
32	2	4	3	4	4	3	3	2	3	28	3.11
33	3	1	2	1	2	1	3	2	2	17	1.89
34	5	3	4	4	2	2	2	3	3	28	3.11
35	2	4	1	3	1	3	3	2	2	21	2.33
36	4	2	2	3	4	4	4	2	2	27	3.00
37	3	4	4	4	2	4	1	2	3	27	3.00
38	2	2	3	1	3	2	2	2	3	20	2.22
39	3	4	2	3	3	2	4	3	3	27	3.00
40	3	1	2	2	1	3	2	1	1	16	1.78
41	2	1	2	1	2	3	2	2	2	17	1.89
42	2	5	3	4	4	2	3	3	3	29	3.22
45	2	4	4	2	2	3	2	3	1	23	2.56
46	3	1	1	1	2	4	2	3	2	19	2.11
47	1	1	2	1	1	2	2	1	1	12	1.33
48	3	4	4	5	3	4	2	4	3	32	3.56
49	5	3	4	5	3	2	2	4	3	31	3.44

50	2	5	2	5	5	5	3	4	4	35	3.89
51	2	3	3	2	2	2	1	3	3	21	2.33
52	2	3	2	2	1	4	2	3	2	21	2.33
53	5	2	3	4	2	2	3	4	3	28	3.11
54	4	4	3	4	4	4	4	4	4	35	3.89
55	3	2	2	2	2	3	2	1	1	18	2.00
56	2	2	2	2	3	2	2	2	1	18	2.00
57										.	.
58	2	2	2	3	5	3	4	3	4	28	3.11
59	5	4	4	4	2	3	3	5	3	33	3.67
60	1	2	2	2	1	2	2	2	2	16	1.78
61	3	4	4	3	5	3	3	2	4	31	3.44
62	4	4	3	4	3	3	2	3	3	29	3.22
63	2	3	3	3	4	2	4	2	4	27	3.00
64	4	4	3	4	4	2	3	3	4	31	3.44
67	3	3	2	3	4	3	4	3	2	27	3.00
68	4	2	2	3	5	2	4	2	4	28	3.11
69	3	3	3	3	4	3	2	2	2	25	2.78
70	5	5	4	5	4	5	4	4	3	39	4.33
71	4	4	3	4	3	3	3	4	3	31	3.44
72	1	3	2	3	4	3	2	2	3	23	2.56
73	5	4	3	5	4	5	3	5	4	38	4.22
74	4	4	3	4	2	3	4	3	4	31	3.44
75	3	1	3	1	1	4	1	2	1	17	1.89
76	1	3	3	3	3	2	3	3	3	24	2.67
77	3	4	3	4	4	4	2	3	3	30	3.33
78	1	3	2	2	2	1	2	1	1	15	1.67
79	2	5	4	3	3	3	2	4	3	29	3.22
80	1	5	3	3	4	4	1	4	4	29	3.22
81	5	3	3	4	4	3	5	4	4	35	3.89
82	3	4	4	4	5	3	3	5	5	36	4.00
83	3	2	3	3	4	4	2	3	2	26	2.89
84	4	4	4	3	2	3	2	4	3	29	3.22
85	2	2	3	3	3	4	2	3	2	24	2.67
86	2	1	2	1	2	2	1	1	1	13	1.44
89	2	2	2	2	2	2	2	2	3	19	2.11
90	1	3	2	2	2	2	2	3	3	20	2.22
91	1	2	2	1	1	1	1	1	1	11	1.22
92	1	2	2	1	2	2	2	2	3	17	1.89
93	4	2	2	3	3	3	2	1	2	22	2.44
94	4	4	4	4	3	3	3	5	5	35	3.89
95	2	3	3	3	2	2	3	2	2	22	2.44
96	1	4	3	3	4	4	4	3	5	31	3.44
97	3	3	3	3	4	4	3	5	3	31	3.44
98	4	3	2	3	2	4	4	3	3	28	3.11
99	2	2	2	2	3	2	2	2	2	19	2.11

100	4	1	2	1	1	3	2	2	2	18	2.00
101	1	2	3	2	1	2	2	2	2	17	1.89
102	5	4	3	5	3	2	3	3	3	31	3.44
103	2	4	3	3	4	3	3	4	4	30	3.33
104	1	1	2	2	2	2	2	2	3	17	1.89
105	2	2	2	2	1	2	1	1	1	14	1.56
106	1	3	2	1	2	3	2	2	2	18	2.00
107	4	1	3	2	1	2	2	2	1	18	2.00
108	1	1	1	1	1	1	1	1	1	9	1.00
111	1	1	2	1	1	2	1	2	1	12	1.33
112	1	1	2	1	1	2	1	1	1	11	1.22
113	1	1	2	1	2	3	3	2	3	18	2.00
114	1	1	1	1	2	1	1	1	1	10	1.11
115	4	3	1	2	4	4	5	2	4	29	3.22
116	4	2	4	4	5	4	4	5	4	36	4.00
117	1	2	2	1	1	1	1	1	1	11	1.22
118	4	2	3	4	3	3	3	2	3	27	3.00
119	1	2	2	3	3	2	3	2	2	20	2.22
120	3	3	2	4	5	4	3	2	3	29	3.22
121	3	2	2	3	2	3	2	3	2	22	2.44
122	2	2	2	2	2	2	1	1	1	15	1.67
123	1	1	1	1	1	1	1	1	1	9	1.00
124	3	3	3	4	4	4	4	5	4	34	3.78
125	4	2	2	2	2	5	4	2	3	26	2.89
126	2	2	3	3	5	3	3	2	4	27	3.00
127	2	2	2	2	3	3	3	2	3	22	2.44
128	2	4	3	4	2	2	2	3	3	25	2.78
129	2	3	2	3	5	3	4	3	4	29	3.22
130	2	2	3	3	5	3	4	2	3	27	3.00

15. Examples of the Most Attractive Creations in Experiment Two

☞**On the next two pages are inserted:**

The *three most attractive* designs in each of the six manipulations:

- **the non-target cost setting, easy time objective**
- **the easy target cost setting, easy time objective**
- **the difficult target cost setting, easy time objective**
- **the non-target cost setting, difficult time objective**
- **the easy target cost setting, difficult time objective**
- **the difficult target cost setting, difficult time objective.**

16. Details of the Bonus Pay in Experiment Two

Non-Target Cost Setting, Easy Time (105 Minutes)						
ID Number	Mean score for attractiveness	Cost Level	Within 3 lowest cost	Time Spent	Time Attained	Total Bonus
10	3.89	2194	Yes	81 min.	Yes	700 BEF
15	3.89	2484	No	84 min.	Yes	400 BEF
3	3.78	2468	No	91 min.	Yes	400 BEF
13	3.78	2154	Yes	62 min.	Yes	700 BEF
12	3.67	2104	Yes	80 min.	Yes	700 BEF
Easy Target Cost Setting (3150 BEF), Easy Time (105 Minutes)						
ID Number	Mean score for attractiveness	Cost Level	Target Cost Attained	Time Spent	Time Attained	Total Bonus
23	3.67	2940	Yes	75 min.	Yes	700 BEF
30	3.33	2940	Yes	82 min.	Yes	700 BEF
42	3.22	2164	Yes	90 min.	Yes	700 BEF
32	3.11	2748	Yes	82 min.	Yes	700 BEF
34	3.11	1964	Yes	66 min.	Yes	700 BEF
Difficult Target Cost Setting (2750 BEF), Easy Time (105 Minutes)						
ID Number	Mean score for attractiveness	Cost Level	Target Cost Attained	Time Spent	Time Attained	Total Bonus
50	3.89	2950	No	73 min.	Yes	400 BEF
54	3.89	2676	Yes	52 min.	Yes	700 BEF
59	3.67	3000	No	76 min.	Yes	400 BEF
48	3.56	2980	No	93 min.	Yes	400 BEF
49	3.44	1804	Yes	57 min.	Yes	700 BEF
61	3.44	2880	No	78 min.	Yes	400 BEF
64	3.44	2960	No	80 min.	Yes	400 BEF

Non-Target Cost Setting, Difficult Time (75 Minutes)						
ID Number	Mean score for attractiveness	Cost Level	Within 3 lowest cost	Time Spent	Time Attained	Total Bonus
70	4.33	39	Yes	75 min.	Yes	700 BEF
73	4.22	38	No	75 min.	Yes	400 BEF
82	4.00	36	No	44 min.	Yes	400 BEF
81	3.89	35	Yes	47 min.	Yes	700 BEF
71	3.44	31	Yes	75 min.	Yes	700 BEF
74	3.44	31	No	58 min.	Yes	400 BEF
Easy Target Cost Setting (3150 BEF), Difficult Time (75 Minutes)						
ID Number	Mean score for attractiveness	Cost Level	Target Cost Attained	Time Spent	Time Attained	Total Bonus
94	3.89	3480	No	74 min.	Yes	400 BEF
96	3.44	2960	Yes	63 min.	Yes	700 BEF
97	3.44	2930	Yes	68 min.	Yes	700 BEF
102	3.44	2460	Yes	78 min.	No	600 BEF
103	3.33	2576	Yes	44 min.	Yes	700 BEF
Difficult Target Cost Setting (2750 BEF), Difficult Time (75 Minutes)						
ID Number	Mean score for attractiveness	Cost Level	Target Cost Attained	Time Spent	Time Attained	Total Bonus
116	4.00	2716	Yes	67 min.	Yes	700 BEF
124	3.78	3120	No	54 min.	Yes	400 BEF
115	3.22	3490	No	56 min.	Yes	400 BEF
120	3.22	2136	Yes	74 min.	Yes	700 BEF
129	3.22	2734	Yes	73 min.	Yes	700 BEF

17. Receipt Form for the Bonus in Experiment Two

Example of a 700 BEF Bonus

Bonus 700 BEF

Group id numbers 111-134

I, ... declare that I had the **id number** in the experiment on Thursday March 11, 1999 from 14.00-17.00 in auditorium I, at the Faculty of Economics and Business Administration, University Ghent.

I made a design that was selected as one of the 5 most attractive of all 20 designs made by the participants of my group. So I earned a first bonus of 300 BEF. My design was under the cost objective of my boss of 2.750 BEF. So I earned a second bonus of 300 BEF. I was also finished within the time limit, so I earned a third bonus of 100 BEF.

Thus in total, my whole bonus is equal to 700 BEF.

I declare that I received an envelope with 700 BEF after the experiment on

.....................................……….. (date) …………..…………………………. (signature)

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18. Guessing Real Purpose of Experiment Two (in Dutch)

Answers on the Question: "Can you guess what the real purpose of this exercise was?"

ID Number	Kan je raden wat we met deze oefening wilden onderzoeken?
	Non-Target Cost Setting, Easy Time
2	Creativiteit gecombineerd met kostenbewust denken.
3	Creativiteit.
7	Creativiteit en kostenefficiëntie onderzoeken van de bio-ingenieur.
11	Creativiteit onder druk, presteren onder druk.
12	Zelf proberen op een zo goedkoop mogelijke manier iets moois te produceren.
16	Binnen een tijdslimiet een ontwerp maken dat aan bepaalde voorwaarden voldoet.
	Easy Target Cost Setting, Easy Time
27	Voorkeur tapijten van toekomstige gezinnetjes.
28	Attractieve tapijten en kleuren voor de markt.
37	Marktgerichte creativiteit?
39	Zo mooi en zo goedkoop mogelijk tapijt produceren.
	Difficult Target Cost Setting, Easy Time
46	Ja.
47	Snel vinden van basisideeën.
48	Of deze methode geschikt is om een ideaal tapijt of iets anders te ontwerpen.
49	Of mensen slaafs doen wat je hen vraagt als je ze maar beloont.
52	Invloed van de kosten?
53	Een ontwerp voor een tapijt creëren voor een bedrijf dat het zal produceren.
54	Nagaan wat er in de markt leeft.
58	Creativiteit.
59	Creativiteit en kost.
61	Ik denk dat men het inzicht wil nagaan bij verschillende studiegroepen (bio-ingenieurs versus economen versus talenknobbels).
64	Marketing inzicht.

	Non-Target Cost Setting, Difficult Time
70	Artistiek vermogen bio-ingenieur?
72	Inventiviteit van jonge mensen te samen met hun inzicht in optimaal gebruik van machines met een minimum aan kosten.
73	Marktonderzoek, wij zijn toekomstige jonge ouders.
75	Psychologische test van student.
78	Psychologisch: kleurpatronen, keuzes.
84	Afwegen: mooi design <¯> prijs.
	Easy Target Cost Setting, Difficult Time
89	**Of ingenieurs ook creatief kunnen zijn.**
91	Kleurenpreferenties en prijsbewustzijn onderzoeken voor marketingdoeleinden.
92	Creativiteit van de gemiddelde bio-ingenieur?
93	Nieuwe ideeën.
96	Op zo goedkoop mogelijke manier een tapijt ontwerpen dat beantwoordt aan smaak en wens van de consument.
97	Marktonderzoek voor tapijtindustrie.
98	Prijs en kwaliteit nastreven.
99	Prijs en kwaliteit.
100	Slechte smaak beoordelen.
101	Creativiteit?
102	Psycho-analyse over kleuren onder een prestatiegerichte druk.
103	Motivering nagaan.
106	Iets met psychologie.
107	Kleurenblindheid.
	Difficult Target Cost Setting, Difficult Time
112	Associatie van kleuren en hun effecten op het menselijk lichaam.
115	Ontwerpen maken rekening houdend met tijd en opgelegde kosten.
116	Creativiteit, zowel qua ontwerp en reduceren van kosten (inzicht).
119	Kleurvaardigheden.
123	Beïnvloedbaarheid door tussentijdse evaluatie.
127	Kijken of we kunnen presteren onder druk. Een opdracht (op kleine schaal) zoals we die misschien later kunnen verwachten.
128	Motivatie van ontwerpers en houding ervan ten opzicht van economische regels.
130	Bepalen hoe wij tijdsdruk, inspanning en baat (winst) opvatten.

