Investigating two unresolved issues in fuzzy front end execution

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Investigating Two Unresolved Issues in

FUZZY FRONT END

Execution

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Katrin Eling

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Investigating Two Unresolved Issues in Fuzzy Front End Execution

PROEFSCHRIFT

ter verkrijging van de graad van doctor aan de Technische Universiteit Eindhoven, op gezag van de rector magnificus prof.dr.ir. C.J. van Duijn, voor een commissie aangewezen door het College voor Promoties, in het openbaar te verdedigen op donderdag 23 januari 2014 om 16:00 uur

door

Katrin Eling

geboren te Leverkusen, Duitsland

Dit proefschrift is goedgekeurd door de promotoren en de samenstelling van de promotiecommissie is als volgt:

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	prof.dr. R.K. Moenaert (TiasNimbas Business School)

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When I started studying Industrial Design at the University of Wuppertal in October 2001 no one, including me, guessed that I would start writing a doctoral dissertation seven years later. Nevertheless, some first signs were there. From the very beginning I was more interested in the theoretical aspects of designing new products than in the practical tasks, such as sketching and model building. Soon I started questioning the design process that we were taught. During my Master studies at Delft University of Technology I realized that it would be possible for me and, actually, fun to contribute to academic research on design and product development management and, suddenly, the pieces started falling together. In 2008 my Master thesis supervisor Erik Jan Hultink introduced me to Fred Langerak and some weeks after our very first meeting in Eindhoven I signed up for the most exciting and most challenging period of my educational life… . The resulting dissertation would not be what it is without the support, trust, help, critique, and ideas of many people. On these first pages I would like to take the opportunity to express my gratitude to everyone who helped and supported me in writing this dissertation.

I especially want to thank my promoters Fred Langerak and Abbie Griffin. Fred, thank you for teaching me how to successfully conduct, write up, and publish high-quality academic research through patiently reviewing my drafts and through our innumerable (and often fun!) discussions on methodological, conceptual, and writing issues. Thank you also for your trust and for the freedom that you have given me in the ‘fuzzy front end’ of my Ph.D. project. Your enthusiasm for my research and your ‘thinking along’ increased my own motivation and your always constructive feedback and critical (sometimes even 'nasty') questions made me achieve superior results. I am very, very grateful for all your (also financial!) support during and beyond my Ph.D. project.

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Abbie and Fred, I am very proud and honored to have the two of you as my 'doctoral parents' both because you are so successful scholars and because you are such wonderful persons. Working on our papers together with the three of us in Eindhoven were the best times of my whole Ph.D. trajectory! I hope we will continue our fruitful and inspiring cooperation.

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Katrin Eling, Bielefeld, 2013

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CHAPTER 1

Introduction

This dissertation investigates two unresolved issues in the execution of the fuzzy front end (FFE) of new product development, i.e., (i) the performance effects of accelerating FFE execution cycle time, and (ii) the optimal approach to FFE execution decision making. This introductory chapter explains the overarching focus of this dissertation on these two unresolved issues in FFE execution, presents the resulting research questions, introduces the three studies that were conducted to investigate these research questions, highlights the overall contributions of this dissertation, and provides a general overview of the chapters of this dissertation. The three studies will be presented in Chapters 2, 3, and 4, and Chapter 5 closes with a discussion of the overall findings of this dissertation.

1.1 Research Focus

The proficient execution of activities before the start of the formal new product development (NPD) process, such as identifying new product opportunities, generating new product ideas, developing a product concept, or planning the development project, is one of the key success factors of NPD (Evanschitzky et al., 2012; Langerak et al., 2004). This is not surprising as such pre-development activities define the content, tasks, timing and cost of the entire NPD project. While executing this so called 'fuzzy front end' (FFE) of innovation, the members of the development team decide what new product will be developed by determining which ideas and concepts managers see at formal gate meetings (Bacon et al., 1994; Kijkuit and van den Ende, 2007). Additionally, through project planning and process decisions during FFE execution, they define how the product will be developed (van Oorschot et al., 2011; Verworn et al., 2008).

Despite the importance of the FFE, neither academics nor practitioners completely understand how to execute it proficiently. In this context, 'execute' refers to actually *carrying out* the activities of idea generation and concept definition. Although various research studies have been conducted on the management of the FFE (see Table 1.1 for an overview of the published key studies in the FFE management domain classified by research topic and method), there still are significant gaps in the literature on managing the FFE execution. As a result, many firms still struggle to proficiently execute this important NPD phase (Markham and Lee, 2013). To advance the existing knowledge on how to best execute the FFE, this dissertation focuses on two important FFE management research topics, i.e.: (i) 'FFE acceleration', and (ii) 'FFE decision making'. I chose this focus for four key reasons.

Table 1.1: Overview Table of Published Key Studies on FFE Management Classified by FFE Management Research Topic and Method

	Conceptual Studies	Qualitative Studies	Quantitative Studies
Understanding and managing the overall FFE process			
	Chang et al. (2007)*, **Cooper (1988)**, **Kim and Wilemon (2010; 2002b; 2002a)***, **Koen et al. (2002)**, **Reinertsen (1994; 1999)***, **Smith et al. (1999)***	Gassmann et al. (2006)*, **Khurana and Rosenthal (1997)***, **Koen et al. (2001)**, **Verganti (1997)***	Langerak et al. (2004)*, **Murphy and Kumar (1997)***, **Reid and De Brentani (2012)**,
Industry / firm / project / cultural differences	De Brentani and Reid (2012)*, **Floren and Frishammar (2012)**, **Koen (2004)**, **Reid and de Brentani (2004)***	**Aagaard (2012)***, **Aagaard and Gertsen (2011)***, **Bröring and Leker (2007)***, **Elmquist and Segrestin (2007)**, **Frishammar et al. (2013; 2012)**, **Hannola et al. (2009)**, **Herstatt et al. (2006)***, **Khurana and Rosenthal (1998)***, **McAdams and Leonard (2004)**, **Kurkkio et al. (2011)**, **Nobelius and Trygg (2002)***, **Russel and Tippett (2008)**	**Bröring et al. (2006)**, **Murphy and Kumar (1996)**, **Pavia (1991)**, **Song and Montoya-Weiss (1998)**, **Stockstrom and Herstatt (2008)***, Verworn (2009)*
Development of (IT) support tools	**Montoya-Weiss and O'Driscoll (2000)**, **Schröder and Jetter (2003)**	**Oliveira and Rozenfeld (2010)***, **Williams et al. (2007)**	**Gordon et al. (2008)**, **Soukhoroukova et al. (2012)***
Managing opportunity identification			
	Bond and Houston (2003)*, **Bonney and Williams (2009)***	**O'Connor and Rice (2001)**, **Lettl et al. (2008)***, **Rice et al. (2001)***	**Kornish and Ulrich (2011)***, Stevens et al. (1999)*, **Urban and Hauser (2004)***, **Van Burg et al. (2012)**
Managing concept development			
		Backmann et al. (2007), Kihlander and Ritzen (2012)*, **Kohn (2006)***, **Seidel** (2007)	**Dickinson and Wilby (1997)**

Bold = Article focuses on the research topic;
* = Article contributes to more than one research topic and, thus, appears more than once in a column;

Table 1.1 (continued):

	Conceptual Studies	Qualitative Studies	Quantitative Studies
Managing idea generation			
	Kijkuit and Van den Ende (2007), **Simms and Trott (2010)**	**Badke-Schaub et al. (2010)**, **Björk et al. (2010)***, **Boedderich (2004)**, **Chulvi et al. (2013)***, **Conway and McGuiness (1986)**, **Howard et al. (2010)**, **Rochford (1991)***, **Toubia (2006)***	Barczak et al. (2009), **Björk (2012)***, **Björk and Magnusson (2009)**, **Dahl and Moreau (2002)**, **Griffiths-Hemans and Grover (2006)**, **Kornish and Ulrich (2011)***, **Lukas and Brodowski (1998)***, **Troy et al. (2001)***, **Soukhoroukova et al. (2012)***
Customer integration in idea generation	**Schirr (2012)***	**Bayus (2013)**, **Poetz and Schreier (2012)**, **Schweitzer et al. (2012)**	**Duverger (2012)**, **Kristensson and Magnusson (2010)**, **Schuhmacher and Kuester (2012)**, Urban and Hauser (2004)*, **Witell et al. (2011)**, **Wu and Fang (2010)**
Managing project planning and the transition to development			
		Verganti (1997)*	Langerak et al. (2004)*, **Markham et al. (2010)***, Moenaert et al. (1995)*
FFE strategy / culture			
		Aagaard (2012)*, Aagaard and Gertsen (2011)*, **Brem and Voigt (2009)**, **Burchill and Fine (1997)***, **Khurana and Rosenthal (1998)***, **Lindgren and O'Connor (2011)**, **Zien and Buckler (1997)**	Bertels et al. (2011)*
Leadership and control in the FFE			
	Kim and Wilemon (2002b; 2002a)*	**Artto et al. (2011)**, **Koch and Leitner (2008)***	**Poskela and Martinsuo (2009)***, **Rauniar et al. (2008)**
Portfolio management in the FFE			
		Oliveira and Rozenfeld (2010)*	

Bold = Article focuses on the research topic;
* = Article contributes to more than one research topic and, thus, appears more than once in a column;

Table 1.1 (continued):

	Conceptual Studies	Qualitative Studies	Quantitative Studies
FFE formalization			
	Kim and Wilemon (2002a)*, Reinertsen (1994; 1999)*	Khurana and Rosenthal (1998; 1997)*, **Koch and Leitner (2008)***, Nobelius and Trygg (2002)*, Verganti (1999)*	**Naveh (2007)**, Poskela and Martinsuo (2009)*
Formalization of certain FFE activities	Smith et al. (1999)*	Björk et al. (2010)*, Chulvi et al. (2013)*, Verganti (1999)*	Lukas and Brodowski (1998)*, Martinsuo and Poskela (2011)*, Moenaert et al., (1995)*, Troy et al. (2001)*
FFE decision making			
	Kim and Wilemon (2002a)*, De Brentani and Reid (2012)*	Bröring and Leker (2007)*, Griffin et al. (2009)*, **Kihlander and Ritzen (2012)***, Khurana and Rosenthal (1997)*, **Verganti (1999)***	Moenaert et al. (2010), Murphy and Kumar (1997)*
Gate decision making / idea screening	Kim and Wilemon (2002a)*, Reinertsen (1999)*, Smith et al. (1999)*	**Onarheim and Christensen (2012)**, **Rochford (1991)***	**Carbonell-Foulquie et al. (2004),** Falck and Rosenqvist (2012), **Goldenberg et al. (2001), Hammedi et al. (2011), Hart et al. (2003), Martinsuo and Poskela (2011)***, **Van Riel et al. (2011)***
Decision tools (for idea screening)	**Chang et al. (2008), Huynh and Nakamori (2009), Kahraman et al. (2007)**	**Achiche et al. (2013), Bard (1990), Calantone et al. (1999), Chan et al. (2011), Kudrowitz and Wallace (2013), Lin and Chen (2004a; 2004b)**	**Westerski et al. (2013)**
Cross-functional collaboration / knowledge sharing in the FFE			
	Bond and Houston (2003)*, Kim and Wilemon (2002b; 2002a)*	Aagaard and Gertsen (2011)*, Frishammar and Ylinenpää (2007)*, Gassmann et al. (2006)*, **Kohn (2006)***	**Bertels. et al. (2011)***, **Ernst et al. (2010), Grote et al. (2012), Moenaert et al. (1995)***, Troy et al. (2008), Verworn (2009)*

Bold = Article focuses on the research topic;
* = Article contributes to more than one research topic and, thus, appears more than once in a column;

Table 1.1 (continued):

	Conceptual Studies	Qualitative Studies	Quantitative Studies
Information / knowledge use and management in the FFE			
	De Brentani and Reid (2012)*, Kim and Wilemon (2002a)*	Bröring and Leker (2007)*, Frishammar and Ylinenpää(2007)*, **Heller (2000), Hohenegger et al. (2008)**, **Kohn (2005),** Verganti (1997)*, **Zahay et al. (2004)**	**Björk (2012)***, **Bertels. et al. (2011)***, **Troy et al. (2001)***, Van Riel et al. (2011)*, Veldhuizen et al. (2006), **Zahay et al. (2011)**
Integrating customers / customer information in the FFE	Kim and Wilemon (2002a)*, Smith et al. (1999)*, Schirr (2012)*	**Alam (2006), Gassmann et al. (2006)*, Lettl et al. (2008)*, Noyes et al. (1996), Rosenthal and Capper (2006)**	Creusen et al. (2013)
Uncertainty reduction	**Chang et al. (2007)***, Kim and Wilemon (2002a)*,	**Frishammar et al. (2011), Herstatt et al. (2006)***	**Brun and Saetre (2009), Moenaert et al. (1995)***, Poskela and Martinsuo (2009)*, **Verworn (2006, 2009*), Verworn et al. (2008)***
Learning in the FFE	Kim and Wilemon (2002a)*	**Verganti (1997)***	
Individuals in the FFE			
	Bonny and Williams (2009)*, De Brentani and Reid (2012)*, Kim and Wilemon (2002b; 2002a)*, Reid and de Brentani (2004)*, Smith et al. (1999)*	**Griffin et al. (2009)***, Koch and Leitner (2008)*, Rice et al. (2001)*, **Sim et al. (2007)**, Toubia (2006)*	**Howell and Shea (2001), Markham et al. (2010)*, Stevens and Burley (2003), Stevens et al. (1999)***
FFE acceleration			
	Crawford (1992), **Kim and Wilemon (2010**; 2002b)*, **Reinertsen (1994;** 1999)*, Smith (1999)	Burchill and Fine (1997)*, Murmann (1994), **Thomke and Fujimoto (2000)**	Cooper and Kleinschmidt (1994), Karagozoglu and Brown (1993), Kessler and Chakrabarti (1999)

Bold = Article focuses on the research topic;
* = Article contributes to more than one research topic and, thus, appears more than once in a column;

Table 1.1 (continued):

	Conceptual Studies	Qualitative Studies	Quantitative Studies
Outcome and performance effects of the FFE			
FFE outcome	**Kim and Wilemon** (2002b; **2002a**)*, Smith et al. (1999)*	Verganti (1999)*	Bertels. et al. (2011)*, Martinsuo and Poskela (2011)*, Moenaert et al. (1995)*
NPD success factor	Reinertsen (1999)*		**Cooper and Kleinschmidt (1987),** Evanschitzky et al. (2012), Henard and Szymanski (2001), **Langerak et al. (2004)***, Montoya-Weiss and Calantone (1994), Stockstrom and Herstatt (2008)* **Verworn (2009)***, **Verworn et al. (2008)***

Bold = Article focuses on the research topic;
* = Article contributes to more than one research topic and, thus, appears more than once in a column;

First, both 'FFE acceleration' and 'FFE decision making' are of major importance for the overall success of an NPD project because they are central to proficient FFE execution. The acceleration of the complete new product idea-to-launch cycle time has been found by many studies to increase new product performance (Cankurtaran et al., 2013). Therefore, reducing the time spend on executing the FFE is expected to play an important role in achieving NPD cycle time reduction advantages (Kim and Wilemon, 2010; Reinertsen, 1994). Decision making, on the other hand, is central to FFE management because decisions have to be made during every FFE task and activity that is executed. The decision making during FFE execution has, thus, a major impact on the outcome of the FFE and, ultimately, on the outcome of the whole NPD project (Bertels et al., 2011; Evanschitzky et al., 2012). Consequently, 'FFE acceleration' and 'FFE decision making' are important research topics in understanding how to best execute the FFE in order to increase new product performance.

Second, priority should be given to investigating these FFE management research topics because, due to their centrality in the FFE management domain, the findings are expected to have significant consequences for other research topics listed in Table 1.1. For example, clarifying whether or not the FFE should be accelerated is expected to have consequences for the management of (the speed of) all FFE tasks and activities, such as 'Managing idea generation' or 'Managing concept development', and for research topics that can contribute to FFE speed, such as the level of 'FFE formalization' (Chen et al., 2010; Menon et al., 2002; Reinertsen, 1994). Therefore, 'FFE acceleration' needs to be investigated first, before 'FFE decision making'. 'FFE decision making', in turn, is expected to also have consequences for several other FFE management research topics, such as 'Leadership and control in the FFE', 'Information / knowledge use and management in the FFE' or the management of decision making in FFE tasks, such as 'Managing opportunity identification' or 'Managing idea generation'.

Third, despite the importance and centrality of the research topics 'FFE acceleration' and 'FFE decision making' in the FFE management domain, these research topics are under-researched. Only 6.6% and 5.9%, respectively, of all reviewed articles concerning the management of the FFE deal with these research topics (see Table 1.1). Moreover, only 1.7% of all reviewed studies that have been published in the last five years focus on either research topic. Consequently, it is possible to make a significant contribution to the existing body of knowledge in these FFE management research topics. In contrast, the percentage of articles published in the last five years is much higher for other FFE management research topics such as 'Managing idea generation' (up to 15.3%), indicating that several research groups already are active in contributing to these topics.

Last but not least, the focus on the research topics ‘FFE acceleration’ and ‘FFE decision making’ is a very practical choice because it matches with my fields of expertise and personal interest.

FFE execution can be managed at three different levels, i.e., the company (division), the product platform, or the individual project level. FFE execution management at the company and platform levels involves different activities than at the project level, such as managing the corporate innovation strategy, managing the idea funnel, idea screening, and portfolio management (Brem and Voigt, 2009; Oliveira and Rozenfeld, 2010). Since not much research has yet been conducted on the topics ‘FFE acceleration’ and ‘FFE decision making’, this dissertation research focuses, in line with the little prior research, at the individual NPD project level.

1.2 Research Questions

By reviewing the NPD and innovation management literatures related to the FFE management research topics ‘FFE acceleration’ and ‘FFE decision making’, I have identified two unresolved issues in FFE execution that will be investigated in this dissertation, i.e., (i) the performance effects of accelerating FFE execution cycle time and (ii) the optimal approach to FFE execution decision making. Below the unresolved issues are laid out, leading to the research questions for this dissertation.

1.2.1 The performance effects of accelerating FFE execution cycle time

The arguments on whether or not to accelerate the execution of the FFE are conflicting. The reduction of overall idea-to-launch cycle time is generally found to increase new product performance (Cankurtaran et al., 2013). The FFE, however, needs to be executed *proficiently* to increase new product performance (Evanschitzky et al., 2012). Some scholars argue that 'proficiency' means taking more time in the FFE to complete this stage thoroughly (Burchill and Fine, 1997; Crawford, 1992). Others, in contrast, argue that 'proficiency' means executing the FFE faster to increase new product performance by supporting a timely completion of the overall NPD project (Boeddrich, 2004; Reinertsen, 1994; Smith and Reinertsen, 1997). Unfortunately, explanatory research that could solve this controversy is lacking, resulting in the following research question:

> *RQ_{1a}: What is the main effect of FFE execution cycle time on new product performance?*

Additionally, there are also opposing arguments concerning an interacting performance effect of FFE execution cycle time. On the one hand, it has been argued that a 'proficient' completion means spending more time in the FFE so that time can be saved in the subsequent development and commercialization stages and, thus, new product performance increased (Khurana and Rosenthal, 1998; Thomke and Fujimoto, 2000). On the other hand, a consistent acceleration of all of the stages of the NPD process (i.e., FFE, development and commercialization), including the FFE stage, could increase new product performance because, then, cycle time reduction becomes an integral and clear project goal from the beginning of the project (Kessler and Chakrabarti, 1999; Murmann, 1994; Swink, 2003). These conflicting argumentations result in the following research question:

> *RQ_{1b}: What are the interacting effects of FFE execution cycle time with the performance effects of the subsequent development and commercialization stages' cycle times?*

1.2.2 The optimal approach to FFE execution decision making

Prior studies on FFE decision making have mainly focused on gate decisions (Hart et al., 2003; Martinsuo and Poskela, 2011), leaving the topic of decision making during the in-stage execution of FFE activities under-researched. Therefore, no study to date has focused on identifying the optimal approach to making FFE decisions between the gates. This is surprising since the choice of decision making approaches during the whole NPD process has been found to impact cycle time and NPD performance (Dayan and Di Benedetto, 2011).

For several decades decision making theory has promoted using a conscious, rational decision making approach (Sadler-Smith and Shefy, 2004; Sinclair and Ashkanasy, 2005), so that the tools that support FFE decision making predominately are based on rational methods (Calantone et al., 1999; Kahraman et al., 2007). More recent research, however, suggests that the execution of the FFE may also benefit from intuitive decision making (Bertels et al., 2011; Griffin et al., 2009). Intuitive decision making may lead to better decisions when uncertainty is high (Covin et al., 2001; Khatri and Ng, 2000) and when many decision attributes are involved (Strick et al., 2011), as is typical in FFE execution decisions (Khurana and Rosenthal, 1998; Kim and Wilemon, 2002a). Moreover, intuition is said to allow including tacit knowledge and experiences in the decision making process (Bertels et al., 2011; Griffin et al., 2009; Kim and Wilemon, 2002), to help in recognizing opportunities (DeBrentani & Reid, 2011), and to support idea generation activities (Rochfort, 1991; Sim et al., 2007). Unfortunately, it has not yet been understood what intuition really is and for which decisions and under which conditions the use of an intuitive decision making approach may or may not be beneficial in FFE execution. This raises the following research question:

RQ_{2a}: Why and under which conditions is the use of intuition beneficial for making FFE execution decisions?

Many FFE management scholars argue that rational and intuitive decision making approaches need to be combined to proficiently prepare product ideas and concepts for development (Brem and Voigt, 2009;

Khurana and Rosenthal, 1997; Murphy and Kumar, 1997). This is in line with the postulation of several decision making researchers that combining rational and intuitive approaches may allow a decision maker to benefit from the advantages of both (Dane and Pratt, 2009; Sadler-Smith and Shefy, 2004). To date, however, no empirical research has investigated the performance effects of combining rational and intuitive decision making approaches or the best way to combine the two approaches. This lack of research results in the following research question:

> *RQ_{2b}: Should intuitive and rational approaches be combined in FFE execution decision making and, if yes, how?*

1.3 Research Studies

The above research questions are investigated in three studies. Research questions 1a and 1b concern a mature field in the NPD and innovation management literatures. Additionally, these research questions can be investigated using the same research methodology and data set. Therefore, one causal, objective, archival data-based quantitative study is carried out to answer these research questions (Study 1, Chapter 2). Research questions 2a and 2b concern a relatively new NPD and innovation management research field and require different research methodologies. First, a combination of conceptual development and qualitative research is used to answer research question 2a (Study 2, Chapter 3). Then, based on the conceptual development, a causal, experimental, quantitative study is designed and carried out to test research question 2b (Study 3, Chapter 4). The objectives and methodologies of the three studies are briefly outlined below.

1.3.1 Study 1: FFE cycle time performance effects

Study 1 (Chapter 2) (Eling et al., 2013) uses a stage-wise approach to NPD cycle time to explore the main and interaction effects of FFE, development, and commercialization cycle times on new product performance and, thus, to investigate research questions 1a and b. Four nondirectional hypotheses on the main and interaction effects of FFE cycle time and three directional hypotheses on the main and interaction effects of development and commercialization cycle times are developed from theory. These hypotheses are tested using objective and longitudinal cycle time and sales data for 399 NPD projects completed following a Stage-Gate® type of process in the plastics division of a large and diversified industrial corporation. The data are analyzed using hierarchical moderated regression analysis and slope and slope difference tests (Aiken and West, 1991).

1.3.2 Study 2: A conceptual framework of intuition use in the FFE

Study 2 (Chapter 3) (Eling et al., forthcoming) combines two theoretical perspectives to define intuition in the context of FFE execution decision making and to explain why and under which conditions intuition use may or may not be (as) beneficial for product concept creativity, which adresses research question 2a. A creativity perspective is used to identify the decisions that are made during FFE execution and a dual-processing perspective is employed to define intuitive decision making. A conceptual framework is then developed that hypothesizes which FFE execution decisions may or may not benefit from the use of intuition under certain conditions in individual and team decision making to increase product concept creativity. This study uses product concept creativity as outcome variable of FFE decision making because the outcome of the FFE is a new product concept that is ready to proceed to development (Kim and Wilemon, 2002a) and that is both novel and meaningful (i.e., creative) in the eyes of the target customers to ensure new product success (Im et al., 2013; Im and Workman, 2004). The theorizing is supported and illustrated by exemplar quotes derived from eight exploratory interviews about intuition use in FFE execution decision making with product development practitioners from diverse companies in the Netherlands and Germany.

1.3.3 Study 3: Combining rational and intuitive approaches

Study 3 (Chapter 4) uses an experiment with a 2x2 between-subjects design to explore whether and how rational and intuitive decision making approaches should be combined to improve the quality and speed of FFE execution decision making and, thus, investigates research question 2b. FFE decision making quality and speed are used as dependent variables because the experiment is conducted at the individual FFE decision level. From theory, four different decision making approach combinations are distinguished for the two stages (i.e., the decision options analysis stage and the final decision making stage) of FFE executive decision making, i.e. the combination of: intuition with intuition, rationality with rationality, or two combinations of rational and intuitive decision making: (i) start with intuitively analyzing the decision options and then rationally consider the resulting intuition in making the final decision or (ii) start with rationally analyzing the decision options to produce logical reasons for what decision to make, and then intuitively consider these logical reasons in making the final decision. Two hypotheses on the contrast effects of these four approaches on FFE decision making quality and speed are developed from theory. To test these hypotheses, the experiment manipulates the decision making approach combinations used by 50 NPD professionals in evaluating several new product ideas, a typical FFE execution decision.

1.4 Contributions

This dissertation contributes to diverse literature streams within and outside of the domains of NPD and innovation management. The main contribution is to the FFE management literature in the NPD and innovation management domains. Next, this dissertation also makes a contribution to NPD cycle time reduction and NPD decision making literatures and, finally, also to the general creativity and decision making literatures outside of the NPD and innovation management domain.

1.4.1 Contributions to the FFE management literature

Investigating the two unresolved issues likely will have consequences for several FFE management research topics that are listed in Table 1.1. First, with regard to the research topics that are focus of this dissertation, 'FFE acceleration' and 'FFE decision making', study 1 is the first to empirically test whether the FFE should be accelerated and studies 2 and 3 are the first to inquire about the optimal approach to FFE execution decision making. By investigating these two unresolved issues, this dissertation makes an important contribution to the knowledge on proficient FFE execution. A better understanding of managing 'FFE acceleration' and 'FFE decision making' will be achieved.

Second, this dissertation contributes to several FFE management research topics that may be associated with managing 'FFE acceleration' or 'FFE decision making', as will be illustrated with the examples 'FFE formalization' and 'Leadership and control in the FFE' below. Formalization has been found to be an antecedent of NPD speed (Chen et al., 2010) and may, thus, also be useful for FFE cycle time acceleration. Consequently, depending on the findings of study 1, 'FFE formalization' may play a more important role in FFE management. The same applies to the research topic 'Leadership and control in the FFE' because also a certain type of team leadership (i.e., charismatic or participatory leadership style) and team empowerment are associated with NPD cycle time reduction (Chen et al., 2010). With regard to FFE decision making, 'FFE formalization' and 'Leadership and control in the FFE' may help assuring that the optimal decision making approach is used, depending on the findings of studies 2 and 3.

Finally, study 2 makes a contribution to the FFE management research topics ‘FFE outcome’ and ‘Understanding and managing the overall FFE process’ by applying a creativity perspective to the FFE to identify the decisions that are made during FFE execution and by defining ‘product concept creativity’ as an outcome measure of the FFE. While creativity previously has been considered as a requirement for successful FFE execution (Kim and Wilemon, 2002a; Koen et al., 2002), no study to date has used a creativity perspective to describe the FFE process or to define the FFE outcome.

1.4.2 Contributions to other fields in NPD and innovation management

This dissertation also contributes to two other fields in NPD and innovation management, i.e., NPD cycle time reduction (Study 1) and NPD decision making (Studies 2 and 3). Study 1 uses a new approach to investigate the consequences of NPD speed, namely a stage-wise approach, which is a completely new perspective in the NPD cycle time reduction literature. Earlier studies have investigated only overall NPD cycle time (Cankurtaran et al., 2013) or the use of acceleration methods in individual NPD phases (Karagozoglu and Brown, 1993), but none has looked at the stage-wise antecedents or consequences of NPD speed.

With regard to NPD decision making, as for the FFE, most decision making studies at the NPD process level have focused on gate decision making (Hart et al., 2003). Studies 2 and 3 are, therefore, among the first that explicitly focus at decision making within one of the NPD stages. Also, no study to date has applied a dual-processing perspective to NPD decision making. Dayan and Di Benedetto (2011) distinguish between intuitive and rational decision making at the NPD process level, but do not base their distinction explicitly on dual-processing theory. Last but not least, Study 2 is the first to make an explicit distinction between NPD decision making at the individual versus at the team level.

1.4.3 Contributions to literature outside of NPD

Studies 2 and 3 also contribute to the creativity and decision making literatures outside of the NPD and innovation management domain. Combining creativity and dual-processing perspectives has been done before (Allen and Thomas, 2011; Yang et al., 2012), but not with the purpose to explain the benefits of using intuition for *decision making* during the creativity process. Moreover, in the decision making literature, study 3 is the first that tests the performance effects of combining rational and intuitive decision making approaches at the single decision level. Earlier studies have only investigated the combined use of both approaches across an aggregated number of decisions at the organizational or project level (Dayan and Di Benedetto, 2011; Sadler-Smith, 2004), which does not parse out whether both approaches were combined for making single decisions or whether intuitive and rational decision making were used in an alternating manner.

1.5 Overview of this Dissertation

The remainder of this dissertation is organized as follows. The next chapter, *Chapter 2*, presents study 1, which addresses research questions 1a and 1b by exploring the main and interaction effects of FFE, development, and commercialization cycle times on new product performance. *Chapter 3* contains study 2, which addresses research question 2a by defining intuition in the context of FFE execution decision making and by explaining why and under which conditions intuition use may or may not be (as) beneficial for new product concept creativity. *Chapter 4* presents study 3, which addresses research question 2b by exploring whether and how rational and intuitive decision making approaches should be combined to improve the quality and speed of FFE execution decision making. Finally, *Chapter 5* summarizes and discusses the findings, conclusions, and implications of this dissertation and presents the limitations and ideas for future research.

CHAPTER 2

A Stage-Wise Approach to Exploring Performance Effects of Cycle Time Reduction*

Research on reducing new product development cycle time has shown that firms tend to adopt different cycle time reduction mechanisms for different process stages. However, the vast majority of previous studies investigating the relationship between new product performance and new product development cycle time have adopted a monolithic process perspective rather than looking at cycle time for the distinct stages of the NPD process (i.e., FFE, development and commercialization). As a result, little is known about the specific effect of the cycle times of the different stages on new product performance, or how they interact to influence new product performance. This study uses a stage-wise approach to NPD cycle time to test the main and interacting effects of FFE, development, and commercialization cycle times on new product performance using objective data for 399 NPD projects developed following a Stage-Gate® type of process in one firm. The results reveal that, at least in this firm, new product performance only increases if all three stages of the NPD process are consistently accelerated. This finding, combined with the previous research showing that firms use different mechanisms to accelerate different stages of the process, emphasizes the need to conduct performance effect studies of NPD cycle time at the stage level rather than at the monolithic process level.

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2.1 Introduction

Reducing a new product's idea-to-launch cycle time has become common practice to cope with shrinking product life cycles, increasing competition through technological advancements, and globalization. Prior research has identified a lengthy list of antecedents and consequences of new product development (NPD) cycle time (Chen et al., 2010; Griffin, 2002; Langerak et al., 2008). However, the performance implications of shortening NPD cycle time are still not fully understood. While several studies have found a positive association between reduced NPD cycle time and new product performance (i.e., shorter cycle time increases performance) (Chen et al., 2005; Kessler & Bierly, 2002; Lynn et al., 1999; Montoya-Weiss & Calantone, 1994), others have found no significant relationship between cycle time and new product performance (e.g., Griffin, 2002; Griffin, 1997; Meyer and Utterback, 1995).

Various studies have further investigated these divergent empirical results by examining the moderating effects of contextual factors, such as market and technological uncertainty (Chen et al., 2005; Kessler and Bierly, III, 2002), product innovativeness (Ali, 2000; Langerak and Hultink, 2006), new product strategy (Langerak and Hultink, 2005), team improvisation (Akgün and Lynn, 2002) and customer participation (Fang, 2008). However, these contingency studies still have not fully explained the inconsistent results with regard to the performance effect of reducing cycle time.

This article takes a different angle by attributing the conflicting results of cycle time research to the monolithic process perspective that most prior studies have used. That is, these studies have overlooked the performance effects of the time taken to complete different phases of the NPD process. The stage-wise perspective of this article on cycle time reduction is important, because previous research has shown that firms do not apply one cycle time reduction mechanism across the entire NPD process

(Karagozoglu and Brown, 1993). More worrisome, no firm in their sample purposefully applied some kind of time reduction mechanism across **all** stages of the process. Thus, while actual use of cycle time reduction mechanisms differs across stages, it is not clear which stage, if any, is most important to accelerate, whether multiple stages are important to accelerate, or whether all stages must be accelerated for increased success.

The majority of companies organize the NPD process as a series of stages and gates, also most frequently known as a 'Stage-Gate®' process, in which three generic NPD process stages can be distinguished: (1) the predevelopment stage, referred to as the FFE, (2) the development (DEV) stage, and (3) the commercialization (COM) stage (Barczak et al., 2009; Cooper and Kleinschmidt, 1988; Crawford and Di Benedetto, 2008; Hauser et al., 2006). In this article it is argued that investigating NPD cycle time at the monolithic process level is insufficient, as research has repeatedly shown that the proficient completion of the FFE stage in and of itself is a key NPD success factor (Henard and Szymanski, 2001; Montoya-Weiss and Calantone, 1994). Unfortunately, to date no study has clarified how FFE "proficiency" is interpreted in terms of how it relates to the FFE stage cycle time. As a result, it has been argued both that FFE "proficiency" means taking *more* time to complete the FFE stage *thoroughly* (Burchill and Fine, 1997; Crawford, 1992) and that it means supporting a *timely* completion of the NPD project by completing the FFE stage *faster* (Boeddrich, 2004; Smith and Reinertsen, 1997).

