Revealing unawareness in usability related decision-making

REVEALING UNAWARENESS IN USABILITY RELATED DECISION-MAKING

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CHAPTER 1: Usability issues and 'incorrect' decisions

"Shall I get the manual?", I joked teasingly. My friend did not appreciate the comment. For the last five minutes he has been trying to show me a video of his daughter performing her first ballet act on stage. "I know it is on here", he said, "we watched it last week!". His state-of-the-art hard-disk/DVD recorder was still not budging. In frustration he began pushing buttons randomly in order to get the thing to show me his beloved daughter performing Swan Lake. "Do you know the joke about how many engineers it takes to show a video?", I tease him some more. The electrical engineer disregards my point and continues even more intense and frustrated pushing of buttons. I sip my tea, watching him reminds me of similar struggles with my own electronic products. Some even felt like a battle... Finally his face brightens up, he has found it! The recorder was apparently in DVD mode, switching it to HDD mode revealed the index list of all the recordings. Finally I can see the little five-year-old hopping around in her tutu, enjoying the spotlights and waving at her dad. Will she also face these struggles with future devices? ◆

1.1 **Usability issues**

We all have been there, being irritated by a product that does not work as you expected. Pushing a door while you should pull it, making a movie with your camera while you wanted to make a photo. Or being called by your friend to only hear background noises, apparantly he was calling you by accident. And how often do your parents call with questions about their computer? Or what about your new mobile phone, a week before you managed to alter some settings but now you want to change them again and you cannot find the function in the menu anymore.

These various issues with modern electronic products show todays annoyances; usability issues. Users get irritated and dissatisfied while using their products. This dissatisfaction could result in complain behaviour, complaining to friends or family about the difficulty to use your mobile phone. Writing negative reviews on the internet about the HDD/DVD recorder, or even returning their newly bought camera to the store. The figures in the next section show that the number of complaints and product returns to companies are increasing. ◆

1.2 **User complaints**

Many users experience issues, of which some so irritating that they complain and return the product to the store. Consequent companies face high and rising numbers of product returns and complaints. In the eighties, products were brought back due to technical problems. But thanks to improved structured development processes companies became better in managing the technical product quality, which decreased the number of product returns and complaints. Nevertheless, despite the improved processes the number of complaints and products increased at the end of the nineties [Ouden 2006], see *Figure 1-1*.

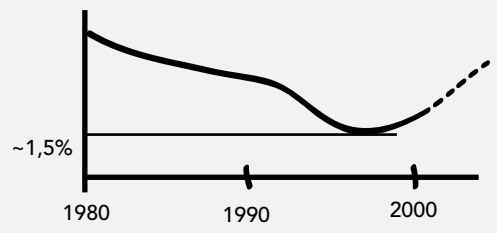


Figure 1-1: Average percentage of consumer complaints on new products [Ouden 2006]

Investigating these complaints and reasons for product return identified other causes than before. Previously the complaints could be traced back to technical problems. Nowadays the cause of the complaints cannot be found within technical aspects, defined as No Fault Found (NFF), complaints of which the cause cannot be retrieved [Brombacher 2005]. In *Figure 1-2* it is shown that the percentage of these NFF is increasing.

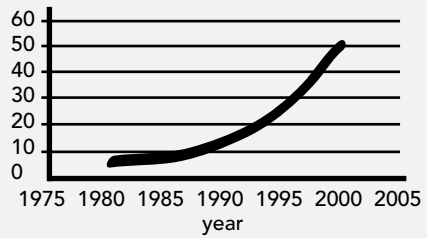


Figure 1-2: Percentage NFF in modern hig-volume consumer electronics [Brombacher 2005]

A large number of these NFF can be attributed to usability issues. Studies within the mobile phone industry indicated that 24.2% of the NFF can be attributed to users who *"are struggling with functionality (usability)"* [Overton 2006] and 8.1% of the NFF is the result of *"devices that do not meet expectations"* [Overton 2006]. Reasons for consumers to return electronic products are:

- *"product broken (52%)*
- *didn't work as thought it would (28%)*
- *no explanation (7%)*
- *no longer wanted (3%)*
- *wanted a different one (2%)*
- *spent too much money (1%)"* [Ouden 2006]

The second one indicates usability issues to which 28% of the product returns can be attributed. The usability issues can be described as a mismatch between the intended use of the designer and the actual use of the user [Babber 2002].

Usability issues irritate the user. They buy a product and find it is not working as they thought it would. The dissatisfaction of the user may result in complaining behaviour. Complaining to friends and family about the not working product are private complaints [Day 1977]. This negative word of mouth may damage the brand image as consumers may not buy the brand again. A modern version of this is when users complain about a product on the internet. Besides this, the user may voice a public complaint [Day 1977], a reaction to the company. The high and rising number of public complaints in response to the usability issues are also a problem for industry; it results in rising after sales costs [Steger 2008]. An estimation of the total costs of return policy in the consumer electronics industry in 2007 of the USA market were $13.8 billion and about $5 billion can be attributed to NFF [Steger 2008]. In the mobile phone industry in 2006 it was estimated that the costs of NFF was $4.5 billion [Overton 2006]. In short, returned products because of NFF result in enormous costs for industry.

The number of users that experience usability issues with their products may even be higher than the previous mentioned numbers suggest, because not every user complains when he is dissatisfied with a product [Mulcahy 1998, Oliver 1996]. Whether a user will complain depends on various factors such as the effect of voicing the complaint, the probability that the complaint will be heard, and the individual's ability and willingness to complain [Hirschman 1970]. Consumer complaint behaviour can be defined as the consequences of customer dissatisfaction [Cho 2002], it is triggered by feelings or emotions of perceived dissatisfaction [Day 1984, Landon 1980]. In summary, the number of publicly addressed user complaints is just a 'tip of the iceberg' of the actual number of usability issues that users experience. Therefore it can be concluded that usability issues are a problem for both the user as well as industry.

Various explanations for these high number of complaints and usability issues can be given. Amongst others, the high complexity of todays electronic consumer products [Brombacher 2005]. The increasing complexity of products can be attributed to the increasing numbers of functions and features of a product, or to the network of products; for example a TV can be connected to a hard disk recorder and a home cinema set. Another explanation is the 'global economy' [Brombacher 2005], products are sold all over the world and have therefore to fit a wide variety of users [Eijk 2006]. So usability is becoming ever more important with these complex products, interactions and wide variety of users. Next, these reasons are explained in more detail. ◆

1.2.1 **PRODUCT COMPLEXITY**

The increasing product complexity is a cause of the increasing number of complaints and usability issues. The more complex the product, the more complex it is for a user to use the product. The increasing complexity can be attributed to various changes within current electronic products:

- a decrease of visual clues on the products
- an increase of the number of product functions and features
- an increase of the number of connected products

DECREASING VISUAL CLUES

A mechanical product often has various visual clues about how to use the product, the pedals of a bicycle, the handle of a rotary grater (*Figure 1-3)*, the grip of a saw etc. The shape of the product communicates the function and how to use it. Also early electronic products communicate the working and function of a product, for example a coffeemaker (*Figure 1-4*) or transistor radio. However todays electronic products have often a sleek design and limited visual clues on how to use the product [Jordan 1994A; Norman 2002, 8]. These limited visual clues may result in simple looking products, which are complex to operate due to the complex underlying systems [Standaert 2004, 2-3], for example the sleek looking microwave (*Figure 1-5)*.

Figure 1-3: Mechanical rotary grater

Figure 1-4: Coffeemaker

Figure 1-5: Microwave

INCREASING PRODUCT FUNCTIONALITY AND PRODUCT FEATURES

The number of functions and features on products are increasing [Norman 2002, 8; Ouden 2006, 85]. The increase of the number of functions of a product results in multi-functional products, products with which the user can perform more than one task. A well-known example is the mobile phone. About 20 years ago it provided only the possibility to call people; just one task. After a while also text messaging and playing games were possible. Nowadays a mobile phone includes many functionalities beside calling, for example, agenda, note block, camera, alarmclock, e-mail, navigator, etc.

The increase of the number of features on a product increases the possibilities on how to accomplish a certain task. Product features are the tools to use the product function [Wood 1995]. Todays compact camera still offers the function of making photos by the features of a shutter release button, adjusting shutter time and aperture, and capturing the photo. The increase of new features on a compact camera makes that photos can be tagged with time and location due to its internal clock and gps. And photos are not only captured on the memory card but can also be saved on a server by the camara's Wi-Fi connection.

The increase of product functions and features is enabled by the current state of technology, technological innovations and low development costs. However not only technology stimulates the increase of number of functions and features. Also the commercial advancements of offering more and new functions and features leads to this increase. All these increasing number of functions and features makes a product more difficult to

use than a product with a limited number of functions and features [Rust 2006].

INCREASING CONNECTIVITY

Products are also more and more connected to each other, creating a network of products [Ouden 2006, 85]. For example, the computer can be connected to printers, scanners, webcams, and the TV can be connected to hard disk recorders, home cinema sets, satellite decoders, etc. Installing and connecting these products could evoke usability issues. Each of these products could have a good usability, but this does not guarantee a good usability for the network of products.

The increasing complexity of electronic products is an explanation for the increased number of usability issues. It is often the combination of the various complicating aspects that may lead to issues. Many functions and features and only a limited number of buttons and visual clues result in difficulties with using the product. The increasing product complexity also clarifies that developing these complex electronic products becomes more difficult as well.

1.2.2 **WIDE VARIETY OF USERS**

The 'global' economy is another explanation for the high and rising number of complaints and usability issues [Brombacher 2005]. Nowadays products are sold all over the world, which makes them being used by a wide variety of users with different needs, preferences and cultures [Eijk 2006]. Good usability for European users does not guarantee good usability for Asian users. The user group is also enlarged by the age of users. Once, computers were only used by professionals at work, nowadays computers are also used by children at primary schools and elderly, for example, to stay in touch with their grand children via skype. This wide variety of users is a big challenge for product developers to create products that fit all these different users in different situations [Wilson 2000].

1.2.3 **COMPLEX INTERACTION**

The complex products and wide variety of users may result in a complex interaction. Interaction is the relationship of use between the user and product by means of an interface [Frens 2006, 13]. The interaction is a result of the created product [Frens 2006, 13], and the result of a users perception (noticing product functionality), cognition (understanding product functionality) and use actions (physically operating product functionality) [Kanis 1998]. Usability issues result from the interaction of the user with the product. How the user will interact with the product depends on many different user characteristics. A selection of user characteristics is obtained from usability literature [Kujala 2004]:

- Personal characteristics (demographics, lifestyle, personality, emotions, attitudes, skills and physical abilities and constraints)
- Task related characteristics (goals, motivation, tasks, training and experience)
- Geographic and social characteristics (location, culture, social connections, society, organisations)

These different user characteristics define the interaction of the user with the product. But also previous experiences [Doane 1991, Sauer 2010] make that users have certain expectations about use [Norman 2002, 16; Standaert 2006, 160]. Based

on their background, experiences, and expectations *"people form internal, mental models of themselves and of the things with which they are interacting. These models provide predictive and explanatory power for understanding the interaction."* [Norman 1983, 7-8]. These models arise naturally through interaction with the product but are not necessarily correct, but as long as they are functional and support the user in the interaction with the product this poses no big problems. *"Mental models will be constrained by such things as the user's technical background, previous experiences with similar systems, and the structure of the human information processing system."* [Norman 1983, 8]. A good mental model has a positive influence on the use of a product [Kieras 1984, Uther 2008]. However, some shortcomings of mental models were observed when studying user's mental models [Norman 1983, 8]. The models are often incomplete. They can be unstable which results in forgetting details, especially when it is a long time ago that the product was used. The mental models do not have firm boundaries, wich may lead to confusion between models of another product, resulting in using the 'wrong' model. The models are 'unscientific'; the user shows superstitious behaviour to save mental efforts. These are some of the shortcomings of mental models that Norman described [Norman 1983, 8]. These shortcomings clarify why users make 'mistakes' during product-interaction and the product does not work as the user thought it would, resulting in usability issues.

Imagine what happens when the complexity of the product increases even more: interaction becomes more complex, which requires a higher cognitive effort of the user during the interaction [Cooper 1999], consequently increasing the possibility of 'mistakes' and usability issues about which users might complain. So the used mental model was probably not adequate enough for the complex product. The complex interactions and potential 'mistakes' in response to the mental model are a reason for a user-centred design approach to create a high level of product usability. The following section explains what usability is and subsequently how usable products can be created. ◆

1.3 **Usability**

Until an 'official' definition of usability was defined, terms like ease of use, usable, and user friendly were used to describe usability. Many definitions of usability are available [Hertzum 2010] but the most well known definition [Jordan 1998; Jokela 2003] is the one of the International Organisation for Standardisation (ISO). It defines usability as: *"The extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use"* [ISO 1998], *Figure 1-6*. The terms effectiveness, efficiency, satisfaction and context of use are defined as:

- Effectiveness
  "the accuracy and completeness with which users achieve specified goals"
- Efficiency
  "resources expended in relation to the accuracy towards the use of the product"
- Satisfaction
  "freedom from discomfort, and positive attitudes towards the use of the product"
- Context of use
  "users, tasks, equipment (hardware, software, and materials), and the physical and social environments in which a product is used."

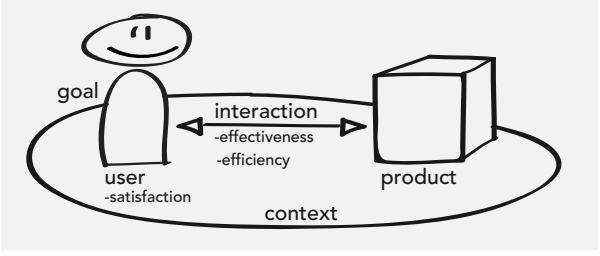


Figure 1-6: Usability

To establish this 'official' definition previous usability definitions were used. Some of these definitions describe different important aspects. For example, in 1984 Shackel defined usability as the *"user's ability to utilise the functionality of a product in practice"* [Shackel 1984]. Aspects stated by Shackel that were important are: effectiveness, learnability, flexibility (adaptation to variation in tasks and environments) and attitude (personal traits). In 1994 Nielsen described usability as how well the user can use the functionality of a product, specifying five attributes: learnability, efficiency, memorability, errors, satisfaction [Nielsen 1994A]. His definition elaborates upon the utility of a product, which is defined as whether or not the functionality of a product can do what is needed [Grudin 1992]. According to Nielsen

"Usability is not a single, one-dimensional property of a user interface. Usability has multiple components and is traditionally associated with these five usability attributes". Some aspects of these definitions are included in the ISO definition of usability, some are not. About the attributes learnability and memorability could be said that they are a consequence of usability. Usable products have an easy to learn interface, which is easy to remember.

The large number of usability definitions, of which some were stated, prove that usability is difficult to describe, it is a rather complex concept. It is this complex because there are various factors that contribute to product usability. It is not only about the effectiveness of efficiency or the product (objective components) but also about satisfaction of the user about the product use (subjective component). On top of that, product usability is no absolute value, it is not the same for every user. It depends on the user, his goals and the context in which the product is used. The usability of a product (or system or service) is focussed on the product functionality and overlaps with another product aspect namely, 'user experience'. The user experience is also a dynamic and context dependent product aspect [Hassenzahl 2006, Law 2009], but has a wider focus. User experience can be described as how the user feels about a product, his perception about the product interaction and product functions. It could be said that user experience is one step beyond usability, specifying the subjective component of usability.

This complexity of the concept usability itself may explain why it is so difficult to create usable products. Defining the objective and subject aspects of usability during product development may become extremely difficult when creating today's very complex electronic products for a wide variety of users. Especially when it is realised that this product development is more and more decentralised [Ketola 2002, 28; Minderhoud 2005] due to the 'global' economy [Brombacher 2005]. Production as well as parts of the (software) development process takes place in low labor cost countries [Davenport 2005; Bharati 2005]. The disadvantage of this decentralisation of development and production is that the communication between departments becomes more complex due to differences in language, culture and timezones [Song 1997]. This has negative influences for usability as decisions are made all over the world. ◆

1.4 Creating usable products

The previous sections described how the situation in product development and the complexity of the concept 'usability' itself complicate the process of creating usable products. Fortunately there are several ways to support the developers in creating usable products. On the one hand there are usability methods and techniques to support them. On the other hand there are so-called process models to help the developer to manage the project. ◆

1.4.1 USABILITY METHODS AND TECHNIQUES

During the Second World War an intensive cooperation between disciplines took place to create a better understanding of the effectiveness of human performance [Wilson 2000], which led to a strong focus on users within product development. Disciplines as *"anatomy, physiology, psychology, industrial medicine, industrial hygiene, design engineering, architecture and illumination engineering"* [Wilson 2000] combined their expertise to gain this understanding. The cooperation between them resulted in the fields of 'Human Factors' in the United States and 'Ergonomics' in Europe. These fields produced more specific methodologies that focus on the user during product development. These methodologies aim for creating products that better suit the user and therefore are more likely to succeed on the market. Examples of these user-centred methodologies are:

- Design for Usability [Gould 1985, Jordan 1998]
- User Centred System Design [Norman 1986, Gulliksen 2003]
- Participatory Design [Kyng 1991, Schuler 1993]
- Usability Engineering [Nielsen 1994A]
- Human Centred Design [ISO 1999, Maguire 2001]
- User Centred Design [Vredenburg 2002]

In 1985 Gould [Gould 1985] was the first to define three basic principles for developing usable products:

- early focus on users and tasks
- empirical measurement
- iterative design

These principles prescribe on an abstract level how to organise the development process to create usable products. Later, others [e.g. Norman 1986; Nielsen 1994A; Maguire 2001] described this process as well, with more detail or with different focus but all include the three basic principles of Gould [Buurman 1997].

Besides the methods and principles of Design for Usability there are also many usability techniques available [Stanton 2005; Goodman 2007]. These techniques prescribe how specific usability design tasks should be executed, like a recipe [Eekels 1973]. Usability techniques can be found in the various 'fields' of usability: Human Centred Design, User Centred Design, Human Factors, etc. However the large number of about 200 usability techniques [Stanton 2005] makes it difficult for the product developer to select the appropriate and required technique. Therefore many collections of techniques are made to create an overview for the (novice) developer and students [Tidball 2010]. But there are many different sources for many different collections; books, articles, internet, and others. These collections are each differently categorised; in alphabetical order, to design phases, to design activities, etc. All these different collections, presenting different usability techniques, make it even more complicated for the practitioner to select the right technique. Examples of these various sources, categorisations, and usability techniques are provided in *Appendix A*. When comparing all these different techniques it can also be concluded that sometimes different names for the same techniques are used [Tidball 2010]. For example, usability testing is also named user testing, implementation testing, verification, or post release testing. An explantion for the overlaps between the collections can be found in the mixed nature of the field and the different perspectives and goals of the collections [Bevan 2003; Tidball 2010]. Nevertheless, the large number of usability techniques and the many different collections of usability techniques failed to create a shared understanding of usability [Tidball 2010] and results in confusion for product developers when to use which usability technique [Goodman 2008].

A few examples of usability techniques are given in this section. There are techniques that can be used to obtain information about the user, his tasks, and context such as focus groups, contextual inquiry, and interviews. Several other techniques are available to (visually) capture this obtained information, for example, creating personas to describe a user of a certain user group or making storyboards to describe and visualise how the user can use the product in certain situations. A third type of usability techniques are techniques to evaluate the product. These techniques provide the product developer feedback about the product concepts, prototypes or final product, for example, field observations, logging use, task analyses, and cognitive walkthroughs. Please refer to *Appendix A* for more details about usability techniques.

In other words, usability techniques support the product developer in obtaining information, presenting information and evaluating the product. However one remark needs to be made, they only support the product developer when creating incremental innovative products [Norman 2012]. Norman and Verganti use a metaphor to explain this statement [Norman 2012]. Each product opportunity can be seen as a hill in space, where a higher hill is a better product. Incremental innovation attempts to reach the highest point on the current hill, while radical innovation seeks for the highest hill in space. The usability methods and techniques support hill climbing, *"extremely well suited for continuous incremental improvements but incapable of radical innovation. Radical innovation requires finding a different hill, and this comes about only through meaning or technology change"* [Norman 2012]. These radical innovative products are often difficult to use, expensive, and limited in capability, therefore incremental innovation is necessary *"to*

transform the radical idea into a form that is acceptable to those beyond early adopters" [Norman 2012]. These incremental innovations to create usable products are the focus of this PhD research project. ◆

1.4.2 PRODUCT DEVELOPMENT PROCESS

Besides the usability methods and techniques is the product developer also supported in creating usable products by predefined processes. An ordering of activities provides the developer a structure on how the work should be done [Davenport 1993, 5] and how the project should be managed [Buijs 2005, 162]. This helps the developer to control the project and to get the product on time on the market within budget. These predefined processes can be described with process models. A well-known model is of the stage-gate process. A stage-gate process is a *"conceptual and operational map for moving new product projects from idea to launch and beyond"* [Cooper 2008]. The process is divided in several stages with at the end of each stage a gate, which is a go/no-go decision, the milestones of a project. Each stage has its own specific deliverables. The five stages Cooper distinguishes are: scoping, build business case, development, testing and validation, and launch [Cooper 2008]. Each of these stages is concluded with a gate, a decision to proceed or not to proceed, to the next stage depending on whether the deliverables of the stage are met. These stage-gate models are considerd an effective way to get (usable) products and services quickly,

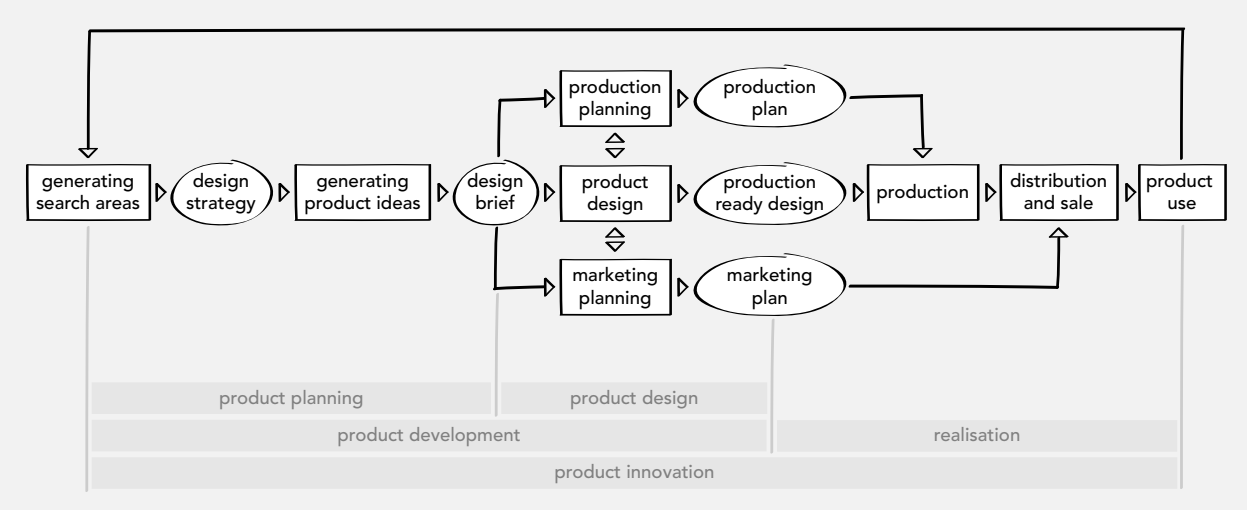


Figure 1-7: The phases of the product innovation process [Roozenburg 1991, 16]

efficiently, and profitability on the market [Buijs 2005, 162]. A well-known innovation process model for industrial design engineers is the Delft Innovation Model [Buijs 2003; Buijs 2005, 168]. This model was developed as a more practical model for professionals in the product development field [Buijs 2003]. Within the product innovation process smaller processes can be identified. The product innovation model of Roozenburg [Roozenburg 1991, 16] explicitly shows these phases, see *Figure 1-7*. The product innovation process is the cycle from identifying product ideas based on the company's strategy, developing products, producing and introducing these products on the market, and collecting feedback from the users to start the process all over again [Roozenburg 1991, 14-16; Buijs 2005, 169]. A smaller process within this product innovation process is the product development process, which ends at the moment that the design is ready for production. The focus of this PhD project is on the product design process, a smaller process with the product development process. This process is from defining the design goal in the design brief until a production ready design, see also *Figure 1-7*.

However, despite these process models and the support of usability techniques it still is difficult to create usable products. The creation of complex electronic products for a wide variety of users is namely further complicated by time pressure from the market as explained in the next section. ◆

1.5 **Product development under pressure**

Creating complex electronic products is supported by structured processes and numerous usability methods and techniques. However creating products is 'under pressure' as there is only limited time available to develop them. The fierce competition of being first on the market has everything to do with gaining market share and profit in order to receive the return on investments. Not only development time decreases, also the adoption cycles are decreasing. This means that the time span within which a product is introduced, accepted, adopted and becomes outdated is becoming shorter, so there is only limited time to get a return on investment [Minderhoud 2005]. This increased pressure from the market is experienced by designers within development teams. When developing first generation products there is only limited time for quality management, resulting in no or only some consumer and usability tests during the whole process. If tests are conducted, only limited time is available to implement the test results [Minderhoud 2005]. On top of that, when developing second generation products the feedback of the predecessor is not yet available [Brombacher 2005] and consequently improvements based on predecessors cannot be made. This all leads to time pressure influencing decision-making in the design process. The limited time available for activities and tests could result in hasty decisions, not collecting the required information, postponing (usability) tests, or even skipping (usability) tests. This may lead to 'incorrect' decisions, which are decisions with negative consequences. In particular 'incorrect' usability related decisions may occur when usability tests are skipped, which are decisions with a negative consequence for product usability, resulting in usability issues about which the user can be dissatisfied and may complain. Research by Den Ouden confirms that 85% of the consumer complaints without a technical malfunctioning of the prodcut, the so-called NFF, can be traced back to decisions made in the product development process [Ouden 2006].

To summarise all of the above, there are aspects that complicate the process of creating electronic consumer products. Usability techniques are available that can support the developer in making usability related decisions and yet there are still usability issues. Therefore, to prevent 'incorrect' decisions and usability issues it is of importance to know what is 'going wrong' when making usability related decisions in the product development process. ◆

1.6 **Research design**

PROBLEM DEFINITION

As described in the previous sections, electronic products are becoming increasingly complex with even more complex interactions nowadays. Due to the global economy these products are sold all over the world and should therefore fit a wide variety of users. Fortunately, many usability methods and techniques are available to support designers in creating more usable complex electronic products. However the development process is also complicated by the limited development time due to pressure from the market, resulting in 'incorrect' decisions and usability issues. The changes in product development make that the currently available usability techniques are inadequate to address this situation in product design and consequently cannot prevent 'incorrect' decisions and usability issues.

AIM

The aim of this PhD research project is to investigate what makes usability related decision-making in design practice 'go wrong'. Identifying the aspects that makes decision-making 'go wrong' may provide directions to improve usability related decision-making. These improvements should result in less 'incorrect' decisions and thereby reduce the number of usability issues.

MAIN RESEARCH QUESTION

The main research question of this project is:

"In design practice, what makes usability related decision-making go wrong?"

There are many usability techniques available to create usable products, however apparently these techniques are not effective enough to prevent all usability issues that are encountered in practice. Therefore it is necessary to investigate practice to find out what induces the usability issues.

RELEVANCE

The current complex electronic products and systems with their ever more complex interactions demand a focus on design for usability. Especially because these products should be suitable for a wide variety of users all over the world. Improving usability related decision-making will support the designers in creating products with less usability issues.

RESEARCH METHOD

A qualitative and explorative research approach is necessary to answer the above stated broad main research question. This chapter identified the following gap between product

development theory and practice: On the one hand, many usability techniques are available to support designers in creating usable products. On the other hand the numbers from practice show that many usability issues still occur despite the availability of these techniques.

So in order to find out what is going on in design practice qualitative research methods are required. In other words, qualitative research methods should be applied to find out what *"the real life is like"* [Miles 1994, 10]. In this chapter some possible explanations were given for the high number of usability issues with electronic products. However there is no clear direction about what influences usability related decision-making in such a way that it results in 'incorrect' usability related decisions in the end. Therefore design practice needs to be explored to find propositions about possible sources, factors or aspects that make usability related decision-making go wrong. In section 1.8 is presented how the research of the PhD project is structured. ◆

1.7 **Research context**

This PhD research project was conducted within a larger project; the 'Design for Usability' (DfU) project. This project is briefly described to show the context of the PhD research project. The author of this thesis, Christelle Harkema, decided to join the 'Design for Usability' project as a PhD candidate after having worked as usability specialist in design practice for a few years. The project *"aims at improving the usability of electronic professional and consumer products by creating new methodology and methods for user-centred product development, which are feasible to apply in practice"* [Eijk 2012]. Within this project several main focus points were defined to improve product usability: methodology, user, usability and usability issues.

METHODOLOGY – PLAN OF APPROACH

Frederik Hoolhorst (University of Twente) focussed on the development of a 'Plan of Approach'. With this approach companies can include existing and new usability methods and techniques into their existing product development processes [Hoolhorst 2012, Eijk 2012].

USER – PRODUCT IMPACT

Steven Dorrestijn (University of Twente) is the philosopher between the industrial designers within the overall 'Design for Usability' project and he has investigated how users change within the process of user product interaction. This knowledge was introduced to design practice with the Product Impact Tool [Dorrestijn 2012, Eijk 2012].

USER – USER CHARACTERISTICS

Chajoong Kim (Delft University of Technology) investigated the relation between user characteristics (cognitive aspects, personality, demographics, and use behaviour), kinds of products, and the probability of usability issues. Subsequently user profiles can be defined that provide an overview of these three elements [Kim 2012, Eijk 2012].

USABILITY – BARRIERS AND ENABLERS

Jasper van Kuijk (Delft University of Technology) investigated which factors in product development contribute to or obstruct usability (enablers and barriers) and how these factors relate to each other [Kuijk 2010, Eijk 2012].

USABILITY ISSUES – DECISION-MAKING

Christelle Harkema (Eindhoven University of Technology) investigated usability related decision-making in design practice to identify the influencing factors. Subsequently these factors were specified to provide a direction to address

these factors to improve decision-making and thereby reduce the number of usability issues [Eijk 2012]. the results of this project are described in this PhD thesis.

All these individual PhD research projects were realised by cooperation between the three Dutch technical universities (TUDelft, UTwente en TU/e) and four Dutch companies (Indes, Océ, Philips en T-Xchange). The companies and Agenschap NL (IOP-IPCR) supported the 'Design for Usability' project financially. ◆

1.8 **Thesis structure**

The research journey of this PhD research project is represented in *Figure 1-8*, it is a visual table of contents of this PhD thesis. It shows per chapter the guiding question for the specific chapter. This question can be compared with a road sign pointing in a certain direction. At the bottom of the figure the research question that is stated and/or answered in the specific chapter is presented. In between the topics and results of investigation are presented, divided into practice and theory. Each of the following chapters starts with a more detailed 'visual table of contents' to guide the reader along the research journey.

In this first chapter the gap between practice and theory was identified; the many usability issues that users experience despite the available usability techniques in theory. Subsequently the main research question was formulated.

In chapter 2 a literature study to design and decision-making is presented along with the possible factors that can influence decision-making in design. Subsequently an explorative study (Study 1) of design practice is presented. This study explored the possible influencing factors on usability related decision-making in design practice.

In chapter 3 the investigation into one of the influencing factors that was found Study 1 is presented: unawareness. The second study (Study 2), presented in chapter 3 investigated whether unawareness is a critical influencing factor on usability related decision-making. It proved to be an important but unclear influencing factor.

So in chapter 4 the research journey continues with a third study (Study 3) in design practice into the sources and types of unawareness. The case and results of this study are described in great detail to provide professionals from industry an example and insight in a different project to enable them to compare the findings and conclusions with their own practice.

In chapter 5 the results of this PhD research project are discussed and consequently the answer to the main research question is given. Subsequently the implications for design theory, education and practice are presented. The findings of this research provided answers to the stated questions, but also raised new questions, therefore the thesis is finalised with suggestions for future research journeys. ◆

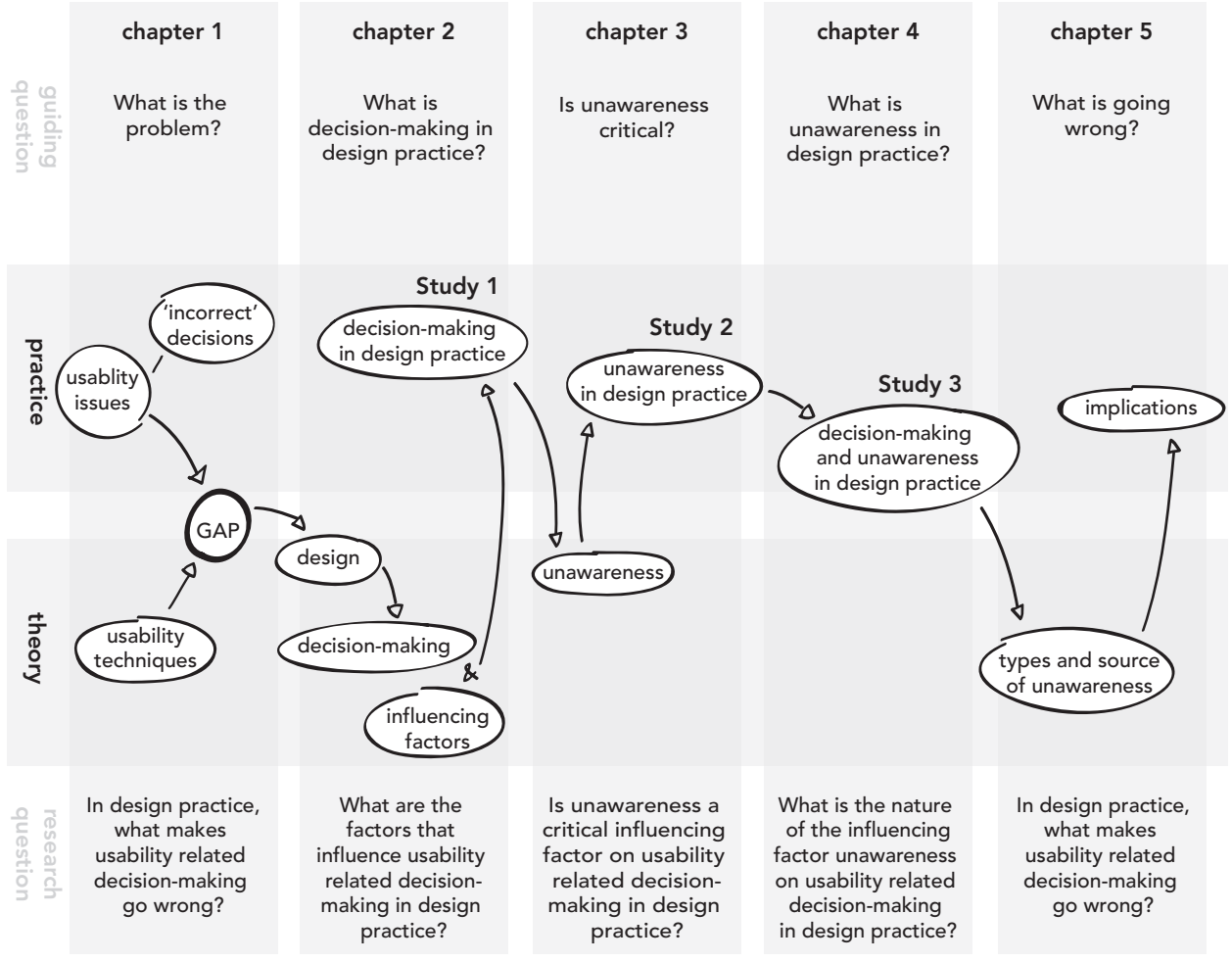


Figure 1-8: Visual table of contents thesis

CHAPTER 2: Understanding decision-making in design practice

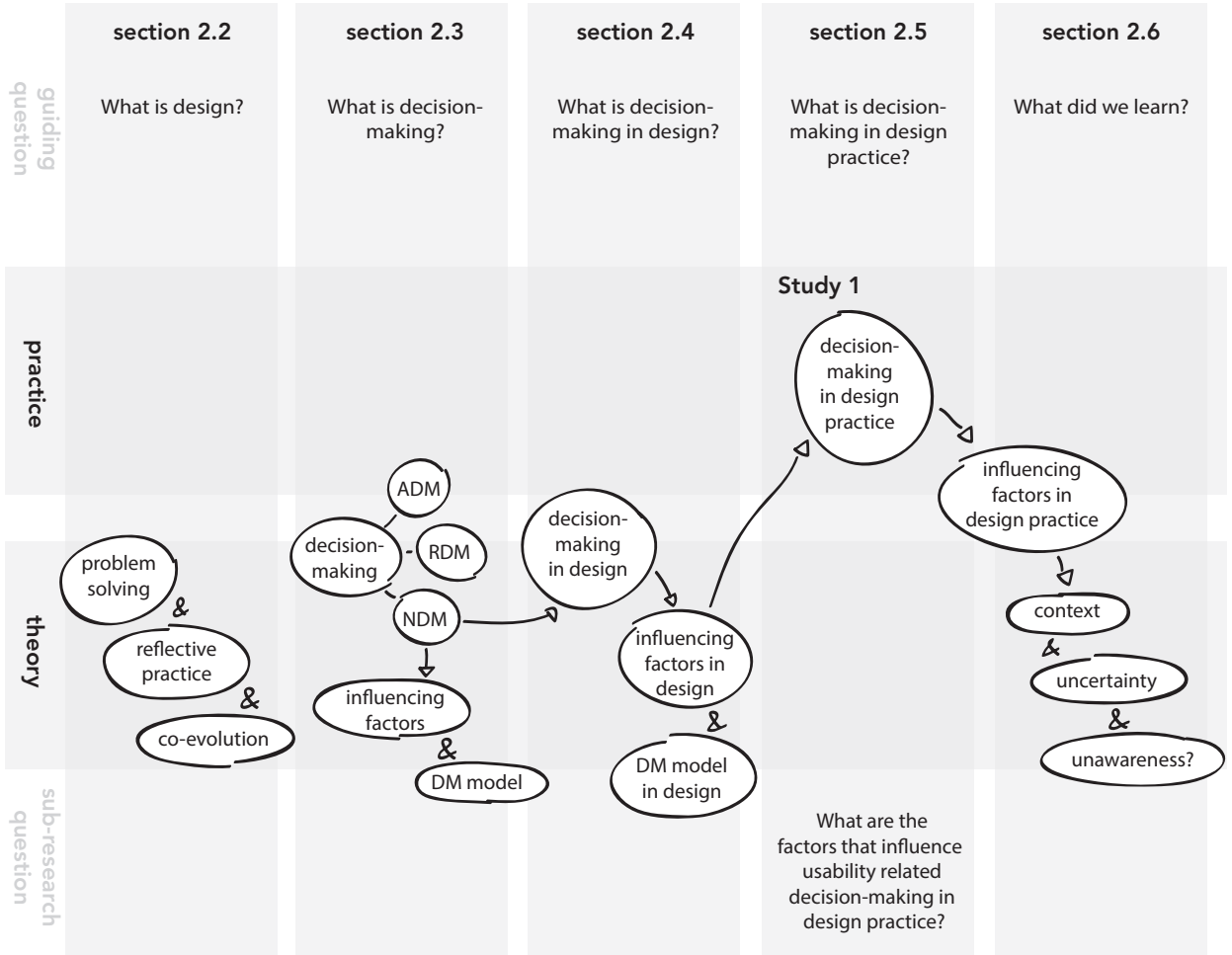


Figure 2-1: Visual table of contents chapter 2

2.1 Introduction

In chapter 1 usability and usability issues were introduced, along with one of the causes of these issues: usability related decisions in the product development process. As stated in chapter 1 the overall aim of the DfU project is to improve product usability. The focus within this project is on the usability related decisions, searching for an answer on the main research question: *"In design practice, what makes usability related decision-making go wrong?"*. This chapter starts by exploring some of the terms used in the research question in literature. The focus of research is design practice, but what is design? In section 2.2 design theories are introduced and discussed. Followed by a literature search on decision-making in section 2.3. This study is further narrowed down to decision-making in design in section 2.4. However it appears to be difficult to gain an understanding of decision-making in design as the available design literature on decision-making is very limited. Therefore the search was extended with an explorative study in design practice. For this study a sub-research question was formulated and described in section 2.5. These sections are visualised in *Figure 2-1*. The aim of the search in chapter 2 is to gain a better understanding of usability related decision-making in design practice and thereby find directions for subsequent research to answer the main research question. ◆

2.2 **Design**

In this section two design paradigms are introduced to explain design. The first introduced paradigm is Rational Problem Solving by Herbert Simon. The second paradigm is Reflective Practice by Donald Schön. Both paradigms deliver relevant descriptions for design [Dorst 1997, 168]. By introducing additional literature, design is explained by describing its characteristics. ◆

2.2.1 RATIONAL PROBLEM SOLVING

In the beginning of the seventies Herbert Simon reacted to classical economics by criticising the perfect-choice theory. The perfect-choice theory aimed for the most optimal decision by selecting all the alternatives, evaluating the consequences and selecting the best alternative. According to Simon there could not be perfect knowledge of alternatives and consequences, and no perfect preferences between consequences to make the most optimal choice. So, within the limitations or boundaries a 'satisficing' choice needs to be made [Simon 76, xxix]. Based on his knowledge of decision-making within its boundaries, Simon introduced Rational Problem Solving (RPS), a theory in which he viewed design as a rational search process: "*the design problem defines the problem space that has to be surveyed in search of a design solution.*" [Newell and Simon 1972 cited in Dorst 2004]. Within this paradigm are four central propositions:

- *"Fewer are the general characteristics of the human information processing system that are invariant over task and the problem solver*
- *These characteristics are sufficient to determine the task environment as a problem space, occurring problem solving in that space*
- *The structure of task environment determines the possible structures of the problem space*
- *The structure of problem space determines the possible programs that might be used in problem solving"*

According to Simon the problem solving activities of the design problem take place inside the problem space that is structured by the task environment. "*The term task environment refers to an environment coupled with a goal, problem, or task – the one for which the motivation of the subject is assumed. It is the task that defines a point of view about an environment, and that, in fact, allows an environment to be delimited*" [Newell 1972, 55]."*The problem space is the space in which the problem solving activities take place*" [Newell 1972, 59], "*it is the internal representation of the task environment used by the subject*" [Newell 1972, 56].

Rational Problem Solving could be summarised as a structured process of setting goals, selecting alternatives, evaluating the consequences and selecting the 'satisficing' alternative.

The paradigm of RPS is developed for well-structured problems. Simon provides six characteristics to describe well-structured problems [Simon 1973]:

1. *"There is a definite criterion for testing any proposed solution, and a mechanizable process for applying the criterion.*
2. *There is at least one problem space in which can be represented the initial problem state, the goal state, and all other states that may be reached, or considered, in the course of attempting a solution of the problem.*
3. *Attainable state changes (legal moves) can be represented in a problem space, as transitions from given states to the states directly attainable from them. But considerable moves, whether legal or not, can also be represented-- that is, all transitions from one considerable state to another.*
4. *Any knowledge that the problem solver can acquire about the problem can be represented in one or more problem spaces.*
5. *If the actual problem involves acting upon the external world, then the definition of state changes and of the effects upon the state of applying any operator reflect with complete accuracy in one or more problem spaces the laws (laws of nature) that govern the external world.*
6. *All of these conditions hold in the strong sense that the basic processes postulated require only practicable amounts of computation, and the information postulated is effectively available to the processes--i.e., available with the help of only practicable amounts of search."*

Simon realises in his paper of 1973 that the paradigm of Rational Problem Solving cannot be simply applied to design as most of the design problems are ill-structured ones [Simon 1973]. Ill-structured problems are usually defined as problems *"whose structure lacks definition in some respect"* [Simon 1973]. In his paper he provides examples of ill-structured problems by showing that they do not address the characteristics of well-structured problems. The problem space of an ill-structured problem is too large to describe. Creating an 'immediate problem space' via a noticing and evoking mechanism decomposes it to sub-problems. Consequently, these smaller sub problems can be approached as a well-structured problem [Simon 1973]. This provides, according to Simon, the opportunity to also use Rational Problem Solving for ill-structured problems. In the next section, Reflective Practice isintroduced and subsequently it is explained why Rational Problem Solving is not suitable for solving ill-structured problems. ◆

2.2.2 REFLECTIVE PRACTICE

The second paradigm which is used to describe design is Reflective Practice (RP) introduced by Donald Schön. In his book The Reflective Practitioner [Schön 1983] he reacts against the paradigm of RPS that solves problems by selecting from available alternatives. Schön advocates that in the real world problems are not presented to the practitioner as givens. "*They must be constructed from the materials of problematic situations which are puzzling, troubling, and uncertain. In order to convert a problematic situation to a problem, a practitioner must do a certain kind of work. He must make sense of an uncertain situation that initially makes no sense.*" [Schön 1983, 40]. According to

Schön the focus of RPS is too much on 'problem solving' and ignoring 'problem setting', *"the process by which we define the decision to be made, the ends to be achieved, the means which may be chosen."* [Schön 1983, 39]. This process of problem setting is an important aspect of design as the problems in the real world are usually complex and ill-defined.

Schön studied practice to find implicit and intuitive processes which are shown by practitioners in the real world. With this he finds a 'mechanism of design': reflection-in-action. *"There is some puzzling, or troubling, or interesting phenomenon with which the individual is trying to deal. As he tries to make sense of it, he also reflects on the understandings which have been implicit in his action, understandings which he surfaces, criticizes, restructures and embodies in further action. It is the entire process of reflection-in-action which is central to the 'art' by which practitioners sometimes deal well with situations of uncertainty, instability, uniqueness, and value conflict"* In the thesis of Dorst this process is summarised as *"a process of naming, framing, making moves and evaluating them"* [Dorst 1997, 74] *In the naming step the object to be considered in the design situation are selected and named. In the framing step these named entities are put into a context, and an overall perspective on the design task is constructed. In making a move the designer takes an experimental action based on the naming and framing of the design task, and this action is then evaluated. The evaluation leads to either satisfaction, the making of new moves, or the reframing of the problem. The evaluation could also lead to a complete reconsidering of the designer's view of the design task, causing the designer to start naming new entities in the design situation"* [Dorst 1997, 74].

Schön compares in the fifth chapter of his book *"The Reflective Practitioner"* the similarities between two provided cases in previous chapters. While describing these similarities he introduces the characteristics of design [Schön 1983,129-130]:

- A design case is a unique case
- The designer is not looking for a standard solution
- The problem is not given
- The situation is complex and uncertain, there is a problem in finding the problem
- The designer finds the situation problematic and therefore has to reframe it
- The designer gives an artistic performance in respond to the complexity, a kind of reflection-in-action ◆

2.2.3 EXPLAINING DESIGN

To explain design two paradigms were introduced which are both relevant to understand design. According to Simon, design can be approached in the same way as problem solving.

Rational Problem Solving can briefly be described as fixing agendas, setting goals, generating alternatives, evaluating the consequences and selecting a 'satisficing' alternative. Although the problems in design may be ill-structured, by breaking them down into smaller sub problems they can be approached as well-structured problems. So, in his opinion no new or other activities and techniques than known for problem solving are necessary for design. A remark should be made that Simon

did not explain how the mechanism of breaking down works and how to control it. So the theory as introduced by Simon appears to be more applicable for structured problems than for ill-structured problems. For ill-structured problems the theory of Schön is more suitable. In reaction to the work of Simon, Schön argues that design is different from problem solving. First of all a problem in design is not given, but must be created by the designer; the process of problem setting, from a problematic situation to a problem. The practitioner has to make sense of the uncertain, complex, unique and ill-defined situation. To do so, they need to juggle with variables, reconcile conflicting values and manoeuver around constraints and in the end there is no unique right answer. Also to this Reflective Practice paradigm a comment can be made that it is not explained how frames are made and what good frames are.

Besides Schön also Hatchuel [Hatchuel 2001] reacted to the problem solving approach of Simon. He appreciates the work of Simon, however the development of a design theory which Simon started remains unfinished. In Hatchuel's paper "*Towards design theory and expandable rationality: The unfinished program of Herbert Simon*" is discussed why the program is unfinished. Hatchuel discusses two points: "*i) Simon always maintained that design and creativity were special forms of problem-solving, while it is more likely that decision-making and problem-solving are restricted forms of design. ii) Simon has limited interest in the construction of social interaction, which is a key resource of design processes.*" Hatchual touches upon two points that explain why RPS is not suitable for ill-structured problems. According to Simon design is problem solving, for design no other activities are necessary than for problem solving. Hatchuel [Hatchuel 2001] uses two real-life situations to show that design cannot be limited to problem solving, and that problem solving is only a stage within a design process. He introduces two examples that clearly illustrate the subtle difference.

Two groups of friends are discussing what to do next Saturday in town. The first group is discussing a 'good movie' and the second group a 'nice party'. Hatchuel argues that the first group is just making a choice from a set of alternatives while the other group is having a design project, no solutions are available, they need to be created. The choice for a good movie cannot be made by watching all the movies to select the best one, nor to read all the reviews. Between the friends may be different opinions and tastes, so strategies are needed. Also criteria are necessary to have a better understanding of 'good'. Expertise about award-winning movies may be of importance. So all kind of theories and strategies of rational problem solving can be used to select a good movie. The same kind of strategies will be used in the second group, however 'party' is an infinitely expandable concept. This means that there are uncountable solutions, it will always be possible to create new parties by combining the listed ones, and so on. Due to the infinitely expandable concept the second group will need also different processes [Hatchuel 2001].

Hatchuel distinguishes three differences between problem-solving and design (ill-structured problems), based on the presented cases.

- The unexpected expansions of the initial concepts

"*The understanding of what is 'a movie we can see in a theatre downtown next Saturday' will remain unchanged. However, unexpected designs of what is a 'party' can emerge from the*

process." [Hatchuel 2001] This difference is explained by Lawson [Lawson 2009, 115] that there is a creative step necessary to define what is meant by a party and also, that there are no predefined solutions for parties.

