EXPLORING AND IMPLEMENTING PLEASANT TOUCH IN THE INTERFACE OF PRODUCTS FOR DESIGN PURPOSES: THE CASE OF A BANG & OLUFSEN TV REMOTE CONTROL

A THESIS SUBMITTED TO
THE GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES
OF
MIDDLE EAST TECHNICAL UNIVERSITY
AND
DELFT UNIVERSITY OF TECHNOLOGY

BY

TIRZA JOHANNA MARIA FENNIS

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR
THE DEGREE OF MASTER OF SCIENCE
IN
DESIGN RESEARCH FOR INTERACTION
IN
INDUSTRIAL DESIGN

AUGUST 2012

Approval of the thesis:

EXPLORING AND IMPLEMENTING PLEASANT TOUCH IN THE INTERFACE OF PRODUCTS FOR DESIGN PURPOSES: THE CASE OF A BANG & OLUFSEN TV REMOTE CONTROL

Submitted by **TIRZA JOHANNA MARIA FENNIS** in partial fulfillment of the requirements for the degree of **Master of Science in Design Research for Interaction, Department of Industrial Design, Middle East Technical University** and **Faculty of Industrial Design Engineering, Delft University of Technology** by,

Prof. Dr. Canan Özgen _____
Dean, Graduate School of **Natural and Applied Sciences, METU**

Prof. Daan J. van Eijk M.Sc. _____
Dean, **Industrial Design Engineering, DUT**

Assoc. Prof. Dr. Gülay Hasdoğan _____
Head of Department, **Industrial Design, METU**

Assoc. Prof. Dr. Bahar Şener-Pedgley _____
Supervisor, **Industrial Design, METU**

Assist. Prof. Dr. Marieke Sonneveld M.Sc. _____
Supervisor, **Industrial Design Engineering, DUT**

Dr. Marco Rozendaal M.Sc. _____
Co-Supervisor, **Industrial Design Engineering, DUT**

Examining Committee Members:

Assoc. Prof. Dr. Gülay Hasdoğan _____
Industrial Design Department, METU

Assoc. Prof. Dr. Bahar Şener-Pedgley _____
Industrial Design Department, METU

Assist. Prof. Dr. Marieke Sonneveld M.Sc. _____
Faculty of Industrial Design Engineering, DUT

Inst. Figen Işık M.A. _____
Industrial Design Department, METU

Anemarie Mink M.Sc. _____
Faculty of Industrial Design Engineering, DUT

Date: 15 August 2012

I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

Name, Last name :

Signature :

ABSTRACT

EXPLORING AND IMPLEMENTING PLEASANT TOUCH IN THE INTERFACE OF PRODUCTS FOR DESIGN PURPOSES: THE CASE OF A BANG & OLUFSEN TV REMOTE CONTROL

Fennis, Tirza Johanna Maria
M.Sc., Department of Industrial Design, METU
M.Sc., Faculty of Industrial Design Engineering, DUT

Supervisor (METU): Assoc. Prof. Dr. Bahar Şener-Pedgley
Supervisor (DUT): Assist. Prof. Dr. Marieke Sonneveld
Co-Supervisor (DUT): Dr. Marco Rozendaal M.Sc.

August 2012, 146 pages

This thesis proposes a design strategy for pleasant touch. Literature is reviewed on the importance of pleasant touch, existing implementations in products and design for tactility. A lack of competence is found on how to design for pleasant touch in the interface of products: functional pleasant tactility. Therefore, a design vision is created by the author as a designer, on how to design functional pleasant tactility. The envisioned design strategy is then implemented through a study where a Bang & Olufsen TV remote control was used as an example case.

The study includes three sequential phases: exploring, designing, and evaluating functional pleasant tactility in the given context. Exploring was done through workshops where design students were asked to touch objects with various material properties. Pleasant movements were performed with the objects, and matching functions were imagined, resulting in 'actions'. Those actions were analyzed to discover three underlying themes of inviting, mastery and logic. In the designing phase, those themes were translated into three corresponding design concepts, and worked out into prototypes. In the evaluating phase, those prototypes were tested with that target group, and the results were used to create a final design concept.

The study then concludes with a design strategy that is expected to work for the broader context of industrial design, and recommendations for further research with this strategy and different products or companies are also provided.

Keywords: Pleasant Touch, Functional Pleasant Tactility, Design Strategy, TV Remote Control

ÖZ

ÜRÜN ARAYÜZLERİNDE HOŞA GİDEN DOKUNMANIN TASARIM AMAÇLI ARAŞTIRILMASI VE UYGULANMASI: BANG & OLUFSEN TV UZAKTAN KUMANDASI ÖRNEĞİ

Fennis, Tirza Johanna Maria
M.S., Endüstri Ürünleri Tasarımı Bölümü, ODTÜ
M.S., Endüstriyel Tasarım Mühendisliği Fakültesi, DUT

Tez Yöneticisi (ODTÜ): Doç. Dr. Bahar Şener-Pedgley
Tez Yöneticisi (DUT): Y. Doç. Dr. Marieke Sonneveld
Ortak Tez Yöneticisi (DUT): Dr. Marco Rozendaal M.Sc.

Ağustos 2012, 146 sayfa

Bu tez çalışması, hoşa giden dokunmaya yönelik bir tasarım stratejisi önermektedir. İlgili literatürün araştırılmasının ardından, ürün arayüzlerinde hoşa giden dokunmaya yönelik tasarımda 'işlevsel hoşa giden dokunma' konusunda gerekli yetkinliğin bulunmadığı tespit edilmiştir. Buna bağlı olarak, yazar, tasarımcı rolünü üstlenerek işlevsel hoşa giden dokunma üzerine bir tasarım vizyonu yaratmıştır. Ardından, öngörülen tasarım stratejisi, Bang & Olufsen televizyon uzaktan kumandası üzerinden örneklenerek uygulanmıştır.

Çalışma, birbirini takip eden üç aşamayı içermektedir: keşif; tasarım; işlevsel hoşa giden dokunmanın ilgili bağlamda değerlendirilmesi. İlk aşama, tasarım öğrencilerinin farklı malzeme özelliklerindeki nesnelere dokunarak keşfetmelerini içeren çalıştaylardan oluştu. Nesneleri keşfederken yapılan hoşa giden hareketler ürün işlevleriyle eşleştirilerek 'eylemler' elde edildi. Bu eylemler analiz edildiklerinde davetkârlık, ustalık ve mantık olmak üzere üç tema ortaya çıktı. Tasarım aşamasında, bu temalar üç ayrı tasarım konseptine dönüştürüldü ve prototipleri yapıldı. Değerlendirme aşamasında ise, prototipler hedef kitle ile test edildi, sonuçlar nihai tasarım konseptini oluşturma amaçlı kullanıldı.

Çalışma, daha geniş kapsamlı endüstriyel tasarım alanında uygulanabilmesi öngörülen bir tasarım stratejisi ve daha sonra yapılabilecek araştırma önerileri ile son bulmaktadır.

Anahtar kelimeler: hoşa giden dokunma, işlevsel hoşa giden dokunma, tasarım stratejisi, TV uzaktan kumandası

To My Parents

ACKNOWLEDGEMENTS

This thesis is dedicated to the author's parents, because they have always supported her decisions, displayed confidence in her capabilities, showed interest in her studies, provided financial support when necessary, gave advice when needed and were always willing to participate in user studies.

The author wishes to express her gratitude to her Supervisors Marieke Sonneveld, Bahar Şener-Pedgley and Marco Rozendaal for their guidance, advice, criticism, and insights throughout the preparations, research and thesis writing.

The author would also like to thank Ditte Hvas Mortensen for her guidance and help inside the company Bang & Olufsen.

The technical assistance of Ole Jensen and the Prototyping Department of Bang & Olufsen (Struer, Denmark) are gratefully acknowledged.

A word of thanks is also given to all those who have participated in the research, and friendly fellow students with whom thoughts were shared during the process.

Any questions or comments can be addressed to Tirza@Fennis.nl.

TABLE OF CONTENTS

LIST OF TABLES

TABLES

LIST OF FIGURES

FIGURES

CHAPTER 1

INTRODUCTION

1.1. BACKGROUND

During the Bachelor's program of Industrial Design Engineering at the Delft University of Technology (DUT) students are encouraged to read books related to design. The books of Donald Norman (1988; 2004; 2007) can be listed as the most frequently read ones. His books deal with the difference between good and bad design, and make people realize how often they come across bad design. An example of bad design is a door handle; there are so many types of door handles, like knobs, bars, turning handles, or just a plate. Some of those handles invite people to push the door open, like a plate, and some invite pulling, like a bar (see figure 1.1).

Figure 1.1: Example of intuitive push plate and pull handle on door
(http:/www.betterimprovement.com/door-pushpull; *retrieved 18 July 2012*)

However, it is often the case that a door has the same handles on both sides, but they require the opposite movement to open; the labels 'push' and 'pull' are then put on opposite sides (see figure 1.2), which is very confusing. Instructions should not be required for simple things like opening doors, because reading requires thinking and opening a door should be unconscious behavior. This design of door handles is inherently linked to touch (or tactility), because handles require to be

touched in order to use them. Therefore, a more intuitive design for tactility could improve the design of door handles.

Figure 1.2: Example of the same door handles on both sides of the door where push and pull labels are required (http://chriselyea.com/design-lessons-learned/badly-designed-doors/ *retrieved 18 July 2012*)

Another example of poor design is buttons; on telephones or remote controls they often look and feel exactly the same (except for a small symbol on them, like an arrow, number or colored square), although they all have different functions (see figure 1.3). It is no wonder that people get confused; especially when each remote control or telephone from a different brand uses different positioning for the same buttons, such as the buttons for switching channels or adjusting volume on remote controls, or select and return buttons on mobile phones.

Such frustrations could be removed if existing designs were improved in functionality, and more precisely with tactility in mind; in cases where the focus should be on the screen, rather than the buttons, tactility becomes more important than appearance. Therefore, the functioning of such products can be made less confusing by focusing on intuitive design for tactility. However, currently there is not enough known on how this could be achieved; therefore further research is required.

Figure 1.3: Example of a poor designed remote control with similar buttons only (http://www.memorybits.org.uk/sumvision-cyclone-micro-remote-control/ *retrieved 18 July 2012*)

Later on, in the Master of Science program Design for Interaction at DUT, as part of her teaching Marieke Sonneveld introduced the topic of 'pleasant tactility': nice to touch. This is where the author's enthusiasm for implementing pleasant tactility into existing products, to improve functionality, started; as Donald Norman (1988) said: Pleasant things work better. The exact cause of pleasant tactility was explored (skin sensations, material properties and movements), so the newly gained knowledge could immediately be used in this research. Moreover, the topic is quite new and unexplored, and has a lot of potential to be used by designers.

The company Bang & Olufsen (B&O) designs and manufactures devices for Home Entertainment Systems, including remote controls (see figure 1.4 for an example of a B&O remote control), with special attention to "high quality", "great service", "unique design" and "surprising interactions" (Bang&Olufsen, 2012). Focusing on uniqueness and surprising, long-lasting interactions provides a great opportunity for B&O to differentiate their products from competitors through the use of pleasant tactility rather than visual pleasantness alone. Therefore they were interested in giving support to the author's research.

Figure 1.4: Beo4 remote of Bang & Olufsen (http://beophile.com/?page_id=240 *retrieved 18 July 2012*)

1.2. PROBLEM STATEMENT

Tactility refers to all the qualities that can be felt through the sense of touch, including skin senses, muscle strength and tendon position (Vavik & Kourennayia, 2006). Pleasant tactility has been explored recently, with a focus on which movements people perform when they try to decide whether it feels pleasant (affective tactile movements). Those movements can be linked to functions of, for example, a TV-system remote control (like caressing something soft to adjust the volume), which can be coined 'functional pleasant tactility'.

Functional pleasant tactility could be a great quality for differentiation in product design, especially for products that look similar for different brands, like cameras (Spence & Gallace, 2011) or remote controls; if there are no tactile attributes to differentiate the product from its competitors, and the appearance is similar, then people will be unable to differentiate the brands on visual attributes alone.

More importantly, the before mentioned frustrations caused by poor tactual design can be solved using functional pleasant tactility in human-product-interaction, because tactility is a very intuitive way of interacting with products (Han, 2006), which is exactly what was missing in the design of those door handles and buttons; the functioning could not be understood intuitively. Frustrations of using a product are of course never good, so it is important to make a product intuitive to use.

Designing for functional pleasant tactility can result in intuitive functioning of products, but also adds a pleasant attribute to the product; the product will *feel nice* in use. This positive user experience is what will make people want to use the product again. The other way around, if a product feels tactually unpleasant (and causes frustrations), people do not want to use the product again. This should of course be avoided.

Furthermore, using functional pleasant tactility as the starting point for a product design can result in very creative designs, because the designs will be 'movement-driven' (the designs will be based on pleasant tactile movements, related to functions) rather than 'user-driven' (based on what users want) or 'technology-driven' (based on new technology). A different design focus can result in different (creative) designs, which is needed to keep life exciting; similar products will make life dull, in the authors' opinion.

Designing for functional pleasant tactility can thus solve frustrations, resulting in a nice touch, a positive user experience, creative designs and repeated use. Yet, designers lack a proper design strategy on how to design for it, because it is quite a new and unexplored concept; research is required.

1.3. RESEARCH AIM AND GOALS

The aim of this research is to explore how pleasant tactility can be implemented in the functioning of products (a design strategy), and what this means for designers. The final objective is therefore to develop a strategy for designing products with functional pleasant tactility. This design strategy can then be used by designers.

The goals (or steps to be taken) are to *explore*, *design* and *evaluate* functional pleasant tactility for the specific case of a B&O television-system (TV) remote

control (a case study), which leads to insights that can be useful in the broader context of industrial design.

1.4. MAIN RESEARCH QUESTIONS

The main question of this research is:

"How can pleasant tactility be implemented in the functioning of products (as a design strategy)?"

Following are the sub-questions that need to be answered through both literature reviews and fieldwork, in order of appearance:

Q.1. How can pleasant tactility be defined?

Q.2. How and in what products is (functional) pleasant tactility currently used?

Q.3. What is currently known about designing for (functional) pleasant tactility?

Q.4. What is functional pleasant tactility in the context of a B&O TV remote?

Q.5. What are the underlying themes of functional pleasant tactility in the context of a B&O TV remote?

Q.6. How can the themes be used in designing a B&O TV remote?

Q.7. What will be the result of implementing the themes in a B&O TV remote?

Q.8. How do people respond to the resulting B&O TV remotes?

Q.9. What does this mean for the design practice?

1.5. EXPECTED OUTCOME

As mentioned before, a clear strategy on how to design for functional pleasant tactility is lacking. Information for this strategy can be gathered through research. Presenting the strategy as a competence will allow designers to acquire it in order to successfully design for functional pleasant tactility. Competence can be defined[1] as a combination of knowledge, insights, skills and attitude (Dankers-van der Spek, 2008). A competence is what is necessary to perform a task, like designing. The four aspects of competence are explained below.

[1] Most definitions of competence include the words 'knowledge' and 'skills' (Cambridge University Press, 2012; Business Dictionary, 2012; Dictionary, 2012; Farlex, 2012) but they mention 'ability' and 'capability' as well, which are synonyms of competence. According to Tempelman and Pilot (2011), competence is comprised of the three elements 'knowledge', 'skills' and 'attitude', and their 'relation' to each other. The Dutch definition uses the word 'insights' as an addition to those three elements (Dankers-van der Spek, 2008; Management Start, 2006), which can replace the 'relation', because they both deal with understanding. The word 'commitment' is also used (Business Dictionary, 2012), but can be seen as part of 'attitude'.

Knowledge is the element of knowing. An example of knowledge in the field of design is to know what symmetry is, in order to recognize it in products.

Insight is the element of understanding. An example of an insight in the field of design is to recognize the product aspects that make a product line.

Skill is the element of doing. Many examples of designer skills can be given, such as drawing, prototyping, teamwork, etc.

Attitude is the element of the way things are done; the manner of doing. A designer attitude can be to design for one specific person's problem, expecting that many people will have that exact same problem (one-size-fits-all).

A design strategy in the form of a competence is initially envisioned for designing functional pleasant tactility in the context of a B&O TV remote, and through research (the case study of the B&O TV remote) the expected outcome is a design strategy that will work in the broader context of design.

1.6. SCOPE OF THE STUDY

The research includes exploring, designing and evaluating functional pleasant tactility for the case of a B&O remote control (see figure 1.5 for a complete overview of the entire research). The results of the research will then be used to create a design strategy for the broader context of industrial design.

The scope of the study is limited in that the results of the research only count for one specific product (a B&O TV remote); further research should be done with other products in completely different categories, like the field of automotive or packaging, and for different companies, to verify that the strategy can be used in the broader context of industrial design.

The scope of the study is also limited to the researcher's subjectivity, the small amount of user study participants, the involvement of the company, and the short amount of time.

Despite these limitations, the outcome of the research should be valuable, because the basics of the expected strategy have been proven to work throughout design education (see Chapter 4: Design Vision for Functional Pleasant Tactility for details). The limitations are expected not to have a big bearing on those basics.

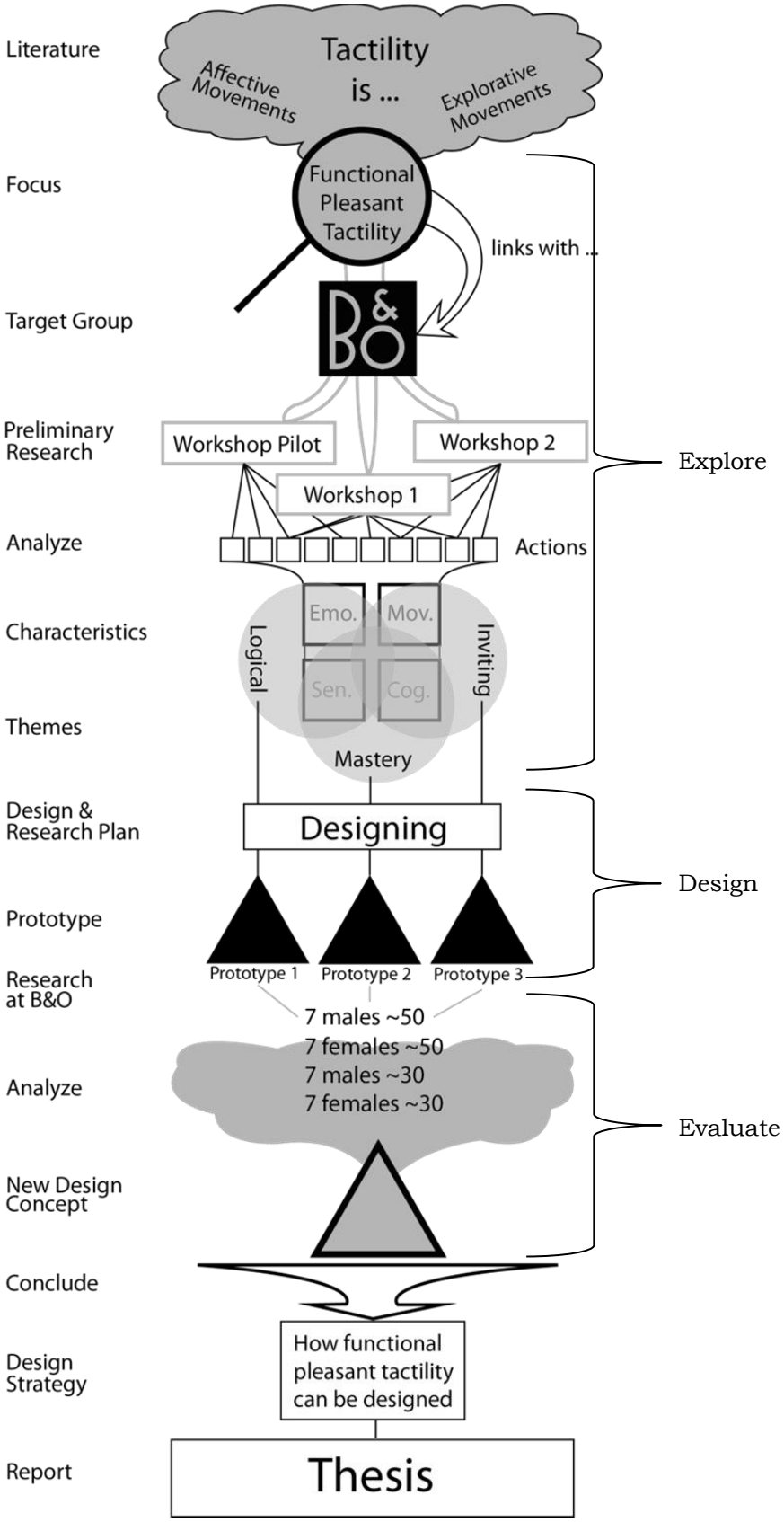


Figure 1.5: Overview of the Research

1.7. BENEFICIARY OF THE STUDY

Designers and students can benefit from the outcome of this research, since it provides them with the appropriate background information, strategy and example of implementation for designing functional pleasant tactility in products.

Design researchers can benefit from the outcomes as well, because they can elaborate on this research by, for instance, performing a similar research with different product categories or by researching different methods to achieve the same result.

Finally, the design educators could benefit from the outcomes, because they can provide students with the design strategy as a self-guide, so they will have more time answering expert questions.

1.8. DEFINITIONS OF TERMS

Tactility refers to all the qualities that can be felt through the sense of touch, which means that the terms 'tactility' and 'touch' refer to the same thing. The sense of touch includes skin senses, muscle strength and tendon position, therefore kinesthetics is also part of tactility. The term haptic is defined as being of or relating to the sense of touch (Farlex, 2012). Therefore, haptics, tactility and touch are used interchangeably. The same goes for the words 'tactile' and 'tactual'.

Pleasantness is a synonym of the word 'nice'. Pleasant is defined as "enjoyable, attractive, friendly, or easy to like"; nice is described similarly, as "pleasant, enjoyable or satisfactory" (Cambridge Dictionary, 2012). Pleasant is used here as the translation of the Dutch (and South-African) word 'lekker', which can be used in many contexts, but is always meant positively.