19. Written Feedback to the Participants of Experiment Two (in Dutch)

Aan: Alle bio-ingenieurs die hebben deelgenomen op 11/03/99
Van: Patricia Everaert
Betreft: Feedback over de laatste sessie "Inleiding tot Industrieel Beheer

1. Doel van het Onderzoek

Het onderzoek waar jullie hebben aan meegewerkt, kadert in mijn doctoraatsonderzoek naar target costing. Target costing is een techniek die vooral in Japan wordt toegepast bij de ontwikkeling van nieuwe producten. Ontwerpers krijgen daar een specifieke kostendoelstelling opgelegd, waaraan het product moet voldoen, vooraleer het op de markt te brengen. Dit betekent dat ingenieurs bij het ontwerpen (naast de kwaliteit van het product en de totale ontwikkeltijd) ook moeten werken aan het verminderen van de kostprijs van het nieuwe product, nog vooraleer het product echt bestaat. Totnogtoe gaat men er in de literatuur van uit dat er een positieve impact is van target costing op de kostprijs van het product. De totale kostprijs van het nieuwe product zou lager zijn onder target costing dan wanneer ontwerpers de boodschap krijgen om de kostprijs van het te ontwikkelen product te minimaliseren. Bovendien zou het gebruik van target costing geen negatieve impact hebben op de kwaliteit en de ontwikkeltijd van een nieuwe product. Het algemeen doel van mijn studie is precies om deze twee stellingen empirisch te gaan testen aan de hand van een aantal experimenten.

2. Experimentele Condities

In de oefening, waar jullie aan meegewerkt hebben, waren er drie verschillende kostendoelstellingen. Een derde van de groep kreeg een *vage kostendoelstelling* ("probeer de kosten van het tapijt te minimaliseren"). Een ander derde van de groep kreeg een specifieke kostendoelstelling, die *gemakkelijk* haalbaar was. ("De baas wil dat de kost van het tapijt niet hoger is dan 3150 BEF.") Het laatste derde van de groep tenslotte kreeg een specifieke kostendoelstelling, die *moeilijk* haalbaar was. ("De baas wil dat de kost van het tapijt niet hoger is dan 2750 BEF.")
Bovendien waren er twee tijdscondities. Voor de ene helft van de groep was er een tijdsdoelstelling van 1 uur en 45 minuten, wat de *gemakkelijke tijdsdoelstelling* was. Voor de andere helft van de groep was er een *moeilijke tijdsdoelstelling* van 1 uur en 15 minuten. Samenvattend, waren er dus zes verschillende condities, zoals weergegeven in onderstaande tabel. In totaal hebben 120 bio-ingenieurs meegewerkt, wat neerkomt op 20 personen per groep.

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Tabel 1: Overzicht van de 6 condities in het Experiment op 11/03/99

	Vage kostendoelstelling: "**Kost van het tapijt minimaliseren"**	Specifieke, gemakkelijke kostendoelstelling. **"Kost < 3150"**	Specifieke, moeilijke kostendoelstelling. **"Kost < 2750"**
Gemakkelijke tijdsdoelstelling **(1.45 u.)**	Groep 1 (n= 20) Nummers 1 - 22	Groep 2 (n= 20) Nummers 23-44	Groep 3 (n = 20) Nummers 45 – 66
Moeilijke tijdsdoelstelling **(1.15 u.)**	Groep 4 (n= 20) Nummers 67 - 88	Groep 5 (n = 20) Nummers 89- 110	Groep 6 (n = 20) Nummers 111 - 132

3. Bonus Systeem

Om de taak au serieux te nemen werd een *eerste* bonus van 300 BEF beloofd aan de 5 meest attractieve tapijten binnen elk van de 6 groepen. Attractiviteit werd hier gemeten aan de hand van de gemiddelde score van de juryleden, die elk ontwerp individueel scoorden op een schaal van 1 tot 5. Bovendien was er een *tweede bonus* voor ontwerpers die niet alleen attractieve, maar ook "low cost" tapijten creëerden. Concreet betekent dit dat mensen die een vage kostendoelstelling hadden een supplementaire bonus van 300 BEF konden verdienen als hun ontwerp bovendien tot de 3 laagste in kost behoorden van deze 5 meest attractieve. Voor mensen die een specifieke kostendoelstelling hadden, was de supplementaire bonus van 300 BEF afhankelijk van het al of niet halen van de kostendoelstelling van 3150 BEF, 2750 BEF respectievelijk. Een *derde bonus* van 100 BEF was voorzien, indien deze 5 meest attractieve ontwerpen binnen de opgelegde tijdslimiet eindigden. Samenvattend betekent dit dat iedereen dus een kans van 5/20 (20%) had om een bonus te verdienen. In onderstaande tabel wordt de bonusberekening per groep weergegeven.

Tabel 2: Bonusberekening voor elk van de 6 groepen op 11/03/99

Bonus voor ontwerpers met de nummers 1-22:					
Nr.	**Kost**	**Totale Score van de jury**	**Gemiddelde Score van de jury**	**Binnen tijdslimiet**	**Bonus**
10	2194	35	3.89	ja	700
15	2484	35	3.89	ja	400
3	2468	34	3.78	ja	400
13	2154	34	3.78	ja	700
12	2104	33	3.67	ja	700
Bonus voor ontwerpers met de nummers 23-44:					
23	2940	33	3.67	ja	700
30	2940	30	3.33	ja	700
42	2164	29	2.22	ja	700
32	2748	28	2.11	ja	700
34	1964	28	2.11	ja	700
Bonus voor ontwerpers met de nummers 45-66:					
50	2950	35	3.89	ja	400
54	2676	35	3.89	ja	700
59	3000	33	3.67	ja	400
48	2980	32	3.56	ja	400
49	1804	31	3.44	ja	700
61	2880	31	3.44	ja	400
64	2960	31	3.44	ja	400

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Bonus voor ontwerpers met de nummers 67-88:					
70	2720	39	4.33	ja	700
73	3000	38	4.22	ja	400
82	3300	36	4.00	ja	400
81	2532	35	3.89	ja	700
71	2760	31	3.44	ja	700
74	3250	31	3.44	ja	400
Bonus voor ontwerpers met de nummers 89-110:					
94	3480	35	3.89	ja	400
96	2960	31	3.44	ja	700
97	2930	31	3.44	ja	700
102	2460	31	3.44	neen	600
103	2576	30	3.33	ja	700
Bonus voor ontwerpers met de nummers 111-132:					
116	2716	36	4.00	ja	700
124	3120	34	3.78	ja	400
115	3490	29	3.22	ja	400
120	2136	29	3.22	ja	700
129	2734	29	3.22	ja	700

4. Hypothesen en Resultaten

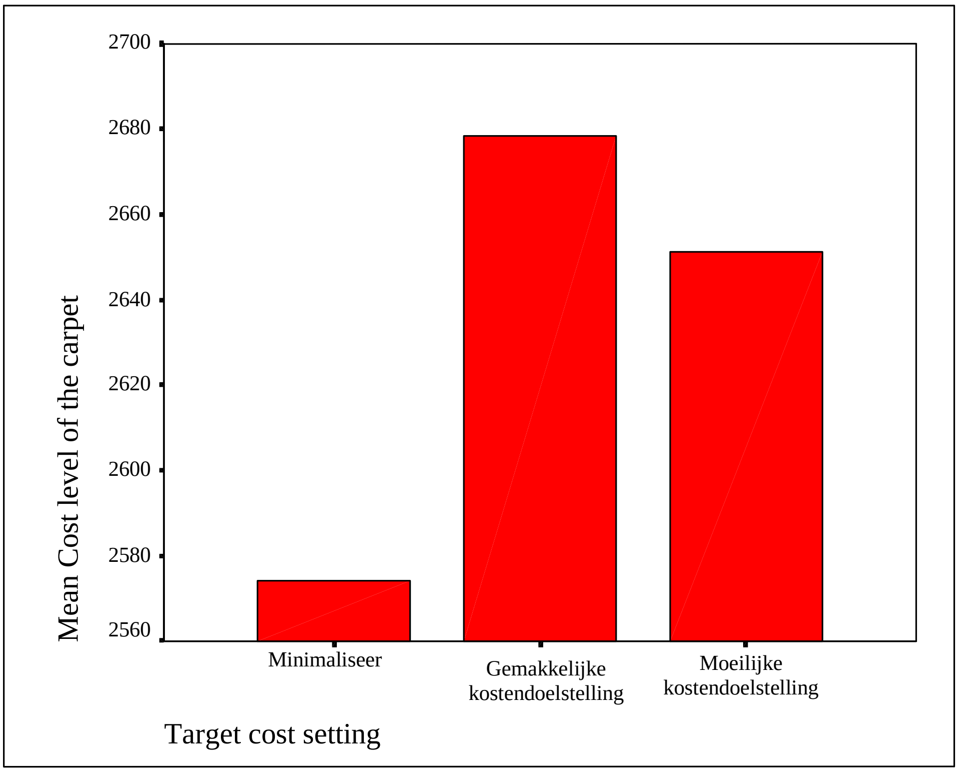
De eerste hypothese dat er geen significant verschil is in de kostprijs van het nieuwe product (het gecreëerde tapijt) tussen ontwerpers met een vage kostendoelstelling (minimaliseer de kosten), de ontwerpers met een gemakkelijke kostendoelstelling en de ontwerpers met een moeilijke specifieke kostendoelstelling kon niet worden verworpen door de data uit het experiment**. Er was dus geen significant verschil in kost tussen de drie groepen**. (F (2, 116) = 0.447, p = 0.641). Zie figuur 1. Bovendien was de gemiddelde kost lager onder de vage kostendoelstelling dan onder een de specifieke kostendoelstellingen.

De tweede hypothese dat er geen significant verschil is in de attractiviteit van het nieuwe product tussen ontwerpers met een vage kostendoelstelling (minimaliseer de kosten), de ontwerpers met een gemakkelijke kostendoelstelling en de ontwerpers met een moeilijke specifieke kostendoelstelling kon wel worden verworpen op basis van de data uit het experiment. **Er was dus een significant verschil in attractiviteit tussen de drie groepen** (F (2, 116) = 7.251, p = 0.001). Zoals uit figuur 2 blijkt, scoorden de ontwerpers onder de vage kostendoelstelling veel beter op het vlak van attractiviteit dan de ontwerpers onder een specifieke kostendoelstelling.

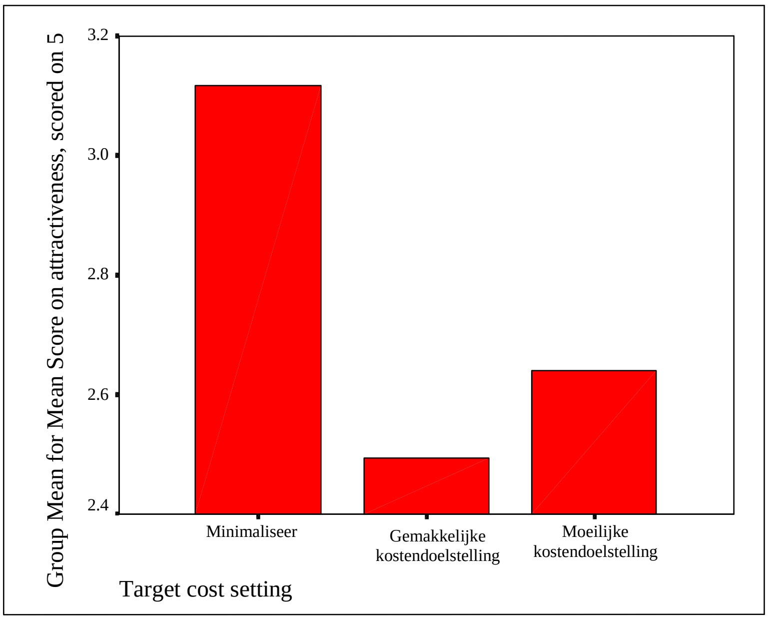
Ten derde was het interactie effect tussen de drie kostendoelstellingen en de twee tijdsdoelstellingen marginaal significant. (F (2,113 = 2.326, p=0.102) Dit marginaal interactie effect kan vooral worden verklaard door het verschil in kostprijs tussen de twee tijdscondities in de vage kostendoelstellingsgroep. **Het verschil in kostprijs tussen ontwerpers met een gemakkelijke en met een moeilijke tijdsdoelstelling was dus veel groter onder de vage kostendoelstelling, dan onder elk van de twee andere specifieke kostendoelstellingen**. Zie figuur 3.

Daarnaast werden via de vragenlijst achteraf heel wat **andere variabelen** gemeten zoals de inspanning om een attractief tapijt te creëren, de inspanning om een goedkoop tapijt te ontwerpen, de ervaren spanning tijdens de taak, de motivatie door het bonussysteem, de ervaren moeilijkheidsgraad van de tijd- en de kostendoelstelling, …. Deze variabelen hebben vooral tot doel te verklaren waarom het werken met kostendoelstellingen hier niet leidde tot een lagere kost, en zelfs negatief was voor de attractiviteit van het ontwerp. *3/5*

Figuur 1: Gemiddelde kost van het tapijt bij een vage kostendoelstelling, bij een gemakkelijke en bij een moeilijke kostendoelstelling



Figuur 2: Gemiddelde attractiviteit bij een vage kostendoelstelling, bij een gemakkelijke en bij een moeilijke kostendoelstelling



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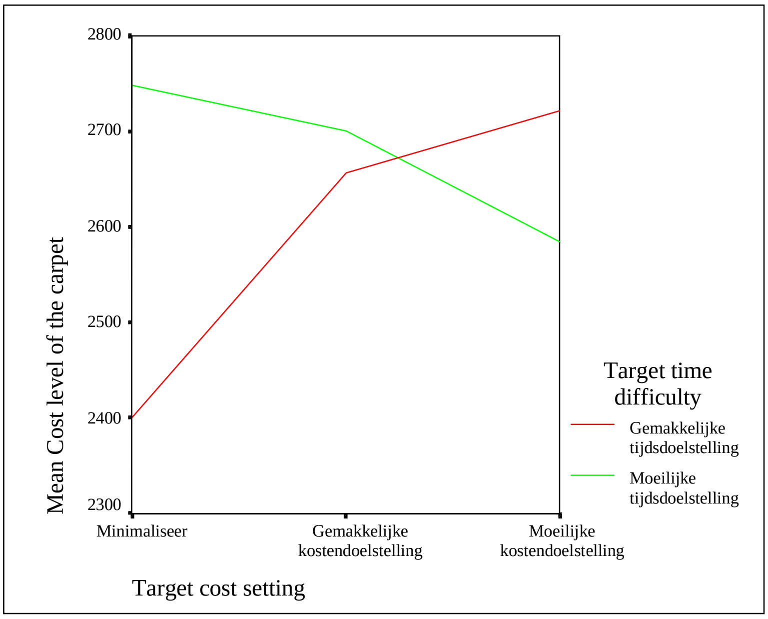
Figuur 3 : Gemiddelde kost onder een vage, een gemakkelijke en een moeilijke kostendoelstelling voor elk van de twee tijdscondities



5. Dank

Tenslotte willen we allen die hebben meegewerkt nog eens hartelijk danken. We wensen u veel succes toe met de komende examens en met het afwerken van de eindverhandeling.