- The design of learning devices

In both cases learning is observable. In the 'movie' group, *"learning results from the exploration of recognised, known areas"* [Hatchuel 2001]. In the 'party' group, *"learning determines the generation of problems and has to be considered as a design area, i.e. as a process designed to generate new concepts and problems"* [Hatchuel 2001]. Learning-devices like experiments, drawings, prototypes support the process to get to a solution.

- Social interaction as a design resource and a designable area

The first group are the 'clients' of their own choices, they are the ones who will watch the movie, while the 'party' group *"has to at least take into account the expected judgements and behaviour of the selected guests"* [Hatchuel 2001]. So, the success of the party cannot be completely controlled by the designers.

By introducing the two paradigms and the examples of Hatchuel it is made clear that problem solving is a part of design, and that design also has other characteristics. To these characteristics can be added the 'core features' of design ability presented by Cross in his paper: "*The nature and nurture of design ability*" [Cross 1990]. Cross describes the features that characterise the designer based on interviews with designers and design studies. According to Cross designers:

- *"Produce novel, unexpected solutions*
- *Tolerate uncertainty, working with incomplete information*
- *Apply imagination and constructive forethought to practical problems*
- *Use drawings and other modelling media as means of problems solving*
- *Resolve ill-defined problems*
- *Adopt solution-focussing strategies*
- *Employ abductive/productive/appositional thinking*
- *Use non-verbal, graphic/spatial modelling media"*

By presenting the paradigms and examples it becomes clear that there are various aspects that characterise design. Designing is creating new and unexpected solutions. It is coping with ill-structured problems which need to be solved, however these problems are not given but need to be extracted from the situation which can be uncertain, instable, complex, unique or have value conflicts. So it is concluded that design is not only problem-solving it is also problem-setting. Design is creating solutions for both structured and ill-structured problems. The solutions to a problem are never pre-defined, are uncountable, and during the design process new and unexpected solutions can emerge. Therefore, it is not selecting one of the alternatives, but the alternatives need to be created.

To get from a problem to a solution designers develop and refine at the same time the formulation of the problem and the ideas for a solution. This model of co-evolution is first presented by Maher [Maher 1996] and used by Dorst and Cross [Dorst 2001] to explain creative design. *"Creative design seems more to be a matter of developing and refining together both the formulation of a problem and ideas for a solution, with constant iteration of design 'spaces'- problem space and solution space."* [Dorst 2001]. *Figure 2-2* describes the iteration that Dorst and Cross observed in their study. The designers start with exploring the problem space and recognise a partial structure.

This structure (P(t+1)) is then used for structuring the solution space (S(t+1)). They consider the implication of the partial structure within the solution space, with this they generate some initial ideas and so develop the partial structuring of the

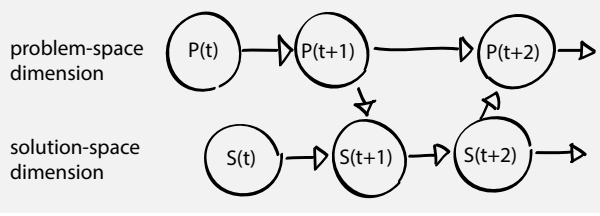


Figure 2-2: Co-evolution of problem – solution [Dorst 2001]

solution (S(t+2)). They transfer the developed partial solution structure back into the problems space; P(t+2). The goal of these iterations is to create a matching problem space and solution space. [Dorst 2001].

The steps between the problem space and solution space can be seen as building a bridge between the spaces, constructed by the iterations. *"This event occurs as the moment of insight at which a problem-solution pair is framed: what Schön called 'problem framing'."* [Dorst 2001]. In the last part of their article Dorst and Cross describe how designers frame the partial problem space. First they recognise a cluster of related information in the problem space that enables them to make a partial structuring of the problem space. They search for expected, default and surprising answers by asking a set of 'standard' questions, checking the current project with previous experiences. The encountered surprises drive the originality within a design project. [Dorst 2001]. ◆

2.2.4 DISCUSSION AND CONCLUSION - DESIGN

The different theories of rational problem solving, reflective practice and co-evaluation illustrate that different problems need different approaches. Structured problems can be solved by the approach of RPS as described by Simon, while ill-structured problems need a more reflective approach as described by Schön and amplified by Dorst for creative design. Within product creation both problems can occur and therefore a combination of these approaches is considered necessary during the product design process.

In this literature overview is focussed on one aspect of design; problem solving. But, the process of product development cannot do without decision-making. To quote Simon: *"The work of managers, of scientists, of engineers, of lawyers, is largely work of making decisions and solving problems. It is work of choosing issues that require attention, setting goals, finding or designing suitable courses of action, and evaluating and choosing among alternative actions. The first three of these activities – fixing agendas, setting goals, and designing actions – are usually called problem solving, the last, evaluating and choosing, is usually called decision making."* [Simon 1986]. Therefore the literature search is continued into decision-making, as the focus of this research project is on what makes usability related decision-making in design practice 'go wrong'. ◆

2.3 **Decision-making**

In chapter 1, it was stated that usability issues result from 'incorrect' decisions, decisions with negative consequences for usability. A better understanding of decision-making is required to get to know how to improve it. However, decision-making is not addressed explicitly in design literature. It is extensively discussed by Simon in relation to structured problems but it is hardly discussed within the presented theories of Reflective Practice [Schön 1983] or co-evolution [Dorst 2001]. Therefore, decision-making literature outside the scope of design theory was explored.

2.3.1 ANALYTICAL DECISION-MAKING

Decision-making is something that people do all the time, as much in daily life as for professional reasons. Decision-making is studied from various perspectives, resulting in a broad overview of what decision-making is, how it should be done, how it is done, and how it can be improved. A long-standing approach in decision-making is the analytical approach of decision-making: defining the problem, generating and evaluating alternatives, selecting and implementing the most optimal alternative and evaluating the result. This analytical approach is done by using specified (statistical) procedures. Examples of these procedures can be found within *"Decision Analysis"* by Raiffa [Raiffa 1968], *"Decision analysis for the manager"* by Brown [Brown 1974], or in *"Decisions with multiple objects"* by Keeney [Keeney 1993]. Within these books procedures are described such as; Bayesian inference or Bayesian probability for making propositions based on incomplete information, or a decision tree analysis for making choices with uncertain outcomes. And a final example, multi-attribute utility analysis for choices with multiple competing criteria of evaluation. It is outside the scope of this research to further explain these procedures. The analytical approach takes *"decision theory as a norm that is fully justified by its formal properties and not by its fit to the way people in fact make decisions"* [Cohen 1993, 44], as people do not make their decisions according to mathematical statistical rules [Kahneman 1982, 272]. It is therefore not useful to focus on these analytical approaches of decision-making as for the focus of this research is on how designers make usability related decisions in design practice. ◆

2.3.2 RATIONAL DECISION-MAKING

Rational Decision-Making (RDM) or Rational Problem Solving as described by Simon is also an analytical approach but does not aim for the most optimal solution but for a

'satisficing' solution. Herbert Simon acknowledges that there are limitations to human being's rationality [Simon 1976, 241]. It is impossible that one could know all the alternatives, or all the consequences that follow each alternative [Simon 1976, 81]. From an individual's standpoint, the limits of rationality can be divided into three categories: *"limited by his unconscious skills, habits and reflexes; limited by his values of conceptions of purposes; limited by his extent of knowledge and information"* [Simon 1976, 241]. Therefore, the individual can be rational by *"being able to pursue a particular course of action; having a correct conception of the goal of action; being correctly informed about the conditions surrounding his action"* [Simon 1976, 241]. Choices can be rational within these boundaries; 'bounded rationality'. This bounded rationality ensures that people cannot make an optimal decision, but need to make a 'satisficing' decision [Simon 1972, 168], finding a solution that is good enough. Within the real and complex world in which humans need to take decisions it is necessary to *"simplify our problem formulations drastically, even leaving out much or most of what is potentially relevant."* [Simon 1986]. So, his prescriptive theory of decision-making is based on observations of simplified situations. A decision-making theory that is based on observation in the real and complex world is Naturalistic Decision-Making, which is described in the next section. ◆

2.3.3 NATURALISTIC DECISION-MAKING

Naturalistic Decision-Making (NDM) is a perspective that built its theories based on observations in the real world context, so outside laboratories. The founder, Gary Klein, reacted to the analytical and rational approach of decision-making. In his opinion, decisions were not made in an analytical manner at all in the real world. No generation of alternative options, no generation of probabilities and utility estimates, and no systematic comparison of options were made to ground a decision on [Klein 2008]. Field research was executed by NDM researchers to investigate how decisions are actually made in the real world. They did not model the most optimal ways of decision-making, but they explored how people make decisions under difficult conditions [Lipshitz 2001, Klein 2008]. *"NDM places the human (and hence bounded rational) proficient decision maker at its centre of interest and as its basis for prescription."* [Lipshitz 2001]. In their research, they studied how people use their experience to make decisions in the real world; it is *"an attempt to understand how people make decisions in real world context that are meaningful and familiar to them"* [Lipshitz 2001]. Various fields of the real world are studied by NDM researchers. For example, Klein [Klein 1986, 1989] studied the made decisions by fire ground commanders at the scene of a fire. Lipshitz [Lipshitz 1996, 1997] studied decision-making at defence forces, and Cohen [Cohen 1994] studied the situation assessment of battlefield commanders. The context of these studies, the real world, are situations in which the commanders have to deal with high stakes, as lives can be at risk in a battle, or situations that are changing and unpredictable when fire expands and buildings may collapse.

This descriptive theory of decision-making in the real and complex world may be relevant for decision-making in design, as that is a complex situation as well. Therefore characteristics of this theory are introduced in some more detail so that it can later on be identified whether it is a relevant theory for decision-making in design practice.

REAL WORLD CONTEXT

NDM researchers observed the task of making decisions by professionals in various contexts of the real world. These various contexts could be characterised by eight elements: *"Ill-structured problems; time stress; multiple players; uncertain dynamic environments; shifting, ill-defined, or competing goals; organizational goals and norms; high stakes; action and feedback loops,"* [Orasanu 1993, 7]. A context characterised by these elements influences the decision task of a decision-maker. Making a decision becomes more difficult when e.g. goals are shifting or many members are involved. The quality of a decision can also be affected when e.g. feedback loops are insufficient. Although the decision task is not necessarily influenced by all elements at the same time, often several of these elements will complicate the decision task [Orasanu 1993, 7].

DECISION-MAKING MODEL

NDM researchers were very much interested in the *"way people use their experience to make decisions in field settings"* [Lipshitz 2001]. Therefore, they studied proficient decision makers in the real world, to discover their strategies [Klein 2008]. This is in contrast to analytical decision-making that is often studied in laboratory settings. The various studies of decision-making in the real world resulted in various decision-making models [Lipshitz 1993, 105-130]. The models were developed separately of each other, but reached similar conclusions: *"People were not generating and comparing option sets. People were using prior experience to rapidly categorize situations. People were relying on some kind of synthesis of their experience to make these judgments."* [Klein 2008]. When fire ground commanders have to make rapid decisions, they do not 'make choices' or 'consider alternatives' but they act and react on the basis of prior experience. Within a minute of decision-making there is no time for comparing alternatives with their (dis)advantages. Instead the commanders rely on their ability to recognise and categorise a situation. Once they know it is 'that' type of situation, they also know a typical way of reacting. Within the available time they evaluate an option's feasibility before implementing it, imagining how it will work. When problems are foreseen another typical action would be explored. This sequence starting with recognising the situation, evaluating an option, and simulating its feasibility and the imagination is modelled by Klein in the Recognition-Primed Decision Model [Klein 1986; Klein 1993, 141], see *Figure 2-3*. This model is identified as an prototypical NDM model [Lipshitz 2001, Klein 2008]. Although the model shows the loop of making one decision, researchers in NDM are aware that a decision is not a single event but a string of actions over time to deal with the problem [Orasanu 1993, 9].

UNCERTAINTY

The quality of a decision -how well a decision is made- and making a decision can be influenced by uncertainty. It is a factor that immediately emerges as an important influencing factor on decision-making [Corbin 1980; Brunsson 1985, 42; Orasanu 1993, 8; Lipshitz 1997]. According to Lipshitz [Lipshitz 1997] the influences of uncertainty on decision-making are *"a sense of doubt that blocks or delays action"*. Although every individual may experience it differently, uncertainty has its effects on actions; making decisions. Hesitancy, indecisiveness and procrastination are terms to describe the delay of action.

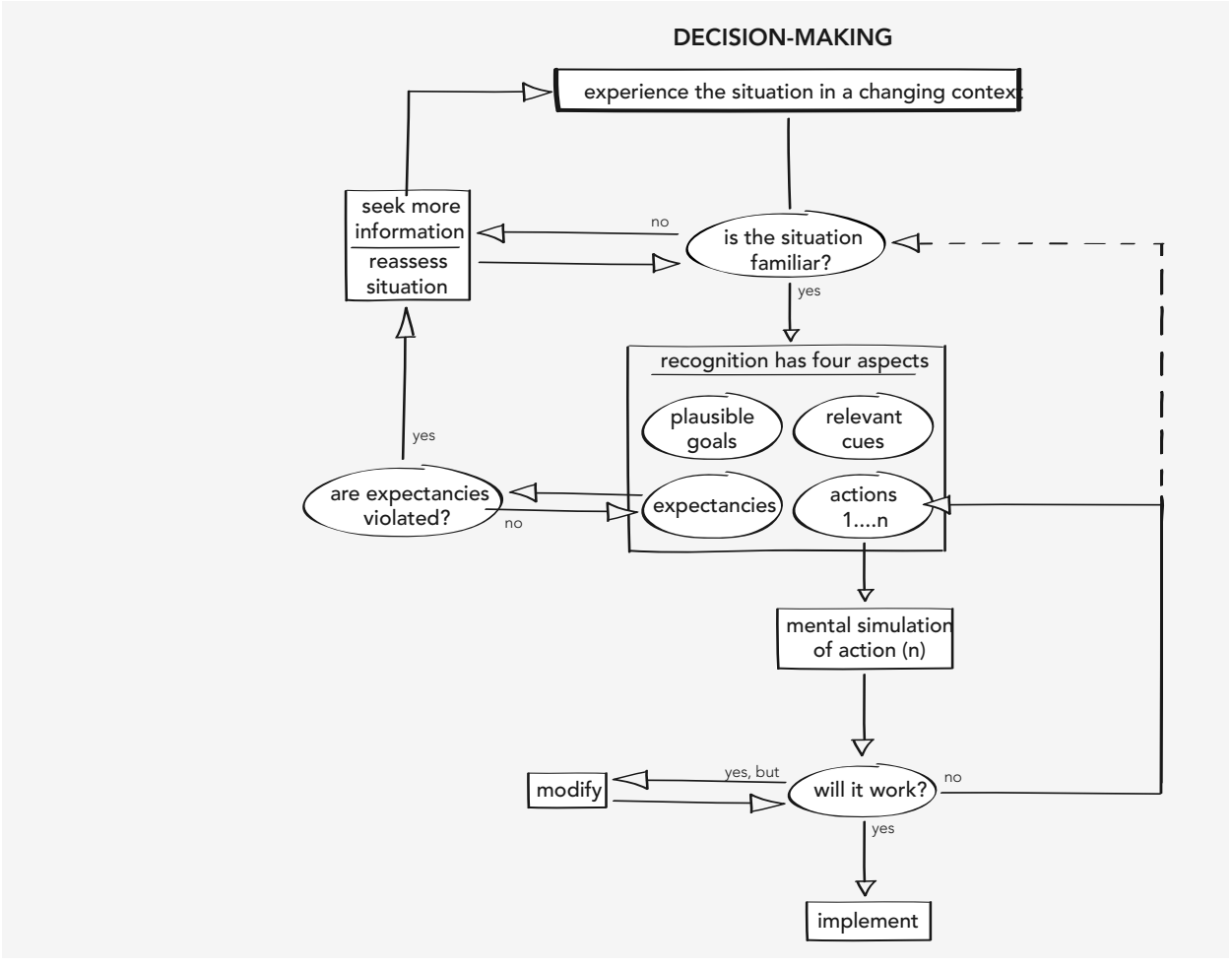


Figure 2-3: Recognition primed decision-making model (RPDM) [Klein 1993, 141]

In his article *"Coping with uncertainty: A naturalistic decision-making analysis"* Lipshitz presents an overview from literature of the different concepts of uncertainty [Lipshitz 1997]. With this overview, he presents the multiple interpretations of uncertainty. A commonly used definition of uncertainty is *"The difference in the amount of information required to perform a task and the amount of information already possessed by the organization"* [Galbraith 1973], or in short; the lack of required information to perform a task.

Lipshitz [Lipshitz 1997] investigated the factor uncertainty from an NDM perspective and created a classification of uncertainty. With this classification he specifies what uncertainty is, related to decision-making in the real world. Uncertainty can be classified according to its issues and sources [Lipshitz 1997].

The issue is what the decision maker is uncertain about, uncertainty about the:

- outcomes
- situation
- alternatives

The source is what induces this uncertainty:

- incomplete information
- inadequate understanding
- undifferentiated alternatives

In this thesis, the issues of uncertainty are called types of uncertainty to prevent confusion with the term usability issues. In *Figure 2-4* the types and sources of the influencing factor uncertainty are visualised.

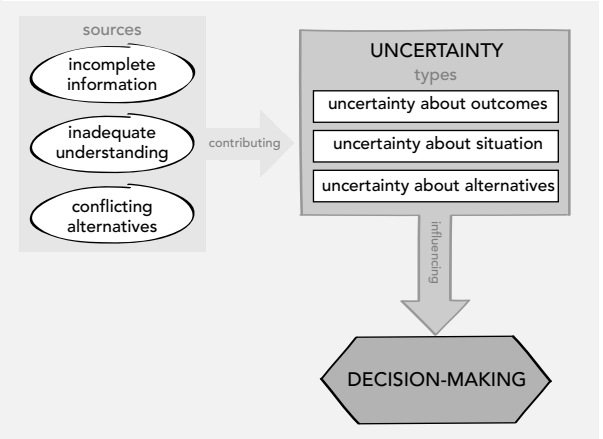


Figure 2-4: The influencing factor uncertainty with its types and sources [Lipshitz 1997]

Incomplete information is mentioned most often in literature as a source of uncertainty; this can be partial lack of information, complete lack of information or unreliable information. Not only incomplete information makes it difficult to make decisions, also difficulties in understanding can block decision makers, due to ambiguous information, the novelty of situations, and fast changing, or unstable situations. But it can also be difficult to make a decision when a decision maker has perfect understanding; then he encounters conflicting alternatives, the solutions have different advantages and disadvantages.

The description of the influencing factor uncertainty by its types and sources is considered relevant for decision-making in a design context. Uncertainty makes decision-making difficult as information or knowledge is missing to ground a decision on. This may result in a lower quality of a decision, which can lead to 'incorrect' decisions resulting in usability issues. ◆

2.3.4 DISCUSSION AND CONCLUSION - DECISION-MAKING

Several theories on decision-making outside design theory were investigated as only limited literature on decision-making in design was available. The NDM theory seems an interesting perspective on decision-making for design practice. NDM researchers observed the real and complex world in which decisions were made by professionals. Based on these observations they identified factors that influence decision-making and created a model of how rapid decisions are made. The NDM approach focusses on decision-making strategies in the real world in which optimal decisions with extensive evaluation of options are not (always) feasible. When a commander at the scene of a fire has only a few seconds to decide, then he does not have the time to apply analytical decision-making strategies. Instead, he will recognise and categorise the situation based on his experience. Once he knows it is 'that' type of situation –based on his experience-, he also knows a typical way of reacting. He will evaluate the action by a mental simulation before implementing the action. This approach of decision-making may better fit design decision-making than the rational approach, also because of its focus on ill-structured problems. Therefore is discussed next how this approach could be used for design decision-making in the following section. ◆

2.4 Decision-making in design

The NDM approach could be useful for understanding decision-making in design. Therefore design theory is investigated to find similarities between naturalistic decision-making and design decision-making. ◆

2.4.1 DESIGN CONTEXT

In NDM theory the context is indicated as an influencing factor on decision-making in the real world. This context is characterised by eight elements and each of these elements can influence decision-making in their own way [Orasanu 1993, 7]. It can influence the decision task by making it more difficult to make a decision, or influence the quality of a decision. Each of these elements is presented and discussed to verify whether the design context can be characterised by the same elements.

ILL-STRUCTURED PROBLEMS

The first element of the real world context is 'ill-structured problems'. Orasanu [Orasanu 1993, 7] describes them as problems that give the decision-maker significant work to recognise what is happening and to develop solutions that might be appropriate responses. As described in section 2.2; problems in design practice are also ill-structured problems [Simon 1973]. Designing is creating new and unexpected solutions for these ill-structured problems. However, these problems are not given but need to be extracted from a problematic situation [Schön 1983, 40]. To make sense of this uncertain, complex, unique and ill-defined situation the practitioner has to juggle with variables and manoeuver around constraints [Schön 1983]. And in the end there is no unique right answer, as ill-structured problems have uncountable solutions [Hatchuel 2001]. This first element is clearly an element that also characterises the design context and could influence decision-making by the significant amount of work that needs to be done to get to a solution.

TIME PRESSURE

The second element is 'time stress'. In the case of a fire, actions can be required within seconds or minutes. This significant time pressure results in two implications [Orasanu 1993, 9]. The first is the experienced high level of personal stress, which may result in exhaustion or loss of awareness. The second is the inclination to use less complicated reasoning strategies like analysing only one or a few options instead of finding the most optimal solution. This element also characterises the design context, but is often called time pressure. Nowadays consumer electronic products are becoming increasingly complex while the time to develop the product is getting shorter; the time-

to-market is decreasing [Brombacher 2005]. Companies want a short development time, because the sooner a product is on the market, the sooner profits can be gained and the chance on profits enlarged. Not only is the time-to-market decreasing, also adoption cycles are decreasing. The timespan within which a product is introduced, accepted, adopted and becomes outdated is becoming shorter, so there is only limited time to get a return on investment [Minderhoud 2005]. This pressure from the market is experienced within development teams. There is limited time to develop the product resulting in pressure on product development activities like usability testing and implementation of the test results [Minderhoud 2005]. But also the market feedback for improvement is often not available, when starting development of a successor product the predecessor is not yet on the market [Brombacher 2005]. This time pressure influences decision-making due to the limited available time for activities, which could result in hasty decisions, not collecting required information, postponing (usability) tests, or complaints about lack of time.

MULTIPLE PLAYERS

The third element described in NDM theory is 'multiple players'. Many of the investigated decisions involved more than one decision maker. It may even be the case that a group has to act as one decision maker or that geographically separated managers have to make one decision. With multiple players, it can be difficult to make sure that they share the same understanding of the goals and situation so that the relevant information is brought forward when needed in the decision process [Orasanu 1993, 10]. Also, a shared understanding of the available information can already be difficult to guarantee. This element is very recognisable for the design context as well. In product development the teams consist mostly of multiple players as the development of complex products demand the expertise of different disciplines. For usability design it is actually recommended to have multi-disciplinary teams [Vredenburg 1999; Göransson 1999; Gulliksen 2003], because working together with various disciplines will enable the team to create a total user experience [Vredenburg 1999]. These different disciplines have different views and address their own perspectives and interests during the development process [Bucciarelli 1996, 76; Lawson 2009, 42]. To complicate things even more, these members of multidisciplinary design teams can be located across the world [Minderhoud 2005]. High levels of collaboration and communication are necessary to enable knowledge sharing and integration within the multidisciplinary teams [Badke-Schaub 1999; Charnley 2001].

DYNAMIC ENVIRONMENTS

The fourth element in NDM is 'uncertain dynamic environments'. Naturalistic decision-making takes place in a world of incomplete and imperfect information [Orasanu 1993, 8]. Information is only partly available for the decision maker that can also be ambiguous or of poor quality, this resulting in uncertainty during decision-making. The world is often changing quickly, being dynamic, like a fire that can change in a few minutes from a small fire into a large one. An environment being uncertain and dynamic influences the decision-making process. In design theory these situations are described as being *"problematic situations which are puzzling, troubling, and uncertain"* [Schön 1983]. The decision maker has to make sense of this problematic situation to convert it into a problem before it can be solved. However in section

2.3 uncertainty is described as a factor that influences decision-making, so it is probably more than an element that characterises the context. Therefore it was decided to limit this element to 'dynamic environments', being a relevant element for the design context. The context in which designers work changes when information becomes available. Within the new perspective, decisions need to be checked, and when necessary be revised, which may have consequences for subsequent decisions. A designer cannot hold on to a decision, but needs to be flexible when new information becomes available.

ILL-DEFINED, SHIFTING OR COMPETING GOALS

The fifth element is 'ill-defined, shifting, or competing goals'. Decision-making in the real world is different from making decisions in a laboratory setting, as studied within analytical decision-making. In laboratory settings, a decision can be dominated by one single, well-understood goal or value. While in the real world the decision maker can be driven by multiple purposes that are not all clear or are even ambiguous [Orasanu 1993, 8]. In a fire the commander wants to save the building and not expose his crew to unnecessary danger. *"As the fire develops, the commander's goal may shift from protecting the building to saving lives. Often, larger goals will provide direction, since decisions typically are embedded in broader tasks"* [Orasanu 1993, 9]. Also within a design project there are various goals which may compete, change or be ill-defined. The goals of a project direct the process of framing a problem and guide the decision maker when making decisions. The process is influenced when goals are ill-defined, conflicting or changing as the goal than cannot guide the process. Thus also the design context can be characterised with this element.

ORGANISATIONAL GOALS AND NORMS

The sixth element is 'organisational goals and norms'. Naturalistic decision-making as well as design decision-making often takes place in organisational environments. This setting implies that the applied values and goals are not necessarily people's personal values and goals. So a decision maker needs to act according to general goals, standard procedures, and organisational rules. These guidelines are difficult to include in 'artificial' environments like laboratory test settings as executed with analytical decision-making [Orasanu 1993, 10]. This element influences decision-making and can only be observed when decisions are studied in the field, yet again another influencing factor from NDM theory that also characterises the design context.

HIGH STAKES

The seventh element is in NDM theory is 'high stakes'. The focus of naturalistic decision-making theory is on decisions that involve outcomes of real significance. Extinguishing a fire has to deal with preserving substantial property on lives. These kinds of decisions matter to the decision makers and they are likely to feel stressed but therefore take an active role in arriving at a good outcome [Orasanu 1993, 10]. According to NDM, researchers undertake many studies of decision-making in laboratory settings that do not take into account these high stakes and commitments that are shown in the real world. Also the design context can be characterised by this element, although the stakes may be different. For a company, investments can be large when a specific mould is necessary for production of the product. This can lead to big losses for the company when the mould is ordered and large changes have to be made. Consequently investments may not be returned

when the sales are disappointing. Stakes can also be high when human lives are involved, for example, designing the safety precautions of a chainsaw, or when designing an airbag deployment mechanism.

ITERATIVE DESIGN

The eighth element in NDM theory is 'action and feedback loops'. In NDM the focus is on the entire series of events, a string of actions. This is in contrast to the traditional decision models that are concerned with an event, a decision moment. Naturalistic decision-making takes into account the various solutions and consequences. For example with the treatment of a patient; *"If a patient responds to drug A, the infection was clearly disease X. If not, we'll move to drug B, which should help if the problem is disease Y, and so on."* Feedback on a solution generates information for corrections later on. These loops of feedback and action provide an advantage when outcomes are tightly coupled to the actions but influence decision-making when the outcomes are loosely coupled to the actions [Orasanu 1993, 9]. These action and feedback loops can be compared with an 'iterative design' approach in design. Not all information is available at the start of a design project. A designer needs to start the project based on the available information. By creating solutions feedback is generated. This feedback provides input for new actions to improve the solution. The output and input becomes more and more detailed during the process of iteration. For example, a design iteration of a user interface; the first idea of this user interface will be sketched and checked by (mental) simulations, the next step can be a paper prototype of the user interface, this being tested again. The results of the test are used as input for a next iteration, resulting in an improved solution being tested, for example by a flash simulation. Again the feedback guides the next iteration. These iterations are a continuous process of learning during product development. A good iteration can be described as double loop learning. Argyris [Argyris 1974; 1978] describes learning as the detection and correction of errors and makes a distinction between single-loop learning and double-loop learning. Single-loop learning is detecting and correcting the error and continuing the process. With double-loop learning the team member questions why the error happened, corrects the error and the source of the error. The latter correction can result in a change of variables, goals, plans or strategies. Also this last element from NDM theory can be used to characterise the design context. However within the design context is it called iterative design instead of action and feedback loops.

The discussion of the eight elements from NDM theory that characterise the real world context verified that these elements are all also applicable for the design context. This suggests that the 'design context' could also be an influencing factor on decision-making in design practice. An overview of the elements that characterise the design context is given in *Figure 2-5*. Three names of elements are changed compared to the elements of NDM theory; time pressure, ill-defined and shifting goals, and iterative design. These names better match the elements for the design context based on design theory. The resemblance between the elements that characterise the 'real world context' and the 'design context' suggest that the influencing factor context could also be applicable for decision-making in design practice as well. In both fields is decision-making influenced by one or more elements of the context. ◆

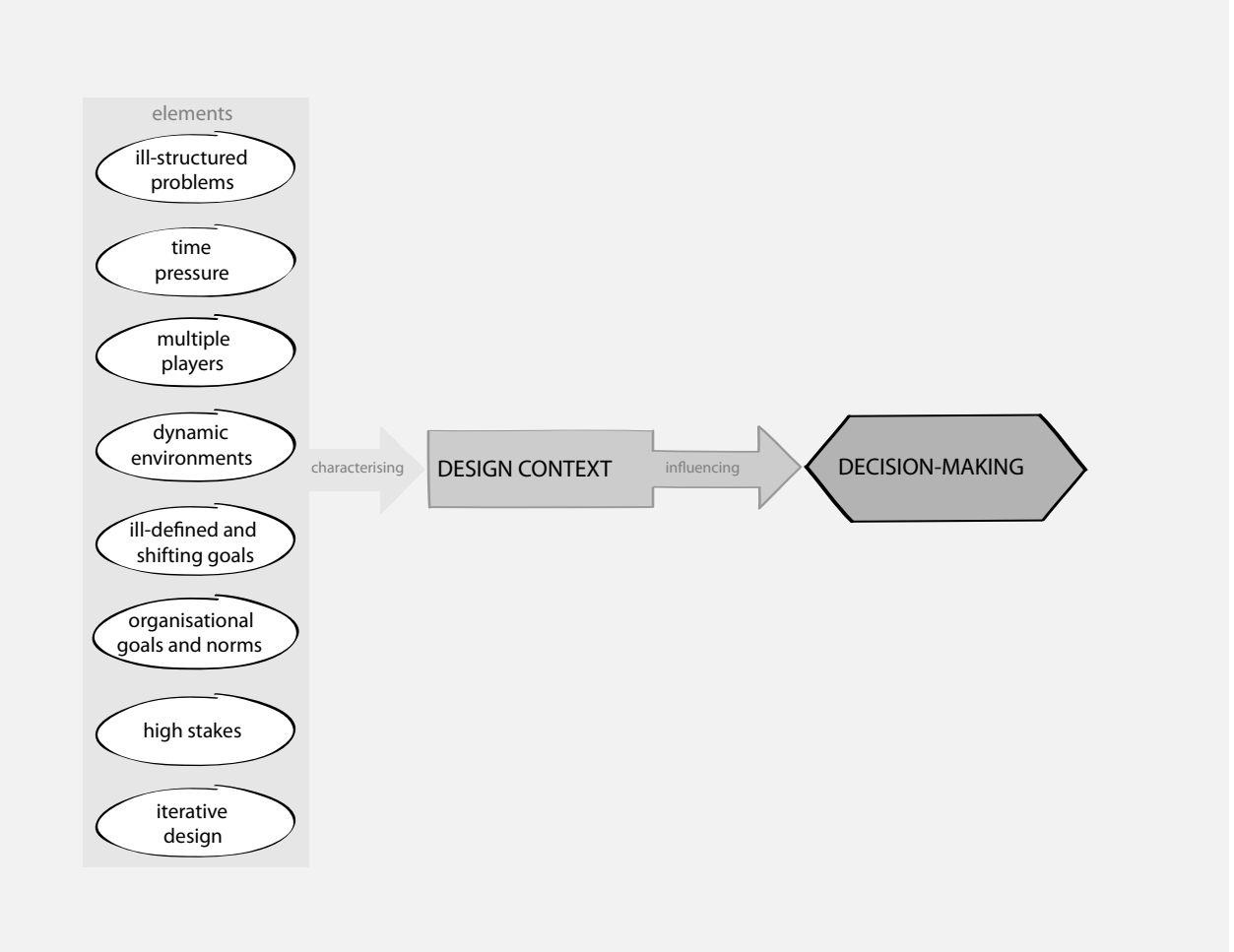


Figure 2-5: The influencing factor design context with its characterising elements

2.4.2 DECISION-MAKING MODEL IN DESIGN

In section 2.3.3, the decision-making model of Klein [Klein 1993, 141] (see *Figure 2-3*) was introduced that described decision-making in the real world. In the real world decisions are made based on experience. The situation is classified as a familiar, or unfamiliar situation. For a familiar situation the team member evaluates the possible actions until a satisfactory one is found. A mental simulation of this action is made to check whether it will work and executed when it does. Information will be retrieved when the situation is not familiar to subsequently run the various phases of making a decision. In design there is no such model that describes decision-making explicitly. However, some similarities between the decision-making model of Klein and the design process as introduced by Schön [Schön 1983] (and presented in 2.2.2) can be found. Both approaches describe an on-going process of recognising the situation, creating options, evaluating actions and simulating these actions before implementing. It is not claimed that the design process as introduced by Schön can simply be transformed into a decision-making model. However, the similarities show that designing and decision-making are closely intertwined processes. Both describe the first step as observing the situation. What is going on in the context? Which objects can be considered and named? Subsequently the observed situation is put into perspective; is the situation familiar? Can it be compared with previous situations? The next step is to select an action that it is necessary to take to address the situation. Within NDM this action is simulated by imagining before implementing the action, a mental simulation. While within design these actions are simulated by 'prototypes'. The action will be implemented when the simulation provides satisfying results. For the decision-maker this can be an implicit process, while the decision-making model of Klein generalises the process and makes it explicit. Within this research it is suggested to use Klein's model as a guidance in understanding design decision-making because of the similarities between NDM decision making [Klein 1993] and the design process as described by Schön [Schön 1983]. ◆

2.4.3 UNCERTAINTY WITHIN DESIGN

In section 2.3.3 it was described how uncertainty influences naturalistic decision-making, another factor besides the context in which decisions are made. Uncertainty is described by its types of uncertainty and its sources of uncertainty. The types describe what the decision maker is uncertain of and the sources explain what induces uncertainty. It is assumed that the factor uncertainty could influence the decision task of the designer too. Therefore the meaning of the types and sources of uncertainty are subsequently explained within the design context.

A design decision maker can be uncertain about the outcomes of a decision, about the situation or about the alternatives. These uncertainties can be induced by incomplete information, inadequate understanding, or conflicting alternatives.

The first source of uncertainty is incomplete information. In the development process all kinds of information are required. It would be difficult to make decisions about the outer form when the sizes of components are unknown, or to make decisions about the menu structure when it is unknown what

the user expects. In some cases it is possible to retrieve the information before making the actual decision, in other cases the designer has to make assumptions and verify these later on in the process. Many usability techniques are available when there is a lack of information about the user, his goals or the context. These techniques support the designer in retrieving the required information and thereby diminish the uncertainty. These techniques are an important tool for addressing uncertainty during decision-making in the product development process and thereby limiting the number of usability issues. Uncertainty can also result from the source inadequate understanding. Inadequate understanding can happen due to ambiguous information, the novelty of situations, or fast changing or unstable situations. Uncertainty can occur when a designer faces a new situation and cannot categorise it according to previous experiences. The inadequate understanding will affect his actions due to hesitancy about what to do. The third source that contributes to uncertainty is conflicting alternatives. It will be difficult for a designer to decide when he has two possible solutions, each with its own advantage and disadvantages. This can block the designer in what to do or delay the action.

Within design theory, uncertainty is mentioned only to some extent. Simon does not mention uncertainty as a factor that influences decision-making. But he does mention that as a designer you cannot know everything and that you have to work within these limits [Simon 1972, 168-169]. Schön describes the situations with which the designers have to cope as problematic, puzzling, troubling and uncertain [Schön 1983, 40]. So he addresses uncertainty in relation to the context. Uncertainty is most explicitly mentioned by Cross [Cross 1990]. He states that one of the design abilities of designers is "*tolerate uncertainty, working with incomplete information*". Working with incomplete information forces the designer to make assumptions during the project. These assumptions generate feedback that can be used as input for iteration, a learning loop. These iterations generate the necessary information for the decision. So it can be assumed that uncertainty is also an influencing factor on design decision-making and that the categorisation of uncertainty as described in NDM theory could be applicable for design theory, because of the identified similarities within theory. ◆

2.4.4 DISCUSSION AND CONCLUSION - DECISION-MAKING IN DESIGN

It was suggested at the start of section 2.4 that NDM theory could be useful for understanding decision-making in design, thus design theory was investigated. Within design theory several similarities on the influencing factors and decision-making model were found. The influencing factor design context could be characterised by the same eight elements of the real world context of NDM. The influencing factor uncertainty with its types and sources is likely to occur in design as well. And Klein's decision-making model [Klein 1993, 141] is not the same as the design process as described by Schön [Schön 1983], but they show that design and decision-making are closely intertwined processes. Therefore it is concluded that for the time being NDM theory could be used for understanding decision-making in design. The influencing factors on decision-making in design are visualised in *Figure 2-6.*

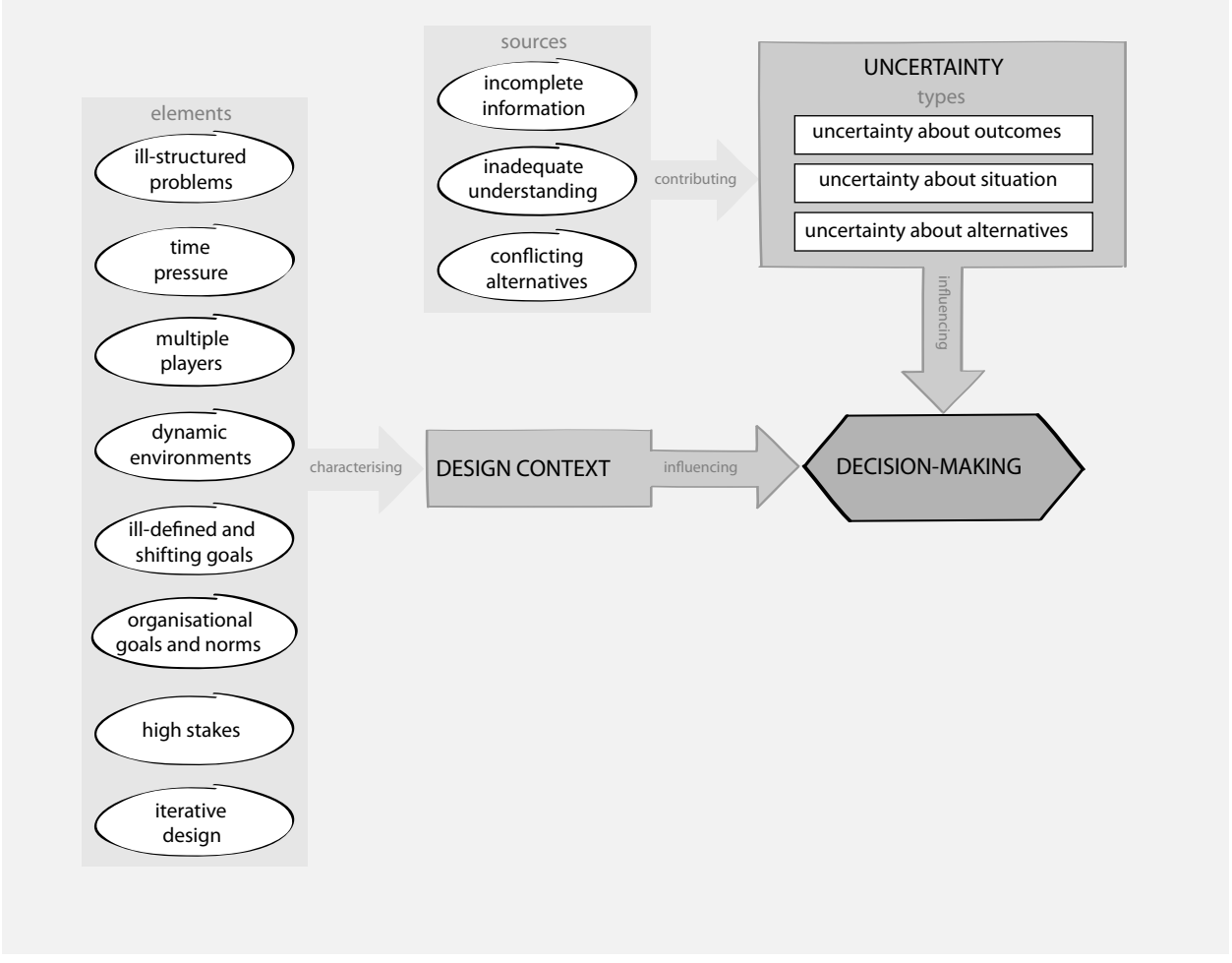


Figure 2-6: Conceptual framework I - Influencing factors on decision-making in design practice

Figure 2-6 is a conceptual framework that shows the factors that possibly influence decision-making in design. This framework shall be elaborated during this PhD research project. Using these factors from NDM theory to understand decision-making in design provided a theoretical basis that is currently lacking in design theory. However these theoretical findings do not answer the research question from chapter 1: *"In design practice, what makes usability related decision-making go wrong?"* It is likely that the found factors from NDM theory influence usability related decision-making in design. Uncertainty makes it more difficult to make a decision, which could lead to a lower quality of a decision, possibly resulting in an 'incorrect' decision, a usability issue. However these theoretical findings do not necessarily provide an insight of how it really takes place in design practice. Therefore the factors that influence usability related decision-making in design were investigated in design practice to gain this insight. ◆

2.5 Study 1: Decision-making in design practice

2.5.1 INTRODUCTION

The NDM theory was considered a suitable perspective for understanding decision-making in design. This literature provided a theoretical basis on decision-making that could not be found in design theory. Based on these findings further directions for research were defined. Investigating how decision-making in design practice is influenced would indicate the actual influencing factors. These factors could be indicators of how to improve decision-making in design practice to reduce the number of usability issues. Therefore it was decided to conduct an explorative study in design practice. For this first study, a specific sub-research question was defined:

"What are the factors that influence usability related decision-making in design practice?"

The focus of Study 1 was on the negative influences. Influences that could lead to 'incorrect' decisions and usability issues, or influences that made it difficult for the team members to make decisions. An inductive and explorative study was conducted to identify influencing factors. This approach provided the possibility to investigate and explore the field without the bias from theory. As it was unknown whether the influencing factors design context and uncertainty would actually influence decision-making in design practice. Subsequently propositions of influencing factors based on the observations were defined. These findings may consequently provide directions for further research to find an answer to the main research question as presented in chapter 1. ◆

2.5.2 RESEARCH METHOD

It was required to retrieve data on decision-making in design practice to answer the sub-research question of Study 1. Preferably data on usability related decisions and subsequently data on its influencing factors. Therefore it was required to identify decisions within a project, subsequently the usability related decisions and then the influencing factors. However the influencing factors were unknown, therefore one of the consequences of the influencing factors was investigated. Influencing factors can complicate the decision task, making it difficult for the decision maker to make the decision, or the quality of a decision can be affected. In this initial study the decisions were investigated that were difficult to make according to the team members, as it was considered more closely related to the influencing factors than 'incorrect' decisions and usability issues.

It was necessary to investigate the field of product development to identify the difficult decisions related to usability. This investigation could be conducted by several techniques, for example, observations, questionnaires and interviews. In Study 1 it was explored whether and which influencing factors have a role in usability related decision-making in design practice. For an initial and quick understanding of these influencing factors conducting questionnaires or interviews would be more efficient than observations. Observations would provide a very rich, detailed and extensive data set on decision-making but is also very time consuming. In addition it is unknown beforehand whether difficult decisions will occur. Therefore a retrospective approach would be more effective and efficient for an initial explorative study. This could be conducted with questionnaires or interviews. Questionnaires would be the quickest way to gather and analyse data, as questions are asked in a fixed structure for each respondent. However in this explorative study it was only assumed that factors would influence usability related decision-making it was unsure whether this would actually occur. Interviews would provide the possibility to ask follow-up questions when answers are unexpected or unclear. Therefore it was decided to conduct retrospective interviews as an efficient approach to gather rich data of a case with difficult decisions.

Though it is commonly known that interviews have several disadvantages, such as personal bias, retrospective sense making and limited recall of details [Eisenhardt 2007]. These disadvantages were partly addressed in Study 1. First of all, the project should not be too long ago so the respondent can recall the project. Project details that could be difficult to recall, for example, dates of project meetings should be verified with documents as the project leader's agenda. The personal bias of the respondent was addressed by interviewing several team members. The personal stories and perspectives of the respondents about the project and difficult decisions were combined to create one story of the project and its decisions. Retrospective sense making was only partly addressed. By interviewing several team members the answers could be verified, however the interviews were not combined with 'real-time' observations [Patton 2002, 247-249]. It was decided to first conduct interviews at one case and to define further research depending on the results of the found influencing factors.

The interviews were specified to be retrospective interviews to enable selecting a project in which difficult decisions related to usability were made. It was also decided to conduct semi-structured interviews. A structured interview with the same questions for each respondent provides the possibility to combine them into one story [Patton 2002, 342]. A semi-structured interview provides the possibility to deviate from the structure and to ask extra questions when unexpected or unclear answers occur or to change the order of the questions when necessary [Patton 2002, 343]. The questions within the interview were open-ended to offer the respondent the possibility to respond in their own words and personal perspectives to learn from their experiences [Patton 2002, 348].

The explorative and inductive research method with retrospective interview techniques provided the possibility to explore the field without hypothesis to obtain propositions about influencing factors on usability related decision-making in design practice.

DATA GATHERING

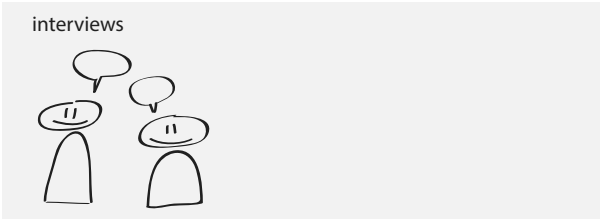


Figure 2-7: Data gathering Study 1

The data of Study 1 was gathered by conducting interviews, see *Figure 2-7*. The following questions and activities were defined to ask during the interviews:

1. What was your role within the project?
2. Here is a timeline of the project. Please mark the moments that you were involved
3. What were, for you, the important decisions within the project?
4. In retrospect, which were the difficult decisions?
5. Which of these decisions had a clear relation to the usability of the product?
6. Please list the difficult decisions, starting with the most difficult one
7. What were the sources that made the decision difficult?
8. Please relate the stated sources to the following categories:
   a) Incomplete information
   b) Inadequate understanding
   c) Conflicting alternatives
   d) Other, ….
9. What would you have done in retrospect to make the decision easier?

Next, the stated questions are explained. The first question to the role of the respondent within the team was asked to get to know his or her perspective and their expertise, contribution and responsibilities in the project. This question was directly followed by the question to indicate on a timeline when he was involved on the project. This timeline was created beforehand with the project leader based on several project documents. It showed the start and end of the project and client meetings. Based on the answers on these first questions an overview of the involved team members was created, see *Figure 2-11*. Several sub-questions were asked to guide the respondent to the question about the sources of difficulty of usability related decisions, this to stimulate recalling the project and its decisions. Question three was the start of the series. What were the important decisions of the project? It was assumed that the important decisions could be most easily remembered. Subsequently the respondent was asked to the difficult decisions of the project, which could be important but also less important decisions. The focus of this PhD research project is on usability, so that directed the fifth question. In the sixth question the respondent was asked to list the various difficult decisions (the most difficult one on top) to obtain an overview of the difficulty of the decisions. Successively, it was asked why the decisions were difficult and whether the respondent could determine a source for this. After discussing the various decisions and sources, it was asked to categorise the mentioned sources against the categories of uncertainty. In section 2.3 and 2.4 literature about influencing factors on decision-making was discussed. This literature suggests that uncertainty could be a factor that influences decision-making. The influencing factor and its categorisation were introduced during the interview after question seven. To the three sources

of uncertainty [Lipshitz 1997], see section 2.3.3, was added a fourth category: 'other'. The respondent could define a specific label where he could not classify the mentioned source. It was assumed that uncertainty can be identified as influencing factor on decision-making in design practice, when the respondent could categorise his mentioned sources to the defined sources of uncertainty from literature. To end the interview the respondent was asked what he would have done differently in retrospect to make it easier to make the decision. All previous questions addressed why a decision was difficult, this question focusses on making the decision easier. With this change of focus other aspects could come up.

All interviews were executed by the author of this thesis. The aim was to interview all involved team members of one specific case. The estimated time for the interviews was about one-and-a-half hours and was executed in quiet surrounding so as not to be disturbed. The interviews were digitally recorded with permission of the respondent. The interviews were held in Dutch when it was the respondent's native language as well, otherwise the interviews were held in English.

DATA PROCESSING

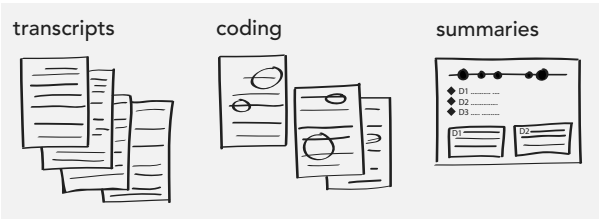


Figure 2-8: Data processing Study 1

The interviews resulted in a set of data that needed to be organised and structured before it could be analysed. The steps of processing the data are visualised in *Figure 2-8*. The first step was transcribing the interviews, having all the interviews on paper. Subsequently, each transcript was summarised according a to fixed pattern, see *Table 2-1*. Structuring the data was necessary as the interviews were semi-structured. These summaries were made by colour coding the transcripts, marking the topics of investigation. The marked nodes were the decisions, the sources for difficult decisions, the influencing factor uncertainty, and the influencing factor context. This coding supported the process of creating the summaries.