This ambiguity with regard to the performance effect of FFE cycle time indicates a need to use a stage-wise approach to uncover which combination(s) of timely completed NPD stages improves new product performance. A stage-wise approach allows for testing overall performance effects against the cycle time of each NPD stage. Again, the expected main effect of FFE cycle time on new product performance is unclear because both a longer and a shorter FFE cycle time have theoretically been argued to increase new product performance. Therefore, the first objective of this study is to use a stage-wise approach to explore the *main effect* of FFE cycle time on new product performance and compare it with the main effects for the cycle times of the DEV and COM stages.

More importantly, using a stage-wise approach allows testing how the interaction between the cycle time(s) of preceding NPD stage(s), i.e. FFE and DEV, and the cycle time(s) of subsequent stage(s), i.e. DEV and COM, is associated with new product performance. For the interaction effects that involve FFE cycle time, two opposing lines of argumentation again exist. On the one hand, it can be argued that a proficient completion means spending more time in the FFE so that time can be "saved" in the DEV and COM stages and, thus, new product performance is increased (Burchill and Fine, 1997; Khurana and Rosenthal, 1998; Thomke and Fujimoto, 2000). On the other hand, a consistent acceleration of all of the stages of the NPD process, including the FFE stage, could increase new product performance because, then, cycle time reduction becomes an integral and clear project goal from the beginning of the project (Kessler and Chakrabarti, 1999; Murmann, 1994; Swink, 2003). Therefore, the second objective of this research is to explore the *interaction effects* of FFE cycle time with DEV and COM cycle times in explaining new product performance.

These objectives are achieved by testing seven hypotheses on the main and interaction effects of stage-wise NPD cycle time with objective cycle time and performance data for 399 NPD projects completed following a Stage-Gate® type of process in the plastics division of a large and diversified industrial corporation. While the use of a single company constrains the generalizability of this study, it avoids data comparability problems across firms due to differences in the management of the NPD process or the definition of when stages start or end and eliminates cross-industry and -firm factors as possible explanations for new product performance differences. In the next section I introduce the framework and hypotheses. Then the methodology is discussed and the results are presented. The article closes with a discussion of the findings and managerial implications, the limitations of the study, and suggestions for further research.

2.2 Framework and Hypotheses

From a monolithic process perspective, theoretical arguments exist for both improved and worsened new product performance through a shorter new product idea-to-launch cycle time. On the one hand, it is argued that shorter idea-to-launch cycle time improves performance because it allows for more accurate forecasting of environmental and technological forces, which may increase new product performance through producing a product with a better fit with forecasted market needs (Cordero, 1991; Gupta and Wilemon, 1990; Kessler and Bierly, III, 2002; Millson et al., 1992). Moreover, when the idea-to-launch time is shorter, the company may achieve sales throughout more of the new product's life cycle before it becomes obsolete due to technological changes (Cordero, 1991; Dyer et al., 1999; Gupta and Wilemon, 1990; Millson et al., 1992; Smith and Reinertsen, 1997). Additionally, reduced time-to-market allows for a more proficient market entry timing, which may increase new product performance when possible pioneer or fast-follower advantages can be gained (Bayus, 1997; Langerak et al., 2008).

On the other side of the coin, reducing cycle time may also result in entering the market too early, i.e. when the new product's window of opportunity is still closed, which harms new product performance due to incompatibility (Langerak and Hultink, 2006). Performance may also be harmed due to coordination problems among team members involved in accelerated projects. Moreover, if shorter overall new product cycle time is achieved through skipping steps in the development process, the resulting product may have defects or quality problems, which leads to decreased market performance (Crawford, 1992). The obverse of that is that taking additional time in development to ensure that product performance is superior to all competing products in the marketplace may lead to greater sales performance.

Empirically, the results for associations between overall NPD cycle time and performance also are mixed. On the one hand, Calantone et al. (1995) and García et al. (2008) both find positive associations between shorter NPD cycle times and market performance. However, Langerak and Hultink (2006) document an inverted U-shaped relationship with performance, suggesting there is an "optimal" development speed. Additionally, Adams-Bigelow and Griffin (2005), report a negative relationship between speed and profitability. Moreover, others show no relationship at all (Griffin, 2002; Griffin, 1997a). The meta-analysis by Cankurtaran et al. (2013) shows a positive main effect relationship of reduced NPD cycle time for many operationalizations of "product performance", while a number of methodological decisions made by researchers (e.g., the use of subjective versus objective measures of cycle time) moderated their results, diminishing or even eliminating the significance between cycle time and product performance.

To conclude, both the theoretical argumentation and empirical research to date on the relationship between NPD cycle time and performance is inconclusive when investigated at the monolithic level of NPD cycle time for the entire project. This research thus investigates these issues at the project stage level to try and bring clarity to why previous results at the overall project level have been so inconsistent.

The conceptual framework tested in this study (Figure 2.1) hypothesizes the stage-wise main and interaction effects of new product idea-to-launch cycle time (i.e., FFE, DEV and COM cycle time) on new product performance. First, I present the arguments for the main effects of the cycle time of each of the three generic NPD process stages on new product performance (Hypotheses 1-3). Then, the effects of the three two-way and the one three-way interactions between the cycle times of the already-completed, preceding stages (i.e., FFE and DEV) and the cycle times of the subsequent stages (i.e., DEV and COM) on performance are hypothesized (Hypotheses 4-7).

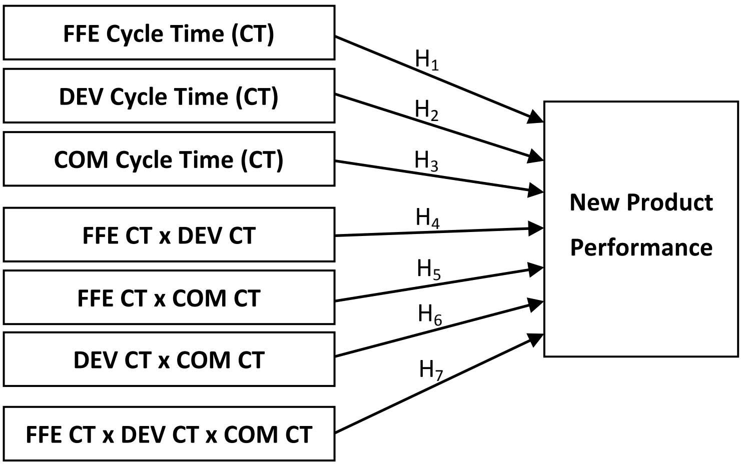

Figure 2.1: Conceptual Model

2.2.1 Main effect of FFE cycle time

The function of the FFE stage is to decide *if, what,* and *how* to develop a new product (Khurana and Rosenthal, 1998; Koen et al., 2002; Reid and de Brentani, 2004). These objectives are achieved through activities such as opportunity identification, idea generation and screening, market and technology assessment, concept development, project planning, product strategy definition, business case development and evaluation. A proficient completion of FFE activities repeatedly has been shown to increase new product performance (Henard and Szymanski, 2001; Langerak et al., 2004; Montoya-Weiss and Calantone, 1994). Unfortunately, these studies leave unclear what 'proficient completion' of FFE activities means with regard to the *cycle time* of the FFE stage.

The FFE stage is initiated when someone identifies an opportunity or idea for a new product (Koen et al., 2002; Reid and De Brentani, 2004) and ends with the gate meeting in which the business case for developing a new product is accepted and physical development starts (Griffin, 2002; Koen et al., 2002). *FFE cycle time* is, thus, defined as the time an NPD project takes from the date of its initiation until the meeting date on which the business case is accepted. A main effect of FFE cycle time on new product performance is expected because the effort that is spent in the FFE stage determines to a great extent the success or failure of the final new product (Cooper, 1988; Reid and de Brentani, 2004). However, due to the importance of a proficient completion of this first NPD stage, theoretical and empirical arguments exist for both a positive (long FFE cycle time increases performance) and a negative (short FFE cycle time increases performance) effect of FFE cycle time on new product performance. Therefore, the arguments for both effects are presented and a non-directional hypothesis is formulated (Atuahene-Gima, 2005; Fang, 2008).

On the one hand, a more proficient completion of the FFE stage could imply spending more time on FFE activities such as environmental assessment, idea generation, and project planning. Important decisions made in the FFE have a great influence on the actual outcome of the NPD project (Cooper, 1988; Reid and De Brentani, 2004). Therefore, it is essential to take sufficient time to understand the target market's characteristics and to gain adequate knowledge about technological possibilities before product concept and strategy decisions are made (Reid and De Brentani, 2004). Indeed, some research has shown that taking more time to reduce project uncertainty and risk in the FFE leads to more successful products (Verworn et al., 2008).

Additionally, spending more time on idea generation can positively affect the NPD outcome. Creativity, which is needed for generating more innovative new product ideas (West, 2002), takes time (Prather, 2000). Typically, both creative problem solving processes and a long incubation or gestation period are required to attain the 'insight,' or the sudden realization of a solution (an 'aha' or 'eureka' experience) that produces the more innovative new product ideas (Hodgkinson et al., 2008). Time is needed in the FFE to fully understand the NPD problem and to create an innovative solution that will result in a successful new product (Griffin et al., 2009).

Finally, spending more time on project planning in the FFE can have a positive effect as it leads, for instance, to a better choice of team members and a higher NPD goal clarity. This in turn increases team motivation and communication (Lynn et al., 1999), suggesting a positive effect of FFE cycle time on new product performance (i.e., longer FFE cycle time increases new product performance).

In contrast, other authors argue that a shorter FFE cycle time increases new product performance (Boeddrich, 2004; Kessler and Chakrabarti, 1999; Kim and Wilemon, 2002a; Reinertsen, 1994; Smith and Reinertsen, 1997). The rationale is that, to date, best practices for FFE management have not been identified (Koen et al., 2002) and the FFE lacks 'methodological, systematic and structured procedures' (Boeddrich, 2004) so that time is often not 'scheduled' in this first getting started stage (Reinertsen, 1994; Smith and

Reinertsen, 1997). As a result, insufficient efforts are made to avoid time consuming delays, debates, and rework, resulting in an FFE that is not executed proficiently (Boeddrich, 2004; Smith and Reinertsen, 1997; Kessler and Chakrabarti, 1999). A "proficient" management of the FFE stage uses methods that are also known to reduce cycle time, such as multifunctional cooperation, learning through iteration, lead user involvement, supplier and customer involvement, frequent and clear milestones, more frequent idea reviews, training and rewarding of employees, and top management support (Brown and Eisenhardt, 1995; Eisenhardt and Tabrizi, 1995; Kessler and Bierly, III, 2002; Kessler and Chakrabarti, 1999; Langerak and Hultink, 2005; Smith and Reinertsen, 1997). Using these methods simultaneously increases FFE proficiency and reduces FFE cycle time without creating harmful side effects on new product performance. This suggests a negative effect of FFE cycle time on new product performance (i.e., shorter FFE cycle time increases new product performance).

Given these two opposing lines of argumentation, I formulate a non-directional hypothesis for the main effect of FFE cycle time on new product performance:

H_1: FFE cycle time is associated with new product performance.

2.2.2 *Main effects of DEV and COM stage cycle times*

Development cycle time is the time that an NPD project takes from the date of the business case acceptance (the end of the FFE) until the date of approval for mass production of the new product (Crawford and Di Benedetto, 2008). *Commercialization cycle time* is defined as the time that an NPD project takes from the date on which the product is approved as ready for mass production (the end of the DEV stage) until the date on which the new product enters the market (Crawford and Di Benedetto, 2008). As with the time spent on FFE activities, also the time spent in the subsequent DEV and

COM stages is expected to affect new product performance. However, it can clearly be argued from theory that reduced DEV and COM cycle times increase new product performance (a negative effect of DEV and COM cycle time on performance).

The FFE stage focuses on *what* new product, and *if* and *how* the new product has to be developed. In contrast, the focal point of the DEV and COM stages is the actual *execution* of development (product design and testing) and launch (manufacturing scale-up) for the new product (Crawford and Di Benedetto, 2008). The most fundamental project decisions already have been made before it enters development. The DEV and COM tasks and activities are more concrete and schedulable than those in the FFE. As such, these activities are more easily speeded up without incurring the hidden costs of accelerated development (Crawford, 1992). Additionally, formal processes, such as Stage-Gate™ (Cooper, 2008), are in place in the vast majority of firms to specifically manage these NPD stages (Barczak et al., 2009). The rules and procedures inherent in such formalized approaches facilitate coordination among different functions and project tasks, reducing conflict, uncertainty, and ambiguity, which, in turn, accelerates the NPD process (Chen et al., 2010; Li and Atuahene-Gima, 1999). Moreover, uncertainty and risks decrease throughout the NPD process so that tasks, goals, and objectives are easier to schedule which enhances the project team's ability to timely complete the DEV and COM stages (Harter et al., 2000) and, thus, to contribute to the advantages of reduced time-to-market without harmful side effects on new product performance. Therefore, I hypothesize:

H_2: *Longer DEV cycle time has a negative effect on new product performance.*

H_3: Longer COM cycle time has a negative effect on new product performance.

2.2.3 Two-way interaction effects

The activities of the initial NPD stages also may determine the content and activities of the subsequent stages (Kessler and Chakrabarti, 1996; Kim and Wilemon, 2002b). Consequently, the time spent in the earlier stages of the process is expected to interact with the performance effects of the cycle times of the later stages. Again the interaction effects involving the FFE are hypothesized in a non-directional manner because of the ambiguity of the effect of FFE cycle time on new product performance.

On the one hand, spending more time in the FFE is said to save time in the later stages and, therefore, could strengthen the negative effect of the cycle time of the DEV and the COM stages on new product performance (Burchill and Fine, 1997; Khurana and Rosenthal, 1998; Veryzer, 1998). The rationale behind this 'leverage effect' (Verworn, 2009) is that the DEV and COM stages both progress faster when more time is spent on market and technological uncertainty reduction and detailed project planning in the FFE (Verworn et al., 2008). When more time is taken in the FFE to solve technical problems, the project is delayed less in development (Thomke and Fujimoto, 2000). Additionally, commercialization can proceed faster when more time is taken in the FFE to reduce market-related uncertainties (Verworn et al., 2008).

There also is evidence that acceleration in the FFE stage can lead to misdirected efforts in the DEV and COM stages, and thus to delays and re-work in those subsequent stages (Burchill and Fine, 1997; Gupta and Wilemon, 1990). Spending more time in the FFE stage allows for more adequate up-front planning for the DEV and the COM stages. As a result, these activities deviate less from FFE specifications, which leads to better directed team effort and communication and, thus, facilitates faster execution of those stages (Verworn et al., 2008; Verworn, 2009). Together these arguments suggest that more time spent on FFE activities facilitates a more efficient execution of both of the subsequent stages (i.e., a longer FFE cycle time strengthens the negative effects of DEV and COM cycle time) and, therefore, new product performance is increased.

In contrast, Karagozoglu and Brown (1993) show that more NPD acceleration methods (e.g., customer involvement, multifunctional teams, or computer-aided tools) are used at the start of the FFE stage than are used later in the process. However, accelerating the FFE in concert with the subsequent DEV and COM stages allows a more consistent application of the acceleration tactics and methods used across the entire process (Cooper, 2008; Hultink et al., 1997). Only when the acceleration goal for the FFE is the same as for the subsequent DEV and COM stages does cycle time reduction become an integral part of the project's goals from the very beginning, which has been shown to be a prerequisite for successfully reducing overall NPD cycle time (Kessler and Chakrabarti, 1999; Murmann, 1994; Swink, 2003).

Several studies show that NPD acceleration methods only lead to a successful reduction of NPD cycle time when clear schedules and time goals are in place from the start of the project (Kessler and Bierly, III, 2002; Swink, 2003; Zirger and Hartley, 1996). Additionally, goal clarity in terms of the time-to-market strategy of the NPD project improves teamwork and communication and enables faster and more effective resource allocation to support the time goal of the project (Kessler and Chakrabarti, 1999; Murmann, 1994; Rauniar et al., 2008). These arguments underline the necessity of starting cycle time reduction in the FFE stage and keeping the acceleration consistent across the subsequent stages (i.e., a short FFE cycle time strengthens the negative effects of DEV and COM cycle time) in order to increase new product performance.

As a result of these opposing lines of argumentation, the hypotheses that capture the possible effects on performance are hypothesized with non-directionally specified interactions:

H_4: The negative effect of longer DEV cycle time on new product performance will be impacted by FFE cycle time.

H_5: The negative effect of longer COM cycle time on new product performance will be impacted by FFE cycle time.

However, while the sign of the interactions between FFE cycle time and the cycle times of later stages is unclear, the directionality for the interaction effect between the cycle times of the DEV and COM stages can be hypothesized. When the cycle times for both stages are shorter, the product in development will come to market faster overall. This means that the product is more likely to gain the advantages of shorter time-to-market, including a better fit with forecasted market needs, increased utilization of the product's life cycle, and more proficient market entry timing (Cordero, 1991; Gupta and Wilemon, 1990; Langerak and Hultink, 2005; Millson et al., 1992). Thus:

H_6: The negative effect of a longer COM cycle time on new product performance is stronger when DEV cycle time is shorter.

2.2.4 Three-way interaction effect

Finally, in line with the argumentation for the two-way interaction effects between the cycle times of preceding and subsequent NPD stages, the cycle times of all three generic NPD stages (i.e., FFE, DEV, and COM) are expected to interact in explaining new product performance. And again, two opposing lines of argumentation are possible. On the one hand, if cycle time improvements are achieved through rushing through the initial stage with the result that the product is not sufficiently well defined at the end of the FFE and the project lacks adequate planning for the two subsequent DEV and COM stages, the resulting product might fall short of customer expectations, leading to lower sales (Burchill and Fine, 1997; Gupta and Wilemon, 1990). This would mean that the combination of a longer, adequately completed FFE stage and shorter subsequent DEV and COM stages increases new product performance. On the other hand, it is likely that the faster completion of all three NPD stages leads to an increase in new product performance because the goal to reduce cycle time is then clear and consistent across all NPD stages and acceleration methods can be applied consistently across all stages of the NPD project (Kessler and Chakrabarti, 1999; Murmann, 1994; Swink, 2003). Therefore, it also can be argued that the consistent acceleration of all three NPD stages' cycle times increases new product performance. Based again on these opposing arguments, I thus hypothesize:

> *H_7:* *The interaction between the cycle times of the FFE, DEV and COM stages will impact new product performance.*

2.3 Method

2.3.1 Data

I use objective data to test the hypotheses, because of the findings of a previous meta-analytic study. Cankurtaran, et al. (2013) found a statistically significant main effect relationship between project cycle time and NPD performance for a variety of different measures of performance. However, when "subjective data" versus "objective data" was investigated as a methodological mediator, the relationship between performance and cycle time was no longer statistically significant for the set of studies using objective data. Thus, using objective data provides a stronger test of the hypotheses.

The data for testing the hypotheses come from the archive of a plastics division of a large and diversified industrial corporation. This division serves customers worldwide in a variety of industries, including aerospace, automotive, construction, data storage, optical media, medical, electronics, telecommunications, computers, and packaging. Although headquartered in the Netherlands, they employ about 10,000 people and operate some 60 facilities in 20 countries. The analysis uses the data for all of the 399 NPD projects that were commercialized between 1996 and 2008.

I chose this company for several reasons. First, as has been found for over two-thirds of the companies developing new products (Barczak et al., 2009), this division uses a Stage-Gate® type of development process. More importantly, the division tracks and records NPD process milestone dates, sales volume and prices for all of its NPD projects, providing objective measures for these variables. Finally, this division commercializes a high number of new products each year: over 30, when the average in industry in general is about 8 (Griffin, 1997a). New product development for them is strategically important.

Since this study is the first to use a stage-wise approach to investigate cycle time, objective data was chosen to provide a stronger test of the hypotheses and to emphasize internal validity over generalizability. They thus focused on a single division in a single company to eliminate cross-industry and -firm factors as possible explanations for product performance differences (Naveh, 2007). This also avoids comparability problems due to differences in stage definitions or the management of the NPD stages across firms (Koen et al., 2002; Murphy and Kumar, 1997).

2.3.2 Measurement

2.3.2.1 Independent variables

While the plastics division of the participating company distinguishes five NPD phases in their formal development process – (1) market development, (2) assessment & initiation, (3) development, (4) scale-up & sampling, and (5) commercialization – the dates of transition from phase (1) to phase (2) are not recorded. Therefore, the study investigates cycle time at the stage level using the three (i.e. FFE, DEV and COM) generic stages distinguished in the literature (Cooper and Kleinschmidt, 1986; Crawford and Di Benedetto, 2008). To this end I asked eight experts in NPD research to group the company's five NPD phases into the three generic NPD process stages. These experts grouped the company's phases (1) and (2) into the FFE stage, phases (3) and (4) into the DEV stage, and designated phase (5) as the COM stage. The proportion of the interjudge agreement (0.95), the proportional reduction in loss reliability measure (1.00) (Rust and Cooil, 1994) and the Cohen's Kappa (0.93) (Fleiss, 1981) all indicate a very high level of agreement among the experts.

As a result, *FFE cycle time* was measured as the number of days that the NPD project took from the date of its initiation in the company (start of phase 1) until the date of approval for DEV (end of phase 2). *DEV cycle time* was measured as the number of days between the end date of the FFE stage (end of phase 2) until the date of approval for production (end of phase 4). *COM cycle time* was measured as the number of days that the NPD project took from the approval meeting at the end of the DEV stage (end of phase 4) until the date of the final approval for launch (end of phase 5).

2.3.2.2 Dependent variable

The measure for new product performance was the cumulative sales of each product, which also was available in the division's database (Langerak et al., 2009).

2.3.2.3 Control variables

To account for differences in new product sales that are not related to the cycle time of the three NPD stages, three control variables were included. First, the number of days that a project was on the market differed highly (Mean = 688.03, σ = 469.52). Therefore, a control variable time on the market was included to account for differences in cumulative sales volume related to the number of days that a product was actually available for sale on the market. Second, a variable project initiation was included that controlled for the different initiation dates across the development projects. This variable accounts for differences in new product sales caused by possible, yet unobserved changes in the firm's innovation strategy, NPD process structure or resources, and by organizational learning that occurred within the time-frame of this study (cf. Boh et al., 2007). Third, another variable controlled for the product's average selling price, as price is an important driver of new product sales (Langerak et al., 2009). In addition, to minimize concerns that the estimation results are affected by product line differences, the data was standardized by forcing the variables to have a mean of zero and a standard deviation of one within each product line prior to analysis. This procedure controlled for the possible performance impact of unmeasured differences across the 24 product lines for which the 399 NPD products were developed, such as target market differences or differences in product line complexity. Means, standard deviations and correlations of the variables are reported in Table 2.1.

Table 2.1: Means, Standard Deviations (σ), and Correlations for Key Constructs (*n* = 399)

	Mean	σ	1.	2.	3.	4.	5.	6.
1. Cum. sales (tons)	990.49	3903.56						
2. Average sales Price ($ / ton)	8123.82	11469.74	-.181*					
3. Project initiation (days)	2948.26	803.34	-.188**	.090				
4. Time on the market (days)	688.03	469.52	.345**	-.052	-.567**			
5. FFE cycle time (days)	85.54	109.51	.162**	.004	-.122*	-.045		
6. DEV cycle time (days)	258.02	273.49	.034	-.016	-.425**	.067	-.019	
7. COM cycle time (days)	148.90	222.93	.078	-.013	-.527**	.234**	-.006	.098*

*$p < 0.05$ (2-tailed); **$p < 0.01$ (2-tailed)

2.3.3 *Analysis*

Following the approach suggested by Aiken and West (1991) to test interaction effects, hierarchical moderated regression analysis was used to test the above stated hypotheses. This analysis approach eliminates the effect of the control variable on the dependent variable before estimating the independent variable effects, and then eliminates the effect of the direct effects of the independent variables before estimating the interaction effects between the independent variables. The estimation results are shown in Table 2.2 (Models 1 to 3). The control variables explain 17.4% of the variance in new product sales (Model 1). Adding the independent variables in the second step (Model 2) increased the adjusted R^2 to 20.2%, a significant improvement over Model 1 (ΔF=5.646, p<0.01). Model 3, with the interaction effects, explains 22.4 % of the variance in new product sales, a significant increase over Model 2 (ΔF=3.899, p<0.01). Therefore, Model 3 was used for hypothesis testing. The highest variance inflation factor across the models was 4.653 and the maximum condition index was 7.154, indicating that multicollinearity was not a problem (Belsley et al., 1980; Hair et al., 1998).

Table 2.2: Regression Results

Dependent Variable: Cumulative Sales		Model 1	Model 2	Model 3
Step 1: Control variables				
Constant	(b_0)	0.000	0.000	0.000
Time on the market	(b_1)	0.254**	0.247**	0.234**
Average sales price	(b_2)	-0.188**	-0.186**	-0.171**
Project initiation	(b_3)	-0.178**	-0.252**	-0.244**
Step 2: Independent variables				
FFE cycle time	(b_4)		0.141**	0.050
DEV cycle time	(b_5)		-0.080	-0.216**
COM cycle time	(b_6)		-0.102	-0.310**
Step 3: Interaction Effects				
FFE cycle time x DEV cycle time	(b_7)			0.157
FFE cycle time x COM cycle time	(b_8)			0.242*
DEV cycle time x COM cycle time	(b_9)			0.319**
FFE cycle time x DEV cycle time x COM cycle time	(b_{10})			-0.292**
Regression statistics:				
n		399	399	399
df		3	6	10
R^2		0.180	0.214	0.244
Adjusted R^2		0.174	0.202	0.224
F-statistic		28.922**	17.793**	12.550**
R^2 change			0.034	0.030
F change statistic			5.646**	3.899**

*$p < 0.05$; **$p < 0.01$

2.4 Results

2.4.1 Main effects

The main effect of FFE cycle time on new product sales is not significant, providing no support for H_1 (b_4 = 0.050, p = 0.521). As hypothesized, longer DEV (b_5 = -0.216, $p < 0.01$) and longer COM cycle times (b_6 = -0.310, $p < 0.01$) both have significant negative effects on new product sales (longer cycle times are associated with lower sales), providing support for H_2 and H_3.

2.4.2 Two-way interaction effects

The interaction between FFE and DEV cycle times is not significant (b_7 = 0.157, p = 0.071), providing no support for H_4. However, the interactions between both the FFE and COM cycle times and the DEV and COM cycle times are positive and significant (b_8 = 0.242, p =< 0.01, and b_9 = 0.319, $p < 0.01$). To interpret whether the overall effects are due to two positive or two negative coefficients interacting, I conducted simple slope tests (Aiken and West, 1991), shown in Figures 2.2 and 2.3. In addition, slope difference tests were conducted to see when the effect of COM cycle time is significantly stronger (Dawson and Richter, 2006). Table 2.3 shows the results of the slope difference tests. The negative effect of longer COM cycle time on new product performance is significantly stronger when FFE is shorter, providing support for H_5. Also, the negative effect of longer COM cycle time is significantly stronger when DEV cycle time is shorter, providing support for H_6. Moreover, the results of the simple slope tests in Table 2.4 reveal that the negative effect of longer COM cycle time on new product performance is only significant when FFE or DEV cycle times are shorter, respectively.

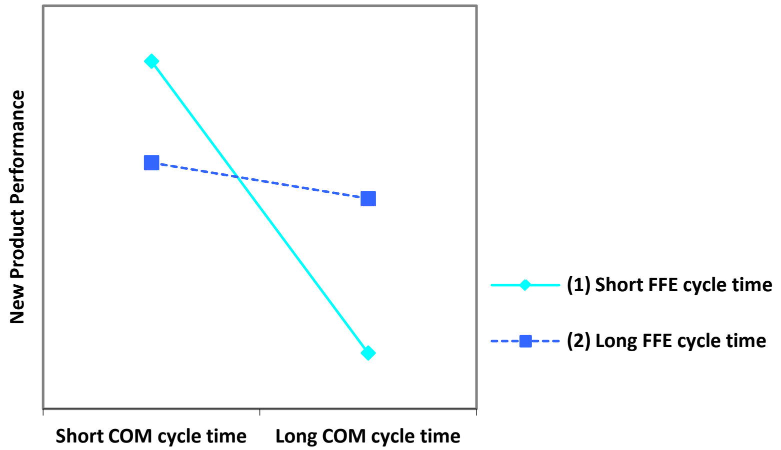

Figure 2.2: Simple Slopes for the Interaction Effect of FFE x COM Cycle Times

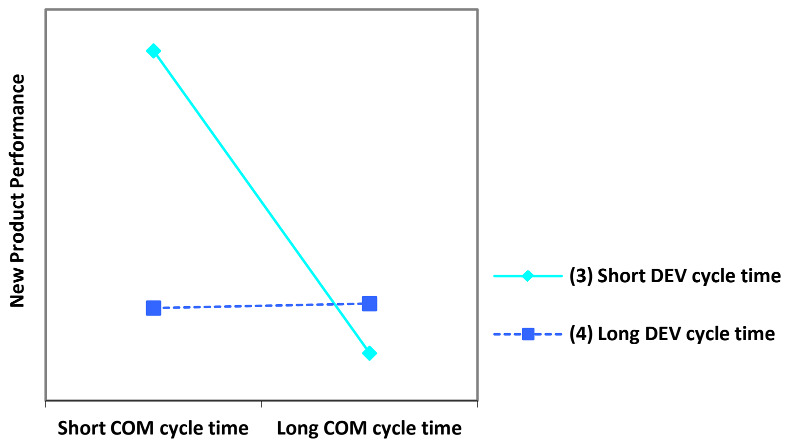

Figure 2.3: Simple Slopes for the Interaction Effect of DEV x COM Cycle Times

Table 2.3: Slope Difference Test for Two-Way Interaction Effects

Interaction Effect	Pair of Slopes	*t*-Value
FFE x COM cycle times	(1) Short FFE cycle time and (2) Long FFE cycle time	3.124**
DEV x COM cycle times	(3) Short DEV cycle time and (4) Long DEV cycle time	4.118**

**$p < 0.01$

Table 2.4: Simple Slope Test for Two-Way Interaction Effects

Interaction Effect	Simple Slope	SE	Simple Slope	*t*-Value
FFE x COM cycle times	(1) Short FFE cycle time	0.166	-0.548	-3.304**
FFE x COM cycle times	(2) Long FFE cycle time	0.088	-0.072	-0.815
DEV x COM cycle times	(3) Short DEV cycle time	0.160	-0.624	-3.900**
DEV x COM cycle times	(4) Long DEV cycle time	0.077	-0.004	0.047

*$p < 0.05$; **$p < 0.01$

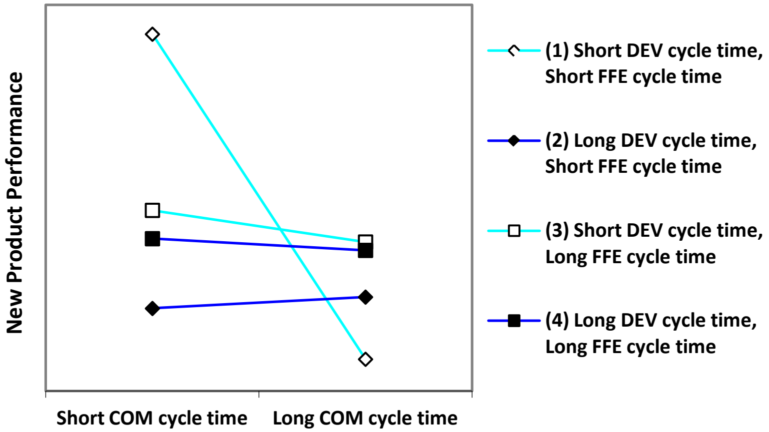

Figure 2.4: Simple Slopes for the Interaction Effect of FFE x DEV x COM Cycle Times

Table 2.5: Slope Difference Test for Three-Way Interaction Effect

Pair of Slopes	*t*-Value
(1) Short DEV ct, Short FFE ct and (2) Long DEV ct, Short FFE ct	3.864**
(1) Short DEV ct, Short FFE ct and (3) Short DEV ct, Long FFE ct	2.940**
(1) Short DEV ct, Short FFE ct and (4) Long DEV ct, Long FFE ct	3.479**
(2) Long DEV ct, Short FFE ct and (3) Short DEV ct, Long FFE ct	0.770
(2) Long DEV ct, Short FFE ct and (4) Long DEV ct, Long FFE ct	-0.707
(3) Short DEV ct, Long FFE ct and (4) Long DEV ct, Long FFE ct	0.285

**$p < 0.01$; ct = cycle time

Table 2.6: Simple Slope Test for Three-Way Interaction Effect

Simple Slope	SE	Simple Slope	*t*-Value
(1) Short DEV cycle time & Short FFE cycle time	0.292	-1.129	-3.860**
(2) Long DEV cycle time & Short FFE cycle time	0.119	0.039	0.330
(3) Short DEV cycle time & Long FFE cycle time	0.159	-0.110	-0.693
(4) Long DEV cycle time & Long FFE cycle time	0.081	-0.041	-0.500

**$p < 0.01$ (2-tailed)

Table 2.7: Means, Standard Deviations (σ), and Correlations in the Subsample (n = 45)

	Mean	σ	1.	2.	3.	4.
1. FFE cycle time (days)	99.717	133.793				
2. DEV cycle time (days)	239.261	225.997	.030			
3. COM cycle time (days)	184.652	226.440	.241	.111		
4. Project initiation (days)	2632.696	543.889	-.511**	-.431**	-.530**	
5. Project innovativeness (radical: yes=1, no=0)	0.457	0.504	.048	.063	.180	-.014

**$p < 0.01$ (2-tailed)

Table 2.8: Effect of Project Innovativeness on FFE, DEV, and COM Cycle Time (n = 45)

Dependent Variable:		Model 4: FFE Cycle Time	Model 5: DEV Cycle Time	Model 6: COM Cycle Time
Independent variables:				
Constant	(b_{10})	-0.236	-0.140	-0.244
Project initiation	(b_{11})	-0.773**	-0.570**	-0.736**
Project innovativeness	(b_{12})	0.089	0.108	0.345
Regression statistics:				
n		45	45	45
df		2	2	2
R^2		0.262	0.189	0.311
Adjusted R^2		0.228	0.151	0.279
F-statistic		7.647**	5.015**	9.695**

**$p < 0.01$

2.4.3 *Three-way interaction effects*

The interaction between the FFE, DEV and COM cycle times is significantly negatively related to new product performance (b_{10} = -0.292, $p < 0.01$). To interpret this interaction effect, again simple slope (Aiken and West, 1991) and slope difference tests (Dawson and Richter, 2006) were conducted. The simple slopes are shown in Figure 2.4. The results of the slope difference test, as reported in Table 2.5, reveal that the negative effect of longer COM cycle time on new product sales is significantly stronger for projects with both shorter FFE and DEV cycle times (all three coefficients have a negative sign) in comparison to projects with any other combination of shorter and longer cycle times across stages. These results provide support for H_7. In addition, the simple slope tests reported in Table 2.6 show that the negative effect of longer COM cycle time on new product performance is significantly stronger only when both DEV and FFE cycle times also are shorter.