Professor Dr. Werner Bruggeman
Patricia Everaert
05/05/99

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Appendix 3: Experiment Three
(University of Ghent, April 28, 1999)

1. Recruitment Letter of Experiment Three (in Dutch)

Aan alle studenten 2de kandidatuur, 1ste licentie en SLFM
Speciale sessie op woensdag 28/04/1998,
10.15 u. tot 12.45 u., Auditorium I van de FEB

Professor Dr. Bruggeman en assistente Patricia Everaert werken aan een onderzoek dat gaat over hoe mensen presteren in een omgeving van standaard kosten. Daartoe werd een oefening opgesteld, die een *simulatie* is van de activiteiten in de ontwerpafdeling van een textielbedrijf.

De simulatieoefening zal tijdens de oefeningenles uitvoerig worden uitgelegd aan de hand van geschreven instructies. De taak vraagt *geen speciale kennis* of specifieke talenten. Uit de pretesten weten we dat iedereen begrijpt wat er precies te doen staat. In zijn totaliteit zal deze sessie niet langer duren dan 2,5 uur. Daarom starten we dit keer *15 minuten vroeger*, dit is om 10.15 uur. Iedereen zal klaar zijn tegen 12.45 uur. De studenten kunnen niets voorbereiden tegen deze sessie.

Wel is het zo dat we een groot aantal studenten verwachten. Om maximale aanwezigheid te stimuleren en omdat we over een onderzoeksbudget beschikken, kunnen we een *bonus* betalen aan 25% van de aanwezige studenten, variërend tussen de 300 BEF en 700 BEF. De precieze hoogte van de bonus, evenals het feit of u een bonus zal verdienen, zal afhangen van de prestaties in de oefening. Wel is er voor iedereen achteraf een drankje voorzien.

Aanwezigheid is vrijwillig. Studenten die niet aanwezig zijn, zullen op geen enkele manier benadeeld worden. Wel willen we *op voorhand* weten hoeveel mensen die dag naar de oefeningenles zullen komen. Dit is hoofdzakelijk om organisatorische redenen, zodat we voldoende kopies met instructies kunnen maken en al het benodigde materiaal op de banken kunnen klaarzetten. Daarom vragen wij u om ons bijgaand inschrijvingsformulier *ten laatste tegen vrijdag 23/04/99* terug te bezorgen.

Indien u nog *vragen* hebt over deze oefeningensessie, kunt u steeds terecht bij Heidi Van Doorne (09/264 35 47, e-mail: heidi.vandoorne@rug.ac.be) of bij Patricia Everaert (09/264 35 00). Beide assistenten hebben hun bureau op het Sint-Pietersplein nr. 5.

Wij wensen u veel succes toe met de komende examens en hopen u te mogen verwelkomen op woensdag om 10.15u. in auditorium I.

Professor Dr. W. Bruggeman   Patricia Everaert

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Invulformulier sessie 28/04/1999

Vergeet uw rekenmachine niet!

Naam: ....

☐ Zal aanwezig zijn op de sessie van woensdag 28 april 1999, van 10.15 u. tot 12.45 u., auditorium I, Faculteit Economie en Bedrijfskunde.

☐ Zal niet aanwezig zijn op de sessie van woensdag 28 april 1999, van 10.15 u. tot 12.45 u., auditorium I, Faculteit Economie en Bedrijfskunde.

Af te geven ten laatste op vrijdag 23/04/99 aan:

Patricia Everaert of

Heidi Van Doorne

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Uw plaats reserveren kan ook telefonisch of per e-mail!

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2. List of Participants of Experiment Three

2nd Year of Applied Economics			
	Name	**Answer on Reply Form (Yes/ No)**	**Participated (Yes/No)**
1.	Al-Abed Mohammed	No reply form returned	-
2.	Balcaen Stefan M. E.	No reply form returned	-
3.	Bauters Saskia	No reply form returned	-
4.	Bauwens Davy L. R.	No reply form returned	-
5.	Beyst Tom	No reply form returned	-
6.	Bolea Petre-Cristian	No reply form returned	-
7.	Boone Bert G. L.	No reply form returned	-
8.	Bouckaert Carl J. D.	No reply form returned	Yes
9.	Braekeveldt Els I. K.	No reply form returned	-
10.	Buggenhout Christiaan L. R. M.	No reply form returned	-
11.	Buyle Katrien	No reply form returned	-
12.	Cocquyt Mieke I.	No reply form returned	-
13.	De Boeck Thomas	No reply form returned	-
14.	Debruyne Bram M.	Yes	Yes
15.	De Buck David S. G.	No	-
16.	De Bue Dimitri P. R.	No	-
17.	De Castro Nicolas J. Y. L.	No reply form returned	-
18.	Declerck Stijn A.	No reply form returned	-
19.	De Clercq Evelyne R. A.	No reply form returned	-
20.	De Clercq Steven A. R.	No	-
21.	Deconinck Aurélie	No reply form returned	-
22.	De Coninck Veerle J. J.	No reply form returned	-
23.	De Dene Ivan E. J.	No reply form returned	-
24.	Defour Marlies L. P.	Yes	Yes
25.	De Groote Isabelle I. R.	No reply form returned	-
26.	De Haeck Bjorn	No	-
27.	De Haeck Dina	Yes	Yes
28.	Dehandschutter Steven J. J.	No reply form returned	-
29.	De Keijser Hans A. A.	Yes	Yes
30.	Dekeyzer Iris E.	No reply form returned	-
31.	De Leeuw Han	No reply form returned	-
32.	Depreiter Inge N. M.	Yes	Yes
33.	Depuydt Björn	No reply form returned	-
34.	Desaer Vanessa J.	Yes	Yes
35.	De Schryver Nico F. D. G.	No reply form returned	-
36.	Desender Marena R.	No reply form returned	-
37.	De Smet Dieter J.	No reply form returned	-
38.	De Smet Joeri	No reply form returned	-
39.	De Storme Cindy A. R.	Yes	Yes
40.	De Vos Ruben B. B.	No	-
41.	De Vriendt Cindy	No reply form returned	-
42.	De Waele Frea	No reply form returned	-
43.	De Wadeler Peter P. K. J.	No reply form returned	-
44.	Deweer Tim R. L.	No reply form returned	-
45.	Dewever Evi N. J.	Yes	Yes
46.	Dhaenens Tom R. L.	No reply form returned	-

47.	D'hooge Stefan L.	No reply form returned	-
48.	Dierens Ingeborg B. E.	No reply form returned	-
49.	Dierick Bruno S. A.	No	-
50.	Dobbelaere Ludovic E. J.	No reply form returned	-
51.	Dossche Gino A. R.	No	-
52.	Emmerechts Frederik M. J.	No reply form returned	-
53.	Faillie Bart D. I.	No reply form returned	-
54.	Fiers Jeroen G. E.	No reply form returned	-
55.	Fontaine Patricia M. I.	No reply form returned	-
56.	Geldof Katty	No reply form returned	-
57.	Gevaert Francis M.	No reply form returned	-
58.	Goegebuer Griet A.	No reply form returned	-
59.	Goegebuer Niek J. R.	No reply form returned	-
60.	Goossens Tom H. S.	No	-
61.	Goossens Tom M.	Yes	Yes
62.	Heyman Dries P.	No reply form returned	-
63.	Hosten Frederik	No reply form returned	-
64.	Janda Linde Y. L.	No	-
65.	Janssens Jeroen F. C.	No reply form returned	-
66.	Joos Aurelie C. G. M.	No reply form returned	-
67.	Kerkaert Bart H. D.	No	-
68.	Klapwijk Michiel C.	No reply form returned	Yes
69.	Labis Anne Sophie L.	Yes	Yes
70.	Lampens Bert	No	-
71.	Larno Nele L. B. M.	No reply form returned	-
72.	Lefevere Eva A.	Yes	Yes
73.	Leus Wim M S.	No	-
74.	Lombaerts Tom R. C.	No reply form returned	-
75.	Longueville David	No	-
76.	Luyckx Robbie D.	No reply form returned	-
77.	Martens Leen	No reply form returned	-
78.	Matton Stefaan E.	Yes	Yes
79.	Merchiers Tom F. F.	No reply form returned	-
80.	Meuleman Miguel L. C. J.	No reply form returned	-
81.	Moerman Sarah M. H.	Yes	Yes
82.	Naudts Thierry M. M.	No reply form returned	-
83.	Pauwels Björn	No	-
84.	Phan Thi Nghia N.	No reply form returned	-
85.	Philips Jef	No reply form returned	-
86.	Phlippo David	No reply form returned	-
87.	Praet Kristoff	Yes	Yes
88.	Rogge Davy	Yes	Yes
89.	Smet Philippe E. Y.	Yes	Yes
90.	Smit Albrecht-Michaël M. B.	Yes	Yes
91.	Soenen Leentje A. M.	Yes	Yes
92.	Steels Ilse S. E.	No reply form returned	-
93.	Terras Nancy A. C.	No	-
94.	Thijs Jo	Yes	No
95.	Tollenaere Kurt J. J.	No	-
96.	Van Acker Ann M. P.	No reply form returned	-
97.	Van Biesen Dirk T. L.	No reply form returned	-
98.	Van Bogaert Wim P. A.	Yes	Yes
99.	Van Conkelberge Geert A. G.	No reply form returned	-
100.	Vanden Berghe Bavo	Yes	Yes

101.	Van den Berghe Jan A. M.	No reply form returned	-
102.	Vandenbulcke Kenneth D. K.	No reply form returned	-
103.	Vandenbussche Ingrid M.M.	No reply form returned	-
104.	Van den Driessche Leen	Yes	Yes
105.	Va den Perre Katrien R. L.	No reply form returned	-
106.	Van der Aa Bruno M. C.	Yes	No
107.	Vanderhaeghe Annelies M.	Yes	Yes
108.	Vandermoere Stijn C. L.	Yes	Yes
109.	Vandersickel Els J. G.	No reply form returned	-
110.	Van De Velde Sylvie M. M.	Yes	Yes
111.	Vandewalle Jeroen R. N.	Yes	Yes
112.	Van Gampelaere Gino M. A.	No reply form returned	-
113.	Van Haudenhuyse Elfie S. M.	No reply form returned	-
114.	Van Haudt Koen	No reply form returned	-
115.	Van Huyck Elke	No reply form returned	-
116.	Van Loo Jens R. S.	No reply form returned	-
117.	Van Neck Nathalie	Yes	No
118.	Van Praet Amélie M. J. P.	No reply form returned	-
119.	Vanquathem Hans F. W.	Yes	Yes
120.	Vanhournout Kevin S.	Yes	Yes
121.	Van Varenbergh Tom F. A.	Yes	Yes
122.	Van Veen Gregorius M. G.	No reply form returned	-
123.	Veldeman Valerie A.	No reply form returned	-
124.	Vellemans Jan	No reply form returned	-
125.	Verbeke Dieter M.	Yes	Yes
126.	Verrecas Jan D. I.	No	-
127.	Verrooten Thomas M. E.	No reply form returned	-
128.	Verstraete Ruth M. A.	No	-
129.	Vlaeminck Nathalie	Yes	Yes
130.	Vlerick Diederik J.	Yes	Yes
131.	Voet Veerle N. H.	Yes	Yes
132.	Wailly Frederik G. A.	Yes	Yes
133.	Willems Arne E.	No reply form returned	-
134.	Loones Cis	Yes	Yes
		Total	*36*
		Cumulative Total	*36*
2nd Year of Applied Economics, option: Technical Engineering			
1.	Aelterman Sofie	Yes	No
2.	Bracke Tomas	Yes	Yes
3.	Brondeel Lode	No	-
4.	Burez Jonathan G. A.	No reply form returned	-
5.	Claus Hiram H. C.	Yes	Yes
6.	Coolsaet Jeroen B.	No reply form returned	-
7.	David Hanne R. J.	No reply form returned	-
8.	Deceunynck Frederike C. A.	No reply form returned	-
9.	Decoussemaker Mieke	No reply form returned	-
10.	De Graeve Gregory N. L.	No reply form returned	-
11.	Denoyel Thibault	Yes	Yes
12.	Deraedt Pierre G. P.	Yes	Yes
13.	De Schrijver Mathias M. S.	No reply form returned	-
14.	Gailly Frederik L. M.	No	-
15.	Godderis Natacha E. C.	Yes	Yes

16.	Keuppens Elisabeth L. B. E.	No reply form returned	-
17.	Moens Ben F. L.	No reply form returned	-
18.	Mornie Hans L. M.	No	-
19.	Overmeire Wouter	Yes	Yes
20.	Parmentier Ann M. F.	Yes	Yes
21.	Pauwelyn Dieter D.	Yes	Yes
22.	Piens Mathieu F. D.	No reply form returned	-
23.	Saver Jan	No reply form returned	-
24.	Van Acker Tom A. J.	Yes	Yes
25.	Vanden Berghe Hendrik D. G.	No	-
26.	Vandenbroucke Tine M. C.	No reply form returned	-
27.	Van Keymeulen Timmy R. C.	No reply form returned	-
28.	Verly Thomas T. O.	Yes	Yes
29.	Wulfrank Evert A.	Yes	Yes
		Total	*11*
		Cumulative Total	*47*
2nd Year of Applied Economics, Special Programme (IAJ)			
1.	Ackx Kris	No reply form returned	Yes
2.	Cattrysse Jimmy	No reply form returned	-
3.	Courtois Vanessa	Yes	Yes
4.	Cromheecke Tiny	Yes	Yes
5.	Demuynck Kurt	No reply form returned	-
6.	Den Haese Annelies	No	-
7.	Devos Katrien	Yes	No
8.	Rigole Ines	No	-
9.	Ryckaert Cedric	No reply form returned	-
10.	Smet Mark	Yes	No
11.	Van Branteghem Cedric	No reply form returned	-
12.	Vandenbogaerde Tom	No	-
13.	Vermeulen Quinten	No reply form returned	-
14.	Verstraete Kristel	Yes	Yes
		Total	*4*
		Cumulative Total	*51*
3nd Year of Applied Economics			
1.	Bourgeois Cedric	Yes	Yes
2.	Cosijns Sofie	Yes	Yes
3.	D'Hondt Christophe	Yes	Yes
4.	Persoons Sven	Yes	No
5.	Vanhauwermeir An	Yes	Yes
		Total	*4*
		Cumulative Total	*55*
Master in Financial Management			
1.	Camerlynck Jan	Yes	Yes
2.	Cavalier Marie	No	-
3.	Colpaert Hilde	Yes	Yes
4.	De Ceuckelaere Kristof	Yes	Yes
5.	De vuyst Veerle	Yes	Yes
6.	Dehaene Alexander	No reply form returned	-
7.	Everaert Edle	No	-

8.	Hovine Jean-François		Yes	No
9.	Koninckx Werner		Yes	Yes
10.	Langenberg Sven		No	-
11.	Middernacht Frederik		No reply form returned	-
12.	Noynaert Joachim		No	-
13.	Serruys Gilles		Yes	Yes
14.	Van Hoecke Lies		Yes	Yes
15.	Van Hyfte Wim		Yes	Yes
16.	Van Mieghem Jan		Yes	Yes
17.	Van Moffaert Michaël		No	-
18.	Van Nevel Laurens		Yes	Yes
			Total	*10*
			Cumulative Total	*65*

3. Instruction Sheets to Participants of Experiment Three

Instruction sheets

1/14

Some Practical Comments

You received when entering the room:

1. a card with your number.