CATEGORY	CATEGORY DESCRIPTION
Timeline	Visualisation of the period of time a team member worked on the project and the important decisions mentioned by him within this period
Listing	Listing the difficult decisions. The effective time spent on a decision was often used as indicator
Decisions	Description of the mentioned decisions
Source	List of sources for each mentioned decision moment. Why was it difficult to make a decision?
Categories	Divide the mentioned causes into the sources of uncertainty [Lipshitz 1997] A: incomplete information B: lack of knowledge C: undifferentiated alternatives D: other,….
In retrospect	Description of what the team member would change in retrospect
Remarks	Description of the remarks of the team member related to the interview

Table 2-1: The structure of the interview summaries

Within the summaries first a timeline was presented to get an impression of the project and the various decisions. The timeline indicated the duration of the project, at which moments the respondent was involved and the by the respondent mentioned decisions beneath. A grey line indicated the complete project and the grey dots on the line indicated the project meetings. The small dots were internal project meetings, the medium dots were important internal project meetings and the large dots were the meetings with the client. The involvement of the respondent was indicated by colouring the line and dots black. An example of a timeline is shown in *Figure 2-9*.

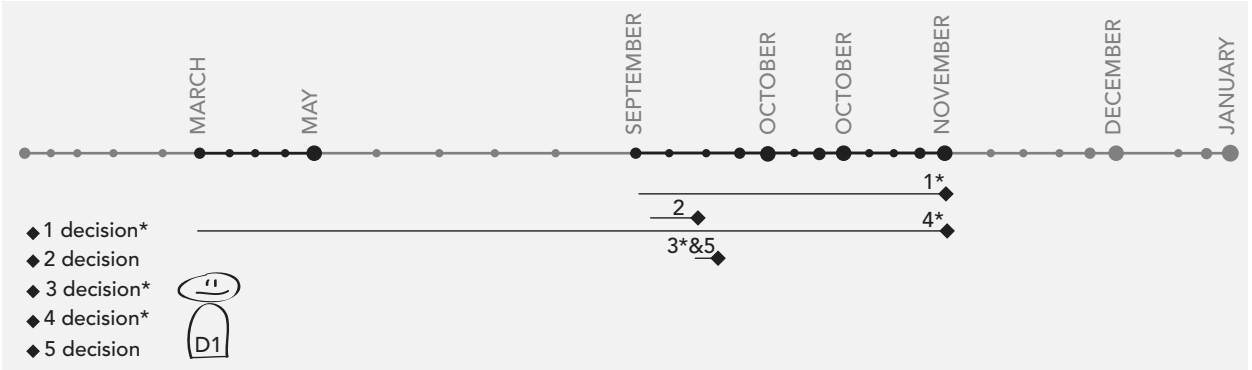


Figure 2-9: Example timeline of one interviewee

On top is shown the timeline with an indication of time in months. On the left side is listed the mentioned decisions according to their prioritising of difficulty. The number 1 position was the most difficult decision. Under the timeline indicated with a diamond is the moment of decision. The line in front of the diamonds give an indication of how long the team discussed the topic before the decision was made. An asterisk indicates that the decision was related to the usability of the product. This timeline with its numbered decisions provided a visual overview of the data gathered.

After having made the timeline the mentioned decisions were described in the summary. What was the decision about, what was the process of making the decision and which sources were mentioned by the respondent why it was a difficult decision. In the summary this was structured by the decisions, as it was expected that it could be mentioned in a less structured way within the interviews. Subsequently, a list of the mentioned decisions was made with an indication of the classified uncertainty source. Category A refers to uncertainty due to incomplete information. Category B is uncertainty due to inadequate understanding, explained as lack of knowledge. And C is uncertainty due to conflicting alternatives, which was explained as 'every alternative has its (dis)advantages'. The respondent could create a new label when the mentioned sources could not be divided into one of the existing categories.

The summary was finalised with a description of what the respondent would do in retrospect to make it easier to make the decision, and any other comments. An overview of all the mentioned difficult decisions and their sources was created by making these structured summaries.

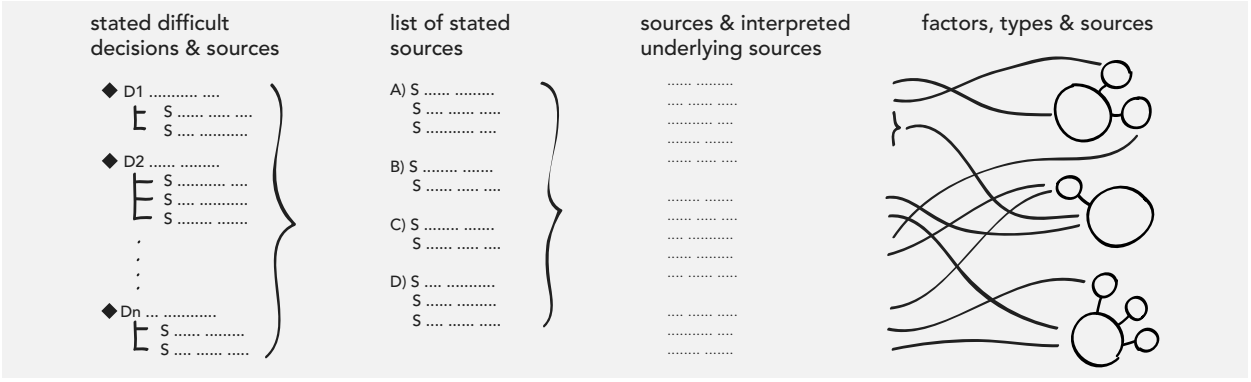


Figure 2-10: Data analysis Study 1

DATA ANALYSIS

Processing the data created a structured overview. The next step was to analyse the data. What kinds of patterns and similarities were visible within the mentioned sources of the difficult decisions. The steps of the data analysis are visualised in *Figure 2-10*. The first step was to group the decisions into the mentioned sources of difficulty. This revealed whether a source was mentioned only once or more often and revealed whether a source influenced one or more decisions. Subsequently the mentioned sources were grouped by looking for similarities between the sources. With this the influencing factors from literature, design context and uncertainty, with their elements and sources were kept in mind. However, grouping the sources of difficult decisions did not yet lead to factors that influence decision-making. For that the sources needed to be studied in more detail. With every source the question 'why?' had to be asked. For example, when time was mentioned as a source for being a difficult question, the reason why time was of influence had to be found. This was done by analysing the transcripts, these provided a greater level of detail than the summaries. By combining the quotes from various respondents the reason why some aspects made a decision difficult could often be found. These analysis and iterations between the mentioned sources and identified reasons resulted in an overview of possible influencing factors, characterising elements and contributing sources. ◆

2.5.3 CASE 1

Several requirements were set to select an adequate case for Study 1. The first criterion was that it should be an electronic consumer product to fit the overall aim of the Design for Usability project. It was of importance that the project was not finished too long ago as retrospective interviews were used to gather the data. Team members should be available for interviews but also be able to recall the activities and decisions of the project. Besides this, it should be a project in which they had to cope with difficult decisions. Thereby the company should give priority to usability. This was to identify the influencing factors on usability related decision-making even when team members had resources and expertise to deal with usability issues during the product development process.

The study was performed at a design agency in the Netherlands. This company has over 20 years of experience in product development. Their experience and expertise is acknowledged by the large number of design awards, including the IF product design award and the Red Dot design award. This company was selected because of their expertise but also because of their focus on creating usable products. This provided a guaranteed amount of resources – time and money – for addressing usability during the product development process. From another study [Harkema 2011] it was known that the designers and usability specialist from this company were familiar with applying usability techniques. Within this company a project was selected that was recently finished and included difficult usability related decisions. The project goal was to develop an electric bike commissioned by an external client. Within this research project the focus was on the development of the display and battery pack of this bike as these parts were most directly related to the electronic interaction with the product. The team that worked on this project consisted of ten members, including a senior and junior project leader, designers, engineers and a usability specialist. An impression of the project process is provided by the following project description. Eight of the ten team members were interviewed, two of them were not involved in the development of the display and battery pack of the bike.

PROJECT DESCRIPTION

The assignment was to develop an electric bike with a detachable battery pack and a display. This display should give information about the cycling speed and the battery life for example. The project started in March with an orientation phase. Within this orientation phase one designer (D1) and one engineer (E1) explored the various possibilities to solve the design case given by the client. The various solutions were presented to the client as a morphological analysis in May. It was decided to place the battery pack in the luggage carrier of the bike and the display on the handlebar. After the summer (and some conflict about the tender for the next phases) the project was continued in September with a kick-off meeting with the client, the project leader (Psr.), the engineer (E1) and the designer (D1). After this kick-off meeting two designers started working on the project, one with a focus on the display (D2) and one with a focus on the battery pack (D1) of the bike. Also two engineers worked on the project, one focussing on the electronics (E3) and one on the mechanics (E1) of the product. An extra designer (D3) was added to the project for only one month just before the interim concept presentation in October. At the interim presentation two variants of the display

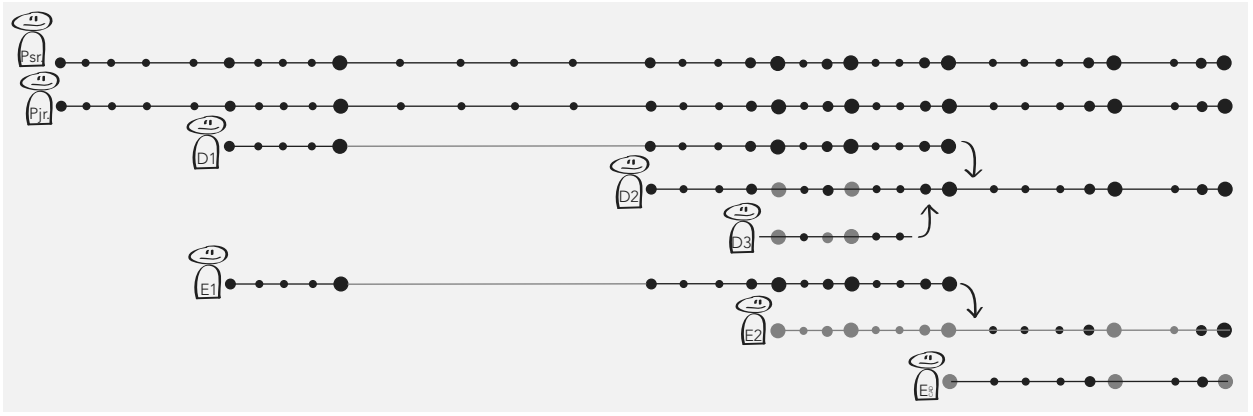


Figure 2-11: Data analysis Study 1

design were presented, again the display designer (D2) was not present and therefore still unfamiliar with the client. The CAD drawer (Ecad) started on the project after this presentation. At the end of the concept phase another engineer (E2) replaced the mechanical engineer and the designer (D1) of the battery pack handed over his work to the display designer (D2). In November the final concept was presented to the client. During this entire process the client was closely involved in the design process because of their expertise about the product and because of the not-yet-defined appearance and appeal of their product range. After the concept phase the project was continued with the detailing phase, detailing all the aspects of the design and making the design ready for production.An overview of the participating team members is given in *Figure 2-11*. The top line shows the project length, from March to January. The larges dots on the line are the meetings with the client, the medium dots are important internal meetings, and the smallest are internal project meetings. Black lines and dots indicate the member's involvement. ◆

2.5.4 RESULTS

2.5.4.1 DESIGN CONTEXT

In section 2.3 the elements that characterise the real world context were introduced, which influence decision-making in the real world [Orasanu 1993, 7]. These elements characterise the context in which decisions are made and how they influence making decisions. These elements were discussed for the design context based on design theory (section 2.4). In the explorative study some of the elements were observed in design practice.

TEAM

The first thing that was noticed in this study was the relatively large team for the kind of project (see *Figure 2-11*). Not only is more than one member of each discipline involved, the members also changed during the project. A reason for these changes related to the capacity planning during the project.

"…it had partly to do with capacity, so tasks were divided, tasks were assigned to different people and um, because the speedometer was assigned to D2, and D2 did not have a lot of time I jumped in. I also lent a hand to D1, because he had a lot of subtasks. With making a model of the rack and battery pack [C] OK [D3] so, the speedometer, rack and battery pack are aspects I was involved in." [1]

[1] *Quotes from interviews are inserted in italics and between quotation marks. Between brackets is the [C] of Christelle, referring to the interviewer or [D1] a number, referring to respondent. Three dots … indicate that a part of the quote is removed. Four dots and an o between brackets (..o..) indicate a pause of the respondent during the interview.*

Another reason for the relatively large project team and changing team members was the element time pressure. The project could make extra progress when team members work together, but this also influenced the process.

"Yes, what was difficult as well was that the project had to be finished within certain time restraints [C] mh [D2] so we worked with several people simultaneously, which leads to things that were done twice [C] yes [D2] that worked quite OK, but when you work with three people, that is, that is actually quite difficult, so the hours pass very quickly, so you must make steps quickly as well [C] mh [D2] to get it arranged."

The described element, a large team and changing team members, influences decision-making in design, according to the respondents because of the difficulties of knowledge transfer. The new members were unfamiliar with the starting points and background of previous decisions. They had therefore a limited overview of the project but also a limited commitment to the project as they did not have a bonding with previous actions and decisions.

TIME PRESSURE

In naturalistic decision-making (NDM) time stress is mentioned as one of the elements that characterises the context in which decisions are made. When extinguishing a fire the commander has only a few seconds to decide before a building may collapse, and this time stress influences the decision-making. In design practice this is called time pressure because of the often limited resources and the pressure to be first on the market. What typically occurs in design when time pressure is high is that team members are forced to make

decisions. Also in this studied project team members were forced to make decisions to make progress.

"At a certain moment you must choose some things [C] and that choosing something at a certain moment, how did you do that? [D2] well, you agreed on a certain lead time with the client and at a certain moment you need to know where something will be placed, so you have to force a decision moment and when the client is there you explain to him the how and why."

Assumptions in the design project were made when time is too short to retrieve the required information. With assumption-based reasoning the decision maker was able to make progress but needed to be aware to verify the assumption later on when the information became available. This strategy of making assumptions is described in NDM theory as a way of coping with uncertainty [Lipshitz 1997].

CLIENT

Projects in design agencies are mostly executed for external clients. In this project the client was closely involved in the product development because of their specific knowledge of the product. But in this project the presence of the client was also experienced as a negative influence on making a decision, as they caused a delay in actions and decisions. The client was considered to be indecisive by the team members since he changed decisions regularly. But the client was also not willing to share their information and knowledge.

"At one moment the engineer E1 asked how they did the engine? And the answer we got was: there is a serial number on it, look it up on internet. Well, then you are keeping each other busy [C] yes [Pjr] that was quite difficult."

The results of this explorative study confirmed that the influencing factor on decision-making 'design context' with its elements exists. The element time pressure was clearly mentioned and recognised as an influencing element, making it difficult to make a decision. The elements team and client could be added to the element multiple players. Decision-making was difficult with more than one decision maker involved. Different understanding of goals and information complicated the communication and thereby the decision-making process. The client was an extra member involved in decision-making and necessary in creating shared understanding as he had the information and knowledge about the product. Also the large team and changing team members influenced decision-making within the team as new team members did not have the same understanding of the project, as they were not familiar with previous decisions.

This explorative study did not reveal or verify all the possible elements that characterise the design context that influences decision-making. Only three elements were clearly identified that influenced usability related decision-making: time pressure, team and client of which the last two could be assigned to the element of multiple players from the presented theory. These findings confirm that the design context is an influencing factor on usability related decision-making. The elements that define the design context can be related to the elements from NDM theory but are not necessarily exactly the same.

2.5.4.2 UNCERTAINTY

From the NDM theory presented in section 2.3 it follows that uncertainty is an important influencing factor during the decision-making process. At the end of 2.4 it is suggested that uncertainty could be an influencing factor on design decision-making as well and that the NDM description of uncertainty could be applicable to design. This assumption was confirmed by the results of Study 1. During the interviews it was asked why a decision was difficult and to categorise the reason into one of the sources of uncertainty; incomplete information, inadequate understanding and conflicting alternatives [Lipshitz 1997] or something else. Most of the respondents were able to categorise their mentioned reasons to one of the sources. For example, a decision was difficult to make because of the limited available information.

"[Pjr.] It was difficult to choose what information the user needs [C] yes [Pjr.] what kind of information does the mechanic or the user himself, the cyclist, need [C] yes [Pjr.] that was quite, some people want to know their maximum distance, but there are also people that are not interested in that information [C] yes [Pjr.] (..o..) [C] yes] [Pjr.] there was some discussion about it [C] mh [Pjr.] and well, actually it was not tested by asking users, or so [C] no [Pjr.] but we just decided that we will do this and that we won't do that [C] yes [Pjr.] and this will be optional, or so."

Also the source of inadequate understanding was mentioned by one of the respondents as a reason for it being a difficult decision.

"[C] Which source can you associate why it took so long to make a decision? [D3] Well the technical, the lack of knowledge, because the knowledge needed to be developed, what information can we retrieve from the battery."

The source of conflicting alternatives is very recognisable in design decision-making and clearly described by one of the designers.

"[D3] erm that was difficult erm (..o..) because (..o..) there was not really a decisive argument, why one or the other. Of course there were arguments, one is close to your hand, the other is central on the handlebars [C] mh [D3] which appeared in weight, the arguments weighed the same so you keep going back and forth. In the centre of the handlebars looks nice, well, and than you get to the left right issues, and yes it is easy to use, but it is in the way for the brakes and gears etc etc so, yes, the arguments were there, but not a decisive one."

These examples showed that the reasons why it was a difficult decision could be categorised into the sources of uncertainty, so uncertainty was also a factor that influences decision-making in design practice. When asking what they would do differently in retrospect it was mentioned that they would gain more information by, for example, executing a usability test. This was not done during this project because of limited time. For designers there is not always the need to diminish uncertainty as they are able to work with incomplete information [Cross 1990]. Tolerating uncertainty provides the designer the possibility to postpone a decision or to use assumptions to 'try' solutions.

2.5.4.3 BEYOND UNCERTAINTY, UNAWARENESS

It seemed that there was another influencing factor on decision-making besides the two influencing factors design

context and uncertainty. This became clear when analysing the consequences of a large team and changing team members in this development project. The first presented result was how the team influenced decision-making, focussing on the element multiple players and how that complicated creating a shared understanding and also the communication. However, the large team and changing team members also resulted in a limited overview during the project. At the start of the project the project leader, engineer and designer were involved and familiar with the client. After the summer a second designer was involved in the project to increase the progress. However, he was not familiar with the client and therefore had a limited understanding of the starting points and motivations of the project. He had to judge his design and decisions based on input and comments from his colleagues instead of the client's information. By discussing the concepts a shared understanding was generated. A third designer was involved in the project for only a month, and he delivered one of the concepts for the display. After three months the second designer had to work with the concept of the third designer, but also with the concepts of the first designer as he left the team. The designer mentioned:

"I understood the design, I knew what it looked like, but I didn't feel it [C] yes [D2] it wasn't my design and it had some elements I didn't choose, or would have if I had done it myself".

So the designer did not have the 'feeling' for the design, he did not feel the commitment to the design as he had not made the decisions ànd would have done it differently. Besides not having the 'feeling' and commitment to the design he also did not know the assumptions that were made by the other designers and therefore was not aware of the issues that needed to be checked, missing a learning loop or iteration to improve the design. Meanwhile the first engineer left the project and was replaced by another engineer. He struggled with the same issues as the designer, not knowing the starting points, not knowing the reasons why decisions were made, not having an overview of the decisions made. Both the designer and engineer felt a limited commitment to the design, resulting in a limited feeling of responsibility within the project.

All these different issues of the team and team changes resulted in a limited overview of the project. Most of the aspects could be related to the factor uncertainty, for instance not knowing the starting points, or not knowing the assumptions, both could be assigned to the source of uncertainty; incomplete information. However, the consequence of having a limited overview is not just uncertainty. A team member that has a limited overview does not know that he 'does not know'. This 'not knowing that you do not know' may result in unexpected issues that were unforeseen during the project. This unawareness is a different concept than uncertainty. With uncertainty the decision maker knows that he does not know. A decision-maker can obtain information when he is uncertain about a situation, by collecting the required information uncertainty will be reduced. However, a decision-maker may make a decision based on incomplete information when he is unaware of the situation. ◆

2.5.5 DISCUSSION STUDY 1

The aim of Study 1 was to find the influencing factors on usability related decision-making in design practice. As stated in chapter 1, it are the 'incorrect' decisions during product development that result in usability issues. So knowing what influences usability related decision-making may indicate how 'incorrect' decisions could be prevented. Study 1 was directed by the following sub-research question to find the influencing factors:

"What are the factors that influence usability related decision-making in design practice?"

The findings of this explorative study were three 'propositions' of influencing factors on usability related decision-making in design practice. The word propositions is between quotes because based on this single explorative case no complete grounded propositions could be stated. Therefore they were formulated as suggestions in the results section. The three influencing factors identified in Study 1 are:

- design context
- uncertainty
- unawareness.

These suggestions are visualised in a conceptual framework in *Figure 2-12*. The conceptual framework was presented for the first time in *Figure 2-6* in section 2.4 after discussing decision-making literature in design. The findings of Study 1 are added to this conceptual framework.

In conceptual framework II the influencing factor design context with its elements is presented on the left side in *Figure 2-12*. The elements characterise the design context. These elements were based on NDM and design theory. Some of the elements were confirmed in Study 1. These findings verify the assumption that the design context is an influencing factor.

As expected, the factor uncertainty also influences usability related decision-making in design practice. Sources that contribute to uncertainty are mentioned by the team members as reasons for making decision-making difficult. In addition to the respondents referring to some of the sources, they were also able to categorise the reasons for the sources of uncertainty from the NDM theory [Lipshitz 1997]. These results verify that this description of uncertainty with its types and sources can be used for design practice. The influencing factor uncertainty is therefore visualised *Figure 2-12* with its types and sources as a factor that influences decision-making in design practice.

The third outcome of the explorative study is shown as a possible factor influencing decision-making: unawareness. This factor is put forward by Study 1 as being a possible consequence when the decision maker has a limited overview of the project. When having a limited overview it can occur that the decision maker is missing information without knowing it. Design theory or NDM theory does not mention this factor in relation to decision-making. Therefore, this factor is indicated as a possible factor by visualising it with dotted lines in the conceptual framework, see *Figure 2-12*.

Although Study 1 did provide suggestions for developing design decision-making theory, it did not provide a convincing or strong basis for theory building. The results are suggestions that need further investigation. The presented theory on decision-making is recognised in design practice but does not

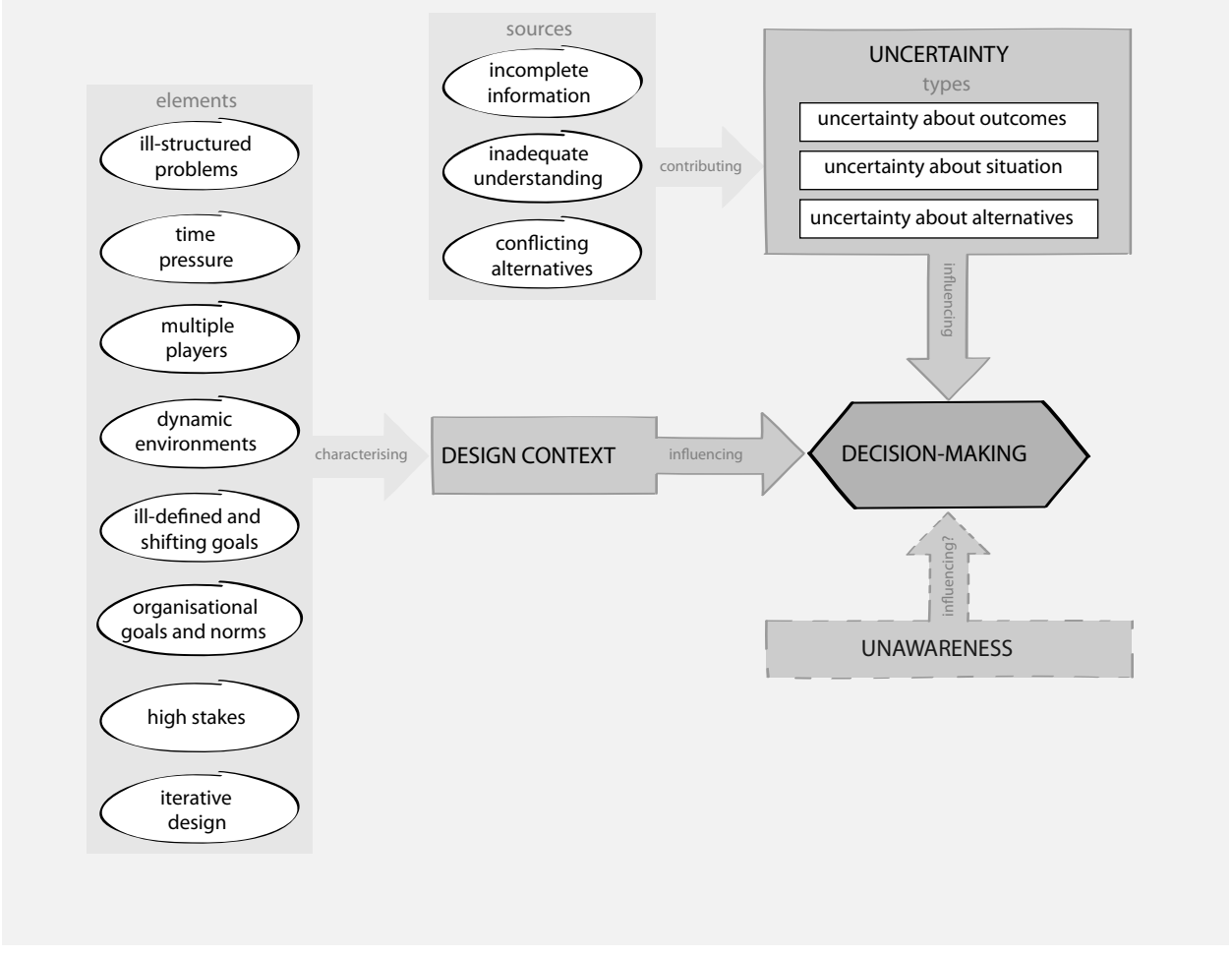


Figure 2-12: Conceptual framework II - Possible influencing factors on decision-making in design practice

provide a more detailed or clearer understanding of decision-making in design practice. Possible directions for subsequent research to improve usability related decision-making are:

- identifying the influencing factors on decision-making in design practice,
- specifying the contributing elements and sources of the factors 'design context' and 'uncertainty',
- exploring the possible factor 'unawareness',
- modelling decision-making in design practice.

The results of Study 1 are based on a single case in which use is made use only of retrospective interviews. These interviews were a valuable and valid input for gaining a better understanding about decision-making in design practice. However, for subsequent research it is important to increase the validity of the data. This can be achieved by using multiple sources of evidence, establishing a chain of evidence and having key informants review the case study report [Yin 2009, 41].

The use of retrospective interviews did not provide detailed information about when a decision was made, or who was involved at the moment of decisions, or what information was available at a certain moment in time. Answers to this kind of question were ambiguous. This disadvantage of retrospective interviews was expected but also considered acceptable in this explorative study as this data was not needed for the interpretation. Where this kind of data would be relevant in future studies other data collection techniques should be used to retrieve the data.

All respondents have their own story about the project. They build this story on their own perspective and perception which is, according to them, the truth, when this already can be an interpretation of reality. Then again, we interpret the project based on the respondent's story and his interpretation of reality. So, we are distanced from reality: how it really happened during this project. To retrieve data that is closer to reality other research methods like observations or document analysis are necessary. By all means, the validity of subsequent research data needs to be strengthened compared to this single case explorative study.

The focus of Study 1 was on identifying factors that negatively influence usability related decision-making in design practice, by questioning the respondents about the difficult decisions within the project. However it is unknown whether these or other decisions actually resulted in usability issues. In other words whether the decisions indeed negatively influenced the product usability. The starting point in subsequent studies should be therefore the usability issues of a product when the aim is to reduce usability issues. Only then would it be possible to investigate in detail which factors influence decision-making and may lead to 'incorrect' decisions and usability issues. ◆

2.6 Conclusion chapter 2

In chapter 1 it was stated that usability issues could be reduced by improving usability related decision-making. Therefore it is necessary to know how decision-making in design practice is influenced in order to improve it. Chapter 2 started with exploring decision-making in design practice to gain a better understanding. Beginning with a general literature search of decision-making and consequently refining this to a search on design decision-making. Although the theory of Naturalistic Decision Making is very useful for understanding how decisions are made in the real world, it does not describe or explain how decisions are made in design practice or what the factors are that influence design decision-making. Therefore Study 1 was executed to explore decision-making in design practice and to find factors that influence decision-making, with a focus on usability related decisions. The results of Study 1 showed that design context is one of the influencing factors on decision-making in design practice. There are various elements that characterise the context and influence decision-making. An example of an element that defines the context is 'time pressure'. The run for being the first on the market with your innovative product results in a short time-to-market. This time pressure during product development limits the designer – for example, in the possibility of collecting all required information – and forces him to make decisions or assumptions to make progress. It is within this situation of design practice that decisions need to be taken. Another factor that influences decision-making is uncertainty. This factor is described in detail in NDM theory but seldom discussed in design theory. Therefore the types and sources of uncertainty were verified in Study 1. It could be concluded that the described types and sources of uncertainty could be used for design practice, because the sources of uncertainty correspond to the sources that respondents referred to, in order to explain why it was difficult to make a decision. A third influencing factor is put forward in Study 1: unawareness, which is a factor that is not described within decision-making theory. Respondents mentioned that they had a limited overview of the project due to the large team and changing team members that caused, amongst others, limited knowledge of the starting points and previous decisions. A consequence of a limited overview is unawareness, 'not knowing that you do not know something'.

It has to be acknowledged that it is a complex situation in which designers have to make their decisions. The various elements that characterise to the design context and influence decision-making cannot simply be addressed by changing the situation. Actually, the design context cannot really be changed, it is something the designers have to cope with. The market will be demanding and will result in time pressure. To create complex innovative products a multi-disciplinary team with multiple

players is necessary. Design problems are ill-structured problems that need significant work to reach a solution. Based on experience the designer will learn to recognise the situation and know how to act to get to a satisfying solution. Therefore subsequent studies will be conducted in this design context with professionals and not in laboratory settings or with design students.

Although the factor uncertainty is not described in design theory, many techniques are available to address uncertainty, in particular when the uncertainty is about usability. Usability techniques provide the team members the possibility to gain information and knowledge about the user, user tasks and context and use this information as design input. Not only are techniques available to gather design input, there are also techniques for evaluating the design, please refer to *Appendix A* for examples. With these usability techniques the decision maker can retrieve information and knowledge and thereby addressing the sources of uncertainty.

Nowadays product development is executed by large multi-disciplinary teams to accomplish the development of highly complex and innovative products within the limited resources. These large teams – with changing team members – who are developing complex products in a design context can result in a limited overview and consequently in unawareness. Technical issues are often identified when the design is tested or handed over to engineering but usability issues are much more difficult to identify. During development the product use can only be simulated with a prototype, potential users and a simulated situation while the technical performance is often objectively measurable. Therefore it can happen that usability issues are found just before product launch, without having the possibility to adjust the product, resulting in usability issues for the user.

The literature and explorative study to decision-making in design practice presented in this chapter provided a better understanding of decision-making and its influencing factors. The emerging third factor unawareness could be a critical influencing factor on usability related decision-making. it was classified as a critical influencing factor on usability related decision-making as it may result in usability issues. Usability issues are difficult to identify during the product development process, which means that it will be even more difficult to identify them when unawareness occurs. This may enlarge the chance on usability issues for the users. Identifying usability issues during project development is difficult as usability is dependent on several variables. Whether a user experiences usability issues depends on the product, the context and the user himself. The goal of the user defines which product or function of a product he will use, these goals can vary from user to user. Also the experience with previous products can guide how the user will use a 'new' product, and as these experiences will vary from user to user, so the results of a usability test can also vary from user to user. Identifying usability issues may therefore be more difficult than identifying technical issues as these will mostly occur with every user in the same way. When unawareness occurs during the development process it will become even more difficult to identify usability issues. Therefore it is assumed that the influencing factor unawareness can be critical to usability related decision-making. Whether unawareness is a (critical) influencing factor on usability related decision-making needs to be investigated. ◆

CHAPTER 3: **Unawareness, a critical influencing factor**

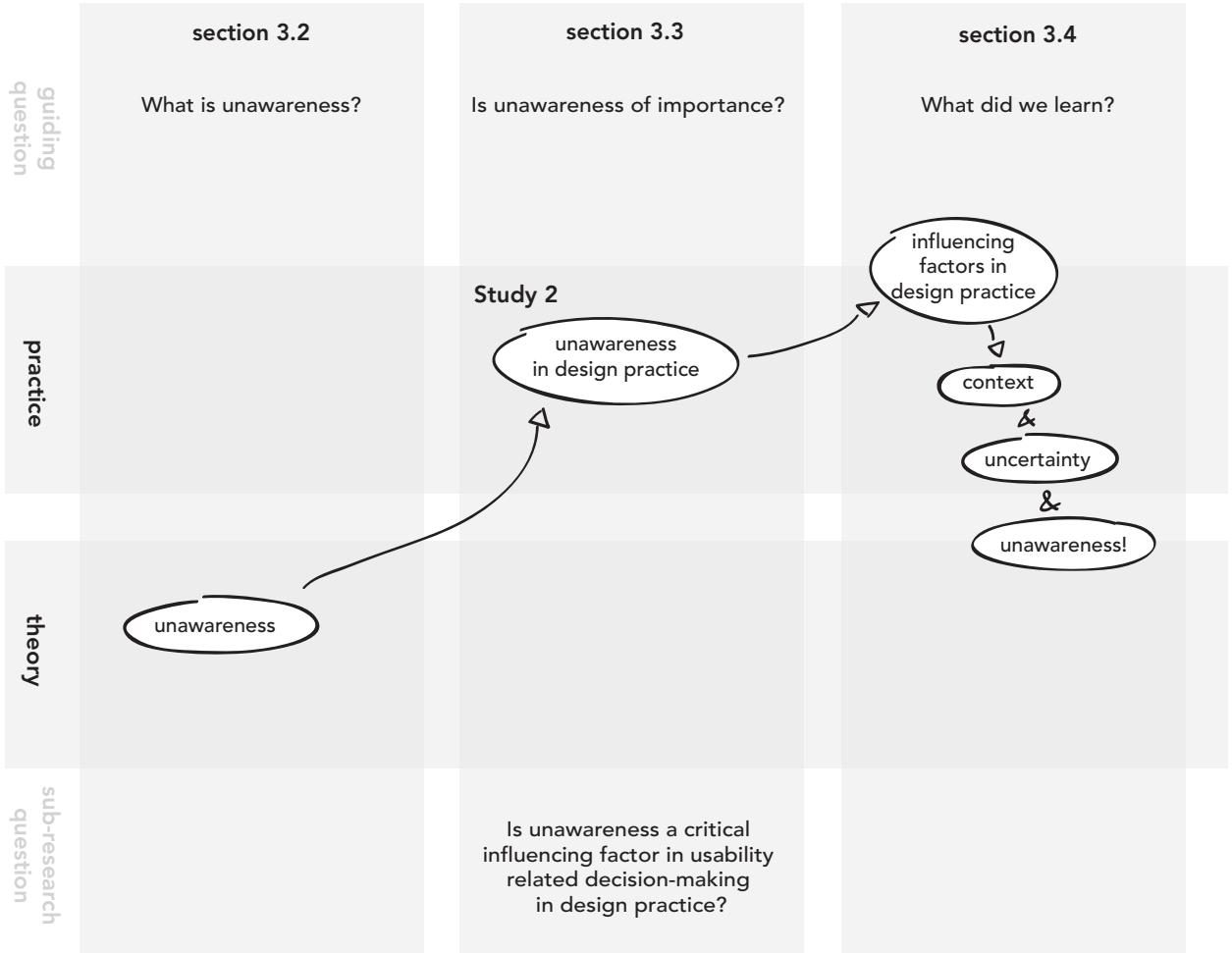


Figure 3-1: Visual table of contents chapter 3

3.1 Introduction

In chapter 2, decision-making in design practice was explored. Besides the literature study an explorative and inductive study of decision-making in design practice was also conducted as the available design literature on decision-making is very limited. This exploration provided understanding about decision-making in design practice and the factors that influence usability related decision-making in design practice. An important influencing factor for usability related decisions may be unawareness. Not knowing that you do not know may result in unpleasant surprises later on. The results from Study 1 show that in this case the source of unawareness was the decision maker's limited understanding caused by the changing team members. The new members did not have a complete overview of the project as the previous members took their knowledge about starting points and decisions with them. Although it sounds plausible that this situation can be a source of unawareness, no evidence was provided by Study 1 that this situation actually made the decision task difficult and in the end resulted in usability issues. Therefore it was needed to first investigate whether unawareness is a critical factor in usability related decisions in design practice. In other words, whether unawareness during decision-making results in usability issues in finished products. However, a better understanding about unawareness is required To gain this understanding literature was studied, guided by the question: What is unawareness? The results of this literature study are presented in section 3.2. Subsequently, the potential critical influencing factor unawareness in design practice was investigated, being presented in 3.3. The conclusions about the factor unawareness are presented in section 3.4. ◆

3.2 **Unawareness**

In this section are presented various literature sources about unawareness as a better understanding of unawareness is required before unawareness in design practice can be investigated. A broad scope for researching information about unawareness was used, because within design theory no information is available about how this factor could influence decision-making. This literature search resulted in an overview of terms and definitions of unawareness and also of some related terms, see *Table 3-1* categorised to the different fields of origin. Each of these terms is discussed afterwards.

ENGINEERING		
Wideman 1992	Unknown unknowns ('unk unks')	*"An item or situation whose existence we cannot imagine. No information, total uncertainty."*
Schrader 1993	Ambiguity level 2	*"Characteristic of a situation in which the set of relevant variables as well as their functional relationship and the problem-solving algorithm are seen as in need of determination."*
ECONOMICS		
Modica 1994	Unawareness	*"When he does not know its truth value, and he does not know that he does not know, he does not perceive the possible object of knowledge, he does not have in mind the possible object of knowledge."*
Modica 1999	Unawareness	*"He may not know P, not know he does not know it, not know he does not know he does not know it, and so on ad infinitum the occurrence of P, or even of its opposite, will be a surprise for that decision maker. Unawareness is the negation of awareness."*

Dekel 1998	Unforeseen contingencies	*"Possibilities that the agent does not 'think about' at the time he makes a decision, he doesn't think of at the time he makes his choice. -these are not events that the agents has considered but assigned zero probability -is not necessarily one the agent could not conceive."*
Heifetz 2006	Unawareness	*"It is hard to argue that decision makers are aware of all facts affecting the outcome of their decisions. Thus unawareness is a rather natural state of mind and its role merits investigation, especially in interactive decision-making."*
MANAGEMENT		
Pich 2002	Ambiguity	*"Lack of awareness of the project team about certain states of the world or causal relationships."*
Sommer 2004	Unforeseeable uncertainty	*"The inability to recognize and articulate relevant variables and their functional relationships."*
Loch 2008	Unforeseeable uncertainty	*"In a novel venture, management often knows much less and is plagued by 'the inability to recognise and articulate variables and their functional relationships'."*
HUMAN FACTORS		
Endsley 1995	Situation awareness	*"Situation awareness is the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning and the projection of their status in the near future."*
Wickens 2008	Situation awareness	*"Knowing what is going on."*
PSYCHOLOGY		
Mack and Rock 1998	Inattentional blindness	*"Inattentional blindness is a striking phenomenon in which people fail to notice stimuli appearing in front of their eyes when they are preoccupied with an attentionally demanding task."*
Most 2000	Inattentional blindness	*"Inattentional blindness refers to the finding that observers who are engaged in attentionally demanding tasks often fail to see unexpected objects or events."*
Dijksterhuis 2004	Unconscious thought	*"Unconscious thought refers to cognitive and/or affective task-relevant processes that take place outside conscious awareness."*

Table 3-1: Overview of unawareness related terms from various fields

Each of these terms is somehow related to the term unawareness. However, not all of them relate to the kind of unawareness which is the focus of this study. The introduced terms are briefly explained and based on this a selection for a definition or explanation of unawareness is made.

An important distinction which needs to be made is between 'unforeseen' and 'unforeseeable'. Starting with a description of both terms from the dictionary and subsequently elaborate on how these terms are used in the different fields. Unforeseen is explained as: *"Not felt or realised beforehand; unexpected"* and unforeseeable is explained as: *"not able to be foreseen or known beforehand"*. Both terms are about 'not knowing beforehand', but with unforeseen the information is not realised, while with unforeseeable the information cannot be known. In economics the terms unawareness and 'unforeseen contingencies' refer to the term 'unforeseen', which they explain as *"not having in mind"* [Modica 1994, Dekel 1998]. In other words: "*The decision-maker cannot be aware of all the variables that affect the outcome of the decision at the moment of decision-making."* [Heifetz 2006]. So unforeseen is an issue that can be addressed, and the relevant variables can be retrieved. This is in contrast to unforeseeable, which cannot be conceived. In management the term unforeseeable uncertainty is used, with this they refer to *"the inability to recognize and articulate relevant variables and their functional relation"* [Sommer 2004, Loch 2008]. Unforeseeable uncertainty can be described as an extreme of uncertainty, no information available at all. In engineering the term unknown unknowns is used for this, or 'unk unks'. This refers to an item or situation that cannot be imagined, there is no information at all, in other words total uncertainty [Wideman 1992].

In the field of human factors the term situation awareness is used. *"Situation awareness is the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning and the projection of their status in the near future"* [Endsley 1995], in other words: *"knowing what is going on"* [Wickens 2002]. This kind of awareness does not relate to the kind of unawareness on which this research focusses. Situation awareness is related to the physical world while 'not knowing that you do not know' does not necessarily refer to physical aspects. Also the term inattentional blindness used in psychology refers to this physical kind of awareness; *"failing to see unexpected objects or events in front of their eyes while being preoccupied with an attentionally demanding task"* [Mack 1998, Most 2000].

It can be concluded that these different terms and definitions from fields outside design theory do provide some understanding about unawareness related terms but do not provide an applicable definition or explanation of the term unawareness for design practice. Based on this literature study it was decided to describe unawareness – for the time being – as unforeseen; not having in mind [Modica 1994, Dekel 1998], the information or issues that were not realised beforehand. However, this still does not provide adequate support for understanding and describing unawareness in design practice. Because it does not explain what a decision maker in design practice can be unaware of and how this unawareness can happen. As Schmidt [Schmidt 2002] explains in his article *"The problem with awareness"*, the term awareness is only meaningful if it refers to a person's awareness of something. This is also the case for unawareness, it is an attribute of action. A description of unawareness can be given by describing about what one can be unaware. Understanding of unawareness is gained by explaining the aspects that contribute to it.

It is relevant to know whether usability issues actually result from unawareness during usability related decision-making before we can start studying unawareness in detail. When unawareness leads to various unforeseen usability issues, than the factor 'unawareness' can be defined as a critical influencing factor. When usability issues do not result from unawareness than it is not a critical factor and therefore no further research is required. When it is a critical influencing factor a better understanding and explanation for unawareness in design practice is required. So, Study 2 (in section 3.3) investigates whether unawareness is a critical factor for usability related decision-making in design practice. ◆

3.3 **Study 2: Unawareness in design practice**

3.3.1 **INTRODUCTION**

In this section, the second study of this PhD research project is introduced. Within Study 2 design practice was investigated to answer the following sub-research question:

"Is unawareness a critical influencing factor on usability related decision-making in design practice?"

Unawareness can be classified as a critical influencing factor when a considerable number of usability issues result from unawareness. From the introduced theory in section 3.2 only a limited understanding of what unawareness is was gained. The best way to describe unawareness at this moment is as unforeseen, not having in mind [Modica 1994, Dekel 1998], the information or issues that were not realised beforehand. The sub-research question can be answered with 'yes' when several unforeseen usability issues with a product are identified. Unforeseen usability issues with a product are issues of which the team was unaware at the moment of decision-making, or these might have been detected by the team in such a late phase of the process that no or only limited changes were possible. Therefore these unforeseen usability issues indicate unawareness during the project. The directions for further research within this PhD research project depend on the answer to this sub-research question. Therefore the usability issues of a finished product were investigated, a product that was already available on the market for its users. ◆

3.3.2 **RESEARCH METHOD**

This second study was a retrospective study to investigate the usability issues of an electronic consumer product. Starting the study from the usability issues provides the possibility to investigate the source of these issues within the design process and whether the team members were aware of these issues. An involvement of the team members was required as only they can tell which information was available at the moment of decision-making and whether the issues were foreseen. Identifying the unforeseen usability issues and their sources is thus only possible in a few ways, namely by conducting; surveys or interviews. Again, it was decided to use retrospective interviews. Although surveys are a more efficient way to gather and analyse data, they do not provide the possibility to ask follow-up question by unclear or unexpected answers. Just as in Study 1 there made use of retrospective, semi-structured, and open ended interviews. This to create the possibility to deviate from the questions [Patton 2002, 342] and to provide the respondent the possibility to answer the question in his

own words and from his personal perspective [Patton 2002, 348]. The drawback being, that it may need some more data processing before it can be analysed as the data set is less structured. Several precautions were taken to address the disadvantages of interviews; personal bias, retrospective sense making and recalling details [Eisenhardt 2007]. Various team members from different disciplines would be interviewed to combine these personal stories and different perspective into one story [Patton 2002, 342] about the origin of usability issues and whether these were foreseen. The selected case should not be finalised too long ago, so the respondents were still available and able to recall the project. In addition to these precautions, which were also made in Study 1, were the results verified with the team members. Firstly the interpretations of the data were verified with two key team members and subsequently the overall results were discussed with the team members.

DATA GATHERING

In *Figure 3-2* the steps of gathering the data of study 2 are visualised. Firstly, a product with usability issues was selected, an alarm clock, please refer to section 3.3.3 for more details. Secondly, a list of the usability issues of the selected product was created. This list was based on data from online product reviews, company test reports and – when available – feedback from the call centre. Combining all the different sources of data about usability issues led to an overview of usability issues which were used as input for the interviews. Each of the usability issues was described and explained on a card to be used during the interviews to ensure that each respondent had the same explanation of the usability issue. The interviews focused on investigating the various usability issues. This was done by asking each respondent to introduce himself and the project and then to discuss the usability issues on the cards. The interviews would provide information about the usability issues, what the sources of the usability issues were, about the decisions that resulted in the end in usability issues, about the data that was lacking, and also which of these issues were unforeseen during the project. During a period of time the researcher worked at the company to conduct the interviews but also to observe the company context. The following questions were used as a guide during the interviews:

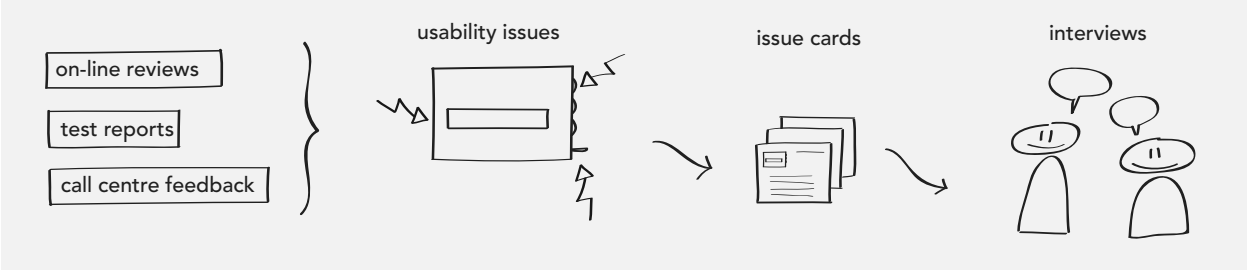


Figure 3-2: Data gathering Study 2

1. Can you briefly explain the project and your role within the project?
   And per usability issue:
2. Do you recognise the usability issue described on the card?
3. What is the source of this usability issue?
4. Which decision led to this source?
5. What were the grounds (information, arguments) for this decision?

The interviews started with a question to the respondent to explain the project and his or her role within the project. At this time the respondent could tell his story about the project in his own words. This provided a better understanding of the project and the perspective from which the respondent answered the questions. After the introduction of the project, the cards with usability issues were introduced. With each usability issue the respondent was stimulated to discuss the involved usability issue. At first it was verified whether the respondent recognised the usability issue. This was done to make sure that the respondent talked about familiar issues. The card was skipped when he did not know about the issue. Subsequently, was asked to the source of the usability issue: why did the issue occur? When the source of the issue was known the decision(s) that resulted in this issue could be traced. The next step was to ask the respondent to the grounds of the decision, i.e. based on what information was the decision made? The information, or rather the lack of information revealed whether the usability issue was foreseen at the moment of decision-making. In retrospect it is known what the usability issues are and which information would have been required for making a 'correct' usability decision. In other words, if they had had this information, they could have made the decision differently to prevent the usability issue. The issue was unforeseen when they were unaware of the lack of this information. The unforeseen usability issues were identified by comparing the required information and the available information at the moment of decision-making and by asking the respondent. When there was a lack of information and they were unaware of it, then it was an unforeseen usability issue.