2.4.4 *Additional analysis*

Previous research has shown that a number of project characteristics, especially innovativeness, affect cycle time (Griffin, 1997a; Griffin, 1997b). Unfortunately, the archival data of the division did not include information on any project characteristics. However, I collected additional information on project innovativeness from the project managers in a subsample of 45 of the more recently commercialized projects. Previous researchers have used many different operationalizations of project radicalness. Overall, however, about one-third have used a simple, dichotomous measure of innovativeness in their analyses (Danneels and Kleinschmidt, 2001). Because this evaluation was obtained retrospectively, this simple operationalization was chosen to maximize the response rate. The terms "radical" and "incremental" were thus defined and each project manager was asked to indicate which definition best fit their project (Olson et al., 1995; Sivadas and Dwyer, 2000).

Table 2.7 provides the descriptive statistics for this subsample. The results of the regression analyses in Table 2.8 show that project innovativeness has no significant association with the cycle time of any of the three NPD stages for this subsample.

2.5 Discussion and Conclusion

Many organizations reduce NPD project cycle time with the intention of improving new product performance, even though empirical research is still equivocal as to whether faster NPD actually leads to improved product performance (Griffin, 2002). Indeed, while in their meta-analysis of this relationship, Cankurtaran et al. (2013) show a positive main effect relationship for many operationalizations of "product performance," they also find that a number of methodological decisions made by researchers moderated their results, diminishing or even eliminating the significance between cycle time and product performance. The overarching goal of this study was, therefore, to increase the understanding of the performance effects of NPD cycle time by using a stage-wise approach. Because of the meta-analytic results of Cankurtaran et al. (2013), objective data were used as a stronger test of the hypotheses. Figure 2.5 provides a summary of the results.

In these data, faster completion of the DEV and COM stages is associated with increased new product performance, as expected. However, the non-significant effect of FFE cycle time negates the idea that more time spent in the FFE stage, and thus a more thorough completion of certain FFE activities, increases new product performance as suggested by Crawford (1992) and Reid and De Brentani (2004). On the other hand, this finding also is contrary to the argument that reduced FFE cycle time directly increases new product performance through a more efficient completion of this first

NPD stage (Boeddrich, 2004; Reinertsen, 1994). From these data, the conclusion, therefore, is that the performance effect of FFE cycle time should not be examined independently, but that the interactions between the cycle time of the FFE and the other NPD process stages needs to be investigated.

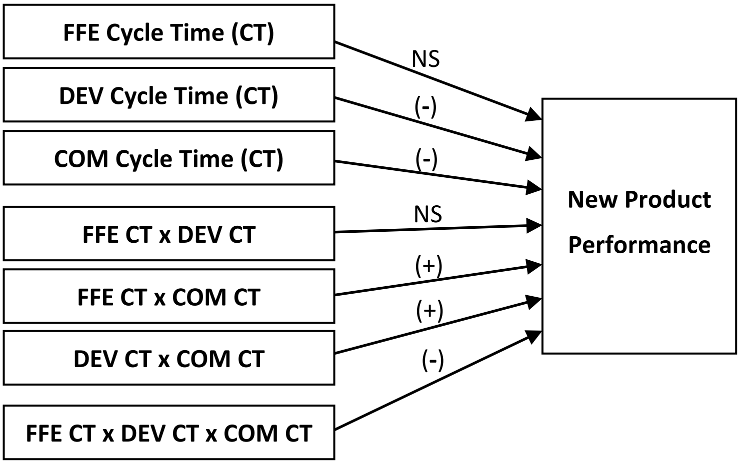

Figure 2.5: Summary of Results

Several plausible explanations for the absence of a direct effect of FFE cycle time on performance also are worth considering. First, the effect could be insignificant because cycle time and product quality are contradictory performance drivers in the FFE. Faster completion of the FFE might result in inferior product quality because design mistakes may be more likely under time pressure. While this quality loss may harm new product sales (Song et al., 1997), those losses might simultaneously be (at least partly) offset as FFE cycle time reduction allows firms to capture first mover advantages (Kerin et al., 1992). Although Kessler and Bierly (2002) did not find such a trade-off at the monolithic process level, it might be present when looking at just the FFE stage. Future research should examine this.

Second, the insignificant main effect of FFE cycle time might be due to the fact that the different activities in the FFE require different amounts of time to be proficiently executed. As such, speeding up certain activities (e.g., planning activities) might increase new product performance, while a faster completion of others (e.g., creative activities) might be harmful. These opposing effects might again lead to a non-significant effect of the average time spent on *all* FFE activities. Unfortunately, data limitations inhibited investigating this possibility. Again, future finer-grained research investigating how much time is spent on which FFE activities and how that relates to performance might provide further illumination.

A final explanation might be that factors at the product line (e.g., target market, product life cycle) or product level (e.g., innovativeness, project complexity) across the projects in the database masked the effect of FFE cycle time on new product performance (Chen et al., 2005; Kessler and Bierly, III, 2002; Langerak and Hultink, 2006; Langerak and Hultink, 2005). While the standardizing of the variables was supposed to control for product line differences, this may not have been sufficient to completely control for them. Additionally, although no effect of product innovativeness on cycle time in the subsample analysis was found, a larger study with a more refined operationalization of this construct may reveal them. Future research clearly should investigate additional product line and product level factors using a stage-wise approach

The results from these data with regard to the interaction effects reveal no significant interaction effect between FFE and DEV cycle times and performance. However, the remaining results demonstrate consistent patterns with regard to all other potential interactions between various stages and new product performance. Specifically, the findings show that shorter COM cycle time is significantly associated with increased new product performance for shorter FFE and DEV stage cycle times individually, as well as with shorter FFE and DEV stage cycle times jointly. Figure 2.4 illustrates that, for these data, it is only the combination of reducing all three stage-specific cycle time lengths simultaneously that is associated with increased new product performance. This means that, when total project cycle time (i.e., measured at the monolithic process level) is reduced through a faster completion of only one or two of the three NPD stages, new product performance may not improve (even if total project cycle time is decreased more than through a consistent acceleration of all three NPD stages). Indeed, this explanation is supported by the results of the additional analysis reported in Table 2.9, which shows that total project cycle time (FFE plus DEV plus COM) has - in support of Cankurtaran et al. (2013) - no significant effect on new product sales for this data ($b17 = -0.093$, $p = 0.153$). Substantively, these results show that, while the first two stages' cycle times do not interact in explaining new product performance, when looking at the entire project only a consistent acceleration of all three NPD stages leads to an increase in new product performance.

An explanation for these interaction effects could be that a proficient completion of the FFE includes deciding on and implementing the acceleration strategy of an NPD project and planning the project so that this strategy can be kept consistent across all NPD stages. The rationale is that cycle time reduction would be an integral and clear goal from the beginning of the project, which improves team communication and allows for applying acceleration methods consistently and allocating resources accordingly (Kessler and Chakrabarti, 1999; Murmann, 1994; Swink, 2003). Interestingly, the two-way interaction results suggest that, while the performance effect of COM cycle time seems to profit from implementing an acceleration strategy in both of the preceding stages (FFE and DEV), the performance effect of shortening the DEV stage cycle time is independent of accelerating the FFE stage – the only stage that precedes it. Perhaps this may be explained by the temporal distance between these two stages. It is possible that some of the aspects of the acceleration strategy that are decided on and implemented in the FFE stage do not become effective immediately, but manifest themselves more as the project proceeds. As a result, there may be a less significant impact on the cycle time effect of the DEV stage that follows immediately after the FFE than there is on the performance effect of the cycle time of the posterior COM stage. However, the fact still remains from the three-way interaction analysis that new product performance is only increased when all three stages of the NPD process are shorter.

Table 2.9: Regression Results of Additional Analysis

Dependent Variable: Cumulative Sales		**Model 7**
Independent variables:		
Constant	(b_{13})	0.000
Time on the market	(b_{14})	0.224**
Average sales price	(b_{15})	-0.184**
Project initiation	(b_{16})	-0.257**
Total project cycle time (FFE+DEV+COM cycle times)	(b_{17})	-0.093
Regression statistics:		
n		399
df		4
R^2		0.184
Adjusted R^2		0.176
F-statistic		22.261**

**$p < 0.01$

To conclude, this study leads to a new perspective on the performance effect of NPD cycle time reduction. First, it delivers a better understanding of the main and interacting performance effects of FFE cycle time in that it shows that only the interaction effect of FFE cycle time is important for new product performance. Second, the finding that only the consistent acceleration of NPD cycle time across all three generic NPD stages leads to an increase in new product performance serves as a possible new explanation as to why some earlier studies have not found an impact of NPD cycle time on new product performance (Griffin, 2002; Griffin, 1997a; Meyer and Utterback, 1995). Therefore, this study underscores the superiority of a stage-wise investigation between performance and NPD cycle time over the monolithic process perspective.

2.6 Managerial Implications

It has become common practice for organizations to reduce NPD cycle time. However, applying a cycle time reduction strategy is risky as product performance implications have not been fully understood based on previous research. This study adds to the understanding of these relationships by showing that, for these data from this company, shorter NPD cycle time only leads to an increase in new product performance when it is managed across all of the stages of the process. This is a very important finding, as previous research has shown that companies in the past have not managed cycle time reduction consistently across stages (Karagozoglu and Brown, 1993). Firms have used different time reduction mechanisms in different stages of the process, and have not been careful to implement mechanisms to shorten every stage of the process. Although the results of this study are not strictly normative because they were obtained from a single company, they provide insights for managing the FFE as well as for managing the overall NPD process.

First, the widely acknowledged importance of FFE proficiency for increased new product performance (Henard and Szymanski, 2001;

Langerak et al., 2004; Montoya-Weiss and Calantone, 1994) has led to confusion among managers on how FFE cycle time should be managed. Time often is not considered as an important measure in this messy getting-started stage (Smith and Reinertsen, 1997), because of the assumption that only an exhaustive and thorough completion of FFE activities leads to improved new product performance. The findings of this study show, however, that all NPD stages, including the FFE stage, have to be accelerated in order to increase new product performance. To achieve such a consistent acceleration, managers likely will have to implement the time-to-market strategy of the NPD project in the FFE stage. To make this decision, managers have to determine that a faster completed FFE will not result in delays in the subsequent DEV and COM stages, before resources are spent on project cycle time reduction. Moreover, it would appear that there may be "good" ways to reduce FFE cycle time – ones that also produce faster DEV and COM cycle times – and that there are "bad" ways – speeding through some tasks or activities that ultimately will have detrimental effects on cycle times for stages later in the NPD process. It is thus likely that a good overview and planning for the NPD project early on is of paramount importance, which means an increased need for planning and forecasting tools in the FFE stage. Moreover, this research also suggests that, building on the finer-grained approach by Karagozoglu and Brown (1993) of exploring the use of acceleration methods for different NPD activities, an excellent future research study would be to investigate which FFE tasks can be accelerated and which should not, as they would detrimentally impact later stage cycle times.

Second, the consistent acceleration of all three NPD stages may require a more deliberate choice of NPD acceleration methods than companies have used in the past, (Karagozoglu and Brown, 1993). NPD teams may either need to use one acceleration method that reduces cycle time consistently across all stages of the NPD process (e.g., parallel processing and elimination of unnecessary delays), or assemble a complementary group of acceleration techniques for each NPD stage that together provide for acceleration consistency across the whole development process. While Karagozoglu and Brown (1993) have explored which acceleration methods firms have used in different NPD activities or phases, no one to date has built an understanding of which mechanisms work best at accelerating which stages. Building on this finer-grained approach, additional research is clearly needed to determine this, as well as which stage-specific techniques produce synergy across the entire NPD process.

2.7 Limitations and Further Research

As indicated in some of the previous sections, the findings of this research offer several opportunities for further research. So do several of the research's limitations. The first and most important limitation of this study is that it explores the main and interaction effects of the stage-wise NPD cycle times with the data of a single company. While this approach allowed ruling out confounding firm and industry effects, it warrants caution regarding the generalizability of the findings. Therefore, the present findings need further testing using larger and more cross-industry samples. Second, the findings of this study do not apply to companies that use a different development approach than the Stage-Gate® process to manage their NPD process, such as approaches with iterative, spiral or overlapping NPD stages (Brown, 2008; Hauser et al., 2006). Third, the study focused on new product sales as dependent variable. However, sales only constitutes one aspect of the new product success equation. Future research should consider other dependent variables such as profit, market share, and customer satisfaction, which have been shown to be other dimensions of NPD performance (Griffin and Page, 1993). Fourth, using single measures for the stage-wise cycle times and for new product performance did not allow accounting for possible systematic measurement errors in the objective data (Bagozzi et al., 1991). Fifth, the possibility of endogeneity affecting the estimation results has to be acknowledged as cycle time may vary across projects with different characteristics, although no effects of product innovativeness were found in a subsample of the data. Future research should also control for other product line and project characteristics that previously have been shown to influence NPD cycle time, which was precluded by data limitations in this study. Finally, the attention of the study was restricted to new products that had reached the market, a choice rendered necessary by the performance measure of interest, and therefore the study did not include projects that were terminated. Different results could surface if development failures were included in the analysis as well.

In addition to the future research possibilities suggested earlier in this article, several other key avenues for future research result from the findings of this study. First, given the finding that cycle time is only associated with improved new product performance if all three stages are consistently accelerated, it would be intriguing to stage-wise investigate the effectiveness of the acceleration techniques identified by Millson et al. (1992), Karagozoglu and Brown (1993), and Langerak and Hultink (2005). To date, the effectiveness of these techniques has only been investigated at the monolithic process level. Moreover, it would be interesting to investigate if and how certain acceleration methods can support a consistent acceleration of all NPD stages.

Second, it is clear that the antecedents to and contingency factors for NPD cycle time should be investigated stage-wise. For example, it would be interesting to extend Chen et al.'s (2010) cycle time meta analysis by identifying the antecedents of cycle time by NPD process stage. In addition, the non-significant main effect of FFE cycle time finding has raised new questions regarding possible contingency factors or trade-offs among certain tasks within the FFE stage.

Third, the time-to-market decision and planning in the FFE stage should be further investigated, since these activities may play a key role in the success of accelerated NPD. For example, it would be intriguing to determine the most appropriate point in time for making these FFE decisions, and to investigate further the contextual circumstances for making these decisions (e.g., decision making style, authority, and criteria).

Finally, it would be interesting to examine if and how the cycle time of the three generic NPD process stages predicts the new product's incubation time (time between launch and the beginning of substantial sales) (Kohli et al., 1999) and the shape of the sales curve, including time to breakeven and peak revenues.

CHAPTER 3

Using Intuition in Fuzzy Front End Decision Making: A Conceptual Framework*

The goal of decision making during the execution of the FFE is to develop a creative new product concept. Although intuitive decision making has been found to increase new product creativity, the theoretical knowledge-base as to why and under which conditions intuition use during the process of generating a creative outcome is beneficial, is rather limited. Therefore, this study develops a conceptual framework theorizing why and under which conditions using intuition in FFE execution decision making may or may not be (as) beneficial for new product concept creativity. To develop this framework, a creativity perspective of the FFE and a dual-processing perspective of intuition are combined. Interviews with eight FFE practitioners are used to support and illustrate the framework development. Based on the theorizing it is postulated that intuition use may be beneficial to making generation and evaluation decisions during FFE execution because of the capabilities of the unconscious mind from which intuition results. However, the framework acknowledges that, due to the shortcomings of the unconscious mind, intuition may not be as beneficial to FFE decision-making in some situations. The conceptual framework is expected to offer researchers a fertile area for further research and practitioners better insight into when intuition might be effective in FFE execution decision making.

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3.1 Introduction

> *For making a creative step you have to think out of the box and be able to think freely. And when you are thinking out of the box… you can go in any direction, but the intuition sometimes will point you: "There might be an interesting solution which is really different from everything that's available now."* **Product director, ship manufacturer**

The development of a creative new product concept in the FFE of NPD is crucial to new product success (Evanschitzky et al., 2012; Im et al., 2013; Langerak et al., 2004). The decisions made by the development team during FFE execution define the creativity of the new product concept by determining which idea and concept options managers see at the formal gate meetings (Bacon et al., 1994; Kijkuit and van den Ende, 2007).

Anecdotal and empirical evidence have shown that new product creativity can be increased by using intuition in decision making (Dayan and Di Benedetto, 2011). Therefore, several NPD scholars have argued that FFE execution decision making may require using intuition in addition to the generally accepted rational approach (Armstrong and Hird, 2009; de Brentani and Reid, 2012; Koen et al., 2002). However, the role that intuition plays for decision making during the process of generating creative outcomes is under-researched (Dane and Pratt, 2009; Doerfler and Ackermann, 2012). More precisely, to my knowledge, no research to date has identified the *decisions* that are made during the process of generating creative outcomes or the *benefits* of using intuition in making these decisions. As a result, it also is not known for *which decisions* intuition could be used in FFE execution to increase the creativity of the product concept and *why* using intuition may be beneficial.

Although potentially beneficial, intuition may lead to inaccurate or erroneous decisions when used incorrectly (Akinci and Sadler-Smith, 2012;

Dane and Pratt, 2007). To date no research has examined *why* and *under which conditions* intuition may be erroneous when used for FFE execution decision making. As a result, neither academics nor practitioners understand when intuition use in FFE execution decision making may or may not be *beneficial* for the creativity of the product concept, as a ship manufacturer's product director said in an interview: *'Sometimes I have an intuition and I'm not sure if I can trust it.'*

Against the background of the potential benefits and drawbacks of intuition use, the objective of this study is to develop a conceptual framework theorizing *why* and *under which conditions* the use of intuition in FFE execution decision making may or may not be (as) *beneficial* for the creativity of the resulting new product concept.

To realize this objective, a creativity perspective is used to identify the decisions that are made during FFE execution and a dual-processing perspective is employed to define intuition and intuitive decision making in the context of the FFE. The framework combines these two theoretical perspectives to propose why and for which FFE execution decisions intuition use may be beneficial, and why and under which conditions these benefits might not fully accrue. Even though intuition is often combined with rational analysis in making decisions (Burke and Miller, 1999; Shapiro and Spence, 1997), the framework focuses on the theoretical situation in which only intuition is used because investigating its individual use is the first step in fully understanding how decisions are made in FFE execution. The theorizing is supported and illustrated by exemplar quotes derived from eight exploratory interviews about intuition use in FFE execution decision making with product development practitioners from diverse companies in the Netherlands and in Germany. All interviewees have been involved in the decision making during the execution of numerous FFE projects and, therefore, qualify as experts for FFE execution decision making.

3.2 Theoretical Background

3.2.1 A creativity perspective of FFE execution decision making

The FFE is the dynamic getting-started stage of the NPD process that ends when a new product concept has been defined that is ready to proceed to development (Kim and Wilemon, 2002a). There are three major FFE tasks: (i) *problem definition*, consisting of basic market and technology analysis and opportunity identification activities; (ii) *idea generation*, further information gathering and analysis and idea or solution generation and selection activities, and (iii) *concept development*, the refining of the idea into a concrete new product concept, planning of the NPD project and development of a new product business case (Griffin et al., 2012; Koen et al., 2002; Reid and de Brentani, 2004).

The decisions made during FFE execution determine the content, tasks, timing, and cost of the entire NPD project (Bertels et al., 2011; Cooper, 2008; Kim and Wilemon, 2002a). NPD teams decide *what* new product will be developed by determining which ideas and concepts managers will see at the gates (Bacon et al., 1994; Kijkuit and van den Ende, 2007). In addition, project planning and process decisions during FFE execution define *how* the product will be developed (Van Oorschot et al., 2011; Verworn et al., 2008). Depending on the level of process formalization, FFE execution decisions may be made either jointly by members of a formally assigned development team or by an individual around which a development team is assembled more or less formally (Griffin et al., 2009; Khurana and Rosenthal, 1997).

The three major FFE tasks described above are essentially the three general steps of a classical creativity process: (i) problem identification and preparation; (ii) problem solving or idea generation (incubation and illumination); and (iii) solution verification and implementation (Amabile, 1983; Lubart, 2001; Wallas, 1926). The key objective of this first NPD stage is the generation of a creative (i.e., novel and meaningful) product concept (Amabile, 1983; Dahan and Hauser, 2001; Im et al., 2013). Thus, I use a creativity perspective to describe the decisions made during FFE execution.

Creativity theory distinguishes between *generation* (diverging) and *evaluation* (converging) phases within each step of the creative process. A continual, loose cycling between generation and evaluation phases takes place across the whole process from problem identification to idea implementation (Basadur et al., 1982; Finke et al., 1996; Lubart, 2001). For example, going through several rounds of generation and evaluation phases in identifying problems and defining them as precisely as possible has been shown to lead to more creative outcomes (Brophy, 1998).

In the FFE context, creativity theory suggests that a development team will alternate between generation phases *during* problem definition, idea generation, and concept development and evaluation phases *after* a problem has been defined, an idea has been generated, and a concept has been developed in an interactive and circular manner (Figure 3.1). Accordingly, I distinguish between *generative decisions* made during the process of generating creative outcomes and *evaluative decisions* made about the creative outcomes generated. An NPD team striving for a highly creative outcome will move back and forth between the FFE tasks in a non-sequential manner with several rounds of problem, idea and concept refinement (Griffin et al., 2012; Reid and de Brentani, 2004).

Making generation and evaluation decisions means committing to a course of action during generation or evaluation phases (Mintzberg et al., 1976). Commitments to action that are made during generation phases in the

FFE are, for example (Brophy, 1998; Griffin et al., 2012; Kim and Wilemon, 2002a; Koen et al., 2002):

- *Deciding what to focus on* (e.g., which information, research domain, technology, market, or trend or certain concept features): What is important?
- *Deciding whether to continue the generation process with the current focus or not* (e.g., search for a new focus or stop the project): Will there eventually be a creative outcome?
- *Deciding what to do next in the generation process* (e.g., analyze available information; integrate and combine information; gather new information; involve certain people in the project; request resources; brainstorm; or move to evaluation).

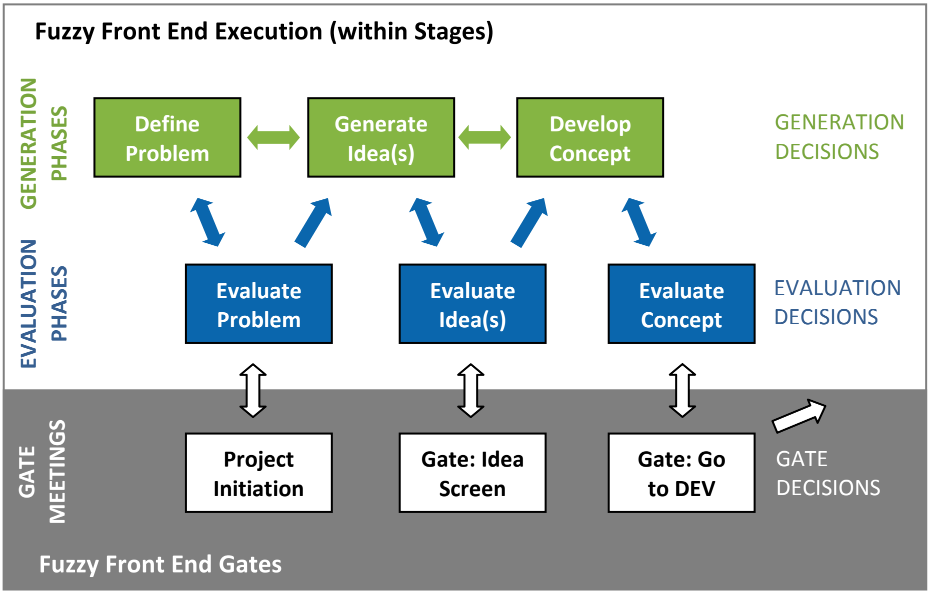


Figure 3.1: Fuzzy Front End Execution Decisions (White Area) and Gate Decisions (Grey Area) (DEV = Development)

The commitment to action that needs to be made in the *evaluation phases* of the FFE is (Finke et al., 1996; Griffin et al., 2012; Kim and Wilemon, 2002a):

- *Deciding what to do with the generated problem, idea, or concept* (e.g., initiate or continue the project based on the generated outcome;

present the generated outcome at a gate meeting; modify the generated outcome; or stop the project)

Both prior research (de Brentani and Reid, 2012; Koen et al., 2002) and the exploratory interviews suggest that intuition may indeed be useful in making these FFE evaluation decisions. A consumer electronics company engineer noted in the interviews:

> *When I see a certain question [or] I see a certain solution …whether that [solution] will work or not… I think that is intuition. … That is why I like certain directions and certain directions not.*

To understand *why* intuition use may be beneficial in making such decisions, next, the literature will be reviewed to develop a precise definition of intuition.

3.2.2 A dual-processing perspective of intuition

In dual-processing theory, unconscious (System 1) and conscious (System 2) processing are two parallel, complementary information processing systems that often are combined in making decisions (Dane and Pratt, 2009; Epstein et al., 1996; Simon, 1987). From a dual processing perspective, intuition has been associated with unconscious processing, while rational argumentation has been linked to conscious processing (Evans, 2008; Stanovich and West, 2000).

To define intuition, I combine this distinction between conscious and unconscious processing with the two most common conceptualizations of intuition across a variety of disciplinary domains (e.g., cognitive science, psychology, and management. See Appendix 1 for an overview and references). Thus intuition for decision making is defined as *a seemingly unsubstantiated attitude toward a decision alternative or course of action that communicates the result of unconscious processing to the conscious mind of the decision maker.* The intuition, or attitude toward a decision alternative, thus is a ‘signal’ from the unconscious to the conscious mind (Gore and Sadler-Smith, 2011). This ‘signal’ has been described variously as a:

- ‘tacit or implicit perception of coherence’ (Bowers et al., 1990);
- ‘sense of knowing,’ ‘hunch,’ or ‘gut feel’ (Hodgkinson et al., 2008; Khatri and Ng, 2000; Miller and Ireland, 2005; Shirley and Langan-Fox, 1996);
- feeling of harmony or peacefulness (Agor, 1986; Langan-Fox and Shirley, 2003);
- feeling of rightness of choice or ‘overpowering certainty’ (Dijksterhuis and Nordgren, 2006; Hodgkinson et al., 2008; Miller and Ireland, 2005; Shapiro and Spence, 1997);
- ‘euphoric excitement’ (Agor, 1986).

An engineering manager at an automation equipment manufacturer I interviewed explicitly described intuition during FFE execution as: *‘feeling,’ ‘enthusiasm,’* and *‘excitement’*. A negative attitude also may constitute an intuition, such as a ‘wrong feeling’ (Dijksterhuis and Nordgren, 2006), a ‘sense of anxiety’, ‘mixed signals’, ‘discomfort’, an ‘upset stomach’ or even ‘sleepless nights’ when considering a course of action (Agor, 1986).

Intuition is sometimes mistaken for ‘insight,’ ‘seeing the solution’ (Sadler-Smith and Shefy, 2004, p. 81), or the ‘Aha’ or ‘Eureka’ moment (Hodgkinson et al., 2008; Lieberman, 2000; Policastro, 1995), which also is an unconscious processing result. However, an *insight* has both an explicit conscious awareness of a solution (a concrete knowledge of the “what to do” and “how to do it”), as well as a conscious awareness of the specific reasoning that supports that solution (the “why to do it”). In contrast, *intuition* produces only an unsubstantiated ‘feeling’ supporting an alternative or course of action (Dane and Pratt, 2009). It produces a sense of “what direction,” but does not include “why.” Intuition arrives in the conscious mind before the insight, and is, therefore, a precursor to insight

(Gore and Sadler-Smith, 2011; Wallas, 1926). Becoming fully conscious of a complete insight can be slow and sometimes answers never arrive to the conscious awareness as a complete insight (Hodgkinson et al., 2009; Sadler-Smith and Shefy, 2004). Consequently, it may be advisable to use the unsubstantiated intuition in decision making, rather than waiting for the insight.

3.2.3 *Using intuition*

Using intuition in FFE decision making is a two-step process (Figure 3.2). The first step is the process that occurs in the unconscious mind of an individual, and which results in an unsubstantiated attitude toward a decision alternative or course of action arriving in their consciousness. It is experienced *only* at the individual level ("having an intuition"). The second step applies this intuition in making an FFE decision that results in a commitment to action ("applying intuition"). "Applying intuition" can take place either at the individual or the team level (Akinci and Sadler-Smith, 2012; Dayan and Di Benedetto, 2011). An individual can make FFE execution decisions based on his own intuition or an FFE team can base FFE execution decisions on the intuition(s) of one (or several) individual(s).

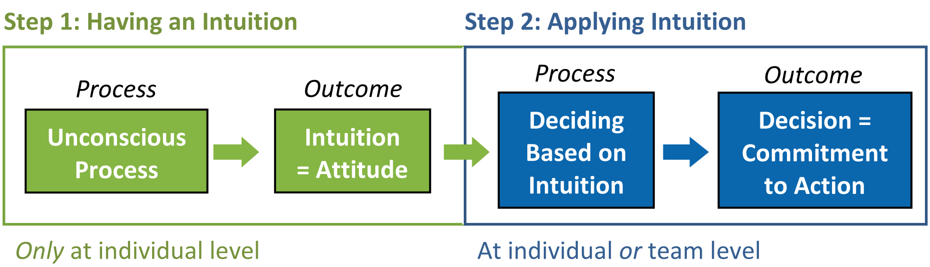


Figure 3.2: The Two-Step Process of Using Intuition

3.2.4 Benefits and drawbacks of intuition use

Both the unconscious and the conscious mind are goal-driven in processing information and require access to all relevant information to make good decisions (Agor, 1986; Bos et al., 2008). Other than these similarities, the unconscious differs significantly from the conscious mind and, thus, has benefits and drawbacks when compared to the conscious mind.

The literature, as summarized in Table 3.1, reveals six capabilities of the unconscious (Dane and Pratt, 2009; Dijksterhuis and Nordgren, 2006; Evans, 2008; Gore and Sadler-Smith, 2011; Sinclair, 2011). The three traits of *higher capacity*, *access to implicit and tacit knowledge*, and *openness* allow the unconscious to process more and different kinds of information than the conscious mind. Through the three distinct processes of *precise weighting*, *making new associations*, and *matching complex patterns,* the unconscious also processes information differently than the conscious.

On the other hand, Table 3.2 identifies three shortcomings of the unconscious mind compared to the conscious. Unconscious processing is *not universally applicable* to every decision problem (Dane and Pratt, 2007; Dijksterhuis and Nordgren, 2006), the decision maker has *no awareness of the processes* occurring in the unconscious (Frank et al., 2006; Strick et al., 2011), and *reasons for why an intuition has been formed are not delivered* by the unconscious mind (Behling and Eckel, 1991; Hogarth, 2001; Shapiro and Spence, 1997). As a result, decision makers may not realize when they have or are applying an inaccurate intuition.

Due to the capabilities and shortcomings of unconscious processing (which will be explicated further in the next section), intuition use may be beneficial in certain decision situations, but not in others. Next, the creativity perspective of FFE execution decision making and the dual-processing perspective of intuition will be combined to develop a conceptual

Table 3.1: The Benefits of Unconscious Processing for FFE Decision Making

Capabilities of Unconscious Processing			Key References	Benefits for FFE Decision Making
Traits	*High capacity*	The unconscious has a higher information processing capacity than the conscious mind.	Dijksterhuis & Nordgren (2006), Evans (2008), Kihlstrom (1987)	Taking the large amounts of information and requirements relevant for FFE decision making simultaneously into account.
	Access to implicit & tacit knowledge	Unconscious processing has access to implicit and tacit knowledge, which is not available to the conscious mind.	Brockmann & Anthony (1998), Evans (2008), Kihlstrom (1987)	Taking FFE relevant implicit and tacit knowledge, e.g., from previous NPD projects into account.
	Openness	The unconscious mind is open to evenhandedly integrate new information with already processed stored knowledge, while the conscious mind is biased and strives for stereotyping.	Bos et al. (2008), Dijksterhuis & Nordgren (2006), Glöckner and Witteman (2010)	Reconsidering decisions without bias when, e.g., market requirements, technological possibilities, regulations or FFE outcome change.
Processes	*Precise weighting*	The unconscious weights information and decision attributes according to their precise relevance for the decision problem at hand, while conscious analysis disturbs this process.	Bos et al. (2011), Dijksterhuis & Nordgren (2006), Glöckner & Witteman (2010), Wilson & Schooler (1991)	Taking information and requirements, such as approximate market size information or qualitative interview data, with their precise relevance and importance into account.
	Making new associations	Unconscious processing combines stimuli from the environment with stored knowledge into new and meaningful patterns or interpretations. This associative capability cannot be mimicked by conscious, logical analysis.	Dane & Pratt (2007, 2009), Dijksterhuis & Meurs (2006), Frank et al. (2006), Gore & Sadler-Smith (2011) , Sinclair (2010)	Recognizing opportunities or generating ideas by newly combining new information on, e.g., the market or technologies, with stored knowledge and patterns.
	Matching complex patterns	The unconscious recognizes complex decision situations by matching environmental stimuli with stored patterns and schemas, while the conscious mind is not able to make such complex relations.	Dane & Pratt (2009), Glöckner & Witteman (2010), Kahneman & Klein (2009), Sadler-Smith & Shefy (2004)	Recognizing current FFE decision situations based on (implicitly) stored patterns and schemas from previous FFE decision situations.