On your desk there should be a box with the following items:

6. 1 folder that is open and that contains:
   - these instruction sheets and
   - a bundle of 15 patterns,
7. 1 folder that is closed and that contains a questionnaire ("vragenlijst"),
4. a ballpoint,
5. a set of 9 color pens,
6. a colored picture of a living room interior,
7. two blue cards with your number on it,
8. an open envelope.

Please *check now* if you have all these items in your box.

Remark 1: These instruction sheets belong to *you* during the whole exercise. You can make notes on these sheets, if you want.

Remark 2: You might or might not have received the same instructions for the exercise as your neighbor. So don't compare *your* task with the task of your *neighbor*!

Remark 3: This exercise is *voluntary*. You can stop with this exercise, if you feel you should do so.

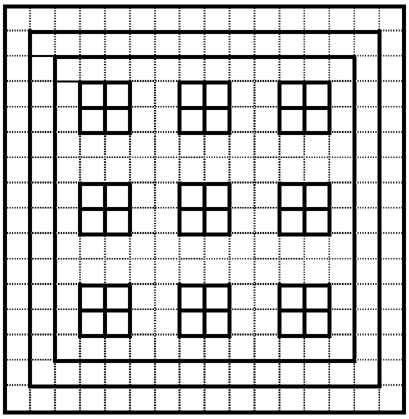
Please wait before reading the next page!

2/14

Pattern

From now on, you are carpet designers. Your task is to design a carpet for a *living room* for the market of young families, with small children. Your boss decided on the type of design, but you have to decide on the colors of the carpet. You find this basic design in the middle of the page. This pattern represents a square of two by two meters.

Make sure you see the difference between the *small squares* and the *predefined fields* of small squares. As you can see, some of the small squares belong together, because a bold line surrounds them. Take a look at that design now.



There are 16 * 16 small squares, i.e. 256 in total.

Outside border:	1 predefined field of 60 small squares =	60 small squares
Inside border:	1 predefined field of 52 small squares =	52 small squares
Background:	1 predefined field of 108 small squares =	108 small squares
Singles:	<u>36 predefined fields of 1 small square</u> =	<u>36 small squares</u>
	39 predefined fields in total	256 small squares

Since your boss decided already on the type of design, you can only use a different color within each predefined field. You can <u>no</u>t use *different* colors within the same predefined field. If you want to make neighbor fields in the same color, you can. So, merging fields is allowed, but splitting a predefined field is not allowed. The instructor will show two good and one bad example on slide. If you still have questions after these examples, ask her.

Please wait before reading the next page!

3/14

Colors

You received a set of 9 color pens:

blue,
light blue,
green,
light green,
yellow,
orange,
red,
brown,
black.

If you leave a square blank, this means you use the color white.

So in total you can decide between *10 different colors*, i.e. the 9 color pens and white.

You can use as many of these colors as you want, but you *cannot combine* colors, since these are the 10 colors we have in yarn. They look the same in reality as the color pens you are using now.

Please, use only these color pens to color the designs. Don't use the ballpoint as a color.

Please wait before reading the next page!

4/14

Costs: Page 1

As design engineer, you know of course a lot about the cost of the carpets you create.

You know that the cost of a carpet is mainly determined

1) by the *sort* of colors you use and
2) by the *number* of colors you use.

You know that there exist 3 categories of colors: the *neutral* colors, the *bright* colors and the *dark* colors. Yarns in neutral colors are the least expensive, yarns in bright colors are more expensive and yarns in dark colors are the most expensive.

These 3 classes of colors are:

Class A: Neutral colors:

white
black

Class B: Bright colors:

yellow
orange
light blue
light green

Class C: Dark colors:

blue
brown
red
green.

Please wait before reading the next page!

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Costs: Page 2

You also know that the machines have *a standard setting of 5 colors*. These are called the standard colors. You can decide yourself which colors you will use as standard colors. If you use an additional color (i.e. a sixth, a seventh, an eight, a ninth or a tenth color), the machines will have to be set up more times, making this additional color more expensive.

Make sure you understand the following table. The cost of the colored yarn is given for each small square:

	Cost per small square *standard* color	cost per small square *additional* color
	Class A:	Class A+:
White	3	6
Black	3	6
	Class B:	Class B+:
Yellow	10	13
Orange	10	13
Light blue	10	13
Light green	10	13
	Class C:	Class C+:
Blue	15	18
Brown	15	18
Red	15	18
Green	15	18

Lets have a look at a few examples now.

If you have questions after those examples, please ask your instructor.

Please wait before reading the next page!

6/14

Costs: Page 3

Example 1:

R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
R	B	B	B	B	B	B	B	B	B	B	B	B	B	B	R
R	B	B	B	B	B	B	B	B	B	B	B	B	B	B	R
R	B	B	G	G	B	B	Y	Y	B	B	G	G	B	B	R
R	B	B	G	G	B	B	Y	Y	B	B	G	G	B	B	R
R	B	B	B	B	B	B	B	B	B	B	B	B	B	B	R
R	B	B	B	B	B	B	B	B	B	B	B	B	B	B	R
R	B	B	Y	Y	B	B	W	W	B	B	Y	Y	B	B	R
R	B	B	Y	Y	B	B	W	W	B	B	Y	Y	B	B	R
R	B	B	B	B	B	B	B	B	B	B	B	B	B	B	R
R	B	B	B	B	B	B	B	B	B	B	B	B	B	B	R
R	B	B	G	G	B	B	Y	Y	B	B	G	G	B	B	R
R	B	B	G	G	B	B	Y	Y	B	B	G	G	B	B	R
R	B	B	B	B	B	B	B	B	B	B	B	B	B	B	R
R	B	B	B	B	B	B	B	B	B	B	B	B	B	B	R
R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R

R = Red, B = Blue, G = Green, Y = Yellow, W = White

Color Issues	Color	Type	Cost per small square	*Number*	Total Cost
Outside border:	Red	C	15	60	900
Inside border:	Blue	C	15	52	780
Background:	Blue	C	15	108	1.620
Singles:	White	A or A+	3	4	12
	Black	A or A+	-	-	-
1	Yellow	B or B+	10	16	160
2	Orange	B or B+	-	-	
3	Light Blue	B or B+	-	-	
4	Light Green	B or B+	-	-	
5	Blue	C or C+	-	-	
	Brown	C or C+	-	-	
	Red	C or C+	-	-	
	Green	C or C+	15	16	240
			Check Total	256 ☑	**3.712**

We are using here 5 colors. So there are no additional costs (no A+, no B+, no C+).

All costs per small square are coming from the second column of the cost table of the previous page.

Please wait before reading the next page!

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Costs: Page 4

Example 2:

B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B
B	G	G	G	G	G	G	G	G	G	G	G	G	G	G	B
B	G	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	G	B
B	G	Y	B	B	Y	Y	W	R	Y	Y	B	B	Y	G	B
B	G	Y	B	B	Y	Y	R	W	Y	Y	B	B	Y	G	B
B	G	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	G	B
B	G	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	G	B
B	G	Y	R	W	Y	Y	L	L	Y	Y	W	R	Y	G	B
B	G	Y	W	R	Y	Y	L	L	Y	Y	R	W	Y	G	B
B	G	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	G	B
B	G	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	G	B
B	G	Y	B	B	Y	Y	W	R	Y	Y	B	B	Y	G	B
B	G	Y	B	B	Y	Y	R	W	Y	Y	B	B	Y	G	B
B	G	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	G	B
B	G	G	G	G	G	G	G	G	G	G	G	G	G	G	B
B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B

B = Brown, G = Green, Y = Yellow, R = Red, W = White, L = Light green

Color Issues	Color	Type	Cost per small square	*Number*	Total Cost
Outside border:	Brown	C	15	60	900
Inside border:	Green	C	15	52	780
Background:	Yellow	B	10	108	1.080
Singles:	White	A or ~~A+~~	3	8	24
	Black	A or A+		-	
1	Yellow	B or B+		-	
2	Orange	B or B+		-	
3	Light Blue	B or B+		-	
4	Light Green	~~B~~ or B+	13	4	52
5	Blue	C or C+		-	
6	Brown	C or ~~C+~~	15	16	240
	Red	C or ~~C+~~	15	8	120
	Green	C or C+		-	
			Check Total	256 ☑	**3.196**

We are using here 6 colors: 5 standard colors and one additional color.

Remark that the color with the least total number of small squares (here 4 small squares in light green) should be chosen as the additional color (indicated by a B+ in stead of a regular B).

If you have questions on these tables, please ask your instructor now!

Please wait before reading the next page!

8/14

Task

The task involves creating an *attractive* carpet for a living room, for the market of young families with small children. You can color as many copies of the basic design as you want, but at the end of the exercise, you have to decide which carpet you will hand in. Your boss only wants *one* colored design. Since your boss is going to show your colored design to judges (representing the market), make sure your pattern is not looking dirty and make sure you are *not* writing anything above the horizontal line. On that line, we will fold your sheet in two parts: the pattern part and the cost part. The judges will only see the pattern part, without your cost part.

[Non-Target Cost Setting]
Furthermore, the company uses a cost plus approach to determine the sales price. This means that the cost of the carpet is used as a basis to set the sales price. More specific, the sales price is set at a level equal to the cost of the carpet plus a profit percentage of 20%. Hence, your boss wants you to create an attractive carpet, while trying to *minimize* the cost of that carpet. Your boss is convinced that young families are not prepared to pay a lot of money for their living room carpet. In order to survive in this competitive market of living room carpets, you *should* come up with an attractive carpet at the *lowest cost* possible. So, do your best in minimizing the cost level of the design you create.

[Difficult Target Cost Setting]
Furthermore, the sales price for carpets is determined on the market. For the coming season the market price for a given carpet is estimated at 3.300 BEF. The general manager decided that living room carpets should earn a profit of 550 BEF apiece. Hence, your boss wants you to create an attractive carpet that costs *no more than 2.750 BEF* (i.e. the difference between the estimated market price of 3.300 and the profit margin of 550). Your boss is convinced that young families are not prepared to pay more than the estimated market price of 3.300 BEF. Furthermore, the company needs the profit margin of 550 BEF apiece, in order to survive in the competitive market of living room carpets. So, you *should* come up with an attractive carpet that costs no more than 2.750 BEF, unless you really think that designing an attractive carpet under that cost is impossible.

[Easy Time]
Finally, your boss wants you to be finished *within 1 hour and 45 minutes*. If you are finished earlier, you should not wait to hand in your design. If you think that designing an attractive carpet in this time period is not possible, you can take some extra time.

[Difficult Time]
Finally, your boss wants you to be finished *within 1 hour and 15 minutes*. If you are finished earlier, you should not wait to hand in your design. If you think that designing an attractive carpet in this time period is not possible, you can take some extra time.

9/14

Market information

To help you with the kind of style, your boss already selected the *interior* where the collection of designs of this year should fit in. A picture of that interior is enclosed. We cut a frame out of the yellow ground, so you can easily place your colored design behind this interior page, to see if your design is an attractive one for this kind of interior. Can you see how it works? Please do not make notes on that picture.

Furthermore, your boss also has some market data available on what the market liked and disliked during the previous season. The 8 *most attractive* designs are given as well as the 10 *least attractive* designs, as perceived by the market (judges). The judges used the same interior as you have now. Please use this information when creating your carpet for this year!

In the previous season, we had *violet* ("paars"), but your boss deleted violet as a color for this season.

As you will see, the basic design of last season was totally different from the one of this year. Slight differences in colors between your color pens and the colors on these pages can be caused by the color copy machine we used to multiply these pages. All judges used earlier the original designs to give a score.

Please do not write on these pages with the 8 most attractive and the 10 least attractive designs.

If you have questions, please ask your instructor!

10/14

Judges

Most of the judges, who did the scoring of the designs earlier, are also present now. Today there are __________ judges present. They will score your design as 1, 2, 3, 4 or 5. The *higher* the score, the *more* they like the design, as indicated in the following table.

	Score
Very attractive	5
Rather Attractive	4
Something in between	3
Rather non-attractive	2
Not at all attractive	1

Each of the judges will score *individually* and they will do it according to their *own norms*.

Let's assume that there are 10 judges and that each of these 10 judges gave the following scores:

Judge 1	Judge 2	Judge 3	Judge 4	Judge 5	Judge 6	Judge 7	Judge 8	Judge 9	Judge 10	Total sum
5	4	5	4	3	4	5	4	3	4	?

To come to a global score on attractiveness, you can calculate the *mean*. Hence, you make the sum of all scores and you divide this sum by the number of judges. In this example, the sum is 41 and the mean is 41/10 = 4,1.

Since, there are _______ judges today, you will get ______ scores from the judges and you should divide the total of these scores by ________.

Please wait before reading the next page !

11/14

Organization of the Feedback by the Judges

To get scores from the judges (representing the market), your boss set up some rules:

- If you want scores of the judges for a given design, you should *fold your pattern sheet* in the *correct way*. First, fold the page in two on the horizontal line. One part shows the design and the other part shows the cost. Right? Secondly, fold the cost part in two again, so the judges cannot see the cost information. Your instructor will show an example.
- A *courier* will walk around. If you have a design ready to score, hold up one of the blue cards. He/she will come to you as soon as possible to bring your design to the judges in front of the room.
- Give the *blue card* to the courier.
- Since you are having only two blue cards, you can use the judges *only two times*, to give you some feedback on what the market likes. You can give two designs together or you can give them at different times. Please remark that you are *not obligated* to use the judges during the task.
- It might take 15 minutes before you will get your design back. In the mean time, you can work on some other designs.

If you have questions on this, please ask your instructor!