The functioning of a product refers to how a product works or operates, like function is defined as "to work or operate" (Cambridge Dictionary, 2012). Therefore, the word functional is defined as "designed to be practical and useful rather than (visually) attractive" (Cambridge Dictionary, 2012). In the concept of functional pleasant tactility, the term functional thus refers to the product-part that is being touched during use (interface), so pleasant tactility is practical and useful.

1.9. STRUCTURE OF THE THESIS

Chapter 1 sets the background for this research, and introduces the thesis. In Chapter 2 the Importance of Touch is presented to answer the first three research questions (Q.1-Q.3), after which the methodological framework of the research is introduced in Chapter 3: Methodology. The research required the envisioning of a design strategy (Chapter 4: Design Vision for Functional Pleasant Tactility) as a starting point, which led to testing the strategy by implementing it for the specific case of a B&O TV remote: an exploration of functional pleasant tactility in the context of a B&O TV remote was conducted and offered in Chapter 5: Exploring Functional Pleasant Tactility (answering Q.4 and Q.5), followed by designing functional pleasant tactility for the B&O TV remote in Chapter 6: Designing Functional Pleasant Tactility (answering Q.6 and Q.7), and evaluating functional pleasant tactility for the B&O TV remote in Chapter 7: Evaluating Functional

Pleasant Tactility, with a final design concept (answering Q.8). This resulted in making the envisioned strategy concrete for the broader context of industrial design in Chapter 8: Design Strategy for Functional Pleasant Tactility). Finally, the results are discussed and reflected upon in Chapter 9: Conclusions (answering Q.9).

CHAPTER 2

IMPORTANCE OF TOUCH

2.1. CHAPTER INTRODUCTION

The literature review on touch was carried out in the areas of product design, design research and everyday life. The aim was to discover the depth of the research area, to understand the research topic of functional pleasant tactility better and to present the relevance of the research. Because this research elaborates on Marieke Sonneveld's research on pleasant tactile movements (*forthcoming*), her previous work (Sonneveld, 2007) has been used as the main source of information.

All this background information will be presented in the following sections, commencing with the broad topic of tactility, then leading to more specific uses relevant to industrial design.

2.1.1. Research Questions

The following research questions were aimed to be answered through the literature review.

Q.1. How can pleasant tactility be defined?

Q.2. How and in what products is (functional) pleasant tactility currently used?

Q.3. What is currently known about designing for (functional) pleasant tactility?

With these research questions in mind, findings from the literature are presented under five topics: tactility, pleasant tactility, functional pleasant tactility, current implementations and design for tactility. The following paragraphs will present the findings and finish with the main conclusions.

2.2. TACTILITY

Touch, or tactility, is one of the human senses, like sight and hearing. Tactility is, however, very different from for instance sight in the amount of different things it senses; sight refers to the eyes sensing light frequencies, but tactility refers to the combination of skin (or dermal) sensors, tendon positions and muscles sensing temperature, pressure, strain, etc. (Saladin, 2001). Tactility therefore makes a person experience sensations like pain when something is too hot, too cold or too much pressure, or prickling when something pointy touches the skin (Vander, Sherman & Luciano, 2001). Some parts of the body can differentiate between small textures, like Braille, better than other parts of the body. This is because those dermal sensors are more sensitive for discrimination on some places of the body (see figure 2.1), like the tongue, lips and hands, and less sensitive on other places of the body, like the legs and arms, which can also differ slightly per person (Lederman & Klatzky, 1998).

Figure 2.1: Sensory Homunculus (http:/aimse.blogspot.com/2011/01/sensory-homunculus.html *retrieved 18 July 2012*)

In general, tactility plays an important role throughout the human life. As an infant, the physical world is first experienced through touch (Dewey, 1938); babies do not see much yet, but they can feel the surroundings with their bodies and interact with the physical world that way. By touching physical matter, infants also recognize the boundary between themselves and the material world, which creates self-awareness (Bermudez, Marcel & Eilan, 1995); when the child hits his arm against a table leg, he does not just discover that there is a table leg there, but also that his arm is part of himself, because he can feel the pain. This boundary is also where the difference between active (touching) and passive (being touched) tactility can be found (Gibson, 1962); a person touching a ball might notice its material and flexibility (active touch), but at the same time the ball touches the skin which the person can notice through the pressure on and temperature change of the skin (passive). This is also noticeable in tactility between people; when one person touches another, the other touches the one simultaneously.

Tactility between people (interpersonal touch) is also a very broad topic (Gallace & Spence, 2010). Infants first learn to communicate through touch (Finnegan, 2002). Touch is even the main language for communicating affection, and different types of touch can be identified, like public touch, sexual touch, etc. (Fagan, 1998). Therefore, through touch, feelings and emotions are also created (Montagu, 1971; Fields, 2003). Tactility can even be seen as a language on its own; communication through touch only. This can be explained by the fact that there are not many words that describe different feelings of touch; touch exceeds words (Polyani, 1967). Simply put, what people feel through touch cannot easily be described with words; it can only be understood through touch itself, which makes it a language on its own.

It should be noted, however, that the older people get, the less sensitive their sense of touch will become. The elderly do not just lose eyesight and hearing, but also tactual (discriminative) sensitivity (Ijsselsteijn, 2007). This is another reason why attention should be paid to tactility in design. Many other topics relate to touch as well, like culture, art, medicine, etc. (Classen, 2005), and more importantly (for this research), design for interaction. Interaction design is related to touch, because

tactility is a very intuitive way of interacting (Han, 2006); the following section on pleasant tactility will focus on touch in interaction design.

2.3. PLEASANT TACTILITY

In the field of design for interaction, one of the important aspects is how 'nice', 'pleasant' or 'enjoyable' a product feels to touch, which can be defined as 'pleasant tactility'. Experiencing this (pleasant) tactility is illustrated by the elaborated version (see figure 2.2) of the basic human-product interaction model, called the "Tactile Experience Model". The older basic human-product interaction model by Dirken (1997) only defines an action between (inter-action) the attributes of the human (physical, sensomotoric, cognitive and affective) and the attributes of the product (geometrical, material and mechanical), in a physical and social context.

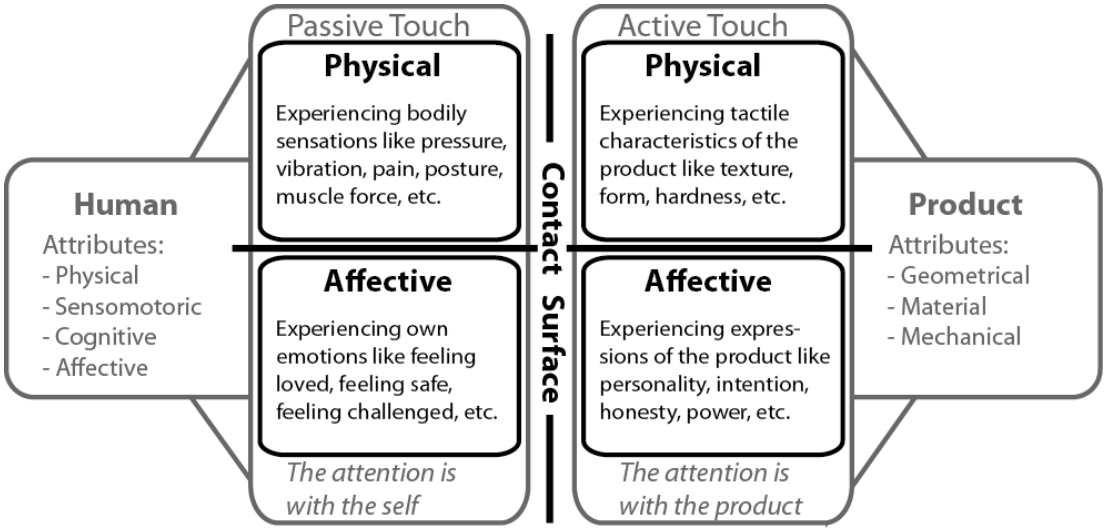


Figure 2.2: Tactile Experience Model (Sonneveld, 2010a; translated by author)

The elaborated version (figure 2.2) by Sonneveld (2010a) describes how a product is tactually experienced by people. On one side is the human with its attributes and on the other side is the product with its attributes, just like in the basic model. In between is the contact surface, or the interface, where the interaction happens. The model also shows the difference between active and passive touch; passive touch is on the human side, because the attention is with the self, and active touch is on the product side, because the attention is with the product. Therefore, passive human-product interaction can be seen as sensing and feeling, and active human-product interaction as moving and thinking.

Moreover, this expanded model includes the physical and affective aspects of tactility. On the human side, the physical aspects of passive touch are experienced through sensing, because the bodily sensations are felt. On the product side, the physical aspects of active touch are experienced through moving, because tactile characteristics of the product are explored. The affective aspects of touch are experienced through feeling on the passive side and thinking on the active side; the

reasons can similarly be found in figure 2.2. It is now clear that tactility in the field of design for interaction is relevant and has many aspects.

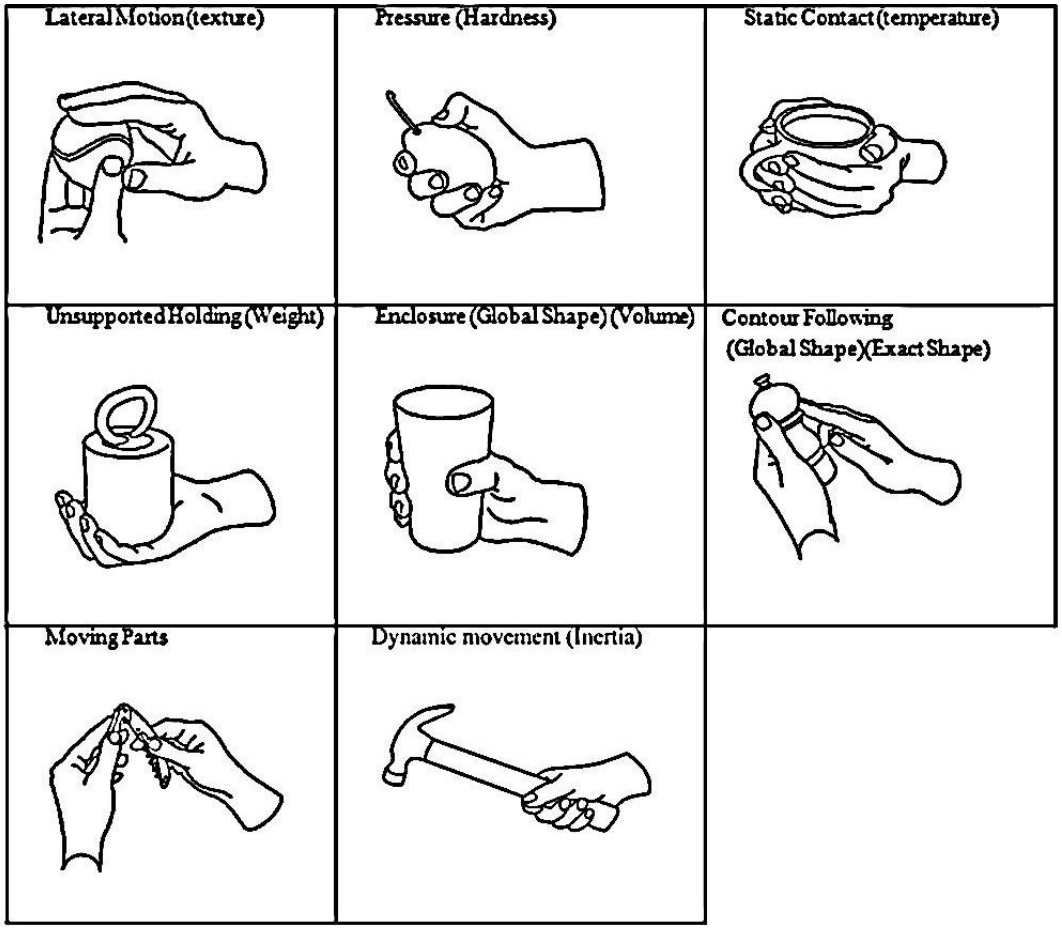


Figure 2.3: Exploratory Movements (Sonneveld, 2007)

In human-product interaction, touch is also used (while the other senses are blocked) in identification (Klatzky, Lederman & Metzger, 1985). Specific exploratory movements (see figure 2.3) are used to identify specific aspects of the object (Sonneveld, 2007). This means that different movements, like lateral motion and pressure, are used to feel different product aspects, like texture and hardness correspondingly. Clearly, different movements provide our touch sensors (in the hands) with different information.

The sense of touch has also been proven to provide the most important information when classifying objects according to preference, specifically switches (Mortensen, Bech, Begault & Adelstein, 2009). This preference is based on the magnitude and quality of the tactile feedback, such as size and height, round or sharp, soft or hard to press, modern or old, aesthetics and the magnitude of the clicking sound (Bech & Mortensen, 2010). The importance of tactile feedback can also be seen in picking up objects, because the size and weight can be predicted from visual cues, which can be tricked; so only through the sense of touch the real weight can be known

(Flanagan & Johansson, 2002). Thus tactile feedback is an important aspect of functional tactility.

More related to the concept of functional pleasant tactility is the finding that objects are not just pleasant or unpleasant in tactility, but have a tactual aesthetic potential. This means that the same object can be found pleasant and unpleasant to touch, according to the way they are touched (Sonneveld, 2007). A simple example is caressing a smooth rock to feel the pleasant texture, or high impact on the smooth rock to feel the unpleasant hardness resulting in pain. This has to do with the earlier mentioned difference between sensed information depending on the different movements made with the object. The concept has expanded to aesthetic (tactile) movements (in contrast to exploratory movements), which are used to explore the pleasantness of an object (Sonneveld, *forthcoming*).

Evaluating the tactual pleasantness of an object can also be done quantitatively, by (mechanically) rubbing specific textures on specific body parts with specific force (Essick, et al., 2009). This quantitative method, with rating questions, however only evaluates passive touch, because the textures are rubbed on the body rather than letting the participants actively touch the textures. Also, the conclusions drawn from this quantitative research were already common knowledge: First, pleasant tactility of a specific texture is dependent on many factures, like context, gender, the type of texture, the amount of force used, the specific bodily area that is rubbed, etc. Secondly, rubbing rough textures on a person's face with more force becomes less pleasant. This concludes that quantitative research on pleasant tactility does not result in new or deep insights.

More interesting for the current research is finding beauty in touch, because (with respect to the definitions used in this thesis) tactile beauty is just another way of expressing tactual aesthetics, or pleasant tactility; just like beauty in vision, tactile aspects can be found that are aesthetically pleasing to touch, like soft material properties or the act of recognizing an object (Gallace & Spence, 2011). The tactile aspects that were found to be aesthetically pleasing, from an artistic point of view, could be used in designing for tactility. Surprisingly, the principles behind the tactile aspects resemble those for the visual sense. For instance, the Gestalt theory (which states that when certain laws are respected in an object, it is perceived as more beautiful than an object that does not possess those properties) is similar for visual and tactile perception (yet not identical). Those Gestalt laws that are also present in tactile perception are the following: the law of proximity and similarity (organizing stimuli into patters, shapes and groups according to their perceptual similarity or spatial proximity), the law of good continuation (perceptually continuing contours when parts of a pattern suggest a trend), and closure (perceptually enclosing an area by completing a contour and ignoring gaps.). The Gestalt laws of tactility do differ from vision in for instance the amount of time it takes to recognize them. Also, it is unclear whether they actually determine aesthetic pleasantness of the tactile experience, even though their presence in tactile perception is confirmed (Gallace & Spence, 2011). Because of this indistinctness, the Gestalt laws have not been directly used in this research.

Other principles behind tactually pleasant aspects can be identified: the mere exposure effect, stating that previous exposure to stimuli increases their preference (so using a common object to design a new interaction), is also present in tactile perception. This seems to be the case for 'superstimuli' as well, which are stimuli that are exaggerated or amplified versions of the original (extreme metaphors) and elicit a stronger response than the original. As an example, a Venus fertility figure with disproportionately large hips and breasts can be given. The final principle that governs tactual aesthetics is the natural preference for soft sensations, like a fluffy

teddy bear (Gallace & Spence, 2011). All three principles can be used in designing for functional pleasant tactility (see Chapter 6: Designing for Functional Pleasant Tactility).

Additional material aspects could be used in the design for functional pleasant tactility, like the visual aspects that were found to be inviting to touch (Klatzky & Peck, 2011). They state that haptics is used to make a more informed purchase decision, because it gives material information and invokes affective sensory experiences. Therefore, they explored which visual aspects invite tactility, so buyers would touch the products and feel emotionally attached to them. In the experiment they made participants look at pictures of objects with different textures and shapes. It resulted in the conclusion that people would rather touch less extremely shaped and less rough objects. However, the results were based on testing images (not the actual physical products) of random 3D shapes and perfume bottles, so there was no direct reason for inclusion in the current research.

2.4. FUNCTIONAL PLEASANT TACTILITY

In design for tactility, pleasant tactility can be implemented in many ways. For instance, it is possible to implement pleasant tactility in the playful, or non-functional, aspects of products (Sonneveld, 2010b). As an example, a pen could be designed that is nice to repeatedly click with while trying to concentrate on work; this is non-functional, because it is an unintended aspect of use for the pen (though this can be counter-argued by the fact that specifically designing for it, makes it intended).

Another way of implementing pleasant tactility in a product is by making the entire outside of the product (the shell) pleasant to touch. A speaker box can for instance be completely covered in an extremely pleasant tactile material, like fur. However, when the speaker box is initially positioned in a room, the speaker box will (normally) not be touched anymore. Therefore, it is not always useful to have pleasant tactility implemented in the outside of a product.

According to the author, it is more important to design pleasant tactility for the functional aspect of a product (the part that is being touched during use, also called the interface), because it is expected that this will result in a better user experience than implementing pleasant tactility in any other way. This belief originated from a constant discomfort and frustration while using (not playing with or aimlessly touching) different kinds of products, like phones, laptops, remote controls, etc. (It might have been magnified by being sensitized for tactile pleasantness through the industrial design education). The example of a cell phone can be given that feels tactually pleasant to hold (in the hand), but unpleasant when used to call someone (against the ear), or a pen that feels tactually pleasant to play with (do tricks), but unpleasant to write with; both examples have a negative user experience, because both examples have not implemented pleasant tactility in the functioning of the product.

This is why the topic is called ‘functional pleasant tactility’; pleasant tactility implemented in the intended functionality (control, use) of the product (the user interface).

2.5. CURRENT IMPLEMENTATIONS

Even though not much literature exists on designing for functional pleasant tactility, some examples from products can be given for current implementations with an emphasis on tactility. Closest to the new topic of functional pleasant tactility is the design concept for the control of a music player, by scratching or tapping on the differently textured surfaces of the stone shaped controller (see figure 2.4) that easily fits in someone's hand or pocket (Murray-Smith, et al., 2008). The functional interaction here is completely derived from an intuitive form of pleasant tactility: scratching a surface when it is textured (even unconsciously), especially in relation to wanting to hear sound (because scratching produces sound), which is the main goal for a music player; a good example of innovative and creative interactions.

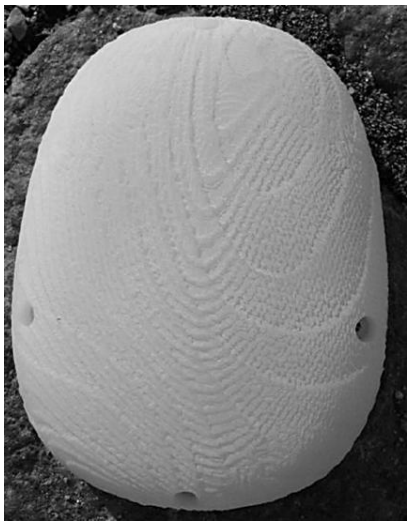


Figure 2.4: Stone Shaped Controller with Textured Surfaces (Murray-Smith, et al., 2008)

Some older creative examples of functional pleasant tactility, which are still useful today, can be found in the design direction of 'tangible (or graspable) user interfaces' (TUIs). Here the goal is to make virtual controls physical, so the interaction with digital data or environments can be more intuitive. Examples are physical objects to store and retrieve virtual or digital information (Holmquist, Redström & Ljungstrand, 1999; Ishii & Ullmer, 1997). The authors here explored the pros and cons of tokens (physical objects linked to digital content) to access that digital information. As an example they mention WebStickers, which are barcodes that can be pasted on any object, and scanned for retrieving the digital information linked with it; in this case websites. One of the pros is the ease with which people can now remember where things are stored, because the sticker can be put on an object that represents the data (rather than in a file somewhere). One of the cons is that physical objects can easily get lost. Pleasant tactility can be added by putting the WebSticker on an object that feels pleasant to touch. The creative way of retrieving digital data, by scanning an object rather than pressing a button, makes the interaction more physical; this is one of the goals of functional pleasant tactility as well. So it can be used as inspiration.

Also, moving and tilting digital displays in space to read and scroll through digital information (Small & Ishii, 1997) can be given as an example. The authors describe three different ways to make the interaction with digital information more direct and engaging hands and body. This is done through metaphors of reading a horizontal scroll or a newspaper; the natural movements that people perform to read a newspaper (tilting, moving away/toward, moving left/right) are used to create a display that needs to be moved in space to scroll to the next information. The same goes for the large horizontal scroll, for which a display (on wheels) needs to be moved over the floor from left to right to display the entire scroll. The purpose is to overcome the feeling of disconnect between what the hands do and the eyes see. Tactility is here added through the intuitive and direct movements. Intuitive movements play a big role in functional pleasant tactility as well, but pleasantness is not directly involved, so this can be seen as an example of functional tactility, where only pleasant could be added.