The author of this thesis executed all the interviews. The aim was to interview at least 10 closely-involved team members

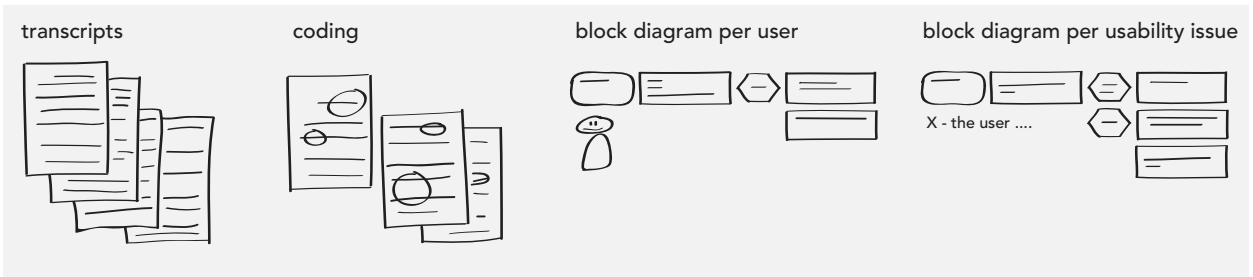


Figure 3-3: Data processing Study 2

about one and a half hours. The interviews were digitally recorded with the permission of the respondent. They were held in Dutch where the native language of the respondent was also Dutch, otherwise the interviews were held in English.

DATA PROCESSING

After collecting the data it was processed to create a structured overview, see also *Figure 3-3*. No interpretations were made yet. The first step was to transcribe the interviews, having them on paper offers the opportunity to analyse them in detail. Secondly, the data was structured by coding the interviews. The following predefined nodes were used: the stated usability issues, the described sources of the usability issues, the mentioned decisions, and the grounds of the decisions. Subsequently these results were structured within a block diagram. A block diagram provided a visual overview of the relationship between the usability issue, its source, the made decisions, and the grounds of the decision. For each mentioned usability issue in each interview a block diagram was made. In the block diagram the usability issue was stated first in a rounded corner rectangle. Followed by a rectangle with the source of the issue according to the respondent, this can be more than one. After the source at least one hexagon with the decision is presented. It can be that more than one decision was mentioned by the respondent, each decision is presented in a separate hexagon. The last rectangle presents the grounds of the decision, i.e. the basis for the decision. For an example of the outline of a block diagram, see *Figure 3-4*. Short statements within the diagram are used as the goal of the block diagram is to present a visual overview of the interview results. Full text quotes from the interview are not provided this overview. Processing the codes from each transcript into individual block diagrams resulted in numerous block diagrams.

These numerous block diagrams per usability issue per respondent were merged into one block diagram per usability issue. The

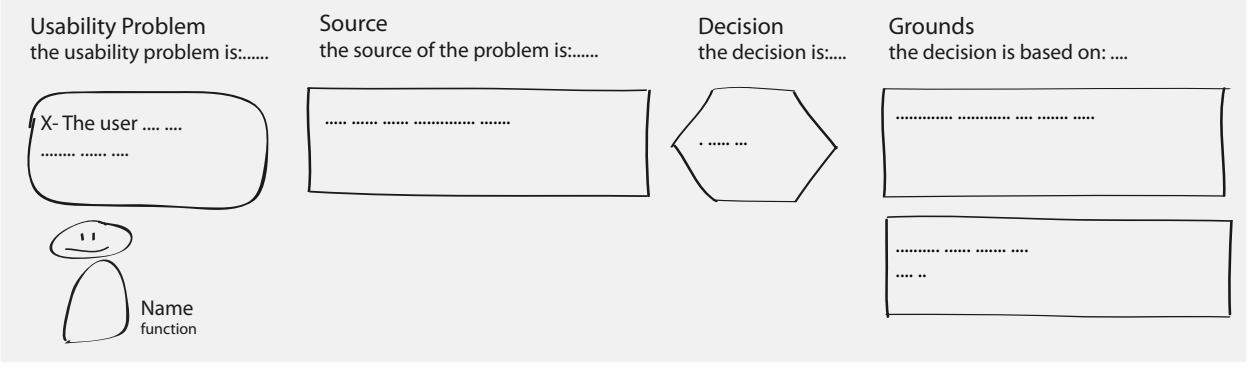


Figure 3-4: Outline block diagram per usability issue, per respondent

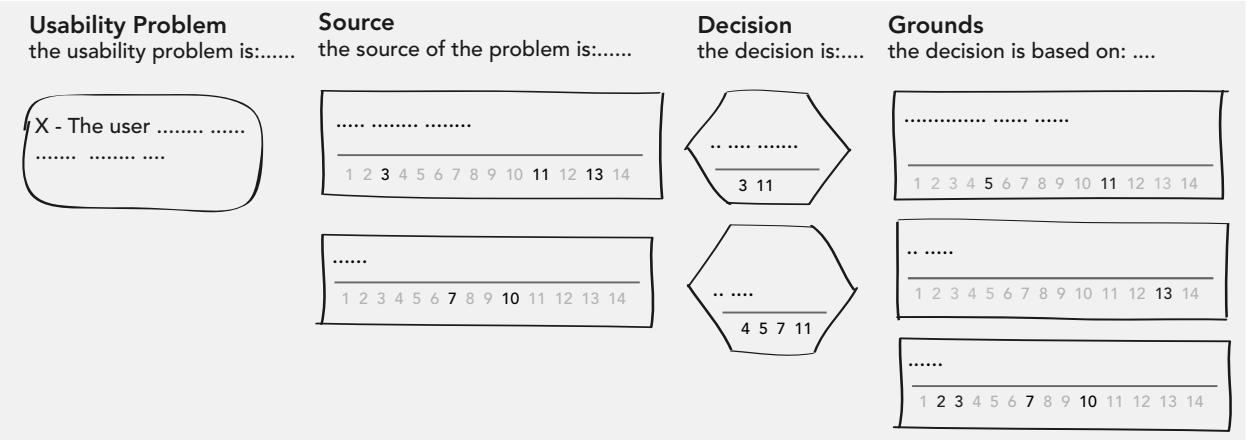


Figure 3-5: Outline block diagram per usability issue

individual statements related to the issue were stated in one block diagram. Similar statements of various respondents were grouped into one statement. With every made statement of the respondent a reference was mentioned. An example of the outline of these block diagrams is given in *Figure 3-5*.

DATA ANALYSIS

After organising and structuring the data the analysis of the data (see *Figure 3-6*) was started to identify whether the usability issues were foreseen or not. The information, or rather the lack of information, at the moment of decision-making revealed whether the usability issue was foreseen. With each usability issue it was identified in retrospect which information would have been required to make a 'correct' usability decision, so as to prevent the current usability issue. This was done for every usability issue and verified with the data whether this information was available. The issue was indicated as unforeseen when the information was not available at the moment of decision-making. The usability issue was indicated as foreseen when the information was available at the moment of decision-making. This interpretation of the data was verified with at least two key respondents. These respondents should have shown a good understanding of the total project during the interviews. Discussing the interpretation provided an argued check whether the issue was foreseen or unforeseen. This discussion was created by showing the list of usability issues and the missing information that could have prevented the usability issue. The key respondents were asked to agree or disagree whether this information was indeed required. Subsequently it was debated whether this information was

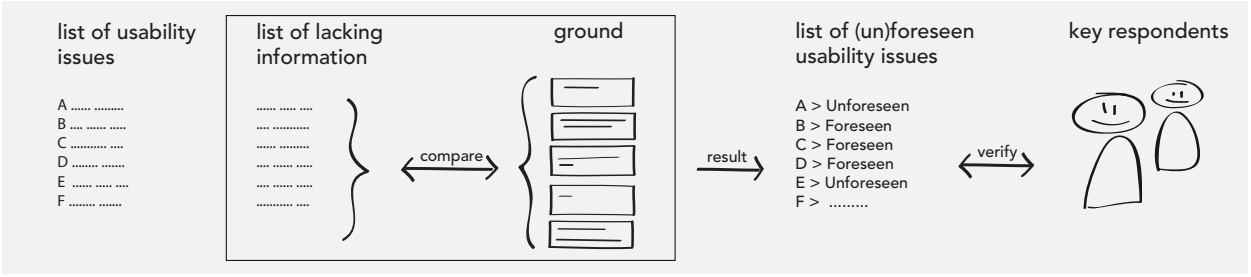


Figure 3-6: Data analysis Study 2

or was not available at the moment of decision-making. Consequently they could indicate whether the usability issue was foreseen or unforeseen. The results of this analysis are presented in section 3.3.4. ◆

3.3.3 **CASE 2**

In Study 2 retrospective interviews with multiple members of one specific project were executed to answer the research question:

"Is unawareness a critical influencing factor on usability related decision-making in design practice?"

The interviews focused on detecting possible unforeseen usability issues and the sources of why these could occur. Several requirements for selecting an adequate case for this second study were defined. Again, it should be an electronic consumer product to fit the goal of the overall Design for Usability research project. More specifically, it should be an electronic consumer product with usability issues. The product should be on the market for a while so feedback from actual users is available. However, the product should not be launched too long ago as we want to interview development team members. It will be difficult for them to recall the project when it is too long ago. There is a focus on usability within every product development project, but we want to select a company with an explicit focus on usability to guarantee usability involvement and expertise.

The selected case involved an innovative electronic consumer product from a world leading company, first introduced on the global market in 2008. This multinational was selected as a representative sample because of their longstanding experience with product development, their multi-disciplinary teams, their well-defined processes, and their experience and expertise to develop usable products. It is a company with a longstanding track record and can be expected to reflect a good product design process, hence the results can be used for generalisation. The selected product was chosen for its relative newness to the market, since at the time the case study was conducted, the product had been commercially available

worldwide for only 18 months. Although 18 months is quite a while, it was assumed that team members could still recall the project. The company which developed the product aims to develop usable products, yet in spite of this aim, users experienced usability problems with this specific product.

The selected product is a successor of the first electronic consumer product within this product range that this company put on the market. The official product name and description cannot be stated for reasons of confidentiality, so a generic product is used as a metaphor to describe this project; an alarm clock. The first product of this range that the company put on the market – product A – is called 'Ant' and the second product, its successor, – product B – 'Bear'. Project Bear was an incremental innovation, 'doing better what we already do'. With this product the user can change various settings like the time the alarm goes off, the sound and volume of the alarm, etc. The digital display shows the time and gives feedback when changing the settings by operating the buttons.

PROJECT DESCRIPTION

In January 2006 the Bear project was initiated by investigating the possibilities for technological improvements. In the summer of that year, a design roadmap was made, including sketches for the Bear but also for future products in this line. In September 2006, the predecessor Ant was launched on the market and turned out to be a huge success, thus there was a demand for the successor 'Bear''. At the beginning of 2007 project Bear was officially started. The feedback on Ant was very positive in relation to the functionality but less positive with respect to the aesthetics and large number of buttons. So, the aim for the successor was to develop a more attractive looking product. The development of the successor focussed on a concept of attractiveness with a reduced number of buttons, while retaining all functionality. In spring 2007, three consumer tests were conducted to select a design concept for further development. However, these tests were inconclusive. Besides the consumer tests a computer simulated user interface (UI) test was done. It was concluded that a concept with only four buttons and a display could work, but adjustments and re-testing would be necessary. The first concept for the UI test had a horizontally positioned rectangular display on the front of the product. Underneath the display were three large round buttons which can be turned and pushed. Above the display is one small round push button, see *Figure 3-7*.

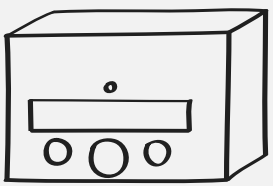


Figure 3-7: First concept of alarm clock Bear

Large changes within the company brought turbulent times and only a few team members stayed on the project during the complete project period, including the usability engineer (Emma). In May 2007 a re-start of the project was announced with a new focus: the successor should be a design icon. New design concepts were developed, most including the UI of a display and four buttons. Although many design concepts were developed, none could satisfy higher management. A

new designer (Craig) was involved in the project. One of his concepts and one of the previous concepts were developed into further detail to judge the feasibility of the concepts. In September a final decision in favour of Craig's new design was made. This concept had the display on the front of the product and three rotary-push wheels and a lever that can be pushed up and down on the side, see *Figure 3-8*.

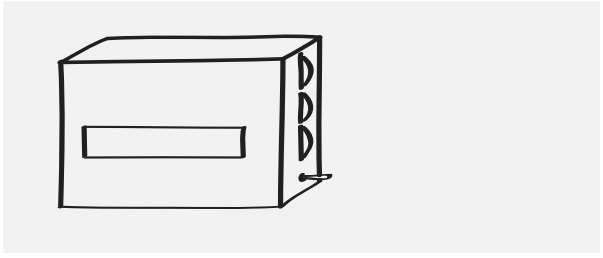


Figure 3-8: Final design alarm clock 'Bear'

From October 2007 until January 2008 four UI tests and various design iterations were conducted to develop a satisfying UI. In spring 2008 the First Out of Tool products were tested by users at home for one to three weeks. The results of these tests were below target, so further adjustments to the UI were necessary. The final usability test proved that the successor had improved and was better than its predecessor. ◆

3.3.4 **RESULTS**

In this section the results of Study 2 are presented, the investigation of unforeseen usability issues and their sources. This investigation was done by conducting interviews. During the interviews the usability issues of an alarm clock (metaphor) were discussed, as introduced in section 3.3.3. The various functions of the product are represented by the functions of an alarm clock; setting time, setting the alarm, choosing personal alarm sounds including radio, setting the volume of the alarm, etc. These usability issues were obtained from various data sources: feedback from users via the call centre, feedback from users via online consumer reviews, and company test reports. The data logs of the call centre over the last year were checked. Several websites, like 'Amazon.com' and 'Kieskeurig.nl' for feedback about the product were investigated; this resulted in 255 user statements about the product. In addition two test reports of the company were analysed. Combining these sources resulted in a list of 13 usability issues that were investigated during Study 2 , see Table 3-2. The presented overview of issues is generalised to guarantee the anonymity of the product.

Each usability issue is mentioned and explained on a separate card and used as input during the interviews. Fourteen interviews with key team members of the project team were conducted. The interviews with the different team members provided a better understanding about the project, for example: what the context was in which the project was done, who worked on the project and why decisions were made. Each team member had his own story about the project. These stories are based on their personal involvement in the project, based on their duration of

ISSUE	DESCRIPTION
A1	the user does not understand how to return to the main menu
A2	the user cannot use the product as fast as he wants
A3	the user does not have enough time to change the settings
C1	the user cannot create separate settings for the alarm
D1	the user thinks the product is broken
E1	the user does not know how to operate the buttons
E2	the user does not know which button is for which function
E3	the user does not know which way to turn the button
F1	the user does not know how to operate the radio
F2	the user is confused about which buttons to use for operating the radio
G1	it is difficult for the user to confirm settings
H1	the user expects to find the button at a specific location
L1	the user is not sure whether the setting is turned off

Table 3-2: Overview of 13 usability issues

involvement, and their hierarchical posistion in the organisation and discipline. By combining all these stories from different perspectives a more or less complete understanding of the project, the usability issues and their sources was achieved. The results described in this section are based on the 'complete' story. The following list is an overview of the 14 respondents and their disciplines; their real names are not mentioned for reasons of confidentiality:

- Junior usability engineer - Alice
- Product architect - Brian
- Designer - Craig
- Consumer marketing manager - Daniel
- Usability engineer - Emma
- Quality manager - Frank
- Project leader - George
- Engineer - Henry
- Designer - Ian
- Engineer - John
- Quality manager - Kevin
- Team manager - Leo
- Engineer - Mandy
- Interaction designer - Naomi

Each interview is transcribed, resulting in 14 transcripts of in total 91.944 transcribed words. These transcripts were coded to the predefined nodes: the mentioned usability issues, the described sources of the usability issues, the mentioned decisions, and the ground of the decisions. This data was subsequently structured within a block diagram. Each usability issue discussed with every respondent resulted in a block diagram, see *Figure 3-9* for an example.

The statements within the diagram are shorter than the original quotes from the interviews. The original quotes are often very long, which would not be advantageous for the overview, so the original quotes were re-written to shorter statements. For example a short statement about the grounds of the decision

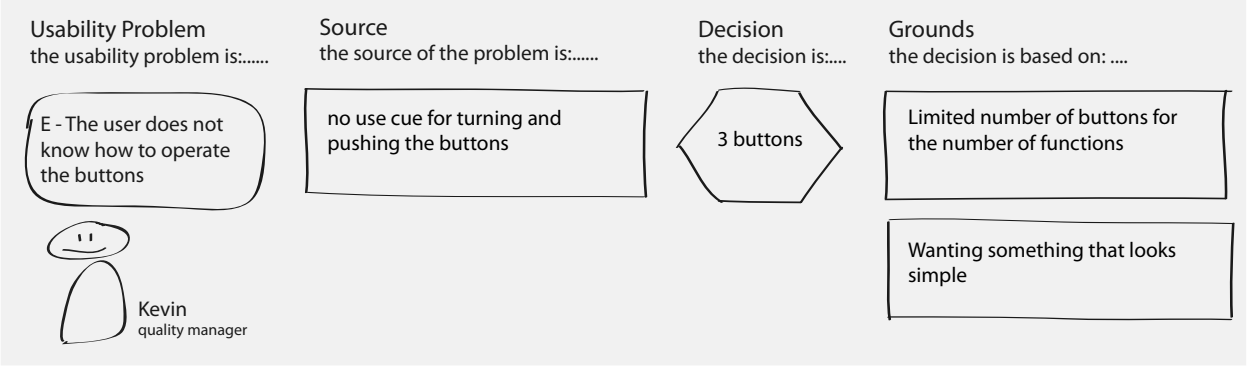


Figure 3-9: Example block diagram per usability issue, per respondent

from *Figure 3-9* is: 'limited number of buttons for the number of functions' and 'wanting something that looks simple' the original quote from the respondent was: *"…that was basically coming from the design, the industrial designer, they wanted something with hidden, they wanted very few buttons, they wanted a complete front that had nothing on it, as you see it, no buttons on the front here and they also wanted the buttons somewhat hidden from the side. So, as few buttons as possible means multi-functional…"*

All these different individual block diagrams are merged into one block diagram per usability issue, an example is presented in *Figure 3-10*. All the statements of the different respondents about the usability issue are mentioned in the block diagram per usability issue. Similar statements are grouped and not mentioned individually. Under every statement is a reference to the respondent who made the statement.

In the example of *Figure 3-10* the first statement 'multi-functional buttons' is mentioned by the respondent's number 3, 11 and 13. Often the respondents associated various sources, decisions and grounds to the usability issues, these were combined in the descriptions in section 3.3.4.1. Within the block diagrams the same order and shapes for presenting the mentioned aspects is used as in the block diagrams per respondent.

The analysis was based on the gathered and structured data. The results of this analysis were descriptions of usability issues and the identification of whether it was an unforeseen usability issue. The issues were identified by studying it in detail, i.e. what was the source of the issue and what was the decision that caused it. Subsequently it was investigated what the grounds of the decisions were. In retrospect, it could be identified which information would have been required to make the 'correct' decision, thus what information was necessary to prevent the usability issue. The unforeseen usability issues

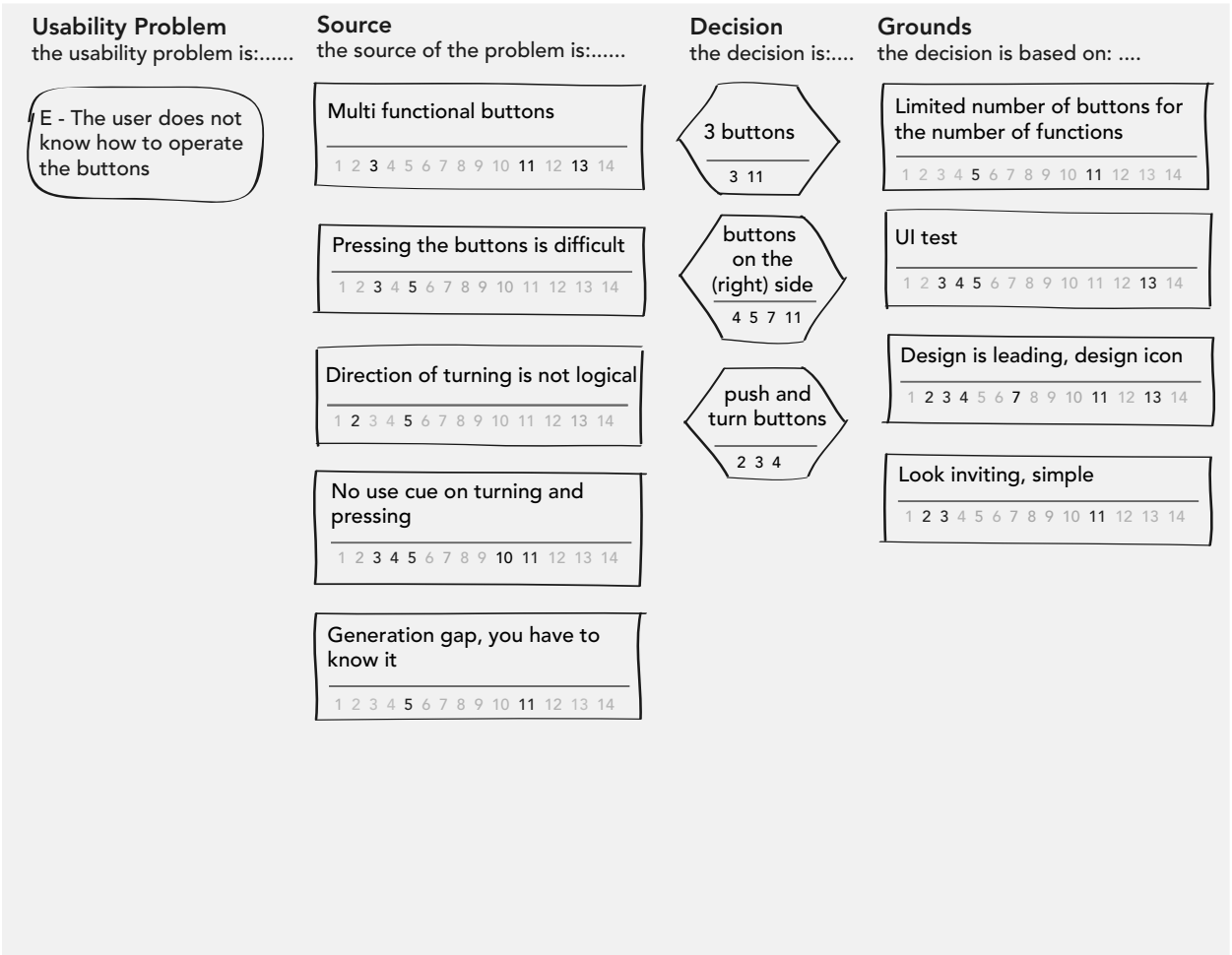


Figure 3-10: Example block diagram per usability issue

could be identified by comparing the required with the available information. It was an unforeseen usability issue when the required information was not available and the team was unaware of that. It was a foreseen usability issue when the required information was available but the team decided differently, in favour of something else other than usability. The decision was influenced by unawareness in the case of an unforeseen usability issue.

The identification of lacking but required information and the identification of unforeseen usability issues were verified with two respondents. These respondents agreed with the identified 'lacking information' and arrived at the same identification of unforeseen usability issues, except for one. Both the respondents said –independently of each other- that they were aware of this usability issue, but that is was technically not possible to solve the issue. We will next describe the usability issues and afterwards present an overview of (un)foreseen usability issues.

3.3.4.1 USABILITY ISSUES

A – MAIN MENU

The issues A1, A2 and A3 are related to the same product feature; the user interface automatically returns to the main menu. The user that expects a 'return button' is confused and does not understand how to return to the main menu. A user who knows how it works changes his settings and then has to wait until the menu returns to the main menu, getting irritated by the delay. A user who does not know exactly how to enter the settings might have too little time or get confused because nothing happens. These issues occur because there is no separate 'return button' and it takes five seconds before it returns to the main menu. The timing of the 'return' was tested as to whether it should be three, five or eight seconds, and it was concluded at that time that five seconds would be the best solution. The team was aware about the lacking information and possible consequences of this decision, so this was a conscious decision. The decision about the timing resulted from the decision of not using a return button, which in turn related to the decision of using a limited number of buttons. Because only a limited number of buttons were available and a large number of functions needed to be included there was no button left to assign the function 'return' to. At the time it was not realised that this could confuse a user who expects a hard return button. The decision to use only a limited number of buttons for this product while preserving all the functionalities is therefore also relevant in relation to these issues. So it is more than one decision that can be associated to this issue. At the moment of the decision in favour of using a limited number of buttons, these issues were not foreseen.

C – ALARM

This issue does not result in large problems for the user but it is a function that the user expected. The user expected to be able to create certain settings in the product; however this was not possible because the function was not available. It was decided after UI tests not to implement this function because it made the UI rather more complex. The availability of the function was considered not important enough to increase the product complexity. Therefore it was a conscious decision not to implement the function.

D - BROKEN

Unfortunately this example cannot be explained in too much detail because it would reveal the product. The user thinks the product is broken, while it is not, and therefore returns the product or calls the service desk. With the correct instructions the settings can be changed to solve the issue. A running change was made to solve this issue in reaction to these calls and returns. A running change is an adjustment made to the product and implemented in the products yet to be manufactured without stopping production. This issue was foreseen during product development, but it was considered technically too complex to solve it. The running change that was made in reaction to customer feedback was not considered during the development process.

E - OPERATING

The issues E1, E2 and E3 are the key usability issues of this product. The user does not know how to operate the buttons, and more specifically; he does not know which button is for which function, and also which way to turn the button wheel. These issues result from the product solution of three rotary-push wheels and a lever located on the right side of the product and the display on the front panel of the product. Not all users are familiar with a button like a mouse wheel that you can turn and push, while it was assumed that the user would know how to operate buttons like this. The decision in favour of these buttons was made because of the possibilities provided. With one button there is the possibility to increase and decrease settings and to confirm the setting by pushing. However, when testing the complete product with test persons from the target group it proved to be difficult for the users. These problems were not only caused by the kind of buttons but also because of the location of the buttons. Locating the buttons on the right side of the product creates confusion. Increasing the setting; would that be turning the rotary wheel up or turning clock-wise? This confusion for the user was realised during development and, it was tested whether there would be a significant preference for a turning direction. There appeared to be no preference and because most of the users are right handed it was decided to keep the buttons on the right side. The confusion of the user is that he does not know, which button is for which function, this is caused by the limited number of buttons and the number of functions but also because there is no direct connection between the buttons and display. The display is located on the front of the product and the buttons on the right side. At the time it was decided to locate the four buttons on the side of the product it was not realised that it would thus result in all these usability issues. These issues were only discovered with usability tests at the end of the project. By then only changes in the software could be made to improve the UI.

F – RADIO

The issues the user encounters to operate the radio relate to the previous described issues (E). With this issue the user does not know how to operate the radio and he is confused about which buttons to use to operate it. This issue is caused by two decisions. The first decision is the decision to place the buttons on the right side that disconnects the relationship between the display and the buttons. And second, the decision to use a limited number of buttons for the number of functions. At the time of making both decisions it was not realised that they would cause usability issues. The team considered adjusting the UI when they realised the usability issues with the radio

function. These changes were not executed because it would complicate the complete UI operation.

G – CONFIRM

It is difficult for the user to confirm settings. The settings can be confirmed by pushing the rotary-push wheels on the side. Not all users understand that they should push the wheel and besides, it is also difficult to push the wheel. The team was aware of the relevance of the pushing force, which was therefore tested. It was not realised that it would still result in issues. When pushing the wheel it can turn by accident, making you confirm the incorrect settings. This was adjusted with running changes during manufacturing by adjusting the sensitivity of the turning wheel. Later on different buttons were even used, which would block the turning when pushing the wheel.

H – LOCATION OF THE SNOOZE BUTTON

The user expects the snooze button on top of the product, based on experiences with other products. The designer decided to locate the button at a different location than usual. This location would be easier to reach for the user and shows immediately whether the function is on or off. So the different location was a conscious decision, as they were aware that it could cause confusion by users who expect it to be located on top.

L - OFF

The user is not sure whether a setting is turned off. These doubts resulted in calls to the service centre to verify whether the setting is turned off or not. Users were confused as the setting showed the levels: 3-2-1-0 in the digital display. The zero was meant as 'off' by the developers, but interpreted by the users as the lowest level. This issue was only realised in hindsight. The confusion was taken away by changing the settings to 3-2-1-OFF. This running change could easily be executed by changing the software for the digital display.

The descriptions of the various usability issues briefly explain the issues, the decisions that led to the issue, and whether the issues were foreseen or not. These descriptions are based on the 14 interviews and the discussion with 2 respondents. The results show that there were indeed usability issues that were unforeseen at the moment of decision-making. The (un) foreseen usability issues are listed in *Table 3-3*.

These results were presented to the group of respondents and their colleagues as feedback on their project, but also to create a discussion about the influencing factor unawareness in product development. During this group session the factor unawareness was acknowledged and recognised as relevant during decision-making. It was discussed how they could have prevented this unawareness in the studied project but also how they could use these discoveries in new projects. One of the respondents a metaphor to describe the factor unawareness: *"[5] I wonder if we realised soon enough after we left the highway and started exploring an interesting wood, did we pick up the signals fast enough?" ….. "[4] we didn't clearly recognize the magnitude, we didn't realise how big they (CH: the issues) were" …. "[5] I just wonder how can we, let's say, better uhm, reception of the signals that we are heading off in the wrong direction, because it is not that we are neglecting that but we may have underestimated the magnitude until it was impossible to…."* The vivid discussion about the factor unawareness confirmed

ISSUE	DESCRIPTION	(UN)FORESEEN
A1	the user does not understand how to return to the main menu	Unforeseen
A2	the user cannot use the product as fast as he wants	Foreseen
A3	the user does not have enough time to change the settings	Foreseen
C1	the user cannot create separate settings for the alarm	Foreseen
D1	the user thinks the product is broken	Foreseen
E1	the user does not know how to operate the buttons	Unforeseen
E2	the user does not know which button is for which function	Unforeseen
E3	the user does not know which way to turn the button	Foreseen
F1	the user does not know how to operate the radio	Unforeseen
F2	the user is confused which buttons to use for operating the radio	Unforeseen
G1	it is difficult for the user to confirm settings	Unforeseen
H1	the user expects to find the button to be at a specific location	Foreseen
L1	the user is not sure whether the setting is turned off	Unforeseen

Table 3-3: Overview of (un)foreseen usability issues

that it is a relevant factor in decision-making but also that it is not yet well enough understood to address it properly in order to prevent unawareness in the development process of the next project. ◆

3.3.5 DISCUSSION STUDY 2

Study 2 was executed to find an answer to the sub-research question:

"Is unawareness a critical influencing factor on usability related decision-making in design practice?"

To answer this sub-research question the various usability issues of the product were studied and it was identified whether there were issues that were unforeseen by the team at the moment of decision-making. The results show that there were several usability issues unforeseen during the product development process. These unforeseen issues indicated that there was unawareness within the team about these issues at the moment of decision-making. Therefore it can be concluded that unawareness is a critical influencing factor, as it results in usability issues. The other identified usability issues are a result of consciously made decisions. At these moments the team members were perfectly aware of the consequences of a decision but made the trade-off in favour of something else rather than usability. Based on these results the conceptual framework that was presented in chapter 2 (*Figure 2-12*) was adjusted. Study 2 proved that unawareness is a critical influencing factor; therefore the dotted lines were replaced with a line, see *Figure 3-11*.

The conceptual framework now shows three influencing factors that make design decision-making difficult; the context,

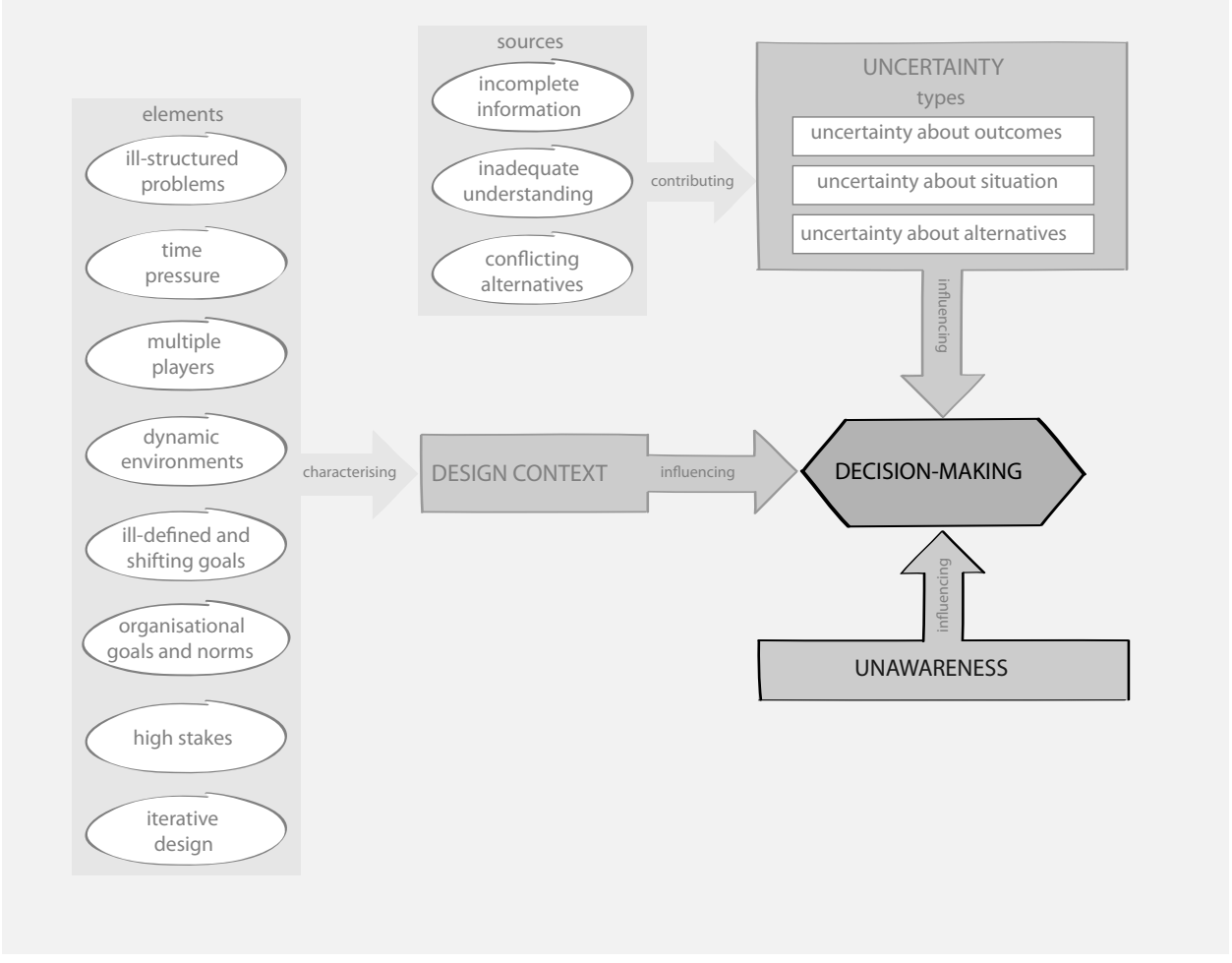


Figure 3-11: Conceptual framework III - Influencing factors on decision-making in design practice

uncertainty and unawareness. The design context is defined by eight elements. Uncertainty is described by its types and sources. The types of uncertainty are what the decision maker can be uncertain of and the sources of uncertainty are what induce the uncertainty. The factor unawareness cannot yet be described in further detail. The presented literature in section 3.2 did not provide an applicable definition or explanation of unawareness for, or from design practice. Before we proceeded to investigate unawareness we needed to know whether unawareness is a critical influencing factor. Study 2 proved that unawareness is a critical factor during the decision-making process, as usability issues do result from unawareness. This result provides a direction for further research. We now know that unawareness is an important influencing factor in design decision-making. So to answer the research question from chapter 1: *"In design practice, what makes usability related decision-making go wrong?"* we need to have a better understanding of unawareness. During the interviews of Study 2 we did gain a first impression of unforeseen usability issues and their sources. We will discuss these insights and consequently use them to define further research.

As expected several elements of the design context (see section 2.4) are mentioned as influencing the process that is investigated in Study 2. For example organisational changes within the company: *"…[5] I stayed on the project, but a lot of new members were involved… but also many people left"*. The organisational changes resulted in changing team members on the project. Experienced members changed to other projects and new members joined the project. Several of the respondents were only involved later in the project, for example the second designer:

"I came in, quite late, in a way [C] OK [3] but as it turned out, there was enough time to turn something around and do it [C] mh, yeah [3] but, as I, I wasn't involved from the beginning of the project, I came in some months after, basically" .

The organisational changes relate to the element of the design context 'multiple stakeholders'. Working on design projects is mostly done with multiple people from different disciplines. The involvement of multiple people complicates the creation of a shared understanding of information and goals. When these team members on a project change due to organisational changes it will become even more difficult to create this shared understanding. This is one of the elements that determine the situation in which the team members had to make decisions.

The changes within the organisation were also of influence on the goal of the project. The goal changed from developing a more energy-efficient, user-friendly and aesthetically attractive looking product to creating a design icon.

"There's been a real turning point in strategy [C] mh [9] … it was a new impulse on the project, a real new start [C] mh [9] a complete focus on a design icon … suddenly a lot of resources were available to really make it a design icon".

This changing goal made decision-making within the project more difficult. Decisions and assumptions were made in the perspective of the old goal. Some members wanted to lever to the old decisions, but other (and new) members adapted to the new goal and were motivated to make different decisions.

Another context element that influenced decision-making is the element time pressure. It is mentioned by several respondents that the time pressure was high in this project.

"[7] and there was only very little time … a lot of new things had

to happen in a very limited time frame".

Time pressure results in limited time to consider decisions:

"Purely because of time pressure, you don't go back another time and say, gee, shall we have another look at what different kinds of buttons there are. The plant has to start within x weeks, which means that tooling should be made and that there is enormous pressure on it"

This time pressure resulted in a certain frustration among some of the team members. The time pressure was partly caused by technical challenges within the project:

"…it appeared to be a very difficult job, which ultimately put an enormous pressure on the project."

Study 2 suggests just like Study 1 that a limited overview during the project could result in unawareness during the decision-making process. The organisational changes resulted in different team members on the project and also in different goals for the project. The new team members were not familiar with previous decisions, assumptions and starting points, this was formulated by one of the respondents as follows:

"it is quite simple things actually, you know, had everybody been at the starting point, at the same level, we are going to make a successor and it is going to be great, we are learning from the last one and we are going to this and this differently, and we are going [C] mh [3] uhm, really, you know, uh ...o... get those things right, that is the way you ideally want to do it [C] yes [3] ideally but, than, you know, it doesn't often happen that way, no, unfortunately because of all kinds of mitigating circumstances that are quite out of your control" .

The limited overview could be the source of unawareness during the process resulting in unforeseen usability issues. One of the respondents says the following about unforeseen issue G1, 'confirming settings':

"this is the turn and push problem, I assume [C] yes [7] yes, what can you say about that, it's something we realised in hindsight that it could be a problem [C] mh [7] so in that sense it was not a conscious decision, except that it was a conscious decision to use rotary wheels [C] *yes [7] in that way we could achieve more functionality with less buttons [C] yes [7] so it's a case of 'shit happens'".*

Identifying the factors with their elements that influenced decision-making provided a better understanding of the context in which the decisions were made. The situation helped in understanding the made decisions, but it did not explain why unforeseen usability issues occurred. Only the changes in team members and consequently the limited overview provided some explanation for the identified issues that were unforeseen. In section 3.3.4.1 the usability issues of the alarm clock were described. The description of these examples showed that issues are often associated with more than one decision. An explanation for unforeseen usability issues may be found in the chain of made decisions. For example, the unforeseen issue: 'the user does not know how to operate the buttons' (E1). Respondents mentioned that the causes of this issue were the decisions in favour of: three buttons; multifunctional buttons; and a disconnection between the display and buttons. These decisions could be studied as separate decision moments or as a chain of decisions. What can be understood from Study 2 is that it was probably a chain of decisions that led to this unforeseen usability issue. There was a wish or decision, to retain all functionality of the predecessor and to have a smaller number of buttons. This resulted in a search to reduce the

number of buttons while keeping the same functionality. The result is a concept with four buttons (three large buttons and a small one) and a display, respondents refer to this concept as 'three buttons'.

"This was the first real starting point, we can operate all functions with these three buttons, which is the result of our search for what is the most, what is the smallest number of buttons with which I can control the functions".

But multifunctional buttons are necessary to address all the functions, buttons that can be turned and pushed. This was called a conscious decision:

"….it was a conscious choice to use rotary wheels [C] yes [7] this was a way to provide more functionality with less buttons."

However the consequences of that decision were not foreseen at that moment. The decision to disconnect the display from the buttons is described by one of the respondents while drawing the first and final UI design. This description of the product architect explained that it is a chain of decisions that led to the unforeseen issue of users having difficulties with operating the buttons. But we cannot exactly understand why and how these decisions are made, let alone understand how unawareness in such a project could arise. Therefore, it is necessary to study this case and the process of decision-making in more detail to gain a detailed understanding of the origins of unforeseen usability issues.

Some remarks about the limitations of this study have to be made. Study 2 was a single case investigated by retrospective interviews. As described in the discussion of Study 1 (see section 2.5.5) such a study has a limited level of validity, details are difficult to retrieve, and the researcher's interpretation of the respondent's personal story makes that we are distanced from reality. The level of validity was increased in Study 2 by conducting more interviews, verifying the results with two respondents, and discussing the results with respondents and colleagues. However from the interview no details about dates or sequences of activities could be obtained. Neither did we get closer to what really happened during the project. For that are other techniques such as observations or document analysis necessary. But observations were not possible with a retrospective study and documents could at this stage of the research not explain whether required information was available at the moment of making a decision and if the team was (un)aware of that.

A project from a world leading company in product development was selected for this case study. It was assumed that when unawareness occurred in their decision-making process that it would also occur in other company's processes. As the basis of making decisions and creating products is the same for small and large companies and for consumer and professional electronic products. However a limitation of this and the next study could be that it is unknown what the level of experience and expertise on product usability of the individual team members is. This makes that general statements on decision-making can only be made with a some caution. ◆

3.4 **Conclusion chapter 3**

In chapter 1 the main research question of this PhD research project was introduced: *"What makes usability related decision-making in design practice go wrong?"* In chapter 2 a start was made to answer this question by investigating decision-making in literature. Unfortunately design literature did not provide a description of decision-making in design practice that could directly answer the main research question. Some suggestions of influencing factors on decision-making were gained from Naturalistic Decision Making theory. In Study 1 these factors were explored in design practice to gain a better understanding about what influences decision-making in design practice. One of the outcomes of Study 1 was the suggestion of the possible influencing factor unawareness. It was necessary to identify whether this is a critical factor for decision-making in design practice before studying it in detail. Based on the interviews of Study 2 it was concluded that usability issues result from 'conscious decisions' and unawareness. A foreseen usability issue results from a decision in which the trade-off is made in favour of something else rather than usability. An unforeseen usability issue results from unawareness during the decision-making process. So, study 2 confirms that unawareness is indeed an important factor, resulting in unforeseen usability issues. It can be concluded from these two studies that usability related decision-making in design practice is not only influenced by the factors 'design context' and 'uncertainty', but also by the factor 'unawareness'. The design context and uncertainty are explained in chapter 2, but unawareness is still an undefined concept. What are decision-makers unaware of in the decision-making process? And what are the sources that contribute to unawareness in the decision-making process? A better understanding of the factor unawareness will eventually enable us to answer the research question from chapter 1. Therefore a third study is presented in chapter 4. This study focusses on the details of the decision-making process to find clues to describe and explain the influencing factor unawareness in product development. ◆

CHAPTER 4: Understanding unawareness

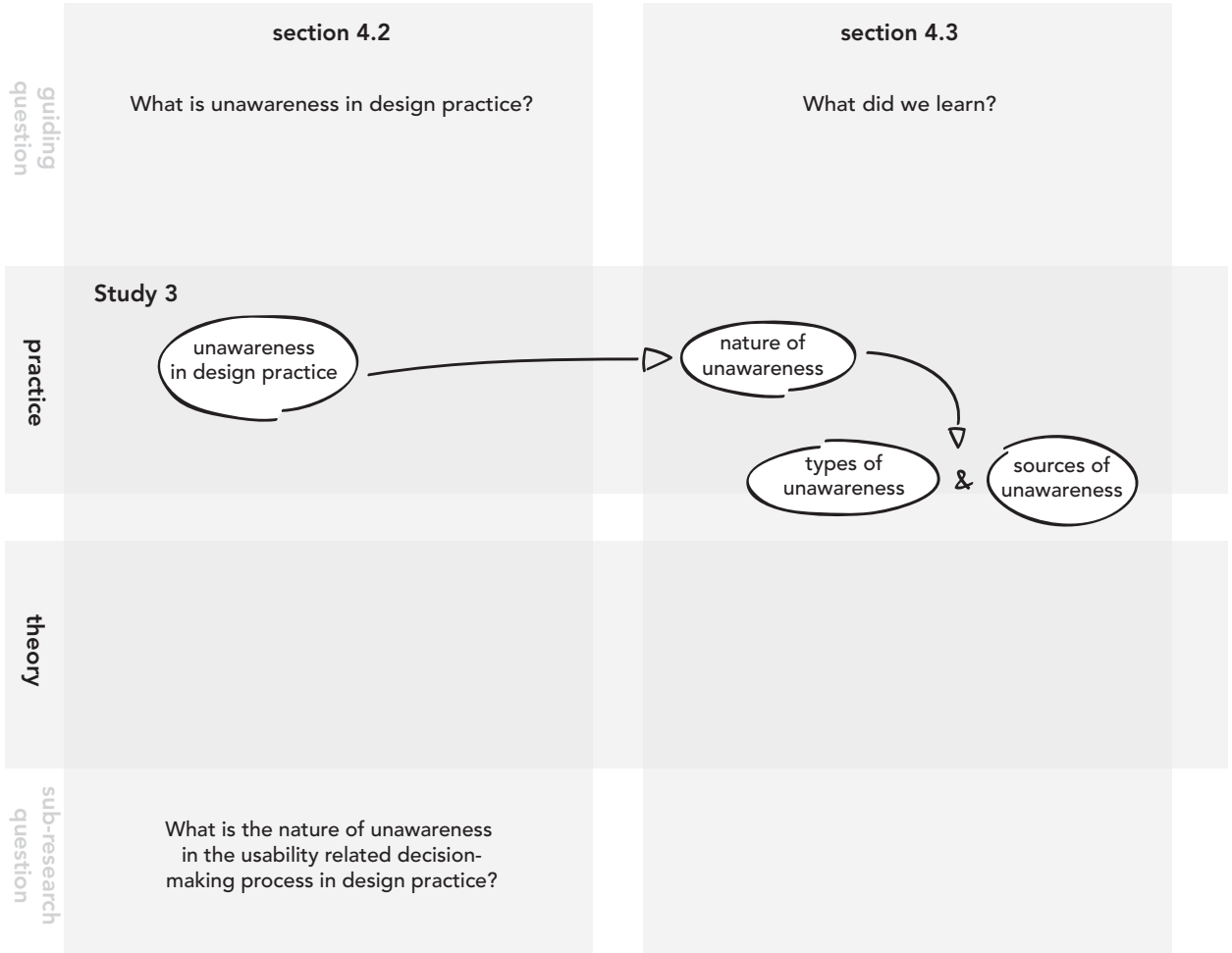


Figure 4-1: Visual table of contents chapter 4

4.1 Introduction

From Study 1 it was learned that unawareness is possibly an influencing factor on usability related decision-making in design practice. Study 2 confirmed that unawareness is a critical influencing factor in decision-making, as usability issues result from unawareness during decision-making in design practice. Based on these two studies it is known that decision-making is influenced by the three factors 'design context', 'uncertainty' and 'unawareness'. However the term unawareness is still an undefined term. In section 3.2 it was defined as 'unforeseen'; not having in mind [Modica 1994, Dekel 1998], the information or issues that were not realised beforehand. But this definition does not define what the decision-maker is unaware of, and what the sources of unawareness are. Unawareness is only meaningful when it refers to a person's unawareness of something [Schmidt 2002]. In this third study is investigated the nature of unawareness to learn what the decision-maker can be unaware of and what the sources of unawareness can be. This to answer the following sub-research question of Study 3:

"What is the nature of the influencing factor unawareness on usability related decision-making in design practice?"

An inductive study to unawareness in practice is necessary as only limited literature on unawareness is available. The retrospective interviews of Study 2 provided some understanding of unawareness, but not enough due to the limited level of detail. Study 3 is a detailed document analysis of the same case that was used in Study 2. This provides the possibility to triangulate the data and thereby strengthen the data. Moreover, the documents of this case can provide details about the project that could not be obtained from the interviews.

The description of the nature of unawareness should provide leads on how to address unawareness. Addressing unawareness may result in better usability related decisions and thereby in less unforeseen usability issues. Section 4.2.1 describes the research method of Study 3. The results are presented from section 4.2.3 to section 4.2.8 the final results of this study, which are propositions to build theory about the types and sources of unawareness. These results are followed by a discussion of the study in 4.2.8 and a conclusion in section 4.3, see also *Figure 4-1*. ◆

4.2 Study 3: Decision-making and unawareness in design practice

4.2.1 RESEARCH METHOD

In Study 3 the nature of unawareness was investigated to get to a description and explanation of unawareness in design practice. An inductive study was conducted to find out what a decision-maker can be unaware of and what the sources of unawareness can be, as literature did not provide a description (see section 3.2). To gain this understanding a study needed to be conducted that provided a high level of detail and a strong basis to build theory about unawareness. The high level of detail was required to fully understand the influencing factor unawareness and to identify the possible types of unawareness, and the sources that contribute to unawareness. The results of Study 2, presented in section 3.3.4 provided a first insight into unawareness but did not give a clear description. However, when the same case for Study 3 would be used as was for Study 2, than the results of Study 2 could be used as input for Study 3 and triangulate the data. Data triangulation strengthens the results as the case is investigated with different techniques. Different techniques might reveal different data, by combining the data consistencies and inconsistencies in the data that can be found to provide a deeper insight into the phenomenon unawareness.