Table 3.2: The Drawbacks of Unconscious Processing for FFE Decision Making

Shortcomings of Unconscious Processing			Key References	Drawbacks for FFE Decision Making
Individual Decision Making	*Not universally applicable*	Unconscious processing does not follow precise rules, such as rules of logic or rules regarding the decision criteria. Applying intuition may, therefore, be inadvisable when the decision problem is organized according to such rules.	Dijksterhuis & Nordgren (2006), Dane & Pratt (2007)	The danger of having and, therefore, applying an inaccurate intuition in *individual* FFE execution decision making may be higher for *incremental product development projects* because more of the decision problems for such projects during FFE execution may be organized according to precise rules.
	No process awareness	Unconscious processing requires access to the information relevant for the decision problem at hand and always follows an implicit goal. Decision makers may apply an inaccurate intuition because they may not notice that the unconscious is lacking the relevant knowledge or that the unconscious is following a different (implicit) goal than intended.	Bos et al. (2008), Dane & Pratt (2007), Hodgkinson et al. (2009), Kahneman & Klein (2009)	When *FFE team members are inexperienced* in NPD or pursue *multiple goals,* chances are higher that their intuition is inaccurate because the unconscious may lack the information relevant to develop a successful new product or the unconscious may pursue a different goal than to develop a creative new product concept.
Team Decision Making	*Reasons for intuition not delivered*	Different team members might not experience the same intuition toward a decision alternative or course of action. Since no reasons are available for an intuition, a correct intuition may be ignored in team decision making, while the incorrect intuition of one or several team member(s) may be used.	Bowers et al. (1990), Dane & Pratt (2009), Hogarth (2001), Kahneman & Klein (2009)	The danger of applying an inaccurate intuition in *team* FFE execution decision making may especially be high when a *rational decision culture* is in place or when *hierarchical or democratic decision rules* are applied. The reasons are, first, that individuals may require the freedom to follow their intuition without justifying each decision in order to develop out of the box solutions and, second, that the intuition of the most knowledgeable team member may be more accurate than the intuitions of the majority or of the team leader.

framework for how the capabilities of the unconscious might increase new product concept creativity, and how the shortcomings of the unconscious may inhibit these benefits from accruing under certain conditions.

3.3 Conceptual Framework

The goal of using intuition in decision making during FFE execution is to improve the outcome of FFE decision making (Eisenhardt and Zbaracki, 1992). Generally, the outcome of the FFE is a new product concept that is ready to proceed into development (Kim and Wilemon, 2002a). This concept should be both novel and meaningful in the eyes of the target customers to ensure new product success (Im et al., 2013; Im and Workman, 2004). Accordingly, this study focuses on the creativity (the novelty and meaningfulness) of the product concept as the consequence of using intuition in FFE execution decision making.

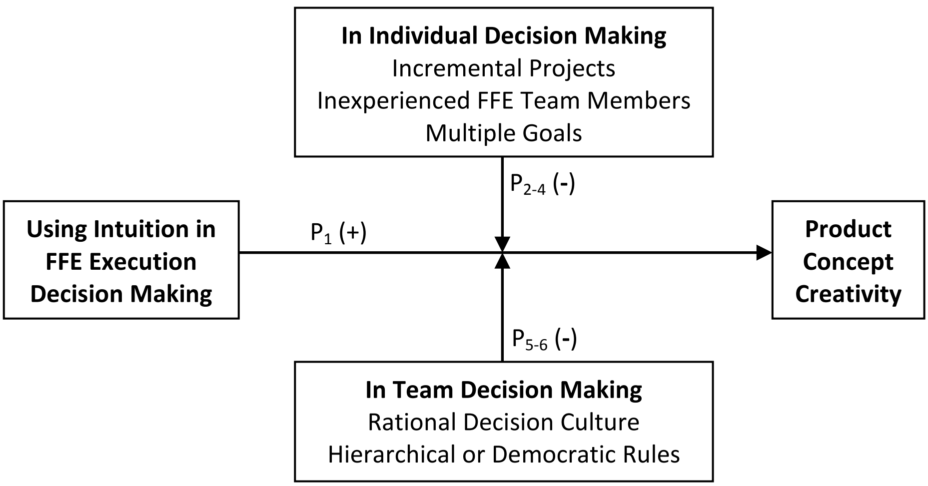


Figure 3.3: Conceptual Framework

The conceptual framework (Figure 3.3) first proposes a direct effect of intuition use in FFE execution decision making on new product concept creativity that is based on the benefits of intuition use (P_1). Several propositions for contingency factors that may ameliorate this effect are then presented, derived from the drawbacks of intuition (P_2-P_6).

3.3.1 Direct effect of the use of intuition in FFE execution decision making

Using intuition in FFE execution decision making means that either an individual team member or the development team commit to one or more actions during execution of the FFE by following an intuition. I propose that the use of intuition in FFE both generation and evaluation decisions increases the creativity of the new product concept.

3.3.1.1 Generation decisions

In making FFE generation decisions, intuition may provide useful guidance on the way to developing a creative product concept (Policastro, 1995). As an engineer in a consumer electronics company I interviewed explains:

> *For me, also for technical work, [intuition] gives me a direction. It is a very first sign for me if something is a good direction, yes or no.*

Key to this guiding ability of intuition is the capabilities of the unconscious mind (Table 3.1). The most important unconscious process for generative intuitive decision making may be *making new associations* (Bowers et al., 1990; Duggan, 2007; Finke et al., 1996). New and meaningful patterns or interpretations are created by the unconscious through combining new information with disparate pieces of knowledge already stored in memory (Dane and Pratt, 2007; Glöckner and Witteman, 2010; Hodgkinson et al., 2009; Sinclair, 2010). The unconscious can, for example, combine information on technology developments, emerging customer needs, and market gaps to identify opportunities or interesting problems at the very beginning of the FFE. This process cannot be mimicked by the conscious mind (Baron and Ensley, 2006; Frank et al., 2006; Rice et al., 2001). Unconsciously making new associations across information can result in new ideas or concepts that are more creative than those derived from conscious processing (Dijksterhuis and Meurs, 2006).

Other capabilities of the unconscious support making new associations in generating creative outcomes. The *higher capacity* of the unconscious allows FFE decision makers to simultaneously take into account larger amounts of company, technology, and market information than the conscious mind can, which has a much smaller processing capacity (less than one millionth of the data simultaneously processed by the human system) (Dijksterhuis and Nordgren, 2006; Evans, 2008; Khatri and Ng, 2000; Kihlstrom, 1987).

In addition, the unconscious has *access to implicit and tacit knowledge* stored in the unconscious minds of FFE team members (Brockmann and Anthony, 1998; Kihlstrom, 1987; Pretz and Totz, 2007) and is capable of *matching patterns* of complex decision problems to previously generated patterns and schemas already stored in memory (Gore and Sadler-Smith, 2011; Hodgkinson et al., 2008). As a result, decision makers can make use of, for example, process development knowledge from previous NPD projects, knowledge on the product usage context derived from one's own experiences or qualitative customer research, or implicitly stored information on new technological developments, socioeconomic trends, market changes or competitors when using intuition (Dane and Pratt, 2007; Dougherty et al., 2000; Moorman and Miner, 1997; Sadler-Smith and Shefy, 2004).

Due to the *precise weighting* process of the unconscious, qualitative and approximate information derived from in-depth interviews or observations can be taken into account based on its relevance for the generation of a creative product concept (Adams et al., 1998; Dijksterhuis and Nordgren, 2006; Levine et al., 1996). Conscious thought, in contrast, only identifies attributes associated with a decision that are accessible, plausible, and easy to verbalize, focusing on explicit facts and numbers during FFE generation decision making (Bos et al., 2011; Wilson and Schooler, 1991).

Finally, the *openness* of the unconscious mind allows FFE decision makers to evenhandedly integrate changes in market requirements, technology capabilities, or regulations with previously processed knowledge, allowing previously made creative associations to be reconsidered and refined in an unbiased manner (Agor, 1986; Burke and Miller, 1999; Schröder and Jetter, 2003; Seidel, 2007). For expediency, conscious thought stereotypes and is biased by previously derived heuristics (Bos et al., 2008; Dijksterhuis and Nordgren, 2006). New information may be used only to support previously generated ideas or concepts.

By combining the six capabilities of the unconscious, the resulting intuition can guide an FFE team member to an appropriate course of action even before unconsciously combined information in terms of a creative solution or concept is available to the conscious mind (as insight). The FFE team member may immediately know *what to focus on* when the discovery of a certain technology or customer problem causes an unsubstantiated enthusiasm because it leads to an interesting new association in the unconscious (Agor, 1986). A quote from an engineer in a consumer electronics company illustrates:

> *When you have some vague direction, you are getting enthusiastic and you think, yes, this can work.*

Intuition also may indicate *whether it makes sense to continue* the generation process with the chosen focus through excitement or 'gut feel' that signals the availability of a creative solution in the unconscious

(Hodgkinson et al., 2008), as an engineering manager at an automation equipment manufacturer describes:

> *Then the excitement - it is exciting - the excitement comes on that makes you want to go on and on and on and not stop before you have it solved.*

By intuition, the FFE team member may have an idea of *what to do next* and intuitively continues information gathering and analysis activities until the creative solution becomes consciously accessible (de Brentani and Reid, 2012; Griffin et al., 2009). However, new information that becomes available and leads to a negative association also can turn an excitement into an unsubstantiated feeling of discomfort and lead to the search for a new focus or to the project's end (Agor, 1986; Dijksterhuis and Nordgren, 2006).

3.3.1.2 Evaluation decisions

During FFE evaluation phases, intuition may help evaluate the novelty and meaningfulness of the outcomes because it is based on an *in-depth understanding of the decision situation* (Hodgkinson et al., 2008; Miller and Ireland, 2005). Key to this evaluation ability of intuition are the *weighting* and *complex pattern matching* processes of the unconscious. Unconscious *weighting* allows the FFE decision maker to weight the importance of information and project requirements when, for example, multiple opportunities or ideas appear undifferentiated because they deliver incomparable advantages (e.g., slightly lower development cost and time versus a better met customer need) (Bos et al., 2011; Dijksterhuis et al., 2006; Zhang and Doll, 2001). The unconscious also can weight decision criteria that differ by evaluation decision depending on the stage (problem, idea, concept), nature (technology-push versus market-pull) or innovativeness of the project (de Brentani and Reid, 2012). For example, an estimated development time that is too long for an incremental new product might be acceptable for a radical new product. Finally, unconscious weighting may be useful to assess the risk that using approximate information entails, resulting in a new, subjective understanding of the decision situation.

The *complex pattern matching* capability of the unconscious allows experienced FFE decision makers to consider all of the interrelations that exist among project requirements when evaluating FFE outcomes (Dane and Pratt, 2007; Khurana and Rosenthal, 1998; Kim and Wilemon, 2002a). For example, an experienced FFE team member knows that planned development time impacts a new product's expected sales (as it affects market entry timing) and may take this into account intuitively without explicitly bringing it to consciousness. Intuition may thus move him to choose not to develop a feature that would delay launch.

The other capabilities of the unconscious support these two processes in evaluating FFE outcomes. The *higher capacity* of the unconscious can take large amounts of project requirements, such as market potential, financial and technical feasibility, manufacturability, and fit with company's goals and capabilities, and a larger number of concept options simultaneously into account (Gore and Sadler-Smith, 2011; Hammond et al., 1997; Hart et al., 2003). *Access to implicit and tacit knowledge* allows hidden or forgotten requirements, for example, customer needs that have been observed in an ethnography study, but never reported explicitly, to be considered (Langan-Fox and Shirley, 2003; Rosenthal and Capper, 2006). O*penness* helps FFE decision makers to neutrally reconsider evaluation decisions when project requirements change (Glöckner and Witteman, 2010; O'Connor and Rice, 2001). Finally, by *making new associations* the unconscious mind knows whether better solutions or concept options may exist (Bowers et al., 1990; Dijksterhuis and Meurs, 2006).

As a result, the use of intuition in making evaluation decisions during FFE execution may cause FFE decision makers to commit to an activity that leads to a more creative outcome, for example, when considering an opportunity:

> *Asking the question: "Is it an interesting problem?" There comes the intuition. The others are rejected.* **Manager, automation equipment manufacturer**

From intuition, an overpowering certainty or perception of coherence may help make a choice when comparing several solutions:

> *…this is where intuition plays a role: When you have a few concepts next to each other.* **Design manager, consumer goods company**

A development team member also may experience mixed feelings when considering a proposed solution because his unconscious mind has already developed a more novel and meaningful solution (Agor, 1986). Consequently, following his intuition the team member moves back to generation activities in order to bring the better solution to consciousness.

To conclude, in FFE execution decision making, intuition may bring unconsciously generated creative problems, ideas, or concepts to consciousness (generation decisions) and continue the FFE process with more novel and meaningful FFE outcomes (evaluation decisions). When used correctly, intuition may increase the creativity of the new product concept by helping team members navigate effectively through the FFE. I thus propose:

> *P_1: The use of intuition in making FFE execution decisions increases new product concept creativity.*

3.3.2 Contingency factors influencing intuition's effectiveness

The benefits of using intuition in individual and team FFE execution decision making may not fully accrue because of the shortcomings of unconscious processing (Table 3.2). Since unconscious processing is not universally applicable to every decision problem and a decision maker has no process awareness, an individual may inadvertently have an inaccurate intuition because, as a design manager in a consumer goods company said: *'[Intuition] is an uncertain thing. You cannot quantify it.'*

Since unconscious processing does not deliver reasoning supporting an intuition, an incorrect intuition also may be applied in team decision making, while a correct intuition of a different team member may be ignored. Based on these drawbacks, next, propositions will be developed on the most important project, team, and organizational conditions under which the positive effect of intuition use in individual and team FFE execution decision making on the creativity of the new product concept may be weakened.

3.3.2.1 Contingency factors influencing individual decision making

I identified three characteristics that may create inaccurate intuitions for individuals making FFE execution decisions, leading to less successful FFE outcomes: the *incremental nature of the project* (P_2)*; FFE team member inexperience* (P_3); and the *existence of multiple goals* (P_4).

Incremental nature of the project. An NPD project is more incremental when the project's market or technological newness to the firm is lower, such as for simple product evolutions, modifications, or adaptations (Garcia and Calantone, 2002; Reid and de Brentani, 2004). Because unconscious weighting does not follow precise rules, such as rules of logic or rules regarding the decision criteria (Dijksterhuis and Nordgren, 2006), intuition may lead to incorrect decisions when arithmetic and logic are required, when decision criteria consist of exact numbers, or when one decision criterion prevails over all others (Dane and Pratt, 2007). FFE execution decisions for incremental projects are more structured and more likely to follow precise decision rules than radical projects for several reasons, which may lead to incorrect decisions, if intuition is used (Reid and de Brentani, 2004; Veryzer, 1998).

First, less new information on markets and technologies is required for incremental projects and the information available is more precise and complete, which is not the case for radical innovation projects (O'Connor and Rice, 2001). As a result, exact numbers are often available for generation and evaluation decision making in incremental projects, which require arithmetic and logic. Second, rules for decision making in FFE execution for incremental projects are usually stricter (Reid and de Brentani, 2004). The project has to fit with the existing product architecture, product portfolio, manufacturing line, and address the same product needs to be considered meaningful (Koen, 2004). Finally, incremental projects are more likely to have one decision criterion that prevails over all others in FFE decision making. For example, evaluation decisions for incremental projects often are based only on financial attractiveness (Koen, 2004). Because of these three characteristics, there is a higher probability that using intuition in generation and evaluation decisions during FFE execution may be inaccurate when the NPD project is more incremental. Thus:

> *P_2:* *The positive effect of the use of intuition in making FFE execution decisions on the creativity of the new product concept is weaker for more incremental product development projects.*

FFE team member inexperience. FFE team member experience is defined by the amount of explicit, implicit and tacit knowledge a person possesses that is relevant for developing this particular new product concept. The less relevant knowledge an FFE decision maker has, the less accurate may the decision maker's intuition be (Dayan and Di Benedetto, 2011). An inexperienced person's intuition may be inaccurate because the unconscious does not have access to sufficient relevant knowledge to make a creative decision (Kahneman and Klein, 2009; Policastro, 1995). In order to have unconscious access to all relevant knowledge, each individual decision maker in the FFE needs to be 'multi-knowledgeable' (Griffin et al., 2009; Park et al., 2009; Troy et al., 2001).

FFE decision making requires experience in the marketing and R&D domains and a good understanding of the company's strategy and capabilities (Henard and Szymanski, 2001; Koen et al., 2002; Moenaert et al., 1995). To be able to match complex patterns, the unconscious requires a certain amount of domain specific knowledge (Dane and Pratt, 2007; Policastro, 1995). In addition, the weighting process is only accurate when all of the most important information and requirements are available to the unconscious. Thus, team members must have multidisciplinary knowledge to proficiently generate and evaluate creative FFE outcomes (Kim and Wilemon, 2002a; O'Connor and Rice, 2001).

Knowledge unrelated to the project domain may be required in addition to domain relevant knowledge to produce accurate intuitions (Sinclair, 2011). Making new associations benefits from both general experience and knowledge from unrelated domains (Bowers et al., 1990; Duggan, 2007), such as knowledge about unrelated markets, new technologies and different companies, as well as completely unrelated life experiences.

A decision maker may not realize when the unconscious lacks knowledge because so much information is implicitly integrated into unconscious processes (Brockmann and Anthony, 1998; Pretz and Totz, 2007). Therefore, the experience level of an FFE team member may be the only indicator of how likely his intuition will be accurate for FFE execution decision making:

> *For me intuition has also to do with the years of experience you have. The more experience you have, the more your intuition will be reliable because you rely then on the perceptions of the question and the relation to memories of former projects or former product development trajectories that you did and the lessons learned from that.* **Engineering manager, automation equipment manufacturer**

Accordingly, when a decision maker lacks sufficient experience relevant for the execution of the FFE the resulting intuition may be less accurate. Thus I propose:

> *P_3: The positive effect of the use of intuition in making FFE execution decisions on the creativity of the new product concept is weaker the less relevant experience the individual decision maker has.*

Existence of multiple goals. Goals are the overall objective of, or intention behind every action that a team member carries out while making generation and evaluation decisions during FFE execution (Locke et al., 1981). Because unconscious processing is goal-driven (Evans, 2008; Kihlstrom, 1987), the resulting attitude toward a decision alternative depends on a decision maker's goals. For example, when the organization consistently communicates that creative innovation is the only way to organizational success (Koen et al., 2002), and development team members are rewarded or promoted only on the basis of overall NPD outcomes rather than for attaining their respective functional goals (Sethi et al., 2001), FFE team members likely will have only one intention: to produce a creative new product concept that can be developed into a successful new product. Having just one clear goal motivates team members and provides them with clear direction, supporting intuition use in decision-making (Lynn et al., 1999; Sivasubramaniam et al., 2012).

However, if a decision-maker has multiple goals, the unconscious mind might use the 'wrong' goal for the decision problem at hand. In addition, because the goal for unconscious processing is as implicit as the process, the decision maker cannot be conscious of it (Bos et al., 2008; Duggan, 2007). As a result, the unconscious might focus on a different goal than the decision-maker consciously intends (Bargh et al., 2001). For example, a decision maker consciously planning to develop a creative product concept might inadvertently use an unconsciously held departmental or career advancement goal, such as not risking failure, in creating an intuition (Bargh et al., 2001; Kester, 2011). These other goals may overwhelm the FFE goal, resulting in an inaccurate intuition that will not increase the creativity of the new product concept. Thus:

P_4: The positive effect of the use of intuition in making FFE execution decisions on the creativity of the new product concept is weaker when FFE team members pursue multiple goals simultaneously during FFE execution.

3.3.2.2 Contingency factors in team decision making

Since intuition is only experienced at the individual level, using intuition in team decision making is especially problematic:

> *I would trust my own [intuition], but if you ask: "Would you trust everybody else's?" I am not so sure.* **R&D manager, electrical equipment manufacturer**

Different decision makers in a team may not experience the same intuition toward a decision alternative or course of action because intuition results from the implicit knowledge in each individual's unconscious, which may differ by experience level, function and goal (Bowers et al., 1990; Kahneman and Klein, 2009).

> *[The Finance department's] intuition is different than mine and that is the problem. So when I think something is really awesome, they do not necessarily need to see that.* **Engineer, consumer electronics company**

When decision makers disagree on a decision that has been made in a conscious, rational manner, the arguments for making that decision are available to the decision makers' conscious minds, and can be shared and discussed (Hogarth, 2001). However, since the reasons for an intuition are hidden in the unconscious, it is difficult or impossible to articulate support for the attitude the decision maker has (Dane and Pratt, 2009).

> *If you have an intuition it is difficult to convince people based on "I feel like that".* **Business development VP, packaging manufacturer**

Due to this shortcoming of the unconscious, it may be difficult to explain why one individual's intuition differs from another's or to determine whose will most likely lead to the desired outcome, and thus, an incorrect intuition might be applied in team decision making. This likelihood is largest when team level decisions are made in the context of (i) *a rational decision culture*, or (ii) when *hierarchical or democratic decision making rules* are applied.

A rational decision culture. The effectiveness of intuition use depends heavily on the culture in an organization (Agor, 1986; Dane and Pratt, 2009; Miller and Ireland, 2005). A decision culture of trust and empowerment may allow team members to freely communicate intuitions and act on them (Koen et al., 2002). Even when one does not share the intuition of a team member, allowing them to follow a seemingly unsubstantiated attitude and act on that decision might lead to very out of the box solutions (Duggan, 2007; Policastro, 1995).

In contrast, a rational decision culture is one in which every FFE execution decision and resulting activity needs to be justified. Since support for an intuition is difficult to articulate, a team member with a correct intuition may be prevented from using it because the other team members have different intuitions and request justification (Andersen, 2000). As an R&D manager at an electrical equipment manufacturer related: *'This is a really technical environment and everything is [debated].'* Thus, when a rational decision culture is in place, inaccurate intuitions that can be easily justified might be more often applied in making FFE decisions. Accordingly:

> *P_5: The positive effect of the use of intuition in making FFE execution decisions on the creativity of the new product concept is weaker when a rational decision culture is in place.*

Hierarchical or democratic decision making rules. In hierarchical decision making, the highest person in the hierarchy makes the final decision. In democratic decision making, the votes of all persons involved in the decision have equal weight.

Democratic or hierarchical decision making works best when the reasons for decision making can be discussed. All facts and requirements can be put on the table so that everyone is able to arrive at the same rational conclusion regarding the decision problem at hand (Hogarth, 2001). The reasons for an intuition, however, cannot be articulated (Dane and Pratt, 2009). Others often do not understand the unsubstantiated attitude of a FFE team member even though it could lead to a more creative new product concept. An important chance to improve new product concept creativity may be lost, when this FFE team member is outnumbered or the boss decides:

> *"So it is fine, you disagree, but we are doing it anyway."* **Product Director, ship manufacturer**

Accordingly, development teams might base generation or evaluation decisions during FFE execution on an inaccurate intuition when following hierarchical or democratic decision rules if the team leader's intuition or the intuitions of the majority of the team members are inaccurate. Thus:

> *P_6:* *The positive effect of the use of intuition in making FFE execution decisions on the creativity of the new product concept is weaker when hierarchical or democratic decision making rules are applied in team decision making.*

3.4 Discussion and Future Research

By theorizing why and under which conditions the use of intuition in FFE execution decision making may or may not be (as) beneficial for the creativity of the resulting new product concept, this article makes three theoretical contributions to the NPD and innovation literature. The first contribution is that this study explicitly focuses on decision making within a stage's execution. In developing the final deliverables that senior management will use to make a go/no-go FFE gate decision (e.g., product concept acceptance), both individuals as well as groups of FFE team members make numerous decisions that may impact project success. By applying a creativity perspective, this study distinguishes between two FFE stage execution decision types: generation and evaluation decisions. This distinction helps explain why the FFE process is so dynamic (Griffin et al., 2012; Reid and de Brentani, 2004) and also why intuition may be beneficial for making FFE execution decisions.

Second, while previous research has acknowledged intuition's utility in making FFE execution decisions (de Brentani and Reid, 2012; Dayan and Di Benedetto, 2011; Koen et al., 2002), this study develops theory to explain *why* and *under which conditions* using intuition for making FFE execution decisions may or may not be as beneficial. Using a dual-processing perspective of intuition, the benefits and drawbacks of intuition use in FFE execution decision making have been identified. Through combining this perspective with the creativity perspective of the FFE, I postulate that the unconscious processing producing intuition may be useful in improving the creativity of a new product concept because of the traits and processes of the unconscious mind. At the same time, it has been recognized that the benefits of intuition use may not always fully accrue due to the shortcomings of the unconscious mind. Accordingly, the conceptual framework supports many of the experiences with intuition use in FFE execution decision making that practitioners told me about.

Third, by distinguishing between individual and team decision making, intuition use has been made applicable to the FFE context in which not only individuals, but often groups of people with multi-disciplinary backgrounds are responsible for decision making (Nederveen Pieterse et al., 2011; Troy et al., 2008). Previously, intuition has primarily been considered as an individual construct (Akinci and Sadler-Smith, 2012). To my knowledge, only one research team has considered intuition as a team construct (Dayan and Di Benedetto, 2011; Dayan and Elbanna, 2011). However, they did not address the difficulties of applying intuitive decision making in a team.

Three research implications follow from these contributions. First, NPD decision making is more than just about how formal gate decisions are made. Decisions made within the execution of a particular stage may require a different approach to decision making than formal gate decisions. Consequently, theories of decision making need to be developed and tested that apply within the more informal context of development stages. Second, distinguishing between generation and evaluation phases within FFE execution adds a new theoretical level to existing FFE process models

(Griffin et al., 2012; Khurana and Rosenthal, 1997; Koen, 2004) and allows for a refinement of these models. Third, while dual-processing theory has been used by researchers studying individual consumer choice and decisions (Bos et al., 2011; Dijksterhuis and Nordgren, 2006), it is a new theoretical lens for NPD and innovation management research, which may lead to the development of theories that have the potential to increase new product success.

This article also has practical implications for NPD and innovation managers because, as shown in the interviews, FFE practitioners do use intuition in FFE execution decision making. However, most practitioners only have a vague idea of what intuition actually is and why and when it may be beneficial. This study may, therefore, provide to managers a better understanding of the concept of intuition and its benefits and drawbacks for decision making during the FFE. This understanding might encourage managers and team leaders to facilitate intuition use among FFE team members when the conditions of individual and team decision making make it appropriate to do so. This research may also lead to a more deliberate use of this decision making approach among FFE executors because the contingency factors of the conceptual framework suggest the following managerial lessons about intuition use:

- Before following an intuition in FFE decision making, decision makers should reflect on the characteristics of the decision task, on their personal knowledge with regard to the decision domain, and on their motivation or goal for making the decision to ensure that the decision task may benefit from intuition use, that they have sufficient knowledge to support unconscious processing, and that they are acting in the best interest of the firm;
- FFE teams should take the time to discuss if and how to apply the intuitions of individual team members in their team decision making, based on the knowledge available in the team and the individual goals of the team members;

- Managers of FFE teams should ensure that multi-functional knowledge is shared extensively among team members and that all team members understand the overall goal of the project and that they focus their attention on this goal; and
- For projects where intuition may be beneficial, team leaders and managers may want to accept, encourage, and facilitate the use of intuition during the execution of FFE activities and give individuals the freedom to explore opportunities and ideas based on their intuition.

The obvious next step in this research is to test empirically the propositions. While this may be impactful for both academia and practice, testing the propositions will be challenging, as key constructs must be operationalized (e.g., intuition use, and creativity of the new product concept). One method for testing part of the framework may be to conduct a series of experiments like those summarized in the meta-study by Strick et al. (2011) that manipulate the decision making style (conscious vs. unconscious processing). However, because of the technical nature of the outcomes of the FFE, rather than use students, as most previous research has, these experiments would best be conducted with practitioners skilled in the tasks of the FFE.

Other potentially impactful future research on the use of intuition in FFE decision making might be a more exploratory approach focusing on four key research areas:

- How training, education, encouragement, personal traits, and motivation of individuals moderate the relationship between intuition use and new product concept creativity, e.g.:
    - Which and how much experience is required;
    - What training or education could be useful; and
    - How the (unconscious) motivation of individuals can be influenced.

- How the organization, culture, and process of the FFE and the management and leadership of FFE teams moderate the relationship between intuition use and new product concept creativity, e.g.,:
  - How the FFE process should look like so that intuition use is beneficial; and
  - What type of leadership is required.
- How an individuals' decision processes moderate the relationship between intuition use and new product concept creativity, e.g.,:
  - How intuition is combined with rational analysis;
  - How much information gathering is required;
  - Whether incubation time is required for certain unconscious processes, e.g., the making of new associations (Dane and Pratt, 2009); and
  - How information gathering and incubation time relate to a possible decision speed-quality trade-off.
- How a team's decision processes and characteristics moderate the relationship between intuition use and new product concept creativity, e.g.:
  - How the reasons behind an intuition can be made explicit;
  - How intuition is used and aggregated in team decision making; and
  - How team composition changes decisions;

To conclude, this article theoretically discussed *why* using intuition during the execution of the FFE may increase the creativity of the new product concept and *under which conditions* this effect may not fully accrue. Therefore, my framework and propositions define the playing field on which intuition enthusiasts and cynics may interact both in NPD research and practice. Hopefully, this framework will ignite a stream of future research on the topic of intuitive decision making in NPD.

CHAPTER 4

Performance Effects of Combining Rational and Intuitive Approaches in Making Fuzzy Front End Execution Decisions*

Previous research suggests that combining rational and intuitive decision making approaches may be advantageous for making decisions during the execution of the FFE of NPD. However, empirical research on the performance effects of combining rational and intuitive decision making is lacking. To start filling this gap in the NPD and decision making literatures, this research empirically explores whether and how rational and intuitive approaches could be combined to improve the quality and speed of FFE execution decision making. To this end, an experiment with NPD professionals was conducted that manipulated the combinations of approaches used for making an FFE execution decision, i.e. combining: intuition with intuition; rationality with rationality; or intuition with rationality in two different sequences. The results show that one combination of the different approaches, starting with intuitively analyzing the decision options and then rationally considering the resulting intuition in making the final decision, leads to both the highest quality and speed in FFE execution decision making. This finding has important implications for theory and practice and provides several opportunities for further research on this under-researched topic.

* This chapter was runner-up for the 2013 Best Student Paper Award of the College of Product Innovation and Technology Management (PITM) of the Production and Operations Management Society (POMS) and it has been presented at the Annual Research Forum of the 2013 Product Innovation Management Conference of the Product Development & Management Association (PDMA), Phoenix, AZ.

4.1 Introduction

Decision making is a cognitive process that results in a commitment to a course of action (Mintzberg et al., 1976). The commitments to action (decisions) made by development team members during the execution of the FFE of NPD are crucial to new product success (Evanschitzky et al., 2012; Koch and Leitner, 2008). In the FFE, development team members decide which idea and concept options managers will see at the formal gate meetings, determining the content, tasks, timing, and cost of the entire NPD project (Bertels et al., 2011; Kijkuit and van den Ende, 2007). Despite the high importance of within-stage FFE decisions, research has predominantly focused on formal gate decisions. This study adds to the literature by investigating how rational and intuitive decision making approaches influence the performance of FFE execution decisions, i.e., the decisions made *between* the gates, in terms of quality and speed.

A decision making approach (rational or intuitive) consists of a *process* and an *outcome*. The rational approach processes decision information in the conscious mind, resulting in logical reasons supporting a particular course of action (Dean and Sharfman, 1993; Epstein et al., 1996). Intuitive decision making, in contrast, processes information in the unconscious mind, while the conscious is disengaged (Dane and Pratt, 2007; Frank et al., 2006). The resulting intuition is a seemingly unsubstantiated attitude toward a decision option or course of action that communicates the result of the unconscious process to the conscious mind of the decision maker (Chapter 3) (Eling et al., forthcoming). Because of their different information processing mechanisms, the intuitive and rational approaches each have different benefits and drawbacks, as identified in Table 4.1.

For several decades, decision making theory has promoted using a rational decision making approach (Sadler-Smith and Shefy, 2004; Sinclair and Ashkanasy, 2005). Rational decision making follows rules of logic, which is beneficial to effective decision making when the criteria are clear, one or a few criteria dominate, or when arithmetic is required (Dijksterhuis and Nordgren, 2006; Evans, 2008). A rational decision making approach can be understood and its logic retraced and is thus considered to be objective in nature. For these reasons, conscious processing tools such as multi-attribute models are being promoted for making effective FFE decisions (Kahraman et al., 2007).

However, the findings of study 2 and other more recent research suggest that FFE execution decisions also may benefit from an intuitive approach (Chapter 3) (Eling et al., forthcoming; Griffin et al., 2009). An unconscious, intuitive decision making approach may lead to better decisions when uncertainty is high (Covin et al., 2001; Khatri and Ng, 2000) and when many decision attributes are involved (Strick et al., 2011), as is typical in FFE execution decisions (Khurana and Rosenthal, 1998; Kim and Wilemon, 2002a). Intuition use also may increase decision making speed (Dayan and Elbanna, 2011; Wally and Baum, 1994), which may be important in reaping NPD cycle time reduction advantages (Chapter 2) (Eling et al., 2013; Zehir and Ozsahin, 2008). Using an intuitive decision making approach may thus be useful in delivering high quality FFE decisions quickly.

In practice, both rational and intuitive decision making approaches are used in making FFE execution decisions (Sim et al., 2007). Researchers have hypothesized that combining rational and intuitive approaches may allow a decision maker to benefit from the advantages of both (Dane and Pratt, 2009; Sadler-Smith and Shefy, 2004). To date, however, no empirical research has investigated whether this is true. As a result, it is not known whether combining rational and intuitive approaches in making single FFE execution decisions leads to higher decision making *quality* and/or *speed* when compared to using the same (i.e., only rational or only intuitive) approaches.