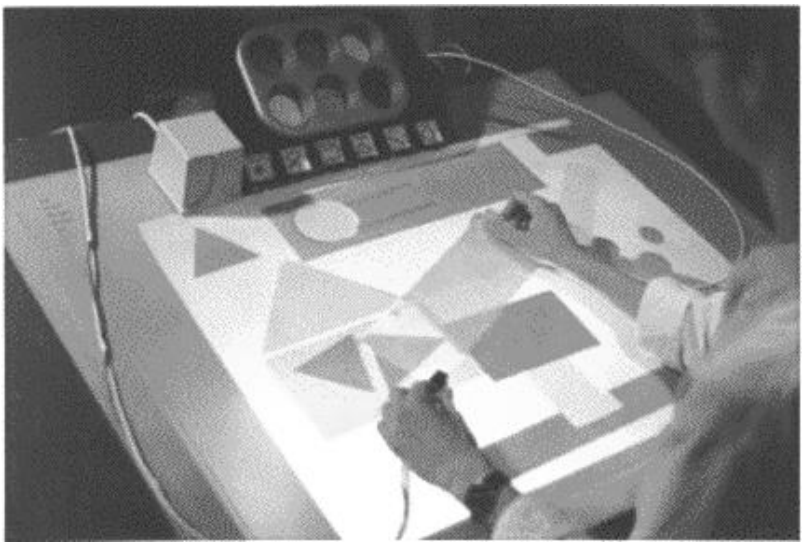


Figure 2.5: Demonstration of the Bricks in Drawing Software (Fitzmaurice, Ishii & Buxton, 1995)

Furthermore, physical cubes linked to virtual content (in a drawing software) to change position, size and curvature (Fitzmaurice, Ishii & Buxton, 1995) are great examples as well. The physical cubes all have different shapes and are positioned on a table surface with a projected screen on there (see figure 2.5). The cubes are tracked for their position and direction, so they can be used for manipulating digital content by anchoring the brick to that content. This should offer a seamless blend between the physical and virtual worlds by introducing a tangible interface. The physicality and directness of the interaction is what makes this functional tactility again. Pleasantness could be added by making the cubes pleasant to manipulate.

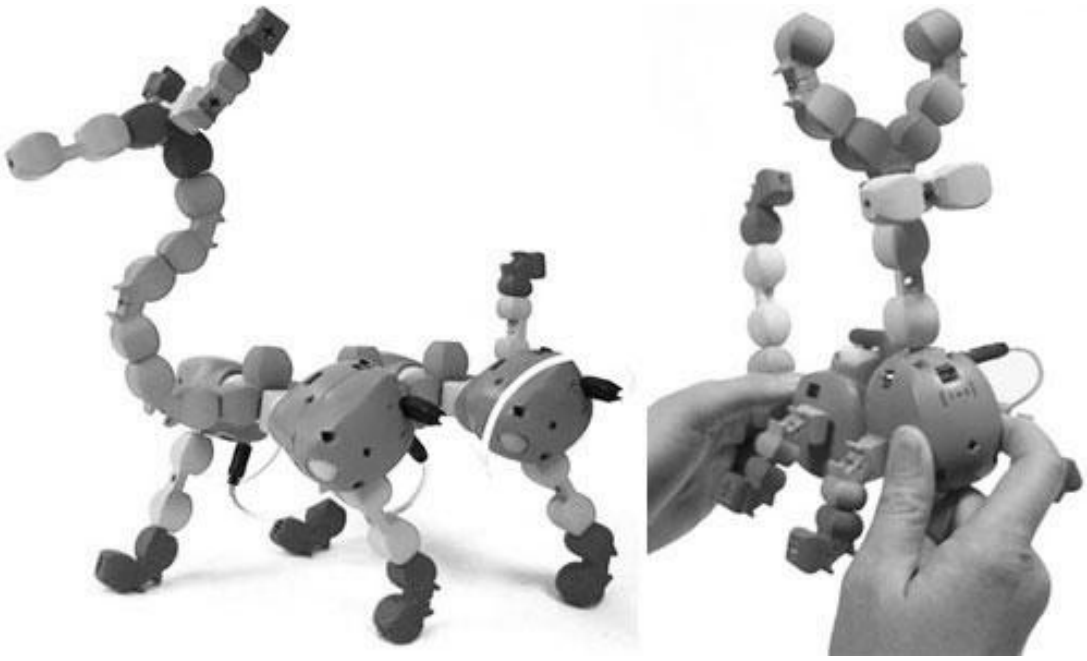


Figure 2.6: Topobo the 3D constructive assembly system with kinetic memory (Raffle, Parkes & Ishii, 2004)

Some newer examples can be named as well, like Topobo (see figure 2.6), which is a 3D constructive assembly system with kinetic memory (Raffle, Parkes & Ishii, 2004). This means that it has the ability to record and playback physical motion. In other words, a creature can be assembled from separate building blocks, which can then be taught to walk by moving the legs, after which the creature will repeat that movement. This is clearly a toy, and functionality is included in animating the assembled creatures. Although pleasant tactility is somewhat lacking, the strong focus on tactility and intuitive physical manipulation make this example worth noting.

The I/O Brush (Ryokai, Marti & Ishii, 2004) is also a newer example of functional intuitive tactility. This is a drawing tool to explore colors, textures, and movements found in everyday materials by scanning them with a little camera inside the brush, followed by printing the texture on a digital screen by moving the brush over the surface like an actual paint brush (see figure 2.7). An eye that is blinking can even be the texture that is painted with. The physical movements that have replaced a mouse input here, are realistic and intuitive, which makes the I/O Brush a good example of functional tactility again. However, the movements are not necessarily pleasant, so it is not a complete example of functional pleasant tactility.

Figure 2.7: I/O Brush for scanning and painting real-life textures (Ryokai, Marti & Ishii, 2004)

Another newer example of TUI design is the Sound of Touch (see figure 2.8). This is a "new instrument for real-time capture and sensitive physical stimulation of sound samples using digital convolution". The hand-held tool is used to record sound and then play the recording by brushing, scraping, striking or moving the tool over other physical objects. This causes the recorded sound to be "continuously filtered by the acoustic interaction" between the tool and the touched material. A toolkit of textures is available for exploration (Merrill & Raffle, 2007). This is a very physical and intuitive way of exploring sound and tactility together, but the tool takes away the directness and therefore the pleasantness of tactility; touching the textures by hand could improve that pleasantness.

Figure 2.8: The Sound of Touch to explore sound tactility (Merrill & Raffle, 2007)

A topic that has been explored quite extensively is the tactility of product push buttons. The focus, however, is more on improving buttons, rather than coming up with intuitive tactile interactions. A new kind of button was for instance invented, as a combination of a hard and soft button: a hydro-dynamic textile button (see figure 2.9). It is made of an air-tight elastic textile for screen projection, which is stretched flat when not in use. It can be filled with air (by a hydro-pump) when and where needed, and the air pressure is measured in order to determine button activation. Three button types were tested: normal buttons (with less flexibility for multiple functions but real tactile feedback), digital 'soft' buttons (with much flexibility for multiple functions, but no tactual feedback), and the new hydro-dynamic textile buttons (with medium flexibility and tactual feedback) and compared. The new buttons showed great promise for decreasing errors and time needed to find the right buttons, and concluded that tactual feedback is important in pressing buttons (Harrison & Hudson, 2009). The functional tactility is here only added for better usability, not for pleasantness, even though it might be more pleasant in tactility than normal buttons.

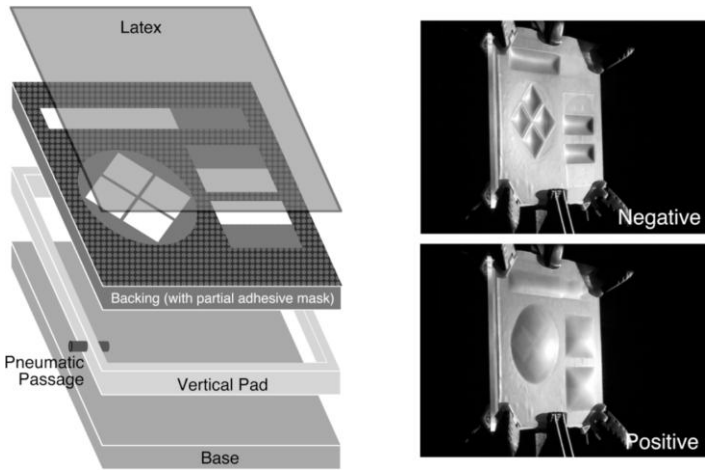


Figure 2.9: Hydro-dynamic textile buttons for flexibility (Harrison & Hudson, 2009)

Joystick input has also been considered for tactual improvement, like in using wrist-motion and key operation of the Wii-mote for faster (Japanese) text entry (Aoki, et al., 2010), or by designing a small physical joystick for more accurate gaming on a tablet, rather than using touch screen interaction (see figure 2.10). This all improves the tactility during use, like adding a soft rubber on a handle for better grip, or adding tactility to product packaging to make the outside more congruent with its contents (Spence & Gallace, 2011). However, pleasantness is again not assured.

Figure 2.10: Fling Joystick for Tablets (http:/tenonedesign.com/fling.php *retrieved 18 July 2012*)

Much research has also been done in the field of multi-modal interaction, on improving the tactile feedback of virtual (touch screen) buttons. Different ways of adding vibrational feedback have been explored, like an external vibrator on a PDA device for on-screen stylus and finger text entry, to decrease errors and increase corrected errors. The vibrator gave off a smooth sine wave as the cue for successful text entry, and a rough amplitude modulated wave for slip and double-tap errors. It was tested both in laboratory settings and on a moving metro train. Laboratory settings were positive, real life were subjectively positive, but not significantly (Brewster, Chohan & Brown, 2007). This suggests that enhanced tactile feedback is not as straightforward as real-life button feedback.

Another way of adding vibrational feedback was explored by performing three experiments to find the most pleasant tactile feedback for digital display buttons, because pleasantness is seen as part of usability. With pleasant tactile feedback they do not mean functional pleasant tactility; the absence of pleasant tactility is also fine, as long as the tactility is not unpleasant. It was done by exploring and comparing piezo and vibration-motor activated feedback of pulses with different strengths and durations. The vibrators were connected to the screen only, to require less energy, and number entry with fingers only was used. It is concluded that piezo activated feedback is preferred above no tactile feedback and vibro-motor feedback, but intensity and duration were subjective and context related (Koskinen, Kaaresoja, & Laitinen, 2008). Knowing that pleasantness is part of usability improves the worth of exploring functional pleasant tactility, even though usability is neither the same as product functionality nor user experience; they are closely related.

Different frequencies of vibrational feedback for different buttons were also explored. A small vibrating motor was used to give tactual feedback, with duration difference for noticing the edge of the button with the finger, and intensity difference for more or less pressing force (or lingering time). The different buttons had different frequencies, and were clustered by rows of buttons. It was only a small test with 12 colleagues, but the encouraging results concluded that differentiation was possible (Nashel & Razzaque, 2003). This strengthens the idea that enhanced tactile feedback is not as straightforward as real-life button feedback.

The interaction of basic graphical user interface (GUI) elements (e.g. buttons, scroll bars and menus) of small mobile devices was enhanced with tactile feedback as well. A small vibration motor was used and different frequencies for different uses (touch down, holding, dragging, lift off) were created. Though only a small test with 10 colleagues was done, the tactile feedback was exceptionally well received, and often judged as similar to mechanical switches. Especially for small GUI elements it provided fast and reliable feedback (Poupyrev & Maruyama, 2003). This was done because it is important to have real feel, and it is believed that touch is a superior feedback channel, five times faster than vision. It suggests that real tactile feedback should always be present in design for tactility, as well as in functional pleasant tactility.

A special vibrator was even designed for vibrational feedback in small mobile devices: the TouchEngine. It is a miniature low-power tactile actuator for mobile devices, based on a multi-layered piezo-ceramic bending motor. It can produce a wide variety of tactile feelings from simple clicks to complex vibro-tactile patterns. The use for ambient background interaction was considered, like a tactile progress bar, by decreasing the time between tactile pulses as the bar progresses. It was also used for 2D and 1D scrolling, where 1D scrolling through a list was tested with users in a real experiment and resulted in faster operation as well as better user experience. It was concluded that tactile feedback should also feel pleasant for the user experience to be better (Poupyrev, Maruyama & Rekimoto, 2002). This is exactly what functional pleasant tactility is based on.

2.6. DESIGN FOR TACTILITY

In the recently emerged field of design for tactility, some toolkits and guidelines have been created to help out designers with understanding and designing for tactility, which will be discussed in this section.

Four basic heuristics have been found for successful tangible interfaces (Sharlin, et al., 2004):

i) the interface needs to be spatial (physical);

ii) the input needs to be unified with the output (one and the same thing or place);

iii) trial-and-error needs to be possible; and

iv) logical mapping (link between the controls and the functions) is necessary.

The four heuristics can be seen as the basics for tactility design as well (except for the second one, because a remote control can be tactually pleasant but is by definition 'remote'). This is because they strive to improve the user experience through physicality, which is exactly what design for tactility aims for as well. Therefore, they are used throughout this research.

In industrial design, part of the process of designing is material selection. For this part, a user-centered material selection approach has been created, made up of stepwise questions to decide on the required sensory properties and to translate those into material properties (Van Kesteren, 2010; Pedgley, 2010). Material selection can be done through trial-and-error as well, by prototyping and testing the materials, but this new approach is meant to be less expensive and time-consuming. However, a toolkit with specific sample materials is required, which is not (yet) available.

Two examples of design for tactility courses across Europe are described here as well, both quite creative. The first is given at the Oslo School of Architecture and Design (Vavik & Kourennayia, 2006). A large course was set up with 24 students, who got the task to define and make arguments for areas where tactile qualities play or could play an important role in the experience of the product; to explore the differences in the tactile elements of design; to compare and contrast the tactile qualities in products; to analyze and evaluate tactile characteristics in products and suggest new methods; and to develop ideas for improving products by identifying, synthesizing and reflecting upon tactile elements. The focus of the course was to compare existing products for their tactile elements and use those to develop new ideas for improving products on their tactility. Tactility is definitely present in this course, but the focus exists on neither pleasantness nor functionality, which is why none of it has been used in this research.

The second design for tactility course is given at the Industrial Design Engineering department of the Delft University of Technology (Sonneveld, 2007). Here, a Tactual Experience Guide is used with the purpose of helping designers understand aesthetic aspects of tactile perception, by calibrating their own tactile perceptions. This is done by providing them with a consistent framework of 5 domains to access this tacit experience. The 5 domains of movements (what motivated the interaction), tactual properties (like texture, hardness and temperature of the product), sensations (like pain, pressure, soft touch of the skin), affective behavior (how the product is experienced, like emotions), and gut feelings (what is feelings are caused by the product, like feeling energetic) provide the opportunity for associative thinking, because they are presented like mind-maps. Though this greatly improves the understanding of tactual pleasantness, which is needed in designing for functional pleasant tactility, it does not provide a strategy for designers on how to design for it. Moreover, there is no knowledge created on the impact of pleasant tactility on the user experience. Therefore, this guide is not used in the present research, except for the attitude it advertises, which is a hands-on attitude, based on actively touching real objects and products.

2.7. CHAPTER CONCLUSION

In conclusion, tactility refers to all the qualities that can be felt through the sense of touch, and plays a role in many aspects of life, like learning, communication and of course human-product-interaction; this shows the importance of touch in life, and specifically in design.

Much has been done to understand tactility, such as the tactile experience model to understand the experience of pleasant tactility. Furthermore, different movements provide our touch sensors with different information, so exploring and potentially enjoying different properties of a product is done by performing different movements. These movements can be the basis of functional pleasant tactility, because different functions can be linked to those different movements. Progress has also been made on understanding the design principles that govern pleasant tactility, like the mere exposure effect, super-stimuli and softness, which are used throughout the research. Understanding tactility is a necessary starting point, in order to be able to design for it; the research builds on this understanding.

Pleasant tactility is already somewhat established in the field of design for interaction, because tactility is an intuitive way of interacting, and pleasantness is seen as part of usability. Functional pleasant tactility has a relevant place in this field of tactility design, because designing pleasant tactility for the functioning of a product is expected to create a better user experience than any other way of implementing (pleasant) tactility. This belief is based on previous experiences with products that were in some way tactually pleasant but had a negative user experience.

Current implementations prove that the concept of functional pleasant tactility is not really applied in design, yet, even though it was found to be present in the example of the scratchable music player. This is because often a part of the concept of functional pleasant tactility is lacking. For instance, all the examples taken from the field of TUI design show common characteristics, like allowing for very physical and realist movements in functionality, which are therefore intuitive; however, the aspect of pleasantness of tactility is missing. The same goes for (soft) push button improvements, of which the large amount of literature does suggest that buttons are in need of improvement, and that realistic tactual feedback is important for usability and user experience. It can be expected that adding this pleasant part of functional pleasant tactility will improve those design concepts, for the same reasons as described above.

Design for tactility shows some useful examples of guidelines and toolkits for designers as well, like three heuristics on spatiality, trial-and-error and logical mapping requirements, and following a hands-on attitude by actively touching materials. However, a clear strategy on how to design for functional pleasant tactility is still lacking. So it should now be clear that there is not much literature on the specific topic of functional pleasant tactility in design, but overlapping and surrounding fields help create an understanding of the topic. Functional pleasant tactility can, however, be used by designers in order to create a positive user experience with creative and intuitive designs. Therefore, this topic is worth exploring.

CHAPTER 3

METHODOLOGY

3.1. CHAPTER INTRODUCTION

This chapter introduces the methodological framework of the entire research carried out in order to answer the main research question of how to design for functional pleasant tactility. The aim of this study is therefore to find out how pleasant tactility in the functioning of products can be designed for. To achieve this purpose, a design strategy was envisioned and tested through a case study, made up of three sequential phases. First, 'functional pleasant tactility' was explored in the context of the chosen product and company; secondly, the insights found during the exploration phase were used to create design concepts and implement them into actual design prototypes; finally, the prototypes were assessed by users, in order to come to one design concept. This case study led to insights to turn the design vision into an actual design strategy that can help designers to design for tactility.

In each of the three phases, multiple research methods were utilized; a description of each phase of the research can be found in the following sections, where these methods are introduced with reasons for their inclusion. However, the research questions and full details of the data sources for each phase, (including participant selection, venues, equipment, interview questions, workshop set-ups and protocols, if relevant) are described in related chapters later in the thesis.

3.1.1. Research Methodology Overview

The overall study is explorative in nature, because the aim is to find out (explore) how to design for functional pleasant tactility, and is based mostly on qualitative research. It can be split up into three phases (see Table 3.1) with their main aim, corresponding methods and tools, and related chapters.

Table 3.1: Research Methodology Overview

Phase	1: Exploration of Functional Pleasant Tactility	2: Creation of Design Concepts and Prototypes	3: Evaluation of Functional Pleasant Tactility
Main Aim	Understanding the concept	Translating insights into designs	Concluding the final design
Methods and Tools Utilized	Literature Review on touch	Participatory Design Approach on translating the themes into design concepts	User Study on assessing the user experience of the prototypes
	Participatory Design Approach on exploring functional pleasant tactility	Design through Research to create prototypes	Design through combining results of the User Study for the final design concept
Relevant Chapters	Chapter 2: Importance of Touch; Chapter 5: Exploring Functional Pleasant Tactility	Chapter 6: Designing Functional Pleasant Tactility	Chapter 7: Evaluating Functional Pleasant Tactility

3.2. PHASE 1: EXPLORATION OF FUNCTIONAL PLEASANT TACTILITY

3.2.1. Aim

The aim of Phase 1 was to understand the concept of functional pleasant tactility, discover what has already been done in this field, and specifically what functional pleasant tactility is in the context of the case study. A literature review on touch was carried out, followed by a preliminary research exploring functional pleasant tactility in the specific context of the product and company brand of the case study.

3.2.2. Methods and Data Collection Tools

Literature Review on Touch, its Importance and its Implementations in Design

A literature review was carried out on touch in the areas of everyday life, design research and product design. Articles, books and websites were consulted and the relevant information was gathered to respond to the research questions that can be found in Chapter 2.

Participatory Design Approach on Exploring Functional Pleasant Tactility

The specific topic of functional pleasant tactility in the context of the case study was required, therefore several workshops, in the form of creative sessions, were

carried out to explore this topic further. Workshops can be seen as a participatory design approach, because the skills and knowledge of others are used to explore the concept in context. Fellow design students (from DUT, first year Bachelor) were invited to explore functional pleasant tactility in small groups. They were asked to try out different ways of implementing functional pleasant tactility in a specific product, by finding inspiration from touching 50 available objects, that they were given, all presenting diverse tactual properties. The everyday product of a TV-system remote control was chosen to make sure everybody was familiar with the product, and to keep the research manageable (detailed reasons for choosing this specific product can be found in Chapter 4).

Data collection during the workshops was done by video recording the participants of the workshops exploring different ways of implementing functional pleasant tactility. Those different ways were always a combination of an object, a (pleasant) movement with that object, and the imagined function (of the TV remote). Such combinations were named 'actions' by the author, and those actions were then all put into one table for a clear overview, with pictures of the objects, quotes of the participants and interpretations of the movements (see tables 5.1 and 5.2 in Chapter 5).

3.2.3. Data Analysis

The data from the literature study was analyzed by organizing the information gathered under the sub-categories of tactility, pleasant tactility, functional pleasant tactility, current implementations and design for tactility (see Chapter 2). Relevant conclusions were drawn from the information presented, with an eye to better understand the topic.

The data gathered from the workshops, namely the table of actions previously described, was content analyzed by comparing all the separate actions for similarities, through the use of the grounded theory. This method implies that the qualitative information was studied with a complete open mind, in order to find commonalities that form a logical conclusion (Charmaz, 2003). It helped to conclude three major themes that make functional pleasant tactility possible in the given context.

3.3. PHASE 2: CREATION OF CONCEPTS AND PROTOTYPES

3.3.1. Aim

In Phase 2 of the research, conclusions (or insights) from the previous phase were used to create prototypes. A workshop was held to turn the three major themes, identified in the previous phase, into actual design concepts. Then prototypes were created from those concepts, using the method of design through research. The final aim was therefore to translate the previously gained knowledge into designs with functional pleasant tactility.

3.3.2. Methods and Data Collection Tools

Participatory Design Approach on Translating the Themes into Design Concepts

The author argues that all three major themes (i.e. inviting, mastery and logic), resulted from Phase 1, are required to be embedded into a product, for a product to have a positive user experience. Therefore, the themes needed to be used to implement pleasant tactility in the functioning of a product. So, a visual overview of all the actions in the three different themes has been created by the author (see figure 5.3), to have readily access to the insights of the previous phase. Creating a visual overview can be referred to as a common method (for designers) to collect and represent data (Van der Lugt, 2005).