Techniques that provide a high level of detail are observations and document analysis for example. Observing team members during a project, recording the decisions, the available information and the activities provides a very detailed overview of the project. However, it is unknown beforehand whether the results of the project are a product with (unforeseen) usability issues. Therefore it was decided to execute a retrospective study on a finished product with usability issues by document analysis. Documents provide a look behind the scenes; details which are not debated during interviews. Although documents can be incomplete, inaccurate or variable in quality they are a much more objective and detailed data source than interviews, which can be distorted due to personal bias [Patton 2002, 306]. A combination of the two techniques of 'interviewing' and 'document analysis' were used to prevent the limitations of Study 1 and 2. The 'personal bias' and 'retrospective sense making' is limited by cross checking the answers from the interviews with the data from the objective data source 'document analysis' and by interviewing various team members from different perspectives [Patton 2002, 293]. This use of multiple data sources increased the validity of the data [Yin 2009, 41]. The results of the interviews of Study 2 were used as a guide for the document analysis of Study 3. The overview of the project gained from the interviews provided a

direction for investigating in detail the unforeseen usability issues and their sources. Subsequently the document analysis provided detailed information about the specific moment of decision-making, the involved team members, the available information, the use of information in decisions, etc. With this data the project was described in detail, i.e. tell its story. What happened during the process? Why were certain decisions made? How could this result in usability issues? The basis of two data sources provided a firm ground to make sense of the project, to find elements which explained the unawareness during the project, and to create a description of unawareness in design practice.

The aim of this study was to identify the nature of unawareness during usability related decision-making in design practice by specifying the types of unawareness and the sources of unawareness. The types of unawareness describe what the decision-maker is unaware of and the sources are what induce unawareness. This distinction between types and sources is made by Lipshitz [Lipshitz 1997] for describing uncertainty. As the distinction worked well for uncertainty it was assumed that unawareness could be described by this same distinction of types and sources. In the next section it is explained how the types and sources of unawareness were extracted from the interviews and document analysis.

DATA GATHERING

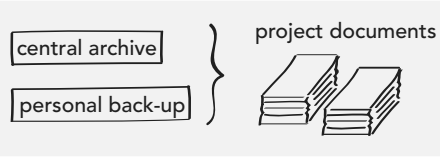


Figure 4-2: Data gathering Study 3

The data of Study 3 was gathered by collecting documents (see *Figure 4-2)* from the central archive system of the company. Extra documents were retrieved from team members' personal back-up.

DATA PROCESSING

In *Figure 4-3* is shown the process of processing the data of Study 3. It was expected that the number of collected documents would be enormous, as it was an extensive project. So it was needed to define a way to process the data before

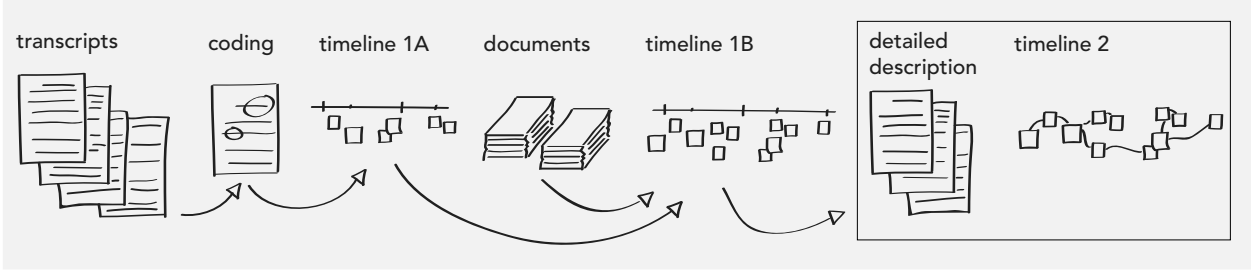


Figure 4-3: Data processing Study 3

analysis could be started. The data from the documents needed to be organised and structured in such a way that it provided an overview of the project. This overview was required to support gaining an understanding of the project; what activities were executed, which team members worked on the project, which information was available at the moment of decision-making, etc. An overview of the project was created by making a timeline of the project. All the activities and involved team members of the project were allocated to a moment in time. A first overview of the project was created based on the interviews of Study 2. From these interviews it was already learned about the team members who were involved and the activities of the project. The advantage of creating an initial timeline based on the interviews was that this timeline guided the investigation through the enormous number of documents. This first and probably simplified timeline pointed out the activities to look for within the documents.

This first timeline (timeline IA) was made by analysing the interviews. Although it was realised that the source of interviews did not provide detailed information, it did provide an initial understanding of the project. The analysis was done by coding the transcripts of the interviews to the following nodes: the team members who worked on the project, the mentioned activities, and time indicators. These nodes were written on coloured Post-It notes with which the timeline was built, purple notes for time indicators, orange notes for the team members who worked on the project, blue notes for usability activities, and yellow notes for design activities. This timeline provided an initial overview of the project and subsequently was used as a guide for investigating the project documents. If the mentioned activities could be found within the documents, then what were other relevant documents in relation to usability activities? So the first timeline provided a direction in selecting the key documents of the project related to usability. Based on the selected key documents the 'Post-It notes' timeline was updated to timeline IB. Activities, team members, and specified dates of activities were added on timeline IA. A different coloured pen was used to write the notes, to make a distinction between the data sources. The data from the documents overruled the data from the interviews in the case of conflicting data. This extended timeline provided a more detailed overview of the project but did not explain the relationship between documents and activities.

To gain a deeper understanding of the project the relationship between the activities had to be identified. What was the input for a certain activity, and what was done with the output of activity? To find these relationships the content of the key documents had to be studied in detail. Which information is provided within the documents and what is done with the information of a document. Based on this detailed information a detailed project description could be written, the story of project Bear, see section 4.2.4. Within this story it was told what the context of the project was, which team members were involved, what activities were done, and why these activities were done. Quotes from the documents were used to create the story so as to stay as close as possible to the real story.

DATA ANALYSIS

The collected data was enormous, so several steps were required to structure the data, and some extra steps were necessary to analyse the data. During data analysis the data was grouped, abstracted, and interpreted (see *Figure 4-4*) to find an answer to our sub-research question:

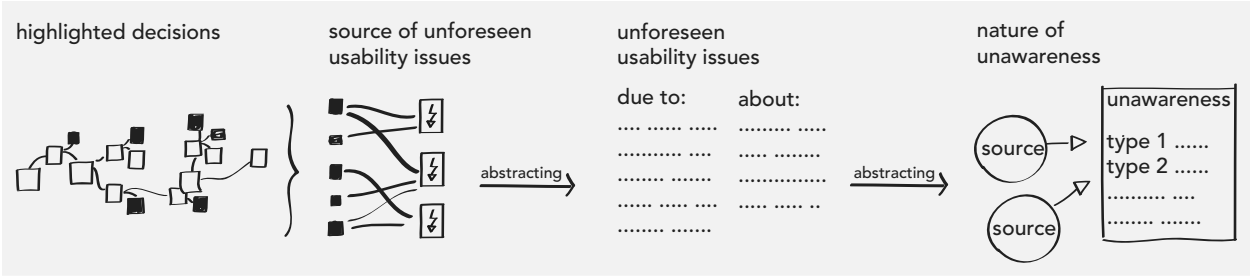


Figure 4-4: Data analysis Study 3

"*What is the nature of the influencing factor unawareness on usability related decision-making in design practice?*"

First the decisions that related to the unforeseen usability issues (that were identified in Study 2, see section 3.3.4.1, *Table 3-3* were highlighted. By studying the decisions related to the unforeseen usability issues more was learned about unawareness at the moment of decision-making. After highlighting the decisions related to the unforeseen usability issues we searched for the source, i.e. what led to the decision being made as it was. For this the data from the interviews and the documents were combined. For each unforeseen usability issue was described how the decisions resulted in issues, see section . The types and sources of unawareness were extracted from these examples, by combining various examples, and then grouping them into more abstract and general terms. These results are presented in section 4.2.7. ◆

4.2.2 **CASE 2**

In this study the same case as in Study 2 was used, see section 3.3.3. This case at a world leading company was selected because of their experience and expertise of developing usable electronic products with multi-disciplinary teams. The product was selected because of its newness to the market and the issues the users had with this product. A metaphor for describing the product was used to tell the story of this project, as the real identity could not be revealed for reasons of confidentiality. The product was described as being an alarm clock. This clock has a display on the front showing the current time. On the side are three rotary buttons and a lever, see *Figure 4-5*. With these buttons the user can adjust several features of the product, e.g. the alarm time, the volume and sound of the alarm, or the radio being used as the alarm. Feedback is provided on the display when the user wants to change one of these settings. Settings can be selected by turning the wheel and confirmed by pressing the wheel. The user enters a menu as soon as one of the wheels is turned. The menu automatically returns to the main screen after a few seconds of inactivity. This product was

called 'Bear' by the team members, the predecessor was called 'Ant' and the third product in this line was called 'Camel'. ◆

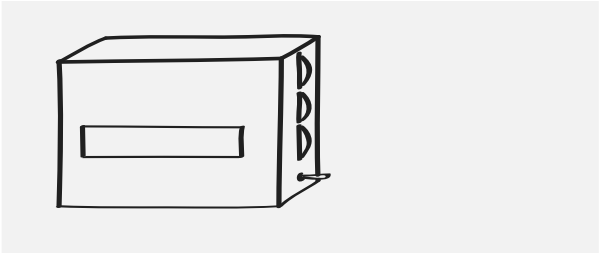


Figure 4-5: Alarm clock final design

4.2.3 **RESULTS**

During a period of 3 months the researcher – the author of this thesis – worked for two days a week at the company where the data was collected. Although the project was already finished, observing and experiencing the context provided a better understanding of the situation in which the decisions were made. During this time all the interviews in Study 2 were conducted and the documents were collected. The collected documents were project documents with an 'archive' number, the official stored documents, the archived documents of Ian a designer, including preliminary documents and all design sketches, as well as documents from project Bear collected by a team member working on the successor, project 'Camel'. There were also documents collected from a quality manager who did an internal audit on project Bear. This resulted in a final collection of 2.056 documents. Unfortunately this is not the complete set of documents; many documents from engineering and management were missing. Luckily, these documents were not key documents for this research project, as the interviews directed the research to the design and usability activities.

Organising all the documents was an iterative process of reading the documents, selecting the key documents, and categorising the documents, and then finally the process could be reconstructed. The reconstruction of the process was done by creating a project timeline of activities and decisions. The timeline provided a visual overview of the sequence of activities and thereby a flow of information of the input and output of activities. It also provided an overview of involved team members and peaks in the project. The timeline was a result of the data processing from organising the documents. However, the timeline was also a tool for guiding the data processing. Finding the relationship between the documents directs the course of reading the documents and selecting the key documents. A document that described the results of a usability test is a point on the timeline. This was a trigger to find the next activity that uses these results or a trigger to trace back the reason for this test in previous activities. By iterating between the timeline and documents a reconstruction of the project was made. The final timeline was based on two earlier versions and a detailed project description. This final timeline and project description are presented in section 4.2.4.

TIMELINE IA - INTERVIEWS

The first timeline was based on the interviews of Study 2. Although the information about time from the interviews could be ambiguous, it did provide a first insight into the project process. The interviews were coded to highlight the team members who worked on the project, the mentioned activities and time indicators. Each of these codings were

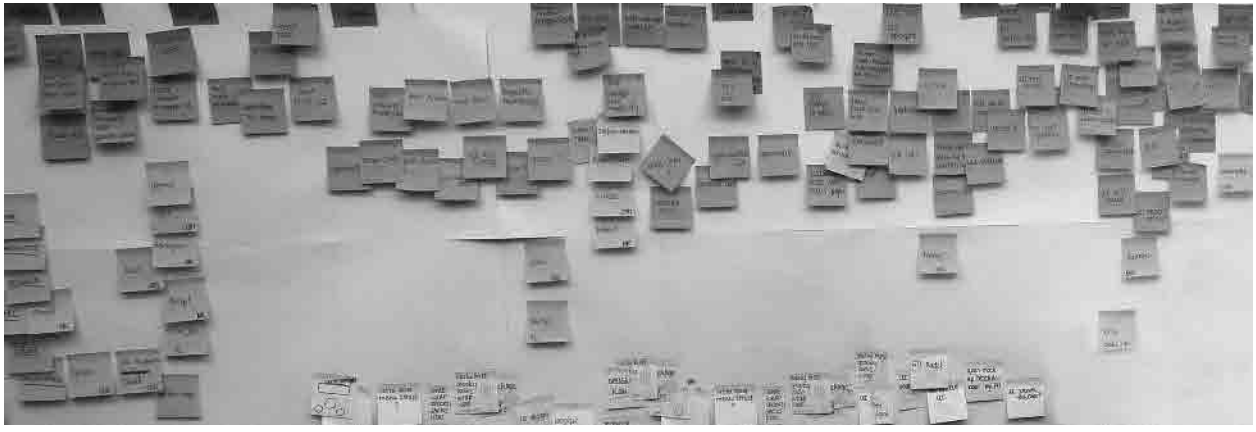


Figure 4-6: Timeline IA – Post-It notes timeline based on interviews

written with a blue pen on different colours Post-It notes. This timeline covered 2,5 meters of the wall next to the desk of the researcher, see *Figure 4-6* for an impression of this timeline. The timeline provided for the researcher an initial overview of the project with its team members and activities. At a glance it could be seen, for example, that new team members joined the project during the proces. This timeline was a guide through the enormous number of documents. Based on the interviews it was roughly known what to expect when reading the documents.

TIMELINE IB – DOCUMENTS

The documents needed to be read and selected before the first timeline could extended and specified. The collected documents were retrieved from various sources and contained an enormous digital computer folder structure which made it very cluttered. Moving all documents to one folder was the first step in creating order. From these 2.056 documents 155 key documents were selected. This was done by reading every document and selecting the documents that showed design concepts, test reports, progress reports and other documents that provide details about the project process, such as activities, design iterations and usability tests. The selected key documents were detailed in an Excel list, each with basic information about the document such as; name, author, date (mentioned in the document and its digital date), version number, file type (.doc / ppt / jpg / etc.), content description (test protocol, results, status, planning, etc.) and was assigned a category (design, testing, management). This provided a clear list of the key documents. The final overview of this list is provided in *Appendix B*.

Only the key documents were used to complete the coloured Post-It notes timeline. All notes added were written with a green pen to make a distinction between the data sources. Team members were added, dates were specified, and activities supplemented. The information from the documents overrules information from the interviews in case of conflicts. This resulted in a longer, more detailed, and more extensive timeline, including references to documentation, see *Figure 4-7*. Again, this timeline gave the researcher an impression of the project, for example its peaks of activities when Post-it notes are clutered and changing team members as an orange flag in the timeline. But it did not yet provide or explain relationships between activities and results or the decisions made during the project.

TIMELINE II – DETAILED DESCRIPTION

Timeline II (*Figure 4-8, page 112*) is the timeline that provided a detailed overview of the project. This timeline shows all the activities of the project that relate to the usability issues. Not only were the activities and decisions marked on the timeline, also the relationships between the activities were shown by lines between the documents. These lines show how the documents relate to each other, the input and output information flow of the project. The relationships between documents were mostly found within the content of a document. The relationship between, for example, test protocol and test results were often clearly defined within the document. It could happen that relevant documents for the project description have no relationship to other mentioned documents in the timeline, in that case the 'orphan' is explicitly stated within the description. The source of this final timeline was the 155

Figure 4-7: Timeline IB – Post-It notes timeline based on documents

selected key documents. The basis of this timeline was the 'Post-It notes' timelines IA and IB. The final timeline was created by writing a detailed project description at the same time. There was a constant interaction between writing the project description and creating the timeline. This interaction was necessary to clarify and understand the links between the documents. The story of project Bear is presented in section 4.2.4. Each stage of the project was described and explained. For reasons of confidentiality the presented project description is less detailed than the description that was used for data analysis. By writing a detailed description of the project the number of key documents was reduced to 99. The anonymous list can be found in *Appendix B*. During the writing process the documents were read in more detail and the less relevant documents – not directly related to usability decisions – were removed from the list. The complete timeline is shown in *Figure 4-8,* the large figure on the next page.

The start and end of the project is stated over the top of the timeline and the months underneath as time indicators. Subsequently seven stages of the project are mentioned. These stages do not necessarily correspond with the project phases of the company or design phases, but reflect the main activity of the stage.

- Start design
- Design verification
- Design search
- Winning design outer form
- Winning design UI
- UI verification
- Design validation

The activities of the project that relate to the identified usability issues are shown in the middle of the timeline. The orange squares are 'design activities', documents that represent design results. The blue triangles are 'usability activities', documents that represent usability results. A distinction is made between test reports (light blue triangle pointing down) and other documents regarding the user and interaction (dark blue triangle pointing up). The pink circles are 'management activities', documents summarising the project status. All the numbers [dxx] under the shapes refer to the specific document; please refer to *Appendix B* for an overview of these key documents. The lines between the documents show the links, the interactions. For example, the result of a design activity functions as input for a usability test, these results are input to a management activity, the output of this being input for another design activity, and so on and so on. The focus was especially on the dialogue between design and usability as decisions in this dialogue were closely related to the usability issues.

In section 4.2.4 the story of project Bear is presented. Subsequently the results of the data analysis are presented. Several steps within the data analysis were required to reveal the nature of unawareness. Although it was a complex process, in the end unawareness could be described by carefully executing the required steps. These results are discussed in 4.2.7. The step of describing the various examples of unawareness in this project was required to be able to describe the nature of unawareness but was not presented as a separate section in this thesis because it would have introduced too much repetition in describing the data. ◆

Project 'Bear'

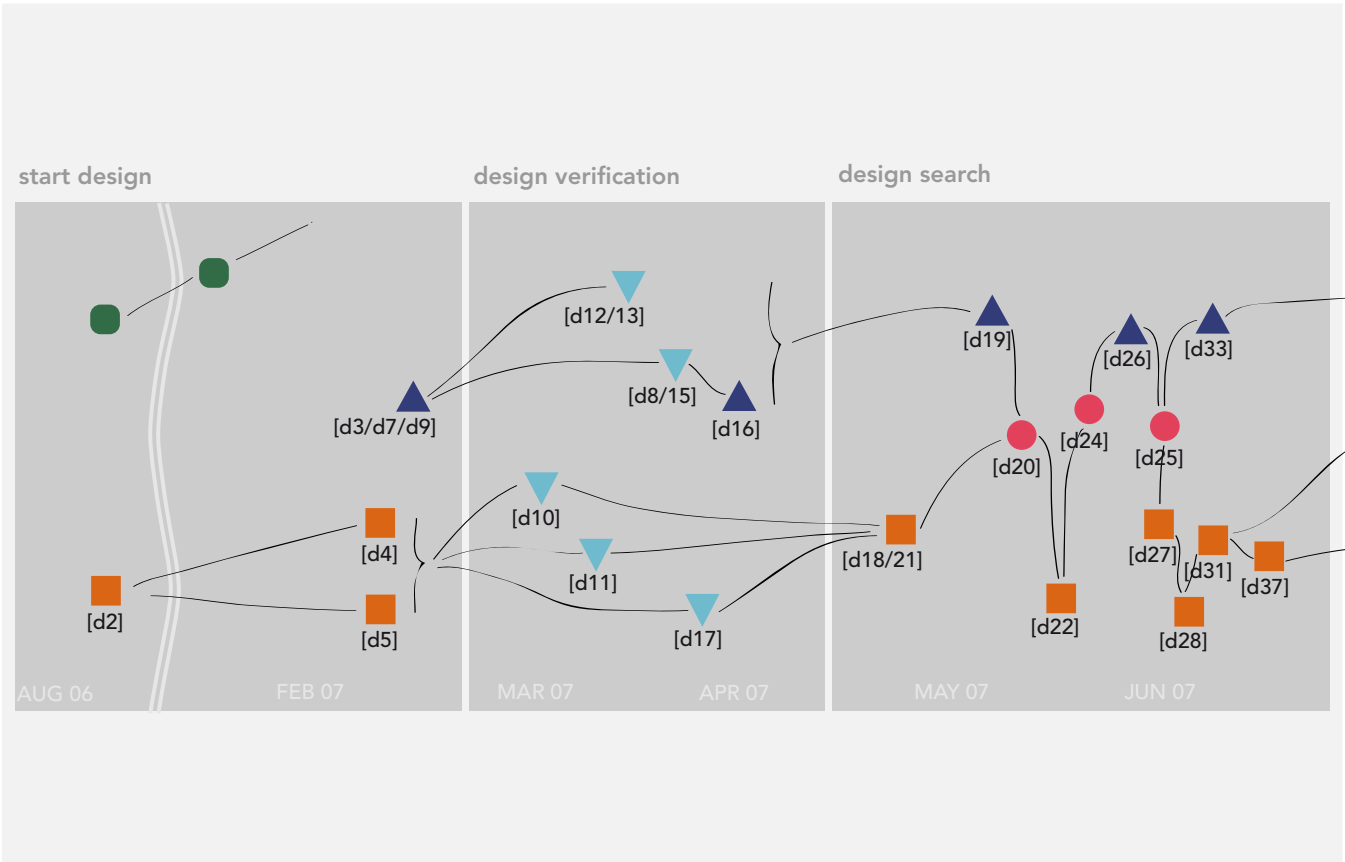
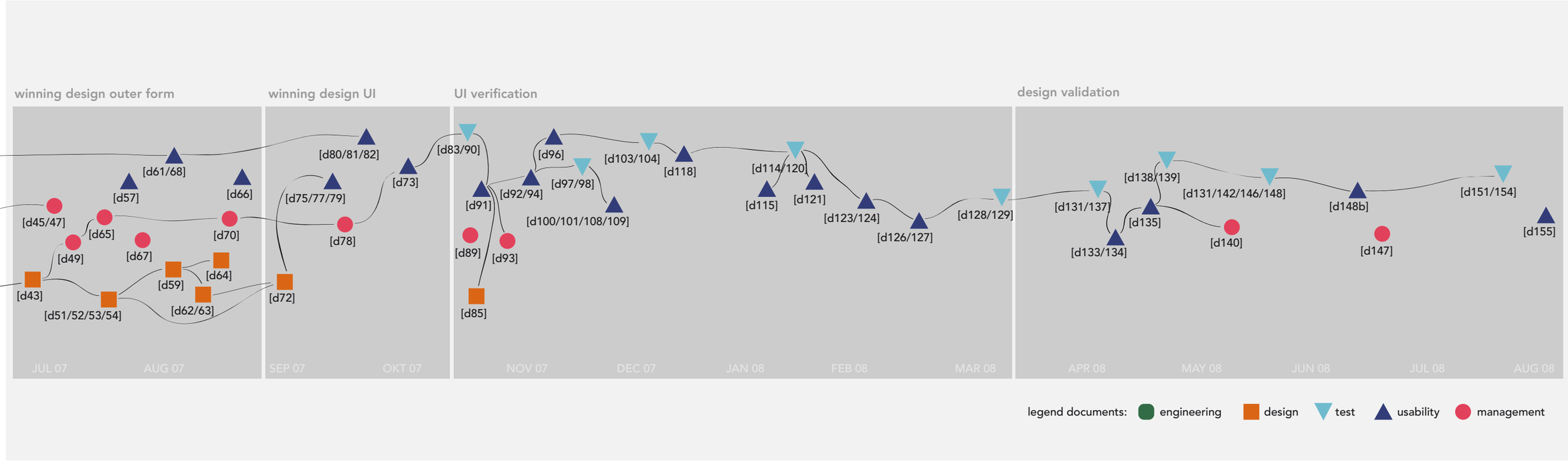


Figure 4-8: Timeline IIA, a timeline of the key documents and activities


winning design outer form
winning design UI
UI verification
design validation
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4.2.4 RESULTS - DETAILED PROJECT DESCRIPTION

This detailed project description is given to provide a thorough insight into what happened during this project, telling you the real story of project 'Bear'. The story is told per stage of the project supported by parts of the timeline. Each stage description starts with a part from timeline II (*Figure 4-8*). The stage of attention is tinted dark grey. The timeline visualises the activities and documents of the project in shapes and numbers shows the relationships between them with lines and provides thereby guidance through the story of the project. Though, be prepared, it is a long story. The project is described with all its details to present a real-life project and show the richness of this empirical study. However it was a balancing act between describing all the details and keeping it a confidential description, resulting in a description without pictures. The project is also objectively described to prevent any judgements on what went good or wrong before the next section. In this and following sections is the description analysed step-by-step. In section 4.2.5is elaborated on the description by highlighting the decisions related to unforeseen usability to create a focus for further analysis. In section the sources of the unforeseen usability issues are described to specify the relationship between the unforeseen usability issues and decisions. These analysing steps resulted in a description of unawareness in section 4.2.7.

START DESIGN

In the summer of 2006 the design team at location B started exploring the design possibilities for Bear, a successor of the first product Ant, see *Figure 4-9*. The chief designer in this team was Ian, an experienced designer. The start of the project was to define a roadmap for future products, creating design

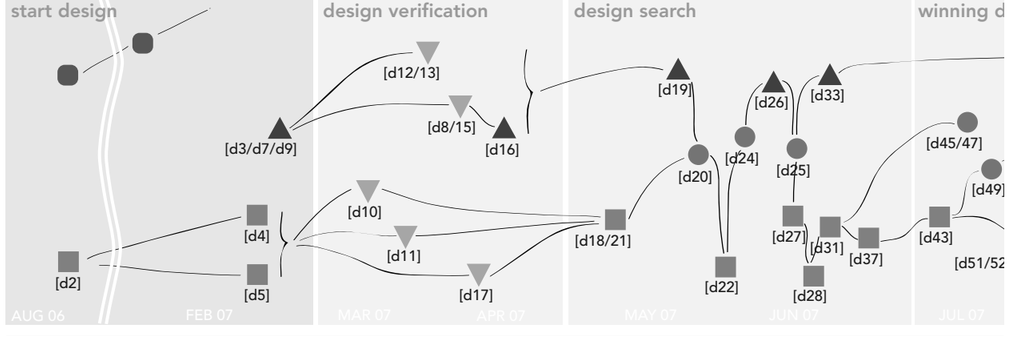


Figure 4-9: Timeline IIA – start design

proposals for a successor (horizon 1) but also proposals for future products (horizon 2) [d2] (please refer to *Appendix B* for an overview of the project documents). The horizon 1 ideas were inspired by product 'Ant' which was launched at the end of summer 2006. The concept choice parameters they used were: 'wellness' and 'lifestyle'. In the concept phase they focussed on simple shapes, natural materials and simple analogue interfaces [d2]. Besides variations in shape, suggestions for 'mood' settings were also suggested. The names of the ideas were inspired by their shapes, for example; Spooky, Icon, Rhythm, Vase, Wrap, Orb and Tower. These ideas are all focussed on the shape of the product and not on the user interface. In most of the ideas the interface only showed the display and one button. All the horizon 1 and 2 ideas are gathered in the roadmap presentation of 7th August 2006 [d2].

One of the first available project documents is titled 'State-Event Bird' [d3] from January 2007. So, the project 'officially' started in January 2007 under the name 'Bird'. This state-event document is an overview in Excel of the states and events of a user interface (UI) with only three buttons. This UI has a digital display with three buttons underneath [d7]. Each button can be pushed and turned clockwise as well as anti-clockwise. The left button is related to 'function 1' and the right button is related to 'function 2', the volume of the alarm. The middle button is the 'set' button. In the display the 'function 1' icon is placed on the left and the 'function 2' icon placed on the right as a reference to the function of the left and right buttons. Above the display is located a tiny push button for the snooze function. A motivation for this UI can be retrieved from various interviews of Study 2: "*this was really the first starting point, we can operate all functions with these 3 buttons, that is the result of our search to what is the smallest number of buttons with which I can control the functions*". It was intended for the UI design concept to have as few buttons as possible but with the same functionality as the first product. The decisions related to this document are discussed in section 4.2.5. Based on the state-event overview [d3], a simulation of the UI was made in order to test this first concept [d9]. Meanwhile the design ideas of August 2006 were developed into more detailed concepts [d4, d5]. Four of the designs; Wrap, Icon, Vase and Spooky were chosen for further development and also a design from another project was added to the selection of designs [d4]. This concept was called Jacks. These aesthetic design proposals [d4, d5] were used in 3 consumer tests.

DESIGN VERIFICATION

To verify the design various tests were conducted, see the triangles in *Figure 4-10*. The first consumer test in February 2007 was performed in the USA with five two-hour focus groups in which four of the five Horizon 1 concepts were used, to explore *"the appeal and fit of the concept in the US market and to optimize the communication for the new design"* [d10]. A fifth concept was included in the test, which was the design of the first product, Ant. The designs that had the most 'universal appeal' among US consumers were concepts C (Ant) and V (Vase) [d10], because *"both designs appear to fit the bedroom decors"* and *"both designs were perceived to enhance functionality."* From this test is concluded that there is *"a great opportunity to introduce this product to the US market."* [d10].

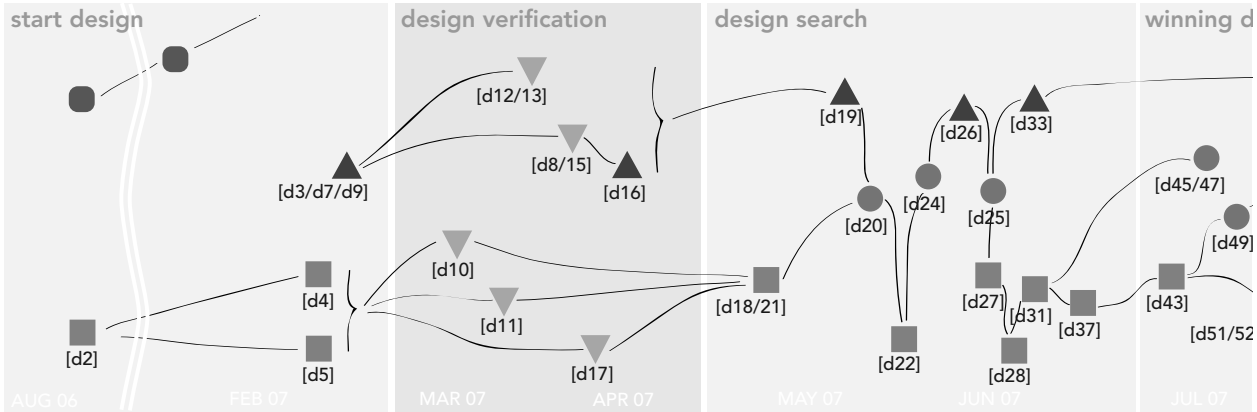


Figure 4-10: Timeline IIA – design verification

Hereby are some remarks from the report about the two selected concepts:

"Design C (Ant)

- *It was perceived as easy to use because it had the buttons right in the front.*
- *This design was also perceived as innovative because most had not seen a similar shaped appliance.*

Although this design was well-liked, when consumers became aware that it was larger than the other designs, most rejected it. This design has the potential to work due to its shape that reinforces functionality, but it is imperative that it is small and not bulky." [d10]

"Design V (Vase)

- *This design was well liked by both males and females.*
- *It appeared easy to use and it did not take away from room décor*
- *Some consumers were concerned, however, that it was not sturdy enough and that it could potentially be tipped over because its base was perceived as too narrow."* [d10]

The second consumer test [d11] was performed in The Netherlands in March 2007. In this test five of the original concepts (Spooky, Jacks, Wrap, Icon and Vase) were involved and also five future concepts, so they covered both the short and long term introductions. This qualitative research is performed to *"check the fit between the proposition and the different executions"* [d11] in order to be able to decide on *"the best design direction, fitting the proposition"*. The new designs are judged in this test on three elements: personal taste fit with consumer's room decor and fit with the proposition. *"Based on those three elements there is no clear winner. None of the designs succeeds to enter the home easily as regards to design and style. All*

designs fit only partly (or not at all) with the proposition. Jacks and Wrap are best of the rest, but have also too many rejecters. The Wrap is more likeable as a stand-alone design, but stands far away from the proposition and the room. The Jacks design is disliked more often, but fits the proposition and home better." [d11] Based on these test results it was advised to redesign the new product.

"Suggestions for redesign

- *softer, more personal, less cold*
- *more natural colouring*
- *round shapes*
- *as small as possible*
- *a better fit with the room allows a bigger design, we believe*
- *keep exclusiveness, well designed, quiet and clean lines*
- *a 'wall attachment' option"* [d11]

But *"if forced to choose: we advise to further develop Jacks"* as *"Product Ant proved to be successful in France, despite of its 'presumed' unattractive design. Apparently, for many users, the benefits of the product are more important than the design"* [d11]

At the end of March 2007 the third test [d17] to judge the design was performed in France. This test consisted of 50 face-to-face interviews of 30 minutes with closed questions in which 4 designs were judged: Early, Vase, Wrap and Vase2. The results of this test should provide *"a better basis for further market expansions with new design directions"* and *"the most promising design direction"* [d17]. The Wrap and the Vase were the preferred designs.

These three consumer tests in different countries did not provide a clear answer on which design should be used for the successor. The first test in the USA shows preferences for Ant and Vase. The second test does not result in any preference but Jacks and Wrap scored best and a forced decision would result in Jacks. The third test shows the Wrap and Vase as preferred designs but Jacks and Spooky were not in the selection. As one of the team members said in the interviews: *"we had difficulties finding a winning design"*

Besides tests to judge the aesthetical design of the product a test to judge the UI design was also executed [d8, d15]. The objective of the test was to judge *"how well the user interface is" and "what the improvement points are"* [d8]. For this test a Flash simulation was used to let users interact with the UI. The UI was a digital display with three buttons underneath, one large 'set' button supported by two smaller buttons for functions one and two and a small press button above the display. The objective of the test is addressed by three key questions:

- *"Is the user interface simple to use? (5-point-scale)*
- *What are the main points that are good to use?*
- *What are the main improvement points?"* [d8]

To answer these questions a questionnaire was used which started with instructions such as: *"change the alarm"*, *"turn on the radio"*, *"turn off the radio"* and finished with questions like: *"what was easy to do?"*, *"what is difficult to do?"* The results show that the first use of this UI is very complex, that it has a steep learning curve. The conclusion suggests *"It is recommended to adjust the UI on the following issues and to test again. > adjustments Henry, testing Emma"* [d15]. This recommendation is also discussed in section 4.2.5. One of the suggestions is: *"More buttons, to have fewer functions under the Set button."* The end score of the participants on the UI was a 3.8 out of 5, *"in*

general the interaction with the UI was easy" [d15] although the participants needed a lot of time to make settings, especially the first time. This UI test did not immediately result in a new UI or follow-up test, but an update of the state-event was made [d16].

In this same period of testing the aesthetic design and the UI design, a 'required feature study' was also executed [d12, d13]. The objective of this study was: *"To decide what kinds of features must be in Bird"* [d12]. The test resulted in an overview of *"the basic criteria, exciting criteria, reverse criteria, best performance criteria. Almost every feature is irrelevant, except for the snooze with eyes closed."* [d13] The results were referred to during the development when decisions need to be made on the functionality of the product, including the decision on the number of functions as described in section 4.2.5.

DESIGN SEARCH

The process was continued with a search to the winning design, see *Figure 4-11*. The tests prove to be inconclusive about the best product design, so new designs were made. A workshop with four designers at location B was done including Ian and Craig, a designer from location C. Together they searched for better solutions matching the proposition. This workshop resulted in new ideas [d18]. The focus was on the aesthetics, the outer form of the product. Only in a few sketches was paid attention to the UI. The ideas from the workshop were developed by making digital 3D models and further sketching resulted in another three design proposals; Globe, Nextbox and Sun [d21]. In these concepts the buttons in the UI were a touch screen slider or a remote control. The concepts Globe and Nextbox are used in a status presentation [d19] and a project review presentation [d20] at the beginning of May. Globe is favoured for reasons of aesthetics, but there are also

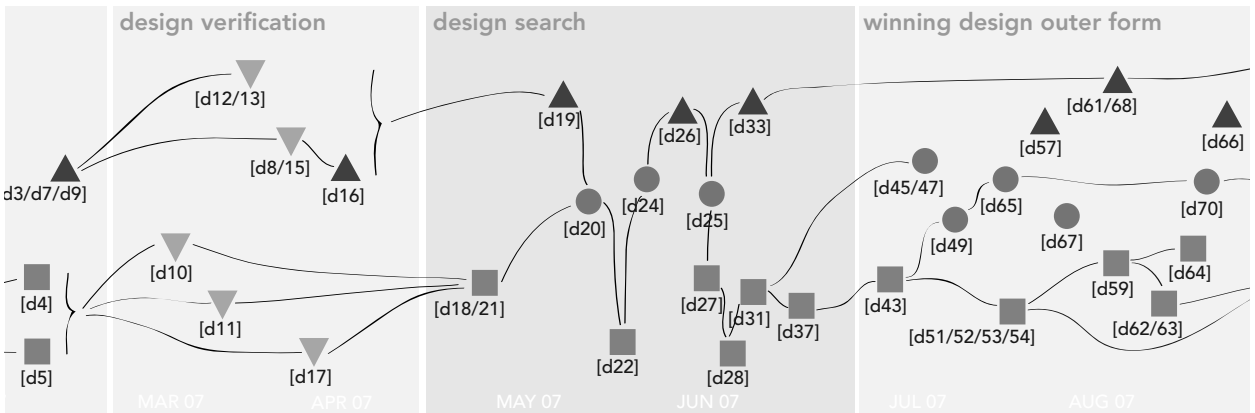


Figure 4-11: Timeline IIA – design search

reasons for rejecting this proposal: *"overall we can conclude that the two rounded concepts are too inflated. If we recall the starting point of project Bird – make it smaller in order to 1) take less space on the table, 2) generate more sales per cm3 shelf space – then the preference goes to concept 3 (Nextbox)."* [d20] There are also serious doubts for design proposal Globe in relation to the UI: *"The ball-concept seems unstable to use the UI. How to use the snooze button (which must be hidden and can be pushed hard)? Also the user must be able to see the display. I hope the display can be big enough to show the alarm (as proven in tests). The best option for the UI, leaving out the design with the three buttons, seems the design with the touch bar, but also with push buttons. Only a touch bar will probably not be as easy to use for everybody."* [d20]. In this project review [d20] also two new concepts for the UI were presented. These were based on the results of the UI test [d15]. The first proposal is a touch sensitive slider and push buttons, instead of turning buttons as in the first UI concept. The second UI proposal in this presentation was one with only a touch sensitive slider and one button.

In this same project review [d20] is also a reference to the unstable organisation of the project due to organisational changes. The consequences of this unstable organisation are changing team members or changing environments for several team members. The overview shows the functions and people and whether there will be a 'change of key people', 'stable function / unstable organisation', or 'stable function/stable organisation'. The presentation [d20] finishes with a request for *"better coordination in design and an aim for selection of a design direction by May 2007."* It is a change of the design context with which the team has to cope, resulting in changes of the elements 'dynamic environment' and 'multiple stakeholders' of the design context (*Figure 3-11*).

In the second design update [d22] by Ian, the same design proposals were presented as in the first design update presentation [d21] but now including technical drawings. These proposals show the slider in the UI and no physical buttons. These design proposals were used in the 'Bird' status update [d2] and were input for a large meeting in May 2007 [d25]. This meeting was a large team meeting to reflect on the project so far and to redefine the brief for the next part of the project. The planned date for launch, September 2008, was not rescheduled. An earlier version of the document was called kick-off Bear [d24]. So at this point the project name also changed from Bird to Bear. The brief in the presentation contained an overview of the aspects of the successor and the project:

- *"Main function > must have*
- *Design is leading > priority*
- *High quality radiation*
- *Application requirements*
- *Improve on user interface*
- *Meet cost price targets*
- *Meet launch in September 2008"* [d25]

The statement that *"design is leading"* is also explicitly mentioned by the respondents in the interviews, it was a clear priority since the meeting in May. This is another change in one of the elements of the design context, this time in the 'ill-defined and shifting goals' (*Figure 3-11*). In this second project review [d25] three design proposals are presented; Globe, NextBox and Sun. Together with some earlier design proposals, an overview is made of cost price and some specifications. In the beginning of May was stated *"aim for selection of Design Direction 19th May 2007"* [d20]. This aim was not reached at the time of the presentation in May 2007 [d25]. At the end of May there are

some variations on Globe and NextBox of where to place the display [d27]. Also possibilities were explored of using the UI with three buttons and having a stable Globe that does not roll away when pushing the buttons [d27]. In the third design update [d28] these variants are not shown, only a list of the benefits and disadvantages of Globe and Nextbox is added to the previous updates [d21, 22].

In this same week the usability department wrote a document [d26] about issues to keep in mind for the current design. The most important ones are: *"Current status UI nextbox -> to be optimized & tested and Remote control -> redesign UI & test & optimized & test."* [d26]. These suggested tests are not executed. The document number 26 is used as input for a workshop [d31] at location B in July 2007 with Ian the chief designer and three engineers. Within the workshop all running design issues are discussed including the design brief from May 2007 [d22]. The workshop resulted in several general remarks about both design concepts [d22]. Both the concepts are developed to the same level of detail. An expert opinion about the two concepts is given in document 37, it is quite a biased opinion about the two concepts, probably from a designer at location C, Craig. This expert opinion pushed the decision towards NextBox.

Subsequently, [d33] three options for the UI are explored; interaction with the UI with three buttons and not a touch sensitive slider. Option A is with a separate confirm button, B with an integrated confirm button, C without a confirm button. It was concluded that A would be most user friendly, referring to the test of March 2007 [d15]. No decision on an option is made, but the task was set for Ian to explore other possibilities.

WINNING DESIGN OUTER FORM

Figure 4-12 shows the process of deciding on the final design. Although various concepts on the aesthetic design and UI design were explored in spring 2007, still no consensus on the design was found. It was only 14 more months to the planned launch date and there was still no winning design for the outer form. A new design concept [d43] was proposed by designer Craig from location C in June 2007. This decision is further discussed in section 4.2.5. It is also again another change of design context element 'multiple stakholders'. Within this presentation two new design proposals for Bear were proposed. The two proposals have: *"a frosted finished outer form either plastic or glass, simply geometry, seamless integration of the display"* [d43]. The difference in the designs is the shape and the loading. One is bottom loaded with the display at the bottom and one is top loaded with the display on top.

In the planning [d45, d47] following this design proposal no explicit decision is made on the design proposals. In the reporting update of 10th July 2007 [d49] one of the new proposals of [d43] is presented with the other concepts Globe and Nextbox. About the alternative third concept is mentioned that the *"feasibility is not checked"* and that *"launch in September 2008 is questionable"* because of *"7 weeks delay in one of the phases."* [d43] The cost price of the UI is based on three mechanical buttons and a segmented LCD display, although none of the three designs shows this UI. It is concluded from the documents that followed that the team decided on developing the 'new' concept, as the last documents in which the other concepts are presented was a previous document [d43], please refer to section 4.2.5 for this decision. There are no documents available on this decision.

In June 2007 [d51] three variants on the 'new' concept are discussed in relation to manufacturing details:

- *"Blow moulding*
- *Click and twist interface on side surface of object Injection moulding front and back*
- *3 button interface on side of product, lever on the side act as function 4 Injection moulding top and button*
- *3 button interface on front surface beneath display and lever on the side"* [d51]

With this 'new' concept also a new concept for the UI [d52, d53, d54] is developed at the end of July 2007 by the interaction designer Naomi from location C, the same location as designer Craig who designed the 'new' concept. She listed all the functions and setting and assigned a priority according to use cases [d52] which leads to several recommendations for the requirements of the UI. Based on this, three concepts are introduced. All three concepts make use of a rotating switch (the lever on the side) and the last concept also has a plus/minus button and another button for a specific function. The second presentation [d53] shows in more detail (with pictures) how it would work. A statement from the presentation about the lever on the side: *"Side benefit of rotating switch is that physical position corresponds with a function: the status of the display is visible from the product exterior. This is especially beneficial for the main function: 'alarm on'."* [d53]. Within the document are some remarks from the designer about the variants. One of the conclusions is: *"using the same control for all three 'modes' makes product look simple, but makes interaction complex."* [d53]

Two weeks after these new UI proposals the first official document (with an archive number) about the UI of the product was created, [d61] related to the state event document [d68]. Surprisingly, these documents do not correspond with the 'new' UI concepts but with the previous UI concept [d33].

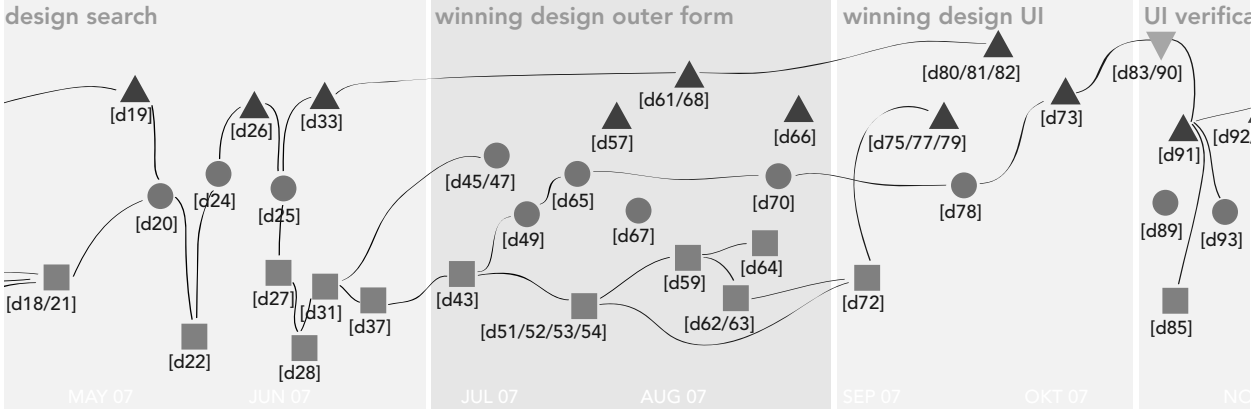


Figure 4-12: Timeline IIA – winning design outer form

To check the design an overview is made in July 2007 of all the user requirements, targets and test which need to be done to verify the targets [d57]. This includes testing the: *"alarm performance, user experience, user safety, ergonomics, user interface (all buttons, display readability), lifetime and reliability, packaging, direction for use, quick start guide, FAQ."* [d57]. This document is not made in reaction to other documents and is furthermore not referred to in other documents.

On the first of August 2007 the outer form and UI design are presented [d59]: a shape with three buttons and lever on the side and display on the front. It is proposed to make the front and back parts by injection moulding. The presentation is filled with pictures of this concept explaining the details of the design such as: *"Digits shining through the body material white light (has to be tested). Up and down lever three positions, please make these sleek click material: chromed metal"* [d59]. Besides documents on the outer form and UI design also documents about the feasibility of the concept are created [d62]. To judge the feasibility several items need to be investigated. The proposal of the three buttons on the side is an item to investigate and that is done by expert opinion, but it is not clear who the expert is and how this information is gained. Again new solutions for the UI and the functionality of the buttons are proposed in three variants, listing the advantages and disadvantages of the UI concepts [d62]:

"A) Three push & turn buttons on the side, push button on top
Usability will score lower than 3 push & turn in the front:

- *No relation of the buttons with the display*
- *No very easy reach of the buttons*
- *No readability of symbols on buttons*

B) Three push buttons and "turn" lever on the side, push button on top
Usability will score lower than 3 push & turn in the front:

- *Instead of 1 step to adjust settings it takes 2 steps!*
- *Extra level in menu for separated function level settings for the alarm*
- *No relation of the buttons with the display*
- *No very easy reach of the buttons*
- *No readability of symbols on buttons*
- *Adjustment of xxx are not separated -> turn the lever will take longer*

C) Two push buttons and "turn-push" lever on the side, push button on top
Usability will score lower than 3 push & turn in the front:

- *Instead of 1 step to adjust settings it takes 2 steps!*
- *Extra level in menu for separated function level settings for the alarm*
- *No relation of the buttons with the display*
- *No very easy reach of the buttons*
- *No readability of symbols on buttons*
- *Adjustment of xxx are not separated -> turn the lever will take longer*
- *'Uncontrolled' operation by user (user can easily adjust other functions by rotating and pushing the lever the same time)*
- *Lever is very thin for a push button"*

It is concluded that each of these concepts will score lower than the very first concept of three push and turn buttons on the front of the product beneath the display. *"All functions fit in the User Interface, but options A, B and C is less preferable than 3P&T-buttons in the front. UI must be verified with user!"* [d62].

This document is revised after a week [d63] and after two weeks [d72]. Besides the documents which state the items for investigation, also a presentation is made in August 2007 with the 'new' design proposal [d64]. This document presents the 'new' design and gives the impression that it is used to convince others of the 'new' design proposal. So, although the recent documents are all about the 'new' concept, no final decision on the design is made yet. One of the management documents shows a project overview [d65]. It mentions that for 'Nextbox' the launch date is achievable within the planning, however for the 'new' concept, Vase, it is still unsure whether the launch date can be matched with the original milestone planning. *"For Vase, we cannot match the milestone with proven planning: we need an extra month. We have no solution (yet?) to prevent that this will lead to a comparable delay. We strongly recommend preparing for this potential delay that result from the late arrival of this design direction."* [d65]. The issue list of August 2007 [d66] is an overview of different issues which needs to be checked. This document does not show a decision on the design proposals 'Globe', 'Vase' and 'Nextbox', neither on the outer form nor on the UI proposal. This is the last document in which the concepts 'Globe' and 'Nextbox' are mentioned.