Table 4.1: Comparing Characteristics of Rational and Intuitive Approaches

	Rational Approach	**Intuitive Approach**
Process	Conscious	Unconscious
Outcome (in consciousness)	Rational reasons	Intuition (i.e., a seemingly unsubstantiated attitude toward a course of action)
Focus of the process	Diverging: Developing an exhaustive list of reasons from the available information	Converging: Synthesizing all available information into an intuition
Benefits	Process follows precise rules and logic; Process and included information can be retraced and controlled; Outcome is objective and can be explained to and understood by others	Process: - Can take many attributes into account simultaneously (high capacity); - Has access to implicit and tacit knowledge; - Is open toward new information; - Precisely weights facts, approximate and implicit or tacit information; - Recognizes complex patterns; - Makes complex associations among information
Drawbacks	Process: - Cannot take many attributes into account simultaneously (low capacity); - Has no access to implicit and tacit knowledge; - Is biased by earlier conclusions; - Values facts more than approximate and implicit or tacit information; - Does not recognize complex patterns; - Cannot make complex associations	Process does not follow precise rules and logic (not suitable for e.g. arithmetic or when 1 or 2 criteria prevail); Process and included information cannot be retraced or controlled (no awareness of the process); Outcome is subjective, cannot be explained, and may not be understood by others

Moreover, rational and intuitive decision making approaches may be combined in two ways: (i) start with intuitively analyzing the decision options and then rationally consider the resulting intuition in making the final decision or (ii) start with rationally analyzing the decision options to produce logical reasons for what decision to make, and then intuitively consider these logical reasons in making the final decision (Agor, 1986; Sadler-Smith and Shefy, 2004). No research has yet shown which combination leads to better decision making performance. Thus it is not clear *how* best to combine the two approaches to make FFE execution decisions.

To begin addressing these gaps in the literature, this research empirically explores *whether* and *how* rational and intuitive decision making approaches could best be combined in making FFE execution decisions to improve decision making *quality* and *speed.* To achieve this objective, an experiment with experienced NPD professionals is conducted that manipulates the decision making approach combinations used to evaluate different new product ideas, a typical FFE execution decision. An experiment is used, as this methodology overcomes possible retrospective recall errors that may occur when post-hoc subjective measures are used.

4.2 Theoretical Framework

4.2.1 FFE execution decision making

In carrying out FFE tasks two types of FFE execution decisions need to be taken: *generation* and *evaluation* decisions (Chapter 3) (Eling et al., forthcoming). Generation decisions determine what to focus on, which information to look for and use going forward, where to look for new information, and which paths of inquiry to go down in finding potential ideas and opportunities. Individuals differ significantly in how they make generation decisions, in part due to the differences in decision makers' backgrounds. Generation decisions are thus highly idiosyncratic nature, which makes them extremely difficult to investigate empirically.

Evaluation decisions assess the potential for an opportunity or idea to be developed into a successful new product (Chapter 3) (Eling et al., forthcoming; Kim and Wilemon, 2002a). They typically result in committing to a rank-ordering of a number of potential opportunities, or to one of three actions for any single opportunity: select, refine or abandon. Because evaluation decisions can be investigated more easily across decision makers than generation decisions, as every individual can be exposed to the same set of potential ideas and criteria when they are described in an abstract way, this research focuses on evaluation decisions. When there are a number of potential opportunities, making an evaluation decision includes both distinguishing between ideas or opportunities that have very different potential, where the best decision may be more obvious, as well as those with very similar potential, where the best choice is much more subtle (Zhang and Doll, 2001).

FFE evaluation decisions may be made jointly by members of a formally assigned development team or by an individual around which a development team is assembled more or less formally (Grote et al., 2012; Koch and Leitner, 2008). Given the limited body of knowledge on FFE decision making, this study focuses on individuals making FFE evaluation decisions as a starting point for later building a better understanding of FFE team level decision making.

FFE evaluation decision making performance can be measured on two dimensions: quality and speed (Eisenhardt and Zbaracki, 1992; Kessler and Chakrabarti, 1996). Higher *quality* implies that the potential of opportunities or ideas is assessed more correctly (Khurana and Rosenthal, 1998; Kim and Wilemon, 2002a), producing a higher probability of selecting and developing the opportunity or idea with the highest objective potential to become a successful new product.

Faster *speed* means making the evaluation decision in less time (Cankurtaran et al., 2013). FFE decision making speed is important because cycle time advantages accrue only when all stages of the NPD process, starting with the FFE, are executed more quickly (Chapter 2) (Eling et al., 2013). Making FFE execution decisions too slowly may, therefore, negatively affect new product success (Menon et al., 2002; Zirger and Hartley, 1994).

4.2.2 Combining approaches for making FFE evaluation decisions

Two decision making process stages can be distinguished in FFE evaluation decision making (Baum and Wally, 2003): (1) the decision options analysis stage (i.e., analyzing the ideas or opportunities) and (2) the final decision making stage, which includes the consideration of the analysis outcome and the final commitment to action. These two decision making process stages can be completed by combining the *same* or *different* rational or intuitive decision making approaches (Figure 4.1).

For example, in an *intuitive-intuitive (II)* decision making approach combination, the decision options are first analyzed unconsciously, resulting in an intuition. The decision maker then considers that intuition unconsciously in making the final decision. As such the commitment to action is based only on intuition. In contrast, in a *rational-rational (RR)* combination of approaches, the decision maker first consciously analyzes the decision options, resulting in logical reasons for what decision to make, and then considers those reasons consciously and rationally in making the final decision, basing the commitment to action on only rational reasons.

Combining the different approaches can be done in two ways (Agor, 1986; Sadler-Smith and Shefy, 2004; Shapiro and Spence, 1997):

- Intuitive-rational (IR) combination of approaches: Start with an intuition resulting from unconsciously analyzing the decision options and consider it with rational reasons in making the final decision, so that the commitment to action is based on intuition and reasons.

- Rational-intuitive (RI) combination of approaches: Start with rational reasons resulting from consciously analyzing the decision options and consider them intuitively in making the final decision, so that the commitment to action is based on reasons and intuition.

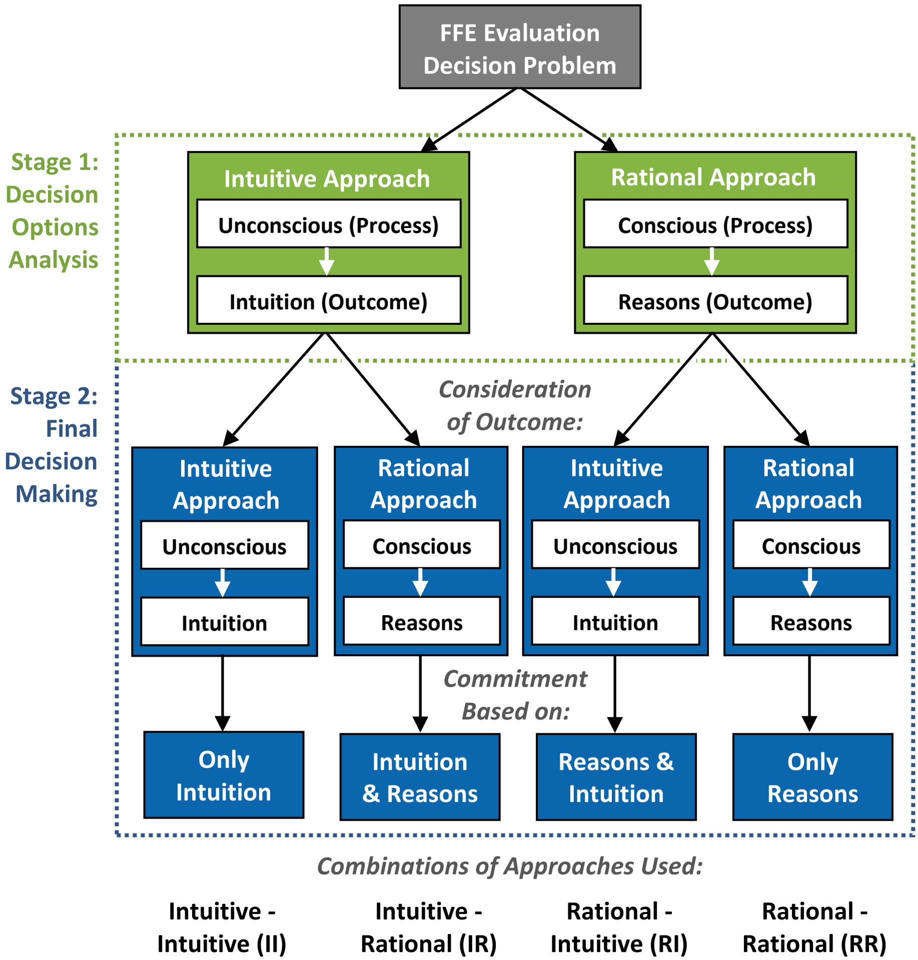


Figure 4.1: Combining Decision Making Approaches for Making FFE Evaluation Decisions

Distinguishing between the decision making approaches used in the *decision options analysis* stage and in the *final decision making* stage, this study investigates the FFE evaluation performance effects of four different decision making approach combinations (Figure 4.1).

4.3 Hypotheses Development

Two hypotheses are presented below that contrast the quality (H_1) and speed (H_2) effects of these four decision making approach combinations (Figure 4.2).

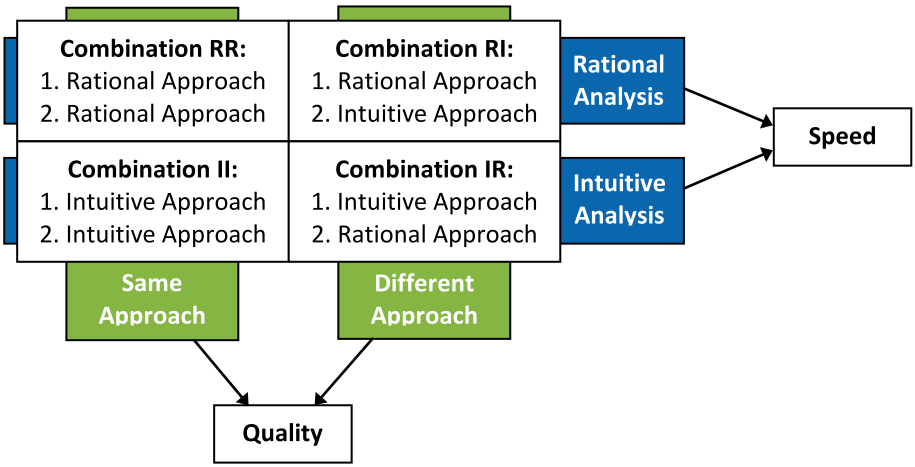


Figure 4.2: Conceptual Model: Effects of the Four Decision Making Approach Combinations on FFE Evaluation Decision Making Quality and Speed

4.3.1 FFE evaluation decision making quality

I hypothesize that combining *different* decision making approaches (IR and RI) will lead to higher FFE evaluation decision making quality than using the *same* approaches (II or RR) for an identical decision problem (i.e., for the same information and decision options). The rationale is that the two decision making approaches complement each other as shown in Table 4.1

(Dane and Pratt, 2009; Sadler-Smith and Shefy, 2004). The drawbacks of one approach are the advantages of the other and vice versa (Dijksterhuis and Nordgren, 2006; Hammond et al., 1997).

The conscious mind processes a decision problem differently than the unconscious. Conscious, rational processing follows precise rules, such as rules of logic and rules regarding the decision criteria, which is most beneficial to effective decision making when the criteria are clear, one or a few criteria dominate, or when arithmetic is required (Dean and Sharfman, 1993; Epstein et al., 1996). Decision makers are consciously aware of the decision making process and can rationally reflect on the way information has been processed, what information has been included and what has not. Consequently, the conscious decision process can be retraced (Bos et al., 2008; Evans, 2008). Conscious processing results in rational, logical arguments that validate a decision's accuracy and can be communicated to FFE team members and management (Hogarth, 2001).

Using an intuitive in addition to a rational approach may be advantageous for FFE evaluation decision making because there can be too much information to process consciously, important information frequently is in (non-numerical) forms that are difficult to process consciously, and because some important information may not be available to the conscious mind. The unconscious process from which an intuition results can handle more and different types of information than can the conscious (Dijksterhuis and Nordgren, 2006; Evans, 2008). As such, the large amount of information and number of requirements and decision options relevant in FFE evaluation decision making can simultaneously be considered (Brockmann and Anthony, 1998; Kihlstrom, 1987). The unconscious considers implicit and approximate information equally important to explicit facts and numbers (Glöckner and Witteman, 2010; Wilson and Schooler, 1991) and can precisely determine the importance of the many criteria that can be relevant in the FFE (Heerkens, 2006), allowing discrimination between even very similar idea or concept options (Bos et al., 2011). Finally, the unconscious also can quickly integrate new information and changing requirements into the decision making process (Bos et al., 2008; Dijksterhuis and Nordgren, 2006).

These complementarities between the rational and intuitive approaches suggest that FFE decision makers may increase evaluation decision making quality by combining them because the analysis result of the first can then be 'inspected' by the complementary capabilities of the other in making the final decision (Sadler-Smith and Shefy, 2004). When starting with an intuitive analysis and then reconsidering the intuition rationally (IR), the decision maker consciously checks that all required information is included in developing the intuitive attitude and ensures that no logical or arithmetic mistakes were made (Dane and Pratt, 2009; Epstein et al., 1996). By starting with rational analysis and then intuitively considering the rational reasons (RI), the decision maker uses his unconscious to check whether the conscious process included all important implicit, tacit and new information and attached sufficient meaning to approximate or tacit information (Dijksterhuis and Nordgren, 2006; Sadler-Smith and Shefy, 2004).

In contrast, when combining the same decision making approach (II or RR), the complementary capabilities of the other approach are not available. The decision maker is left with only an unconscious or conscious understanding of the decision problem (Sadler-Smith and Shefy, 2004). When using only intuitive approaches for both analysis and final decision, the fully unconscious process may have arrived at intuitive estimations when exact arithmetic was required or clear rules needed to be followed (Dane and Pratt, 2009; Kahneman and Klein, 2009). When only rational approaches are used, an incorrect FFE evaluation decision may be made because there were too many decision attributes to accurately compare simultaneously, or because important implicit, tacit, or approximate information was not considered by the conscious mind (Frank et al., 2006; Glöckner and Witteman, 2010). Accordingly:

H_1: Combining different decision making approaches (IR and RI) for decision options analysis and final decision making is associated with higher FFE evaluation decision quality than combining the same approaches (II or RR).

4.3.2 FFE evaluation decision making speed

I expect that starting with an intuitive analysis (II and IR) of the decision options will produce faster FFE evaluation decisions than starting with a rational analysis (RI and RR) for the identical decision (with the same information and decision options). Starting with an intuitive analysis saves time in making the final decision regardless of whether an intuitive or a rational approach is used to consider the resulting intuition because of the different ways in which the unconscious and the conscious mind analyzes the decision options.

The unconscious organizes all explicitly and implicitly available information and requirements about decision attributes according to their importance for the decision problem at hand (Bos et al., 2011; Kihlstrom, 1987). It simultaneously searches for potential new and meaningful associations between information and requirements that may support one new product idea (e.g., an idea with a product advantage that fulfills a trend in the category) and eliminate another (Glöckner and Witteman, 2010). The unconscious also compares complex patterns of information and requirements from the current decision problem to patterns stored in memory from previous decision problems, identifying and using only the matching patterns to guide the analysis (e.g., the characteristics of an idea are comparable to a past product that accrued first mover advantages) (Dane and Pratt, 2009; Kahneman and Klein, 2009). The result from these unconscious processes is a summarizing intuitive attitude toward a decision option or course of action that allows decision makers to quickly make the final decision, either by considering it intuitively (II) or by developing only those rational reasons that support or reject the intuition (IR).

In contrast, in rationally analyzing the decision options the conscious mind gathers as much information and finds as many arguments as possible for and against each decision option (Bourgeois and Eisenhardt, 1988; Sadler-Smith and Shefy, 2004) to produce a comprehensive list of rational reasons, which still need to be considered before committing to an action (Baum and Wally, 2003; Fredrickson, 1984). In FFE evaluation decision making, this list of reasons can be quite long because huge amounts of information, decision criteria and decision options may be relevant (Hart et al., 2003; Zahay et al., 2004). Therefore both rational (RR) and intuitive (RI) consideration of the large numbers of rational reasons in making the final decision still takes a significant amount of (unconscious incubation) time (Agor, 1986; Dijksterhuis, 2004).

Together these arguments explain why scholars claim that intuition use leads to faster decision making than rationality (Dane and Pratt, 2007), despite taking more information (implicit and tacit) into account (Eisenhardt, 1989) and requiring unconscious 'incubation' time in the analysis stage (Agor, 1986; Dane and Pratt, 2009). Even with taking incubation time to intuitively analyze the decision options, the overall evaluation decision still is faster because the resulting summary intuition helps focus the final decision making no matter which approach (rational or intuitive) is used. The few empirical studies available support this line of reasoning, showing that intuition use leads to faster strategic decision making (Wally and Baum, 1994) and shorter development cycle time (Dayan and Elbanna, 2011). Thus:

> *H_2: Starting with an intuitive analysis of the decision options (II or IR) is associated with faster FFE evaluation decision making speed than starting with a rational analysis (RI and RR).*

4.4 Method

The hypotheses were tested experimentally because preparatory interviews with eight NPD professionals suggested that it is nearly impossible to retrospectively report on the decision making approach actually used or how decision making approaches were combined. An experiment allows me to purposefully manipulate the decision making approaches used to make a typical FFE evaluation decision and to randomly assign participants to different decision making approach treatments.

The experimental design followed the set-up of numerous prior experiments manipulating the approach to the decision options analysis stage by focusing on the process (unconscious vs. conscious), as summarized in the meta study by Strick et al. (2011). In addition, the experiment also manipulated the approach used in the final decision making stage by instructing participants to use either rational reasons or intuition in making the final decision (Dane and Pratt, 2009). Together this creates a 2 (intuitive vs. rational analysis approach) x 2 (intuitive vs. rational final decision approach) between-subjects design (Table 4.2). A typical FFE evaluation decision problem was designed, namely evaluating four new product ideas. As advocated by Bono and McNamara (2011) this experiment used experienced and knowledgeable NPD professionals as subjects so that the results are as applicable to real-life FFE evaluation decisions as possible.

Table 4.2: Manipulating Four FFE Evaluation Decision Making Combinations

		MANIPULATION 2: Final Decision Making Approach	
		Instructions to Use Intuition	**Instructions to Use Rational Reasons**
MANIPULATION 1: Decision Options Analysis Approach	**Intuitive (Unconscious) Analysis Condition**	**Combination II:** 1. Intuitive Approach 2. Intuitive Approach	**Combination IR:** 1. Intuitive Approach 2. Rational Approach
	Rational (Conscious) Analysis Condition	**Combination RI:** 1. Rational Approach 2. Intuitive Approach	**Combination RR:** 1. Rational Approach 2. Rational Approach

4.4.1 Instrument development

Each of four new product ideas was described by 12 typical new product characteristics. The ideas were described on an abstract level to eliminate potential choice biases due to previous participant knowledge or experience. One idea was designed to have the highest potential to develop into a successful new product, the second a medium-high potential, the third a medium-low potential, and the fourth had the lowest potential. This was achieved by combining positive or negative formulations of the 12 idea characteristics in different ways (cf. Dijksterhuis, 2004). The highest potential idea had eight positive and four negative characteristics while the lowest potential idea had eight negative and four positive characteristics. The medium-high potential idea was described by six positive and six negative characteristics, where the positive characteristics were more important for evaluating the new product ideas than the negative characteristics (Bos et al., 2008). The medium-low potential idea, in contrast, was described by six more important negative and six less important positive characteristics.

To develop the four ideas, eight in-depth interviews with NPD professionals were conducted to identify a list of typical new product idea characteristics and develop their positive and negative formulations. Two pre-tests with a total of 35 academics in product innovation and management then were carried out to:

- Determine the importance of the characteristics for evaluating new product ideas and identify potential 'killer' criteria;
- Test the positiveness and negativeness of the characteristics in order to fine-tune the formulations (see Table 4.3 for the final formulations);
- Verify the potentials of the four new product ideas as highest, medium-high, medium-low, and lowest; and
- Assess the average reading time for each idea described by its 12 characteristics.

The characteristics used had to be of relatively equal importance to prevent a 'killer'-criteria from making the evaluation decision problem unrealistically simple. For example, an idea that is not technically feasible creates an unrealistically simple decision situation. 'Market potential,' 'competitive advantage,' and 'technical feasibility' were identified as 'killer' criteria that always must be met. Accordingly, these characteristics were included in the description as three fundamental criteria met by all four new product ideas.

To prevent immediate decision making in the experiment and ensure that the decision attributes were not explicitly memorized, the reading time for each idea was restricted (Strick et al., 2011; Strick et al., 2010). The average reading time per idea in the pre-test was 23.2 seconds with a standard deviation (σ) of 6.2 seconds. The final idea-reading time for the experiment was, therefore, set at 30 seconds (mean + σ).

Table 4.3: Positive and Negative Formulated Idea Characteristics and Idea Compositions

Highest Potential Idea	Medium High Potential Idea	Medium Low Potential Idea	Lowest Potential Idea	Positive Formulation (+)	Negative Formulation (-)
+	+	-	-	Seems to fulfill most customer needs.	Does not seem to fulfill most customer needs.
+	-	+	-	Perfectly aligned with the firm's innovation strategy.	Not completely aligned with the firm's innovation strategy.
+	+	-	-	Probably serves as platform for subsequent products.	Will not serve as platform for subsequent products.
-	-	+	+	Short development time is foreseen.	Long development time is foreseen.
-	-	+	+	Estimated development costs are relatively low.	Estimated development costs are relatively high.
+	+	-	-	Fits a current trend in the product category.	Does not fit a trend in the product category.
+	+	-	-	Will probably result in a patent.	Probably won't result in a patent.
+	+	-	-	Final product probably won't require costly maintenance.	Final product will probably require costly maintenance.
-	-	+	+	Estimated unit cost is relatively low.	Estimated unit cost is relatively high.
+	-	+	-	Existing production facilities can likely be used.	New production facilities are likely required.
-	-	+	+	Technical development seems easy.	Technical development seems difficult.
+	+	-	-	Draws on the existing supplier base.	New suppliers need to be found.

4.4.2 Procedure

The experiment was conducted on computers in a temporarily arranged laboratory setting at the annual meeting of the Dutch chapter of the Product Development and Management Association (PDMA). During the day-long meeting, the 263 attendees could voluntarily participate in the experiment. The experimental materials were in English.

Participants were introduced to the same decision problem scenario, and then randomly assigned to one of four different idea sequences to prevent order effects. Each idea was individually presented, described by its 12 positively and negatively formulated characteristics with a timer counting down from 30 to 0 seconds. After 30 seconds the next idea description appeared automatically, using a different sequence and combination of the 12 characteristics. Taking notes was prohibited.

After reading the four ideas, participants were randomly assigned to one of two decision options analysis treatments for 180 seconds (3 minutes) to ensure a fixed and, hence, comparable analysis time. Participants in the *rational analysis* treatment (RI and RR) were asked to use the time to think carefully about the attractiveness of each of the four ideas before evaluating them. During this time only the instructions and the countdown were shown on the screen. Participants in the *intuitive analysis* treatment (II and IR) were distracted for 180 seconds to allow for unconscious processing (Frank et al., 2006). They were asked to solve a word search puzzle for a good cause before evaluating the ideas (Strick et al., 2011).

After three minutes of rational or intuitive decision options analysis, participants were randomly assigned to one of two final decision making treatments. The participants in the *rational final decision* treatment (IR and RR) were instructed to use "rational, logical reasoning" to evaluate each idea. Participants in the *intuitive final decision* treatment (II and RI) were instructed to use their "intuition and 'gut' feeling" to evaluate each idea. After reading the instructions, all participants indicated their attitude toward each idea on a graphical, bipolar modified Stapel scale running from -50 (very negative) to 50 (very positive) (Dijksterhuis and van Olden, 2006).

4.4.3 *Dependent variables*

To account for the two types of distinctions that have to be made in one FFE evaluation decision, i.e., between ideas or opportunities that are very different as well as between those with very similar or undifferentiated appearing potential (Zhang and Doll, 2001), quality was measured in two ways. The first measure focuses on how well participants distinguished between the two *obviously dissimilar* idea options, that is, the idea with the highest potential from the idea with the lowest (Dijksterhuis, 2004). The second measure takes into account how well participants distinguished between two *very similar* idea options: the medium-high potential and medium-low potential ideas. Two difference scores were calculated for each respondent by (i) subtracting the rating of the lowest potential idea from the rating of the highest potential idea and by (ii) subtracting the rating of the medium-low potential idea from the rating of the medium-high potential idea.

Decision making speed was measured as the time recorded by the computer from when the participant saw the instructions for the final decision treatment until pressing the 'Next' button after evaluating all four new product ideas on the 101-point scales.

4.5 Results

Of the NPD professionals attending the PDMA conference, 50 (46 men and 4 women) participated in the experiment, a response rate of 19.01%. Participants averaged 42.82 years of age (σ = 8.72), 7.3 years of higher education (σ = 2.42), and 12.46 years of NPD experience (σ = 8.47). Of the respondents, 38% worked in R&D or engineering, 22% in marketing or sales, 12% in strategy, 8% in design and 20% in other functional areas. These characteristics suggest very high respondent qualifications for the research.

4.5.1 Evaluation decision making quality

Overall, the highest potential idea was evaluated most positively (M_H = 18.56), the lowest potential idea most negatively (M_L = -14.34). The medium-high (M_{MH} = 7.64) and medium-low (M_{ML} = -10.68) potential ideas also were evaluated in the correct in-between order. Figure 4.3 illustrates that, regardless of which combination of the decision making approaches was used, all subjects successfully distinguished between the *obviously dissimilar* idea options with highest differences for the participants combining different approaches, i.e., IR (M_H - M_L = 33.83) and RI (M_H - M_L = 39.60). Figure 4.4 shows that in distinguishing between the *very similar* ideas, participants combining different approaches performed well (IR: M_{MH} - M_{ML} = 33.75; RI: M_{MH} - M_{ML} = 25.80), while those who used the same decision making approach for both decision stages did not (II: M_{MH} - M_{ML} = 10.07; RR: M_{MH} - M_{ML} = -1.89).

H_1 was tested using two 2 (intuitive vs. rational analysis approach) x 2 (intuitive vs. rational final decision approach) mixed ANOVAs, one for each quality measure. For the distinction between the *obviously dissimilar* ideas the direct effects of the decision analysis treatments ($F(3,46) < 1$, n.s., η^2 = .003) and of the final decision treatments ($F(3,46) < 1$, n.s., η^2 = .001) are both insignificant, as is the two-way interaction ($F(3,46) < 1$, n.s., η^2 = .012).

For the distinction between the *very similar* idea options the direct effects of decision analysis treatments ($F(3,46) < 1$, n.s., η^2 = .016) and final decision treatments ($F(3,46) < 1$, n.s., η^2 = .001), again were insignificant. However, the two-way interaction ($F(3,46) = 5.02$, $p < .05$, η^2 = .098) was significant. Interpreting the interaction effect using a contrast analysis indicates that combining different approaches (IR or RI) leads to a significantly better distinction between the medium-high and the medium-low potential ideas than combining the same approach (II or RR) ($t(46)$ =

2.24, $p < .05$). Participants performed similarly well independent of the order in which the approaches were combined, IR or RI ($t(46) = .52$, n.s.).

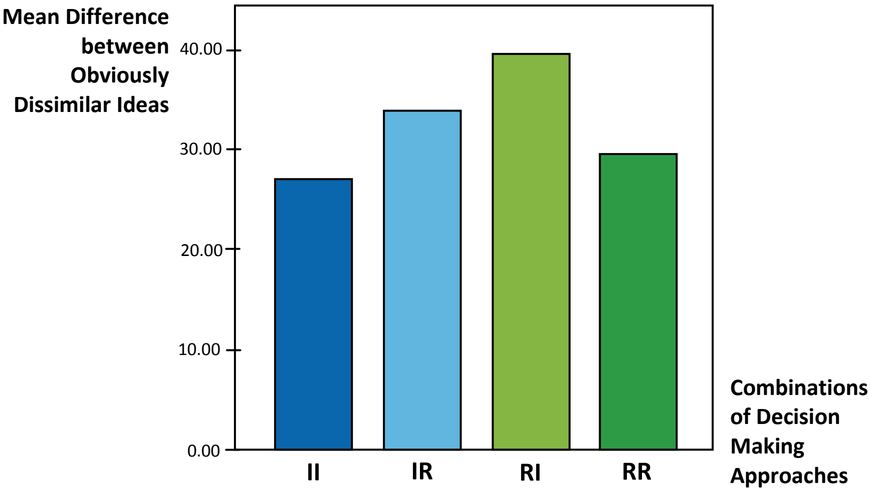


Figure 4.3: Mean Distinction between the Obviously Dissimilar Ideas (101-Point Scale)

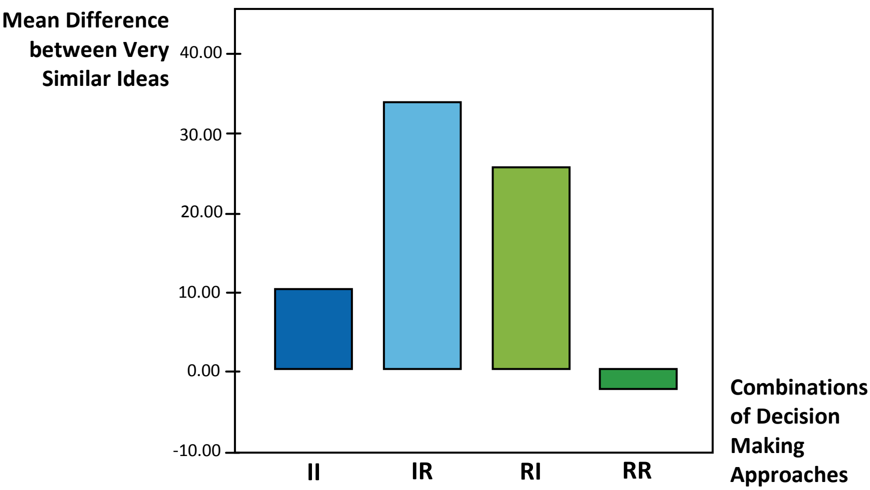


Figure 4.4: Mean Distinction between the Very Similar Ideas (101-Point Scale)

To summarize, while the combination of decision making approaches used (II, RR, IR, or RI) has no effect on making the distinction between the *obviously dissimilar* ideas, combining different approaches (IR and RI) leads to a significantly better distinction between *very similar* ideas than does combining the same approach (II or RR). Together these results provide partial support for H_1.

4.5.2 Evaluation decision making speed

The average final decision making time was 33.10 seconds. As Figure 4.5 illustrates, participants who started with an intuitive analysis approach made the final decision quicker (II: T = 31.44 seconds; IR: T = 27.50 seconds) in comparison to those starting with a rational analysis approach (RR: T = 38.06 seconds; RI: T = 36.16 seconds).

To test H_2, a 2 (intuitive vs. rational analysis approach) x 2 (intuitive vs. rational final decision approach) mixed ANOVA also was conducted, yielding a significant effect for the decision analysis treatments ($F(3,46) = 8.67$, $p < .01$, $\eta^2 = .156$). Results for the final decision treatments ($F(3,46) < 1$, p = n.s., $\eta^2 = .003$) and the two-way interaction between the treatments ($F(3,46) < 1.3$, p = n.s., $\eta^2 = .023$) were insignificant. A contrast analysis shows that participants that started with an intuitive analysis approach (II and IR) took significantly less time to make the final decision than participants that started with a rational analysis approach (RI and RR) ($t(46) = -2.94$, $p < .01$), providing support for H_2.

Overall, one combination of decision making approaches leads to the highest FFE evaluation decision making quality *and* speed, namely combination IR: starting with an intuition resulting from unconsciously analyzing the decision options and considering the intuition rationally in making the final decision. That only one combination of approaches stands out also implies that there is, at least at the individual level, no quality-speed trade-off in making FFE evaluation decisions.

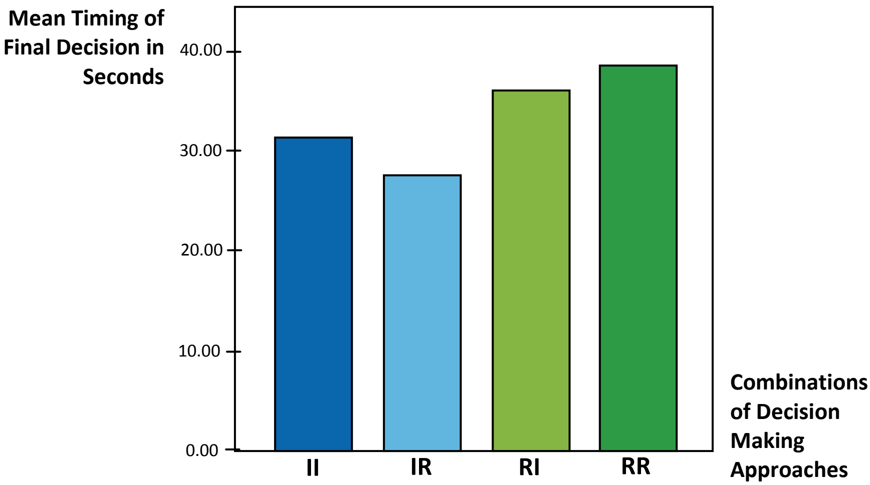


Figure 4.5: Mean Timing of Making the Final Decision (in Seconds)

4.5.3 Control variable: Order effects

To check for possible idea presentation order effects, three 1-way ANOVAs were conducted for the quality and speed measures. The order in which the ideas were presented had no significant effect on any dependent variable (all F-values < 1 and p-values > .05).

4.6 Discussion and Conclusion

Rational and intuitive decision making approaches often are combined in FFE execution practices, even though the performance effects of combining these different approaches have not been tested empirically. To fill part of this research gap, this study is the first to experimentally test *whether* and *how* rational and intuitive decision making approaches are best combined to increase the *quality* and *speed* of FFE evaluation decisions. As such, this study makes a contribution to the innovation and NPD literatures.

The experimental results show that when the decision options in FFE execution are obviously dissimilar, all combinations of decision making approaches that decision makers may use lead to the same level of decision quality. However, when there is high similarity between the decision options, combining rational and intuitive decision making approaches significantly increases FFE evaluation decision making quality. This finding supports previous claims in the literature that rational and intuitive approaches should be combined in making FFE execution decisions, as these decisions are frequently about comparing options which are rather similar in nature or between which the differences may not be obvious (Murphy and Kumar, 1997; Zhang and Doll, 2001). In these situations, the complementary advantages of rational *and* intuitive decision making approaches, as summarized in Table 4.1, indeed help decision makers identify the FFE outcome with the highest potential to be developed into a successful new product.