Another workshop was carried out, as a form of participatory design approach. A creative session was planned for the brainstorm workshop with colleagues at the company facilities of Bang & Olufsen (Denmark), to come up with multiple design concepts for the three different themes, using the visual overview of all the actions. Later, those design concepts were used as inspiration sources for the actual prototypes (see Chapter 6).

The workshop sessions were video recorded in order to capture the conversations between the participants to assess how they came up with ideas and concepts. Also, the brainstorm sheets, containing creative explorations of the three themes, and the final design concepts created by the participants were digitally photographed to create a visual archive.

Design through Research to Create Prototypes

In order to turn the three design propositions into actual prototypes, the method of Design through Research was used (as opposed to the method of Research through Design, which describes the entire research, because a design strategy is researched by designing a product with that strategy, i.e. the case study). Design through research is simply the act of designing through constantly researching the design (Archer, 1995); in design for tactility, the prototype needs to feel pleasant, which cannot easily be predicted beforehand (while drawing the concepts), so the prototype is created by constantly checking (research) whether it feels pleasant.

3.3.3. Data Analysis

The method of 'immersion' (Sleeswijk Visser, et al., 2005) was used to analyze the data from the brainstorm workshop. This method is based on completely immersing oneself in the data gathered (in this case the brainstorm sheets with sticky-notes and the final design concepts), so it can be used as inspiration. Laying out the (physical) data and feeling empathy with the participants are two important parts of the immersion technique. The empathy with the participants was created by personally being part of the brainstorm workshop. This technique helped to gain inspiration for designing the prototypes.

3.4. PHASE 3: EVALUATION OF FUNCTIONAL PLEASANT TACTILITY

3.4.1. Aim

In Phase 3, the final phase of the research, the resulting three prototypes from the previous phase were used to test and evaluate the strength of the underlying design vision. This was done by exploring the user experience of the created prototypes with different target groups. This led to further insights that can be used in the broader context of industrial design. From here on, the effectiveness of the design strategy can be evaluated.

3.4.2. Methods and Data Collection Tools

User Study on Assessing the User Experience of the Prototypes

In order to evaluate the strength of the underlying design vision, a large user study was carried out; the three prototypes created were assessed by the target group with a total of 28 people (i.e. 8 younger males, 8 older males, 6 younger females, and 6 older females), within-subject. The user study involved a combination of multiple research methods (see figure 3.1), in order to answer the different research questions. Details can be found in Chapter 7.

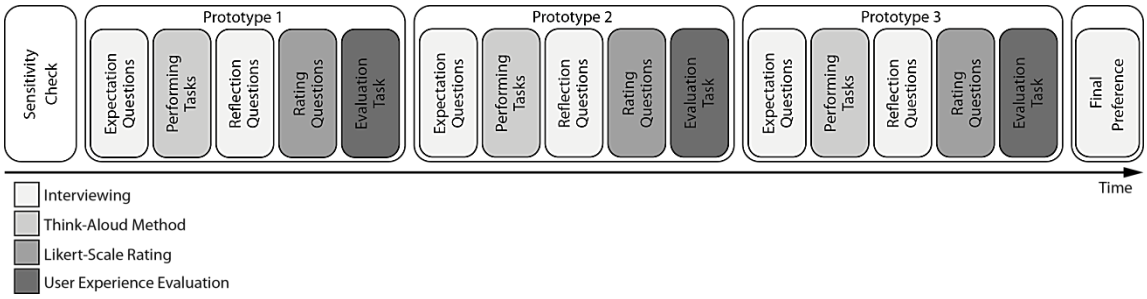


Figure 3.1: Overview of User Study in Time

For each prototype, the process of the user study was exactly the same. To avoid any order effects, the three prototypes were randomly presented to the participants.

The participant was interviewed to ask questions about the expectations in relation to functioning and tactility of the presented prototypes. Then the participant was asked to experience the prototype by performing specific tasks. Here the think-aloud method was used while performing the tasks, to check if the participant understood the functioning of the prototypes. Through the think-aloud method it was also verified if the prototypes were working properly. The interview questions helped provide more specific information.

The participant was interviewed again to reflect upon the expectations in relation to functioning and tactility of the prototypes. This reflection clarified what was unexpected and why, creating insights into the implementation of functional pleasant tactility. Probing was used at times to get more complete answers.

A Likert-scale rating question followed, to determine the (subjective) rate of the presence of the three themes in the three prototypes; each prototype was supposed to represent one theme, but a small presence of the other themes was expected. This was done to verify if the prototypes actually represented the three separate themes. It also checked if the theme was implemented in a positive or negative way, because the Likert-scale does not only check the rate, but also the direction of agreement (Matell & Jacoby, 1972) across prototypes as well as between participants.

Finally, a user experience evaluation technique (Rozendaal, *forthcoming*) was used to evaluate the user experience. The technique involves the participant to match his or her feelings and experiences of the specific prototype to an existing set of images (see Appendix A). The participant first chose three images of the presented set that best expressed the experience, and then described what specific part of the experience it related to and how it best expressed this. This technique was used to find out how participants experienced the prototypes, and how specific aspects of the prototypes were evaluated.

The user study sessions were completely video recorded to have all the information digital, and quick notes were also made by the author to refer to during the user study.

Design through Combining Results of the User Study for the Final Design Concept

From all the insights gained in the user study, a new concept of a TV-system remote control for the target group was designed by the author. The final design concept clearly shows a combination of the three themes into an innovative and intuitive design. Showing that this was possible strengthened the design vision, so it could later be turned into a design strategy on how to design for functional pleasant tactility.

3.4.3. Data Analysis

All the data that was gathered from the user study was transcribed into a Microsoft Excel spreadsheet (for part of the spreadsheet, see Appendix G), with the questions listed on one axis and the participants on the other. The data in this spreadsheet was mostly qualitative, and grouped by prototype to create a visual overview of the most important information. The data was then content analyzed for commonalities for the same prototype. From those commonalities and differences, insights were drawn to serve as input for the final design concept. Some of the data was also checked for quantitative significance by using statistics.

3.5. CHAPTER CONCLUSION

In conclusion, the aim of the entire research was to explore how to design for functional pleasant tactility in the field of industrial design. The research tested an envisioned design strategy through a case study. This case study was done in three phases: understanding the concept, translating insights into designs, and concluding the final design. Each phase was made up of two separate studies, correspondingly: literature review on touch and participatory design approach on

exploring the concept in context, participatory design approach on designing for functional pleasant tactility and design through research for creating prototypes, and user study on assessing the user experience of the prototypes and design through combining results of the user study for the final design concept. For each study, methods were used for researching, collecting and analyzing data, in order to answer the corresponding research questions and thereby concluding with a design strategy on how to design for functional pleasant tactility.

CHAPTER 4

DESIGN VISION FOR FUNCTIONAL PLEASANT TACTILITY: THE CASE OF A B&O TV REMOTE

4.1. CHAPTER INTRODUCTION

As a designer, the author has experience with pleasant tactility. From this experience stems the urge to improve products by designing them with a focus on pleasant tactility in the functioning of the product. The author's personal insights and interpretations of the literature have been used to come up with a design vision on how to design for functional pleasant tactility: an envisioned design strategy for functional pleasant tactility. This design vision can be explained as the competence that designers lacked, so far. Therefore, the design vision is presented through the four elements that form a competence: the combination of knowledge, insights, skills and attitude (see figure 4.1).

Figure 4.1: Overview of Design Vision Competence

The design vision on how to design for functional pleasant tactility will here be offered for the specific context of a Bang & Olufsen (B&O) TV-system remote control. This context will be introduced in the following section. Implementing and evaluating the design vision will lead to the substantiated design strategy (Chapter 8: Design Strategy for Functional Pleasant Tactility). Thus, this chapter gives a first concrete look at the design strategy, introduced in Chapter 1.

4.1.1. Bang & Olufsen TV-system Remote Control

TV-system remote controls are a good context in which to design for functional pleasant tactility. With TV-system remote control is meant 'a device that remotely operates the functioning of a TV that may be part of a system including music players, game consoles or other devices of home entertainment'.

The topic was chosen, because remote controls have buttons that often look and feel exactly the same (except for a small symbol on them), but they all have different functions. As a result, this provides the opportunity to improve the interaction and thereby the user experience of remote controls through the use of functional pleasant tactility. Furthermore, all TV-system remote controls at least have the three basic functions of power, volume and channel control. Those three basic functions are enough for a simple remote, to keep the interactions manageable. Moreover, they can be implemented in many different ways (turning a knob, moving a slider, pressing or holding a button, etc.), because there is not one standard.

Finally, the company B&O manufactures TV-system remote controls, and their mission statement perfectly fits with the goal of the research. In their company vision, B&O expresses to have the "courage to constantly question the ordinary in search of surprising, long-lasting experiences". Functional pleasant tactility provides this great opportunity to create that user experiences for product differentiation. Therefore, B&O was involved to provide the materials, support, location and target group for the research.

4.2. KNOWLEDGE

Knowledge is the element of knowing. In designing functional pleasant tactility for the specific context of B&O TV-system remote control, explicit knowledge on functional pleasant tactility, TV-system remote control, and the Bang & Olufsen brand is expected, besides basic design knowledge. That knowledge is presented in more detail in the following sections.

4.2.1. Basic Design Knowledge

The basic design knowledge that is expected of designers for designing functional pleasant tactility in a B&O TV remote is quite standard. Knowledge of the research, design and production methods presented in Chapter 3, and what they imply, is required; like the Participatory Design Approach, Immersion, the Grounded Theory, etc. This is needed for knowing how they work, and planning them. Knowledge about the new and existing technologies of capacitive sensors, infrared and radiofrequency remote control, magnetic sensors, touch sensors, buttons, sliders and switches, is also important. This is needed to be able to use them in creative interactions. Knowing how to create concept posters and user

scenarios is needed as well, to use the best fitting presentation for the product designs.

4.2.2. Functional Pleasant Tactility

In order to design for it, knowledge about the concept of *functional pleasant tactility* is obviously required (see Chapter 2). This knowledge is needed to be able to do an exploration of functional pleasant tactility in the context of a B&O TV remote, which is part of the design process (see section 4.3: Insights). The exploration in this context is what will provide the three themes (after analysis) of Inviting, Mastery and Logical, including characteristics of each theme (the principles that a theme is based on). This will then form the contextual knowledge of functional pleasant tactility, necessary for the design activity.

4.2.3. TV-System Remote Control

Naturally, the to-be-designed object needs to be known: a TV-system remote control. Its definition is essential: a device that remotely operates the functioning of a TV that may be part of a system including music players, game consoles or other devices of home entertainment. Also, knowledge about the context, functioning, use, existing interactions, differences and similarities, and existing models of TV-system remote control is desired (for details, see Chapter 6).

4.2.4. Bang & Olufsen

Knowledge about the company B&O is logically required as well. Knowing B&O's mission statement, product portfolio, resources, production capabilities, intended style, technologies, target group and desired interactions is necessary to design for that company. These details can be found in Chapter 6.

4.3. INSIGHTS

Insight is the element of understanding. Understanding the basic process is very important for designing functional pleasant tactility (see figure 4.2). The design process of this design vision is obviously part of the entire research of this thesis, because it is the case study of implementing the envisioned design strategy.

As can be seen in figure 4.2, first knowledge is required, which is represented by the 'Literature', 'Focus' and 'Target Group'. Then, the 'Preliminary Research' exploration on functional pleasant tactility in the context is performed to find the three themes, represented by 'Analyze', 'Characteristics' and 'Themes'. Using these pre-defined themes *Inviting*, *Mastery* and *Logical* to base the prototypes on represented by 'Design & Research Plan' and 'Prototype', is expected to follow. This strategy of using pre-defined themes to start the design process is often used in design education (the course ID4250: Project Exploring Interactions in the Master of Science Design for Interaction at the Industrial Design Engineering Department of DUT is a good example); this is done to give a focus, keep the design process short and add something from the designer's personality.

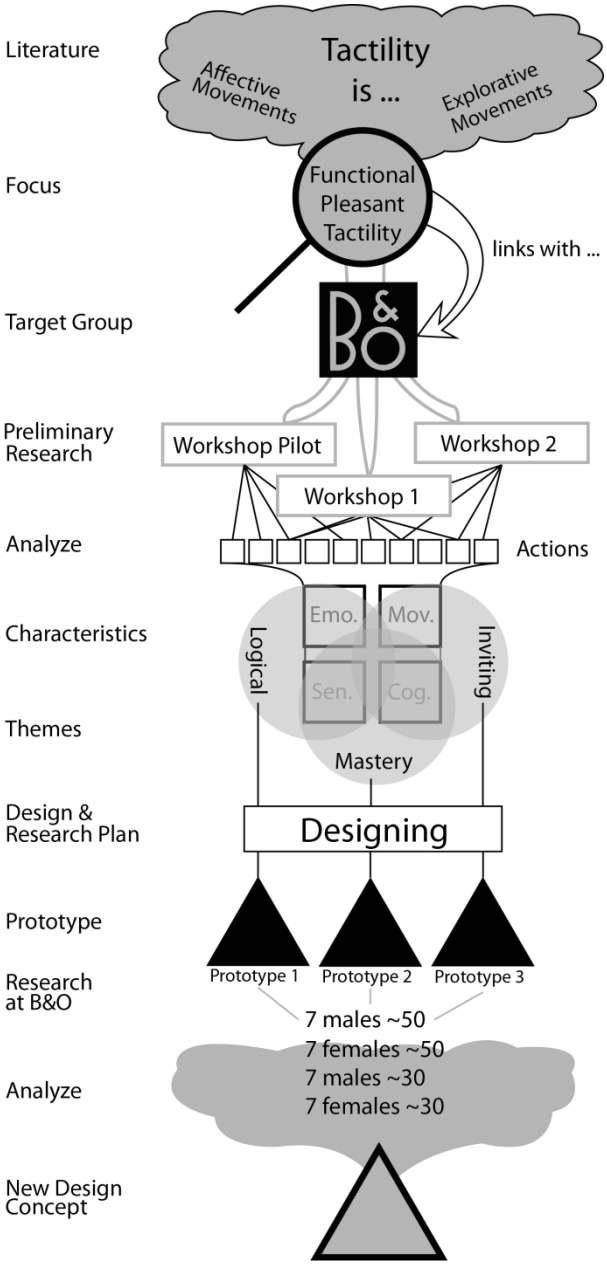


Figure 4.2: Design Process Overview

It is envisioned that testing the prototypes with the intended target group represented by 'Research at B&O' and 'Analyze', will lead to a single design concept 'New Design Concept'. This process of turning three designs into a single one is based on the common practice in design education to come up with three design concepts and evaluate those, with evaluation techniques, to come to the best fitting design concept. Most Bachelor courses at the Industrial Design Engineering Department of DUT encourage this, such as IO1011 Introduction to Industrial Design Engineering.

Insights into this process are necessary to perform it oneself; knowledge of the process is not enough, understanding is needed to draw the proper conclusions, make the right decisions and color the basic process with personal insights.

4.4. SKILLS

Skill is the element of doing; experience is often involved. The basic designer skills are necessary, like collecting information, analyzing data, performing user studies, combining design propositions, visually presenting design concepts, etc.

Some specific skills for designing functional pleasant tactility are required too. The most important one is 'designing through research'; a design concept is created, but the specifics of the design are not known yet, because the feel and interaction of the prototype is more important than its looks, and those are hard to predict. Therefore, the prototype is made while constantly checking (researching) and adjusting the feel and interactions; allowing personal (and others') experiences of the prototype guide the design of it.

Another specific skill that is needed is how to facilitate creative sessions. Participatory design is a useful way to explore many creative options, because in participatory design multiple people are involved, and multiple people can do more than one person. Performing participatory design requires a good facilitator that can guide the group through a creative session, so the participants only have to focus on creativity (Tassoul, 2009).

4.5. ATTITUDE

Attitude is the element of the way things are done; the manner. A hands-on attitude is required in designing for functional pleasant tactility; exploring, designing, prototyping and evaluating functional pleasant tactility can only be done by touching the actual objects or materials. Tactility is all about the feel and interactions, which can only be correctly imagined by touching physical examples. Familiarizing oneself with tactility (sensitizing) is important to become more aware of tactility.

4.6. CHAPTER CONCLUSIONS

The design vision for functional pleasant tactility in the context of a B&O TV remote is made up of general and specific knowledge, skills, insights and attitude. This vision is expected to generate innovative and intuitive design concepts. To research if this design vision is effective, the envisioned strategy is implemented in the given context through a case study (see Chapters 5, 6 and 7). If the case study results in an innovative and intuitive design concept, the strategy is effective in this context.

It can then be expected that the envisioned design strategy is effective in similar contexts as well, because the basics behind the strategy have been proven to yield results throughout design education. Therefore, if the design vision is verified through the case study, it can be generalized (the attitude will remain the same,

and specific knowledge on B&O will become specific knowledge on the *company* (brand), just like the TV remote will become the chosen *product*, etc.) into a design strategy for functional pleasant tactility in the broader context of industrial design (see Chapter 8).

CHAPTER 5

EXPLORING FUNCTIONAL PLEASANT TACTILITY

5.1. CHAPTER INTRODUCTION

A literature review was conducted in order to understand the topic of tactility, its pleasantness and the role it plays in design. In Phase 1 of the case study, the aspects of functional pleasant tactility in the context of a B&O TV remote control are explored. This chapter will describe that preliminary research that was carried out, report the results that were found, analyze them for underlying themes, and conclude on what functional pleasant tactility in the specific context of a B&O TV-system remote control is. It thereby answers the two main research questions (Q.4 and Q.5): 'What is functional pleasant tactility in the context of a B&O TV remote?' and 'what are the underlying themes of functional pleasant tactility in the context of a B&O TV remote?'

5.2. GOAL

The aim of this preliminary research is to explore how functional pleasant tactility is expressed in the specific context of TV-system remote control, in order to improve the user experience. Intuitive use plays a large role in positive user experiences, because then no manuals are needed, and tactility is a very intuitive way of interaction (Han, 2006). Therefore, the goal of this preliminary research is to 'find things (objects, fabrics, materials, etc.) that are intuitive and pleasant to touch, in relation to (creative) functions of TV-system remote control'.

5.3. RESEARCH QUESTIONS

The following main and sub research questions of this preliminary research are aimed to be answered in order to understand what functional pleasant tactility in the given context is, and how it works.

Q.4. What is functional pleasant tactility in the context of a B&O TV remote?

- Q.4.1. What things (objects, fabrics, materials, etc.) are intuitive and pleasant to touch, in relation to the given context?

Q.5. What are the underlying themes of functional pleasant tactility in the context of a B&O TV remote?

- Q.5.1. What are the characteristics and commonalities in the identified examples of functional pleasant tactility in the given context?

5.4. METHOD

5.4.1. Approach

This exploratory research was performed to obtain qualitative information on functional pleasant tactility in remote controls. In small groups, the participants were guided through a creative session. This was done by letting the participants touch objects with different tactual qualities, in order to imagine different ways of implementing functional pleasant tactility in remote controls.

5.4.2. Participants

The workshop was performed three times with different participants, to make sure that there was enough variety of identified examples of functional pleasant tactility. The participants did not know too much about touch or tactility in design, like bachelor students and Integral Product Design (IPD) or Strategic Product Design (SPD) master students.

The groups had between 3 and 6 participants to make them feel more comfortable and to inspire each other. The participants were sampled by convenience; fellow students from DUT Industrial Design Engineering. Age and gender were not relevant, but all of the participants spoke Dutch, to keep the communication in their native language.

5.4.3. Objects

The author gathered 50 objects presenting different visual and tactile qualities. The objects varied in material, size, shape, texture, hardness, weight and in appearance, but most of all in the movements that they inspire: large, precise, fast, slow, small, push, pull, one or two hands, lateral, squeeze, shake, turn, twist, static, roll, bend, etc.

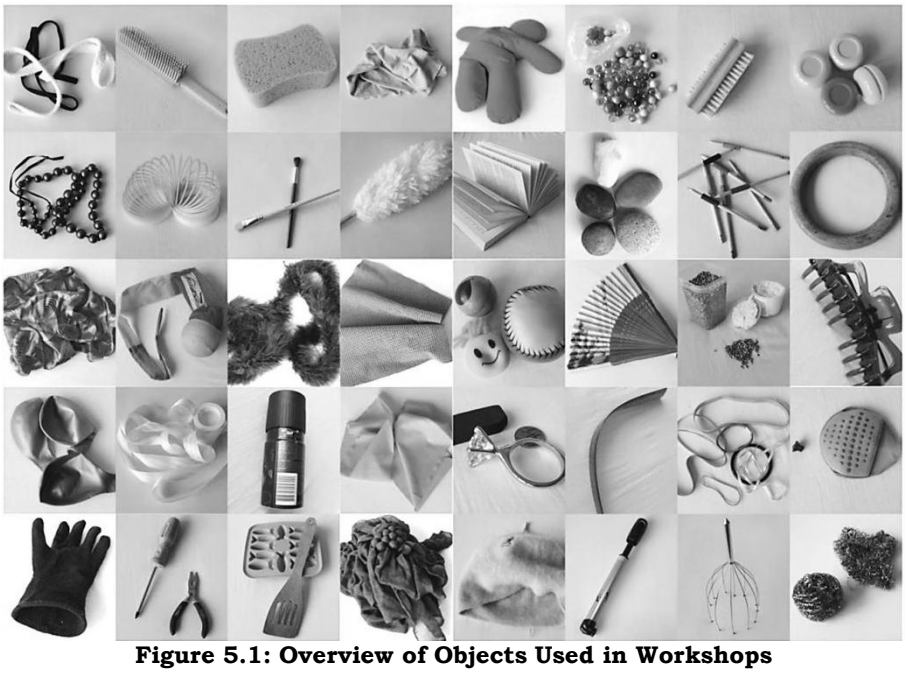


Figure 5.1: Overview of Objects Used in Workshops

The objects were not too complex, so the characteristics could easily be derived. The 50 objects that were used, of which some might be very similar but differ in one characteristic like shape or color, can be found in figure 5.1. They might not all be clear from the image, which is not necessary, but what should be clear is that they form a large variety.