12/14

Bonus [Non-Target Cost Setting, Easy Time]

In total there are 20 design engineers in your firm. They are all students Economics, who volunteered in this experiment and who received the same information as you have now. There should be no difference in ability to create carpets between you all.
You will hand in *one* created carpet. This design might or might not have received scores from the judges yet. If it did not receive scores from the judges, the judges will score it at the end of the session.

The designers of the *5 most attractive* carpets of your group of 20 will receive a bonus of 300 BEF. Among those 5 most attractive carpets, the 3 carpets with the *lowest cost* will get an additional bonus of 300 BEF. This means that 3 persons will receive a bonus of 600 BEF because their design is one of the 5 most attractive and because their design is one of the 3 lowest cost designs of those 5 most attractive designs. Similarly, 2 persons will get a bonus of 300 BEF, because their design is one of the 5 most attractive, though not belonging to the 3 (of those five) with the lowest cost.

An additional bonus of 100 BEF is provided for those 5 most attractive carpets, if the designer was finished *within the time limit* of 1 hour and 45 minutes.

The bonus numbers will be posted "ad valvas" *this afternoon*. We will pay you your bonus tomorrow Thursday (13.45 h. – 14.00 h.) or on Friday (13.00 h. – 13.30 h.) in aud. I. Look at the examples in the following table to see if you understand how the bonus system works.

Identity Number	Mean score	Total cost of the carpet (these figures are *not* realistic)		Time spent	Bonus
15	3,8	10.000		1 hour 20 minutes	300 + 0 + 100 = 400
23	3,7	9.000	2°	1 hour 15 minutes	300 + 300 + 100 = 700
2	3,3	11.000		1 hour 55 minutes	300 + 0 + 0 = 300
8	3,2	7.000	1°	1 hour 45 minutes	300 + 300 + 100 = 700
14	3,1	9.500	3°	2 hour 00 minutes	300 + 300 + 0 = 600
31	2,9	7.000		1 hour 10 minutes	0

Why is number 31 not getting a bonus? Because he/she was not within the 5 most attractive of his/her group of 20 design engineers. If you have questions on the bonus determination, please ask your instructor now!

Please wait before reading the next page!
13/14

Bonus [Difficult Target Cost Setting, Easy Time]

In total there are 20 design engineers in your firm. They are all students Economics, who volunteered in this experiment and who received the same information as you have now. There should be no difference in ability to create carpets between you all.

You will hand in *one* created carpet. This design might or might not have received scores from the judges yet. If it did not receive scores from the judges, the judges will score it at the end of the session.

The designers of the *5 most attractive* carpets of your group of 20 will receive a bonus of 300 BEF. Among those 5 most attractive carpets, the carpets which costs no more than 2.750 BEF will get an additional bonus of 300 BEF. This means that you will receive a bonus of 600 BEF if your design is one of the 5 most attractive and if your design has a cost lower than or equal to 2.750 BEF. If you are among the 5 most attractive designs, but your design costs more than 2.750 BEF, you will only get 300 BEF.

An additional bonus of 100 BEF is provided for those 5 most attractive carpets, if the designer was finished *within the time limit* of 1 hour and 45 minutes.

The bonus numbers will be posted “ad valvas” *this afternoon*. We will pay you your bonus tomorrow Thursday (13.45 h. – 14.00 h.) or on Friday (13.00 h. – 13.30 h.) in aud. I. Look at the examples in the following table to see if you understand how the bonus system works.

Identity Number	Mean score	Total cost of the carpet	Time spent	Bonus
15	3,8	3.300	1 hour 20 minutes	300 + 0 + 100 = 400
23	3,7	2.260	1 hour 15 minutes	300 + 300 + 100 = 700
2	3,3	3.840	1 hour 55 minutes	300 + 0 + 0 = 300
8	3,2	2.676	1 hour 45 minutes	300 + 300 + 100 = 700
14	3,1	2.560	2 hour 00 minutes	300 + 300 + 0 = 600
31	2,9	2.224	1 hour 10 minutes	0

Why is number 31 not getting a bonus? Because he/she was not within the 5 most attractive of his/her group of 20 design engineers. If you have questions on the bonus determination, please ask your instructor now!

Please wait before reading the next page!

13/14

Bonus [Non-Target Cost Setting, Difficult Time]

In total there are 20 design engineers in your firm. They are all students Economics, who volunteered in this experiment and who received the same information as you have now. There should be no difference in ability to create carpets between you all. You will hand in one created carpet. This design might or might not have received scores from the judges yet. If it did not receive scores from the judges, the judges will score it at the end of the session.

The designers of the *5 most attractive* carpets of your group of 20 will receive a bonus of 300 BEF. Among those 5 most attractive carpets, the 3 carpets with the *lowest cost* will get an additional bonus of 300 BEF. This means that 3 persons will receive a bonus of 600 BEF because their design is one of the 5 most attractive and because their design is one of the 3 lowest cost designs of those 5 most attractive designs. Similarly, 2 persons will get a bonus of 300 BEF, because their design is one of the 5 most attractive, though not belonging to the 3 (of those five) with the lowest cost.

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23	3,7	9.000	2°	1 hour 00 minutes	300 + 300 + 100 = 700
2	3,3	11.000		1 hour 25 minutes	300 + 0 + 0 = 300
8	3,2	7.000	1°	1 hour 15 minutes	300 + 300 + 100 = 700
14	3,1	9.500	3°	1 hour 45 minutes	300 + 300 + 0 = 600
31	2,9	7.000		0 hour 40 minutes	0

Why is number 31 not getting a bonus? Because he/she was not within the 5 most attractive of his/her group of 20 design engineers. If you have questions on the bonus determination, please ask your instructor!

Please wait before reading the next page!

13/14

Bonus [Difficult Target Cost Setting, Difficult Time]

In total there are 20 design engineers in your firm. They are all students Economics, who volunteered in this experiment and who received the same information as you have now. There should be no difference in ability to create carpets between you all.

You will hand in *one* created carpet. This design might or might not have received scores from the judges yet. If it did not receive scores from the judges, the judges will score it at the end of the session.

The designers of the *5 most attractive* carpets of your group of 20 will receive a bonus of 300 BEF. Among those 5 most attractive carpets, the carpets which costs no more than 2.750 BEF will get an additional bonus of 300 BEF. This means that you will receive a bonus of 600 BEF if your design is one of the 5 most attractive and if your design has a cost lower than or equal to 2.750 BEF. If you are among the 5 most attractive designs, but your design costs more than 2.750 BEF, you will only get 300 BEF.

An additional bonus of 100 BEF is provided for those 5 most attractive carpets, if the designer was finished *within the time limit* of 1 hour and 15 minutes.

The bonus numbers will be posted "ad valvas" *this afternoon*. We will pay you your bonus tomorrow Thursday (13.45 h. – 14.00 h.) or on Friday (13.00 h. – 13.30 h.) in aud. I. Look at the examples in the following table to see if you understand how the bonus system works.

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14	3,1	2.560	1 hour 45 minutes	300 + 300 + 0 = 600
31	2,9	2.224	0 hour 40 minutes	0

Why is number 31 not getting a bonus? Because he/she was not within the 5 most attractive of his/her group of 20 design engineers. If you have questions on the bonus determination, please ask your instructor!

Please wait before reading the next page!
13/14

Summary [Non-Target Cost Setting, Easy Time]

Let's briefly summarize your task.

1. You are a carpet designer and can use 10 different colors in your design: 9 color pens and white.

2. Remember to use one color within the predefined fields. You are not allowed to split predefined fields, but you are allowed to merge those fields.

3. Your boss asks you to design an attractive carpet for a living room, within a given interior, while trying to minimize the cost. You have examples of last year's collection and can consult the market (judges) two times, if you want.

4. Your boss thinks that you will be finished within 1 hour and 45 minutes. If you are finished earlier, do not hesitate to hand in your creation. If you want some more time, you can take.

5. The 5 most attractive creations out of the 20 in your group will get a bonus of 300 BEF. The 3 carpets with the lowest cost among those 5 most attractive will get an additional bonus of 300 BEF, making their total bonus 600 BEF. Furthermore, all 5 most attractive creations that were finished within 1 hour and 45 minutes get a supplementary bonus of 100 BEF.

6. Here goes the cost table again.

	cost per small square *standard* color	cost per small square *additional* color
	Class A:	Class A+:
White	3	6
Black	3	6
	Class B:	Class B+:
Yellow	10	13
Orange	10	13
Light blue	10	13
Light green	10	13
	Class C:	Class C+:
Blue	15	18
Brown	15	18
Red	15	18
Green	15	18

7. You can create as much carpets as you want, but your boss needs only one. If you are finished, put your selection in the white envelope. Make sure this carpet is a fully colored pattern (except for the white squares). Indicate on the envelope if the judges already scored your selected design (yes or no). Hold this envelope *up* and your instructor will come to pick it up and she/he will write the time spent on it. Then (and only then) you can open the sealed folder. There is a questionnaire of four pages in it. This questionnaire will take more or less 10 minutes to fill out. We started at _________ hour. Good luck designer!

14/14

Summary [Difficult Target Cost Setting, Easy Time]

Let's briefly summarize your task.

1. You are a carpet designer and can use 10 different colors: 9 color pens and white.

2. Remember to use one color within the predefined fields. You are not allowed to split predefined fields, but you are allowed to merge those fields.

3. Your boss asks you to design an attractive carpet for a living room (see interior), and which costs no more than 2.750 BEF. You have examples of last year's collection and can consult the market (judges) two times, if you want.

4. Your boss thinks that you will be finished within 1 hour and 45 minutes. If you are finished earlier, do not hesitate to hand in your creation. If you want some more time, you can take.

5. The 5 most attractive creations out of the 20 in your group will get a bonus of 300 BEF. The carpets among those 5 with a cost level equal to or lower than 2.750 BEF will get an additional bonus of 300 BEF, making their total bonus 600 BEF. Furthermore, all 5 most attractive creations that were finished within 1 hour and 45 minutes get a supplementary bonus of 100.

6. Here goes the cost table again.

	cost per small square *standard* color	cost per small square *additional* color
	Class A:	Class A+:
White	3	6
Black	3	6
	Class B:	Class B+:
Yellow	10	13
Orange	10	13
Light blue	10	13
Light green	10	13
	Class C:	Class C+:
Blue	15	18
Brown	15	18
Red	15	18
Green	15	18

7. You can create as much carpets as you want, but your boss needs only one. If you are finished, put your selection in the white envelope. Make sure this carpet is a fully colored pattern (except for the white squares). Indicate on the envelope if the judges already scored your selected design (yes or no). Hold this envelope *up* and your instructor will come to pick it up and she/he will write the time spent on it. Then (and only then) you can open the sealed folder. There is a questionnaire of four pages in it. This questionnaire will take more or less 10 minutes to fill out. We started at _________ hour. Good luck designer! *14/14*

Summary [Non-Target Cost Setting, Difficult Time]

Let's briefly summarize your task.

1. You are a carpet designer and can use 10 different colors in your design: 9 color pens and white.
2. Remember to use one color within the predefined fields. You are not allowed to split predefined fields, but you are allowed to merge those fields.
3. Your boss asks you to design an attractive carpet for a living room, within a given interior, while trying to minimize the cost. You have examples of last year's collection and can consult the market (judges) two times, if you want.
4. Your boss thinks that you will be finished within 1 hour and 15 minutes. If you are finished earlier, do not hesitate to hand in your creation. If you want some more time, you can take.
5. The 5 most attractive creations out of the 20 in your group will get a bonus of 300 BEF. The 3 carpets with the lowest cost among those 5 most attractive will get an additional bonus of 300 BEF, making their total bonus 600 BEF. Furthermore, all 5 most attractive creations that were finished within 1 hour and 15 minutes get a supplementary bonus of 100 BEF.
6. Here goes the cost table again.

	cost per small square *standard* color	cost per small square *additional* color
	Class A:	Class A+:
White	3	6
Black	3	6
	Class B:	Class B+:
Yellow	10	13
Orange	10	13
Light blue	10	13
Light green	10	13
	Class C:	Class C+:
Blue	15	18
Brown	15	18
Red	15	18
Green	15	18

7. You can create as much carpets as you want, but your boss needs only one. If you are finished, put your selection in the white envelope. Make sure this carpet is a fully colored pattern (except for the white squares). Indicate on the envelope if the judges already scored your selected design (yes or no). Hold this envelope *up* and your instructor will come to pick it up and she/he will write the time spent on it. Then (and only then) you can open the sealed folder. There is a questionnaire of four pages in it. This questionnaire will take more or less 10 minutes to fill out. We started at _________ hour. Good luck designer! *14/14*

Summary [Difficult Target Cost Setting, Difficult Time]

Let's briefly summarize your task.

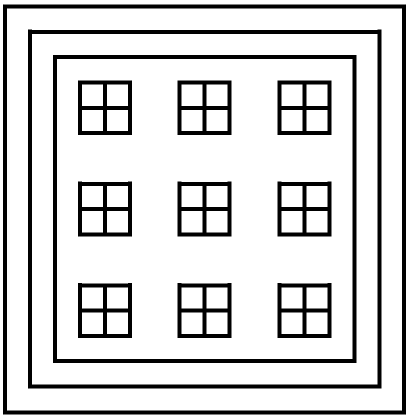
1. You are a carpet designer and can use 10 different colors: 9 color pens and white.
2. Remember to use one color within the predefined fields. You are not allowed to split predefined fields, but you are allowed to merge those fields.
3. Your boss asks you to design an attractive carpet for a living room (see interior), and which costs no more than 2.750 BEF. You have examples of last year's collection and can consult the market (judges) two times, if you want.
4. Your boss thinks that you will be finished within 1 hour and 15 minutes. If you are finished earlier, do not hesitate to hand in your creation. If you want some more time, you can take.
5. The 5 most attractive creations out of the 20 in your group will get a bonus of 300 BEF. The carpets among those 5 with a cost level equal to or lower than 2.750 BEF will get an additional bonus of 300 BEF, making their total bonus 600 BEF. Furthermore, all 5 most attractive creations that were finished within 1 hour and 15 minutes get a supplementary bonus of 100.
6. Here goes the cost table again.

	cost per small square *standard* color	cost per small square *additional* color
	Class A:	Class A+:
White	3	6
Black	3	6
	Class B:	Class B+:
Yellow	10	13
Orange	10	13
Light blue	10	13
Light green	10	13
	Class C:	Class C+:
Blue	15	18
Brown	15	18
Red	15	18
Green	15	18

7. You can create as much carpets as you want, but your boss needs only one. If you are finished, put your selection in the brown envelope. Make sure this carpet is a fully colored pattern (except for the white squares). Indicate on the envelope if the judges already scored your selected design (yes or no). Hold this envelope up and your instructor will come to pick it up and she/he will write the time spent on it. Then (and only then) you can open the sealed folder. There is a questionnaire of four pages in it. This questionnaire will take more or less 10 minutes to fill out. We started at _________ hour. Good luck designer! *14/14*

4. Pattern Sheet of Experiment Three

ID_Number



ID_Number

Color Issues	Color	Type	Cost per small area	*Number*	Total Cost
Outside border:				60	
Inside border:				52	
Background:				108	
Singles:	White	A or A+			
	Black	A or A+			
	Yellow	B or B+			
	Orange	B or B+			
	Light Blue	B or B+			
	Light Green	B or B+			
	Blue	C or C+			
	Brown	C or C+			
	Red	C or C+			
	Green	C or C+			
			Check Total	256 ☐	

1/1

5. Market Information distributed in Experiment Three

☞ **Inserted on the next page:**

- **Eight *Most Attractive* Designs of Last Year, as perceived by the Market (Judges)**

☞ **Inserted earlier on page 429:**

- **Ten *Least Attractive* Designs of Last Year, as perceived by the Market (Judges)**

6. Overhead Sheets used during the Instructions to Participants in Experiment Three

- **The same overhead sheets were used in Experiment Three as we used in Experiment Two:**

  .. See page 440

7. Instruction Sheets for the Assistants of Experiment Three

- **The same instruction sheets were used for the assistants in Experiment Three as in Experiment Two: .... See page 431**

8. Instruction Sheets for the Judges of Experiment Three

- **The same instruction sheets were used for the Judges in Experiment Three as in Experiment Two: ....See page 434**

9. Post Experimental Questionnaire of Experiment Three (in Dutch)

Vragenlijst **ID_Number**

Zou je nog even deze vragen kunnen beantwoorden? De antwoorden zullen niet op een individuele basis worden gebruikt. Niemand zal dan ook inzage krijgen in jouw antwoorden. Enkel algemene conclusies voor de totale groep zullen worden gemaakt.