This finding complements Dayan and Di Benedetto's (2011) results, which show that the equipollent use of intuition and rational decision making by teams across the entire NPD process increases new product creativity. However, their study measured the extent to which rational and intuitive decision making were used across an aggregated number of decisions at the project level. It does not parse out whether the two styles were combined to make individual decisions during the project, as is done in this study, or whether they were applied individually by decision in an alternating manner. Nevertheless, my results with regard to FFE evaluation decision quality complement their findings and, thus, allow me to form two propositions for future research:

P1: *Combining rational and intuitive approaches for making single execution decisions is associated with higher decision making quality in all stages of the NPD process.*

P2: *Combining rational and intuitive approaches is associated with higher NPD decision making quality for team level decision making.*

Hart et al. (2003) found that intuition and rational reasons often are combined to make gate decisions in the FFE, especially for idea screening. Other authors also argue for combining intuitive and rational approaches in idea screening activities (van Riel et al., 2011; Tassoul and Buijs, 2007). Since idea screening at the gate level is comparable to idea evaluation decisions made by FFE members within the FFE stage, a combination of rational and intuitive decision making may, indeed, also be beneficial in FFE gate decision making. Future research is needed to investigate this possibility.

As expected, FFE evaluation decision making speed is highest when the decision maker starts with an intuitive analysis of the decision options, no matter how the final decision is made. The unconscious mind's ability to produce a quick synthesizing intuition is necessary to most expediently make FFE evaluation decisions. Thus, starting with an intuitive analysis in making evaluation decisions during FFE execution may significantly contribute to FFE cycle time reduction (Zehir and Ozsahin, 2008). Future research should investigate the extent to which this combination of decision making approaches can contribute to shorter FFE cycle time and new product success (Chapter 2) (Eling et al., 2013).

This research also adds to the intuition literature as it distinguishes between the use of intuition in two decision making process stages, i.e., the analysis of the options and the final decision making. To date intuition scholars have failed to make this distinction when making assumptions about the speed effect of using intuition, which has led to inconsistent theories about the time advantages of intuition use. Some scholars agree that intuitive decision making is faster than rational decision making (Behling and Eckel, 1991; Dane and Pratt, 2007). Others however, have posited and shown that intuitive decision making requires 'incubation time' to unconsciously analyze the decision options (Agor, 1986; Dane and Pratt, 2009; Dijksterhuis, 2004). The results of this study unequivocally show that intuitive FFE decision makers are faster than rational decision makers, when taking intuitive analysis (i.e., incubation) time.

To conclude, the results show that only one decision making approach combination leads to the highest overall FFE evaluation decision making performance. By starting with an intuitive analysis and then rationally reflecting on the resulting intuition in making a final decision (approach IR), the FFE decision maker is able to correctly *and* quickly identify the FFE outcome with the highest potential to become a successful new product. By using this combination the often mentioned quality-speed trade-off (Eisenhardt and Tabrizi, 1995) does not appear to exist for making evaluation decisions during FFE execution. Thus when both quality and speed matter in making FFE evaluation decisions there is only one preferred combination of decision making approaches. An interesting avenue for future research is to determine whether this combination of approaches is also the best for making *generation* decisions during FFE execution.

4.7 Managerial Implications

The experimental results suggest that decision makers may want to make a more deliberate choice with regard to the type and the order in which rational and intuitive decision making approaches are used in the FFE evaluation decision making process. Although any combination of different approaches will lead to the highest FFE evaluation decision making quality for either dissimilar or similar decision options, decision speed will only be highest when starting with an intuitive analysis. Since starting with an intuitive approach to analyze the decision options requires 'incubation' (unconscious analysis) time, FFE decision makers need to be consciously distracted from the evaluation decision problem for a period of time before reflecting upon their intuition by developing rational reasons in making the final decision. The take away is therefore that FFE evaluation decisions should not be made immediately upon presentation of the options.

Although used in the FFE, intuitive decision making is frequently neither trusted nor commonly accepted by senior management (Chapter 3) (Eling et al., forthcoming). In addition, many NPD professionals do not realize what the advantages of intuitive decision making are. By showing that combining intuition with rational decision making is advantageous for FFE evaluation decision making, this study helps NPD team members overcome a hesitation to complement rational decision making with an intuitive approach. Managers can facilitate and support intuition use by team members by providing education and training to make them aware of its advantages, to make them aware of their intuition, and to teach them how to facilitate unconscious analysis and combine intuition with rational decision making (Burke and Miller, 1999; Shapiro and Spence, 1997).

4.8 Limitations and Further Research

This research experimentally examined the quality and speed effects of using different combinations of decision making approaches, which inherently results in a stylized research setting. As such, it has several limitations that offer additional opportunities for future research.

First, to match the experimental design with the research questions (Bono and McNamara, 2011) I chose to use a sample consisting only of experienced NPD professionals. This design choice inherently resulted in a limited sample size but I chose to emphasize validity over generalizability as this study is the first to investigate whether and how rational and intuitive decision making approaches are best combined. Therefore additional testing of the hypotheses with larger, independent, and more international practitioner samples is needed.

Second, by presenting the subjects with four new product ideas I focused on evaluation decisions only. In practice FFE team members often make a series of generation decisions over time to generate FFE outcomes before making an evaluation decision with regard to these outcomes (Eling et al., forthcoming). Investigating both types of decisions simultaneously in an experimental design is virtually impossible as the generation of realistic FFE outcomes requires significant time, resources, and a real-life NPD problem. Therefore, a longitudinal, qualitative study would be most suitable to investigate decision making during FFE outcome generation *and* evaluation.

Third, in real-life FFE evaluation decision making, information and requirements may change during the decision making process. Dealing with this possibility requires the openness of the unconscious mind. A different combination of decision making approaches may result in higher quality and speed under such circumstances. To investigate this, an additional experiment could be conducted that also manipulates the idea characteristics during the decision making process next to the different decision making approaches.

Fourth, although a typical FFE evaluation decision, the decision problem in this study was only one example of different types of evaluation decisions that NPD practitioners take. Other FFE evaluation decisions may, for example, include numbers or strict decision making rules or require logic and arithmetic and, therefore, a more rational approach to decision making (Chapter 3) (Eling et al., forthcoming; Koen, 2004). Future research is needed to distinguish between the different types of FFE execution decision problems and investigate which combination of decision making approaches is most effective and efficient for each.

Fifth, in this experiment, the time taken for the decision options analysis stage was identical for the rational and the intuitive approach through manipulation. However, different analysis times may be required for intuitive and for rational analysis to achieve the highest quality, which also may impact speed. Future research should, therefore, be conducted to determine the optimal 'incubation' or rational analysis time for different FFE evaluation decision problems.

Finally, in real-life much more switching back and forth between intuitive and rational processes and outcomes may occur while making FFE execution decisions (Sadler-Smith and Shefy, 2004). Neither experiments nor surveys can, however, capture such subtle decision making processes. Instead, future research may make use of neuroimaging studies to understand how good and timely decisions during FFE execution are made.

CHAPTER 5

Discussion

The objective of this dissertation was to advance the existing knowledge on how to best execute the FFE by investigating two unresolved issues in FFE execution: (i) the performance effects of accelerating FFE execution cycle time and (ii) the optimal approach to FFE execution decision making. This concluding chapter summarizes the key findings from investigating each of these two issues and synthesizes them into an overall conclusion. The overarching finding is that proficiently executing the FFE means both accelerating the FFE in such a way that the development and commercialization stages also can be consistently accelerated and making decisions by using intuitive and rational approaches in the right temporal sequence and under the appropriate conditions in individual and team decision making. The theoretical implications of this overarching finding for FFE management and the general NPD and innovation management literatures and the resulting ideas for future research are discussed. Finally, this chapter presents the managerial implications and overarching limitations of this dissertation.

5.1 Synopsis

Despite the importance of the FFE, neither academics nor practitioners completely understand how to execute it proficiently because there still are significant gaps in the literature. This dissertation has focused on two important FFE management research topics, i.e. 'FFE acceleration' and 'FFE decision making' to advance the knowledge on how to best execute the FFE. To this end, two unresolved issues in FFE execution have been identified with regard to these research topics, i.e. (i) the performance effects of accelerating FFE execution cycle time and (ii) the optimal approach to FFE execution decision making. To investigate these issues I executed three studies: Study 1 (Chapter 2) to investigate issue (i) and studies 2 (Chapter 3) and 3 (Chapter 4) to investigate issue (ii). Below, the key findings of all three studies are summarized by each issue and synthesized into an overall conclusion.

5.2 Summary of Key Findings

5.2.1 The performance effects of accelerating FFE cycle time (Study 1)

The theoretical arguments on the directionality of the main and interaction effects between accelerating FFE execution cycle time and new product performance have been conflicting. Therefore, the following two research questions were investigated:

> *RQ_{1a}: What is the main effect of FFE execution cycle time on new product performance?*

> *RQ_{1b}: What are the interacting effects of FFE execution cycle time with the performance effects of the subsequent development and commercialization stages' cycle times?*

I addressed both research questions in study 1 (Chapter 2) using objective and longitudinal cycle time and sales data for 399 NPD projects completed following a Stage-Gate® type of process in the plastics division of a large and diversified industrial corporation. The results of the hierarchical regression analysis show that, contrary to expectations, FFE cycle time is not directly associated with new product performance, which provides an answer to research question 1a. However, FFE execution cycle time has an indirect effect on new product performance. The slope tests for the two-way and three-way interactions with (development and) commercialization cycle time show that new product performance is only increased through reducing NPD cycle time when the cycle times of all three NPD stages (i.e., FFE, development and commercialization) are simultaneously reduced, which provides an answer to research question 1b. Cycle time reduction in NPD needs to be an integral, clear, and consistent goal from the beginning of the development project in order to be effective. Consequently, proficiently completing the FFE includes deciding on and implementing an acceleration strategy right at the start of an NPD project and planning the project so that this strategy can be consistently implemented across all three NPD stages.

5.2.2 *The optimal approach to FFE decision making (Studies 2 & 3)*

Previous research has suggested that FFE execution decision making benefits not only from the commonly accepted rational approach, but also from using intuition. Combining rational and intuitive approaches in FFE execution decision making may allow decision makers to make use of the advantages of both approaches. To understand and test these suggestions, I investigated the following two research questions:

> *RQ_{2a}: Why and under which conditions is the use of intuition beneficial for making FFE execution decisions?*

RQ$_{2b}$: Should intuitive and rational approaches be combined in FFE execution decision making and, if yes, how?

Research question 2a was investigated in study 2 (Chapter 3), which combined a creativity perspective of FFE execution decision making and a dual-processing perspective of intuition to develop a conceptual framework that explains why and under which conditions individual and team-based FFE execution decisions may or may not benefit from the use of intuition. The conceptual framework proposes that intuitively making generation and evaluation decisions during FFE execution increases the creativity of the resulting product concept because of the benefits of the unconscious processes from which an intuition results. Due to the drawbacks of the unconscious processes this positive effect is, however, proposed to be weaker under certain circumstances. When individuals use intuition in FFE execution decision making, the incremental nature of the NPD project, the inexperience of the FFE decision maker, and the availability of multiple goals may weaken this positive effect. When using the intuition(s) of individuals in team FFE execution decision making, a rational decision culture and hierarchical or democratic decision making rules may weaken the positive effect of intuition use. This provides an answer to research question 2a.

Research question 2b was investigated in study 3 (Chapter 4) using an experiment with a 2x2 between-subjects design that manipulated the use of four different decision making approach combinations by 50 NPD professionals for the two stages (i.e., the decision options analysis stage and the final decision making stage) of making a typical FFE execution decision, i.e., evaluating several new product ideas. The results of the experiment show that, as hypothesized, both combinations of *different* decision making approaches (intuition-rational and rational-intuition) lead to a significantly higher FFE execution decision making quality than combining the *same* approaches (intuition-intuition or rational-rational), when there is high similarity between the idea options. This suggests that the advantages of both approaches are required to make good evaluation decisions during FFE execution. Moreover, also as expected, the FFE execution decision was made significantly faster when the decision makers started with an intuitive decision options analysis, no matter which approach was used in the final decision making stage (intuition-rational or intuition-intuition). Starting with an intuitive decision options analysis allows a faster *final* decision making. Consequently, to achieve simultaneously higher quality and faster speed in evaluating new product ideas during FFE execution, rational and intuitive decision making approaches should be combined in one specific sequence, i.e., starting with intuitively analyzing the decision options and then rationally considering the resulting intuition in making the final decision. This finding provides an answer to research question 2b.

5.3 Conclusion

The ultimate goal of investigating the two unresolved issues was to find out how NPD performance may be increased through managing the execution of the FFE more proficiently. Figure 5.1 integrates the conceptual models and individual findings of all three studies that were conducted to investigate the two issues and links them to the ultimate goal of new product performance. In study 1, I directly used new product performance as a dependent variable. Studies 2 and 3 focused on FFE outcome variables at the project level and at the individual decision level, which are then theorized to link to new product performance. The dependent variable of Study 2 (Chapter 3), product concept creativity, has been found to increase new product performance in earlier research (Im et al., 2013; Im and

Workman, 2004). Additionally, the dependent variables in Study 3 (Chapter 4), i.e., FFE decision making quality and speed, are expected to be associated with new product performance directly and indirectly through product concept creativity and FFE cycle time (Kessler and Chakrabarti, 1996; Khurana and Rosenthal, 1998; Kim and Wilemon, 2002a).

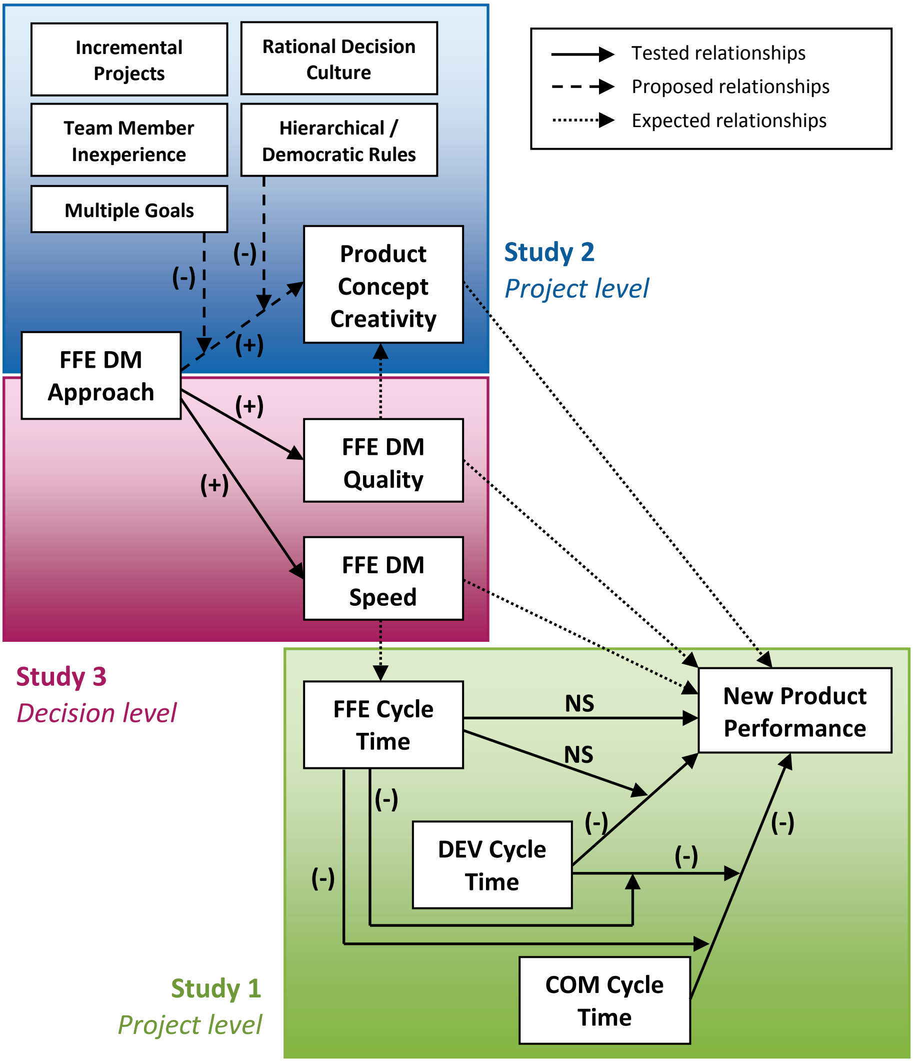


Figure 5.1: Overview and Link of All Three Studies
(DM = Decision Making, DEV = Development, COM = Commercialization)

By focusing on new product performance directly and on three important FFE outcome variables that are theoretically associated with new product performance, this dissertation advances the knowledge on proficient FFE execution with two key findings. First, to increase new product performance through cycle time reduction advantages, the execution of the FFE needs to be accelerated in such a way that the subsequent development and commercialization stages also can be consistently speeded up (Study 1). Second, increasing new product performance through decision making during the execution of the FFE requires the appropriate use of not only rational decision making, but also intuition (Studies 2 & 3). More precisely, to increase the quality and speed of making evaluation decisions during FFE execution, intuitive and rational decision making approaches need to be combined in the right temporal sequence (Study 3). Additionally, intuitive decision making is only beneficial for new product performance when it is used under certain conditions in individual or team FFE execution decision making (Study 2).

Consequently, proficiently executing the FFE means both, accelerating the FFE in such a way that the development and commercialization stages also can be consistently accelerated and making decisions by using intuitive and rational approaches in the right temporal sequence and under the appropriate conditions in individual and team decision making. This overall conclusion has theoretical and managerial implications.

5.4 Theoretical Implications and Future Research

In addition to the theoretical implications of the individual findings of each study, which have already been presented in Chapters 2-4, the overarching finding of this dissertation also has theoretical implications for the FFE management and the general NPD and innovation management literatures that will be discussed in the following paragraphs. These implications result in significant opportunities for future research.

5.4.1 Implications for the FFE management literature

By showing that proficient FFE execution requires both an appropriate FFE acceleration and a certain FFE decision making approach, this dissertation has several implications for the FFE management literature because this finding has consequences for future investigations into several of the FFE management research topics listed in Table 1.1.

5.4.1.1 Implications for 'FFE acceleration' and 'FFE decision making'

The implications for the literature on the FFE management research topics that were the focus of this dissertation, i.e., 'FFE acceleration' and 'FFE decision making' are the following. By showing that using the right temporal sequence of rational and intuitive approaches increases FFE execution decision making speed, the findings of study 3 (Chapter 4) suggest that the two research topics are linked (Figure 5.1). The possibility that faster decision making leads to shorter NPD execution cycle times previously was theorized by Kessler and Chakrabarti (1996). Additionally, previous research showed that using an intuitive approach in NPD decision making can lead to shorter overall NPD cycle time (Dayan and Elbanna, 2011). Future research should test whether and under which circumstances faster FFE decision making speed is, indeed, associated with shorter FFE cycle time and, ultimately with increased new product performance.

Both FFE management goals (i.e., appropriately managing FFE execution acceleration and decision making) may then be achieved by only assuring that the right FFE decision making approach combination is used. However, using intuitive decision making is currently not commonly accepted in FFE decision making because little is known about intuition and its appropriate use in the FFE (Chapter 3: Eling et al., forthcoming). Future research is, therefore, required to develop appropriate education and training methods to support and facilitate optimal FFE decision making. Furthermore, to fully understand the relationship between the use of certain FFE decision making approaches and new product performance, future research also should test the other theoretical links between the three studies in this dissertation (Figure 5.1), i.e. between the use of FFE decision making approaches, FFE decision making outcomes (i.e., quality and speed), FFE outcomes (i.e., product concept creativity and FFE cycle time) and new product performance.

5.4.1.2 Implications for other FFE management research topics.

The implications of the overarching finding of this dissertation for other FFE management research topics (listed in Table 1.1), result in several additional opportunities for future research, as the following three examples illustrate.

First, simultaneously managing FFE acceleration and decision making may have consequences for the research topic *'Leadership and control in the FFE'.* A certain type of team leadership and the empowerment of the FFE team have both been identified as antecedents of shorter cycle time at the overall NPD process level (Chen et al., 2010) and may, therefore, also lead to shorter FFE cycle time. On the other hand, study 2 (Chapter 3) suggests that the leadership type and team empowerment may be antecedents or contingency factors to the beneficial use of intuition in FFE execution decision making. In order to be able to effectively use intuition in making generation and evaluation decisions during FFE execution, individuals may need a certain freedom that allows them to actually follow their intuitions. In addition, a certain type of leader (i.e., a charismatic leader or a leader with a participatory style) could support and facilitate intuition use at the individual level and ensure that 'correct' intuitions are used at the team level (Chapter 3) (Eling et al., forthcoming). Consequently, future research on the topic of 'Leadership and control in the FFE' should take this possible link with the proficient management of both, FFE acceleration and decision making, into account.

Second, future research on the topic '*Information / knowledge use and management in the FFE'* may benefit from the overarching finding of this dissertation. For example, team member experience and learning (i.e., accumulated knowledge) have both been found to be antecedents of overall NPD cycle time reduction (Chen et al., 2010). They may, therefore, also be antecedents of shorter FFE cycle time. Regarding FFE decision making, study 2 (Chapter 3) has introduced FFE team member (in)experience as a contingency factor for effectively using intuition in FFE execution decision making. The positive effect of intuition use in FFE execution decision making on product concept creativity may be weakened when FFE team members are inexperienced in the domain or in executing the FFE process. Through learning from previous projects, FFE team members may increase their experience and, therefore, strengthen the positive effect of intuition use. Consequently, team member experience and learning may play a role for simultaneously managing appropriate FFE execution acceleration and decision making. This possibility could be taken into account by future research on the topic of 'Information / knowledge use and management in the FFE'.

A third FFE management research topic that may be impacted by the overarching finding of this dissertation is '*FFE formalization*'. Also formalizing the NPD process has been associated with NPD speed (Chen et al., 2010), and is, therefore, also expected to help accelerate the FFE (Kim and Wilemon, 2010; Reinertsen, 1999). In contrast, FFE creativity is constrained by formalization (Troy et al., 2001). One reason may be that increased formalization is often accompanied with a more rational decision culture, which has, in turn, been proposed to weaken the positive effect of intuition use on product concept creativity in study 2 (Chapter 3). Consequently, the findings of this dissertation ask for a formalization of the FFE that allows both, a faster FFE execution and optimal FFE execution decision making. This could, for example, be achieved by assuring higher goal clarity for the members of the FFE team, which has been found to increase NPD speed and is expected to increase the positive effect of intuition use in FFE execution decision making (Chapter 3: Eling et al., forthcoming). Future research is required to identify the appropriate way of formalizing the execution of the FFE to support both, appropriate FFE acceleration and optimal FFE decision making.

5.4.2 *Implications for the NPD and innovation management literatures*

The overarching finding of this dissertation that execution acceleration and decision making have to be managed simultaneously, may not apply only to the FFE, but to the whole NPD process. Consequently, this dissertation also has all-embracing implications for future research on general NPD and innovation management.

First, this dissertation has implications for the research on NPD decision making and NPD cycle time reduction and the potential link between those two research domains. Study 1 (Chapter 2) has shown that a shorter development and commercialization cycle time increases new product performance and study 3 (Chapter 4) suggests that using the right temporal sequence of rational and intuitive approaches in NPD execution decision making may very well be an antecedent of NPD speed. However, research on decision making during the execution of the two subsequent NPD stages after the FFE is completed, is lacking. Future research should, therefore, focus on identifying the optimal approach(es) to decision making during the execution of the entire NPD process, as well as on the potential link between using NPD decision making approach(es) and NPD cycle time reduction.

Second, the overarching finding of this dissertation may have implications for other NPD and innovation management research domains because other factors may also play a role in managing NPD acceleration and decision making. These may, for example, be the antecedents of NPD cycle time that have also been discussed in section 5.2.1.2 for the FFE level, namely team leadership, team empowerment, team member experience, team learning, process formalization, and goal clarity. Consequently, through its implications, this dissertation delivers ample opportunities for future research on the management of the overall NPD process.

5.5 Managerial Implications

Because of the gaps in the FFE management literature, companies are still struggling in executing this important NPD stage. From previous research, NPD professionals executing the FFE did not know whether they should be fast in FFE execution, or which decision making approach they should adopt how during FFE execution. The findings of this dissertation provide initial advices on the proper acceleration of the FFE and on the effective use of the optimal approaches for making generation and evaluation decisions in FFE execution, which are presented in Chapters 2-4. Looking across the three studies, a proficient execution of the FFE simultaneously requires accelerating the FFE in such a way that the development and commercialization stages also can be consistently accelerated and using intuitive and rational decision making approaches in the right temporal sequence and under the appropriate conditions in individual and team decision making. To achieve this combined FFE execution management goal, I suggest the following.

First, linking the findings of study 3 (Chapter 4) with theories on NPD cycle time reduction, optimal decision making also may allow a team to accelerate the FFE execution properly. Consequently, one way to improve the execution of the FFE may be to focus on applying intuition and rationality in the right temporal sequence when making (evaluation) decisions during the execution of the FFE (see managerial implications in Chapter 4) and assuring that intuition is used under the appropriate conditions in individual and team decision making (see managerial implications in Chapter 3). Since intuitive options analysis is important for faster overall FFE execution decision making, the use of this not yet commonly accepted decision making approach needs to be supported and facilitated among FFE team members.

To this end, the findings of studies 2 and 3 (Chapters 3 and 4) can be used. The favorable effects of combining rational decision making with intuition on decision making quality and speed (see Study 3) and theorizing on the capabilities of the unconscious processes behind intuition (see Study 2) may help to convince NPD professionals of the benefits of intuition use. Moreover, the findings on how best to combine intuitive and rational approaches (see Study 3) and the conceptual framework on the conditions of effective intuition use (see Study 2) can both be used to design education and training programs for FFE team members and leaders in (intuitive) decision making.

Second, other FFE management factors may impact the management of both FFE acceleration and decision making. For example, composing the FFE team of people with the suitable experiences and assigning the right leader to the team may ensure that the FFE is appropriately accelerated *and* that decisions are made in an optimal way. Also, establishing a learning culture in the FFE, i.e. learning from previous projects and learning from other functions, and ensuring goal clarity among FFE team members, may be useful for both. Moreover, the FFE execution process may have to be formalized in a way that allows individuals to follow their own intuition, that tolerates the use of intuition in team decision making, and that supports the simultaneous acceleration of the FFE.

5.6 Limitations and Further Research

In addition to the individual limitations of each study that have already been presented in Chapters 2-4, this dissertation also has overarching limitations, which offer additional opportunities for future research.

First, different research methodologies (i.e., empirical vs. conceptual) and different types of data (i.e., archival, objective data vs. experimental data) have been used for each of the three studies of this dissertation in order to answer the different types of research questions. Moreover, the studies have been conducted on different levels of analysis (i.e., project level vs. individual decision level). To draw a more empirically validated overarching conclusion on managing both, FFE acceleration and optimal FFE decision making, and the potential link between the two issues, future research should investigate the antecedents, contingency factors, interactions and consequences of FFE acceleration and optimal FFE decision making approach use with the same methodology and data type and at the same level of analysis.

Second, based on previous research findings, this dissertation has made several assumptions concerning the interrelations of FFE decision making outcome variables (i.e., FFE evaluation decision making quality and speed), FFE outcome variables (i.e., product concept creativity and FFE cycle time), and new product performance (Figure 5.1). For example, higher FFE decision making quality and higher product concept creativity are expected to be associated with increased new product performance. Future research should test these expected associations to get a better and more definite understanding of the relationships between FFE decision making outcomes, FFE outcomes, and new product performance and to validate the theorized links between the three studies of this dissertation.

Third, the findings of all studies in this dissertation are of a limited generalizability because the samples used are not representative for all companies and practitioners involved in NPD. To rule out confounding firm and industry effects, study 1 (Chapter 2) used the data of one division in a single industrial corporation. To support the development of the conceptual framework, study 2 (Chapter 3) used eight interviews with practitioners from companies in the Netherlands and in Germany. The choice to use a sample consisting only of experienced NPD professionals for study 3 (Chapter 4), resulted in a sample size of 50 participants that all work in the Netherlands. Consequently, the findings of this dissertation may not apply to different companies and different NPD practitioners in other countries and, therefore, need to be validated using larger, independent, and more international samples.

Fourth, many studies on the management of the FFE have argued and shown that the FFE needs to be managed differently for different product types (i.e., radical vs. incremental) and in different industries (i.e., software industry vs. high-tech industry) (Aagaard and Gertsen, 2011; Hannola et al., 2009; Koen, 2004). Due to the focus on one company in study 1 and due to the huge complexity of the experimental design in study 3, this dissertation has not (consistently) controlled for industry and project differences with regard to the acceleration of and the optimal decision making approach in the FFE. Finding out how to manage FFE acceleration and optimal FFE decision making and the potential link between the two issues in different industries and for different product types, would be another interesting opportunity for future research.

Finally, as outlined before, all studies in this dissertation have focused on the management of FFE execution at the project level. Since the execution of the FFE can also be managed at the platform or company (division) level, another interesting avenue for future research would be to investigate how FFE acceleration and optimal FFE execution decision making should be managed at the platform or at the company (division) level.

REFERENCES

Aagaard, A. (2012). The Contribution of Innovation Strategy Development and Implementation in Active Facilitation of Pharmaceutical Front End Innovation. *Systemic Practice and Action Research* 25(6): 457–477.

Aagaard, A. and Gertsen, F. (2011). Supporting Radical Front End Innovation : Perceived Key Factors of Pharmaceutical Innovation. *Creativity and Innovation Management* 20(4): 330–346.

Achiche, S., Appio, F.P., McAloone, T.C. and Minin, A.D. (2013). Fuzzy Decision Support for Tools Selection in the Core Front End Activities of New Product Development. *Research in Engineering Design* 24(1): 1–18.

Adams, M.E., Day, G.S. and Dougherty, D. (1998). Enhancing New Product Development Performance: An Organizational Learning Perspective. *Journal of Product Innovation Management* 15(5): 403–422.

Adams-Bigelow, M. and Griffin, A. (2005). Product Development Cycle Time and Success: New Results from PDMA's Comparative Performance Assessment Study, In: *Proceedings of the Product Development and Management Association International Conference*, San Diego, CA,

Agor, W.H. (1986). The Logic of Intuition: How Top Executives Make Important Decisions. *Organizational Dynamics* 14(3): 5–18.

Aiken, L.S. and West, S.G. (1991). *Multiple Regression: Testing and Interpreting Interactions*. Newbury Park, CA: Sage Publications.

Akgün, A.E. and Lynn, G.S. (2002). New Product Development Team Improvisation and Speed-to-Market: An Extended Model. *European Journal of Innovation Management* 5(3): 117 – 129.

Akinci, C. and Sadler-Smith, E. (2012). Intuition in Management Research: A Historical Review. *International Journal of Management Reviews* 14(1): 104–122.

Alam, I. (2006). Removing the Fuzziness From the Fuzzy Front-End of Service Innovations Through Customer Interactions. *Industrial Marketing Management* 35(4): 468–480.

Ali, A. (2000). The Impact of Innovativeness and Development Time on New Product Performance for Small Firms. *Marketing Letters* 11(2): 151–163.

Allen, A.P. and Thomas, K.E. (2011). A Dual Process Account of Creative Thinking. *Creativity Research Journal* 23(2): 109–118.

Amabile, T.M. (1983). The Social Psychology of Creativity: A Componential Conceptualization. *Journal of Personality and Social Psychology* 45(2): 357–376.

Andersen, J.A. (2000). Intuition in Managers: Are Intuitive Managers More Effective? *Journal of Managerial Psychology* 15(1): 46 – 63.

Armstrong, S. and Hird, A. (2009). Cognitive Style and Entrepreneurial Drive of New and Mature Business Owner-Managers. *Journal of Business and Psychology* 24(4): 419–430.

Artto, K., Kulvik, I., Poskela, J. and Turkulainen, V. (2011). The Integrative Role of the Project Management Office in the Front End of Innovation. *International Journal of Project Management* 29(4): 408–421.

Atuahene-Gima, K. (2005). Resolving the Capability—Rigidity Paradox in New Product Innovation. *Journal of Marketing* 69(4): 61–83.

Backman, M., Börjesson, S. and Setterberg, S. (2007). Working with Concepts in the Fuzzy Front End: Exploring the Context for Innovation for Different Types of Concepts at Volvo Cars. *R&D Management* 37(1): 17–28.

Bacon, G., Beckman, S., Mowery, D. and Wilson, E. (1994). Managing Product Definition in High-Technology Industries: A Pilot Study. *California Management Review* 36(3): 32–56.

Badke-Schaub, P., Goldschmidt, G. and Meijer, M. (2010). How Does Cognitive Conflict in Design Teams Support the Development of Creative Ideas? *Creativity and Innovation Management* 19(2): 119–134.

Bagozzi, R.P., Yi, Y. and Phillips, L.W. (1991). Assessing Construct Validity in Organizational Research. *Administrative Science Quarterly* 36(3): 421–458.

Barczak, G., Griffin, A. and Kahn, K.B. (2009). Perspective: Trends and Drivers of Success in NPD Practices: Results of the 2003 PDMA Best Practices Study. *Journal of Product Innovation Management* 26(1): 3–23.

Bard, J.F. (1990). Using Multicriteria Methods in the Early Stages of New Product Development. *Journal of the Operational Research Society* 41(8): 755–766.

Bargh, J.A., Gollwitzer, P.M., Lee-Chai, A., Barndollar, K. and Trötschel, R. (2001). The Automated Will: Nonconscious Activation and Pursuit of Behavioral Goals. *Journal of Personality and Social Psychology* 81(6): 1014–1027.

Baron, R.A. and Ensley, M.D. (2006). Opportunity Recognition as the Detection of Meaningful Patterns: Evidence from Comparisons of Novice and Experienced Entrepreneurs. *Management Science* 52(9): 1331–1344.

Basadur, M., Graen, G.B. and Green, S.G. (1982). Training in Creative Problem Solving: Effects on Ideation and Problem Finding and Solving in an Industrial Research Organization. *Organizational Behavior and Human Performance* 30(1): 41–70.

Baum, J.R. and Wally, S. (2003). Strategic Decision Speed and Firm Performance. *Strategic Management Journal* 24(11): 1107–1129.

Bayus, B.L. (2013). Crowdsourcing New Product Ideas over Time: An Analysis of the Dell IdeaStorm Community. *Management Science* 59(1): 226–244.

Bayus, B.L. (1997). Speed-to-Market and New Product Performance Trade-Offs. *Journal of Product Innovation Management* 14(6): 485–497.