5.4.4. Protocol, Data Collection and Venue

The workshop was designed as a creative session, which started with an icebreaker before the introduction to the exploration. The participants were asked to try to touch all the objects in a tactually pleasant manner, and later imagine functions that matched with the pleasant movements they did. The workshop concluded with the participants presenting their results in front of the camera and receiving a small gift, thanking them for their participation. Data was collected by video (and audio) recording of the entire workshop, which was held in a separate room with a large table for all the objects to be laid upon. Full details of the protocol, data collection and venue can be found in Appendix B.

The pilot proved that the protocol worked. Since nothing changed after the pilot, the results of the pilot study were treated as the first workshop results, and used for analysis as well.

5.5. RESULTS

The workshops resulted in a database of intuitive pleasant movements with objects, and the comments of the participants. The comments were in relation to the TV-system remote control functions that they had matched with the available objects and associated movements. Therefore, the database is presented as a table with three columns; the first column shows an image of the movement with a generalized object, the second column describes the movement that the participant performed with the object (and why it is a pleasant movement) interpreted from observations and quotes of the participants, and in the third column the imagined function that matched with it is presented. Each row then represents one combination of an object, movement and function. Such a combination will, from here on, be referred to as an 'action'.

The database is split up into two tables: table 5.1 of the actions that were presented in the final part of the workshop (those actions were the most valuable ones, because they were reflected upon by the participants before they were presented), and table 5.2 of actions that were merely explored during the course of the workshop.

5.5.1. Presented Actions

The following table (table 5.1) shows the actions that were presented at the end of the workshops, per row. Each row shows one action, split up into the object, movement and function as described above. The symbols in the lower right corners of the rows are category specifications, which are explained in the analysis section.

Table 5.1: Overview of Presented Actions (object, movement, function)

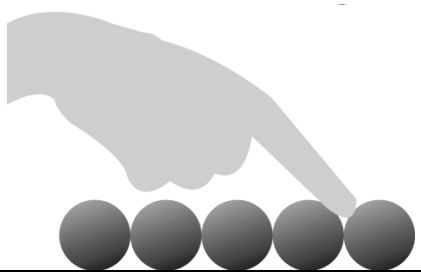
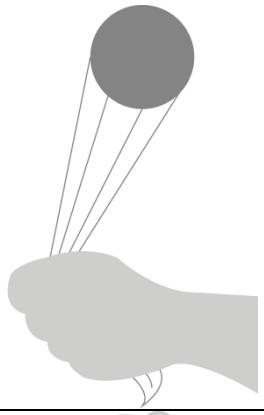
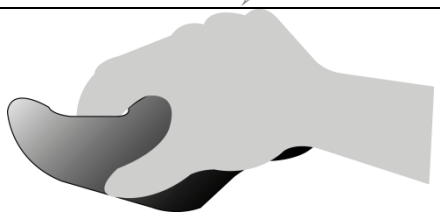
Object	Movement	Function
Pilot Study		
	Moving with hand over the beads (beads could be integrated in arm of chair), in both forward and backward motion. Both fast and slow movements. Feels nice and clear.	Scrolling (through songs or channels). Slow movements (bead-per-bead) are for more precise scrolling. 
	Swinging the ball around its tail, with different speeds in both directions possible. It is a nice movement.	The ball could have a sensor that counts the swings, so each swing can bring you to a previous or next channel. 
	Combining the little balls from inside the red cushion with the tail, to move down the tail with the hand around it, because it feels nice to squeeze the little balls.	You could control another function with this, like the sound for instance. 
	Squeezing the ball, because it feels nice to exert force on it. But the squeezing goes kind of difficult, so you don't want to do it that often.	A function that you don't need that often, like on and off. 
	Wearing the glove feels really nice, because it's so soft inside. So by moving your fingers you can feel the softness. The glove should close tightly around the wrist as well, that will feel better. Stroking the soft outside also feels pleasant. It does get warm, so I hope you won't get sweaty hands.	I'm thinking of different function where you need to combine things; combinations of functions (because of multiple fingers). 

Table 5.1: Overview of Presented Actions (object, movement, function) (continued)

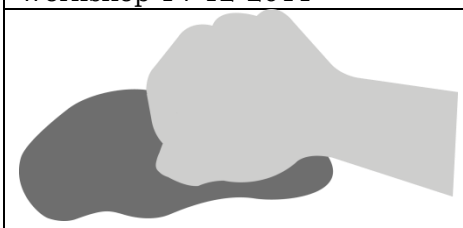
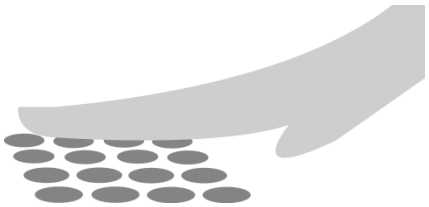
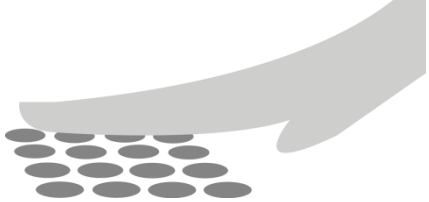
	I chose this one because it has nice colors and it's funny. It's a bit uncontrolled, but you can make so many movements with it (pulling in many directions, shaking, bending, and turning). Fun to play with. You might focus too much on the object instead of the TV.	Different movements can be different functions, like pulling to a certain extent can be a specific channel. Other movements can then control sound or whatever. ●
	This one also feels very pleasant. It fits nicely in my hands, it feels nice to squeeze. Can be a simple control, moving with your thumbs over the surface, or squeezing it in different places. Even bending it feels nice.	Squeezable controls in different places, and moving over the surface can be like a more old-fashioned control of functions (like a game controller). △
Workshop 14-12-2011		
	It is stress relieving, you have to hit the red cushion, can be in different places. It feels nice to hit something soft, because it absorbs the hit.	Different places can be different functions, like a mouse-pad: navigation, volume; it's all programmable. [Hitting real hard can mean volume real loud] □
	Moving with your fingers over the rubber hairs of this yellow brush, in multiple directions. It feels flexible and the ends give the feeling of being precise.	This could be the new touch-pad, because the small rubber things give a feeling of precision. △
	With the handle of this screw driving you can also move your fingers over a pattern of little bumps (grip). It feels even more precise than the yellow brush.	The multiple areas where the little bumps are, give multiple options for functions, with the feeling of doing something precise. △

Table 5.1: Overview of Presented Actions (object, movement, function) (continued)

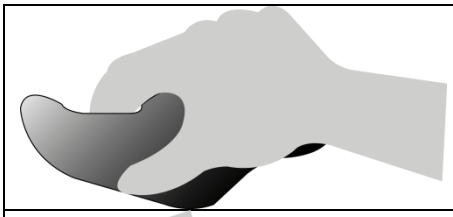
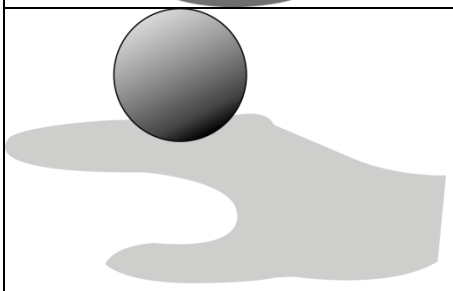
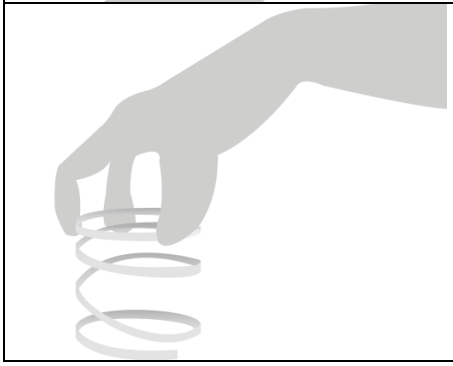
	With this clay ball you can knead different shapes, and that feels really nice.	A different shape can mean a different function; so you can mold it into a pause button, and then the movie will pause.
	Moving your hands through this bowl full of little stones feels nice. You can move with one finger in different directions, or in circles, or push really deep.	The functions can be dependent on the movement you make in the bowl, like drawing a circle in one direction can be volume up, and in the other direction can be volume down.
	Playing with a ball is nice to do; it reminds me of playing sports as well. I can throw it, catch it, or bounce it on top of my hand, or roll it between my hands.	Each different action can be a different function, like throwing it against the wall can make the TV go on or off.
	I've heard that people like to put their finger through a ring or hole, and that feels nice as well. You can move your finger along the ring, or swing the ring around the finger.	The different movements can have different functions, also according to speed or angle. I'm sure you can think of plenty.
	I find this an interesting movement. I also like the change in colors.	This movement can be leafing through things, like a book or a song list or pages or whatever.

Table 5.1: Overview of Presented Actions (object, movement, function) (continued)

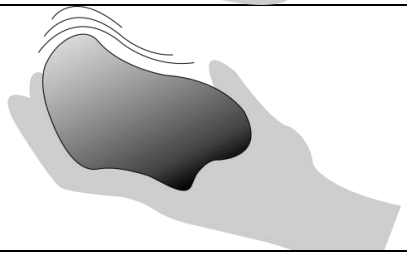
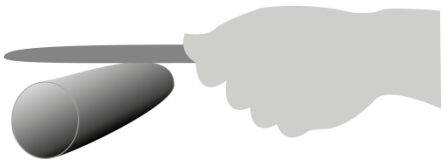
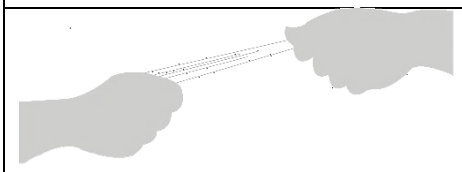
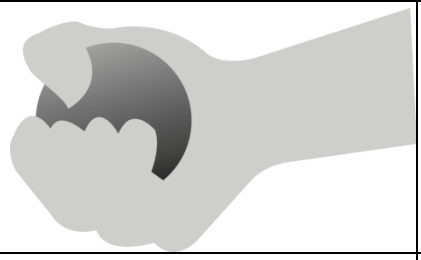
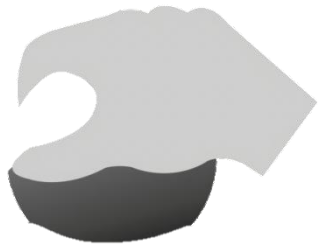
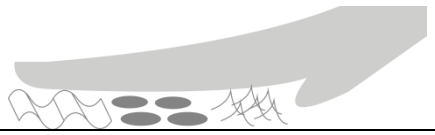
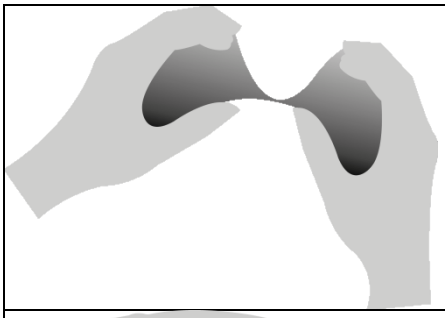
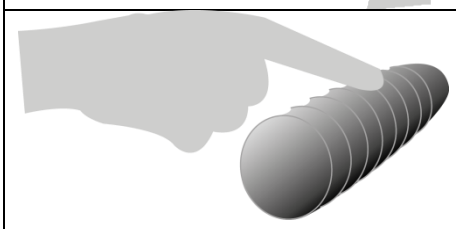
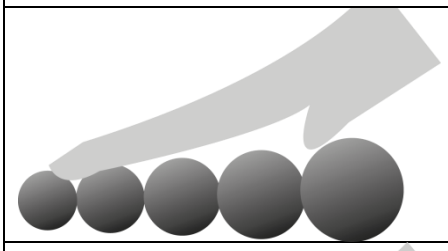
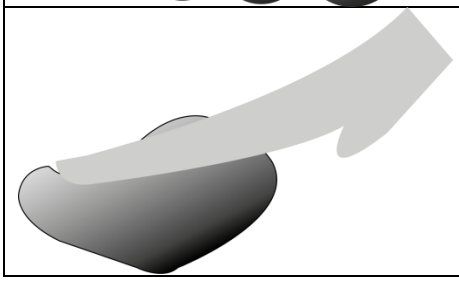
Workshop 15-12-2011		
	Winding this around my hand feels nice, because it's so soft. It reminds me of a puppy.	Every winding could be another channel forwards, or doing it really fast can be fast-forward in a movie. ☆
	When you watch TV you don't want to look at your remote, so you need feedback that you can feel.	That's why I think the remote should change its surface to more or less rough, as feedback. △
	This bendable ruler made me think of a slap-wrap, which I always love to play with. I always slap it around my arm and then bend it back, and do it again.	It can be a function, but it's also nice that you can carry your remote with you, so your little brother can't steel it from you. ○
	This hair elastic feels nice to play with, moving my fingers outward to stretch the elastic. Playing with the metal part of the elastic feels nice as well.	It could be controlling the volume, like moving it outward makes it go louder. And rolling the metal part between my fingers can be scrolling or something. ▦
	When you're watching a movie and it gets scary, you would squeeze this dough ball.	Squeezing the dough ball can then start the alternative happy ending of the movie. □
	I would put a gyroscope inside this stone, to play with feeling. The surface of the stone feels very pleasant as well.	Turning the gyroscope stone can control different functions, without looking, like volume or channels. With the surface I haven't found a function yet. ▦
	Moving over this surface with one hand feels really nice and funny.	I can imagine it can be an alternative way of scrolling. ☆

Table 5.1: Overview of Presented Actions (object, movement, function) (continued)

	Another good idea is a divisible remote control.	You can control the TV together. Or it can create a split screen, like with gaming. △
	Going over these ridges with a stick or with your fingers feels nice as well, especially if the ridges are clearer.	The ridges could differ in size to feel what you're doing, and different parts (colors) can control different functions, like volume, channels, etc. ◯
	These beads differ in size, and thus you can feel what you're doing.	With the beads you can control the volume. △
	This feels really pleasant, to press it.	It could be like a single button, but it should come back up as well, so you can use it again. ☆

5.5.2. Explored Actions during the Workshops

The following table (table 5.2) shows the actions that were observed during the workshops, per row, excluding the ones that were presented at the end of the workshop (as shown in the previous table 5.1). Each row again shows one action, split up into a representation of the movement done with the object, the interpretation of the movement (taken from observations and quotes of the participants) and the matching function that was imagined by the participants. The symbols in the lower right corners of the rows are again category specifications, which are explained in the following analysis section.

Table 5.2: Overview of Explored Actions (object, movement, function)

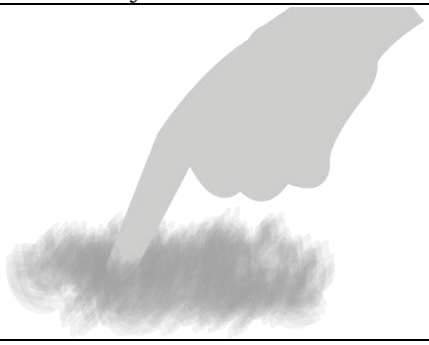
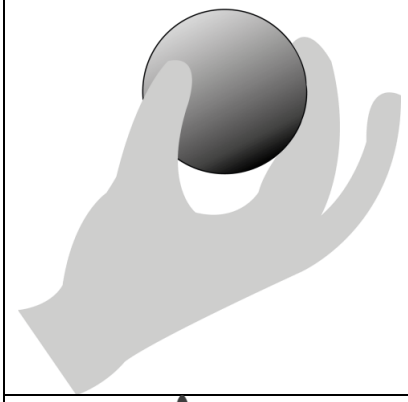
Object	Movement	Function
Pilot Study		
	Stroking the soft fluff in all directions.	Can be like the touchpad on your laptop, but then softer. It could just be touch-sensitive, and have the same functions as moving over a screen. 
	Throwing a soft green bouncing ball against the screen, because it's a new and pleasant movement.	Where the ball hits is where you zoom in, but you need to find a way to get the ball back after throwing. 
	Moving the brush over a surface, while covering the brush in a soft cloth. Feels pleasant, because you can put more or less pressure on it.	It can also be a sort of scroll function, or like a tablet pen. 
	Squeezing the hair pin and letting it close automatically again (even around the arm).	Holding it in squeezed position could fast-forward a movie or something. And then letting it close automatically could be to pause again. 

Table 5.2: Overview of Explored Actions (object, movement, function) (continued)

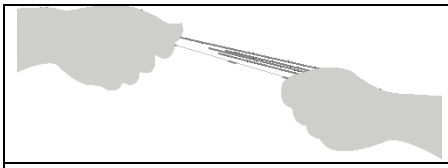
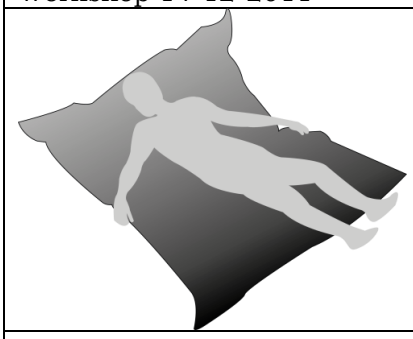
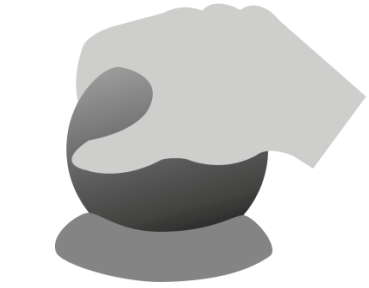
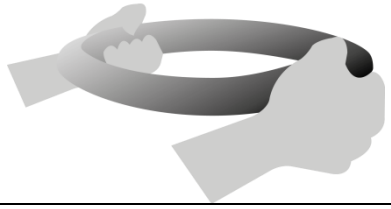
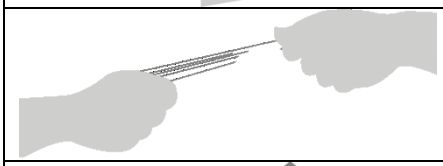
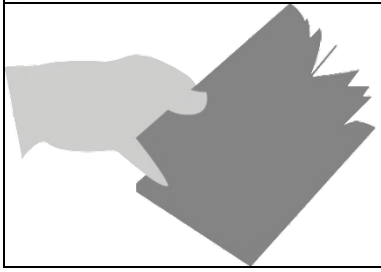
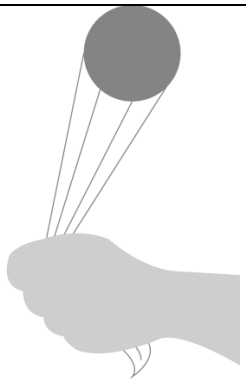
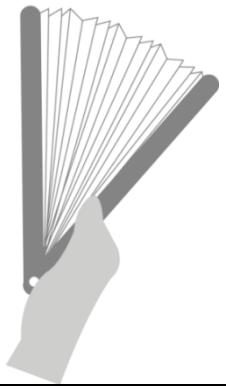
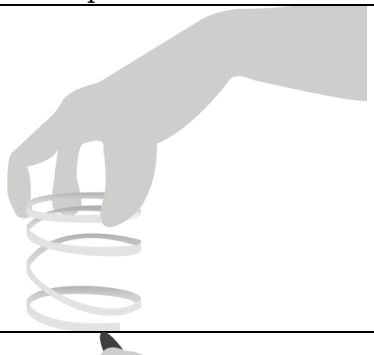
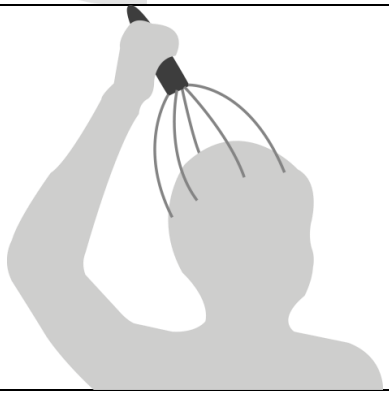
	Pulling this elastic, more or less.	It could turn on and dim lights; the more you pull; the lighter it goes, or something. △
Workshop 14-12-2011		
	I can imagine myself being a complete couch potato, lying inside a sleeping bag made of the little balls inside this red cushion, and then just moving body parts to control the TV.	Moving each separate body part can be a separate function. ☆
	Moving over this rock feels nice as well.	The rock can be a huge track ball, to navigate. ☆
	Moving this ring between your hands, like a steering wheel.	And this can be a track wheel. △
	I always like playing with things while I'm watching TV. With this little coin I could play, letting it go through my fingers (trick).	Playing with the coin can be made into something functional. ▦
	With this little elastic I could also play, stretching it and letting it pull back.	It could control the volume or something. ●
	Leaving through this book can feel nice. I mostly like the smell of it; the smell of old books.	It can be the simple function of leafing through something, like pages of music; scrolling, page up, page down, next album. △

Table 5.2: Overview of Explored Actions (object, movement, function) (continued)

	Swinging this ball with tail around, in both directions. The movement is nice.	It can be volume up, volume down, depending on the direction.
	It feels natural to move over a stone, just like moving over glass with the iPhone.	This could be like navigating through an iPhone, but then a touch sensitive stone.
	This is a nice movement, resolutely closing the fan.	Such a resolute movement can be good for turning something off.
Workshop 15-12-2011		
	Twisting this feels pleasant, because it bounces back, like with an old phone dial.	Holding it in twisted position could be like a fast-forward function.
	This is super relaxing. It feels really pleasant, like feeling high.	It could be that when you're watching a movie in which people use drugs, that your chair automatically makes you feel the same way (4D).

5.6. ANALYSIS

The data gathered from the workshops, namely the tables of actions previously described, was content analyzed by comparing all the separate actions for similarities, through the use of the grounded theory. This method implies that the information was studied bottom up (without any framework) from the data itself, in order to find commonalities.

Most of the objects used in the study were unknown to the participants, or at least the participants had not paid much attention to the tactility of these objects before. Therefore, everything that the participants did with the objects was automatically intuitive.

The data show a large variety of actions, from simple squeezing actions to complex mastering actions, and from small quick strength exertion actions to body encompassing soft caressing. Some actions can be found multiple times as well, like playing with the colored spring or squeezing different materials. There are surely more actions possible, which could be predicted through extrapolating the following analysis.

5.6.1. Characteristics

Through the exploratory method of grounded theory, the actions were compared to see if commonalities exist, by coding the intentions behind the actions. Four groups of intentions were identified, which can be found in the table with their representative icons, assigned by the author for the purpose of analysis.