In August 2007 the deadlines are set for product order and launch because *"the design models are ready for a consumer test in Paris, Stanley is positive"* [d67]. The last remark shows the close involvement of higher management within the project, as Stanley is not a team member but business unit manager. This document is a reflection document and not directly related to other documents in the timeline. The planning [d65] is updated at the end of August [d70]. In this plan is mentioned that the *"Face value test selects: Vase received positive, but we aren't yet at 'order' level."* Unfortunately, there are no documents available about these tests. Since the beginning of the project it was proven that a certain technological improvement would be possible but to get it to the right level had been quite a struggle. In [d70] was mentioned: *"Tentative requirement: xxx. World record!"* At this time also a lot of effort is made to get to the required technical level

WINNING DESIGN USER INTERFACE

The activities that followed showed the iterations until the final UI of the Vase concept, the stage of the winning design UI, see *Figure 4-13*. None of the documents stated the final choice in favour of the Vase concept, but the concept Nextbox is not stated anymore either. The following topics are discussed in the 'Vase investigation' [d72]: *"Construction, Build-up shade, Gradient, User interface, function 4, Led display, Venting, Other issues"*. For the housing shell are three proposals for production: *"blow moulding, injection moulding front back, injection moulding top button"*. These are the same proposals as in [d51] within the 'Vase investigation' the decision for injection moulding front and back is made. Blow moulding is rejected because of a no-go for the display/UI: it would only be the lever and no buttons. Injection moulding top button is rejected because of a no-go on design: a parting line in the shell in the front of the product. Injection moulding front back is considered to be most feasible for a design as it includes three buttons and a lever on the side.

Besides the three proposals for production also three proposals for the UI are discussed in the 'Vase investigation' [d72], which match the proposals and conclusions in [d62], an earlier version of this document. The conclusion is that: *"1) All*

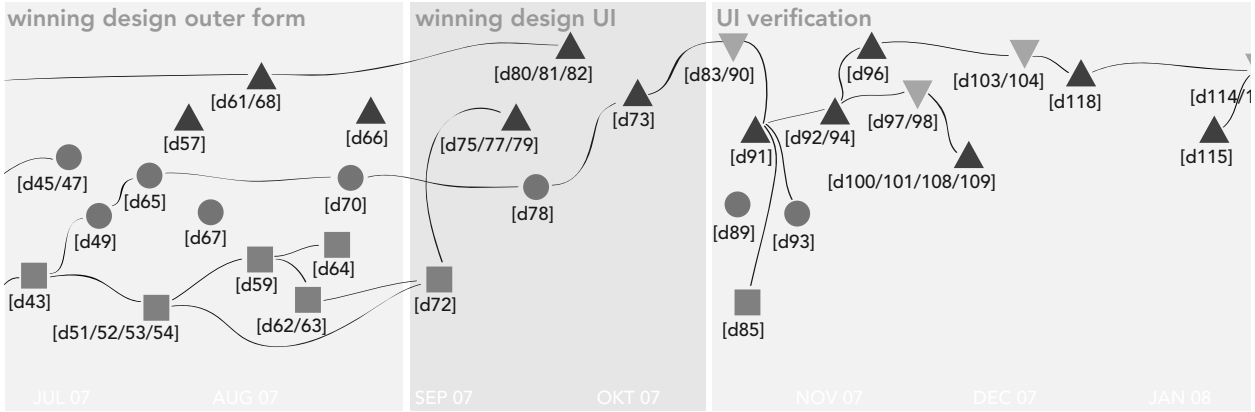


Figure 4-13: Timeline IIA – winning design user interface

functions fit in the User Interface, but options A, B and C are less preferable than 3 push and turn-buttons in the front. 2) UI must be verified with user!" [d72]. Within this document [d72] the position of the button for the snooze function is also discussed; on top, at the bottom (pushing whole object), a lever on the side. The decision is made to choose for integrating the function in the lever on the side. *"Choose for scenario 3 (1 push and turn + 3 push) and discuss ASAP with design and usability"*. This decision is also made because: *"push button on the side improves robustness and costs"*. For decisions based on this document see section 4.2.5. As a follow-up of [d72] two new UI variants are proposed in [d75] which both have the snooze function in the lever on the side. In these proposed variants is made use of rotary wheels to keep the same functionality of the turn and push buttons but result in different aesthetics. It is the first time that these rotary wheels are seen in a UI proposal. The proposed UI variants in [d75] are complemented by six UI concepts in [d77]:

- *"Concept A - 3 turn & push buttons*
- *Concept B - 3 rotary wheels & lever*
- *Concept C - 3 turn & push buttons & lever*
- *Concept D - 5 way navigator & lever*
- *Concept E - lever & rotary wheel & button*
- *Concept F - 5 way navigator & lever"*

A picture is shown of each concept, a simple state-event and the pros and cons. In the end concept B is chosen, a concept with a horizontally positioned display on the front. Three rotary push wheels are positioned on the right side underneath each other in vertical direction. Under these wheel a lever is positioned that can be pushed up and down.

- *"For usability reasons: - minimum operations*
- *For engineering reasons: - PCB one direction - Standard buttons.*

- *For design reasons: - 3 scroll buttons less visible - 3 buttons the same."* [d77]

This document is updated after one week [d79], and document [d70] was updated to [d78]. All these design iterations come together in the project update [d73], bringing together several decisions, see also section 4.2.5. It shows an overview of the six UI concepts and their positive and negative aspects. The 'official' state-event description [d61, 68] of this UI is at the beginning of August 2007. The documents were adjusted in September [d81] and October [d82] with as input document 80 [d80]. However, the confusing part of these documents is that they are state event and display solutions for a UI with 3 push and turn buttons under the display, while all previous documents (also from this author) are about a new UI for the Vase with buttons on the side. It is assumed that the concepts are developed in parallel until here.

USER INTERFACE VERIFICATION

The previous sections described an intensive search for the winning design concept, both for the outer form as for the UI design. For the outer form the concept 'Vase' is finally chosen [d51] with the UI concept B [d73, d79] an interface with three rotary wheels, a lever on the side of the object and the display on the front. In this stage we describe the verification of the winning designs, *Figure 4-14*. This UI proposal is tested in October 2007 on: *"How good is the user interface and what are the improvement points?"* [d83]. The test is performed by an external company testing the UI via a Flash simulation and an inoperative physical model. In document 90 the results of the UI test [d83] are reported. The scoring of the UI is below target, 88% of the respondents accepted the UI instead of the aimed for 95%. Within the report several actions are mentioned to improve the UI. Relocate settings to the 'set' button, which *"requires more actions, but will be more simple!!!!"* [d90] and add

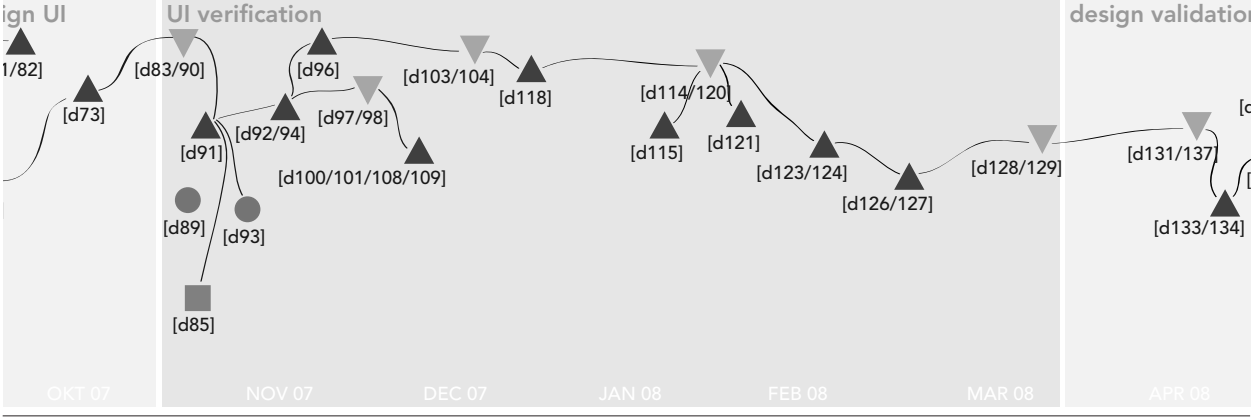


Figure 4-14: Timeline IIA – user interface verification

text to one of the buttons. Other remarks are: *"The device is not stable while pushing the wheels"*, *"Lever too loose and feels cheap, children and pets can easily adjust it"* and *"Pushing & turning wheels together is a risk, but wheels also need more resistance and pushing needs less resistance."* [d90] Actions and improvements are suggested for all the remarks. At the end 'other ergonomic topics after the test are stated: *"Push & turn wheels need to be optimized. Last design proposal is not user friendly enough; it levers out less, so people can not push good, there is no grip, the rims are to round and don't function as a stop."* [d90]. Based on the UI test [d83, d90] a document [d91] is made by Emma at location A about how to address all the issues at the moment of product order. Within all the documents are only a few project meeting minutes. One of these documents [d85] sums up a list of issues and decisions about the actions that need to be taken.

Text and symbols support the buttons in relation to the UI design. In document 92 three proposals are made for the text and symbols. This document [d92] results from one of the results of the UI test: *"MHz symbol next to set button -> test"* [d90, 91]. The UI optimisation from a technical perspective is presented in [d94]; where to place the text and symbols and how much space is needed around the buttons to be able to operate the rotary wheels.

After a hectic period of finding the winning design for both the outer form and the UI, a reflection is made. This document [d89], called 'Technical and Managerial Learnings', and an overview is made in it of the learned aspects in this project so far. This is a reflection document, therefore on its own in the timeline. For each issue is a five times why mentioned. At the end of October, a large presentation is held [d93] to propose the passing of two milestones. This meeting was the Go / No-Go meeting for the next phase. In the presentation all running issues are discussed and a green, yellow or red flag is decided on. A red flag would mean a No-Go, only green and yellow flags were assigned to the issues. The key messages in this presentation on usability are: *"UI confirmed. Planned optimization to 95% positive score (from 87 % now) and improved handability at next milestone."* And *"Timing and resources till next milestones still very critical due to number of risks and lack of time-buffer."* [d93]. This presentation has an additional slide at the end with the minutes, decisions, and actions of project order meeting: *"Put traffic light status of Drop Test and usability in presentation at yellow. Manage Green flagship status. Make clear statement available at next milestone."* [d93]

Document [d96] is a revision of [d91], the usability issues at product order. Most of the issues are still the same but in the design, changes are made to improve turning the wheels [d94]. Based on the issues mentioned in [d96] and the improvements of the design [d94] a third UI test [d97] during the project is performed, the second in autumn 2007. During this test the UI is adjusted after testing with several users to optimise the UI. *"The primary goal is to optimize the user interface and not to check the status!"* After the test of 16 users, the result of the test was an optimised UI [d98]. As the test was performed with 'boundary users' (the most inexperienced users) it was assumed that when they can use the product, everyone can use the product. The test was performed at location A by Emma in face-to-face observations. In the test the users made use of a Flash model and were shown a foam model to get the impression of the size and shape of the product. About the

settings of function 1 and 2 is mentioned: *"it is something they do correctly in the end, but they have to get used to it."* [d98]. It is suggested that the "*total score of user-friendliness for the whole test group with boundary users is acceptable and is a 4. After first time use it definitely has the possibility to score a 5*." [d98].

The outcomes of the third UI test [d98] result in an update of the products state-event [d100] and an update of the 'official' document [d101] which describes the complete UI of the product. The separate state-event document [d100] is integrated from now on in the 'official' document [d101] which had several updates in one week [d108, d109]. A decision based on these documents is described in section 4.2.5.

Besides an optimisation of the UI an optimisation for the physical use of the UI is also needed. In [d96] was mentioned that *"… wheels also need more resistance and pushing needs less resistance-> find optimum"* [d96]. The test protocol as described in [d103] is to find *"the optimal force to adjust the push/rotary buttons and the lever"* [d103]. The results [d104] were based on a test executed with a mechanical model that only tested the forces of the buttons. No visualisation of the object is shown. After testing with 19 participants the ideal forces were defined. A remark is made in the conclusions: *"People like to see where the buttons are before they push."* [d104], and recommendations are made for the next tests including: *"Test with real weight"* and *"Make a model with housing, so user can touch the buttons like in real life."* [d104]. Following the test an update is made of the UI [d118].

To keep the team up to date about all the usability issues another document [d115] is made by Emma to list the points needing attention and the milestone consolidation. This document is made after the forth UI test in November 2007 [d103, d104] and before the fifth test in January 2008 [d114, d120] mentioning all the issues and attention points which relate to using the product. An update [d118] of the UI design was input for the fifth UI test. The protocol [d114] for this test was written in December 2007, the test results [d120] were presented in January 2008. The forth UI test with the mechanical model [d103, d104] set the optimal forces of the buttons but a list of actions is mentioned to test again after an update of the 'official' UI document with the state event [d109]. In the fifth test is investigated whether; *"the press forces and the rotate forces on buttons with grips are acceptable by the users. What do people think/do when they put function 1 on? And what do people think of the display feedback?"* [d114]. The results of the fifth test [d120] are based on a test executed by Emma at location A with 24 participants. The prototype used in this test was a model of the outer form with a display taped to the front and an attached weight to simulate the real weight of the object. There was no manual available for the participants or explanation about the product. As it was still a prototype, no text was printed next to the buttons. The results were reported in question and answer, for example:

- *"What do people think of the pushing force of all 3 buttons? Do they feel any force differences? If so, what are they?*
  - 37.5 % feel a force difference, but can't say specifically what the difference is, at least not in correspondence with measuring instrument results.
- *Which direction of number change do people prefer when rotating? E.g. clockwise rotation leads to number decrease or increase?*
  - This question doesn't lead to a clear answer, 54,2%

prefer the way the prototype works now (clockwise means decrease in number), the rest prefer the other way round, but it would be in contrast with turning the volume up and down. Therefore the rotation remains the same." [d120]

At the end of the conclusion some extra remarks were made:

- *"People can't understand the meaning of all the menu icons.*
- *People get confused by the menu's structure, it's easy for them to fell into the loop of the menus and get into trouble.*
- *When function 1 is on and people want to turn it off by pushing the top button, they sometimes unintentionally push the middle button. Now function 1 can't be turned off because the middle button activates the menu and disables the top button which controls function 1. As a result, people have to wait until the menu goes back to idle status after a few seconds but they usually keep on trying and pushing the buttons, and then get stuck in the menu.*
- *When people enter the menu by pushing middle button once, they don't know they need to push it once more to enter the submenu, and they don't know they can switch to a different submenu by rotating the button. To summarize; they can't tell when to push or rotate the button to reach their expectations."* [d120]

The conclusions are addressed by a list of actions at the end of the report, to adjust on the product or the manual.

At the end of January a document [d121] produced by Emma updates about the running UI issues. After the fifth test [d114, d120] the UI description is updated to version 4.0 [d123] and updated again after a check between the software and UI description [d124]. The focus of the fourth and fifth UI tests was mainly on the physical interaction with the product, in the forces of the buttons. It was not the goal to judge the cognitive interaction of the UI but after the tests a proposal for changes was made by Emma. Three variants were proposed where all three had all the settings of the alarm under the lever and not divided under the rotary wheels anymore [d126]. It was assumed that having the settings on one button would be *"less confusing"* [d126]. Based on this proposal the description and state-event of the UI needed to be changed as well, resulting in version 5 [d127]. The Flash simulation for the sixth UI test was based on version five. The protocol of the sixth UI test is described in [d128] in which the concept (demo B) with all alarm functions under the lever is compared with the previous concept, demo A. The objective of UI test number six is to *"test the new UI proposal against the current."* The participants in the test are woman and men between 25 and 55 years old and capable of working on the computer with a mouse. Users with a technical background or high education are excluded. Two computer simulations were tested with 18 respondents. The results of the sixth UI test are presented in [d129]. It was concluded that there is no significant preference for the concepts with all alarm functions under the lever. Therefore, it was decided to retain the previous UI. *"From the test it became clear that the respondents prefer the alarm functions under SET instead of under the lever. It does not seem logical to switch between the lever and the SET button. There are a lot of functions under the SET button, but at least it is clear where to look."* [d129]. In general the respondents say that both demos are easy to use after trying a couple of times. Using and adjusting the main functions is clear, except for adjusting the radio station, and also some of the alarm settings (alarm sound, alarm volume) are difficult to adjust. *"Using and adjusting the settings of the alarm is a lot more difficult. The main issue with this is that they do not have enough time to look and press the right button under SET (5 second period)."* [d129].

Since October 2007 the focus has been on verifying the UI design, a display in front and three rotary wheels and a lever on the side of the product. In the period of six months five UI tests were executed as iterations to improve the UI design.

DESIGN VALIDATION

In the last stage is the design validated with its user group, see *Figure 4-15*. The previous tests [d83, d90, d97, d98, d103, d104, d114, d125, d128, d129] were conducted to verify and optimise the UI on all aspects; interaction, button forces, symbols, display, menu structure, etc. All these tests were done with Flash computer models, foam models and mechanical models, in-house at location A. The tests described in this stage are done to verify and validate the complete product. These tests are done with First Out of Tools (FOT), almost finished products. With these items only small changes in the hardware are possible, the software allows larger last-minute adjustments.

The objective described in the protocol of the Large Test (LT) [d131] is to test the complete product for a longer period of time at home to simulate the real life situation as much as possible. Users are not observed and the findings and conclusions of the tests are therefore based on the questionnaires before and after three weeks of use. The objective of the Large Test is:

- *"To measure overall satisfaction of the product*
  Qualitative statements
  Likes and dislikes of the product
- *To get feedback on overall satisfaction compared to other products*
  After 3 weeks: would you go back to your old product?
- *To get feedback on overall effectiveness of the product.*
- *To get feedback on friendliness of the user interface.*
- *Identify and exclude potential technical failures of software and hardware"*[d131]

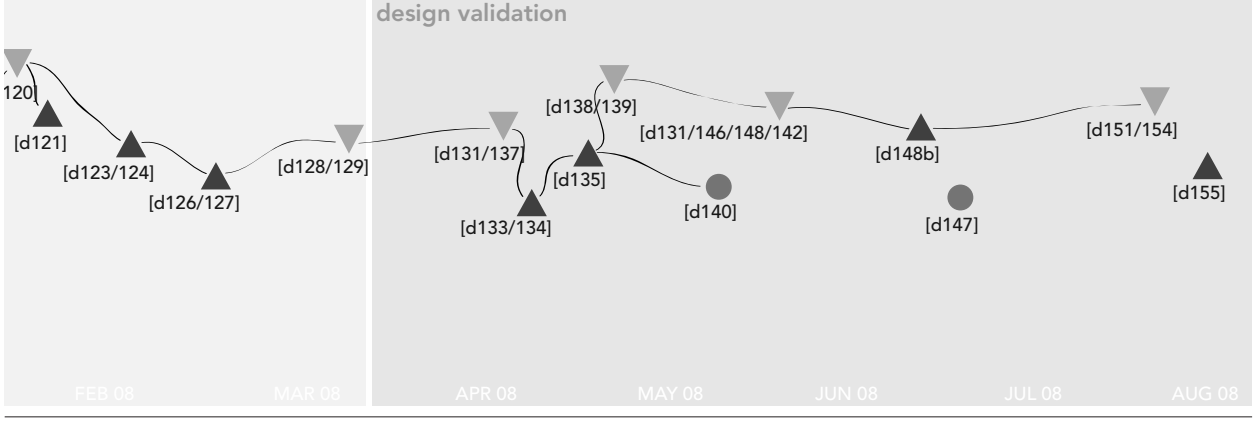


Figure 4-15: Timeline IIA – design validation

The first Test (LT1) [d137] is executed with 10 participants as a pilot for the Large Test to *"get some initial responses to the usability of Bear, find software bugs and prepare for the Large Test. Test the questionnaire and find out whether gained data is usable."* The pilot was a simplification of the described Test in the protocol [d131] as the item was only used for one week. The execution and analysis were done within the company and the report was made by a new colleague of Emma's. LT1 was not executed by an external company as would be the case for the following Large Tests. The results of this first Test [d137] were *"below target". "Especially for first time use, usability was not good enough."* [d137]. Also the questions were not all understood, so: *"We changed unclear questions and asked more open questions to gain more information from the respondents in the Large Test."* [d137]. And *"as a result of this Large Test we decided to make changes to the User Interface to simplify the usability."* [d137]. These simplifications are formulated in actions, for example:

- *"Make UI more intuitive for first time use. Contents of menu (SET) should be clear. (team)*
- *Simplify DFU and QSG Make sure push and turn of selection wheels is clear. (Emma)*
- *Finding radio frequency is hard. -> Not possible to change! Make very clear that this setting is under middle selection wheel in manual. (Emma)*
- *From any place in menu there is a return time of 5 seconds. This is too short, certainly for settings of function 2 -> already changed.*
- *Middle selection wheel is often confused with lower selection wheel. Because middle selection wheel contains most functionality it should be clearly defined. -> make tactile feedback at middle selection wheel, define which size/material. (Emma/Craig)*
- *Respondents think it is a good thing that the product has a special component, but do not like the fact that it cannot be replaced. -> use FAQ's to explain,*
- *Bigger symbols on the side of the appliance with more contrast are needed. Change -> (Daniel)" [d137]*

At the same time that the pilot was conducted, an expert opinion [d133, d134] on the UI is made by the UI expert from location B, Oliver, resulting in another decision on 'returning time as described in section 4.2.5. The expert made a visualisation of how the flow of the menu should be [d134]. The largest change within the menu was to remove two settings of the alarm function. The suggested changes are made in the 'official' UI document, resulting in version 6.0 [d135]. Besides the changes in functionality also the return to main menu when no input is changed to 3 seconds. *"After completion of a menu item, return to menu level, not to top idle level. Return to idle after 3 seconds no action. (avoid having to travel all the way to a setting several times to complete a normal workflow)"* [d135]. The document also contains a list with bugs which should be solved in the next UI prototype. The sixth version of the UI is used in the test of April 2008. The first version of the protocol for this interim test is made in March but revised of April [d138] just before the start of the test. The results are documented in [d139]. The test is done to: *"Measure overall satisfaction of the product with statements"* [d138]. A first out of tools prototype and a Flash demo on the PC are used during the test. The test is executed by an external company at location B with 24 participants [d139]. The assignments and questionnaires are done three times to measure the satisfaction after first time use and after several times. The overall target

of the test is: *"that the average of the six statements is 80% or above (Top 2) (Scale 1-5) and the friendliness of the user interface on main functions should be at least 95% 3, 4, 5."* The results of the test are below target as the *"statements are not meeting the norm"* [d139]

On the occasion of the pilot (LT1) [d131, d137], the expert opinion review [d133, d134] and the satisfaction test [d138, d139] a project update is made [d140] in May 2008. Based on this project update it is decided to pass one of the last milestones.

The Large Test (LT2) is conducted in May 2008. The protocol [d131] was the same as used for the pilot (LT1). The Large Test was executed by an external company with an initial questionnaire before using the product and a second questionnaire after three weeks use. The results of this Large Test are presented in an 'executive summary' [d146], overviews of all the (technical) problems are mentioned in a separate excel document [d148], and a simple overview in a Word document [d142]. These overviews were meant to report all the software problems, but users also mentioned usability problems. So again the results were disappointing *"the action standard was partly achieved:"* [d146]. It was recommended to *"consider launch, but improvements should be made"* [d146]. In the executive summary were also user quotes which suggest usability issues with the product [d146]:

- *"product is not intuitive in use, manual is required and there are 'mistakes'."*
- *"pressing on the wheels is very new and confusing"*
- *"setting or difficult / impossible"*

The department of location A made another document with attention points for the milestone meeting [148b] including the results of the Large Test: *"Results disappointing due to a lot of bugs"* and *"Results not usable for performance and usability"* [148b].

The third overall test (LT3), after the pilot (LT1) [d131, 137] and the Large Test (LT2), [d131, d146] is executed to measure the performance of the product compared to its predecessor and the overall satisfaction [d151]. The test is not executed to find any usability problems or issues for improvement. The goal of the third Test was to:

- *"Measure satisfaction score of Ant and Bear*
- *To measure overall satisfaction of the product -> Bear should score better than Ant*
- *To get feedback on overall satisfaction compared to current products*
- *To get feedback on overall effectiveness of functionality compared to current products*
- *To get feedback on friendliness of the user interface compared to Ant*
- *Identify and exclude potential technical failures of software and hardware"*

The findings of the test are based on a questionnaire before use and a questionnaire after two weeks of use. Most of the questions were closed questions and there were some open questions asking for an explanation. The only available results of this third test (LT3) were an overview of the quantitative results [d154]. There is no summary or conclusions in this document, empty slides suggest that more information needed to be added. The general conclusions are that the successor is an improvement of the predecessor.

The document [d147] 'learning list' is an overview of the internal discoveries per category; electronic, mechanical, usability, managerial, etc. being on its own on the timeline. The conclusions mentioned in a usability department document [d155] are more product specific and reveal also some of the usability issues in the final product.

- *"Pushing and turning with one button is often not understood, especially by elderly people.*
- *When user pushes on button, the button also turns and thus changes settings.*
- *Alarm is confusing: one button "setting 1" and "setting 2", and then another one "setting 3". These buttons are often confused while operating.*
- *Users often expect the snooze button at another location*
- *The current lever looks fragile*
- *When settings for the alarm are set it should be able to re-use these settings the next time.*
- *Often user uses the third button by accident while they want to use the second (from above)"* [d155]

This detailed description is the real life story of project Bear based on documents. It provided a clear overview of the project, in words and in a visualisation; the timeline. Processing the data on this detailed level is the basis for the data analysis. The first step of analysing the data is highlighting the key decisions of the project. ◆

4.2.5 RESULTS - HIGHLIGHTED DECISIONS

In this section some of the decisions in this project were highlighted. Only the decisions that in the end resulted in unforeseen usability issues were stated. These unforeseen usability issues were identified in section 3.3.4.1 and repeated in *Table 4-1*. Highlighting the decisions related to unforeseen usability issues provided a focus on certain stages in the process. In this section these stages are analysed. The timeline that was introduced in section 4.2.4 was used again in this section to add the identified decisions with purple rectangles. The timeline IIB (*Figure 4-16, page 134*) directs us once more through the project providing guidance and overview.

START DESIGN

The first decisions are found in the first stage; 'start design'. After some technical (green squares) and design (orange squares) explorations it was decided to develop this product, starting with improving the UI. The challenge was to improve the UI while retaining all the features of its predecessor. The design of the UI [d7] defined how all the functions could be assigned to the buttons, three large buttons and one small button. The three large buttons are placed under the display, the small button above the display. This user interface design could be applied to every outer form design. At this moment three decisions are made about the UI A) a limited number of four buttons, B) no return button and C) to wait 3 seconds before returning to the main menu. Although decisions are made to select a design and to assign functions to buttons no final decision about the solutions are made yet. They are ideas, concepts about how the solution could look and how these solutions perform during tests.

DESIGN VERIFICATION

After the 'start design' stage several solutions for the outer form were suggested and also a solution for the user interface. The second stage in the project; 'design verification' was to judge the several solutions. Two of the usability activities were studies related to the UI, a study of which functionality of the previous product was appreciated [d12/13] and a usability test of the user interface [d8/15]. The first study resulted in the conclusion that all functions of the previous product were appreciated and therefore it was decided D) to keep all the functions. The study of the user interface resulted in recommendations to adjust the user interface so further adjustments to the state event of the user interface were made. The lower three triangles are three tests [d10/11/17] of the appreciation of the outer form design. The results of the tests are input for the next stage 'design search'.

DESIGN SEARCH

This stage of searching for the right design was a close interaction between product usability, how to improve this and design, finding the right solution. In between was management to guide and direct the solutions. Meanwhile they had to cope with all the changes due to organisational changes, like changing team members and project goals. Although many design solutions were presented in this stage no decisions related to unforeseen issues were made.

WINNING DESIGN OUTER FORM

In this stage four important decisions were made. The design search in the previous stage did not result in a final design. There was a decision E) to ask a different designer to make a concept proposal. This proposal [d43] was so much appreciated, not

Project ‘Bear’

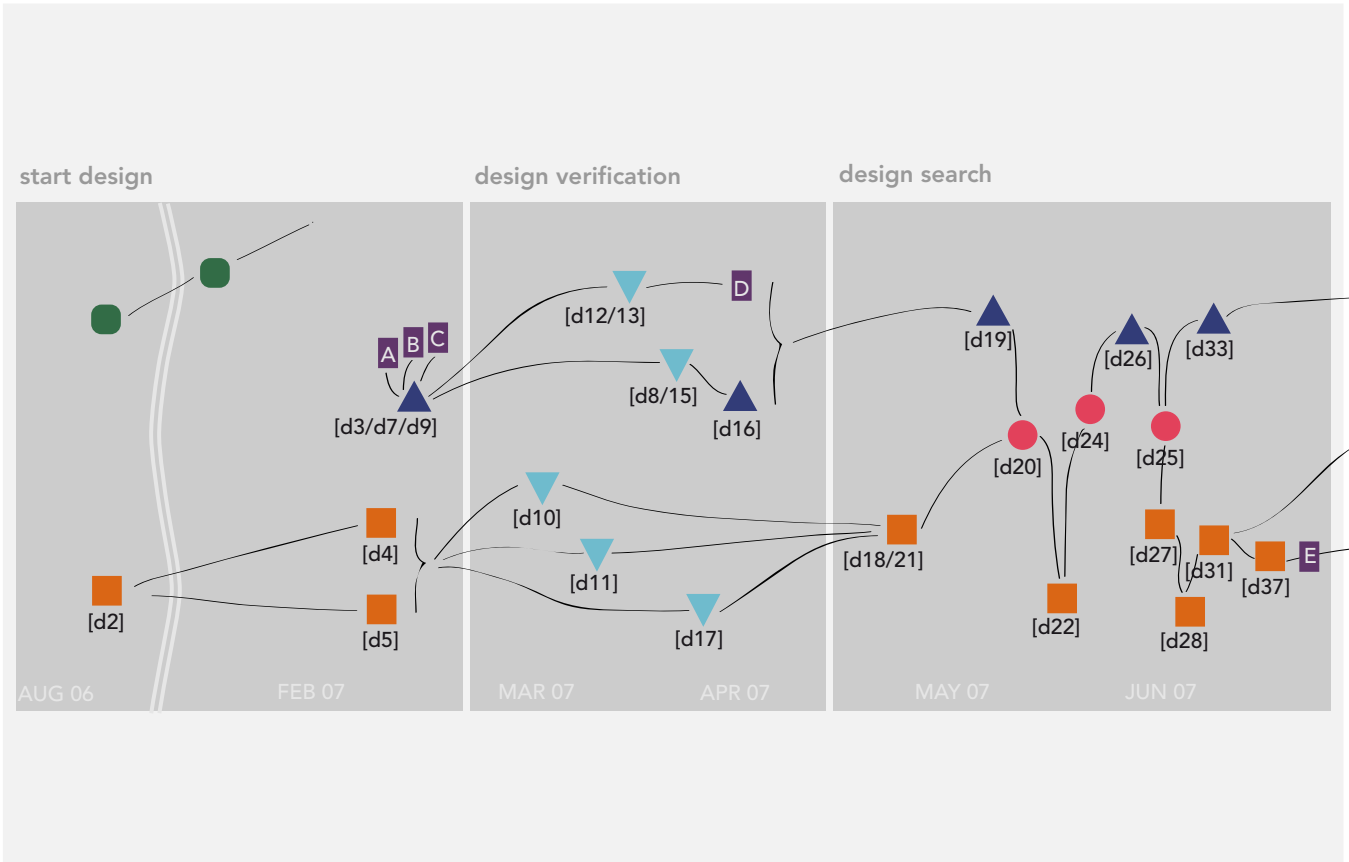
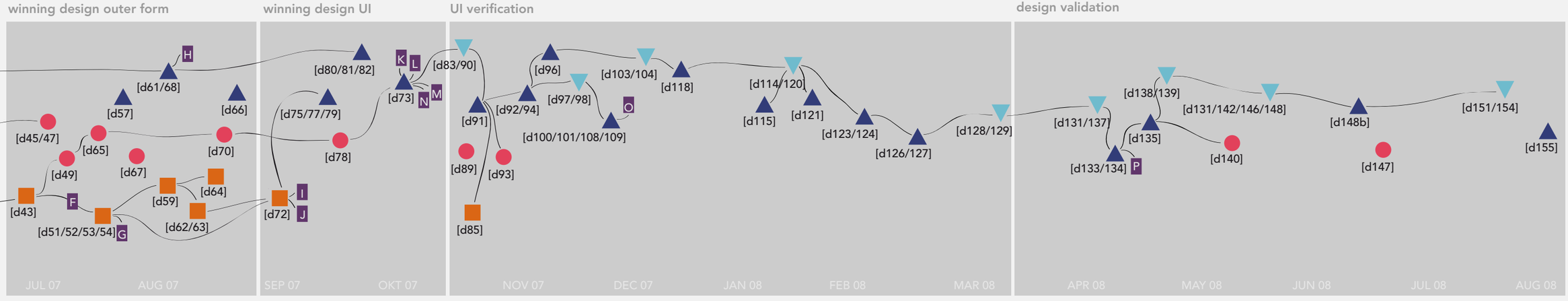


Figure 4-16: Timeline IIB, a timeline of the key documents and decisions


winning design outer form
winning design UI
UI verification
design validation
[d61/68]
H
[d57]
[d66]
[d45/47]
[d65]
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[d43]
F
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[d64]
[d51/52/53/54]
G
[d62/63]
[d80/81/82]
K
L
[d83/90]
[d73]
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DEC 07
JAN 08
FEB 08
MAR 08
APR 08
MAY 08
JUN 08
JUL 08
AUG 08
legend documents:
engineering
design
test
usability
management

ISSUE	DESCRIPTION
A1	the user does not understand how to return to the main menu
E1	the user does not know how to operate the buttons
E2	the user does not know which button is for which function
F1	the user does not know how to operate the radio
F2	the user is confused which buttons to use for operating the radio
G1	it is difficult for the user to confirm settings
L1	the user is not sure whether the setting is turned off

Table 4-1: Overview of unforeseen usability issues

only by the team but also by (higher) management that is was decided F) to develop this concept including the user interface. Choosing this design solution included the decision in favour of buttons on the side of the product and a display on the front, so G) separating buttons and display. Further development and specification of this concept resulted in various solutions for operating the buttons on the side [d51/52/53/54]. One of the remarks on the concepts was: *"Conclusion: using the same control for all three functions makes product look simple, but makes interaction complex."* [d52]. Before the final decision could be made for using this 'new' outer form a few things needed to be investigated: manufacturing of the housing, three buttons on the side, and functionality of lever on the side [d62]. Investigating the user interface solutions triggered the remark that separating the display and buttons would have consequences: *"Usability will score lower than three push and turn buttons in the front"* [d62]. The 'old' design was up-dated with the decision H) to have to wait five seconds [d68] before returning to the main display. At the start of the design this was only three seconds [d3].

WINNING DESIGN UI

In this stage several critical decisions were made. First a decision about the manufacturing of the housing sheel; blow moulding would not be possible for the assembly of the display and buttons. Injection moulding could be done with a parting line shell between top and bottom or front and back. The parting line between top and bottom would be more obvious and therefore it was decided to I) place the parting line between front and back [d72]. Consequently, it would be cheaper to place the buttons on the side of the product in the parting line. Next to the buttons on the side it was also decided to J) add a lever for a specific function (function 4) [d72]. Regarding the various solutions for the user interface it is noted that: *"UI must be verified with user!"* [d72]. The various solutions are contributed to the usability specialist with more concepts for operating the product with buttons on the side. The preferred solution that was selected was a user interface with the display in front and buttons on the right side, consisting of three rotary-push wheels and a lever. This solution matches best all the different discipline requirements

and wishes. Again the remark was made: *"Test UI on side"*. The final decisions on the user interface were presented as an update [d73]. This document shows the choice for the concept with the rotary wheels. Choosing this concept includes several decisions: K) separating display and buttons, L) locating buttons on the side, L) locating buttons on the right side, M) using three rotary-push wheels, M) using three of the same rotary-push wheels, and N) using a lever next to the three buttons [d73]. Updating several documents [d80/81/82] was the last activity on the 'old' design. Some of the information in these documents was used for the 'new' design.

UI VERIFICATION

The previous two stages resulted in the final design of the product. This final design is tested for the first time in the stage 'UI verification'. Several tests are executed to fine-tune the user interface. One of the decisions in response to the tests was to O) change the waiting time to return to the main menu from five to eight seconds.

DESIGN VALIDATION

In this last stage before product launch the design was validated with extensive tests including testing the product at users' homes. The first test results were a reason to make some thorough changes in the user interface including removing a certain functionality to simplify it. An aspect that was changed several times during the project was changed again; the time of inactivity before returning to the main menu was changed to P) 3 seconds.

All the important decisions are summarised in *Table 4-2*. These decisions are input for further analysis to the sources of the unforeseen usability issues. ◆

DECISION	DESCRIPTION
A	a limited number of four buttons
B	no return button
C	to wait 3 seconds before returning to the main menu
D	to keep all the functions
E	ask a different designer to make a concept proposal
F	to develop this 'new' concept including the user interface
G	buttons on the side of the product and a display on the front, separating buttons and display
H	to have to wait 5 seconds before returning to the main display
I	place the parting line between front and back
J	add a lever for a specific function
K	separate display and buttons
L	locate buttons on the (right) side
M	use three (identical) rotary-push wheels
N	use a lever next to the three buttons
O	change the waiting time to return to the main menu from 5 to 8 seconds
P	the time of inactivity before returning to the main menu was changed to 3 seconds

Table 4-2: overview critical decisions

4.2.6 RESULTS - SOURCE UNFORESEEN USABILITY ISSUES

In the previous section the decisions that resulted in unforeseen usability issues were highlighted based on the detailed project description of section 4.2.4. In this section the various decisions were related to the usability issues to explicitly show the sources of the usability issues. In Study 2 this was done based on interviews. For this Study 3 the data from the project documents was analysed, which provided a more detailed insight. Again, focus was only on the unforeseen usability issues, see *Table 4-1*.

A - MAIN MENU

One of the issues that lead to a lot of difficulties for the user is A1) 'return to the main menu'. The users did not understand how to return to the main menu because there was no separate button or information about it. Although it is not uncommon to have an automatic 'return', it was not what the users expected. The users want to do an action to return to the home menu. The decision that caused this issue is the decision B) not to have a separate 'return' button. Indirectly this decision relates to the decisions of D) having a large number of functions and A) only a limited number of buttons. These decisions resulted in the decision of J) using a lever for the snooze, M) using three (identical) rotary-push wheels, and N) using a lever next to the three buttons. Another result from the decisions was the timing of returning to the main menu. Four decisions related to timing are identified: C) to wait 3 seconds before returning to the main menu, H) to have to wait 5 seconds before returning to the main display, O) change the waiting time to return to the main menu from 5 to 8 seconds, and P) change the time of inactivity before returning to the main menu to 3 seconds.

E –OPERATING

The first hurdle users have to cross when using this product is operating the buttons. The operation of the buttons can manifest itself to the users in different ways: E1) the user does not know how to operate the buttons and E2) the user does not know which button is for which function. Three buttons of the product are rotary wheels which can be turned and pushed, like a mouse wheel. That the wheels can be turned is clear for most users, that the wheels can be pushed is not always obvious to the user. Once you know that the wheels can be pushed the usability issue is 'solved'. The decisions to M) use rotary wheels which can be pushed are the 'source' of this usability issue. Indirectly this decision relates to the decisions to D) have a certain number of functions and A) a certain number of buttons. These decisions resulted in the decisions for J) using a lever, M) using three (identical) rotary-push wheels, and N) using a lever next to the three buttons.

In addition to that the user needs to know that he can push the buttons, he also needs to know which button relates to which function. The three rotary-push wheels are identical and almost no cues are provided about which function relates to which button. Next to the buttons are displayed the functions, but the feedback from operating the button is on the display on the front of the product. You have to remember which functionality relates to one of the three buttons. The decision to G/K) 'disconnect' the relationship of the buttons to the display is the 'source' of this usability issue. This decision can be traced to the decision; L) locating the buttons on the side,

this decision being a result of previous decisions; F) to develop this 'new' concept including the user interface and I) place the parting line between front and back. It could be suggested that decision E) ask a different designer to make a concept proposal, is the root of all these decisions. Also the use of three identical rotary-push buttons (M) complicates the distinction between functions and buttons as one has to remember which function relates to which button.

F – RADIO

Two issues that relate to the radio function are that F1) the user does not know how to operate the radio and F2) the user is confused which buttons to use for operating the radio. To operate the rotary-push wheels on the side you need to know that you can turn and push the buttons. Turning the buttons is clear for most users, that the wheels can be pushed like a mouse wheel is not obvious for most (mainly elderly) users. This issue is specific to the radio function of the product, but actually it is the same issue as mentioned at first: operating the buttons. So, the decision to M) use rotary wheels which can be pushed are also the 'source' of this usability issue. Indirectly this decision relates to the decisions to have D) a certain number of functionalities and A) a certain number of buttons that resulted in the decisions J) using a lever, M) using three (identical) rotary-push wheels, and N) using a lever next to the three buttons.

On the side of the product are three rotary wheels and one lever. To operate the radio two of the rotary wheels are necessary. As there is no distinction between the three buttons one has to remember which button is for which functionality, unless you turn the product to read the inscription next to the buttons and then return to the front for feedback on the display. This issue also relates to the earlier mentioned issue 'not knowing which button is for which function'. The decision G/K) to 'disconnect' the relation of the buttons with the display is the 'source' of this usability issue, as well as M) using three identical buttons.

G – CONFIRM

When the user knows that the rotary wheels can be pushed to confirm settings another issue encounters; G1) it is difficult for the user to push the button without turning and therefore changing the settings. This issue is experienced as: "it is difficult for the user to confirm settings". The usability issue is that the wheel turns easily when the user wants to press the rotary wheel, this makes it difficult for the user to actually push the button. But the other issue is that the settings can be changed when confirming, creating confusion. The decision that contributed to this issue is M) to use rotary-push wheels.

L – OFF

For setting the volume of the alarm the numbers 0 to 3 are shown in the display. 0 is off and 3 is the maximum volume. The indication 0 is confusing for the user, is it the minimum setting or is it off? This issue is experienced by users as: L1) the user is not sure if the function is turned off. This issue was discovered after product launch when users called to the service desk to inform if the level zero is the minimum level or if it was off. The 'source' of this issue is the decision to display 0 as feedback to the users. This decision cannot be found in the documentation as being discussed. So, it is not clear who made this decision and whether it was a conscious decision. ◆

4.2.7 RESULTS - NATURE OF UNAWARENESS

In the previous section the sources of the unforeseen usability issues were described, and how the decisions contributed to the usability issue. During the analysis process these descriptions were abstracted to examples of unawareness. These examples described unawareness in project Bear. So the data was not structured to the decision (as in 4.2.5) or to the source of the issues (as in), but it was structured to unawareness. These different examples were grouped into more general and abstract terms presenting the nature of unawareness by describing its types and sources. These types and sources of unawareness are introduced in this section and are illustrated by examples of unawareness from project Bear. The type of unawareness is what the decision maker is unaware of and the source of unawareness is what contributes to unawareness. The identified examples of unawareness that were used during the analysis process were not presented as this would give too much repetition of the data.

4.2.7.1 TYPES OF UNAWARENESS

Three types of unawareness were proposed based on the results of Study 3 (*Figure 4-17*):

- Unawareness about information
- Unawareness about consequences
- Unawareness about decisions

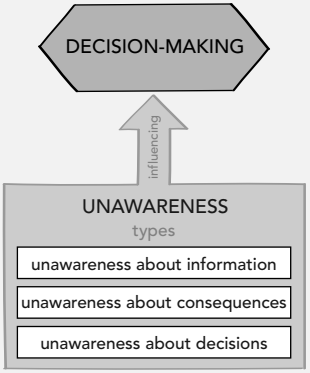

Figure 4-17: Types of unawareness

UNAWARENESS ABOUT INFORMATION

The first usability test was executed to judge a user interface with only four buttons and fourteen functions without a return button and three seconds waiting time before returning to the main menu. The research question for this test was: *"Is the user interface simple to use?"* [d8]. The results show that the first use of this UI is very complex; it has a steep learning curve. The conclusion suggests *"It is recommended to adjust the UI on the following aspects and to test again."* [d15] One of the suggestions was: *"More buttons, to have fewer functions with Set button?"* The end score of the participants on the UI was in the end a 3.8 out of 5, *"in general the interactions of the UI were easy"* [d15], although the participants needed a lot of time to create settings, especially the first time. The results of this test are twofold; on the one hand were the interactions with the UI

in general easy, however on the other hand it was suggested to make adjustments including additional buttons and to test the user interface again.

At the moment of testing they were aware of the risks and difficulties of a user interface with many functions and only four buttons, but the suggested adjustments were only partly made and not tested again. During further development the user interface retained its four buttons and functions as it tested as a good user interface. The radical changes to the user interface later on in the project (separating display and buttons) were not seen as an indicator to reconsider the tests results and the previously made remarks. After five months the user interface was tested for the second time. The UI still had four buttons and fourteen functions but with a completely different outer form, location of the buttons, and type of buttons. The remarks after the first test to adjust the UI and test again were not taken into account.

This is an example of unawareness about information. The test results were only partly taken into account. Only the aspect *"in general the interactions of the UI were easy"* [d15] was taken into account. The first test showed that four buttons could work, but that adjustments were necessary and a subsequent test was needed. The adjustments were not made and tested, while the UI kept its four buttons because of the generally easy interaction. The team were not aware that they 'lost' some of the information from the test results. Another issue of which they were unaware is that the information of the first test is not applicable for the 'new' UI. They did not realise that the test results of the first UI are not applicable for the 'new' UI with its separated display and buttons and different type of buttons.

UNAWARENESS ABOUT CONSEQUENCES

Unawareness about the consequences occurred several times during the project. It is about not foreseeing the consequences of a decision, or the severity of consequences. For example, in project Bear was already decided in an early stage of the project that the product should have the limited number of four buttons and all the functions of its predecessor. The successor should be better looking and easier to use but also keeping the same functionality. A user interface with four buttons could work as confirmed with the first UI test, so it should be only four buttons, looking simple. The presence of the product would even be friendlier and looking more simple when locating the buttons on the side. This resulted in three rotary wheels and a lever on the side of the final product. However these multifunctional buttons proved to be difficult to operate. At the time deciding for these wheels it was realised that it could be difficult to operate, but the gravity of the consequences were underestimated. And at the moment of deciding for four buttons it was not foreseen at all by the team that this decision would result in usability issues. At the start of the project it was not foreseen whether 4 buttons could cover all the needed functionality within the new concept. Nor was foreseen how 4 buttons would function in the total product design. The complexity of multifunctional buttons for the average user was not foreseen either.

UNAWARENESS ABOUT DECISIONS

Unawareness about a decision occurs when it is an implicit decision, a decision which is not seen or interpreted as a decision. In the beginning of this project a user interface was designed to test whether a design with only four buttons would work. Within this concept was decided to have four

buttons, fourteen functions, no return button and waiting three seconds before returning to the main menu. In the final product there are still four buttons, twelve functions, no return button and a three-second wait before returning to the main menu. So, although it was only a first concept proposal many of the decisions in this solution are kept and not reconsidered. None of the documents show the solution of adding a return button although they did struggle with the amount of time returning to the main menu. The decision of keeping all the functions of its predecessor is only adjusted at the very end of the project. Two functions were removed because it made the user interface too complicated weighed against to the advantage of keeping the functions.

The 'new' concept designed by designer Craig showed an object with a hidden display on the front and buttons on the right side. Although the focus of the concept was on the outer form, the final design shows an object with a display separated from the buttons and buttons on the right side. These examples show unawareness about decisions. Proposals in a design were included when choosing the design and not seen as separate decisions.

Based on the results of Study 3 three types of unawareness were proposed, illustrated in *Figure 4-17*. The decision-maker can be unaware of information that is missing or incorrect, can be unaware of the consequences of a decision, or can be unaware of a decision that was not explicitly made. The types of unawareness explain what decision-makers can be unaware of, but do not explain why this unawareness occurs, therefore the different sources of unawareness were identified as well.

4.2.7.2 SOURCES OF UNAWARENESS

Three sources were proposed based on the results of Study 3 (Figure 4-18):

- Unawareness due to inadequate consideration
- Unawareness due to inadequate overview
- Unawareness due to fixation

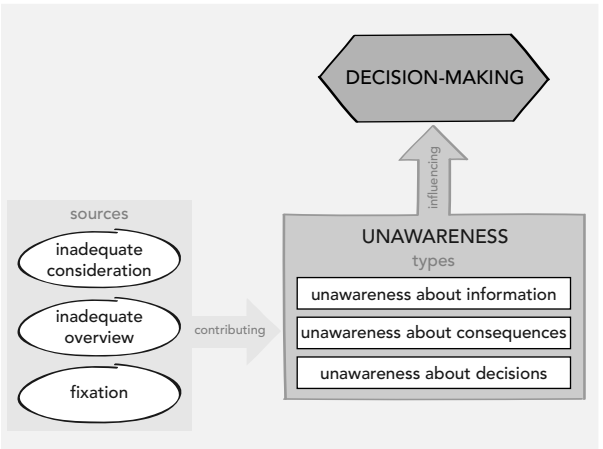

Figure 4-18: Sources of unawareness

UNAWARENESS DUE TO INADEQUATE CONSIDERATION

The first source that contributes to unawareness during usability related decision-making in design practice was inadequate consideration. This source can be explained as disregard for usability. When usability is not on the agenda at the moment of decision-making the usability expert will not be heard. During

project Bear it was decided to use the 'new' design, a design with a separated display and buttons as the buttons were located on the side and the display on the front. Within a few weeks several solutions for the buttons were investigated to check the feasibility of the (UI) design. Various solutions for the number, shape and location of the buttons on the side were presented. In the presentation that was made with each proposal the same remark was made: *"All functions fit in the User Interface, but options A,B and C are less preferable than 3 push & turn-buttons in the front."* and that the *"UI must be verified with user!"*. In the conclusions is mentioned again that *"Buttons on side is feasible (less preferable, usability will score less)"* [d72].

In this same document the decision is made to manufacture the object with a front and back part by injection moulding. This decision is made based on the following aspects: design, costs, moulding, assembly and shade. The aspect usability was not taken into account when choosing the front-back parts. Using front-back parts implies that buttons will be placed on the parting line on the side for reasons of assembly and costs.