1. Mijn leeftijd is (**AGE**): ....

2. Geslacht (**GENDER**):
   - 1 ☐ Mannelijk
   - 2 ☐ Vrouwelijk

3. Mijn studierichting is (**OPTION**):
   - 5 ☐ 2de kan. TEW
   - 6 ☐ 2de kan. TEW, technische bedrijfskunde
   - 7 ☐ 1ste lic. TEW
   - 8 ☐ SLFM
   - 9 ☐ andere (IAJ, …)

4. Heb je in het verleden al eens ontwerptaken uitgevoerd? (**EXPERIEN**)
   - 1 ☐ Ja namelijk: ....
   - 2 ☐ Neen

5. Kan je raden wat we met deze oefening wilden onderzoeken? (**PURPOSE**)
   - 1 ☐ Ja namelijk: ....
   - 2 ☐ Neen

6. Verstond je de taak voldoende om ze goed te kunnen uitvoeren, na het lezen van de instructie-bladzijden? (**UNDERSTA**)
   - 1 ☐ Ja
   - 2 ☐ Neen

   Suggesties tot verbeteringen: ....

7. Hoeveel volledige designs heb je in totaal gemaakt? (**TOTALDES**)

   ☐ ....

8. De feedback over de appreciaties van de markt over de collectie van vorig seizoen vond ik __________ bij het ontwerpen van de collectie van dit jaar. (**FEEDBACK**)

1	2	3	4	5
☐	☐	☐	☐	☐
Niet nuttig	eerder niet nuttig		eerder nuttig	heel nuttig

9. Hoeveel inspanning heb je geleverd tijdens de oefening om een attractief (mooi) tapijt te creëren? (**ATTREFFO**)

1	2	3	4	5
☐	☐	☐	☐	☐
Geen of weinig	middelmatig	veel	heel veel	extreem veel

1/5

10. Hoeveel inspanning heb je geleverd tijdens de oefening om de *kost* van het tapijt naar beneden te halen? (**COSTEFFO**)

1	2	3	4	5
☐	☐	☐	☐	☐
Geen of weinig	middelmatig	veel	heel veel	extreem veel

11. In het algemeen beschouwd, vond ik deze oefening _________. (**LIKETASK**)

1	2	3	4	5
☐	☐	☐	☐	☐
Saai	nogal saai	gewoon	eerder leuk	leuk

12. Ik hechtte ______ belang aan de scores van de juryleden bij de finale keuze van mijn ontwerp. (**JURYIMPO**)

1	2	3	4	5
☐	☐	☐	☐	☐
Geen of weinig	middelmatig	veel	heel veel	extreem veel

13. Ik werkte aan de *kosten* van mijn ontwerp, met _________ doorzettingsvermogen. (**COSTPERS)**

1	2	3	4	5
☐	☐	☐	☐	☐
Geen of weinig	middelmatig	veel	heel veel	extreem veel

14. Tijdens het ontwerpen, legde ik _________ doorzettingsvermogen aan de dag om het tapijt er *aantrekkelijk* te doen uitzien. (**ATTRPERS**)

1	2	3	4	5
☐	☐	☐	☐	☐
Geen of weinig	middelmatig	veel	heel veel	extreem veel

15. Ik wist precies hoe hoog de toelaatbare kost van het te ontwerpen tapijt mocht zijn. (**COSTSPE1**)

1	2	3	4	5
☐	☐	☐	☐	☐
absoluut niet akkoord		neutraal		absoluut akkoord

16. De tijdslimiet was eerder kort om deze taak uit te voeren. (**SHORTTIM**)

1	2	3	4	5
☐	☐	☐	☐	☐
absoluut niet akkoord		neutraal		absoluut akkoord

17. Tijdens het uitvoeren van de oefening, was ik nogal gespannen omdat ik dacht dat ik het ideale ontwerp nooit zou vinden. (**TENSION1**)

1	2	3	4	5
☐	☐	☐	☐	☐
absoluut niet akkoord		neutraal		absoluut akkoord

2/5

18. Tijdens de taak vond ik van mezelf dat ik heel veel aandacht besteedde aan de totale *kostprijs* van het tapijt. (**COSTATTE**)

1	2	3	4	5
☐	☐	☐	☐	☐
absoluut niet akkoord		neutraal		absoluut akkoord

19. Het zoeken naar een attractief *en* goedkoop tapijt binnen de tijdslimiet leidde bij mij tot nogal wat spanning tijdens de oefening. (**TENSION2**)

1	2	3	4	5
☐	☐	☐	☐	☐
absoluut niet akkoord		neutraal		absoluut akkoord

20. De instructies van mijn baas in verband met de toelaatbare kost van het te ontwerpen tapijt waren eerder vaag. (**COSTSPE2**)

1	2	3	4	5
☐	☐	☐	☐	☐
absoluut niet akkoord		neutraal		absoluut akkoord

21. De *tijds*doelstelling van mijn baas was makkelijk haalbaar. (**TIMEEASY**)

1	2	3	4	5
☐	☐	☐	☐	☐
absoluut niet akkoord		neutraal		absoluut akkoord

22. De *kosten*doelstelling van mijn baas was makkelijk haalbaar. **[Difficult Target Cost Setting] (COSTEASY)**

1	2	3	4	5
☐	☐	☐	☐	☐
absoluut niet akkoord		neutraal		absoluut akkoord

23. Door een mogelijke bonus van 300 BEF was ik sterk gemotiveerd om een aantrekkelijk tapijt te maken. (**BONUS1**)

1	2	3	4	5
☐	☐	☐	☐	☐
absoluut niet akkoord		neutraal		absoluut akkoord

24. Door een mogelijke bonus van 300 BEF was ik sterk gemotiveerd om een aantrekkelijk tapijt te maken, dat *bovendien* zo weinig mogelijk kostte. (**BONUS2**)

1	2	3	4	5
☐	☐	☐	☐	☐
absoluut niet akkoord		neutraal		absoluut akkoord

25. Door een mogelijke bonus van 100 BEF was ik sterk gemotiveerd om een aantrekkelijk tapijt te maken, *binnen* de tijdslimiet. (**BONUS3**)

1	2	3	4	5
☐	☐	☐	☐	☐
absoluut niet akkoord		neutraal		absoluut akkoord

3/5

26. Het was moeilijk om de kost van het te ontwerpen tapijt onder de toelaatbare kost te krijgen. **[Difficult Target Cost Setting] (<u>COSTDIF</u>)**

1	2	3	4	5
☐	☐	☐	☐	☐
absoluut niet akkoord		neutraal		absoluut akkoord

27. Ik voelde me relatief op mijn gemak bij het streven naar de verschillende doelstellingen van mijn baas tijdens de oefening. (**<u>TENSION3</u>**)

1	2	3	4	5
☐	☐	☐	☐	☐
absoluut niet akkoord		neutraal		absoluut akkoord

28. In het algemeen, besteedde ik heel veel aandacht om de attractiviteit van mijn ontwerp te verbeteren. (**<u>ATTRATTE</u>**)

1	2	3	4	5
☐	☐	☐	☐	☐
absoluut niet akkoord		neutraal		absoluut akkoord

29. Geef aan in welke mate volgende strategieën voor jou van toepassing waren bij het creëren van de ontwerpen daarnet. Geef een score van 8 tot 1. (**<u>CARD1</u>** … **<u>CARD8</u>**)

8 = <u>Meest</u> van toepassing voor mij 1= <u>Minst</u> van toepassing voor mij

8 Strategieën	**Uw score**
Ik vond het *belangrijk* om een tapijt te creëren met lage kostprijs (ofwel kostenobjectief van mijn baas niet te overschrijden). Ik vond het belangrijk om de tijdslimiet van mijn baas *niet* te overschrijden. Ik vond het *belangrijk* om een attractief tapijt te maken.	…………
Ik vond het *belangrijk* om een tapijt te creëren met lage kostprijs (…). Ik vond het *niet erg* om de tijdslimiet van mijn baas te overschrijden. Ik vond het *belangrijk* om een attractief tapijt te maken.	…………
Ik vond het *niet zo belangrijk* om een tapijt te creëren met lage kostprijs (…). Ik vond het belangrijk om de tijdslimiet van mijn baas *niet* te overschrijden. Ik vond het *belangrijk* om een attractief tapijt te maken.	…………
Ik vond het *niet zo belangrijk* om een tapijt te creëren met lage kostprijs (…). Ik vond het *niet erg* om de tijdslimiet van mijn baas te overschrijden. Ik vond het *belangrijk* om een attractief tapijt te maken.	…………
Ik vond het *niet zo belangrijk* om een tapijt te creëren met lage kostprijs (…). Ik vond het belangrijk om de tijdslimiet van mijn baas *niet* te overschrijden. Ik vond het *minder* belangrijk om een attractief tapijt te maken.	…………
Ik vond het *belangrijk* om een tapijt te creëren met lage kostprijs (…). Ik vond het *niet erg* om de tijdslimiet van mijn baas te overschrijden. Ik vond het *minder* belangrijk om een attractief tapijt te maken.	…………
Ik vond het *niet zo belangrijk* om een tapijt te creëren met lage kostprijs (…). Ik vond het *niet erg* om de tijdslimiet van mijn baas te overschrijden. Ik vond het *minder* belangrijk om een attractief tapijt te maken.	…………
Ik vond het *belangrijk* om een tapijt te creëren met lage kostprijs (…). Ik vond het belangrijk om de tijdslimiet van mijn baas *niet* te overschrijden. Ik vond het *minder* belangrijk om een attractief tapijt te maken.	…………

4/5

30. Ik vond deze vragenlijst (**<u>QUESTION</u>**):

1	2	3	4	5
☐	☐	☐	☐	☐
te kort	eerder kort	juist goed	eerder lang	te lang

31. Ik zou nog de volgende opmerkingen willen maken over deze oefening (**<u>COMMENT</u>**):

....

....

....

....

Hartelijk dank voor je medewerking! Laat nu alles in de doos liggen, laat de doos op je bank staan en verlaat de zaal. **Zorg er wel voor dat je het *witte kaartje* met je nummer meeneemt**. Tegen vertoon van dit kaartje, kan je morgen of vrijdag je bonus komen afhalen. Vergeet bij het buitengaan ook niet om een blikje Cola en een Leo mee te nemen!

EINDE

5/5

10. Post Experimental Questionnaire of Experiment Three (in English)

Variable Labels, Names and Headings were Added[120]

General Kind of Questions

Age (AGE)

1. My age is: ....

Gender (GENDER)

2. Gender:

    1 ☐ Male
    2 ☐ Female

Discipline of Education (OPTION)

3. My discipline of Education is:

    5 ☐ 2nd Year of Applied Economics
    6 ☐ 2nd Year of Applied Economics, option TBK
    7 ☐ 3rd Year of Applied Economics
    8 ☐ Master in Financial Management
    9 ☐ Other (IAJ, …)

Experience with Design Tasks (EXPERIEN)

4. Have you had experience with designing tasks before?

    1 ☐ Yes Please specify: ....
    ....
    2 ☐ No

Guessing the Real Purpose of the Task (PURPOSE)

5. Can you guess what the real purpose of the exercise is?

    1 ☐ Yes Please specify: ....
    ....
    2 ☐ No

1/6

[120] The 2 questions on **target cost difficulty** are only presented to the difficult TCS group.
Questions 20, 21, 22 and 27 are **reverse scaled** for data analysis purposes.

Questions to give Feedback on the Task

Understanding of the Task (UNDERSTA)

6. Did you fully understand the task, after reading the instruction sheets?

1 ☐ Yes
2 ☐ No
Suggestions for improvements: ....
....

Relevance of Market Information (FEEDBACK)

8. I found the market information on the collection of last season _______ when I created my design.

1	2	3	4	5
☐	☐	☐	☐	☐
Not relevant	rather not relevant		rather relevant	relevant

Total Number of Designs Made (TOTALDES)

7. How many designs did you made in total?

☐ ....

Perception of the Task (LIKETASK)

11. In general, I found this exercise _________.

1	2	3	4	5
☐	☐	☐	☐	☐
boring	rather boring	interesting	rather fun	fun

Importance to the Scores of the Jury (JURYIMPO)

12. I took ______ account of the scores of the jury.

1	2	3	4	5
☐	☐	☐	☐	☐
No or rather few	medium	many	high	extremely high

Perception of the Length of Questionnaire (QUESTION)

30. This questionnaire was:

1	2	3	4	5
☐	☐	☐	☐	☐
too short	rather short	just right	rather long	too long

General Comments on the exercise (COMMENT)

31. Do you have other comments on this exercise? Please write below:

....
....
....