Venting emotions [emotions]

Doing inviting playful motions [movements]

Doing inviting pleasant actions [senses]

Doing logically-linked (functional) actions [cognition]

The intentions behind the actions in the groups of *venting emotions, doing inviting playful motions, doing inviting pleasant actions* and *doing logically-linked (functional) actions* can be explained as follows.

> **Venting emotions** is to express the emotion in an action, in order to feel better about it. Example actions are: hitting a pillow filled with little balls to lose aggression and switch the channel, or throwing a ball against something to lose frustration and turn the TV off.
>
> **Doing inviting playful motions** is to pass time by doing, perhaps absent-mindedly, a playful action that the properties of the object invite. Example actions are: swinging a ball around its tail to turn the channel, or squeezing a hairpin to fast-forward a movie.
>
> **Doing inviting pleasant actions** is the desire to feel nice object properties that are inviting to touch. Example actions are: moving fingers over a funny surface as a way of scrolling through possibilities, or lying in a body

encompassing pillow filled with little balls and moving body parts to control the TV.

Doing logically-linked (functional) actions is to do an action that matches the response. Example actions are: leafing through a book to go to the next page, or moving a hand over beads that differ in size, to move to another channel.

Because these four groups represent the four compounds of any human activity - namely emotions, movements, senses and cognition – it could be expected that those four groups are complete.

Some actions proved to put in a single category, because they showed intention of another group as well. After further exploration, it was found that nearly all actions showed all four characteristics, but in different amounts of prominence (see figure 5.2).

Figure 5.2: Representation of Different Amounts of Prominence of the Four Characteristics

Figure 5.2 shows the four intentions of the first action in table 5.1, with the amount of prominence for each characteristic. It is clear that the action of moving with a hand over beads for precise scrolling falls in the group of doing logically-linked (functional) actions, because there is a strong match between moving from bead to bead and scrolling, emphasized by the word 'clear'. However, the intention to feel something nice to touch, as in the characteristic of doing inviting pleasant actions, is also present, because it is said to feel nice and clear. Moreover, this action can be compared with a child running past a fence while touching the fence and feeling the bars of the fence tap against the fingers, which shows the playful characteristic more clearly, as in the group of doing inviting playful motions. The intention could be to vent cheerful emotions, but the category of venting emotions is not prominent.

Such a representation could be made for all the actions. It is noticeable to mention that the amount of actions that prominently show the first characteristic of emotion is very small, whereas the other three characteristics are nearly equally present. So it can be said that all actions are pleasant in touch, as well as somewhat playful and logically-linked.

5.6.2. Playfulness

The characteristic of *doing an inviting playful motion* can mean many things, because playfulness is a broad topic. Furthermore, it can be said that each action

has some degree of playfulness in it. It was therefore deeper explored, to uncover what kind of playful actions were involved in doing them. The following kinds of playful actions can be seen as the goal or reason for the action (adopted from Korhonen, Montola & Arrasvuori, 2009). These codes can again be found in tables 5.1 and 5.2, for the actions that have a high prominence for the playful characteristic.


Discovery / Exploration


Creativity / Expression


Control / Mastery


Relaxation


Captivation


Sensation

These different kinds of playfulness were first reported in 'Understand Playful User Experience through Digital Games (Korhonen, Montola & Arrasvuori, 2009). Examples for each of them will now follow.

> **Playful discovery or exploration** can be found in the action of squeezing in a pillow to explore the little balls inside as a way to change the sound.
>
> **Playful creativity or expression** can be found in the action of sculpturing a clay-like ball into different shapes to activate different functions.
>
> **Playful control or mastery** can be found in the action of moving a coin over the outer-side of the fingers, without extra help, to switch channels.
>
> **Playful relaxation** can be found in the action of giving a personal head-massage as a way of enjoying a movie better.
>
> **Playful captivation** can be found in the action of playing with the colored spring to scroll through possibilities. The downside of being captivated by the controller is that the TV is not paid attention to anymore.
>
> **Playful sensation** can be found in the action of squeezing or pulling something to feel the force it exerts as the reaction, as a way of fast-forwarding a movie. The playful characteristic of sensation overlaps greatly with the characteristic of doing inviting pleasant actions, because they both involve tactile-experiencing as the prominent goal. They differ in the presence or absence of the playful character, which can be explained by being able to do the movement absent-mindedly or not, correspondingly. The large amount of actions that focus on the senses is due to the initial expressed goal of the preliminary research to find pleasant tactility (in relation to functionality).

So these different kinds of playfulness are subcategories of the group of doing inviting playful motions. Adding these subcategories results in a deeper understanding of the intentions behind the actions, and therefore makes it possible to find three themes that constitute different aspects of functional pleasant tactility in the context of a B&O TV remote control.

5.6.3. Themes

Now that all actions have been coded with their most prominent characteristic and subcategory of playfulness in tables 5.1 and 5.2, three major themes (overlapping characteristics) became apparent, which constitute different aspects of functional pleasant tactility in the context of a B&O TV remote control:

- Inviting
- Mastery/Control
- Logically-linked

The *inviting* theme became apparent through the inviting aspects of the characteristics in both groups of doing inviting playful motions and doing inviting pleasant actions. Also, the discovery or exploration goal as well as the captivation goal of playfulness are closely related to the inviting them. This is because exploring is only done when there is a cause (the invitation), and captivation is only possible when there is something (inviting) that keeps the person captivated. The inviting theme is thus made up of actions that are focused on being nearly irresistible to touch. Characteristics of this inviting theme can be described as having clear contrasts, colors, mysterious materials, etc.

The *mastery/control* theme became apparent through its subcategory of playfulness, which was accounted for 8 times. It is made up of actions that are focused on challenging oneself to be able to achieve something tricky. It can involve exerting a large amount of force, as well as fine coordination or perseverance.

The *logically-linked* theme became apparent through the fourth group of characteristics: doing logically-linked (functional) actions, which were found in the tables 13 times. It is made up of actions that are focused on the logic connection between the action and the function, like the before mentioned action of leafing through a book to go to the next page. This theme can involve metaphors as well as being based on the (old-fashioned) mechanics of the function.

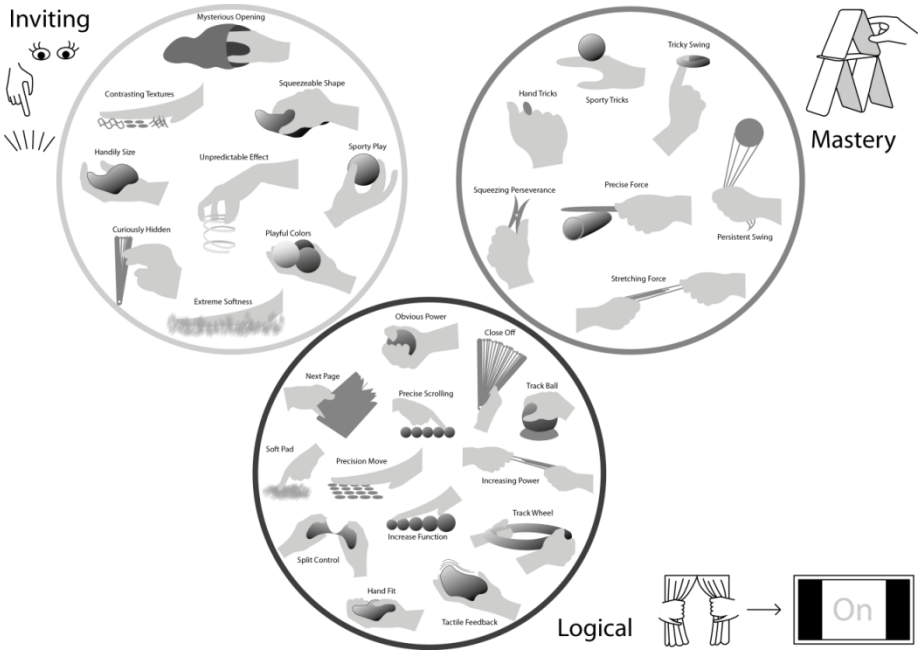


Figure 5.3: Overview of the Resulting Themes with Their Corresponding Actions

Figure 5.3 shows the resulted actions, divided over the three themes. Each theme is depicted by an image. The inviting theme shows two eyes that see something inviting, and a hand that can barely resist touching it. For the mastery theme the building of a house of cards is depicted, because it requires a lot of tactual mastery and control to do so. The logical theme is represented by two hands opening a curtain to see something, which is linked to a Bang & Olufsen TV screen that always turns on as if theatre curtains are opened.

The actions in each theme can relate to all three functions(power, volume and channel control) of a B&O TV remote, except for the actions in the logically-linked theme, because those need to be logically linked (as the name of the theme suggests). For example, continuous pleasant movements (like caressing something soft) are more suitable for continuous functions, like volume control. This should become clear in the following chapter (Chapter 6).

5.7. CHAPTER CONCLUSIONS

To conclude on what functional pleasant tactility in the specific context of TV-system remote control is, a preliminary research in the form of a set of workshops was carried out. The information gathered was presented in a database of actions (combination of object, movement and function) that was content analyzed by using the grounded theory.

The analysis showed that when objects are unknown to the participants, or at least the participants had not paid much attention to the tactility of the objects, everything they did with the objects was automatically intuitive, because it is inherent to the definition of intuition (instinctive).

The data then shows a variety of actions that are pleasant in its tactility, where the movement was the thing that made the object pleasant to touch. The variety of the actions is based on the four compounds of any human activity, namely emotions, movements, senses and cognition (Rozendaal, *forthcoming*). The intentions behind the actions could be further categorized by the reasons for playful behavior: discovery/exploration, creativity/expression, control/mastery, relaxation, captivation and sensation.

By stimulating the participants to be creative, they imagined matching functions for the movements with the objects. Those combinations, named actions, could be divided over three major themes (see figure 5.3) concluded from the analysis: inviting, mastery/control, and logically-linked. Consequently, those three major themes were the main ingredients in the design concepts for functional pleasant tactility in a B&O TV remote control.

Given the answers to the research questions it can be concluded that the exploration in the context of a B&O TV remote control was effective in finding three major themes to be used as a starting point for designing functional pleasant tactility in the given context.

CHAPTER 6

DESIGNING AND PROTOTYPING

6.1. CHAPTER INTRODUCTION

This chapter answers the research questions (Q.6 and Q.7) of 'how can the themes be used in designing a B&O TV remote?' and 'what will be the result of implementing the themes in a B&O TV remote? The objective is to design and prototype three different remote controls for a B&O TV-system by using the three different themes that resulted from the exploration phase. First, the process of designing (Section 6.2) is presented, where three design concepts were created, based on the insights from the preliminary research (see Chapter 5). Second, the prototyping process (Section 6.3) is presented, through the use of design through research, with the three prototypes as the result. Conclusions related to the envisioned design strategy are discussed in the end.

6.2. DESIGNING

This section will describe the entire design process in a summarized manner, from creating design propositions from the themes, doing a participatory design session to come up with ideas and turning those into design concepts. The details can be found in appendix C.

6.2.1. Creating Design Propositions

To create design propositions, the following information is needed: i) the theme characteristics from the previous exploration; ii) requirements for the prototypes; iii) chosen functions of the remote; and iv) desired interactions.

6.2.1.1. Theme Characteristics

The following three sections summarizes the characteristics that are common to the specific themes, based on the results from the preliminary research workshops (see Chapter 5).

Inviting

The inviting theme is made up of actions that are focused on being nearly irresistible to touch. Characteristics of this inviting theme are: clear contrasts, colors, mysterious materials, extreme softness, hand-sized shapes, hints for more (partially hidden), unpredictable (not knowing what to expect) looks, etc.

Mastery/Control
The mastery/control theme is made up of actions that are focused on challenging oneself to be able to achieve something tricky. It can involve exerting a large amount of force, as well as fine coordination or perseverance. An aspect of playfulness is also involved.

Logically-Linked
The logically-linked theme is made up of actions that are focused on the logic connection between the action and the function. This theme can involve metaphors and similar movements, as well as being based on the (old-fashioned) mechanics of the function.

6.2.1.2. Requirements for the Prototype Concepts

The requirements for the design concepts are based on the parties involved, the desired experience and style, and the context.

Stakeholders
Parties that are involved are:

- The company Bang & Olufsen (B&O)
- The expected users or customers of Bang & Olufsen in their context
- The author, as a designer with a vision

B&O Experience and Style
To fit with B&O, the design propositions should include their idea of creating an extraordinary (uncommon), surprising (unexpected), long-lasting (wanting to keep on using it) experience (Bang & Olufsen, 2012). This can be done by designing a creative interaction based on the proposed concept of functional pleasant tactility. The B&O style can be described as minimalistic, classic and notable, with a small playful accent. This can be seen as part of the description of the context for the prototypes.

Context
The context of use is important to be aware of, because it provides the design with certain restrictions. Here the focus will be on the prototype set-up. The context can be seen as a living room with seats around a table facing the B&O TV system. The target group is B&O customers; there can be multiple people involved, young and old, and they will usually be in sitting position (somewhat passive and relaxed) when using the prototypes. Each different living room also has its own style, in which at least the B&O TV-system fits (see figure 6.12 for a picture of the context).

List of Requirements for the Design Concepts of the Prototypes
Environment: Controllers should be resistant to vibrations, humidity, rough handling and falling. Controllers should not damage anything. Controllers should not take in too much space.

Life in Service & Maintenance: Controllers should be usable every day. The insides of the controllers should be repairable / replaceable by technicians.

Manufacturing Facilities: The controllers need to be prototyped in 3 weeks.

Aesthetics, Appearance and Finish: The controllers have to fit with the B&O style.

Materials: Material selection should be focused on the tactile properties.

Ergonomics: The controllers should be understandable in use, with a very steep learning curve. Tactile pleasantness is the main focus.

Quality and Reliability: The controllers should survive the research phase.

Testing: The controllers should function properly with a specific B&O TV system.

Safety: The controllers should not harm anyone.

6.2.1.3. Functions

All prototypes should have the same functions, because participants will automatically start comparing the different prototypes, so a preference should not be made based on the amount or kinds of functions. The following list shows the functions that are required:

- On/Off
- Next Channel/Previous Channel
- Volume Up/Volume Down

6.2.1.4. Interactions Vision based on Functional Pleasant Tactility

Inviting
The experience of the interaction should fit with that of B&O. To create the theme 'inviting', things to consider are an open or welcoming character, with a low threshold to use (touch). Also, clear usability cues and immediate feedback are important.

Most of the inviting character will be visually noticeable, because when inviting to be used, the product is not actually in use yet, and is therefore not being touched yet. However, because it invites to be touched, it should have visual aspects that make people assume that touching the controller will be pleasant. The inviting visual aspects therefore have to point out pleasant tactile aspects. The inviting character will also be present in the tactile aspects, to invite continued use, for instance by making it a habit.

For inspiration, existing inviting aspects can be considered, with or without (pleasant) tactility (see figure 6.1).

Figure 6.1: Collage of Inviting Interactions

Mastery/Control

For the theme of mastery or control, it is important to have this playful character that makes people want to challenge themselves to prove themselves.

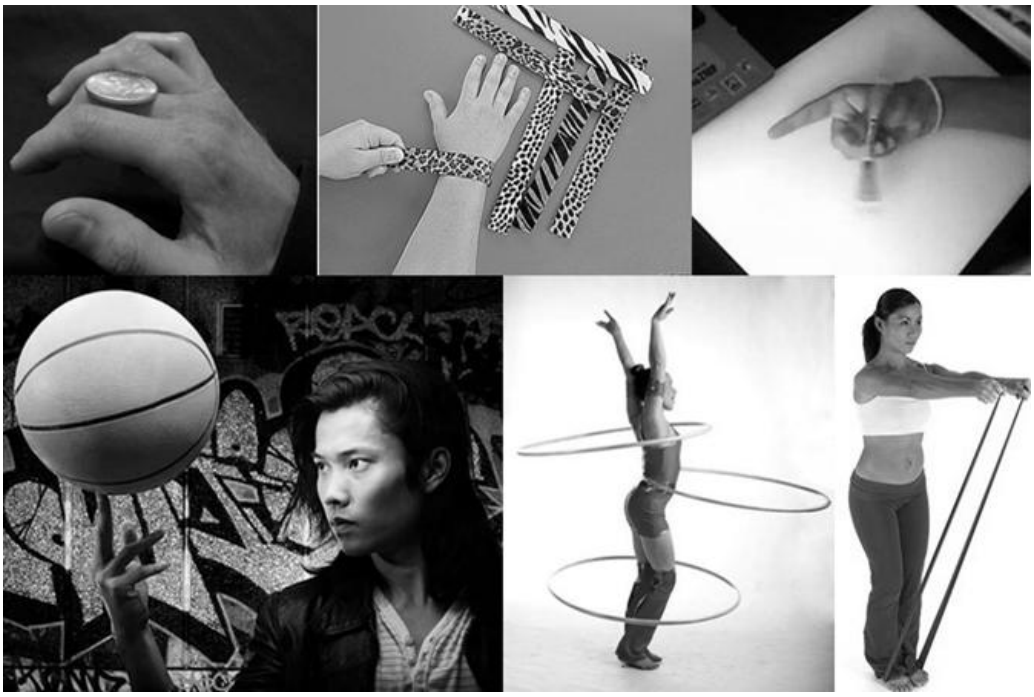


Figure 6.2: Collage of Mastery/Control Interactions

Functional pleasant tactility should be in the form of doing something tricky. It can be about exerting a large amount of force, as when stretching a training-elastic as far as possible or squeezing a (hair-) pin as hard as possible. It can also deal with fine coordination, like playing with a coin through the fingers or balancing a ball (sports related). It can also be something that is not too difficult, but done for a really long time (perseverance). Figure 6.2 can give inspiration.

Logically-Linked

In the theme of logically-linked functions, it is important that the function that is linked to the pleasant movement can be expected. The function should be predictable before (feed-forward) or during the movement made (feed-back).

Metaphors can be used to make this logical link. Those metaphors should be based on a similar goal, like paging through a book could be the function to page through channels. Many metaphors would be possible.

The interaction can also be linked by similar movements, like moving a mouse to the right will also move the cursor to the right. This can also be seen as linked to the movement of the (old-fashioned) mechanics behind the function, like with turning the wheels of a VHS tape to forward or rewind the movie. See figure 6.3 for inspiration.

Figure 6.3: Collage of Logically-Linked Interactions

6.2.2. Participatory Design Session

The participatory design session was done to turn the design propositions into real design concepts, with the help of designers at B&O. Here the method will be explained in detail, after which the results and conclusions follow.

6.2.2.1. Research Questions

The following research question, split up into three, was aimed to be answered through this participatory design session.

Q.1. How can pleasant tactile functions for controlling a B&O TV system be integrated into a design concept?

Q.1.1. Through the use of the inviting design proposition?

Q.1.2. Through the use of the mastery/control design proposition?

Q.1.3. Through the use of the logically-linked design proposition?

6.2.2.2. Approach

This brainstorm session was in the form of a creative workshop (as a form of participatory design approach), to gain qualitative information that could lead to three prototype concepts.

6.2.2.3. Participants

The workshop was performed with a variety of participants, all employees of B&O. The participants were aware of the background and the goal of the project. To keep the workshop manageable, the group consisted of 5 participants (including the author); more would have been too chaotic and less would have provided too little interaction and inspiration.

The participants were sampled by preference; one male and four female employees that are creative as well as have knowledge of the internal product development, with age ranging from 23 to 45, mean 30 years old.

6.2.2.4. Tools

Besides the necessary papers, markers, sticky notes and tape, inspirational material was needed; for each design proposition clear images of example actions, as results from previous sessions, were present (see figure 6.4), as well as pictures of existing examples (found online, based on personal insights) and printed explanations of each design proposition (from the design plan). Real objects were also present for inspiration.

Figure 6.4: Inspirational Images for the Three Themes Used in the Workshop

6.2.2.5. Protocol

The workshop was designed as a creative brainstorm session, which took about 2 hours and was made up of several phases: icebreaker, introduction, understanding the opportunity, creating ideas (diverging), a break, reorganizing ideas, selecting ideas (converging), possible second break, and conceptualizing ideas. The session was held in a separate room at the company B&O. The entire protocol can be found in Appendix C, including the procedure, data collection, venue and equipment, results, analysis and concluding design propositions.

Figure 6.5: Scene from the Brainstorm Workshop Venue

6.2.3. Design Concepts

In the following paragraphs the three design concepts, inspired from the workshop, for the prototypes will be presented and substantiated (note how left or right handedness does not influence the control of any of the remote controls). In each prototype the same functions are implemented in different ways, and to avoid

complications in the analysis of the research, the overlap of the design concepts is kept as small as possible.

6.2.3.1. Design Concept for Inviting Theme

The design concept for the inviting theme looks like a pillow with four different surface textures that look very soft and nearly irresistible to touch (see figure 6.6). Even though all four textures are soft to touch and invite caressing (this actives the corresponding function, see figure 6.7), they do contrast each other visually through their clear difference in texture, which is also a characteristic of the inviting theme. Colors were not considered, though, because it is expected to make it look childish and invite too much playfulness, which is not required here.