Three solutions are presented for the snooze function, placing it on top of the object, on the bottom or on the side. It was decided to locate the function on the side including the remark: *"Choose for scenario 3 and discuss ASAP with design and usability."*[d72]. This remark indicates that the decision was made without intensively involving the responsible team members of design and usability.

The various examples showed unawareness due to inadequate consideration. Decisions were made three times in favour of the 'new' design and disregard usability several times. Apparently usability was not 'on the agenda' when making these decisions.

An explanation for the inadequate consideration of usability could be the unbalanced dialogue between the disciplines. The consequences for usability were only limited considered, although they were clearly stated in the document. The priority of aesthetic design -it had to be a design icon- resulted in a limited attention to usability. This unbalance in the dialogue also occurred due to the interference of higher management. It took away the power of the team and thereby disturbed the project dialogue. As mentioned by one of the respondents in the interviews: *"That takes away a lot of power from the team when the highest manager from the company defines what needs to be done, ….. Who are we to say something about it?"*.

UNAWARENESS DUE TO INADEQUATE OVERVIEW

The second source that contributes to unawareness was an inadequate overview. An inadequate overview means that the team members do not exactly know what is going on. With a complete overview the team member knows the important elements of the project and the relationship between the different elements. The starting points of a project and the chain of decisions are known, including the assumptions that are made. In large projects it is not possible that this overview is kept by one person, but the core project team should have the overview together. In this project the inadequate overview occurred due to changes in the formation of the team and redefinition of the project goals. Three months after the first UI test organisational changes confronted the team, resulting in an almost completely new team. The new project leader made some changes to the project. He re-named the project and he also re-defined the goals of the project; the product should not only be easy to use and better looking than its predecessor, it should become a design icon. These changes

suggest a new start, but that was not the case, the project with all its previous decisions and solutions just went on. The new team members did not know the starting points of the project and the motivation and implication for previous decisions and assumptions. So the changes in project team and project goals resulted in a limited overview.

UNAWARENESS DUE TO FIXATION

The third source of unawareness was fixation. Fixation can be defined as: holding on to a solution or finding it difficult to move away from a developed concept [Purcell 1996]. This fixation results in a focus on a certain solution. The source fixation was seen in project Bear with the first UI design of four buttons and a display on the front of the product. They hold on to this design despite the twofold results of the first UI test. Fixation is seen during the fifth test. The user interface test number five was a first test with the 'complete' product. The test had three parts with three different mock-ups. The first and third parts were about finding the right forces for operating the buttons. The second part was about certain aspects of the user interface and the users' opinion about these aspects. These aspects were attention points from previous tests. The users were directed by questions to execute certain activities and to give their opinion about the activity by giving a score from 1 to 5. The results of the test were reported and after this test the researchers focussed on improving the scores of the test results. However within the report were also stated several remarks of the users about the product use outside the scope of the test. In hindsight these remarks could be related to usability issues in the final product. Why were these remarks not addressed? Probably because the team members focussed on the final design and improving the specific test results.

The examples from Study 3 showed how different sources contributed to unawareness, these sources of unawareness were illustrated in *Figure 4-18*. Unawareness could occur due to fixation, inadequate overview, or inadequate consideration. In these examples the sources of unawareness resulted in a type of unawareness. It is not yet investigated whether there is a relation between the sources and types of unawareness. At this moment it is assumed that each source could result in any type of unawareness. ◆

4.2.8 DISCUSSION STUDY 3

The aim of this study was to identify the types and sources of unawareness in order to define unawareness on usability related decision-making. This study was directed by the following sub-research question:

"What is the nature of unawareness in usability related decision-making in design practice?

We elaborated on Study 2 to answer this sub-research question. The results of the interviews directed the investigation of the document analysis. The results of the data sources were combined to strengthen the data of Study 3, providing a strong basis for the description of unawareness. The step-by-step approach of analysing the documents resulted in the end in the identification of three types of unawareness; unawareness about information, about consequences, and about decision. And three sources of unawareness were identified; unawareness, due to inadequate consideration, due to inadequate overview, and due to fixation. These types and sources were added to the factor unawareness in the conceptual framework, see *Figure 4-19*. The implications of these findings are discussed in chapter 5.

We need to make some remarks about Study 3 before chapter 5 is presented. A large number of documents as data source for this study were collected. However, the collection was not complete. When analysing documents it was realised that documents were missing, in particular from engineering, but also from management. Also archival documents of design and usability were missing. The archival documents were numbered and some of the numbers were missing. Fortunately, the design documents were added with documents from designer Ian. The downside of the missing documents was that it was more difficult to determine the precise project process. The completion of design documents from the designer was an advantage in the analysing process. The small interim sketches, preliminary presentations, and notes provided very detailed information alongside the archival documents.

The large number of collected documents showed a large difference in quality. Some documents were highly detailed reports, some documents were unfinished presentations, some documents contained additional notes after a meeting, and other documents were hastily-made including many spelling errors. These differences in quality needed a secure check and cross check between the documents to prevent misleading information from 'unfinished' documents.

Another limitation of retrospective document analysis was that the background information about why a document was made was missing, which made it difficult to define the sequence of the documents. This information was sometimes mentioned within the particular document, and then the introduction described why a document was written and which relationship it had to other documents. Sometimes this background information could be found in presentations or meeting minutes. The triangulation of data proved to be very useful at this point, as also the interviews of Study 2 provided information about relationships between activities and documents. However, often the content of the document had to be studied to define which document had been input for other activities. By defining the content of the document the motivation for making the document could be described, thereby determining the sequence of the created documents.

The results of Study 3 are based on a single project of an electronic consumer product within a large company. Based on this single case study no specifications could be made for other types of products, such as professional electronic products or other types of companies, such as small companies. For now it is assumed that the proposition for the nature of unawareness applies for usability related decision-making in each design process, as in general the process of creating products does not differ. Future research should indicate whether a difference needs to be made.

During the analysis of project 'Bear' the focus was on the usability related decisions within the project. However these decisions cannot always be isolated from decisions related to other aspects of the product. Several decisions have a relationship with various aspects of the product. For example the decisions on the number of buttons. From an aesthetic point-of-view no or limited buttons were preferred, from a usability point-of-view various buttons were preferred. So the decision on the number of buttons cannot be isolated to usability. For most decisions applies that they are related to more than one product aspect or project discipline.

Retrospective document analysis provided a detailed data set, but the described limitations show the disadvantages of the technique. A complete data set was determined by triangulation of the techniques interviewing and document analysis. The two data sources supplemented each other. The document analysis overcame the subjectivity of interviews as well as the personal bias and retrospective sense making, while the interviews provided background information about the situation and why activities happened. These techniques supported us in executing an inductive study on the nature of unawareness and finding proposals of types and sources of the influencing factor unawareness. ◆

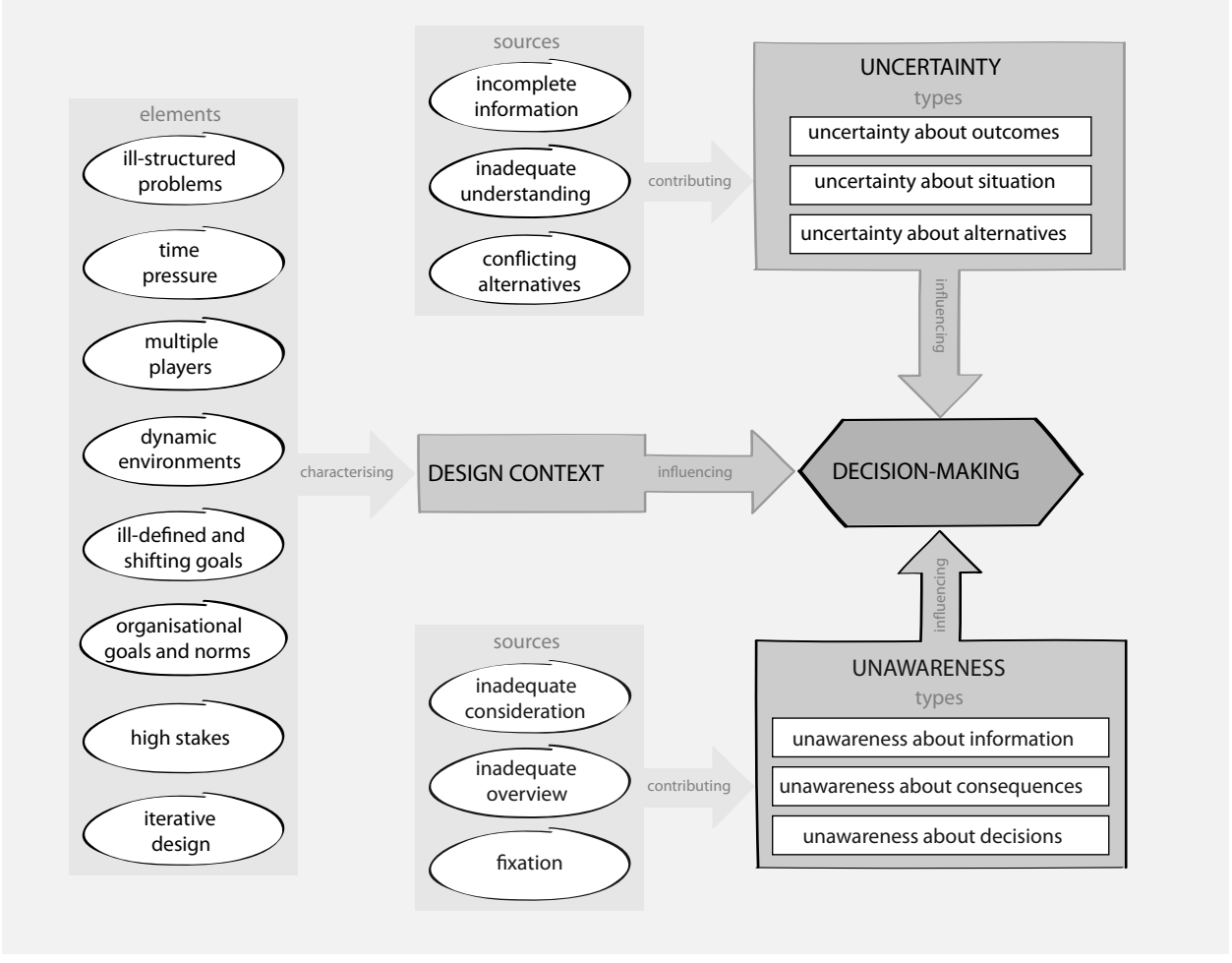

Figure 4-19: Conceptual framework IV - Influencing factors on usability related decision-making in design practice

4.3 **Conclusion chapter 4**

In chapter 1 we stated that something makes decision-making 'go wrong' as many users experience usability issues with electronic products. These issues are a result of the 'incorrect' decisions in the design process. So decision-making needs to be improved to reduce the number of usability issues. It was necessary to study how decision-making is influenced in order to find indicators on how to improve decision-making. This was done in Study 1 and 2. The influencing factor unawareness was identified as a critical and unknown influencing factor on usability related decision-making in design practice. Study 3 in this chapter aimed to gain a better understanding of this factor; about what induces unawareness and what the decision maker can be unaware of. The data sources for Study 3 were 14 interviews and 2.056 project documents. Executing the document analysis was not as straightforward as analysing the interviews in Study 2. Analysing the documents required several steps for organising the data and several interpretation steps for analysing the data. The use of a timeline proved to be very effective in organising the data. The first timeline (*Figure 4-6 – IA*) was based on the interviews and provided an initial overview of the project, directing the researcher in reading and selecting the documents. This timeline was expanded to a more detailed timeline using the documents (*Figure 4-7 – IB*). Based on timeline IB a detailed project description and timeline IIA (*Figure 4-8*) could be created, which also showed the relationship between the documents. From here analysing the data of Study 3 started, identifying the decisions related to the unforeseen usability issues, finding the sources that clarified why these decisions were made as they were, and describing the various examples of unawareness. This detailed study in design practice resulted in rich examples of unawareness during usability related decision-making. Based on these examples a categorisation of unawareness could be made by describing its types and sources. This result is further discussed in chapter 5, as well as the implications of the findings of this PhD research project. ◆

CHAPTER 5: Discussion and conclusions

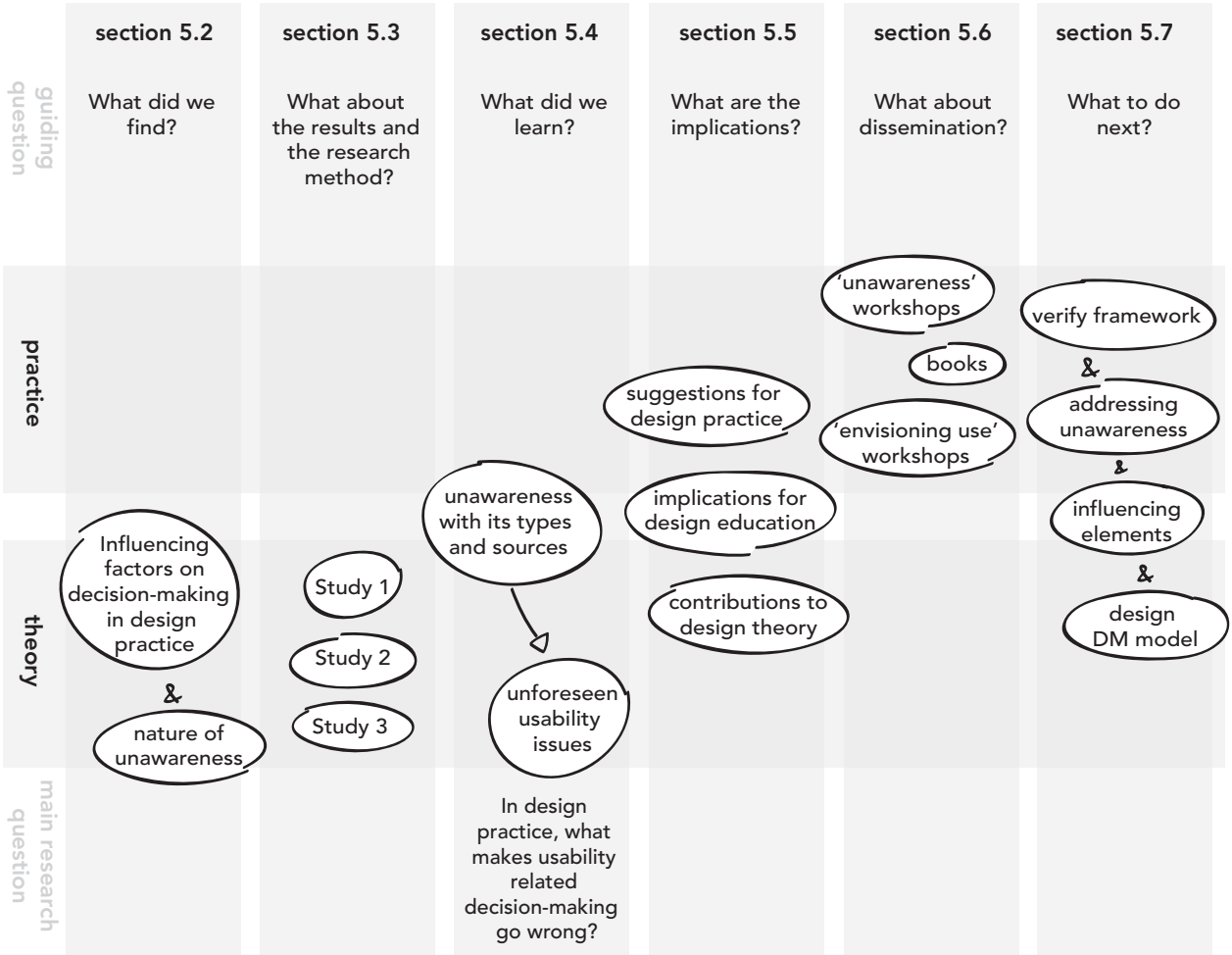

Figure 5-1: Visual table of contents chapter 5

5.1 **Introduction**

This PhD project has been a journey through various studies, to answer the main research question about what makes usability related decision-making go wrong. First the most important findings of this research project are summarised in section 5.2. Subsequently the results of this research are discussed in 5.3 and are reflected upon the used research approach. The implications of this research project for design theory, education and practice are presented in 5.5. How the research results were disseminated to industry is presented in section 5.6. This thesis is finalised with several recommendations for future research in 5.7, as the research results of this thesis triggered additional research questions. ◆

5.2 **Main research findings**

5.2.1 MAIN RESEARCH QUESTION

In chapter 1 the scene of product development and usability was introduced. This chapter explained the situation or the large the number of usability issues in electronic consumer products are, while many usability techniques are available. With these usability techniques product developers should be able to create usable products, however usability issues do still often occur. In the first chapter it was described that the occurring usability issues can be traced to 'incorrect' decisions, suboptimal decisions with negative consequences for usability. In response to this introduction the main research question was stated as:

"In design practice, what makes usability related decision-making go wrong?"

It was a rather blunt and broad question to ensure that usability related decision-making in design practice was investigated in an exploratory and critical way. Three studies were executed with sub-research questions to answer this main research question. ◆

5.2.2 SUB-RESEARCH QUESTION STUDY 1

First, literature was investigated to gain a better understanding of design and decision-making. However, only limited literature was available on design decision-making. Therefore the theory of Naturalistic Decision Making (NDM) was used for acquiring a better understanding on how decisions are made in practice. This theory does not prescribe how decisions should be made but describes how decisions are made by professionals in the field and the influences on decision-making that make the decision task difficult or affect the quality of the decision. Based on this NDM theory it was questioned whether similar factors also influence decision-making in design practice, as difficulties with making a decision or poor quality of a decision could result in 'incorrect' decisions and subsequently may lead to usability issues. Therefore an investigation into the influencing factors on usability related decision-making in design practice was conducted, first in literature, and then an empirical study (Study 1) at a design agency. This study was directed by the following sub-research question:

"What are the factors that influence usability related decision-making in design practice?"

This study was an inductive study in design practice as only little was known about decision-making in design literature

and it explored the possible influencing factors on usability related decision-making. The results of the eight interviews in Study 1 yielded possible influencing factors on decision-making in design practice see also *Figure 5-2*.

Three factors were found as possible factors influencing usability related decision-making in design practice:

- **design context**
- **uncertainty**
- **unawareness**

These factors complicate the decision task or influence the quality of a decision. The first influencing factor 'design context' corresponds with the influencing factor 'real world context' from NDM theory. In this theory eight elements that characterise the context are described. Each of these elements can influence decision-making in its own way. Comparing the elements from NDM literature with design literature suggested a similarity between the elements characterising the context. Some of these elements were stated by the respondents in Study 1, this identified the influencing factor 'design context'. The description of the second influencing factor 'uncertainty' by its types and sources was also based on NDM theory and verified in Study 1. During this study the respondents provided various reasons why it was difficult to make a decision. Several of these reasons could be associated to the sources of uncertainty from NDM theory. Therefore it was concluded that 'uncertainty' is also an influencing factor on usability related decision-making in design practice. The third factor 'unawareness' was identified for the first time in Study 1, while no indications for this factor were found in literature. This factor was identified as a result of limited overview during the project. In Study 1 it was observed that a lack of overview of the team members on the project resulted in unawareness; 'not knowing that you do not know something'. This influencing factor could lead to unpleasant surprises such as usability issues. ◆

5.2.3 SUB-RESEARCH QUESTION STUDY 2

It was decided to focus on the influencing factor 'unawareness' as it could potentially be a critical factor in usability related decision-making and it was an unfamiliar factor in design literature. Unawareness could negatively affect the quality of a decision and therefore may result in 'incorrect' decisions and consequently could result in unforeseen usability issues. The other two influencing factors (design context and uncertainty) were not further investigated. The influencing factor 'design context' was not further investigated because it is something that has to be acknowledged as being the complex situation in which teams have to make their decisions. The various elements that characterise this design context will always exist and are difficult to change. The influencing factor 'uncertainty' is defined by its types and sources. The sources that contribute to uncertainty about usability could be addressed by the use of the various usability techniques. It was assumed that these usability techniques are (correctly) used to retrieve information and knowledge about the user, his needs, tasks and context. With this information and knowledge the decision maker could underpin his decisions and therefore it was decided to not further investigate this factor as it is probably not the reason that makes usability related decision-making to 'go wrong'. The influencing factor unawareness was further investigated as it was an unknown factor, and one that could result in usability issues, being a critical factor.

Study 2 was therefore conducted to verify whether it is a critical influencing factor. This study to the unknown factor 'unawareness' on decision-making contributed to the current knowledge about decision-making in design practice. It was directed by the following sub-research question:

"Is unawareness a critical influencing factor on usability related decision-making in design practice?"

Study 2 was conducted to identify the occurrence of the influencing factor unawareness. For this study a second case was selected to identify whether the influences of unawareness could result in usability issues. Unawareness was an undefined factor, so to identify the possible consequences of this factor it was necessary to investigate the usability issues of a product. Identifying unforeseen usability issues would indicate unawareness within the usability related decision-making process. Therefore a product with usability issues from a world leading product development company was analysed in Study 2. On the basis of 14 interviews it was investigated whether there were usability issues that were 'unforeseen', which are issues that were not expected beforehand, issues that were overlooked at the time of decision-making. Analysing the interviews and verifying the results with team members resulted in a list of thirteen usability issues, of which seven were unforeseen at the moment of making the decision. **So based on this study it was concluded that unawareness actually occurs and is a critical factor as it led to usability issues. ◆**

5.2.4 SUB-RESEARCH QUESTION STUDY 3

The term unawareness was still ill-defined for application within design practice. Therefore a third study was conducted into the nature of unawareness, i.e. what can a decision-maker be unaware of and what sources contribute to unawareness, thus finding a description for the influencing factor unawareness by identifying its types and sources. The classification of this description is similar to the one of 'uncertainty'. The study was directed by the following sub-research question:

"What is the nature of the influencing factor unawareness on usability related decision-making in design practice?"

To identify the types and sources of unawareness an inductive study was conducted. This approach provided the possibility to investigate unawareness in the field of design practice where little is known about this influencing factor. The results of this study are based on the analysis of 14 retrospective interviews and 2.056 project documents of one electronic consumer product from a world leading product development company.

Three types of unawareness were identified to describe what the decision maker can be unaware of:

- **unawareness about information**
- **unawareness about the consequences**
- **unawareness about decisions**

Three sources were identified that contribute to unawareness:

- **inadequate consideration**
- **inadequate overview**
- **fixation**

These types and sources are explained in the following section. The influencing factor unawareness is visualised with its types and sources in the conceptual framework in *Figure 5-2*, together with the two other influencing factors design context and uncertainty. The factor unawareness is

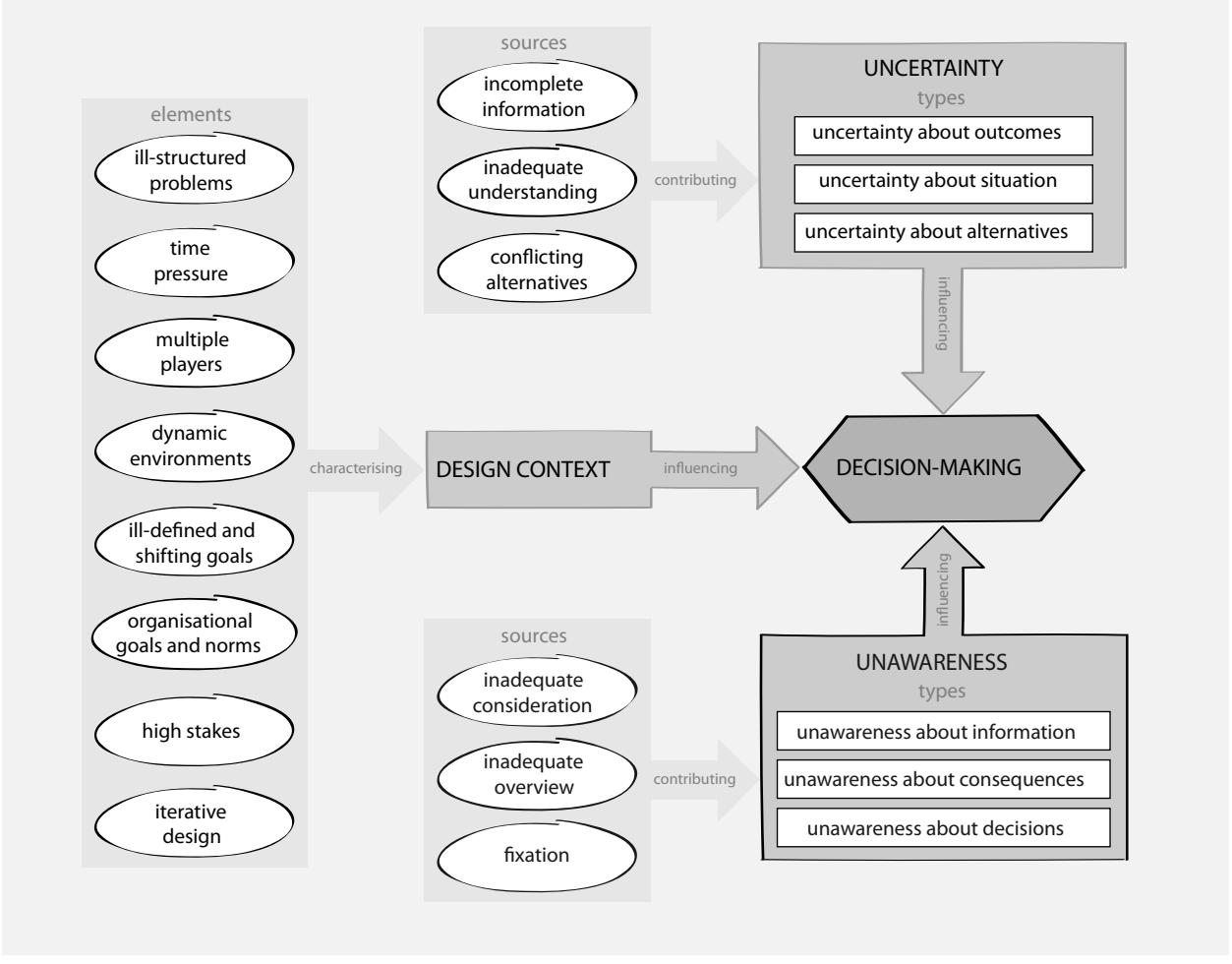

Figure 5-2: Conceptual framework IV - Influencing factors on usability related decision-making in design practice

presented in black as that was the focus of this PhD research project. The framework presents the three proposed factors that influence usability related decisions in design practice.

CONCEPTUAL FRAMEWORK

The conceptual framework IV as presented in *Figure 5-2* is the result of this PhD research project. The framework proposes three influencing factors on usability related decision-making in design practice. This result was obtained by the three empirical studies, Study 1, 2 and 3. In the third study (see section 4.2) we investigated the additional influencing factor unawareness in detail to find aspects to describe what the decision-maker can be unaware of and the sources that induce unawareness. These types and sources of unawareness are emphasised in the conceptual framework (*Figure 5-2*) with black lines as it was the focus of this PhD research project. Next, each type and source of unawareness is described and illustrated briefly with an example. A more extensive description of the examples can be found in 4.2.7

TYPES OF UNAWARENESS

UNAWARENESS ABOUT INFORMATION

This type of unawareness implicates that the decision maker is unaware about the lack of required information, i.e. the required information to make a decision is not available and the decision-maker does not realise this. In the example presented in section 4.2.7 the team members were unaware about the fact that they had 'lost' information about test results during the project. At the start of the project a first UI concept with only four buttons was tested to verify if this UI was simple to use. The results were twofold. On the one hand it was found that the UI was in general simple to use. On the other hand it was suggested that improvements should be made and it should be re-tested. These adjustments were not made and tested, while the UI kept its four buttons because of the *"in general the interactions of the UI were easy"* [d15]. They were unaware that they had 'lost' information about the suggested adjustments.

UNAWARENESS ABOUT CONSEQUENCES

Unawareness about the consequences of a decision occurs when the decision-maker does not foresee the consequences of a decision or when the gravity of the consequences is underestimated. For example, in the studied project 'Bear' it was realised that operating the rotary-push wheels could be difficult, but it was not realised that it could result in such severe usability issues.

UNAWARENESS ABOUT DECISIONS

Unawareness about a decision occurs when implicit decisions are made. For example, an implicit decision in the studied project (see also 4.2.5) was made at the moment that the team decided on the final design. With this they decided on a certain look of the product, but implicitly the team also decided on a display separated from the buttons and buttons located on the right side of the product. This in the end resulted in usability issues for the user.

SOURCES OF UNAWARENESS

UNAWARENESS DUE TO INADEQUATE CONSIDERATION

This aspect contributes to unawareness due to the limited attention on a certain topic. When usability is not on the

agenda at the moment of decision-making the usability expert will not be heard, he will not get the required attention. This is illustrated by an example in 4.2.7 that describes the decision on the outer form for the product. During the project was stated several times that from a usability perspective the 'new' concept was less preferred than a concept with turn and push buttons on the front of the product. However it was decided to choose the 'new' concept with rotary-push wheels on the side of the product, as this was also the preference of higher management.

UNAWARENESS DUE TO INADEQUATE OVERVIEW

After Study 1 it was already suggested that a lack of overview could result in unawareness. Study 2 and 3 confirmed that an inadequate overview results in unawareness. As described in 4.2.6 the project and team had to cope with changing team members due to organisational changes. New team members joined the on-going project and at the same time a new goal was set, to create a design icon. It was felt to be a new project while it was in fact an on-going project with prior goals and decisions. The new team members did not know all the previous decisions and their basis; they did not have the complete overview of the project, resulting in unawareness of information.

UNAWARENESS DUE TO FIXATION

In design literature fixation is defined as holding on to a solution by the designer, finding it difficult to move away from a developed concept. Something like this was also seen in the studied project. The team was so biased towards the final design that they did not address the other results of the test, see section 4.2.7. For example, during the fifth UI test the team focussed on finding the right pushing force for the buttons and on the users' opinion on several specific functions. These results were reported and improved. Beside these results also some remarks of the users were reported. These were remarks about negative issues the user experienced, several of the remarks referred to usability issues in the final product. The focus on the final design made that the team did not address the remarks for which they had to change the design. ◆

5.3 **Discussion of this PhD project**

5.3.1 **REFLECTION ON THE RESULTS**

DISCUSSION – THE INFLUENCES OF THE DESIGN CONTEXT

In chapter 2 the influencing factor 'design context' on usability related decision-making was introduced. It could be discussed that this factor also influences the sources of the other two influencing factors. The factor design context is characterised by various elements. These elements influence decision-making in different ways. For example, 'ill-structured problems' provide significant work for the decision maker to recognise what is happening and to develop solutions, this will make it more difficult to make decisions. The element 'organisational goals and norms' makes the decision maker act according to these norms instead of his own personal goals and norms. Therefore he has to adapt to these organisational norms to make a decision. The 'high stakes' in a project may make the decision maker feel stressed and therefore extra committed to making decisions with good outcomes. Eight elements were described in chapter 2. It was realised that this list may not be complete, but it did provide a theoretical basis to characterise the design context. In this research project, various elements were verified in design practice.

However it was also seen in section 4.2.4 that the elements of the design context not only influenced decision-making but that they also influenced the sources of uncertainty and unawareness. The organisational changes during project 'Bear' as described in the subsection 'design search' of section 4.2.4 was a change in the design context with which the team had to cope. These organisational changes led to many changes within the project team. So the element 'multiple stakeholders' of the design context changed during the project. These new team members were not completely familiar with all the previously made decisions and the set project goals. This influenced the amount of information and understanding of the decision-maker, which contributed to the 'uncertainty' of the decision-maker, resulting in having difficulties in making decisions. The organisational changes also resulted in changes of the project goal. At the start of project 'Bear' it was the aim to improve product 'Ant'. Now it became the aim to create a design icon. The element 'ill-defined and shifting goals' of the design context did change and influenced one of the sources of unawareness; 'inadequate consideration'. Decisions were made in favour of aesthetics, as if usability was no longer on the agenda. This resulted in the situation that remarks about usability were made but not 'heard'. In the described project this led to 'unawareness about consequences'

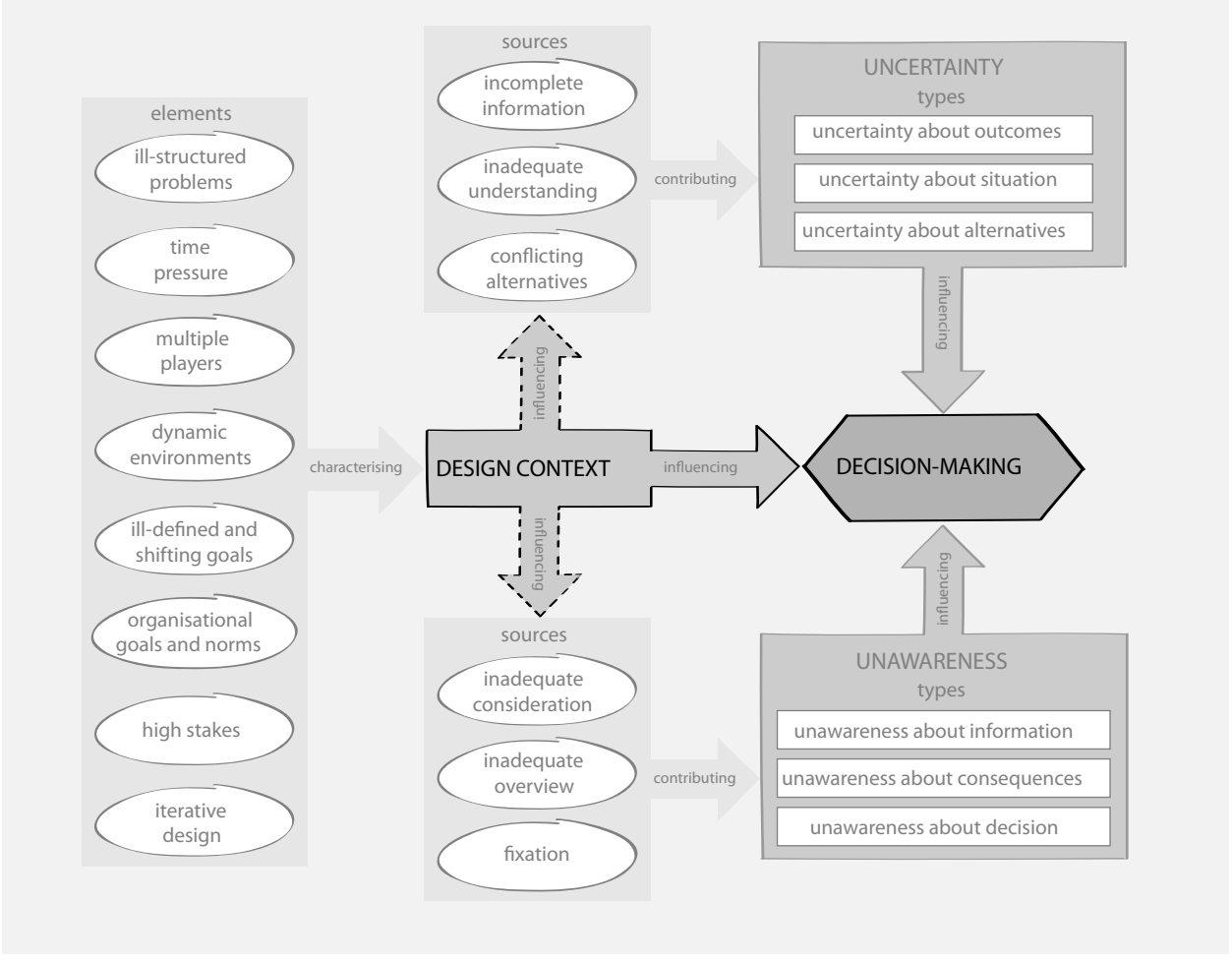

Figure 5-3: Conceptual framework V - Discussing the influencing factors on decision-making in design practice

resulting in unforeseen usability issues. It can also be expected that developing new innovative products involves several 'ill-structured problems' that require some work to define the problem to get to solutions, and only limited time is available due to the pressure from the market. This 'time pressure' lead to no or carelessly executed iterations resulting in incomplete information which could lead to uncertainty.

These examples suggest a possible influence of the elements of the design context on the sources of uncertainty and unawareness. Therefore in the conceptual framework should not only point an arrow from the influencing factor 'design context' to decision-making but also to the sources of uncertainty and unawareness, see *Figure 5-3*. These arrows are drawn with dotted lines as the influences of the design context were not specifically investigated during this PhD research project, but were observed when analysing the data. The possible influence of the design context and changing elements on the sources of uncertainty and unawareness may suggest that the design context and its elements could be an indicator for the occurrence of uncertainty and unawareness. The chance that uncertainty or unawareness may occur is expected to be larger when the design context is more complex. A worst case scenario could be; many ill-structured problems, high time pressure, many changing players all around the world, ill-defined and shifting goals. This scenario may lead to a larger amount of uncertainty and unawareness influencing usability related decision-making.

DIFFERENCES BETWEEN UNCERTAINTY AND UNAWARENESS

In Study 1 it was identified that there might be another influencing factor on design decision-making besides the influencing factors design context and uncertainty. The results of Study 1 showed that a limited overview not only resulted in uncertainty but that it may also result in unawareness. At that stage in the research project, unawareness was explained as 'not knowing that you do not know that information is lacking' and uncertainty as 'not having the required information'. Study 2 verified that besides the factors design context and uncertainty unawareness is a factor influencing usability related decision-making. Based on the results of Study 3 a description of unawareness could be defined by describing and explaining its types and sources in analogy to the description of uncertainty. There is a clear difference between the sources of uncertainty and unawareness, as can be seen in *Figure 5-2*. Uncertainty is induced by the sources incomplete information, inadequate understanding and conflicting alternatives, while unawareness is induced by the sources inadequate consideration, inadequate overview and fixation.

Another difference between the influencing factors uncertainty and unawareness was identified which has not been made explicit so far. This difference is that both factors influence decision-making on a different level. Uncertainty mainly influences on making single individual decisions, while unawareness mainly influences the chain of making decisions. This difference can be illustrated by an example of a usability issue from Study 3; issue E (see also section 4.2.7 and *Figure 4-16*). In Study 3 the activities and decisions related to unforeseen usability issues were investigated. Usability issue E is about the operation of the buttons on the product, whereby the user can experience two different usability issues. E1: the user does not know how to operate the buttons and E2: the user does not know which button is for which function (for a detailed description of this

issue, please refer to section 3.3.4.1). The decision for three rotary-push wheels (M) could be pointed to as a first source for this issue. However this decision is related to decisions at the beginning of the project for a certain number of features (D) and a certain number of buttons (A). These decisions led to the decision later in the project for choosing to operate the product with three rotary push wheels (M) and a lever (J). A second source can be pointed to the decision to 'disconnect' the relationship between the buttons and display (G/K). This decision is linked to decision to locate the buttons on the side of the product (L), which resulted from the decisions to develop a certain concept (F) and place the parting line between the front and back (I). So the unforeseen usability issue resulted from a chain of decisions, it is not one particular decision that resulted in the issue, but the unawareness during the chain of decisions that led to unforeseen usability issues. The chain of decisions (simplified from *Figure 4-16*) and the unawareness is visualised in *Figure 5-4*.

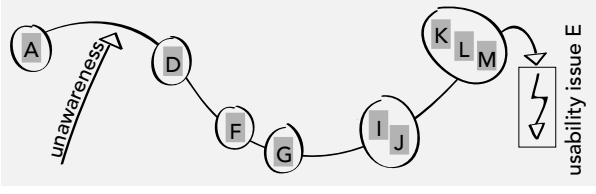

Figure 5-4: Chain of decisions and unawareness

The focus of Study 3 was on unawareness, not on uncertainty. However, analysing the project again, signs of uncertainty can be identified. Usability techniques were used by the team to retrieve required information. The use of techniques indicates inadequate information or knowledge to make a decision, uncertainty, as explained in 4.2.5. This can be illustrated with an example from Study 3. To decide on the number of buttons a usability test [d8, d15] was conducted on the user interface to verify how simple the UI with four buttons was to use. The results of this test – *"in general easy to use"* – provided the team information to decide to design a product with a limited number of buttons (A). A second example is of another test [d12, d13] that was executed to work out the required features of the product. The results of this test made clear what the basic, required and preferred features for the product were. The retrieved information was used as input to make a decision on the number of features (D). A third example of test results that supported the decision-makers to make a decision was three consumer tests [d10, d11, d17]. These tests provided the team directions to decide to develop a certain concept (F). Each of the tests was aimed at retrieving information to base a specific decision on. The use of these tests indicate that in there was uncertainty at the time of making a single decision in this study; see *Figure 5-5* a simplified version of timeline IIB (*Figure 4-16*).

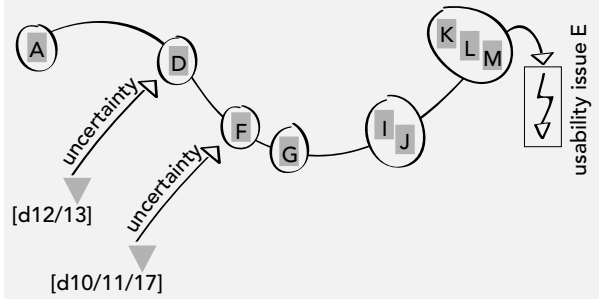

Figure 5-5: Single decisions and uncertainty

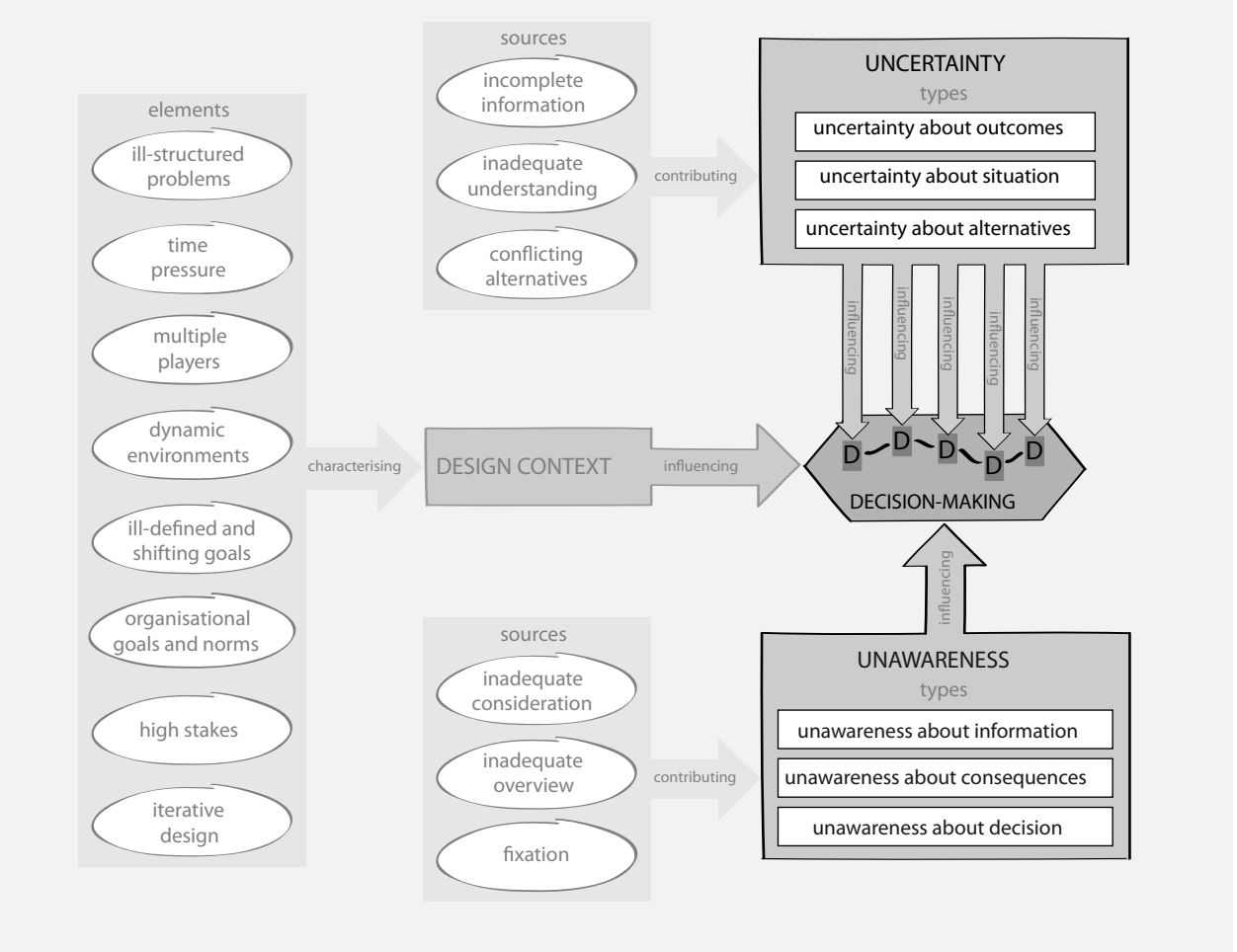

Figure 5-6: Conceptual framework VI- Discussing the influencing factors on decision-making in design practice

Based on the results of Study 3 it can be seen that unawareness was an influence on the chain of making decisions and builds up in the chain of decisions. The use of usability techniques at the time of making a single decision indicates uncertainty. This difference observed in Study 3 between the influencing factors uncertainty and unawareness is visualised in the adjusted framework, see *Figure 5-6*. The results from Study 3 suggest that the factors uncertainty and unawareness influence decision-making on a different level. The influencing factor uncertainty points to single decisions and the influencing factor unawareness points to the chain of decisions. However uncertainty was identified by the use of usability techniques, there might have been also uncertainty that was not addressed at all and could not be identified in this manner. ◆

5.3.2 REFLECTION ON THE RESEARCH METHOD

STUDY 1

Study 1, as presented in section 2.5, was an explorative, inductive and empirical study with the aim of finding influencing factors on usability related decision-making in design practice. The explorative and inductive approach provided the possibility to discover and investigate decision-making in design practice. Only limited literature was available on decision-making in design theory and this first study goal was to gain a better understanding on the factors that influence decision-making in design practice. Retrospective interviews were used to investigate a project from a design agency. This technique has some well-known disadvantages such as poor recollection of details, personal bias and retrospective sense making. However, a verified story about the project was created by combining multiple perspectives from the personal stories of various team members. These interviews proved to be an efficient way in understanding decision-making in design practice. However a single case and a total of eight interviews were insufficient to create propositions about influencing factors on usability related decision-making. It was learned from this first study that the validity of the data sources should be strengthened by using various data sources and larger data sets, in order to build theory on usability related decision-making in design practice. Yet using retrospective interview techniques was an efficient way of investigation.

STUDY 2

In Study 2 (please refer to section 3.3), the possible critical and unfamiliar influencing factor unawareness was verified, by investigating in more detail whether unawareness also occurs in other cases. For this study a world leading company in developing electronic consumer goods was selected because of their experience and expertise in product development. It was assumed that when unawareness occurs at a company with such a high level of experience and in-house experts that unawareness may also occur at other companies. Identifying the influencing factor unawareness in a project of this company would verify the suggestion of Study 1; that unawareness is an influencing factor on usability related decision-making. Retrospective interviews were used to investigate this case, departing from the existing usability issues. These retrospective interviews gave a first impression of the project and confirmed the existence of unawareness in product development. The disadvantages of conducting retrospective interviews such as personal bias, retrospective

sense making and limited recall of details, were addressed by conducting numerous interviews and verifying the results with two key respondents. The combination of fourteen interviews with team members from different disciplines resulted in a complete story about the project. The combination of stories made that personal bias and retrospective sense making could be excluded. The final results of this study - the (un)foreseen usability issues - were verified with two key team members to check the researcher's interpretations. Subsequently the findings of this study were discussed with the respondents in a group session. This study posed together with Study 1 a proposition for the existence of the influencing factor 'unawareness' on usability related decision-making in design practice. This proposition was built on two single cases. No cross-case patterns were investigated between Study 1 and 2 as the set-up of the studies was too dissimilar. The basis for this proposition could have been stronger when another case study with the same set-up and goal as Study 2 was conducted. Then the patterns between the cases could have been investigated and would have strengthened the basis for theory building [Yin 2009]. The interviews from Study 2 not only verified the influencing factor unawareness, they also provided direction for the subsequent study. The personal perspectives on the project gave an indication where to find facts about the sources that contributed to the influencing factor unawareness.

STUDY 3

Study 3 was an inductive and empirical study, see section 4.2. This approach was chosen for its possibility to investigate the nature of unawareness in design practice. It was learned from Study 1 that multiple and extensive data sources are required to generate solid propositions. Therefore two data sources were used: 14 interviews and 2.056 project documents from one design project of a world leading product development company. This company was selected for its experience and expertise in developing usable products. If unawareness occurs in a company with so much expertise and experience it may be assumed that unawareness can also occur in companies with similar or less expertise and experience, as the principle of creating products does not differ. A proposal for a description of unawareness could be made based on the results of analysing the interviews and documents of one design project. The disadvantages of retrospective interviews were addressed by combining the two data sources. In particular the disadvantage of limited recall of details such as the chronology of events is addressed by using documents as data source. The document analysis provided a high level of detail that was required for defining the nature of unawareness. However data analysis has its disadvantages as well, the set of documents was large but not always complete or accurate. The only way to obtain a complete understanding of the project would have been to add results from observations to the data sources. Though studying usability issues of a finalised product implies that real-time observations could not be made. The investigation of a single case at a large multinational company had as disadvantage that only the types and sources of the influencing factor 'unawareness' in large projects was identified. At this moment it is unknown whether unawareness could be defined differently for smaller companies, or other products such as professional electronic products.

Analysing this content-driven project in Study 3 was not straight forward. Such a design project is often directed by its content, which means that the activities within the project

depend on the problems and solutions the designers work on. A tailor made research method was required to investigate such a project in retrospect. This method would be able to follow a content-driven project. It would be steered by the content of the project without losing the guiding function of a research method. This means certain flexibility and amount of freedom was required in the method as it was unknown beforehand what happened in the project. But the approach also needed to provide guidance during the investigation so next research steps were known regardless of the content of the research. It became a research method to create an overview of the content-driven project without losing the valuable details and retaining the traceability of results. From this overview a better understanding of the nature of the influencing factor unawareness could be retrieved. Each step of this research method is described and when necessary reflected upon.