Behling, O. and Eckel, N.L. (1991). Making Sense out of Intuition. *The Executive* 5(1): 46–54.

Belsley, D.A., Kuh, E. and Welsch, R.E. (1980). *Regression Diagnostics: Identifying Influential Data and Sources of Collinearity*. New York: John Wiley and Sons.

Bertels, H.M.J., Kleinschmidt, E.J. and Koen, P.A. (2011). Communities of Practice versus Organizational Climate: Which One Matters More to Dispersed Collaboration in the Front End of Innovation? *Journal of Product Innovation Management* 28(5): 757–772.

Björk, J. (2012). Knowledge Domain Spanners in Ideation. *Creativity and Innovation Management* 21(1): 17–27.

Björk, J., Boccardelli, P. and Magnusson, M. (2010). Ideation Capabilities for Continuous Innovation. *Creativity and Innovation Management* 19(4): 385–396.

Björk, J. and Magnusson, M. (2009). Where Do Good Innovation Ideas Come From? Exploring the Influence of Network Connectivity on Innovation Idea Quality. *Journal of Product Innovation Management* 26(6): 662–670.

Boeddrich, H.-J. (2004). Ideas in the Workplace: A New Approach Towards Organizing the Fuzzy Front End of the Innovation Process. *Creativity and Innovation Management* 13(4): 274–285.

Boh, W.F., Slaughter, S.A. and Espinosa, J.A. (2007). Learning from Experience in Software Development: A Multilevel Analysis. *Management Science* 53(8): 1315–1331.

Bond, E.U. and Houston, M.B. (2003). Barriers to Matching New Technologies and Market Opportunities in Established Firms. *Journal of Product Innovation Management* 20(2): 120–135.

Bonney, F.L. and Williams, B.C. (2009). From Products to Solutions: The Role of Salesperson Opportunity Recognition. *European Journal of Marketing* 43(7/8): 1032–1052.

Bono, J.E. and McNamara, G. (2011). From the Editors - Publishing in AMJ - Part 2: Research Design. *Academy of Management Journal* 54(4): 657–660.

Bos, M.W., Dijksterhuis, A. and Baaren, R.B. van (2008). On the Goal-Dependency of Unconscious Thought. *Journal of Experimental Social Psychology* 44(4): 1114–1120.

Bos, M.W., Dijksterhuis, A. and van Baaren, R.B. (2011). The Benefits of "Sleeping on Things": Unconscious Thought Leads to Automatic Weighting. *Journal of Consumer Psychology* 21(1): 4–8.

Bourgeois, L.J. and Eisenhardt, K.M. (1988). Strategic Decision Processes in High Velocity Environments: Four Cases in the Microcomputer Industry. *Management Science* 34(7): 816–835.

Bowers, K.S., Regehr, G., Balthazard, C. and Parker, K. (1990). Intuition in the Context of Discovery. *Cognitive Psychology* 22(1): 72–110.

Brem, A. and Voigt, K.-I. (2009). Integration of Market Pull and Technology Push in the Corporate Front End and Innovation Management - Insights from the German Software Industry. *Technovation* 29(5): 351–367.

De Brentani, U. and Reid, S.E. (2012). The Fuzzy Front-End of Discontinuous Innovation: Insights for Research and Management. *Journal of Product Innovation Management* 29(1): 70–87.

Brockmann, E.N. and Anthony, W.P. (1998). The Influence of Tacit Knowledge and Collective Mind on Strategic Planning. *Journal of Managerial Issues* 10(2): 204.

Brophy, D.R. (1998). Understanding, Measuring, and Enhancing Individual Creative Problem-Solving Efforts. *Creativity Research Journal* 11(2): 123–150.

Bröring, S., Cloutier, L.M. and Leker, J. (2006). The Front End of Innovation in an Era of Industry Convergence: Evidence from Nutraceuticals and Functional Foods. *R&D Management* 36(5): 487–498.

Bröring, S. and Leker, J. (2007). Industry Convergence and Its Implications for the Front End of Innovation: A Problem of Absorptive Capacity. *Creativity and Innovation Management* 16(2): 165–175.

Brown, S.L. and Eisenhardt, K.M. (1995). Product Development: Past research, Present Findings, and Future Directions. *Academy of Management Review* 20(2): 343–378.

Brown, T. (2008). Design Thinking. *Harvard Business Review* 86(6): 84–92.

Brun, E. and Sætre, A.S. (2009). Managing Ambiguity in New Product Development Projects. *Creativity and Innovation Management* 18(1): 24–34.

Burchill, G. and Fine, C.H. (1997). Time Versus Market Orientation in Product Concept Development: Empirically-Based Theory Generation. *Management Science* 43(4): 465–478.

Van Burg, E., Podoynitsyna, K., Beck, L. and Lommelen, T. (2012). Directive Deficiencies: How Resource Constraints Direct Opportunity Identification in SMEs. *Journal of Product Innovation Management* 29(6): 1000–1011.

Burke, L.A. and Miller, M.K. (1999). Taking the Mystery out of Intuitive Decision Making. *Academy of Management Executive* 13(4): 91–99.

Calantone, R.J., Di Benedetto, C.A. and Schmidt, J.B. (1999). Using the Analytic Hierarchy Process in New Product Screening. *Journal of Product Innovation Management* 16(1): 65–76.

Calantone, R.J., Vickery, S.K. and Dröge, C. (1995). Business Performance and Strategic New Product Development Activities: An Empirical Investigation. *Journal of Product Innovation Management* 12(3): 214–223.

Cankurtaran, P., Langerak, F. and Griffin, A. (2013). Consequences of New Product Development Speed: A Meta-Analysis. *Journal of Product Innovation Management* 30(3): 465–486.

Carbonell-Foulquié, P., Munuera-Alemán, J.L. and Rodríguez-Escudero, A.I. (2004). Criteria Employed for Go/No-go Decisions When Developing Successful Highly Innovative Products. *Industrial Marketing Management* 33(4): 307–316.

Chan, S.L., Ip, W.H. and Kwong, C.K. (2011). Closing the Loop Between Design and Market for New Product Idea Screening Decisions. *Expert Systems with Applications* 38(6): 7729–7737.

Chang, H., Wei, C. and Lin, R. (2008). A Model for Selecting Product Ideas in Fuzzy Front End. *Concurrent Engineering-Research and Applications* 16(2): 121–128.

Chang, S.-L., Chen, C.-Y. and Wey, S.-C. (2007). Conceptualizing, Assessing, and Managing Front-End Fuzziness in Innovation/NPD Projects. *R&D Management* 37(5): 469–478.

Chen, J., Damanpour, F. and Reilly, R.R. (2010). Understanding Antecedents of New Product Development Speed: A Meta-Analysis. *Journal of Operations Management* 28(1): 17–33.

Chen, J., Reilly, R.R. and Lynn, G.S. (2005). The Impacts of Speed-to-Market on New Product Success: The Moderating Effects of Uncertainty. *IEEE Transactions on Engineering Management* 52(2): 199–212.

Chulvi, V., González-Cruz, M.C., Mulet, E. and Aguilar-Zambrano, J. (2013). Influence of the Type of Idea-Generation Method on the Creativity of Solutions. *Research in Engineering Design* 24(1): 33–41.

Conway, H.A. and McGuinness, N.W. (1986). Idea Generation in Technology-Based Firms. *Journal of Product Innovation Management* 3(4): 276–291.

Cooper, R.G. (2008). Perspective: The Stage-Gate® Idea-to-Launch Process - Update, What's New, and NexGen Systems. *Journal of Product Innovation Management* 25(3): 213–232.

Cooper, R.G. (1988). Predevelopment Activities Determine New Product Success. *Industrial Marketing Management* 17(3): 237–247.

Cooper, R.G. and Kleinschmidt, E.J. (1986). An Investigation Into the New Product Process: Steps, Deficiencies, and Impact. *Journal of Product Innovation Management* 3(2): 71–85.

Cooper, R.G. and Kleinschmidt, E.J. (1994). Determinants of Timeliness in Product Development. *Journal of Product Innovation Management* 11(5): 381–396.

Cooper, R.G. and Kleinschmidt, E.J. (1987). New Products: What Separates Winners from Losers? *Journal of Product Innovation Management* 4(3): 169–184.

Cooper, R.G. and Kleinschmidt, E.J. (1988). Resource Allocation in the New Product Process. *Industrial Marketing Management* 17(3): 249–262.

Cordero, R. (1991). Managing for Speed To Avoid Product Obsolescence: A Survey of Techniques. *Journal of Product Innovation Management* 8(4): 283–294.

Covin, J.G., Slevin, D.P. and Heeley, M.B. (2001). Strategic Decision Making in an Intuitive vs. Technocratic Mode: Structural and Environmental Considerations. *Journal of Business Research* 52(1): 51–67.

Crawford, C.M. (1992). The Hidden Costs of Accelerated Product Development. *Journal of Product Innovation Management* 9(3): 188–199.

Crawford, C.M. and Di Benedetto, C.A. (2008). *New Product Management*. Ridge, IL: McGraw Hill Higher Education.

Creusen, M., Hultink, E.J. and Eling, K. (2013). Choice of Consumer Research Methods in the Front End of New Product Development. *International Journal of Market Research* 55(1): 81–104.

Dahan, E. and Hauser, J.R. (2001). Product Development – Managing a Dispersed Process, In: *Handbook of Marketing*, New York: Sage Publications, 179–222.

Dahl, D.W. and Moreau, P. (2002). The Influence and Value of Analogical Thinking During New Product Ideation. *Journal of Marketing Research* 39(1): 47–60.

Dane, E. and Pratt, M.G. (2009). Conceptualizing and Measuring Intuition: A Review of Recent Trends, In: *International Review of Industrial and Organizational Psychology*, Wiley-Blackwell, 1–40.

Dane, E. and Pratt, M.G. (2007). Exploring Intuition and Its Role in Managerial Decision Making. *Academy of Management Review* 32(1): 33–54.

Danneels, E. and Kleinschmidt, E.J. (2001). Product Innovativeness from the Firm's Perspective: Its Dimensions and Their Relation with Project Selection and Performance. *Journal of Product Innovation Management* 18(6): 357–373.

Dawson, J.F. and Richter, A.W. (2006). Probing Three-Way Interactions in Moderated Multiple Regression: Development and Application of a Slope Difference Test. *Journal of Applied Psychology* 91(4): 917–926.

Dayan, M. and Di Benedetto, C.A. (2011). Team Intuition as a Continuum Construct and New Product Creativity: The Role of Environmental Turbulence, Team Experience, and Stress. *Research Policy* 40(2): 276–286.

Dayan, M. and Elbanna, S. (2011). Antecedents of Team Intuition and Its Impact on the Success of New Product Development Projects. *Journal of Product Innovation Management* 28(1): 159–174.

Dean, J.W. and Sharfman, M.P. (1993). The Relationship between Procedural Rationality and Political Behavior in Strategic Decision Making. *Decision Sciences* 24(6): 1069–1083.

Dickinson, J.R. and Wilby, C.P. (1997). Concept Testing With and Without Product Trial. *Journal of Product Innovation Management* 14(2): 117–125.

Dijksterhuis, A. (2004). Think Different: The Merits of Unconscious Thought in Preference Development and Decision Making. *Journal of Personality and Social Psychology* 87(5): 586–598.

Dijksterhuis, A., Bos, M.W., Nordgren, L.F. and van Baaren, R.B. (2006). On Making the Right Choice: The Deliberation-Without-Attention Effect. *Science* 311(5763): 1005–1007.

Dijksterhuis, A. and Meurs, T. (2006). Where Creativity Resides: The Generative Power of Unconscious Thought. *Consciousness and Cognition* 15(1): 135–146.

Dijksterhuis, A. and Nordgren, L.F. (2006). A Theory of Unconscious Thought. *Perspectives on Psychological Science* 1(2): 95 –109.

Dijksterhuis, A. and van Olden, Z. (2006). On the Benefits of Thinking Unconsciously: Unconscious Thought can Increase Post-Choice Satisfaction. *Journal of Experimental Social Psychology* 42(5): 627–631.

Doerfler, V. and Ackermann, F. (2012). Understanding Intuition: The Case for Two Forms of Intuition. *Management Learning* 43(5): 545–564.

Dougherty, D., Borrelli, L., Munir, K. and O'Sullivan, A. (2000). Systems of Organizational Sensemaking for Sustained Product Innovation. *Journal of Engineering and Technology Management* 17(3-4): 321–355.

Duggan, W. (2007). *Strategic Intuition: The Creative Spark in Human Achievement*. Columbia University Press.

Duverger, P. (2012). Variety is the Spice of Innovation: Mediating Factors in the Service Idea Generation Process. *Creativity and Innovation Management* 21(1): 106–119.

Dyer, B., Gupta, A. and Wilemon, D. (1999). What First-to-Market Companies Do Differently. *Research Technology Management* 42(2): 15–21.

Eisenhardt, K. and Tabrizi, B. (1995). Accelerating Adaptive Processes: Product Innovation in the Global Computer Industry. *Administrative Science Quarterly* 40(1): 84–110.

Eisenhardt, K.M. (1989). Making Fast Strategic Decisions in High-Velocity Environments. *Academy of Management Journal* 32(3): 543–576.

Eisenhardt, K.M. and Zbaracki, M.J. (1992). Strategic Decision Making. *Strategic Management Journal* 13(S2): 17–37.

Eling, K., Griffin, A. and Langerak, F. (forthcoming). Using Intuition in Fuzzy Front End Decision Making: A Conceptual Framework. *Journal of Product Innovation Management*.

Eling, K., Langerak, F. and Griffin, A. (2013). A Stage-Wise Approach to Exploring Performance Effects of Cycle Time Reduction. *Journal of Product Innovation Management* 30(4): 626–641.

Elmquist, M. and Segrestin, B. (2007). Towards a New Logic for Front End Management: From Drug Discovery to Drug Design in Pharmaceutical R&D. *Creativity and Innovation Management* 16(2): 106–120.

Epstein, S., Pacini, R., Denes-Raj, V. and Heier, H. (1996). Individual Differences in Intuitive–Experiential and Analytical–Rational Thinking Styles. *Journal of Personality and Social Psychology* 71(2): 390–405.

Ernst, H., Hoyer, W.D. and Rübsaamen, C. (2010). Sales, Marketing, and Research-and-Development Cooperation Across New Product

Development Stages: Implications for Success. *Journal of Marketing* 74(5): 80–92.

Evans, J.S.B.T. (2008). Dual-Processing Accounts of Reasoning, Judgment, and Social Cognition. *Annual Review of Psychology* 59(1): 255–278.

Evanschitzky, H., Eisend, M., Calantone, R.J. and Jiang, Y. (2012). Success Factors of Product Innovation: An Updated Meta-Analysis. *Journal of Product Innovation Management* 29: 21–37.

Falck, A.-C. and Rosenqvist, M. (2012). What are the Obstacles and Needs of Proactive Ergonomics Measures at Early Product Development Stages? – An Interview Study in Five Swedish Companies. *International Journal of Industrial Ergonomics* 42(5): 406–415.

Fang, E. (2008). Customer Participation and the Trade-Off Between New Product Innovativeness and Speed to Market. *Journal of Marketing* 72(4): 90–104.

Finke, R.A., Ward, T.B. and Smith, S.M. (1996). *Creative Cognition: Theory, Research, and Applications*. The MIT Press.

Fleiss, J.L. (1981). *Statistical Methods for Rates and Proportions*. New York: Wiley-Interscience.

Floren, H. and Frishammar, J. (2012). From Preliminary Ideas to Corroborated Product Definitions: Managing the Front End of New Product Development. *California Management Review* 54(4): 20–43.

Frank, M., O'Reilly, R. and Curran, T. (2006). When Memory Fails, Intuition Reigns: Midazolam Enhances Implicit Inference in Humans. *Psychological Science* 17(8): 700–707.

Fredrickson, J.W. (1984). The Comprehensiveness of Strategic Decision Processes: Extension, Observations, Future Directions. *Academy of Management Journal* 27(3): 445–466.

Frishammar, J., Floren, H. and Wincent, J. (2011). Beyond Managing Uncertainty: Insights From Studying Equivocality in the Fuzzy Front End of Product and Process Innovation Projects. *IEEE Transactions on Engineering Management* 58(3): 551–563.

Frishammar, J., Lichtenthaler, U. and Richtnér, A. (2013). Managing Process Development: Key Issues and Dimensions in the Front End. *R&D Management* 43(3): 213–226.

Frishammar, J., Lichtenthaler, U. and Rundquist, J. (2012). Identifying Technology Commercialization Opportunities: The Importance of Integrating Product Development Knowledge. *Journal of Product Innovation Management* 29(4): 573–589.

Frishammar, J. and Ylinenpää, H. (2007). Managing Information in New Product Development: A Conceptual Review, Research Propositions and Tentative Model. *International Journal of Innovation Management* 11(04): 441.

García, N., Sanzo, M.J. and Trespalacios, J.A. (2008). New Product Internal Performance and Market Performance: Evidence From Spanish Firms Regarding the Role of Trust, Interfunctional Integration, and Innovation Type. *Technovation* 28(11): 713–725.

Garcia, R. and Calantone, R. (2002). A Critical Look at Technological Innovation Typology and Innovativeness Terminology: A Literature Review. *Journal of Product Innovation Management* 19(2): 110–132.

Gassmann, O., Sandmeier, P. and Wecht, C.H. (2006). Extreme Customer Innovation in the Front-End: Learning From a New Software Paradigm. *International Journal of Technology Management* 33(1): 46–66.

Glöckner, A. and Witteman, C. (2010). Beyond Dual-Process Models: A Categorisation of Processes Underlying Intuitive Judgement and Decision Making. *Thinking & Reasoning* 16(1): 1–25.

Goldenberg, J., Lehmann, D.R. and Mazursky, D. (2001). The Idea Itself and the Circumstances of Its Emergence as Predictors of New Product Success. *Management Science* 47(1): 69–84.

Gordon, S., Tarafdar, M., Cook, R., Maksimoski, R. and Rogowitz, B. (2008). Improving the Front End of Innovation with Information Technology. *Research-Technology Management* 51: 50–58.

Gore, J. and Sadler-Smith, E. (2011). Unpacking Intuition: A Process and Outcome Framework. *Review of General Psychology* 15(4): 304–316.

Griffin, A. (1997a). PDMA Research on New Product Development Practices: Updating Trends and Benchmarking Best Practices. *Journal of Product Innovation Management* 14(6): 429–458.

Griffin, A. (2002). Product Development Cycle Time for Business-to-Business Products. *Industrial Marketing Management* 31(4): 291–304.

Griffin, A. (1997b). The Effect of Project and Process Characteristics on Product Development Cycle Time. *Journal of Marketing Research* 34(1): 24–35.

Griffin, A. and Page, A.L. (1993). An Interim Report on Measuring Product Development Success and Failure. *Journal of Product Innovation Management* 10(4): 291–308.

Griffin, A., Price, R.L., Maloney, M.M., Vojak, B.A. and Sim, E.W. (2009). Voices from the Field: How Exceptional Electronic Industrial Innovators Innovate. *Journal of Product Innovation Management* 26(2): 222–240.

Griffin, A., Price, R.L. and Vojak, B.A. (2012). *Serial Innovators: How Individuals Create and Deliver Breakthrough Innovations in Mature Firms*. Stanford, California: Stanford University Press.

Griffiths-Hemans, J. and Grover, R. (2006). Setting the Stage for Creative New Products: Investigating the Idea Fruition Process. *Journal of the Academy of Marketing Science* 34(1): 27–39.

Grote, M., Herstatt, C. and Gemünden, H.G. (2012). Cross-Divisional Innovation in the Large Corporation: Thoughts and Evidence on Its Value and the Role of the Early Stages of Innovation. *Creativity and Innovation Management* 21(4): 361–375.

Gupta, A.K. and Wilemon, D.L. (1990). Accelerating The Development Of Technology-Based New Product. *California Management Review* 32(2): 24–44.

Hair, J.F., Tatham, R.L., Anderson, R.E. and Black, W. (1998). *Multivariate Data Analysis*. Upper Saddle River, NJ: Prentice Hall.

Hammedi, W., van Riel, A.C.R. and Sasovova, Z. (2011). Antecedents and Consequences of Reflexivity in New Product Idea Screening. *Journal of Product Innovation Management* 28(5): 662–679.

Hammond, K.R., Hamm, R.M., Grassia, J. and Pearson, T. (1997). Direct Comparison of the Efficacy of Intuitive and Analytical Cognition in Expert Judgment, In: *Research on Judgment and Decision Making*, Cambridge University Press,

Hannola, L., Kortelainen, S., Kärkkäinen, H. and Tuominen, M. (2009). Utilizing Front-End-of-Innovation Concepts in Software Development. *Industrial Management & Data Systems* 109(7): 898–915.

Hart, S., Hultink, E.J., Tzokas, N. and Commandeur, H.R. (2003). Industrial Companies' Evaluation Criteria in New Product Development Gates. *Journal of Product Innovation Management* 20(1): 22–36.

Harter, D.E., Krishnan, M.S. and Slaughter, S.A. (2000). Effects of Process Maturity on Quality, Cycle Time, and Effort in Software Product Development. *Management Science* 46(4): 451–466.

Hauser, J., Tellis, G.J. and Griffin, A. (2006). Research on Innovation: A Review and Agenda for Marketing Science. *Marketing Science* 25(6): 687–717.

Heerkens, H. (2006). Assessing the Importance of Factors Determining Decision-Making by Actors Involved in Innovation Processes. *Creativity and Innovation Management* 15(4): 385–399.

Heller, T. (2000). "If Only We'd Known Sooner:" Developing Knowledge of Organizational Changes Earlier in the Product Development Process. *IEEE Transactions on Engineering Management* 47(3): 335–344.

Henard, D.H. and Szymanski, D.M. (2001). Why Some New Products are More Successful Than Others. *Journal of Marketing Research* 38(3): 362–375.

Herstatt, C., Verworn, B. and Nagahira, A. (2006). Reducing Project Related Uncertainty in the "Fuzzy Front End" of Innovation — A Comparison of German and Japanese Product Innovation Projects, In: *Management of Technology and Innovation in Japan*, Springer Berlin Heidelberg, 329–352.

Hodgkinson, G.P., Langan-Fox, J. and Sadler-Smith, E. (2008). Intuition: A Fundamental Bridging Construct in the Behavioural Sciences. *British Journal of Psychology (London, England: 1953)* 99(1): 1–27.

Hodgkinson, G.P., Sadler-Smith, E., Burke, L.A., Claxton, G. and Sparrow, P.R. (2009). Intuition in Organizations: Implications for Strategic Management. *Long Range Planning* 42(3): 277–297.

Hogarth, R.M. (2001). *Educating Intuition*. University Of Chicago Press.

Hohenegger, J., Bufardi, A. and Xirouchakis, P. (2008). Compatibility Knowledge in Fuzzy Front End, In: *Methods and Tools for Effective Knowledge Life-Cycle-Management*, Springer Berlin Heidelberg, 243–258.

Howard, T.J., Dekoninck, E.A. and Culley, S.J. (2010). The Use of Creative Stimuli at Early Stages of Industrial Product Innovation. *Research in Engineering Design* 21(4): 263–247.

Howell, J. and Shea, C. (2001). Individual Differences, Environmental Scanning, Innovation Framing, and Champion Behavior: Key Predictors of Project Performance. *Journal of Product Innovation Management* 18(1): 15–27.

Hultink, E.J., Griffin, A., Hart, S. and Robben, H.S.J. (1997). Industrial New Product Launch Strategies and Product Development Performance. *Journal of Product Innovation Management* 14(4): 243–257.

Huynh, V.-N. and Nakamori, Y. (2009). A Linguistic Screening Evaluation Model in New Product Development. *IEEE Transactions on Engineering Management* PP(99): 1–11.

Im, S., Montoya, M.M. and Workman, J.P. (2013). Antecedents and Consequences of Creativity in Product Innovation Teams. *Journal of Product Innovation Management* 30(1): 170–185.

Im, S. and Workman, J.P.J. (2004). Market Orientation, Creativity, and New Product Performance in High-Technology Firms. *Journal of Marketing* 68(2): 114–132.

Kahneman, D. and Klein, G. (2009). Conditions for Intuitive Expertise: A Failure to Disagree. *The American Psychologist* 64(6): 515–526.

Kahraman, C., Buyukozkan, G. and Ates, N. (2007). A Two Phase Multi-Attribute Decision-Making Approach For New Product Introduction. *Information Science* 177(7): 1567–1582.

Karagozoglu, N. and Brown, W.B. (1993). Time-Based Management of the New Product Development Process. *Journal of Product Innovation Management* 10(3): 204–215.

Kerin, R.A., Varadarajan, P.R. and Peterson, R.A. (1992). First-Mover Advantage: A Synthesis, Conceptual Framework, and Research Propositions. *Journal of Marketing* 56(4): 33–52.

Kessler, E.H. and Bierly, III, P.E. (2002). Is Faster Really Better? An Empirical Test of the Implications of Innovation Speed. *IEEE Transactions on Engineering Management* 49(1): 2–12.

Kessler, E.H. and Chakrabarti, A.K. (1996). Innovation Speed: A Conceptual Model of Context, Antecedents, and Outcomes. *Academy of Management Review* 21(4): 1143–1191.

Kessler, E.H. and Chakrabarti, A.K. (1999). Speeding Up the Pace of New Product Development. *Journal of Product Innovation Management* 16(3): 231–247.

Kester, L. (2011). New Product Development Portfolios - Identifying the Antecedents and Consequences of Decision-Making Processes. Doctoral dissertation. The Netherlands: Delft University of Technology.

Khatri, N. and Ng, H.A. (2000). The Role of Intuition in Strategic Decision Making. *Human Relations* 53(1): 57 –86.

Khurana, A. and Rosenthal, S.R. (1997). Integrating the Fuzzy Front End of New Product Development. *Sloan Management Review* 38(2): 103–120.

Khurana, A. and Rosenthal, S.R. (1998). Towards Holistic "Front Ends" in New Product Development. *Journal of Product Innovation Management* 15(1): 57–74.

Kihlander, I. and Ritzén, S. (2012). Compatibility Before Completeness—Identifying Intrinsic Conflicts in Concept Decision Making for Technical Systems. *Technovation* 32(2): 79–89.

Kihlstrom, J. (1987). The Cognitive Unconscious. *Science* 237(4821): 1445–1452.

Kijkuit, B. and van den Ende, J. (2007). The Organizational Life of an Idea: Integrating Social Network, Creativity and Decision-Making Perspectives. *Journal of Management Studies* 44(6): 863–882.

Kim, J. and Wilemon, D. (2010). Accelerating the Fuzzy Front-End of NPD Projects: Methods and Management. *International Journal of Engineering Management and Economics* 1(1): 80 – 101.

Kim, J. and Wilemon, D. (2002a). Focusing the Fuzzy Front-End in New Product Development. *R&D Management* 32(4): 269–279.

Kim, J. and Wilemon, D. (2002b). Strategic Issues in Managing Innovation's Fuzzy Front-End. *European Journal of Innovation Management* 5(1): 27–39.

Koch, R. and Leitner, K.-H. (2008). The Dynamics and Functions of Self-Organization in the Fuzzy Front End: Empirical Evidence from the Austrian Semiconductor Industry. *Creativity and Innovation Management* 17(3): 216–226.

Koen, P., Ajamian, G., Burkart, R., Clamen, A., Davidson, J., D'Amore, R., Elkins, C., Herald, K., Incorvia, M., Johnson, A., Karol, R., Seibert, R., Slavejkov, A. and Wagner, K. (2001). Providing Clarity and a Common

Language to the "Fuzzy Front End." *Research-Technology Management* 44: 46–55.

Koen, P.A. (2004). The Fuzzy Front End for Incremental, Platform, and Breakthrough Products, In: *The PDMA Handbook of New Product Development*, Hoboken, NJ, USA: John Wiley & Sons, Inc., 81–91.

Koen, P.A., Ajamian, G.M., Boyce, S., Clamen, A., Fisher, E., Fountoulakis, S., Johnson, A., Puri, P. and Seibert, R. (2002). Fuzzy Front End: Effective Methods, Tools, and Techniques, In: *The PDMA Toolbook for New Product Development*, New York: John Wiley & Sons, Inc., 6–35.

Kohli, R., Lehmann, D.R. and Pae, J. (1999). Extent and Impact of Incubation Time in New Product Diffusion. *Journal of Product Innovation Management* 16(2): 134–144.

Kohn, K. (2005). Idea Generation in New Product Development Through Business Environmental Scanning: The Case of XCar. *Marketing Intelligence & Planning* 23(7): 688–704.

Kohn, K. (2006). Managing the Balance of Perspectives in the Early Phase of NPD: A Case Study From the Automotive Industry. *European Journal of Innovation Management* 9(1): 44–60.

Kornish, L.J. and Ulrich, K.T. (2011). Opportunity Spaces in Innovation: Empirical Analysis of Large Samples of Ideas. *Management Science* 57(1): 107–128.

Kristensson, P. and Magnusson, P.R. (2010). Tuning Users' Innovativeness During Ideation. *Creativity and Innovation Management* 19(2): 147–159.

Kudrowitz, B.M. and Wallace, D. (2013). Assessing the Quality of Ideas From Prolific, Early-Stage Product Ideation. *Journal of Engineering Design* 24(2): 120–139.

Kurkkio, M., Frishammar, J. and Lichtenthaler, U. (2011). Where Process Development Begins: A Multiple Case Study of Front End Activities in Process Firms. *Technovation* 31(9): 490–504.

Langan-Fox, J. and Shirley, D. (2003). The Nature and Measurement of Intuition: Cognitive and Behavioral Interests, Personality, and Experiences. *Creativity Research Journal* 15(2-3): 207–222.

Langerak, F. and Hultink, E.J. (2005). The Impact of New Product Development Acceleration Approaches on Speed and Profitability:

Lessons for Pioneers and Fast Followers. *IEEE Transactions on Engineering Management* 52(1): 30–42.

Langerak, F. and Hultink, E.J. (2006). The Impact of Product Innovativeness on the Link between Development Speed and New Product Profitability. *Journal of Product Innovation Management* 23(3): 203–214.

Langerak, F., Hultink, E.J. and Griffin, A. (2008). Exploring Mediating and Moderating Influences on the Links among Cycle Time, Proficiency in Entry Timing, and New Product Profitability. *Journal of Product Innovation Management* 25(4): 370–385.

Langerak, F., Hultink, E.J. and Robben, H.S.J. (2004). The Role of Predevelopment Activities in the Relationship Between Market Orientation and Performance. *R&D Management* 34(3): 295–309.

Langerak, F., Rijsdijk, S. and Dittrich, K. (2009). Development Time and New Product Sales: A Contingency Analysis of Product Innovativeness and Price. *Marketing Letters* 20(4): 399–413.

Lettl, C., Hienerth, C. and Gemuenden, H.G. (2008). Exploring How Lead Users Develop Radical Innovation: Opportunity Recognition and Exploitation in the Field of Medical Equipment Technology. *IEEE Transactions on Engineering Management* 55(2): 219–233.

Levine, G.M., Halberstadt, J.B. and Goldstone, R.L. (1996). Reasoning and the Weighting of Attributes in Attitude Judgments. *Journal of Personality and Social Psychology* 70(2): 230–240.

Li, H. and Atuahene-Gima, K. (1999). Marketing's Influence and New Product Performance in Chinese Firms. *Journal of International Marketing* 7(1): 34–56.

Lieberman, M.D. (2000). Intuition: A Social Cognitive Neuroscience Approach. *Psychological Bulletin* 126(1): 109–137.

Lin, C.-T. and Chen, C.-T. (2004a). A Fuzzy-Logic-Based Approach for New Product Go/NoGo Decision at the Front End. *IEEE Transactionson Systems, Man, and Cybernetics* 34(1): 132–142.

Lin, C.-T. and Chen, C.-T. (2004b). New Product Go/No-Go Evaluation at the Front End: A Fuzzy Linguistic Approach. *IEEE Transactions on Engineering Management* 51(2): 197–207.

Lindgren, L.M. and O'Connor, G.C. (2011). The Role of Future-Market Focus in the Early Stages of NPD across Varying Levels of Innovativeness. *Journal of Product Innovation Management* 28(5): 787–800.

Locke, E.A., Shaw, K.N., Saari, L.M. and Latham, G.P. (1981). Goal Setting and Task Performance: 1969–1980. *Psychological Bulletin* 90(1): 125–152.

Lubart, T. (2001). Models of the Creative Process: Past, Present and Future. *Creativity Research Journal* 13(3): 295–308.

Lukas, B.A. and Brodowsky, G.H. (1998). Successful Invention Management: Formalizing the Generation and Validation of New Product Ideas. *Competitive Intelligence Review* 9(4): 20–28.

Lynn, G.S., Skov, R.B. and Abel, K.D. (1999). Practices that Support Team Learning and Their Impact on Speed to Market and New Product Success. *Journal of Product Innovation Management* 16(5): 439–454.

Markham, S., Ward, S., Aiman-Smith, L. and Kingon, A. (2010). The Valley of Death as Context for Role Theory in Product Innovation. *Journal of Product Innovation Management* 27(3): 402–417.

Markham, S.K. and Lee, H. (2013). Product Development and Management Association's 2012 Comparative Performance Assessment Study. *Journal of Product Innovation Management* 30(3): 408–429.

Martinsuo, M. and Poskela, J. (2011). Use of Evaluation Criteria and Innovation Performance in the Front End of Innovation. *Journal of Product Innovation Management* 28(6): 896–914.

McAdams, R. and Leonard, D. (2004). Reengineering Based Inquiry Into Innovation in the Front End of New Product and Service Development Processes. *International Journal of Product Development* 1(1): 66–91.

Menon, A., Chowdhury, J. and Lukas, B.A. (2002). Antecedents and Outcomes of New Product Development Speed: An Interdisciplinary Conceptual Framework. *Industrial Marketing Management* 31(4): 317–328.

Meyer, M.H. and Utterback, J.M. (1995). Product Development Cycle Time and Commercial Success. *IEEE Transactions on Engineering Management* 42(4): 297–304.

Miller, C.C. and Ireland, R.D. (2005). Intuition in Strategic Decision Making: Friend or Foe in the Fast-Paced 21st Century? *Academy of Management Executive* 19(1): 19–30.