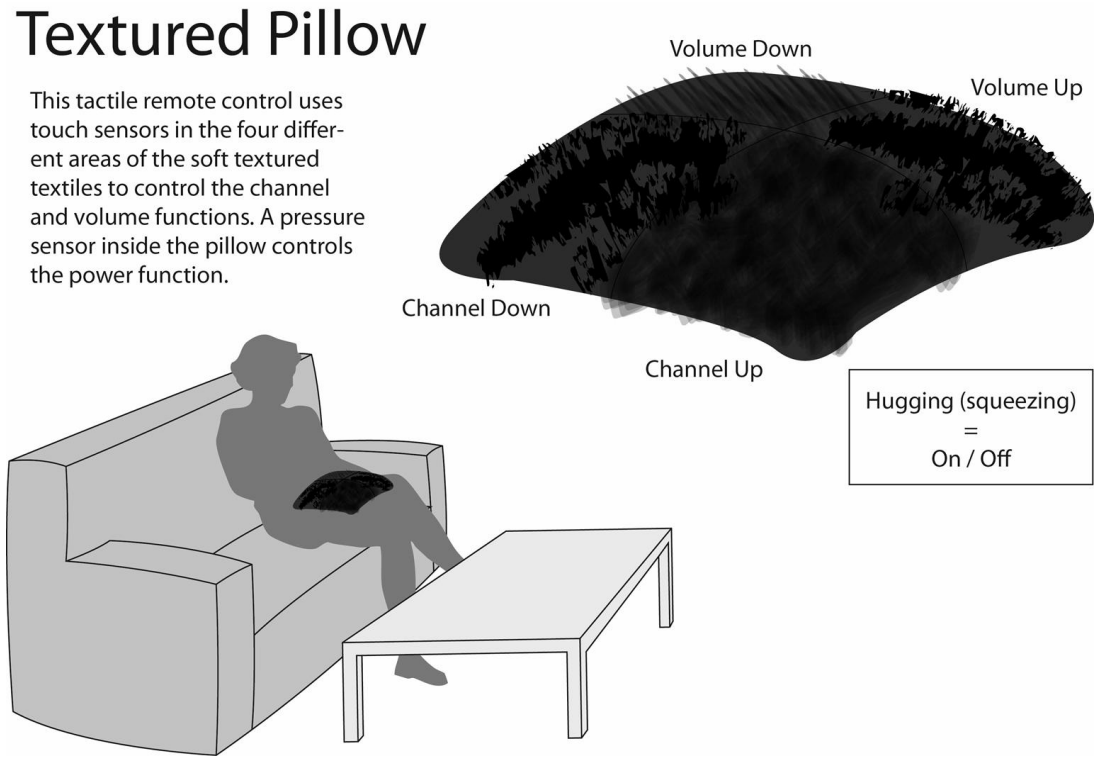


Figure 6.6: Design Concept for Inviting Theme

The different textures make people want to feel the difference, and the fluffiness (or softness) of the textiles makes people want to continue the interaction of caressing. So, in all its aspects, the remote invites caressing of the upper surface; this is therefore what activates the functions.

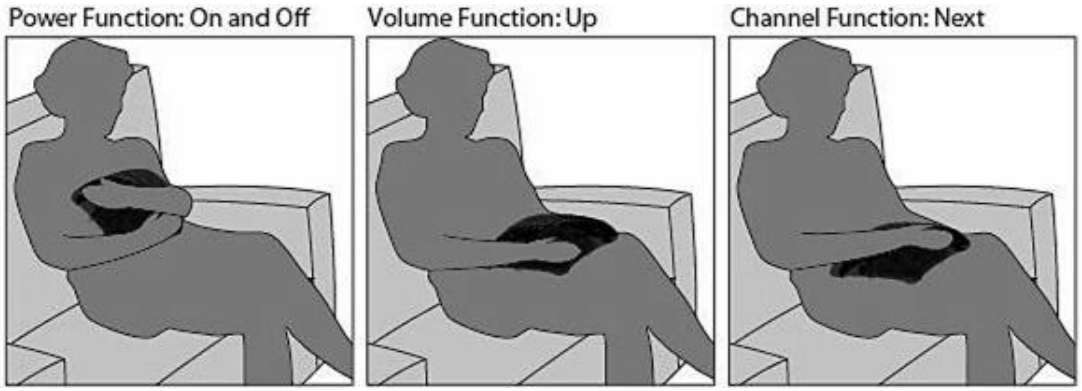


Figure 6.7: User Scenario for Design Concept of Inviting Theme

Additionally, the pillow is flexible in nature, and not heavy. Those aspects, plus the size of the pillow and the unfamiliarity of the hidden insides, invite picking up the pillow and squeezing it as well. This hugging of the pillow is therefore the on and off function. The aspects also invite easy handling of the pillow, as well as laying it down on the lap while watching TV.

Furthermore, the controls of the functions are not made known to the user in any kind of way, so there is an aspect of exploring and discovery involved. This is also part of the inviting theme.

6.2.3.2. Design Concept for the Mastery/Control Theme

The design concept for the mastery or control theme looks like the gear lever in a car (see figure 6.8). This immediately reminds people of driving, and thus controlling, a car. That is something that needs to be learnt, and thus mastery and skill is involved. The difference with a normal gear shift is that this one involves moving the handle through a labyrinth to get to the function controls (see figure 6.9).

Finding the way in a labyrinth is surely something where mastery is required, and it is not just a challenge for the mind, but also for the body, because the handle needs to be properly maneuvered. Eventually, the maneuvering can be done blindly, like in a car, when that skill is mastered and under control.

Exerting a large amount of force is not involved in this remote, but fine coordination is, in maneuvering the handle. Memory is also really important in this design, because that is how the interaction can become easier and faster. This can be mental memory, remembering which way to take, as well as 'muscle' memory, blindly finding the way because of repetition. That could be a skill to show off.

There is some perseverance involved as well, because there is no other way to activate the functions than by going through the labyrinth with the handle. However, it can be addictive as well, like a game, without actually activating any functions.

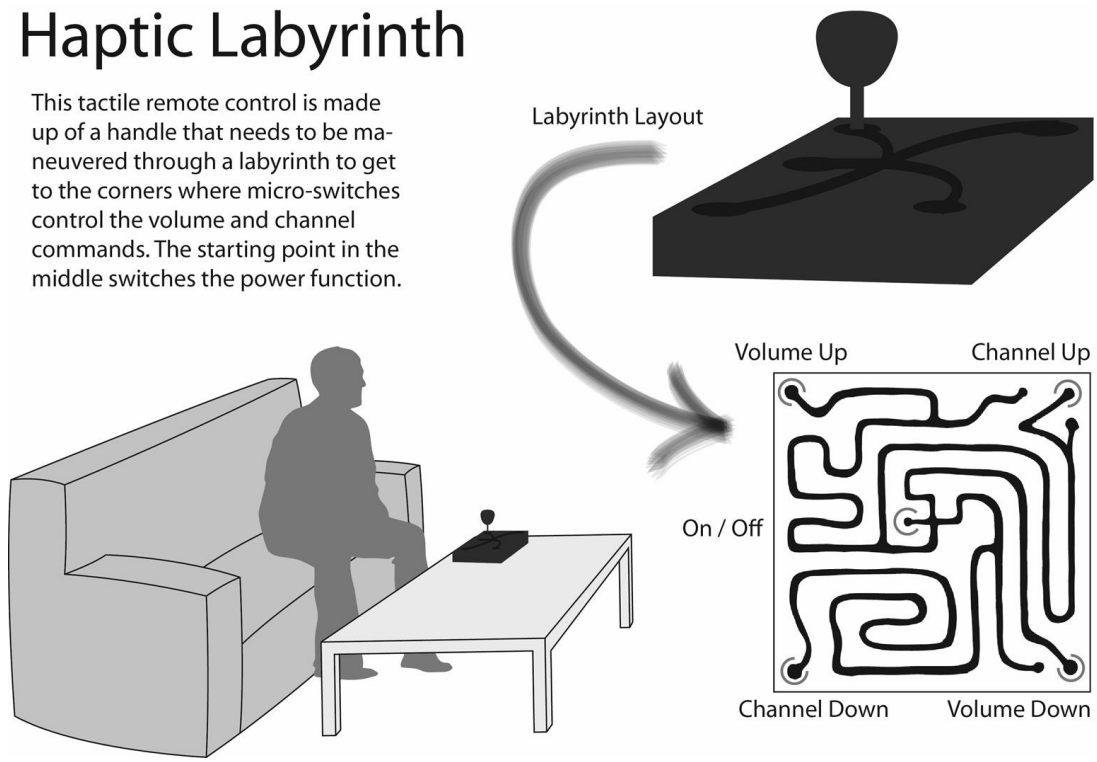


Figure 6.8: Design Concept for Mastery/Control Theme

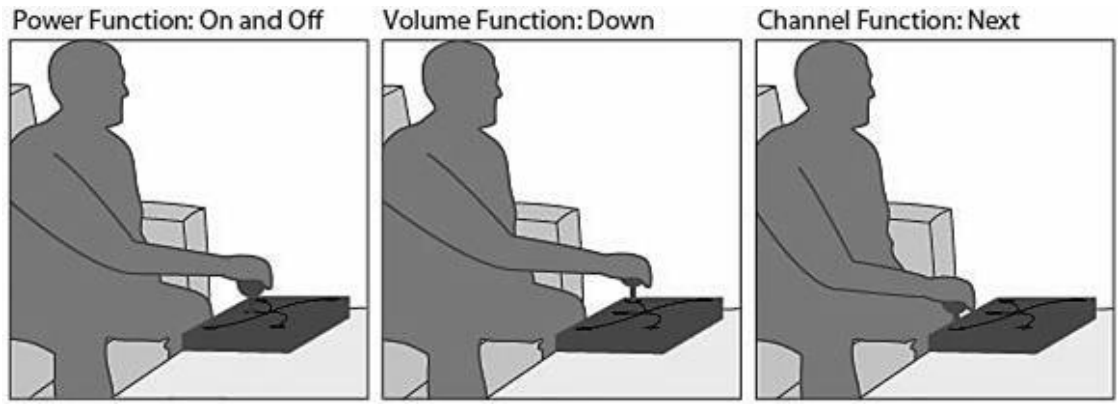


Figure 6.9: User Scenario of Design Concept for Mastery/Control Theme

6.2.3.3. Design Concept for Logically-Linked Theme

The design concept for the logically-linked theme blends in with the armrest (see figure 6.10). Having a remote control right there where people sit when watching TV is the first logical aspect of this remote control.

The volume and channel controls are hidden under a cover; lifting off the cover activates the power function of the TV (see figure 6.11). Covering up the controls with the cover will turn the TV back off. This can be seen as a metaphor of opening the curtains to look outside, which is translated to uncovering the controls to watch

TV. Metaphors and similar movements, like the opening-movement, are both part of the logically-linked theme.

Furthermore, the controls for switching channels and adjusting the volume are very different from each other. This is a very important aspect of the logic theme, and often forgotten in standard remotes.

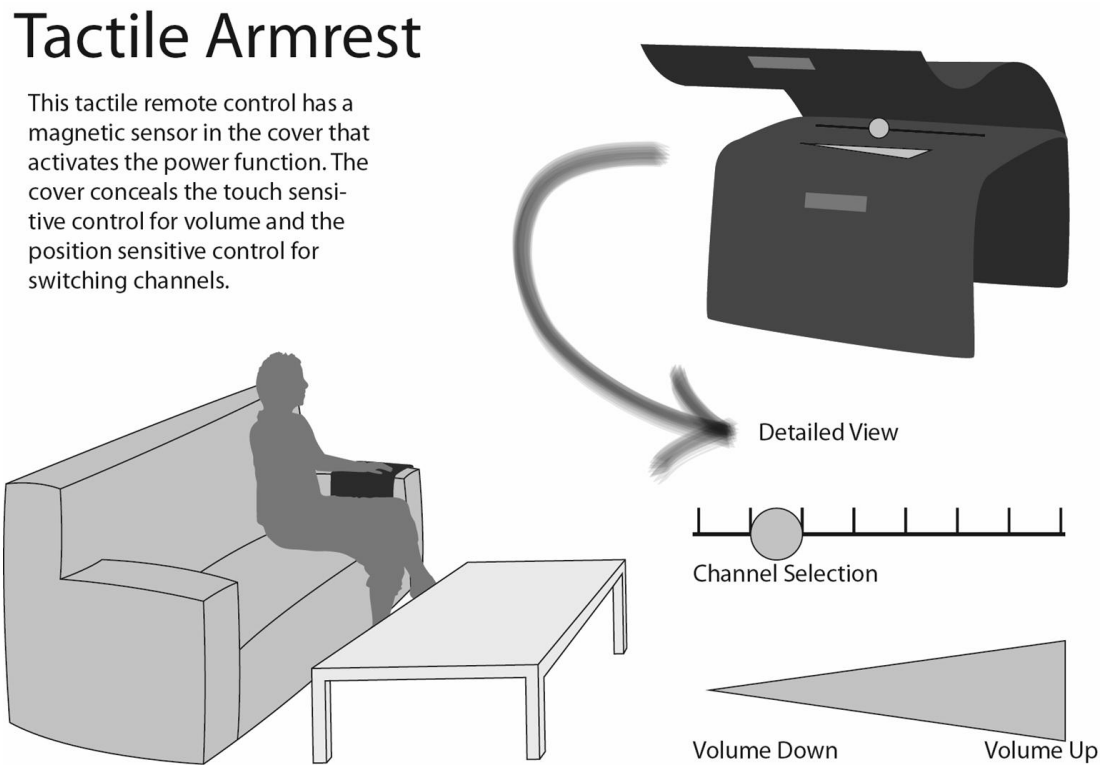


Figure 6.10: Design Concept for Logically-Linked Theme

The physical relationship between the function and the control is important for the logic theme as well. Therefore, the gradual function of volume adjustment has a gradual control, looking like a triangle; moving with the fingers over the touch sensitive triangular area, in the direction of the wide base will increase the volume, and moving in the direction of the narrow point will decrease the volume. Here the logic link is between the wideness of the triangle and the level of the volume; more wideness equals more volume.

Similarly, for changing the TV channel there is a control that has multiple levels, each corresponds with a different channel. Those levels are based on the absolute position of a sliding knob, and this position can be seen as well as felt through touch. So when the knob is moved toward the first position (furthest right in the image), the first channel is chosen; the second position then corresponds with the second channel, etc. This way, just by looking at the position of the knob, the active channel can be derived.

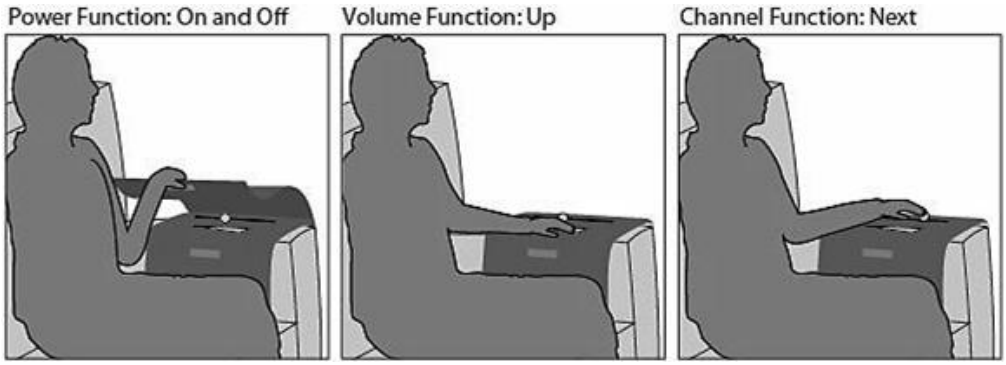


Figure 6.11: User Scenario of Design Concept for Logically-Linked Theme

6.3. PROTOTYPING

The design concepts are worked out as prototypes by implementing the design through research approach, which means that all aspects of the designs are tested constantly. The method of the prototyping process will be presented here, per theme.

6.3.1. Approach and Context

The three design concepts were materialized through experimental prototyping, because the best functioning needed to be achieved for the limited amount of time that was available, and that requires quickly experimenting with simple techniques and sensors. This can be seen as a small research through design, because every step of the prototyping was quickly tested and improved if necessary, so (design) decisions were made on those quick tests. Also, because of the limited amount of time and the purpose of the prototypes as objects in a research, proper functioning was more important than the appearance or finish.

Figure 6.12: Photo of Measure of Pleasure Room at B&O

The testing was done in the Measure for Pleasure room at B&O (see figure 6.12). The room had a couch and an armchair, a table and a TV system, and there were built-in cameras and microphones.

6.3.2. Prototyping the Inviting Theme: The Pillow

The process of creating the pillow prototype, based on the design concept for the inviting theme, will be presented here.

6.3.2.1. Materials

For the body of the pillow prototype, soft filling was of course needed, as well as very soft inviting textiles (4 kinds) and a textile for the back of the pillow. Capacitive touch sensors (4 times) were required for the functioning, in combination with a remote processor board, batteries for powering the remote processer boards (1 pair), an infrared transmitter and cables.

6.3.2.2. Process

For the textured pillow concept a simple pillow of 40 by 40 cm has been acquired, with a soft even filling. For the back of the pillow an existing pillow case was used, with zipper in the middle, made of a thin, somewhat stiff black linen textile. The back textile was not extremely pleasant in touch, and therefore not inviting, so it was clear that the back had no particular use. The textile was rough enough to have some grip while being caressed on someone's lap.

The four different soft textures that were used for the top surface of the pillow can be seen in figure 6.13, as well as the pillow itself and its pillow case.

Figure 6.13: Photo of Pillow, Case and Surface Textures

The very fluffy material in the middle on the right is duck down. It feels extremely soft and invites soft caressing. The fabric on the top right is a more thick pile textile. The texture is opposite of fine, but still very soft. It invites a rougher kind of stroking, with more force involved. The bathrobe on the bottom left has a different texture on the inside than on the outside. Both were used for the pillow surface. The outside is like a pile textile as well, but not so thick. It invites stroking with more force as well. The inside material is more fluffy again and feels extremely soft as well. It also invites soft caressing, but with more force than on the duck down.

Figure 6.14: Photo of Four Surface Textiles Pinned Together

All the fabrics were cut to the right size, and the sides needed to be bound to avoid fray. Then the textiles were sown into one pillow surface (see figure 6.14). The pillow could only be fully sewn together after all the electronics were inside.

The touch sensors were made of electrical tape, which was fixed on a plastic area for proper adhesion (see figure 6.15). The four areas of electrical tape were connected to the processor board through cables that were soldered onto the electrical tape and the processor board. The electrical taped areas then served as capacitors, so that, when an object or hand comes close to it, changing the capacity, the sensors will detect this.

Later, the plastic area was sewn right underneath the top surface of the pillow, in such a way that the electronics were safely hidden.

The touch sensors needed to be tested in combination with all four different textiles, and the sensors needed to be calibrated for noise, preferably in the destined environment. This revealed that the touch sensors were too sensitive, so the double cross in the middle of the touch sensitive areas were removed and only the square outlines were left. The electronics all needed to be firmly connected as well, so the prototype was robust and could resist use situations.

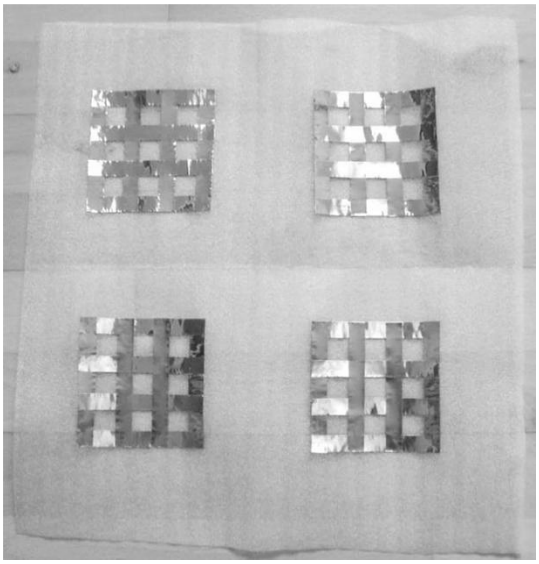


Figure 6.15: Photo of Capacitive Touch Areas

In the prototype an infrared (IR) transmitter was used to control the TV, whereas in a real product a radiofrequency transmitter would be preferable. Because the IR transmitter needed to be oriented towards the receiver on the TV, the IR transmitter could not be inside the pillow. Therefore the IR transmitter was put outside of the pillow, at the end of cables running from the pillow to the transmitter, as can be seen in the resulting prototype in the next section.

6.3.2.4. Result

Figure 6.16 shows the resulting pillow prototype, with its four different textures that can be touched in order to adjust the volume and channel functions, and hugged (touching the four areas simultaneously) to activate the power function.

Figure 6.16: Photo of Final Pillow Prototype for Inviting Theme

6.3.3. Prototyping the Mastery Theme: The Labyrinth

The process of creating the labyrinth prototype, based on the design concept for the mastery theme, will be presented here.

6.3.3.1. Materials

For the body of the labyrinth prototype a plastic foot and board, in which the labyrinth path would be carved, were needed. For the handle connection parts and insides were required, as well as leather for the outside. Micro switches (5 times) were needed for the functioning, in combination with a remote processor board, batteries for powering the remote processer board (1 pair), an infrared transmitter and cables.

6.3.3.2. Process

The layout of the haptic labyrinth was made digital so it could be fed to a CNC machine. The machine then milled it out of a plastic board of 20 by 20 cm with a thickness of about 5 mm (see figure 6.17).

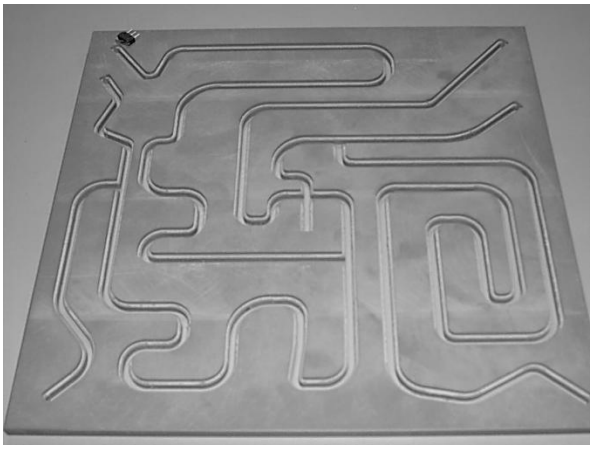


Figure 6.17: Photo of Labyrinth Board

Because of the layout of the labyrinth, parts of the plastic board could not just move up and down, but also left and right. This would change the wideness of the path that the handle should travel, which would have caused mechanical problems like resistance. Therefore, the plastic plate needed to be mounted on top of a 'foot' for stability (see figure 6.18).

Figure 6.18: Photo of Labyrinth Foot with Temporary Handle

The handle that was placed on a runner that moves through the labyrinth path could not be too large or heavy, because that would have caused more mechanical problems. It could not be too small either, because that would make it uncomfortable to grip the handle by hand. The handle was covered in leather to make the metaphor of a car gear lever stronger (see figure 6.19). Leather is also a pleasant material to touch, because it does not get sweaty.