2/6

Manipulation Checks

Manipulations checks for Target Cost Specificity (COSTSPE1, COSTSPE2)

15. I knew exactly the acceptable cost of the carpet. (COSTSPE1)

1	2	3	4	5
☐	☐	☐	☐	☐
absolutely disagree		neutral		absolutely agree

20. The instructions of my boss on the acceptable cost of the carpet were rather vague. (COSTSPE2)

1	2	3	4	5
☐	☐	☐	☐	☐
absolutely disagree		neutral		absolutely agree

Manipulation checks for Target Cost Difficulty (COSTEASY, COSTDIF)

Only for Easy and Difficult Target Cost Setting

22. The *cost* goal of my boss was easy to attain. (COSTEASY)

1	2	3	4	5
☐	☐	☐	☐	☐
absolutely disagree		neutral		absolutely agree

26. It was difficult to have a cost below the acceptable cost. (COSTDIF)

1	2	3	4	5
☐	☐	☐	☐	☐
absolutely disagree		neutral		absolutely agree

Manipulation checks for Difficulty of the Time Objective (SHORTTIME, TIMEEASY)

16. The time limit was rather short to complete this task. (SHORTTIME)

1	2	3	4	5
☐	☐	☐	☐	☐
absolutely disagree		neutral		absolutely agree

21. De time limit of my boss was easy to attain. (TIMEEASY)

1	2	3	4	5
☐	☐	☐	☐	☐
absolutely disagree		neutral		absolutely agree

3/6

Energy expended on Attractiveness, Energy expended on Cost

Energy Expended on Attractiveness (ATTREFFO, ATTRPERS, ATTRATTE)

9. How much effort did you provide to create an *attractive* carpet? (ATTREFFO)

1	2	3	4	5
☐	☐	☐	☐	☐
No or rather few	medium	many	high	extremely high

14. While I was creating the carpet, I worked with _________ persistence to make my design *attractive*. (ATTRPERS)

1	2	3	4	5
☐	☐	☐	☐	☐
No or rather few	medium	many	high	extremely high

28. In general, I took much attention to improve the attractiveness of my design. (ATTRATTE)

1	2	3	4	5
☐	☐	☐	☐	☐
absolutely disagree		neutral		absolutely agree

Energy Expended on Cost (COSTEFFO, COSTPERS, COSTATTE)

10. How much effort did you provide to bring the cost of the carpet down? (COSTEFFO)

1	2	3	4	5
☐	☐	☐	☐	☐
No or rather few	medium	many	high	extremely high

13. I worked with _________ persistence to the cost of my design. (COSTPERS)

1	2	3	4	5
☐	☐	☐	☐	☐
No or rather few	medium	many	high	extremely high

18. During the task, I thought that I took much attention to the cost of the carpet. (COSTATTE)

1	2	3	4	5
☐	☐	☐	☐	☐
absolutely disagree		neutral		absolutely agree

4/6

Strategies

29. Please indicate to which extent you followed the strategies below when designing your carpet. You can score them from 8 to 1.

8 = Most relevant
1= Least relevant

8 Strategies	**Your score**
It thought it was *important* to create a carpet with a low cost (not to exceed the cost objective of my boss). It thought it was important *not to exceed* the time limit of my boss. It thought it was *important* to create an attractive carpet.	…………
It thought it was *important* to create a carpet with a low cost (not to exceed the cost objective of my boss). It thought it was *not so bad* to exceed the time limit of my boss. It thought it was *important* to create an attractive carpet.	…………
It thought it was *not so important* to create a carpet with a low cost (that exceeded the cost objective of my boss). It thought it was important *not to exceed* the time limit of my boss. It thought it was *important* to create an attractive carpet.	…………
It thought it was *not so important* to create a carpet with a low cost (that exceeded the cost objective of my boss). It thought it was *not so bad* to exceed the time limit of my boss. It thought it was *important* to create an attractive carpet.	…………
It thought it was *not so important* to create a carpet with a low cost (that exceeded the cost objective of my boss). It thought it was important *not to exceed* the time limit of my boss. It thought it was *not* so important to create an attractive carpet.	…………
It thought it was *important* to create a carpet with a low cost (not to exceed the cost objective of my boss). It thought it was *not so bad* to exceed the time limit of my boss. It thought it was *not* so important to create an attractive carpet.	…………
It thought it was *not so important* to create a carpet with a low cost (that exceeded the cost objective of my boss). It thought it was *not so bad* to exceed the time limit of my boss. It thought it was *not* so important to create an attractive carpet.	…………
It thought it was *important* to create a carpet with a low cost (not to exceed the cost objective of my boss). It thought it was important *not to exceed* the time limit of my boss. It thought it was *not* so important to create an attractive carpet.	…………

5/6

Tension (Self-Reported) and Motivation by the Bonus System

Tension because of Goal Conflict, 3 items (TENSION1, TENSION2, TENSION3)

17. During the task, I was rather tensed because I thought I would never find the ideal design. (TENSION1)

1	2	3	4	5
☐	☐	☐	☐	☐
absolutely disagree		neutral		absolutely agree

19. Looking for an attractive and cheap carpet made me rather tensed during the exercise. (TENSION2)

1	2	3	4	5
☐	☐	☐	☐	☐
absolutely disagree		neutral		absolutely agree

27. I felt rather comfortable when aiming for the different goals during the exercise. (TENSION3)

1	2	3	4	5
☐	☐	☐	☐	☐
absolutely disagree		neutral		absolutely agree

Motivation by bonus system (BONUS1, BONUS2, BONUS3)

23. By a possible bonus of 300 BEF, I was strongly motivated to create an attractive carpet. (BONUS1)

1	2	3	4	5
☐	☐	☐	☐	☐
absolutely disagree		neutral		absolutely agree

24. By a possible bonus of 300 BEF, I was strongly motivated to create an attractive carpet that had a low cost as well. (BONUS2)

1	2	3	4	5
☐	☐	☐	☐	☐
absolutely disagree		neutral		absolutely agree

25. By a possible bonus of 100 BEF, I was strongly motivated to make an attractive carpet, within the time limit. (BONUS3)

1	2	3	4	5
☐	☐	☐	☐	☐
absolutely disagree		neutral		absolutely agree

6/6

11. Scores of the Judges for "Attractiveness" in Experiment Three

	Scores from 1 to 5 from the 8 Judges									
ID Number	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**Total Score**	**Mean Score**
1	1	1	1	2	4	2	2	3	16	2.00
2	3	2	3	3	5	4	4	5	29	3.63
3	2	2	2	3	3	2	3	2	19	2.38
4	1	1	1	2	2	2	1	2	12	1.50
5	3	3	3	3	2	3	2	3	22	2.75
6	2	1	1	1	2	2	2	2	13	1.63
7	2	2	2	2	1	2	3	1	15	1.88
8	2	1	2	1	2	1	1	1	11	1.38
9	4	2	3	3	3	3	2	2	22	2.75
10	4	4	4	5	5	4	3	4	33	4.13
11	1	2	2	2	3	3	2	3	18	2.25
12	2	4	4	2	2	3	2	5	24	3.00
13	1	1	1	1	2	3	2	2	13	1.63
14	2	3	2	3	4	3	3	4	24	3.00
15	2	2	2	2	2	3	2	5	20	2.50
16	4	3	3	4	4	4	4	4	30	3.75
17	2	1	1	1	3	2	3	2	15	1.88
21	4	3	4	5	5	5	4	3	33	4.13
22	4	1	2	2	2	1	3	1	16	2.00
23	2	1	2	1	1	2	1	2	12	1.50
24	4	2	3	4	3	4	3	4	27	3.38
25	4	2	2	4	4	4	5	4	29	3.63
26	2	1	1	1	1	1	1	1	9	1.13
27	3	1	1	1	2	3	3	3	17	2.13
28	3	2	3	2	3	3	2	3	21	2.63
29	3	2	2	3	3	4	3	4	24	3.00
30	2	2	3	2	3	3	3	3	21	2.63
31	4	2	2	4	4	4	5	4	29	3.63
32	3	2	2	3	3	4	4	3	24	3.00
33	4	2	2	4	4	5	3	3	27	3.38
35	1	1	2	2	2	2	1	1	12	1.50
36	4	3	2	4	3	4	3	4	27	3.38
37	2	2	3	3	4	4	3	3	24	3.00
41	2	1	2	4	4	4	3	4	24	3.00
42	4	3	3	4	3	4	2	4	27	3.38
43	4	3	3	4	4	4	4	4	30	3.75
44	1	2	2	2	3	3	3	3	19	2.38
45	4	3	3	4	4	3	4	5	30	3.75
46	4	3	2	4	3	3	4	4	27	3.38
47	2	2	2	3	3	4	2	3	21	2.63
48	1	1	1	1	1	1	1	1	8	1.00
49	4	5	4	3	3	4	3	3	29	3.63

50	4	3	4	4	4	4	4	4	31	3.88
51	3	2	3	3	3	2	4	4	24	3.00
52	1	2	2	1	2	2	1	2	13	1.63
53	3	2	3	4	5	4	4	4	29	3.63
54	4	3	3	3	4	3	2	3	25	3.13
55	4	4	4	5	4	3	3	3	30	3.75
56	2	2	3	2	2	1	1	2	15	1.88
61	4	4	4	4	4	4	3	3	30	3.75
62	2	2	2	2	2	2	3	2	17	2.13
63	4	4	2	3	4	4	3	3	27	3.38
64	4	2	3	3	3	3	4	2	24	3.00
65	4	3	3	4	4	4	3	3	28	3.50
66	4	3	3	4	4	4	3	3	28	3.50
67	4	3	4	4	3	4	3	3	28	3.50
68	1	2	2	2	3	2	2	2	16	2.00
69	3	2	2	3	4	3	3	3	23	2.88
70	1	3	3	3	3	2	3	3	21	2.63
71	1	1	1	1	2	1	1	2	10	1.25
72	2	5	4	3	3	4	3	4	28	3.50
73	4	2	3	5	4	4	3	4	29	3.63
74	4	3	3	3	3	4	3	4	27	3.38
75	3	3	4	3	3	4	4	5	29	3.63
76	1	2	2	2	3	2	2	2	16	2.00

12. Examples of the Most Attractive Creations in Experiment Three

☞**On the next page is inserted:**

The *three most attractive* designs in each of the four manipulations:

- **the non-target cost setting, easy time objective**
- **the difficult target cost setting, easy time objective**
- **the non-target cost setting, difficult time objective**
- **the difficult target cost setting, difficult time objective.**

13. Details of the Bonus Pay in Experiment Three

ID Number	Cost	Total Score for Attractiveness	Mean Score	Time Spent	Within Time Limit	Total Bonus
Non-Target Cost Setting, Easy Time (105 minutes)						
10	2824	33	4.13	73	Ja	700
16	2800	30	3.75	103	Ja	700
2	2884	29	3.63	85	Ja	700
12	3300	24	3.00	89	Ja	400
14	2944	24	3.00	70	Ja	400
Difficult Target Cost Setting, Easy Time (105 minutes)						
21	2434	33	4.13	60	Ja	700
25	2712	29	3.63	90	Ja	700
31	2712	29	3.63	61	Ja	700
24	2528	27	3.38	80	Ja	700
33	2194	27	3.38	53	Ja	700
36	2848	27	3.38	89	Ja	400
Non-Target Cost Setting, Difficult Time (75 minutes)						
50	3084	31	3.88	47	Ja	400
43	2752	30	3.75	62	Ja	700
45	2580	30	3.75	54	Ja	700
55	2950	30	3.75	57	Ja	400
49	2890	29	3.63	56	Ja	400
53	2460	29	3.63	53	Ja	700
Difficult Target Cost Setting, Difficult Time (75 minutes)						
61	2664	30	3.75	61	Ja	700
73	2436	29	3.63	74	Ja	700
75	3200	29	3.63	74	Ja	400
65	2406	28	3.50	80	Neen	600
66	2460	28	3.50	60	Ja	700
67	2646	28	3.50	48	Ja	700
72	3220	28	3.50	74	Ja	400

14. Receipt Form for the Bonus in Experiment Three

Example of a 700 BEF Bonus

Bonus 700 BEF

Group id numbers 1 - 20

I, ... declare that I had the **id number** in the experiment on Wednesday April 28, 1999 from 10.15-12.45 in auditorium I, at the Faculty of Economics and Business Administration, University Ghent.

I made a design that was selected as one of the 5 most attractive of all 20 designs made by the participants of my group. So I earned a first bonus of 300 BEF. My design was one of the 3 cheapest within those 5. So I earned a second bonus of 300 BEF. I was also finished within the time limit, so I earned a third bonus of 100 BEF.

Thus in total, my whole bonus is equal to 700 BEF.

I declare that I received an envelope with 700 BEF on

.....................................………. (date) ……………...……………………. (signature)

1/1

15. Guessing Real Purpose of Experiment Three (in Dutch)

Answers on the Question: "Can you guess what the real purpose of this exercise was?"

ID Number	Kan je raden wat we met deze oefening wilden onderzoeken?
	Non-Target Cost Setting, Easy Time
1	In welke tijd iemand kan komen tot een harmonieus ontwerp waarvan de basis reeds gegeven (en onveranderlijk) is.
2	Marktonderzoek hoe men de uitvoering van een opdracht goed kan doen en rekening houden met de kosten minimalisatie.
3	Onder welke druk mensen staan bij een opdracht en eventueel binnen bepaalde perioden.
4	Hoe je moet omgaan met standaarden.
5	Werken onder tijdsdruk en stress.
6	Je zal niet gemakkelijk meer dan 5 kleuren gebruiken omwille van de meerkost.
8	Hoe mensen arbitraire beslissingen nemen.
9	Creativiteit van de studenten.
10	Kiezen tussen schoonheid en geld.
12	De manier waarop mensen reageren als ze een opdracht krijgen met opgelegde beperkingen.
14	Onze artistieke kunst.
15	Hoe gelijklopend de ontwerpen zijn om standaardpatronen eruit te halen.
16	Afweging kost versus design.
17	Het nagaan van het inspelen op de markt bij het uitvinden van iets (simulatie oefening).
	Difficult Target Cost Setting, Easy Time
21	Hoe snel een voor de markt aanvaardbaar ontwerp kan worden gemaakt dat voldoet aan de beperkende voorwaarde namelijk kost < 2750.
22	Originaliteit binnen bepaalde limieten.
27	Met een standaard in het achterhoofd toch mooi ontwerp maken.
28	Kosten.
31	In welke mate ontwerpers zich geremd voelen in hun inspiratie door kosten.
32	Hoe goed mensen kunnen werken binnen marges en wat hun reactie is op beloning.
35	Ik denk, hoeveel we ons laten beïnvloeden door vorige collecties en de mate hoe de bonus onze ontwerpen beïnvloedt.
36	Hoe combineer je het marktaspect en het kostenaspect van een ontwerp. Zal je compromissen sluiten of niet.