TRIANGULATION OF INTERVIEWS AND DOCUMENTS

Triangulation of interviews and documents was essential for understanding the content driven project. The retrospective interviews provided – although sometimes subjective – information about the activities and background information of the project. Meanwhile the documents provided objective and detailed facts and information about the project and activities. The differences between the types of data meant that the data sources were complementary. And in cases of doubt the other data source was available for clarification.

TIMELINE I

A simple technique for structuring the data emerged while processing the data from both sources: a Post-It notes timeline (see *Figure 4-6* and *Figure 4-7*). This timeline helped in creating an initial understanding of the project. The different coloured Post-It notes indicated time, team members, and various activities related to design, engineering, management and usability. This timeline directly showed the busy moments in the project; many Post-It notes at a certain moment in time implicated many activities. But it was also directly visible when new team members joined the project. The advantage of Post-It notes was that the timeline was quickly created and it was flexible, but also that it was at any time visible since it was positioned above the researcher's desk. Thus it was always available for looking things up, and new findings from the data could directly be added. The downside of this flexible timeline was the limited level of accuracy, especially when notes were moved by accident. This initial timeline based on the interviews needed to be supplemented with more detailed and objective data from the documents to get to an extensive and complete overview of the project.

TIMELINE II

The Post-It timeline showed an overview of the activities and team members on the project, but a focus was required to prepare the data for analysis. The relationships between the activities had to be made clear to enable analysis of the information flow within the project. A digital timeline was created once all data was structured within the timeline (see *Figure 4-8*). Structuring the timeline was done in combination with writing a detailed and objective project description (see section 4.2.4). This extensive description in combination with the timeline provided the possibility for other researchers to learn about and understand the project without knowing the raw data, so the data could be discussed mutually. This

description also enables professionals to understand the project and to relate the results and conclusions to their own experiences. However the detailed timeline and project description do not provide a quick insight and understanding of the project.

HIGHLIGHT

The timeline and descriptions themselves were still too extensive and broad for analysing the data. A further focus was required; therefore the decisions in the project related to unforeseen usability issues were selected by highlighting the decisions in the timeline (see section 4.2.5). By objectively selecting and numbering the decisions, a clear basis for data analysis was made which could be referred to at any time. Only the decisions which showed a clear relation in hindsight to the unforeseen usability issues were highlighted. Other decisions could have been also of importance but could not be identified in retrospect.

SOURCE

The source of unforeseen usability issues was searched for after highlighting the decisions, i.e. what made these usability issues occur? For every usability issue the data of the documents was searched to find which decisions led to the issue, with the interviews providing an initial direction. Digging into the various sources of unforeseen usability issues expanded the understanding of the project and the discovered occurrences of usability issues, see section 4.2.6. To ensure traceability of the data small interpretation steps during the analysis were made.

EXAMPLES

This step-by-step research method to achieve a better understanding of the nature of unawareness resulted in various examples of unawareness within the project, examples of what the decision-maker was unaware of and examples of how the unawareness occurred. The various examples showed the variety of unawareness. Based on these examples the last step could be made to define unawareness, which was done by abstracting the examples to types and sources of unawareness, please refer to section 4.2.7. ◆

5.4 Conclusions of this PhD project

The following main research question was stated in chapter 1:

"In design practice, what makes usability related decision-making go wrong?"

This question refers to the many usability issues that users encounter with electronic products resulting from 'incorrect' decisions made in design practice. Those are decisions with a negative consequence for product usability. Somehow poor quality decisions are made in design practice that may lead to 'incorrect' decisions, resulting in usability issues. This all is in spite of the many available usability techniques that support the designer in creating usable products. So it was questioned what makes usability related decision-making 'go wrong'? The answer we found to this broad research question might be not the only reason that decision-making 'goes wrong'. The explorative course of this research project and sub-research questions directed the answer into one specific direction; the factor 'unawareness' that influenced usability related decision-making, resulting in sub-optimal decisions and usability issues. Now this influencing factor is known, decision-making can be improved.

Based on the results of the earlier described studies, three factors were identified that influence usability related decision-making in design practice; design context, uncertainty and unawareness. Each of these factors influences decision-making in its own way; influencing the single decision or the chain of decisions and influencing the decision task or the quality of the decision. The influencing factor design context is characterised by eight elements, refer to *Figure 5-2*. The factor uncertainty is defined by its types of uncertainty and the sources of uncertainty, see also *Figure 5-2*. Both factors were based on NDM and design literature and verified in design practice. We identified the influencing factor 'unawareness' in Study 1, a potential critical and unfamiliar influencing factor in decision-making literature. In Study 2 we verified that unawareness is an important influencing factor, as it can result in unforeseen usability issues. In Study 3 this factor was studied in detail to gain a better understanding. We could define the factor unawareness by its types and sources based on the results of this last study. **It is the influencing factor unawareness on usability related decision-making in design practice that makes decision-making 'go wrong'.** Unawareness of the decision maker about i.e. the lack of information, possible consequences of a decision, or the decision itself, may result in decisions of poor quality as the decision is not made on correct or complete information. This can lead to 'incorrect' decisions in the design process resulting in unforeseen usability issues.

The sources that produce unawareness are not addressed by usability techniques which are used to address the sources of the factor uncertainty. Usability techniques can, for example, be used to retrieve information about the user, or about the usability of a prototype, or about the advantages of various concepts. With these techniques information or knowledge is gained to base a decision on. These abilities of usability techniques address the sources of uncertainty. However, as discussed in 5.3.1 the influencing factors uncertainty and unawareness are different. Unawareness plays a role in the chain of decisions while uncertainty is mainly of influence when making a single decision. Moreover the sources that elicit uncertainty and unawareness are very different. The sources of unawareness are not really addressed by the current available usability techniques. Usability techniques do not help in setting priorities or defining the agenda, so they do not address the source of 'inadequate consideration'. Neither is addressed the source 'inadequate overview' as usability techniques do not aim for creating an overview. The source 'fixation' is not addressed either. **In other words, it is the influencing factor unawareness that makes usability related decision-making in design practice 'go wrong' despite the available usability techniques.** To diminish the chance of usability issues, or 'incorrect' decisions, the sources of unawareness need to be addressed to improve the quality of decisions. Addressing the sources of unawareness thus requires a different approach from addressing uncertainty. Suggestions on how to address unawareness in usability related decision-making are presented in section 5.5.3; suggestions for design practice.

This PhD research project revealed the influencing factor 'unawareness' on usability related decision-making in design practice. Although it could be argued that this factor also influences other decisions it is especially critical for usability related decisions. As explained in chapter 1 the usability of a product is "the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use" [ISO 1998]. The different variables make it difficult to predict what the usability or usability issues of a product will be during product development. Also measuring product usability or issues during development is difficult as only a simulation of the interaction can be made. In such a simulation a prototype of the product is used, users with imposed goals and duties are invited, and the context of use is also simulated. Measuring usability in such a manner is the only way to get closer to this more or less subjective product aspect, but can never be as precise as objective product aspects like cost price or reliability. When unawareness occurs during usability related decision-making the chances on identifying usability issues will even further diminish.

Revealing 'unawareness' and creating a framework of influencing factors on usability related decision-making (see Figure 5-2) provides a direction to diminish the number of 'incorrect' decisions and usability issues, which are discussed in section 5.5. ◆

5.5 Implications for design theory, education and practice

5.5.1 CONTRIBUTIONS TO DESIGN THEORY

CONCEPTUAL FRAME WORK

The influencing factors context and uncertainty from NDM theory were used as guidelines to investigate design practice. In the conceptual framework (*Figure 5-2*) three influencing factors on usability related decision-making in design practice are proposed. Each of these factors can influence decision-making by making it difficult to make a decision or affecting the quality of the decision. This conceptual framework contributes to design theory as being a new and descriptive perspective on decision-making in design practice.

CRITICAL INFLUENCING FACTOR

Of the three influencing factors the factor unawareness was identified as a critical factor. Unawareness during decision-making may result in poor quality of the decision, as the decision-maker can be unaware that e.g. he is missing information to base a decision on. This can lead to 'incorrect' design decisions; decisions that may lead to unforeseen usability issues. Addressing the sources of this factor unawareness is an approach which is not yet described in usability and design theory or addressed by the currently available usability methods and techniques.

DESCRIPTION OF UNAWARENESS

A description of unawareness was attained by identifying the sources and types of unawareness. This description provided indications for reducing unawareness. The sources of unawareness need to be addressed to diminish unawareness and subsequently prevent a poor quality decisions and possibly prevent usability issues.

RESEARCH METHOD

A method to investigate content-driven projects was developed for Study 3. Actions and decisions within product development projects depend on the project content, the problems and possible solutions, so it is content driven. It was difficult to predict the progress of such projects beforehand. Investigating these content-driven projects in retrospect required a flexible but guiding research method. The project process can be revealed by creating timelines and analysing the data step-by-step. The step-by-step approach ensured the traceability of the results and retained the details of the project. It proved to be a suitable method to investigate a content-driven project in retrospect.

IMPROVING PRODUCT USABILITY

In chapter 1 was introduced the Design for Usability project and its aim to improve the usability of electronic consumer products. Five PhD projects were executed and each of these projects contributed in its own way to improve product usability. Within the DfU project a model was used to represent the various levels and aspects within the organisation that influences product use, please refer to *Figure 5-7* for the impact model. The closer to usage, the middle of the model, the larger the impact.

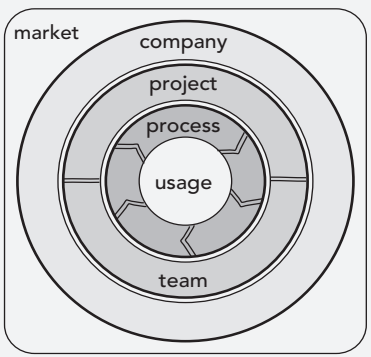

Figure 5-7: Impact model on product use

The research of Van Kuijk [Kuijk 2010] identified four main drivers in product development for creating usable products. He concluded that not only the process but also the organisation needs to be changed to create usable products. His recommendations on how to do this are assigned to the various levels of the impact model. This provided the preconditions for creating usable products. Hoolhorst focused on developing a Plan of Approach to support transitions between the project-team level to process level. This approach focussed on including usability methods and techniques into the existing product development processes of the company. With this approach usability design could be better integrated without disturbing company processes to create usable products [Hoolhorst 2012]. Dorrestein investigated on the usage level how users change their behaviour due to interactions with products. Concerning product impact on users, this knowledge supports developers in creating usable products [Dorrestijn 2012]. Kim also investigated the usage level. He created various user profiles that show the relation between user characteristics, kinds of products, and the chance of usability issues. These insights support the designer in creating the right product for its user [Kim 2012]. The results of the research project of Harkema contributed to the overall project aim by identifying ways to improve decision-making in design practice, resulting in less 'incorrect' decisions and usability issues. Her work relates to decisions on all levels, but focussed on the decisions on the project / team level. Decision-making in design practice can be improved by addressing the sources of the influencing factors on usability related decision-making, especially the factor unawareness. However, before decisions can be improved the practitioners need to know, understand and acknowledge the various influencing factors on usability related decision-making. This understanding can be gained from reflective workshops like, "*How to prevent unawareness in your design practice*", which is described in section 5.5.3 and 5.6. ◆

5.5.2 IMPLICATIONS FOR DESIGN EDUCATION

The results of this PhD research project contribute not only to design theory but have also implications for design education. Educating design students on usability related decision-making in design practice and its influencing factors may prepare them to recognise elements and sources in design projects. Recognising and addressing the sources that contribute to the influencing factors improves usability related decision-making. Reducing the sources of the influencing factors makes it easier to make decisions and to produce an improvement in the quality of decisions, resulting in less 'incorrect' decisions and usability issues.

Learning about the elements that characterise the influencing factor 'design context' makes designers aware of the situation in which they have to make decisions and may alert them when the situation is changing. Addressing or adjusting these elements is difficult, as these elements will always be there to define the context. For example, the market will be demanding which results in time pressure, products will be innovative and complex and therefore, designers will have to cope with this complex situation in which they have to make decisions. However, the ability to recognise the elements of the design context that are changing or are of great influence will alert the designer for possible influences on the sources of uncertainty and unawareness.

The sources of uncertainty within usability related decision-making can be addressed by retrieving required information, knowledge, or by revising the conflicting alternatives. Usability techniques are very supportive in this. These techniques aim for gathering information or knowledge about the user, the product, the context, the interaction, etc. Depending on the type of required information or knowledge a suitable technique is available. When teaching these techniques it is important to teach that using these techniques will not guarantee usable products as there are other factors influencing usability related decision-making as well.

The influencing degree of unawareness on usability related decision-making can probably also be reduced by addressing its sources. However, the suggestions for addressing these sources, see 5.5.3, are not yet validated in design practice. It is yet unknown whether these suggestions actually diminish the influencing degree of the factor unawareness on design decision-making. Learning about the sources that contribute to unawareness will enable the designer to recognise the sources, which is a first step in preventing unawareness. The second step will be to actually address the sources of unawareness. ◆

5.5.3 SUGGESTIONS FOR DESIGN PRACTICE

This PhD research revealed the influencing factor unawareness; it is of influence on usability related decision-making, it can lead to unforeseen usability issues, it has various types, and it has various sources. Now a solution for addressing unawareness in design practice is of course wanted. However, it has not yet been investigated which solutions address the sources of unawareness best or which solutions can prevent unawareness. It was realised that practitioners first need to know about the influencing factors before the sources can be addressed. The following solutions are therefore some suggestions on how

to recognise the influencing factors and its types and sources and on how to address the sources of 'unawareness' in order to prevent unawareness.

REFLECTION

An effective and efficient way to learn about the influencing factors on usability related decision-making is to join the workshop "How to prevent unawareness in your design practice". During this workshop the influencing factors are introduced and explained on the basis of examples from industry, most preferably examples from the participants. Based on these examples the participants can reflect on their own product, their own project, and their own situation and learn from this. Any questions regarding their examples can immediately be answered which makes that the participants quickly understand the influencing factors and the differences between the factors.

CREATING OVERVIEW

It may sound somewhat straight forward, but the source *'inadequate overview'* could be addressed by creating an overview of the project. In this overview, activities, documents, decisions and assumptions of the project could be collected and relationships between them could be indicated. A suggestion coming from the research method of Study 3 is to create a Post-It notes timeline to map the chain of decisions and activities as used in the research method. This overview makes the decisions explicit and may prevent implicit decisions and consequently prevent *'unawareness about decisions'*. The timeline provides an overview and directly shows what is going on, and where, for example, relationships between activities are missing. Creating such an overview as a team may also create an understanding of what is going on in other project disciplines.

BALANCED DIALOGUE

Maintaining a balanced dialogue between the various disciplines in the project team may address the source *'unawareness due to inadequate consideration'*. Communication between the various disciplines ensures that knowledge is shared and thereby creates a shared understanding about the project. On the one hand this shared understanding possibly helps in identifying *'unawareness about information'* as knowledge is exchanged and thereby it becomes clear which knowledge is missing or what the blind spots are. On the other hand shared understanding might help in understanding other people's discipline, knowing what is going on outside your own discipline. The balance within the dialogue is necessary to prevent disciplines constantly overruling other disciplines, making sure that each discipline is heard. The project leader of the project would be the designated person to support and facilitate this dialogue and to ensure that it includes usability.

QUESTIONING

A strategy to uncover *'unawareness about information'* could be by regularly questioning. For example, the project leader could ask the usability specialist a large number of questions about the user, the context, and the possible (critical) scenarios and follow up on these questions. In this manner the unknown information (uncertainty) can be obtained but maybe also blind spots could be identified when questions are asked which did not yet occur to the usability specialist or the design team. New insights can be gained when questioning is done at various moments in time. It should not be interpreted as a

check, but as a support in identifying the overlooked aspects or unforeseen issues. This could also be done by someone from the same discipline but from outside the project, having a fresh perspective.

ENVISIONING USE WORKSHOP

This suggestion of using the 'Envisioning Use' workshop has been validated in practice. It was developed by Mieke van der Bijl-Brouwer of the University of Twente, Stella Boess of the Delft University of Technology, and Christelle Harkema of the Eindhoven University of Technology [Bijl-Brouwer 2010, 2011, 2012]. The goal of this workshop is 'to create a shared vision on product use'. During this workshop various members of the team will share their implicit and explicit knowledge about use. This sharing identifies the known and unknown information and knowledge about the product use. During this workshop they will make use of a validated 'product use mind map', structure and approach. This workshop can be used as a tool by the usability specialist at the start of a project to identify the available and unavailable information and knowledge about the product use. This may identify the unawareness type *'unawareness about information'*.

USABILITY TECHNIQUES

In the conclusion (5.4) it was stated that usability techniques are well suited to address uncertainty at any time during the development process as usability techniques aim for collecting information e.g., about the user, his context and tasks. However, in Study 3 it was observed that fixation on a certain concept occurred because a usability test had indicated that it was 'easy to use'. The test results provided assurance to the team members and therefore they held on to the concept. However, during the project the concept changed but the test results were still taken into account. Early and regular testing of prototypes with an explorative approach may prevent *'unawareness due to fixation'* as there will be new evidence about the usability of the product. The explorative approach may also identify *'unawareness about consequences'* as an explorative approach does not only aim for testing certain expectations but also finding unexpected aspects. The broader perspective during exploration may also result in finding *'unforeseen usability issues'*.

The difficulty for each of these suggestions is to implement them in the current way of working of a development team. Over time a certain process has become familiar. There will not be much time left in the process to add another technique, unless the importance of unawareness is recognised. Study 2 and 3 were executed at a multinational with longstanding experience in product development. It could be assumed that when unawareness occurs at a company with such a high level of experience and in-house experts that unawareness may also occur at other companies. The detailed project description in section 4.2.4 was written to trigger the experiences and empathy of designers in such a way that it would enable them to assess the results and conclusions of this research for their own design practice. A detailed project description as this could convince team members of a product development team of the importance of unawareness, and thereby motivate them to try the suggestions that address the sources of unawareness. ◆

5.6 Valorisation: How to prevent unawareness in your design practice

The aim of valorisation is to actively share developed knowledge from science to industry. This knowledge can then be applied in new products and processes which stimulates innovation. The results of this research are disseminated in several ways. The results are included in two books for industry, as a book chapter in the Design for Usability Tools and Method book [Kuijk 2012] and the IOP Design United book [Bont 2012]. In these chapters the research is described in a less scientific manner, being more accessible for the professionals from design practice. Another way of how the results were disseminated are two workshops.

The Envisioning Use workshop is conducted with industry several times. This workshop aims to support the team in sharing and aligning all the knowledge of team members about the product use. With this workshop the team members could identify the known and unknown information and possibly identify blind spots or unawareness about the product use. All the ins and outs of the Envisioning Use workshop and how to conduct the workshop were described in the booklet 'The Envisioning Use workshop' [Bijl-Brouwer 2011B] that can be downloaded from the DfU website: www.designforusability.org. This booklet guides the professional in how to conduct The Envisioning Use workshop.

A second workshop was developed to support practitioners in reflecting on the made decisions in their product design projects. The first version of this workshop was conducted during the Design for Usability symposium on 12th November 2009 in Delft where preliminary results of the research project were shared with professionals. During the Design for Usability symposium on 10th November 2011 the second workshop was conducted to share the final results of this research project. This workshop was called: "How to prevent unawareness in your design practice". During this workshop the participants could reflect on one of their own projects to learn step-by-step about the different influencing factors on usability related decision-making and in particular about 'unawareness'.

The workshop contains an informative presentation which is alternated with assignments for the participants. After each step the examples are shared with the other participants, so that the participants are confronted with varying usability problems and development contexts. The assignments of the workshop could be related to the executed steps of the research method of Study 3 (please refer to 3.3.2 and 5.3.2), investigating a content-driven project, only more simplified. The first step is to list the usability issues of a product, and describe one of the issues in detail. Describing what the sources of this issue are,

identifying the decisions and basis that led to the source of the issue. The second step is to reconstruct and sketch a timeline of activities and the decisions that related to the usability issue. Step three is to explore which of the factors (design context, usability, or unawareness) had been of influence or whether it was a 'conscious decision' that led to the usability issue. With a 'conscious decision' they accepted the negative consequences for usability in favour of other product aspects. The fourth step is to identify the sources of the factor that induced it. The various steps of the workshop support the participant in reflecting on a project and thereby to investigate why decisions resulted in a product with usability issues. The result of the workshop was that the presented theory about the influencing factors on usability related decision-making could immediately be applied to a personal and well understood example. This resulted in a quick understanding for the participants of the various influencing factors. More information about this and following workshops can be found on the DfU project website: www.designforusability.org.

The positive reactions of the participants about the newly learned insights proved once again the relevance and benefits of the results of this PhD research project. The research project focussed on electronic consumer products, but during the workshop designers from the field of web design and human computer interaction were also attending. They also recognised the earlier stated influencing factors on usability related decision-making from their experiences. ◆

5.7 **Recommendations for future research**

The conducted studies in this PhD project answered several research questions, but also raised new questions. A number of possibilities for future research are stated in this section.

VERIFYING FRAMEWORK

Firstly it would be interesting to investigate whether the conceptual framework that emerged with its influencing factors on usability related decision-making can also be seen in different cases. In this PhD research project an explorative study at a design agency was executed and also a study at a world leading product development company. To further generalise and verify the findings, studies at different companies should be conducted or on different products, for example, a professional electronic product. These studies can indicate whether the influencing factors are especially of influence when developing electronic consumer products or whether the factors are also of influence in different projects. These additional cases may not only verify the current findings but could also identify other influencing factors or identify other elements, sources and types of the influencing factors already found.

ADDRESSING UNAWARENESS

The findings of this research identified three influencing factors on usability related decision-making in design practice. The most promising way to improve usability related decision-making would be to address the influencing factor unawareness, as influences of this factor actually resulted in 'incorrect' decisions and usability issues. Several suggestions were made in section 5.5.3 to address the sources of unawareness. However these suggestions were not yet validated in design practice. Therefore future research is necessary to define which approach or combination of approaches would be most effective in addressing the sources of unawareness.

INFLUENCING ELEMENTS

After conducting Study 3 it could be identified that the usability issues in this case resulted from unawareness or resulted from conscious decisions, i.e. decisions in favour of other product aspects than usability. The usability issues resulting from conscious decisions are outside the scope of this research project. The usability issues resulting from unawareness could be reduced by addressing the sources of unawareness in the decision-making process. Three sources of unawareness were identified and some elements of the design context could be related to the occurrence of the sources of unawareness. However it is not yet known in which situations unawareness will most likely occur or what the correlations between the elements and sources are. For example, the complexity of

products, the multidisciplinary teams, and changing goals might influence the inadequate project overview that could result in unawareness of the decision-maker. Though, how the elements of the design context influence the sources of unawareness is not yet known. It is not known either whether the current list of elements that characterise the design context is complete. Therefore future research is necessary to identify the elements that characterise the design context, and to determine how these elements influence the sources of uncertainty and unawareness and may predict the occurrence of the influencing factors uncertainty and unawareness.

MODELLING UNAWARENESS

A model of unawareness could be created when the correlations between the elements of the design context and the sources of unawareness are investigated in more detail. In this research project the influencing factor 'unawareness' was revealed and based on the two studies a proposition for the types and sources was made. So, the conceptual framework is the result of an explorative research to the influencing factors on decision-making and unawareness. The next question is how to obtain a better and more specific understanding of unawareness. Therefore more studies at different kind of companies and different kind of products are required. With these studies patterns could be investigated to specify the degree of unawareness and the correlations between elements, sources and types of the various influencing factors.

DECISION-MAKING MODEL IN DESIGN PRACTICE

At the start of this research project only limited sources of literature on design decision-making were available. Design literature does describe problem setting, framing, and co-evolution to reach a solution but the role of decision-making is not explicitly described. Therefore NDM literature was used as guidance for investigating decision-making in design practice. The PhD research project focussed on the aspect of influencing factors on decision-making from NDM literature. This literature also provided a model of how decisions are made in the 'real world context', this was not investigated within this project. A future research project could be conducted to pinpoint the task of decision making in design practice and thereby elaborate on the models from NDM theory. A better understanding of the decision task itself would provide more detail on how to support the decision-maker within the task.◆

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APPENDIX A:
Usability techniques

Appendix A: Usability techniques

In chapter 1 it was stated that there are numerous collections of usability techniques, divided over various sources. In this appendix an impression of the various collections and usability techniques is presented to provide insight into the many available usability techniques for product developers. This overview is partly based on the results of a final Master project within the Design for Usability project. This project resulted in *"an on-line library containing all methods and tools for User Centered Design, which are easily searchable, provides practical, actionable descriptions and intends to remain up-to-date with involvement of the UCD community"* [Weevers 2011], which can be found on the internet: www.ucdtoolbox.com.

VARIOUS SOURCES OF USABILITY TECHNIQUES

There are many different sources of collections of usability methods and techniques. Next, some examples for each of the following sources are presented: books, articles, internet and other.

BOOKS

An Introduction to Usability
Jordan, P.W. (1998)
Taylor & Francis, London

Design research: Methods and perspectives
Laurel, B. (2003)
The MIT Press, Massachusetts

Universal principles of design: 125 ways to enhance usability, influence perception, increase appeal, make better design decisions, and teach through design
Lidwell, W. and Holden, K. and Butler, J. (2010)
Rockport publisher, Massachusetts

Usability inspection methods

Nielsen, J. (1994B)
Wiley, New York

Interaction design
Preece, J., Sharp, H. and Rogers, Y. (2007)
John Wiley & Sons Ltd, West Sussex

Participatory design: Principles and practices
Schuler, D. and Namioka, A. (1993)
Lawrence Erlbaum Assiciates, New Jersey

Human Factors Methods: A practical Guide for engineering and design
Stanton, N.A., Salomon, P.M. Walker, G.H., Baber, C., Jenkins D.P. (2005)
Ashgate Publishin Company, Burlington

ARTICLES

UsabilityNet methods for user centred design
Bevan, N. (2003)
Human-computer interaction: theory and practice 1:434-438

User-Centred Design of Smart Products
Buurman den, R. (1997)
Ergonomics 40(10) 1159-1169

Designers' perceptions of methods of involving and understanding users
Goodman, J. and Clarke, S. and Langdon, P. and Clarkson, P. (2007)
Universal Acess in Human Computer Interaction 127-136

Designing for Usability: Key Principles and What Designers Think
Gould, J.D. and Lewis, C. (1985)
Communications of the ACM 28(3): 300-311

Key Principles for User-Centred Systems Design
Gulliksen, J., Goransson, B., Boivie, I., Blomkwist, S., Persson J., Cajander, A. (2003)
Behaviour and information technlolgy 22(6): 397-409

Methods to Support Human-Centred Design
Maguire, M. (2001)
International Journal of Human Computer Studies, 55(4): 587-634

INTERNET COLLECTIONS

Usability Body of Knowledge
www.usabilitybok.org

UsabilityPlanner
www.usabilityplanner.org

UsabilityNet
www.usabilitynet.org

Usability.gov
www.usability.gov
Kaist UCD Methods
http://dpl.kaist.ac.kr/design-methodology/Main_Page

Generic Work Process:
http://project.cmd.hro.nl/cmi/hci/toolkit/index2.php

Inclusive Design toolkit
http://www.inclusivedesigntoolkit.com/

Ideo Human Centered design toolkit
http://ideo.com/work/human-centered-design-toolkit

Selecting a remote research method
http://www.flickr.com/photos/clearleft/4931570875

Mental Notes card set
http://www.getmentalnotes.com/

UX Trading Cards
http://nform.com/tradingcards

Service Design Tools
http://servicedesigntools.org/

Designing with People
http://designingwithpeople.rca.ac.uk/

Toolbox
http://lltoolbox.eu/methods-and-tools/finding-opportunities

OTHER

Ideo method cards
http://www.ideo.com/work/method-cards

Namahn Human-Centered Design of Digital Interactions poster
http://namahn.com/resources/poster.htm

The Methods Lab booklet
http://www.education.edean.org/pdf/Tool039.pdf

VARIOUS CATEGORISATIONS OF USABILITY TECHNIQUES

Each of these collections of usability methods and techniques are categorised differently. For example, some are to alphabetical order, several to the phases of product development, and some to the type of techniques. The IDEO card set categorises 55 techniques to the types: learn, look, ask, and try. The on-line collection of 'Usability Body of Knowledge' categorises 40 techniques in alphabetical order. In the article of Maguire [Maguire 2001] are the techniques categorised to essential processes of the (software) development process: planning, context of use, requirements, design, and evaluation.

VARIOUS EXAMPLES OF USABILITY TECHNIQUES COLLECTIONS

The following tables are examples of usability techniques of the various stated sources.

PLANNING	CONTEXT OF USE	REQUIREMENTS	DESIGN	EVALUATION
usability planning and scoping	identify stakeholders	stakeholder analysis	brainstorming	participatory design
usability cost-benefit analysis	context-of-use analysis	user cost-benefit analysis	parallel design	evaluation workshop
	survey of existing users	user requirements interviews	design guidelines and standards	evaluation walkthrough or discussion
	field study / user observation	focus groups	storyboarding	assisted evaluation
	diary keeping	scenarios of use	affinity diagram	heuristic or expert evaluation
	task analysis	personas	card sorting	controlled user testing
		existing system / competitor analysis	paper prototyping	satisfaction questionnaires
		task/ function mapping	software prototyping	assessing cognitive workload
		allocation of function	wizard-of-oz prototyping	critical incidents
		user usability and organisational requirements	organizational prototyping	post-experience interviews

Table A-1: Usability techniques from 'Methods to Support Human-Centred Design' [Maguire 2001]

PLANNING & FEASIBILITY	REQUIREMENTS	DESIGN	IMPLEMENTATION	TEST & MEASURE	POST RELEASE
getting started	user surveys	design guidelines	style guides	diagnostic evaluation	post release testing
stakeholder meeting	interviews	paper prototyping	rapid prototyping	performance testing	subjective assessment
analyse context	contextual inquiry	heuristic evaluation		subjective evaluation	user surveys
iso 13407	user observation	parallel design		critical incidence technique	remote evaluation
planning	contextual inquiry	storyboarding		pleasure	
competitor analysis	focus groups	evaluate prototype			
	brainstorming	wizard of oz			
	evaluating existing systems	interface design patterns			
	card sorting				
	affinity diagramming				
	scenarios of use				
	task analysis				
	requirements meeting				

Table A-2: Usability techniques from UsabilityNet.org

LEARN	LOOK	ASK	TRY
activity analysis	a day in the life	camera journal	behaviour sampling
affinity diagrams	behavioural archaeology	card sort	be your customer
anthropometric analysis	behavioural mapping	cognitive maps	bodystorming
character profiles	fly on the wall	collage	empathy tools
cognitive task analysis	guided tours	conceptual landscape	experience prototype
character profiles	personal inventory	cultural probes	informance
cognitive task analysis	rapid ethnography	draw the experience	paper prototyping
competitive product survey	shadowing	extreme user interviews	predict next year's headlined
cross-cultural comparisons	social network mapping	five whys?	quick-and dirty prototyping
error analysis	still photo survey	foreign correspondents	role-playing
flow analysis	time-lapse video	narration	scale modelling
historical analysis		surveys and questionnaires	scenarios
long-range forecasts		unfocus group	scenario testing
secondary research		word-concept association	try it yourself

Table A-3: Usability techniques from IDEO card set

APPENDIX B:
Key documents

Appendix B: Key documents

In section 4.2.4 a detailed project description of project Bear was presented, supported by timeline II (*Figure 4-8* and *Figure 4-16*). This description and timeline were based on 99 key documents. All of these documents are presented in *Table B-1*. This table provides an overview of the key documents during data processing. Of each document is mentioned to which discipline it belongs (column 1), which are stated as 'design', 'management' and 'test'. The latter are mostly usability test documents. The column 'category' specifies what kind of document it is, for the design documents whether they are about the UI design or about the outer form, and for the test documents whether they are the test protocol or test results.d column shows the document type; Excel document, Word document, PowerPoint, etc., this was a welcome support when searching for the documents on the computer. The numbers are used for reference to the documents, some numbers are missing as less relevant documents were removed from the list. The fifth column states the name of the document, however for reasons of confidentiality the column is empty. The next column shows the date of the document, mostly the date stated within the document, sometimes supplemented with the 'digital date', the date mentioned within Microsoft Explorer. The authors of the document are stated in the last column using their fictitious names. ◆

DISCIPLINE	CATEGORY	TYPE	NO.	NAME	DOC DATE	AUTHOR
Design	product design	presentation	2		7-8-2006	Design
Design	UI design	xls	3		9-1-2007	Henry
Design	product design	presentation	4		14-2-2007	
Design	product design	presentation	5		15-2-2001	
Design	UI design	picture	7		27-2-2007	Emma
Test	protocol	report	8		27-2-2007	Emma
Design	UI design	simulation	9		1-3-2007	
Test	test protocol & results	ppt report	10		1-3-2007	Extern
Test	test protocol & results	ppt report	11		7-3-2007	Extern
Test	results	report	12		16-3-2007	Emma
Test	results	ppt report	13		16-3-2007	Emma
Test	test results	report	15		22-3-2007	Emma
Design	UI design	overview	16		26-3-2007	
Design	technical	report	18		12-4-2007	
Design	several issues	ppt report	19		4-5-2007	Emma
Management	project status	ppt report	20		7-5-2007	Thomas
Design	product design	ppt report	21		9-5-2007	Ian
Design	product design	ppt report	22		20-5-2007	Ian
Management	kick-off	presentation	24		22-5-2007	
Management	project review	presentation	25		22-5-2007	Thomas
Design	issues	ppt report	26		25-5-2007	Emma
Design	product design	ppt report	27		29-5-2007	design team
Design	product design	ppt report	28		30-5-2007	Ian
Design	workshop product & UI	ppt report	31		1-6-2007	Ian
Design	UI design	proposal	33		6-6-2007	

Design	product design	memo	37		20-6-2007	design team
Design	product design	proposal	43		28-6-2007	design team
Management	planning	overview	45		5-7-2007	Ben
Management	planning	overview	47			
Management	project review	presentation	49		10-7-2007	
Design	product design	proposal	51		20-7-2007	Craig
Design	UI design	proposal	52		23-7-2007	Clair
Design	UI design	proposal	53		23-7-2007	Clair
Design	UI design	proposal	54		24-7-2007	
Design		overview	57		27-7-2007	Emma
Design	product design	proposal	59			
Design	UI design	report	61		31-7-2007	Emma
Design	UI and product design	memo	62		2-8-2007	
Design	UI and product design	memo	63		13-8-2007	
Design	product design	overview	64		17-8-2007	design team
Management	planning	presentation	65			
Design	issues	overview	66		22-8-2007	
Management	project review	presentation	67		w734	
Design	UI design	overview	68			
Management	planning	overview	70			
Design	UI and product design	memo	72		13-8-2007	
Design	UI	ppt report	73		w738	Emma
Design	UI design	overview	75		6-9-2007	Emma
Design	UI design	overview	77		11-9-2007	Emma
Management	planning	overview	78			
Design	UI design	overview	79		11-9-2007	Emma

Design	UI design	overview	80			
Design	UI design	report	81		31-7-2007	Emma
Design	UI design	report	82		31-7-2007	Emma
Test	test protocol	report	83			Emma
Design	technical	memo	85			
Management	learnings	memo	89			
Test	Results	report	90		23-10-2007	Emma
Design	total design	overview	91		w743	Emma & Mandy
Design	UI design	proposals	92			
Management	project review	presentation	93		25-10-2007	
Design	UI design technical	memo	94		1-11-2007	Gerald
Design	total design	overview	96		w745	Emma & Mandy
Test	test protocol	report	97		12-11-2007	Emma
Test	results	report	98		15-11-2007	Emma
Design	UI design	overview	100			
Design	UI design	overview	101			
Test	test protocol	report	103		27-11-2007	Emma
Test	results	report	104		27-11-2007	Emma
Design	UI design	overview	108			
Design	UI design	overview	109		21-11-2007	
Test	protocol	report	114		20-12-2008	Emma
Design	UI design	memo	115		9-1-2008	Emma
Test	results	report	120		23-1-2008	Emma
Design	UI design	memo	121		29-1-2007	
Design	UI design	overview	123		29-11-2007	
Design	UI design	overview	124		29-11-2007	

Design	UI design	proposal	126		29-2-2008	Emma
Design	UI design	overview	127		29-2-2008	
Test	protocol	report	128		4-3-2008	Emma
Test	results	report	129		7-3-2008	Alice
Test	protocol	report	131		13-3-2008	Emma
Test	protocol	report	133		28-3-2008	Emma
Design	UI design	proposal	134			Alice
Design	UI design	overview	135		10-4-2008	
Test	results	report	137		10-4-2008	Alice
Test	protocol	report	138		28-3-2008	Emma
Test	results	ppt report	139		29-4-2008	Emma
Design	technical	memo	140		8-5-2008	
Test	results	memo	142		15-5-2008	
Test	results	ppt report	146		may 2008	extern
Management	learnings	overview	147			
Test	results	overview	148			
Design	attention points	report	148b		27-5-2008	usabilty team
Test	results	memo	150		25-6-2008	Emma
Test	protocol	report	151		13-3-2008	Emma
Test	results	ppt report	154		29-7-2008	Alice
Management	learnings	overview	155		9-10-2008	

Table B-1: 99 key documents of project Bear

Summary

Summary

REVEALING UNAWARENESS IN USABILITY RELATED DECISION-MAKING

Nowadays, many users experience usability issues with their electronic products. It does not work as they expect or otherwise irritates the user, so he becomes dissatisfied about the product and may even complain about it. These numbers of complaints to companies and usability issues are high and rising. Reasons for these increasing numbers are the highly complex electronic products that are being developed, the global economy in which they are created and produced, and the wide variety of users that uses the product.

It is highly challenging to develop these increasingly complex products and interactions and for the wide variety of users. So design for usability is becoming ever more important. Many usability techniques are available to create these products, however the pressure from the market results in limited time to develop usable products. This makes that feedback from the market is not available on time, that usability tests are skipped, and hasty decisions are made. This all, may lead to 'incorrect' decisions and consequently to usability issues. These are some of the aspects that complicate creating products and make that usability issues still occur, despite the available usability techniques. In design practice decision-making was investigated to find out what makes usability related decision-making 'go wrong'. This was in order to improve decision-making and thereby reduce the number of usability issues.

The research started with a literature study to clarify terms such as design and decision-making. Designing products is an iterative process to create products of which problem solving and finding creative solutions are part of. Within this process the designer encounters different kinds of problems; structured problems and ill-structured problems. Each of these problems requires different approaches; Rational Problem Solving for structured problems and Reflective Practice for ill-structured problems. Both approaches are used in the process of creating products.

In design theory only limited literature on decision-making is available, therefore it was required to study decision-making in fields beyond design. Naturalistic Decision Making (NDM) literature appeared to be an interesting perspective on decision-making, possibly relevant to design. NDM researchers observed decision-making in the 'real world', outside the laboratories. They realised that Rational Problem Solving is not always possible in the 'real world' as decision-makers have also to cope with ill-structured problems and other influencing factors and elements.

NDM researchers identified two factors that influence decision-making; the 'real world context' and 'uncertainty'. These factors influence the decision task, making it more difficult to make decisions, and affecting the quality of decisions possibly resulting in 'incorrect' decisions. The factor 'real world context' is characterised by various elements, for example, time pressure, iterative design and multiple stakeholders. The influencing factor 'uncertainty' is defined by the types what the decision-maker can be uncertain of and by the sources that induce uncertainty. Comparing these influencing factors from NDM theory with design theory showed a similarity between the elements that characterise the context and the aspects of uncertainty. This suggested that these influencing factors could also be relevant to decision-making in design. Therefore the NDM perspective was used to investigate usability related decision-making in design practice.

Knowing what influences usability related decision-making indicates how decision-making could be improved in order to reduce the number of usability issues. A first explorative study (Study 1) at a Dutch design agency was conducted to identify possible influencing factors on usability related decision-making. The results of eight retrospective interviews revealed three influencing factors on usability related decision-making:

- design context
- uncertainty
- unawareness

The third influencing factor, which was not mentioned in design literature, might be a critical factor as it could lead to unexpected surprises such as usability issues. Further investigation of this factor was required to verify whether unawareness actually is an influencing factor on usability related decision-making in design practice and whether it is critical or not.

A second study (Study 2) was conducted at a multinational product development company. At that time unawareness was still an undefined term. In order to identify unawareness the consequences of this influencing factor were investigated; unforeseen usability issues. This was done by conducting retrospective interviews with 14 key team members, which revealed various unforeseen usability issues. Tracing them back, it could be concluded that unawareness plays a role during decision-making in design practice and that it is a critical influencing factor as various unforeseen usability issues resulted from it. These critical and unknown influencing factor required further investigation.

The third study (Study 3) was a retrospective study at a multinational product development company to obtain a better understanding of the influencing factor 'unawareness'. The results were based on a document analysis of 2.056 project documents. This study provided detailed examples of unawareness during decision-making that resulted in unforeseen usability issues. A description of unawareness was made based on these various examples of unawareness in design practice. Unawareness is described – similar to uncertainty – by its types and sources.

Three types of unawareness were identified to describe what the decision-maker can be unaware of:

- unawareness about information
- unawareness about the consequences
- unawareness about decisions

Three sources were identified that contribute to unawareness:

- inadequate consideration
- inadequate overview
- fixation

In design practice, it is this influencing factor 'unawareness' that contributes to usability related decision-making going 'wrong'. This in spite of the many available usability techniques, these techniques do not address the sources of unawareness. Unawareness during the decision-making process results in decisions of poor quality, leading to 'incorrect' decisions and usability issues. Therefore unawareness in the design process needs to be reduced to improve the quality of usability related decisions. To do so, it is necessary to acknowledge this influencing factor, recognise the sources of the factor and address the sources that induce the unawareness. ◆

Samenvatting

Samenvatting

REVEALING UNAWARENESS IN USABILITY RELATED DECISION-MAKING

Tegenwoordig werken heel veel elektronische producten werken niet zoals de gebruiker verwacht, wat zorgt voor usability problemen. Dit irriteert de gebruiker waardoor hij ontevreden wordt over het product en zelfs begint te klagen. Het aantal klachten naar bedrijven toe is hoog en blijft stijgen. Redenen voor deze toenemende aantallen zijn de zeer complexe elektronische producten die worden ontwikkeld, de mondiale economie waarin ze worden gecreëerd en geproduceerd, en de grote verscheidenheid aan gebruikers die het product gebruiken.

Het is een grote uitdaging om deze complexe producten en interacties te ontwikkelen voor een grote verscheidenheid aan gebruikers. Daarom wordt design voor usability steeds belangrijker. Vele usability technieken zijn beschikbaar om deze complexe producten te ontwikkelen, echter de druk vanuit de markt zorgt voor een maar beperkte tijd om de producten te ontwikkelen. Dit zorgt ervoor dat feedback vanuit de markt niet op tijd beschikbaar is, dat usability testen worden overgeslagen en overhaaste beslissingen gemaakt worden. Dit alles kan leiden tot 'incorrecte' beslissingen en tot usability problemen. Dit zijn enkele aspecten die het ontwikkelen van producten bemoeilijken en ervoor zorgen dat usability problemen nog steeds voorkomen, ondanks de beschikbare usability technieken. De ontwerppraktijk is onderzocht om te achterhalen wat ervoor zorgt dat usability gerelateerde beslissingen 'verkeerd kunnen gaan'. Dit om de besluitvorming te verbeteren en daarmee het aantal usability problemen te verminderen.

Het onderzoek is van start gegaan met een literatuurstudie om duidelijkheid te krijgen over termen zoals ontwerpen en besluitvorming. Het ontwerpen van producten is een iteratief proces waarvan probleem oplossen en het vinden van creatieve oplossingen deel uit maken. Binnen dit proces krijgt de ontwerper te maken met verschillende soorten problemen; gestructureerde problemen en ongestructureerde problemen. Elk van deze problemen vraagt om een eigen aanpak; 'Rational Problem Solving' voor gestructureerde problemen en 'Reflective Practice' voor ongestructureerde problemen. Beide aanpakken worden gebruikt in het proces van product ontwikkeling.

In de ontwerptheorie is maar beperkte literatuur beschikbaar over besluitvorming; daarom was het noodzakelijk om besluitvorming the bestuderen in velden buiten ontwerpen. De literatuur van 'Naturalistic Decision Making' (NDM)

bleek een interessant perspectief op besluitvorming te bieden, een mogelijk relevant perspectief voor besluitvorming binnen ontwerpen. NDM onderzoekers hebben besluitvorming in de 'echte wereld' geobserveerd, dus buiten de laboratoriums. Zij hebben gevonden dat 'Rational Problem Solving' niet altijd mogelijk is in de 'echte wereld' omdat beslissingmakers ook moeten omgaan met ongestructureerde problemen en andere invloedsfactoren en elementen. Dit maakt het een relevant perspectief voor ontwerpen.

De NDM onderzoekers hebben twee factoren geïdentificeerd die besluitvorming beïnvloeden; de 'context van de echte wereld' en 'onzekerheid'. Deze factoren beïnvloeden de beslissingstaak, ze maken het lastig om beslissingen te maken, ze beïnvloeden de kwaliteit van beslissingen en resulteren mogelijk in 'incorrecte' beslissingen. De factor 'context van de echte wereld' wordt gekenmerkt door verschillende elementen, bijvoorbeeld tijdsdruk, iteratieve processen en meerdere teamleden. De invloedsfactor 'onzekerheid' wordt bepaald door soorten waarover men onzeker kan zijn en de bronnen die onzekerheid veroorzaken. Het vergelijken van deze invloedsfactoren uit de NDM theorie met ontwerptheorie toonde een overeenkomst tussen de elementen die de context kenmerken en de aspecten die onzekerheid bepalen. Dit suggereerde dat de invloedsfactoren ook van belang kunnen zijn voor besluitvorming tijdens ontwerpen. Daarom is het NDM perspectief gebruikt om usability gerelateerde beslissingen in de ontwerppraktijk te bestuderen.

Wanneer bekend is wat de usability gerelateerd besluitvorming beïnvloedt wordt het ook duidelijk hoe de besluitvorming verbeterd kan worden om het aantal usability problemen te verminderen. De eerste exploratieve studie (Study 1) was uitgevoerd bij een Nederlands ontwerpbureau om de mogelijke invloedsfactoren op usability gerelateerde besluitvorming te identificeren. Het resultaat van acht retrospectieve interviews onthulde drie invloedsfactoren op usability gerelateerde besluitvorming:

- Ontwerp context
- Onzekerheid
- Onbewustheid

De derde invloedsfactor, welke niet genoemd werd in de literatuur, is wellicht een kritische factor omdat het kan leiden tot onverwachte verrassingen zoals usability problemen. Verder onderzoek naar deze factor was noodzakelijk om te verifiëren of 'onbewustheid' inderdaad een invloedsfactor op usability gerelateerde beslissingen in de ontwerppraktijk is en of het wel of niet een kritische factor is.

Een tweede studie (Study 2) is uitgevoerd bij een multinationaal productontwikkelingsbedrijf. Op dat moment was 'onbewustheid' een nog niet-gedefinieerde term. Om onbewustheid te kunnen identificeren werden de gevolgen van deze invloedsfactor bestudeerd; onvoorziene usability problemen. Dit is gedaan door retrospectieve interviews te houden met 14 kern teamleden, waardoor verschillende onvoorziene usability problemen onthuld werden. Het traceren van deze problemen laat zien dat 'onbewustheid' een rol speelt tijdens de besluitvorming in de ontwerppraktijk en dat het een kritische invloedsfactor is omdat verschillende onvoorziene usability problemen het gevolg waren. Deze onbekende en kritische invloedsfactor vroeg om nader onderzoek.

De derde studie (Study 3) was een retrospectieve studie bij een multinational productontwikkelingsbedrijf om een beter begrip van de invloedsfactor 'onbewustheid' te verkrijgen. De resultaten zijn gebaseerd op een analyse van 2,056 projectdocumenten. Deze studie resulteerde in gedetailleerde voorbeelden van onbewustheid tijdens de besluitvorming die leidde tot onvoorziene usability problemen. Een beschrijving van onbewustheid kon worden gemaakt op basis van deze verschillende voorbeelden in de ontwerppraktijk. Onbewustheid is beschreven – gelijk aan onzekerheid – aan de hand van de soorten en bronnen van onbewustheid.

Drie soorten van onbewustheid zijn geïdentificeerd waarover de beslisser onbewust kan zijn:

- Onbewustheid over informatie
- Onbewustheid over de gevolgen
- Onbewustheid over de beslissingen

Drie bronnen die bijdragen aan onbewustheid zijn geïdentificeerd:

- Onvoldoende overweging
- Onvoldoende overzicht
- Fixatie

In de ontwerppraktijk is het deze invloedsfactor 'onbewustheid' die bijdraagt aan het 'verkeerd gaan' van usability gerelateerde beslissingen. Dit ondanks de beschikbare usability technieken, want deze technieken adresseren niet de bronnen van onbewustheid. Onbewustheid tijdens de besluitvorming resulteert in beslissingen van slechte kwaliteit die leiden tot 'incorrecte' beslissingen en usability problemen. Daarom is het noodzakelijk om onbewustheid in het ontwerpproces te verminderen om de kwaliteit van usability gerelateerde beslissingen te verbeteren. Om dit voor elkaar te krijgen is het nodig om deze invloedsfactor te erkennen, de bronnen van de factor te herkennen en deze aan te pakken. ◆

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About the author

Christelle Harkema (1979) obtained her Master's degree in Industrial Design Engineering at the Delft University of Technology. During her master the focus was on research and ergonomics. Afterwards she worked several years as a usability specialist at Indes, a design agency in Enschede. In October 2007 she started her PhD within the project 'Design for Usability' at the department Industrial Design at the Eindhoven University of Technology. ◆

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