Millson, M.R., Raj, S.P. and Wilemon, D. (1992). A Survey of Major Approaches for Accelerating New Product Development. *Journal of Product Innovation Management* 9(1): 53–69.

Mintzberg, H., Raisinghani, D. and Théorêt, A. (1976). The Structure of "Unstructured" Decision Processes. *Administrative Science Quarterly* 21(2): 246–275.

Moenaert, R.K., De Meyer, A., Souder, W.E. and Deschoolmeester, D. (1995). R&D/Marketing Communication During the Fuzzy Front-End. *IEEE Transactions on Engineering Management* 42(3): 243–258.

Montoya-Weiss, M.M. and Calantone, R. (1994). Determinants of New Product Performance: A Review and Meta-Analysis. *Journal of Product Innovation Management* 11(5): 397–417.

Montoya-Weiss, M.M. and O'Driscoll, T.M. (2000). From Experience: Applying Performance Support Technology in the Fuzzy Front End. *Journal of Product Innovation Management* 17(2): 143–161.

Moorman, C. and Miner, A.S. (1997). The Impact of Organizational Memory on New Product Performance and Creativity. *Journal of Marketing Research* 34(1): 91–106.

Murmann, P.A. (1994). Expected Development Time Reductions in the German Mechanical Engineering Industry. *Journal of Product Innovation Management* 11(3): 236–252.

Murphy, S.A. and Kumar, V. (1997). The Front End of New Product Development: A Canadian Survey. *R&D Management* 27(1): 5–15.

Murphy, S.A. and Kumar, V. (1996). The Role of Predevelopment Activities and Firm Attributes in New Product Success. *Technovation* 16(8): 431–449.

Naveh, E. (2007). Formality and Discretion in Successful R&D Projects. *Journal of Operations Management* 25(1): 110–125.

Nederveen Pieterse, A., van Knippenberg, D. and van Ginkel, W.P. (2011). Diversity in Goal Orientation, Team Reflexivity, and Team Performance. *Organizational Behavior and Human Decision Processes* 114(2): 153–164.

Nobelius, D. and Trygg, L. (2002). Stop Chasing the Front End Process - Management of the Early Phases in Product Development Projects. *International Journal of Project Management* 20(5): 331–340.

Noyes, J.M., Starr, A.F. and Frankish, C.R. (1996). User Involvement in the Early Stages of the Development of an Aircraft Warning System. *Behaviour & Information technology* 15(2): 67–75.

O'Connor, G.C. and Rice, M.P. (2001). Opportunity Recognition and Breakthrough Innovation in Large Established Firms. *California Management Review* 43(2): 95–116.

Oliveira, M.G. and Rozenfeld, H. (2010). Integrating Technology Roadmapping and Portfolio Management at the Front-End of New Product Development. *Technological Forecasting and Social Change* 77(8): 1339–1354.

Olson, E.M., Walker, O.C. and Ruekert, R.W. (1995). Organizing for Effective New Product Development: The Moderating Role of Product Innovativeness. *Journal of Marketing* 59(1): 48–62.

Onarheim, B. and Christensen, B.T. (2012). Distributed Idea Screening in Stage–Gate Development Processes. *Journal of Engineering Design* 23(9): 660–673.

Van Oorschot, K.E., Langerak, F. and Sengupta, K. (2011). Escalation, De-escalation, or Reformulation: Effective Interventions in Delayed NPD Projects. *Journal of Product Innovation Management* 28(6): 848–867.

Park, M.H.-J., Lim, J.W. and Birnbaum-More, P.H. (2009). The Effect of Multiknowledge Individuals on Performance in Cross-Functional New Product Development Teams. *Journal of Product Innovation Management* 26(1): 86–96.

Pavia, T.M. (1991). The Early Stages of New Product Development in Entrepreneurial High-Tech Firms. *Journal of Product Innovation Management* 8(1): 18–31.

Poetz, M.K. and Schreier, M. (2012). The Value of Crowdsourcing: Can Users Really Compete with Professionals in Generating New Product Ideas? *Journal of Product Innovation Management* 29(2): 245 – 256.

Policastro, E. (1995). Creative Intuition: An Integrative Review. *Creativity Research Journal* 8(2): 99–113.

Poskela, J. and Martinsuo, M. (2009). Management Control and Strategic Renewal in the Front End of Innovation. *Journal of Product Innovation Management* 26(6): 671–684.

Prather, C.W. (2000). Keeping Innovation Alive After the Consultants Leave. *Research-Technology Management* 43: 17–22.

Pretz, J.E. and Totz, K.S. (2007). Measuring Individual Differences in Affective, Heuristic, and Holistic Intuition. *Personality and Individual Differences* 43(5): 1247–1257.

Rauniar, R., Doll, W., Rawski, G. and Hong, P. (2008). The Role of Heavyweight Product Manager in New Product Development. *International Journal of Operations & Production Management* 28(2): 130–154.

Reid, S.E. and de Brentani, U. (2012). Market Vision and the Front End of NPD for Radical Innovation: The Impact of Moderating Effects. *Journal of Product Innovation Management* 29: 124–139.

Reid, S.E. and de Brentani, U. (2004). The Fuzzy Front End of New Product Development for Discontinuous Innovations: A Theoretical Model. *Journal of Product Innovation Management* 21(3): 170–184.

Reinertsen, D. (1994). Streamlining the Fuzzy Front-End. *World Class Design to Manufacture* 1: 4–8.

Reinertsen, D.G. (1999). Taking the Fuzziness Out of the Fuzzy Front End. *Research-Technology Management* 42: 25–31.

Rice, M., Kelley, D., Peters, L. and O'Connor, G. (2001). Radical Innovation: Triggering Initiation of Opportunity Recognition and Evaluation. *R&D Management* 31(4): 409–420.

Van Riel, A.C.R., Semeijn, J., Hammedi, W. and Henseler, J. (2011). Technology-Based Service Proposal Screening and Decision-Making Effectiveness. *Management Decision* 49(5): 762–783.

Rochford, L. (1991). Generating and Screening New Product Ideas. *Industrial Marketing Management* 20(4): 287–296.

Rosenthal, S.R. and Capper, M. (2006). Ethnographies in the Front End: Designing for Enhanced Customer Experiences. *Journal of Product Innovation Management* 23(3): 215–237.

Russell, R.K. and Tippett, D.D. (2008). Critical Success Factors for the Fuzzy Front End of Innovation in the Medical Device Industry. *Engineering Management Journal* 20(3): 36–43.

Rust, R.T. and Cooil, B. (1994). Reliability Measures for Qualitative Data: Theory and Implications. *Journal of Marketing Research* 31(1): 1–14.

Sadler-Smith, E. (2004). Cognitive Style and the Management of Small and Medium-Sized Enterprises. *Organization Studies* 25(2): 155–181.

Sadler-Smith, E. and Shefy, E. (2004). The Intuitive Executive: Understanding and Applying Gut Feel in Decision-Making. *Academy of Management Executive* 18(4): 76–91.

Schirr, G.R. (2012). Flawed Tools: The Efficacy of Group Research Methods to Generate Customer Ideas. *Journal of Product Innovation Management* 29(3): 473–488.

Schröder, H.-H. and Jetter, A.J.M. (2003). Integrating Market and Technological Knowledge in the Fuzzy Front End: An FCM-Based Action Support System. *International Journal of Technology Management* 26(5/6): 517 – 539.

Schuhmacher, M. and Kuester, S. (2012). Identification of Lead User Characteristics Driving the Quality of Service Innovation Ideas. *Creativity and Innovation Management* 21(4): 427–442.

Schweitzer, F.M., Buchinger, W., Gassmann, O. and Obrist, M. (2012). Crowdsourcing: Leveraging Innovation through Online Idea Competitions. *Research-Technology Management* 55(3): 32–38.

Seidel, V.P. (2007). Concept Shifting and the Radical Product Development Process. *Journal of Product Innovation Management* 24(6): 522–533.

Sethi, R., Smith, D.C. and Park, C.W. (2001). Cross-functional Product Development Teams, Creativity, and the Innovativeness of New Consumer Products. *Journal of Marketing Research* 38(1): 73–85.

Shapiro, S. and Spence, M.T. (1997). Managerial Intuition: A Conceptual and Operational Framework. *Business Horizons* 40(1): 63–68.

Shirley, D. and Langan-Fox, J. (1996). Intuition: A Review of the Literature. *Psychological Reports* 79(2): 563–584.

Sim, E.W., Griffin, A., Price, R.L. and Vojak, B.A. (2007). Exploring Differences between Inventors, Champions, Implementers and Innovators in Creating and Developing New Products in Large, Mature Firms. *Creativity and Innovation Management* 16(4): 422–436.

Simms, C. and Trott, P. (2010). Packaging Development: A Conceptual Framework for Identifying New Product Opportunities. *Marketing Theory* 10(4): 397–415.

Simon, H.A. (1987). Making Management Decisions: The Role of Intuition and Emotion. *Academy of Management Executive* 1(1): 57–64.

Sinclair, M. (2011). An Integrated Framework of Intuition, In: *Handbook of Intuition Research*, Edward Elgar Publishing, Inc., 3–16.

Sinclair, M. (2010). Misconceptions About Intuition. *Psychological Inquiry* 21: 378–386.

Sinclair, M. and Ashkanasy, N.M. (2005). Intuition: Myth or Decision-Making Tool? *Management Learning* 36(3): 353 –370.

Sivadas, E. and Dwyer, F.R. (2000). An Examination of Organizational Factors Influencing New Product Success in Internal and Alliance-Based Processes. *Journal of Marketing* 64(1): 31–49.

Sivasubramaniam, N., Liebowitz, S.J. and Lackman, C.L. (2012). Determinants of New Product Development Team Performance: A Meta-analytic Review. *Journal of Product Innovation Management* 29(5): 803–820.

Smith, G.R., Herbein, W.C. and Morris, R.C. (1999). Front-End Innovation at AlliedSignal and Alcoa. *Research-Technology Management* 42: 15–24.

Smith, P.G. (1999). From Experience: Reaping Benefit from Speed to Market. *Journal of Product Innovation Management* 16(3): 222–230.

Smith, P.G. and Reinertsen, D.G. (1997). *Developing Products in Half the Time: New Rules, New Tools, 2nd Edition*. New York: Wiley.

Song, X.M. and Montoya-Weiss, M.M. (1998). Critical Development Activities for Really New Versus Incremental Products. *Journal of Product Innovation Management* 15(2): 124–135.

Song, X.M., Souder, W.E. and Dyer, B. (1997). A Causal Model of the Impact of Skills, Synergy, and Design Sensitivity on New Product Performance. *Journal of Product Innovation Management* 14(2): 88–101.

Soukhoroukova, A., Spann, M. and Skiera, B. (2012). Sourcing, Filtering, and Evaluating New Product Ideas : An Empirical Exploration of the Performance of Idea Markets. *Journal of Product Innovation Management* 29(1): 100–112.

Stanovich, K.E. and West, R.F. (2000). Individual Differences in Reasoning: Implications for the Rationality Debate? *The Behavioral and Brain Sciences* 23(5): 645–726.

Stevens, G. and Burley, J. (2003). Piloting the Rocket of Radical Innovation. *Research-Technology Management* 46(2): 16–25.

Stevens, G., Burley, J. and Divine, R. (1999). Creativity + Business Discipline = Higher Profits Faster From New Product Development. *Journal of Product Innovation Management* 16(5): 455–468.

Stockstrom, C. and Herstatt, C. (2008). Planning and Uncertainty in New Product Development. *R&D Management* 38(5): 480–490.

Strick, M., Dijksterhuis, A. and Baaren, R.B. van (2010). Unconscious-Thought Effects Take Place Off-Line, Not On-Line. *Psychological Science* 21(4): 484–488.

Strick, M., Dijksterhuis, A., Bos, M.W., Sjoerdsma, A. and Baaren, R.B. van (2011). A Meta-Analysis on Unconscious Thought Effects. *Social Cognition* 29(6): 738–762.

Swink, M. (2003). Completing Projects On-Time: How Project Acceleration Affects New Product Development. *Journal of Engineering and Technology Management* 20(4): 319–344.

Tassoul, M. and Buijs, J. (2007). Clustering: An Essential Step from Diverging to Converging. *Creativity and Innovation Management* 16(1): 16–26.

Thomke, S. and Fujimoto, T. (2000). The Effect of "Front-Loading" Problem-Solving on Product Development Performance. *Journal of Product Innovation Management* 17(2): 128–142.

Toubia, O. (2006). Idea Generation, Creativity, and Incentives. *Marketing Science* 25(5): 411–425.

Troy, L., Hirunyawipada, T. and Paswan, A. (2008). Cross-Functional Integration and New Product Success: An Empirical Investigation of the Findings. *Journal of Marketing* 72(6): 132–146.

Troy, L.C., Szymanski, D.M. and Varadarajan, P.R. (2001). Generating New Product Ideas: An Initial Investigation of the Role of Market Information and Organizational Characteristics. *Journal of the Academy of Marketing Science* 29(1): 89–101.

Urban, G.L. and Hauser, J.R. (2004). "Listening In" to Find and Explore New Combinations of Customer Needs. *Journal of Marketing* 68(2): 72–87.

Veldhuizen, E., Hultink, E.J. and Griffin, A. (2006). Modeling Market Information Processing in New Product Development: An Empirical Analysis. *Journal of Engineering and Technology Management* 23(4): 353–373.

Verganti, R. (1997). Leveraging on Systemic Learning to Manage the Early Phases of Product Innovation Projects. *R&D Management* 27(4): 377–392.

Verganti, R. (1999). Planned Flexibility: Linking Anticipation and Reaction in Product Development Projects. *Journal of Product Innovation Management* 16(4): 363–376.

Verworn, B. (2009). A Structural Equation Model of the Impact of the "Fuzzy Front End" on the Success of New Product Development. *Research Policy* 38(10): 1571–1581.

Verworn, B. (2006). How German Measurement and Control Firms Integrate Market and Technological Knowledge into the Front End of New Product Development. *International Journal of Technology Management* 34(3): 379–389.

Verworn, B., Herstatt, C. and Nagahira, A. (2008). The Fuzzy Front End of Japanese New Product Development Projects: Impact on Success and Differences Between Incremental and Radical Projects. *R&D Management* 38(1): 1–19.

Veryzer, R.W. (1998). Discontinuous Innovation and the New Product Development Process. *Journal of Product Innovation Management* 15(4): 304–321.

Wallas, G. (1926). *The Art of Thought*. New York: Harcourt Brace.

Wally, S. and Baum, J.R. (1994). Personal and Structural Determinants of the Pace of Strategic Decision Making. *Academy of Management Journal* 37(4): 932–956.

West, M.A. (2002). Sparkling Fountains or Stagnant Ponds: An Integrative Model of Creativity and Innovation Implementation in Work Groups. *Applied Psychology* 51(3): 355–387.

Westerski, A., Dalamagas, T. and Iglesias, C.A. (2013). Classifying and Comparing Community Innovation in Idea Management Systems. *Decision Support Systems* 54(3): 1316–1326.

Williams, M.A., Kochhar, A.K. and Tennant, C. (2007). An Object-Oriented Reference Model of the Fuzzy Front End of the New Product Introduction Process. *International Journal of Advanced Manufacturing Technology* 34(7-8): 826–841.

Wilson, T.D. and Schooler, J.W. (1991). Thinking Too Much: Introspection Can Reduce the Quality of Preferences and Decisions. *Journal of Personality and Social Psychology* 60(2): 181–192.

Witell, L., Kristensson, P., Gustafsson, A. and Löfgren, M. (2011). Idea Generation: Customer Co-Creation Versus Traditional Market Research Techniques. *Journal of Service Management* 22(2): 140–159.

Wu, S.-C. and Fang, W. (2010). The Effect of Consumer-to-Consumer Interactions on Idea Generation in Virtual Brand Community Relationships. *Technovation* 30(11–12): 570–581.

Yang, H., Chattopadhyay, A., Zhang, K. and Dahl, D.W. (2012). Unconscious Creativity: When Can Unconscious Thought Outperform Conscious Thought? *Journal of Consumer Psychology* 22(4): 573–581.

Zahay, D., Griffin, A. and Fredericks, E. (2011). Information Use in New Product Development: An Initial Exploratory Empirical Investigation in the Chemical Industry. *Journal of Product Innovation Management* 28(4): 485–502.

Zahay, D., Griffin, A. and Fredericks, E. (2004). Sources, Uses, and Forms of Data in the New Product Development Process. *Industrial Marketing Management* 33(7): 657–666.

Zehir, C. and Ozsahin, M. (2008). A Field Research on the Relationship Between Strategic Decision-Making Speed and Innovation Performance in the Case of Turkish Large-Scale Firms. *Management Decision* 46(5-6): 709–724.

Zhang, Q. and Doll, W.J. (2001). The Fuzzy Front End and Success of New Product Development: A Causal Model. *European Journal of Innovation Management* 4(2): 95–112.

Zien, K.A. and Buckler, S.A. (1997). Dreams to Market: Crafting a Culture of Innovation. *Journal of Product Innovation Management* 14: 274–287.

Zirger, B. and Hartley, J. (1994). A Conceptual-Model of Product Development Cycle Time. *Journal of Engineering and Technology Management* 11(3-4): 229–251.

Zirger, B. and Hartley, J. (1996). The Effect of Acceleration Techniques on Product Development Time. *IEEE Transactions on Engineering Management* 43(2): 143–152.

APPENDIX 1

For the development of the conceptual framework in study 2 (Chapter 3) a review of the literatures on intuition was conducted that lead to the definition of intuition as a seemingly unsubstantiated attitude resulting from unconscious processing. The overview table in this Appendix 1 shows that most intuition scholars agree on these two parts of this definition, i.e., that intuition is (i) the outcome of unconscious processing, and (ii) a seemingly unsubstantiated attitude.

APPENDIX 1

Reference	Intuition is the Outcome of Unconscious Processing	Intuition is a Seemingly Unsubstantiated Attitude
Agor (1986)	The steps of the process of intuition are hidden in the subconscious.	Intuition described as a sense of excitement, commitment, or harmony, or, when a decision alternative was wrong as a sense of anxiety, or discomfort.
Behling and Eckel (1991)	Intuition occurs at the unconscious level of the mind (=making choices without obvious formal analysis), while analysis occurs at the conscious level.	
Bowers et al. (1990)		The coherence that leads to an intuition is not consciously accessible at the moment of the intuition. Experiencing an intuition means having a 'tacit or implicit perception of coherence' (p. 74).
Burke and Miller (1999)	Intuitive decisions are subconscious mental processes that happen automatically while conscious processes are disengaged.	Intuition is based on feelings or emotions.
Dane and Pratt (2009)	Intuitions result from information processing in the non-conscious system.	Intuitions involve a feeling that is not consciously or logically accessible or explainable.
Dane and Pratt (2007)	One central aspect of definitions of intuition is that intuitive processing is nonconscious, which means that it occurs outside of conscious thought. The authors explicitly distinguish the process, i.e. intuiting, from the outcome, i.e. intuitive judgment.	There is agreement among intuition researchers that intuition is an affectively charged judgment that is clearly accessible by the conscious mind, but distinct from insight, which is a sudden, unexpected solution to a problem.
Dijksterhuis and Nordgren (2006)	Intuition 'may be the result of extensive unconscious thought' (p. 106). 'Intuitions are the summary judgments the unconscious provides when it is ready to decide' (p. 106).	Experiencing an intuition means feeling that something is right or wrong. Reasons for an intuition are not verbalizable.
Epstein et al. (1996)	Provide evidence for the existence of two fundamentally different modes of processing information: the 'Experiential system' (i.e., intuitive system), which operates at the preconscious level, and the 'Rational system', which operates at the conscious level.	Experiential system (i.e., intuitive system): 'pleasure-pain' oriented (what feels good) - rational system: reason oriented (what is rational).

Reference	Intuition is the Outcome of Unconscious Processing	Intuition is a Seemingly Unsubstantiated Attitude
Glöckner and Witteman (2010)	Intuition is based on automatic (unconscious) processes that rely on knowledge acquired through learning.	The result of unconscious processing (i.e., new interpretations of information) enters awareness as a feeling to choose one option.
Gore and Sadler-Smith (2011)	Classify intuition as outcome of a System 1 process, which allows judgment in the absence of conscious reasoning. Intuition is neither an automatic operation nor deliberate reasoning, but comes to mind as a preferences without reflection.	The unconscious sends positively or negatively loaded (affective) signals to influence and direct conscious decision making of varying intensity.
Hammond et al. (1997)	When using intuition, cognitive control and conscious awareness are low (in contrast to when using analysis where both are high).	Using intuition means having a high confidence in the answer.
Hodgkinson et al. (2008)	Consensus exists that two parallel information processing systems can be distinguished (i.e., System 1 and System 2) supported by evidence from social cognitive neuroscience studies. Intuition is the end-product of unconscious, implicit System 1 processes.	Intuition can be experienced as 'hunch', 'gut feel', 'a sense of calling', or 'overpowering certainty'. Experiencing an intuition means having no conscious awareness of the process behind it.
Hodgkinson et al. (2009)	There is a common agreement about the existence of two human processing systems (i.e., System 1 processes operate beyond conscious awareness and System 2 processes require attention). Intuition is based on non-conscious associations.	Intuition comes to mind as an aura of rightness or plausibility but without clearly articulated reasons or justifications; 'knowing without knowing why' (p. 279). Intuition allows to identify an appropriate course of action without being able to articulate the reasons as to why this course of action is appropriate.
Kahneman and Klein (2009)	'Intuitive judgments are produced by "System 1 operations"' (p. 519)	Intuitive judgments come to mind 'without explicit awareness of the evoking cues and (…) without an explicit evaluation of the validity of these cues.' (p. 519)
Khatri and Ng (2000)	Intuition draws on the knowledge that is available in the subconscious.	Experiencing an intuition means experiencing a 'gut-feeling'.
Langan-Fox and Shirley (2003)	Intuitive processing is described as 'implicit processing'. Some aspects of the tasks that intuition is used for are 'relatively nonconscious'.	Common signals of an intuition can be 'a sense of peacefulness' or 'anxiety, an upset stomach, and mixed or conflicting feelings' (p. 220).

APPENDIX 1

Reference	Intuition is the Outcome of Unconscious Processing	Intuition is a Seemingly Unsubstantiated Attitude
Miller and Ireland (2005)	Intuition results from a 'subconscious synthesis of information drawn from diverse experiences'. (p. 21)	The experience of an intuition as 'gut feeling' or 'a choice that feels right'. Insights and understandings on which intuition is based are not known to the decision maker.
Pretz and Trotz (2007)	View intuition as a product of the tacit system.	The logical steps behind intuitive judgment cannot be articulated and are not transparent.
Sadler-Smith and Shefy (2004)		Intuition described as knowing or understanding without the apparent intrusion of rational thought or logical inference ('inherent perception' or 'inexplicable comprehension').
Shapiro and Spence (1997)	The source of intuition is in the nonconscious. 'Intuitive processes are nonconscious' and not available to the decision maker.	Intuition is often described as 'a positive affective feeling that the thought or idea is correct' (p. 64), as a 'feeling of familiarity', or as 'an increased liking' of a stimulus. The decision maker has no awareness of the rules and knowledge behind an intuition and cannot articulate the reasons.
Simon (1987)	The processes behind these judgments are not within the conscious awareness of the decision maker.	Judgments are reached without evidence of systematic reasoning or being able to report the thought process.
Sinclair (2010)	Intuition results from nonconscious holistic information processing. Differentiates between 'intuiting as nonconscious information processing and intuition as its consciously registered outcome.' (p. 379)	Intuition means direct knowing without reasoning.

SUMMARY

The proficient execution of activities before the start of the formal new product development (NPD) process, such as identifying new product opportunities, generating new product ideas, developing a product concept, or planning the development project, is one of the key success factors of NPD. This is not surprising as executing these so called 'fuzzy front end' (FFE) activities defines the content, tasks, timing and cost of the entire NPD project. However, despite the importance of the FFE, neither academics nor practitioners completely understand how to execute it proficiently. The reason is that several important issues in FFE execution have not at all or only incompletely been researched to date. This dissertation addresses part of this research gap by investigating two unresolved issues in FFE execution, i.e., (i) the performance effects of accelerating FFE execution cycle time, and (ii) the optimal approach to FFE execution decision making.

Issue 1: The performance effects of accelerating FFE execution cycle time

The theoretical arguments in the NPD and innovation management literatures on whether or not to accelerate the execution of the FFE are conflicting. The reduction of overall idea-to-launch cycle time is generally found to increase new product performance. The FFE, however, needs to be executed *proficiently* to increase new product performance. Some scholars argue that 'proficiency' means taking more time in the FFE to complete this stage thoroughly and to save time in the subsequent stages. In contrast, others argue that 'proficiency' means executing the FFE faster to increase new product performance by supporting a timely completion of the overall NPD project and to make cycle time reduction an integral and clear project

goal from the beginning of the project. These conflicting argumentations result in the following research questions:

RQ_{1a}: What is the main effect of FFE execution cycle time on new product performance?

RQ_{1b}: What are the interacting effects of FFE execution cycle time with the performance effects of the subsequent development and commercialization stages' cycle times?

These research questions are addressed in study 1 using objective and longitudinal cycle time and sales data for 399 NPD projects completed following a Stage-Gate® type of process in the plastics division of a large and diversified industrial corporation. The results of this study show that FFE cycle time is not directly associated with new product performance, which provides an answer to research question 1a. Moreover, the results reveal that FFE execution cycle time has an indirect effect on new product performance. Only when the cycle times of all three NPD stages (i.e., FFE, development and commercialization) are simultaneously reduced is new product performance increased through reducing NPD cycle time, which provides an answer to research question 1b. Thus, cycle time reduction in NPD needs to be an integral, clear, and consistent goal from the beginning of the development project in order to be effective. Consequently, proficiently completing the FFE includes deciding on and implementing an acceleration strategy right at the start of an NPD project and planning the project so that this strategy can be consistently implemented across all three NPD stages.

Issue 2: The optimal approach to FFE execution decision making

Previous research has suggested that FFE execution decision making benefits not only from the commonly accepted rational approach, but also from using intuition. Combining rational and intuitive approaches in FFE execution decision making may allow decision makers to make use of the advantages of both approaches. Unfortunately, prior studies on FFE decision making have mainly focused on gate decisions, leaving the topic of decision making during the in-stage execution of FFE activities under-researched. Therefore, no study to date has focused on identifying the optimal approach to making FFE decisions between the gates, resulting in the following research questions:

RQ_{2a}: Why and under which conditions is the use of intuition beneficial for making FFE execution decisions?

RQ_{2b}: Should intuitive and rational approaches be combined in FFE execution decision making and, if yes, how?

Research question 2a is investigated in study 2, which combines a creativity perspective of FFE execution decision making and a dual-processing perspective of intuition to develop a conceptual framework that explains why and under which conditions individual and team-based FFE execution decisions may or may not benefit from the use of intuition. The conceptual framework is developed based on literature study and interviews and proposes that intuitively making decisions during FFE execution increases the creativity of the resulting product concept because of the benefits of the unconscious processes from which an intuition results. Due to the drawbacks of the unconscious processes this positive effect is, however, proposed to be weaker under certain circumstances. When individuals use intuition in FFE execution decision making, the incremental nature of the NPD project, the inexperience of the FFE decision maker, and the availability of multiple goals may weaken this positive effect. When using the intuition(s) of individuals in team FFE execution decision making, a rational decision culture and hierarchical or democratic decision making rules may weaken the positive effect of intuition use. This provides an answer to research question 2a.

Research question 2b is investigated in study 3 using an experiment with a 2x2 between-subjects design that manipulated the use of four different decision making approach combinations by 50 NPD professionals in two stages (decision options analysis and final decision making) of a typical FFE execution decision, i.e., evaluating several new product ideas. The results of the experiment show that when the idea options are highly similar combining rational and intuitive decision making approaches leads to a significantly higher FFE execution decision making quality than using only rational or only intuitive approaches. This suggests that in such a decision context the advantages of both approaches are required to make good evaluation decisions during FFE execution. Moreover, the FFE execution decision was made significantly faster when the decision makers started with an intuitive options analysis. Consequently, to achieve simultaneously higher quality and faster speed in evaluating highly similar new product ideas during FFE execution, rational and intuitive decision making approaches are best combined in one specific sequence, i.e., starting with intuitively analyzing the decision options and then rationally considering the resulting intuition in making the final decision. This finding provides an answer to research question 2b.

Overall conclusion

By investigating these two issues, this dissertation advances the knowledge on proficient FFE execution with two key findings. First, to increase new product performance through cycle time reduction, the execution of the FFE needs to be accelerated in such a way that the subsequent development and commercialization stages can also be speeded up. Second, increasing new product performance through decision making during the execution of the FFE requires combining intuitive and rational approaches in the right temporal sequence and under the appropriate conditions in individual and team decision making.

Theoretical implications

The findings of this dissertation have ample implications for literatures within and outside of the domain of NPD and innovation management. First, the findings have implications for the FFE management literature within the NPD domain. Study 1 highlights the need to already plan and implement a consistent acceleration strategy for the entire NPD project in the FFE. Consequently, additional research is required to investigate when in the FFE and how the NPD acceleration strategy should best be decided on and implemented. Studies 2 and 3 emphasize the importance of the appropriate use of intuition in FFE decision making. Further research will be required to fully understand the role that intuition can play in FFE decision making and to proficiently manage its use at the individual and team level and in combination with the commonly used rational approach. This dissertation also shows that future research on the topics FFE acceleration and FFE decision making in the FFE management literature may be linked because FFE acceleration can be achieved by applying the optimal approach to FFE decision making. Additionally, the overall findings of this dissertation have implications for other research topics in the FFE management literature, because appropriately managing both FFE acceleration and decision making has consequences for the future research on such topics as leadership and control, information and knowledge use and management, and formalization in the FFE.

Next, this dissertation has implications for the research topics acceleration and decision making in the overall NPD and innovation management literature. The findings of study 1 highlight the importance of a stage-wise approach to NPD acceleration. Consequently, new theories on the stage-wise antecedents of NPD cycle time reduction and on stage-wise acceleration methods are required. Studies 2 and 3 have shown that NPD decision making is more than just about how formal gate decisions are made. Theories of proficient decision making need to be developed and tested that apply to the context of NPD process stages. In addition, the future research on NPD acceleration and NPD decision making may also be linked because study 3 suggests that optimal NPD decision making may reduce NPD cycle time.

Finally, the findings of studies 2 and 3 have consequences for the decision making literature outside of the domain of NPD and innovation management. Study 2 highlights the difficulty of managing intuition use in team decision making. The use of intuitive decision making at the group level has to date not received enough attention in the literature. The findings of study 3 suggest that the temporal sequence in which rational and intuitive decision making approaches are combined for different stages in the decision making process has consequences for both the quality and speed of decision making. Consequently, more research in different decision making domains is required that focuses on the use of approaches for different stages in the decision process.

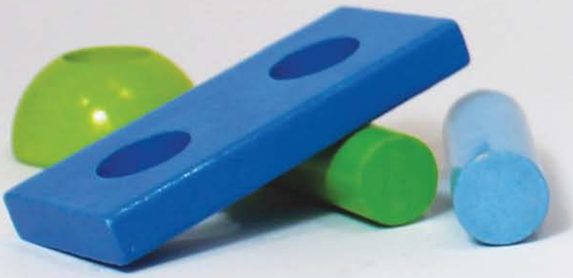
Managerial implications

This dissertation provides several indications on how the FFE and also the overall NPD process can be executed more proficiently. First, practitioners can improve the execution of the FFE by carefully planning and implementing the acceleration strategy of the NPD project in such a way that the cycle time will be consistently reduced in all three NPD process stages. This will also require a more deliberate choice of acceleration methods throughout the whole NPD process. Second, managers should accept, encourage, and facilitate the use of intuition in FFE decision making and ensure that intuition is used in the right temporal sequence with rational decision making and under the appropriate conditions. The findings of studies 2 and 3 can help to design appropriate education and training programs for optimal FFE decision making and to reduce the resistance of intuition critics. Third, practitioners should keep in mind that FFE team composition, team leader choice, establishment of a learning culture, and appropriate formalization of the FFE process may facilitate proficient FFE execution by supporting both FFE acceleration and optimal decision making.

ABOUT THE AUTHOR

Katrin Eling was born in Leverkusen, Germany, on August 27, 1981. After gaining her Diploma in Industrial Design at University of Wuppertal, Germany, in March 2006, Katrin completed a Master of Science in Strategic Product Design at Delft University of Technology, the Netherlands, in September 2008. The paper resulting from her Master thesis project was published in the *International Journal of Market Research* in January 2013. In February 2009, Katrin started her Ph.D. project in the Innovation, Technology Entrepreneurship & Marketing (ITEM) group of the School of Industrial Engineering at Eindhoven University of Technology. Her Ph.D. project proposal was named the winner of the 2011 Dissertation Proposal Competition of the Product Development & Management Association (PDMA) and was among the finalists of the 2011 Business Marketing Doctoral Support Award Competition of the Institute for the Study of Business Markets (ISBM). Katrin was also honored as 2011 Doctoral Fellow at the PDMA - UIC Doctoral Consortium, in Chicago, U.S., in July 2011. The results of her Ph.D. project are presented in this dissertation and published in July 2013 and forthcoming in the *Journal of Product Innovation Management*. Moreover, with one paper resulting from her Ph.D. project, Katrin was runner-up for the 2013 Best Student Paper Award of the College of Product Innovation and Technology Management (PITM) of the Production and Operations Management Society (POMS).

The proficient execution of activities before the start of the formal new product development process, such as identifying new product opportunities, generating new product ideas, developing a product concept, or planning the development project, is one of the key success factors of new product development. This is not surprising as executing these so called 'fuzzy front end' activities defines the content, tasks, timing and cost of the entire development project. However, despite the importance of the fuzzy front end, neither academics nor practitioners completely understand how to execute it proficiently. The reason is that several important issues in fuzzy front end execution have not at all or only been incompletely researched. This dissertation addresses part of this gap in extant knowledge by investigating two unresolved issues in fuzzy front end execution, i.e., (i) the performance effects of reducing fuzzy front end execution cycle time, and (ii) establishing the optimal approach to fuzzy front end execution decision making. In three distinct, yet related studies this dissertation delivers several new theoretical and empirical insights for a more proficient execution of the fuzzy front end of the new product development process. As such this dissertation contributes to diverse literature streams within and outside of the domains of new product development and innovation management.



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