	Non-Target Cost Setting, Difficult Time
41	Nagaan of we voldoende inzicht hebben in de prijs kwaliteit verhouding.
44	Inzicht in productie <-> laagst mogelijke kostprijs.
46	Hoe zeer hebben kosten een invloed op andere uit te voeren taken.
48	Samenhang tussen ontwerp en kosten.
52	Als men standaarden opgelegd krijgt, zal men dan ethisch onverantwoord handelen omwille economische motieven.
53	Het werken tegen tijd, kostenlimiet en bepaalde “schoonheidsvereisten”.
54	Invloed van koststandaarden op designers.
55	Invloed van gebruik van standaardkosten op productie.
56	Combinatie laagste kostenstandaarden en smaak.
	Difficult Target Cost Setting, Difficult Time
68	Resultaten evalueren in functie van vooropgestelde bonussen.
69	Hoe werken onder standaarden.
70	Kennis van potentiële klanten.
73	Motivatie van ontwerp uitvoerder -> dus inzet in ruil voor geld.
74	Reactie op standaarden, op welke standaard reageert men het meest?
	→ Menselijke dus de jury,
	→ kosten of tijd door geld.
75	Ik denk dat je waarschijnlijk wil nagaan door welke parameters mensen zich laten beïnvloeden bij prestatiemeting en of deze gelinkt zijn aan de respectievelijke bonussen.
76	In welke mate rekening gehouden wordt met instructies (het feit dat men feedback krijgt / het feit dat men beloond wordt).

16. Written Feedback to the Participants of Experiment Three

Aan: Alle economisten die hebben deelgenomen op 28/04/99
Van: Patricia Everaert
Betreft: Feedback over de sessie van 28/04/99

1. Doel van het Onderzoek

Het doel van het onderzoek is na te gaan of het geven van specifieke kostendoelstellingen bij het ontwerpen van nieuwe producten leidt tot producten met een lagere kostprijs dan wanneer vage kostendoelstellingen worden gegeven in de zin van "doe je best om de kost te minimaliseren". Bovendien willen we ook nagaan of tijdsdruk al dan niet een impact heeft op dit verschil.

2. Experimentele Condities

In het experiment waar jullie aan meegewerkt hebben, waren er dus twee verschillende kostendoelstellingen. De ene helft van de groep kreeg een *vage kostendoelstelling* ("probeer de kosten van het tapijt te minimaliseren"). De andere helft van de groep kreeg een specifieke kostendoelstelling, die *moeilijk* haalbaar was ("de baas wil dat de kost van het tapijt niet hoger is dan 2750 BEF").

Bovendien waren er twee tijdscondities. Voor de ene helft van de groep was er een tijdsdoelstelling van 1 uur en 45 minuten, wat de *gemakkelijke tijdsdoelstelling* was. Voor de andere helft van de groep was er een *moeilijke tijdsdoelstelling* van 1 uur en 15 minuten. Samenvattend, waren er dus vier verschillende condities, zoals weergegeven in onderstaande tabel.

Tabel 1: Overzicht van de 4 condities in het Experiment op 28/04/99

	Vage kostendoelstelling: **"Kost van het tapijt minimaliseren"**	**Specifieke, moeilijke kostendoelstelling.** **"Kost van het tapijt < 2750"**
Gemakkelijke tijdsdoelstelling van 1 uur en 45 minuten	**Groep 1 (n= 17)** Nummers 1 - 20	**Groep 2 (n = 16)** Nummers 21 – 40
Moeilijke tijdsdoelstelling van 1 uur en 15 minuten	**Groep 3 (n = 16)** Nummers 41 - 60	**Groep 4 (n = 16)** Nummers 61 - 80

1/4

3. Bonus Systeem

Om de taak au serieus te nemen werd een *eerste* bonus van 300 BEF beloofd aan de 5 meest attractieve tapijten binnen elk van de 4 groepen. Attractiviteit werd hier gemeten aan de hand van de gemiddelde score van de juryleden, die elk ontwerp individueel scoorden op een schaal van 1 tot 5. Bovendien was er een *tweede bonus* voor ontwerpers die niet alleen attractieve, maar ook "low cost" tapijten creëerden. Concreet betekent dit dat mensen die een vage kostendoelstelling hadden een supplementaire bonus van 300 BEF konden verdienen als hun ontwerp bovendien tot de 3 laagste in kost behoorden van deze 5 meest attractieve. Voor mensen die een specifieke kostendoelstelling hadden, was de supplementaire bonus van 300 BEF afhankelijk van het al of niet halen van de kostendoelstelling van 2750 BEF. Een *derde bonus* van 100 BEF was voorzien, indien deze 5 meest attractieve ontwerpen binnen de opgelegde tijdslimiet eindigden. Samenvattend betekent dit dat iedereen dus een kans van 5/16 (31%) of 5/17 (29%) had om een bonus te verdienen. In onderstaande tabel wordt de bonusberekening per groep weergegeven.

Tabel 2: Bonusberekening voor elk van de 4 groepen op 28/04/99

Bonus voor ontwerpers met de nummers 1-20:					
Nr.	**Kost**	**Gemiddelde score**	**Afgegeven om**	**Binnen tijdslimiet**	**Bonus**
10	2824	4.13	12.13	Ja	700
16	2800	3.75	12.43	Ja	700
2	2884	3.63	12.25	Ja	700
12	3300	3.00	12.29	Ja	400
14	2944	3.00	12.10	Ja	400
Bonus voor ontwerpers met de nummers 21-40:					
21	2434	4.13	12.00	Ja	700
25	2712	3.63	12.30	Ja	700
31	2712	3.63	12.01	Ja	700
24	2528	3.38	12.20	Ja	700
33	2194	3.38	11.53	Ja	700
36	2848	3.38	12.29	Ja	400
Bonus voor ontwerpers met de nummers 41-60:					
50	3084	3.88	11.47	Ja	400
43	2752	3.75	12.02	Ja	700
45	2580	3.75	11.54	Ja	700
55	2950	3.75	11.57	Ja	400
49	2890	3.63	11.56	Ja	400
53	2460	3.63	11.53	Ja	700
Bonus voor ontwerpers met de nummers 61-80:					
61	2664	3.75	12.01	Ja	700
73	2436	3.63	12.14	Ja	700
75	3200	3.63	12.14	Ja	400
65	2406	3.50	12.20	Neen	600
66	2460	3.50	12.00	Ja	700
67	2646	3.50	11.48	Ja	700
72	3220	3.50	12.14	Ja	400

2/4

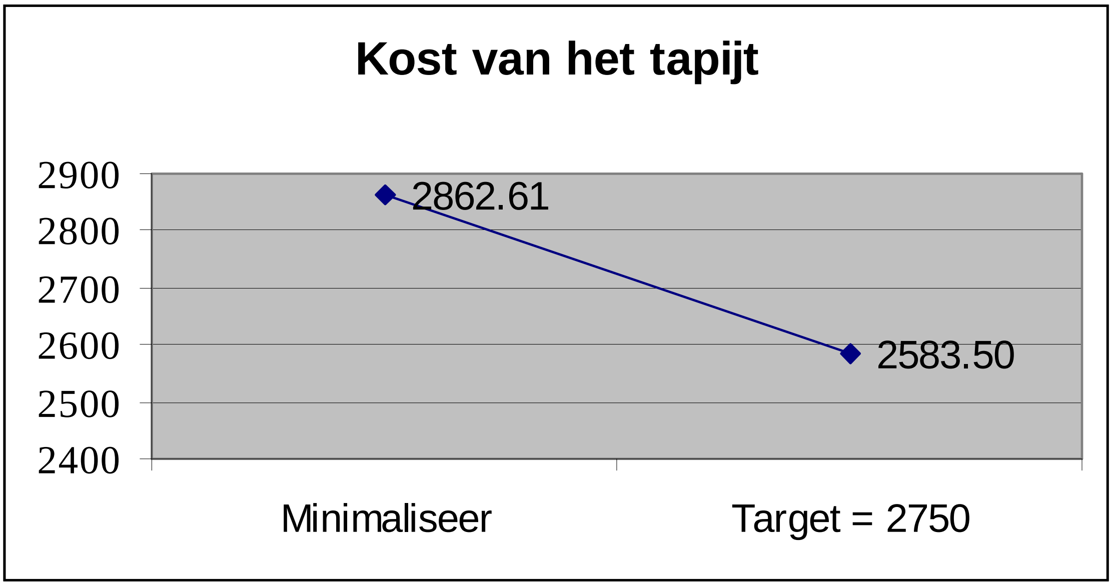
4. Hypothesen en Resultaten

De eerste hypothese dat er een significant verschil zou optreden in de kostprijs van het nieuwe product tussen ontwerpers met een vage kostendoelstelling (minimaliseer de kosten) en de ontwerpers met een specifieke, moeilijke kostendoelstelling werd ondersteund door de data uit het experiment. Het verschil was significant (F (1,63) = 11.04, p = 0.001). Zie figuur 1. Bovendien was er geen significant verschil in de attractiviteit van de creaties tussen deze twee groepen. (F (1,63) = 0.47, p = 0.496).

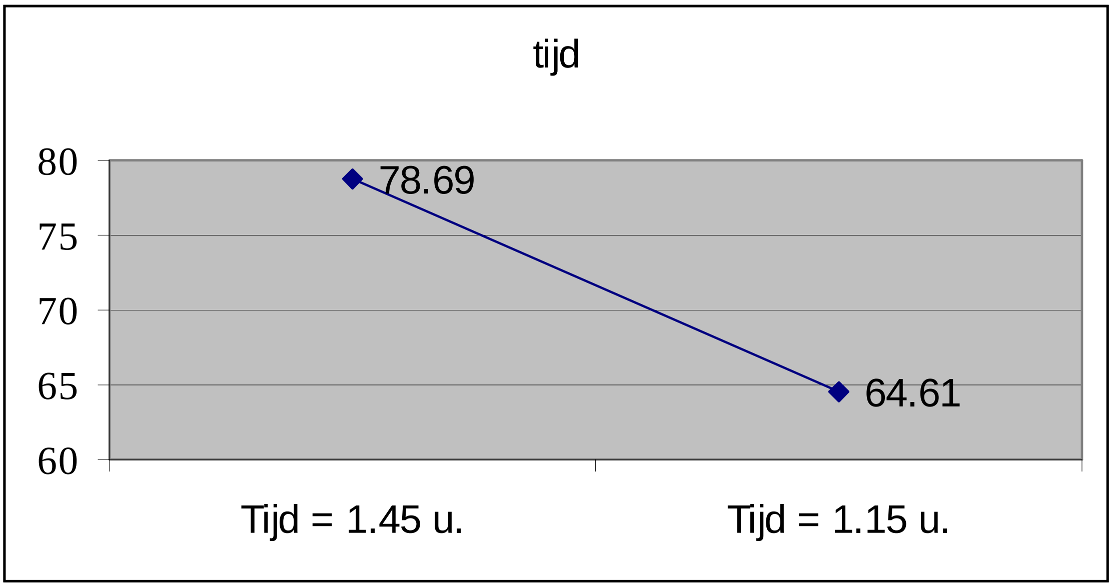
Een tweede hypothese dat dit significant verschil in kost zou afhangen van de tijdsdruk, werd niet ondersteund door de data in het experiment. (F (1,61) = 0.670, p = 0.416)

Wel was er een significant verschil in gebruikte tijd tussen de groep met de moeilijke tijdsdoelstelling en de groep met de gemakkelijke tijdsdoelstelling. Zie figuur 2. Bovendien was ook het interactie-effect significant voor de gespendeerde tijd. (F (1,61) = 6.206, p = 0.015). Het verschil in gespendeerde tijd tussen mensen met een gemakkelijke en met een moeilijke doelstelling was dus veel groter onder het "minimaliseren van de kosten" dan onder de "moeilijke kostendoelstelling". Zie figuur 3.

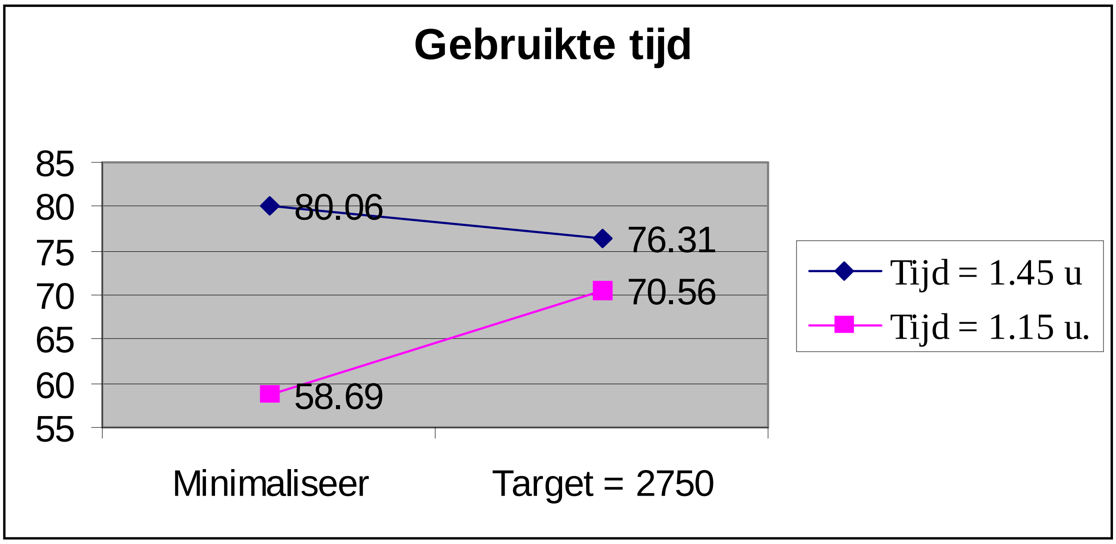
Figuur 1: Gemiddelde kost van het tapijt bij een vage kostendoelstelling en bij een moeilijke kostendoelstelling van 2750 BEF



Figuur 2: Gemiddelde gespendeerde tijd onder een gemakkelijke tijdsdoelstelling (1.45 u.) en onder een moeilijke tijdsdoelstelling (1.15 u.)



Figuur 3: Gemiddelde gespendeerde tijd in elk van de 4 experimentele condities



5. Dank

Tenslotte willen we allen die hebben meegewerkt nog eens hartelijk danken.

Professor Dr. Werner Bruggeman Patricia Everaert
05/05/99

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