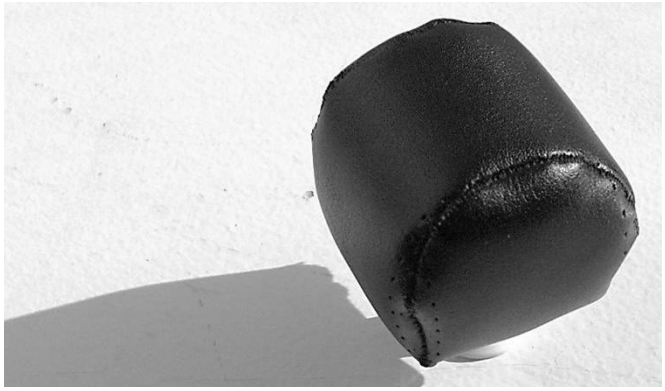


Figure 6.19: Photo of Labyrinth Handle Covered in Leather

The micro switch (see upper left corner of figure 6.17) shows how the functions were activated; the five micro switches were glued in between the two plates of the food, at the four corners and one in the middle. By moving the handle against the switch, the switch is pressed and the function is activated.

The electronics all needed to be firmly connected so the prototype was robust and could resist use situations. Because the prototype did not have enough space inside, the electronics were all put inside a separate box (including batteries), connected with cables to the labyrinth, with the IR transmitter pointing toward the TV receiver (see figure 6.20). The switches needed to be tested for use, preferably in the destined environment. This proved that it worked well and was robust enough for a prototype.

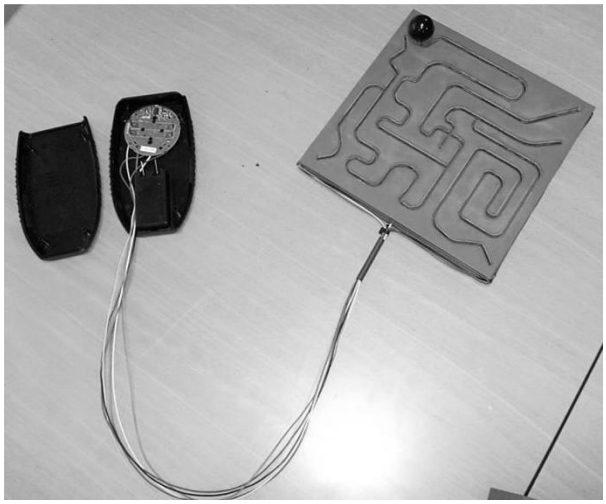


Figure 6.20: Photo of Labyrinth with Electronics in Separate Box

The final prototype was put on a table in front of the TV, so it could be used while sitting on the couch (see figure 6.21).

Figure 6.21: Photo of Labyrinth Prototype in Context

6.3.3.3. Result

Figure 6.22 shows the resulting labyrinth prototype, with its four corners where the volume and channel functions are situated, and the middle to activate the power function by moving the handle to those places.

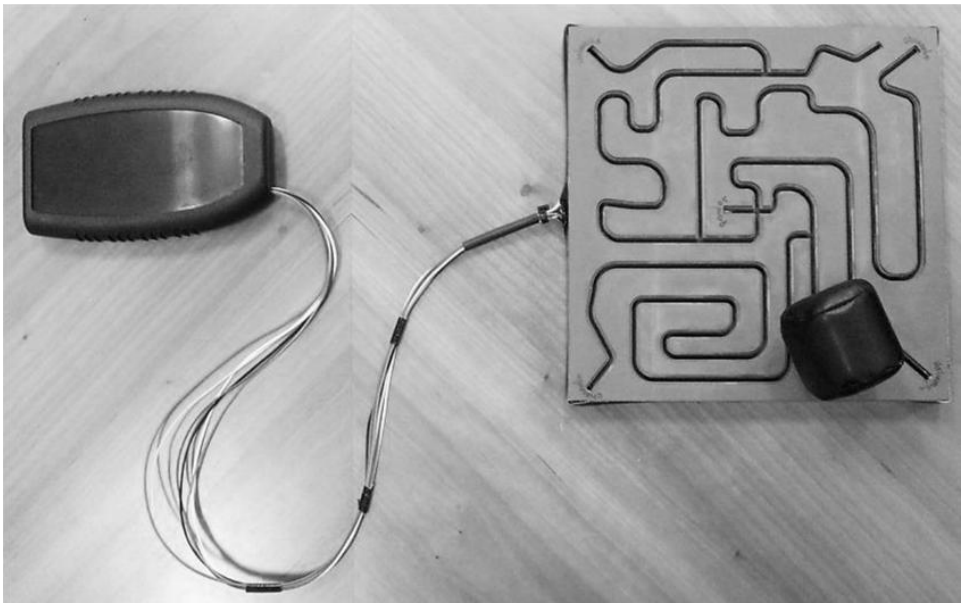


Figure 6.22: Photo of Final Labyrinth Prototype of Master/Control Theme

6.3.4. Prototyping Logic Theme: The Armrest

The process of creating the armrest prototype, based on the design concept for the logic theme, will be presented here.

6.3.4.1. Materials

For the body of the armrest prototype, a plastic board (top only) was necessary, as well as a soft textile for the outside and cover. A magnet sensor (or micro switch and normal magnets) was needed for the cover function. A touch and position (potentiometer) sensor were also needed for the functioning, in combination with a remote processor board, batteries for powering the remote processer board (1 pair), an infrared transmitter, and cables.

6.3.4.2. Process

The tactile armrest design concept of the logically-linked proposition did not need to be universal, because it was only going to be used in the research. Therefore, a specific armrest has been chosen for the prototype to fit around it (see figure 6.23), with dimensions of 45 cm depth, 11 cm width, and 15 cm height measured from the seat.

A rectangular touch sensor of 25 by 100 mm has been found for the volume control (see figure 6.24). The sensor was covered by a thin layer of leather-like plastic to leave only a triangular shape uncovered. The layer could also have the visual position lines of the sliding position sensor on it.

Figure 6.23: Photo of Chair with Armrest Used for Prototype

The sliding position sensor was a potentiometer of about 10 cm in length, with a knob similar to those that can be found on audio mixers (see figure 6.24).

Both sensors were mounted on a plastic plate of 10 by 20 cm, with a thickness that allowed the sliding position sensor to be sunk in, which functioned as the stable upper side of the prototype (see figure 6.24).

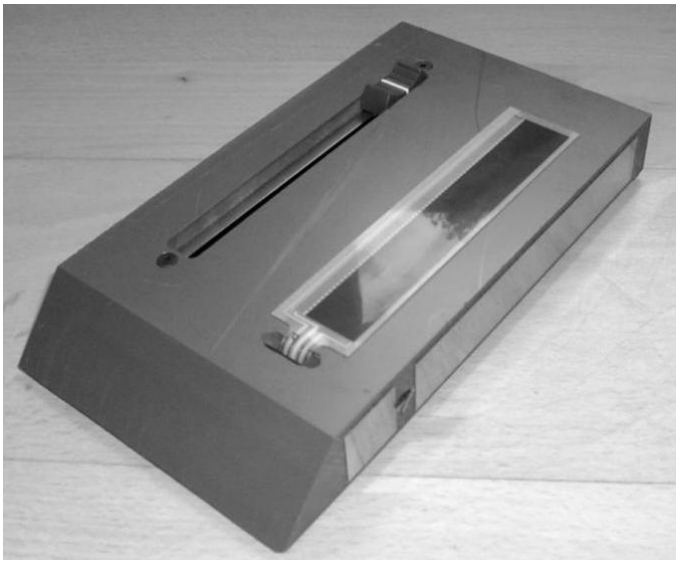


Figure 6.24: Photo of Armrest Body with Touch Sensor, Potentiometer and Side Switch

The electronics, such as the batteries, the side switch and the processing board, were hidden inside the plastic body (see figure 6.25). A hole in the plastic body allowed the IR transmitter to be directed toward the TV. Little rubber feet made sure the plastic body did not move from the armrest.

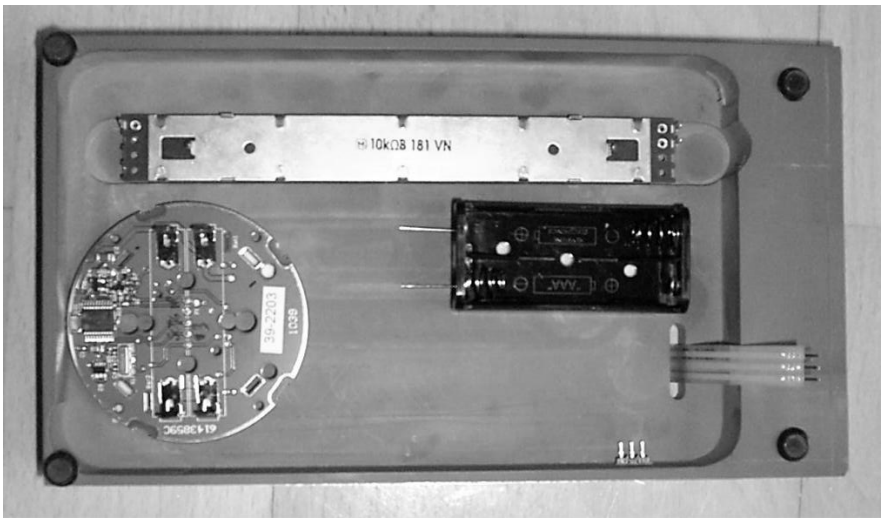


Figure 6.25: Photo of Armrest Body with Electronics Inside

Fabric bands covered the stable plastic plate and the sides of the armrest (see figure 6.26), to make sure the stable plate stayed in position and the electronics were hidden.

Figure 6.26: Photo of Armrest Body with Fabric Support and Cover

A textile cover was connected to the textile of the body, with magnets as the closing mechanism. A micro switch was put right between the magnets, so it is pressed when the cover is closed. This activated the power function; when the cover was opened, and the switch released, the TV went on; when the cover was closed, and the switch pressed, the TV turned off.

The electronics all needed to be firmly connected so the prototype was robust and could resist use situations. The sensors needed to be calibrated for noise, preferably in the destined environment. This showed that the channel slider was a little unstable, but good enough for a prototype. The touch sensitive volume area, however, was not properly implemented; so this part of the prototype did not work, but since everyone has touched a touch-screen in their life, they could imagine its use.

6.3.4.3. Result

Figure 6.276 shows the resulting armrest prototype, with its cover to activate the power function on the left, and the triangular touch area and slider to adjust the volume and channel functions on the right.

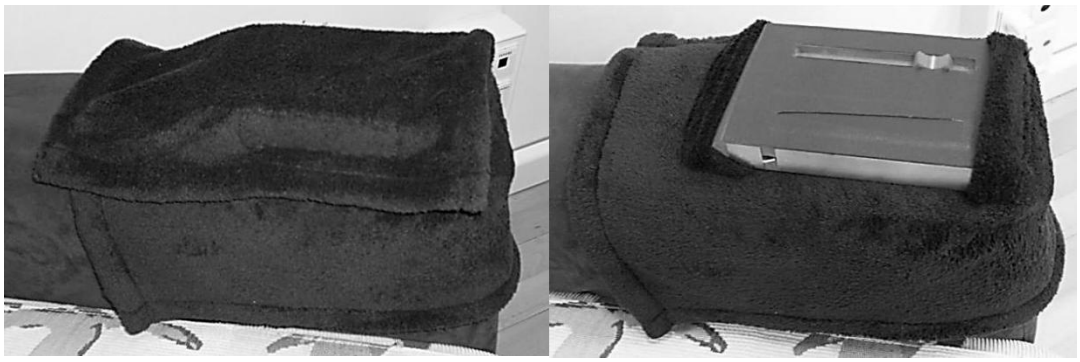


Figure 6.27: Photos of Final Armrest Prototype of Logically-Linked Theme

6.3.5. Reflections

A critic on the designs was that they represented only one way of implementing the themes; the author's personal interpretation of the gathered data. It raises the question whether the themes will be evaluated, or only the author's interpretations. Fortunately, the user study is set up in such a way that for all evaluations the cause will be asked; therefore, the unrelated evaluations can be left out of the results.

The author expected to prototype the concepts independently, but this was not the case; machine work was done by the prototyping department of Bang & Olufsen and programming was done by a B&O programmer. The advantage of this was that it was a lot less trouble for the author, but a lot more trouble for the company. Therefore, the quality of the prototypes was great, but the prototypes were not all finished on time, and the author had less influence in the end result.

6.4. CHAPTER CONCLUSIONS

In the second phase of the case study, the themes were used as starting points to design and prototype three different concepts: a pillow prototype, a labyrinth prototype and an armrest prototype. Several methods were used to get to the final prototypes, like a participatory design session (workshop) for inspiration. It can be concluded that help from other designers is welcome in this phase.

Furthermore, the participatory design session (workshop) can be diverted from; creative sessions always work best when they are tailored to fit the facilitator.

Finally, prototyping skills are required for the process to go smoothly, and it is important to keep on testing the intended functioning and tactility while prototyping, to adjust the design accordingly.

CHAPTER 7

USER EXPERIENCE OF DESIGN PROPOSITIONS

7.1. CHAPTER INTRODUCTION

In Phase 3, the final phase of the case study, the resulting three prototypes from the previous phase were being used to test and evaluate the underlying themes, in order to come to a final design proposition. This was done by exploring the user experience of the created prototypes with the intended target group in a user study. This chapter will therefore answer the main research question of 'how do people respond to the resulting B&O TV remotes?' and is based on the performed user study.

First the goal, research questions and method of the user study will be described. Then the results will be presented and analyzed per section of the user study, with resultant data overviews. Finally the responds to the research questions will be concluded from the analyzed data, and a final design proposition will be presented. From there on, a conclusion could be drawn on the effectiveness of the envisioned design strategy.

7.2. GOAL

The goal that this study aimed to achieve was to explore the effects of the prototypes (based on the implemented themes of inviting, mastery and logic), like the user experience, on the intended target group, to come to a final design proposition.

7.3. RESEARCH QUESTIONS

This phase of the case study tried to respond to the following questions.

Q.8. How do people respond to the resulting B&O TV remotes?

Q.8.1. In what way are the prototypes pleasant in tactility?

Q.8.2. Is pleasant tactility in the prototypes perceived as a positive quality?

Q.8.3. Are the interactions based on functional pleasant tactility perceived positively?

Q.8.4. What user experience do the prototypes bring about?

Q.8.5. Do the prototypes fit with Bang & Olufsen?

Q.8.6. Were the themes effective?

7.4. METHOD

7.4.1. Approach

The user study was held at Bang & Olufsen in a home-like situation with the intended target group, made up of 28 participants, all individually using the three different prototypes in random order (to avoid any order effects), in a within-subject manner.

7.4.2. Participants

The target group was made up of both men and women, as well as younger and older participants (8 males between the ages of 25 to 35 with a mean of 31 years old; 8 males between the ages of 45 to 53 with a mean of 48 years old; 6 females between the ages of 28 to 35 with a mean of 32 years old; and 6 females between the ages of 45 to 48 with a mean of 46 years old).

The participants were sampled by convenience; employees of B&O, who responded to the announcement on the B&O intranet. Family was also invited. They all understood and spoke English.

7.4.3. Prototypes

The three prototypes that were evaluated in the user study can be found in the previous chapter (see Chapter 6, Figures 6.16, 6.22 and 6.27).

7.4.4. Protocol

The user study involved multiple research methods (see figure 7.1), to be able to answer the different research questions, as mentioned in Chapter 3. The complete protocol of the user study will be described here in detail.

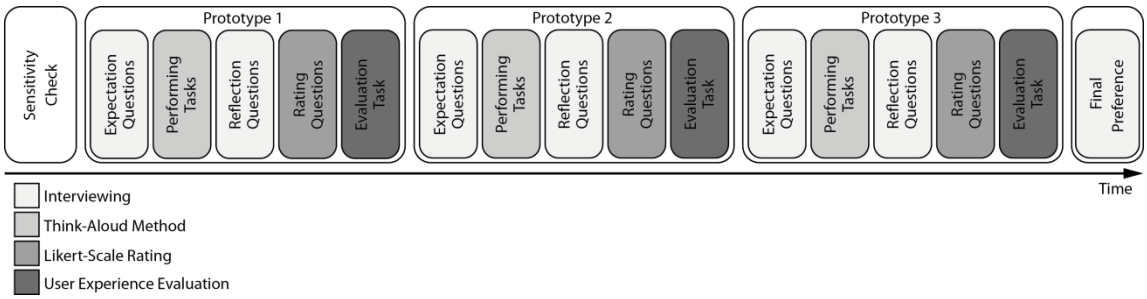


Figure 7.1: Overview of the User Study in Time

The participant was briefly introduced to the aim of the research, and an explanation of the research was given (see Appendix D), so the participant knew what to expect and how long the session would approximately take (30 minutes).

The exploratory research started with testing whether the participants were actually sensitive in their fingers, because a small percent of the people cannot feel much in their finger-tops, which is not desired for testing tactility. This was a very simple and quick test, where the participants were pricked with a pin with two points on 2 and 5 mm distance, and they just had to report how many points they felt, without looking. If they did not feel the two points on 5 mm distance, they were not sensitive enough (Mortensen et al., 2009). The participants were also pricked with a pin with only one point, in random order, to make sure that the results were verified.

Then the first random prototype was shown, and the participant was asked about the expectations derived from the visual aspects. These questions were:

- *Looking at the controller, how do you expect it will **work** (what do you have to do to activate the functions)?*
- *How do you expect it will **feel** (think about: weight, material, texture, temperature, hardness, volume, shape, moving parts, pleasantness)?*

The participant was asked to perform six tasks to explore how the controller worked, while using the think-aloud method: telling us what they are thinking, why they do certain things, how they know certain things, etc. (Someren, Barnard & Sandberg, 1994). These tasks were:

- *Turn the TV system on;*
- *Turn the volume up;*
- *Switch to the next channel;*
- *Turn the volume down;*
- *Switch to the previous channel;*
- *Turn the TV system off.*

Participants were then asked to reflect upon the experience of using the prototype by first answering i) reflection questions and ii) a rating question, and then performing iii) an evaluation task.

i) Reflection Questions

- *Did the controller work as you expected? How so?*
- *Did the controller feel as you expected? How so?*
- *Did you enjoy using the controller? How so?*

- *Does it fit the Bang & Olufsen style? How so?*
- *How would you rate the presence of the following three themes:*
    - *Inviting (irresistible to touch)?*
    - *Mastery/Control (achieving something difficult)?*
    - *Logically-Linked (link between control and function)?*

ii) Rating Question

For the rating question, a piece of paper was laid in front of the participant, with a 6-point Likert scale (no neutral, but enough options to choose from in a small amount of time (Matell & Jacoby, 1972)), from strongly absent to strongly present, for all three themes. The participant was introduced to the three themes, and then simply had to tick the corresponding rate and direction of presence (see Appendix F for an example of the form).

iii) Evaluation Task

The evaluation task asked the participants to express their experience in three pictures (see Appendix A for the full overview of all the images used), by selecting them from Marco Rozendaal's collection (Rozendaal, *forthcoming*) based on what was experienced (positively or negatively) most strongly. A short description of the feelings and product aspects involved were asked from the participants as well.

After the evaluation task, the participant was shown the second random prototype, and the other steps (all the steps described before) followed again. The same happened for the third random prototype. Some final questions closed off the research session:

- *Which controller felt most pleasant, and why?*
- *Which controller felt least pleasant, and why?*
- *Which controller did you enjoy using most, and why?*
- *Which controller did you enjoy using least, and why?*
- *Do you think that pleasant tactility makes the user-experience better?*
- *Did you enjoy participating in this research?*

At the end of a session a small present was given to thank them for their participation. This was candy that is specially designed for tactility.

7.4.5. Data Collection

The entire user study was recorded on video. Notes were made during the user study sessions (see Appendix E for an example form), in order to recall previous answers during the sessions and to have a back-up in case anything went wrong. The results from the magnitude rating of the themes were paper-based (see Appendix F for an example form). The video recordings were transcribed and summarized in a table (for part of this table from the spreadsheet, see Appendix G), including the paper based rating questions and the labels for the images used in the user experience evaluation question. The participants that were not sensitive enough, or did not fit in the target group, were left out.

7.4.6. Data Analysis

The mostly qualitative data was divided over the separate parts of the user study, and grouped by prototype. An overview diagram of the results is created (see figure 7.2), to better understand how they are linked to each other.

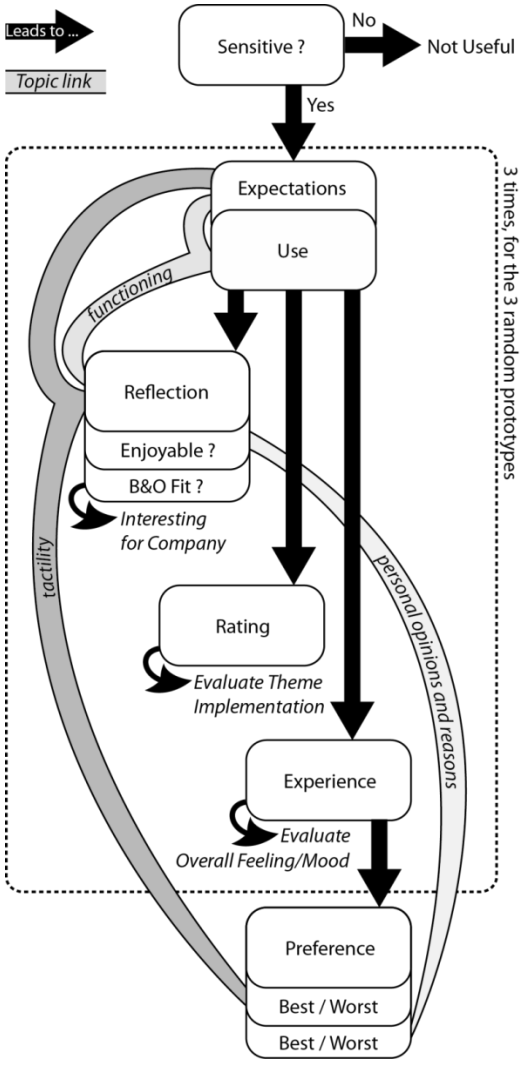


Figure 7.2: Overview of Links between Different Parts of the User Study

The data was interpreted to be able to form clusters; expressions like 'it was not easy', 'it was complicated' and 'it was too difficult' were all put under the same cluster named 'difficult'. It should also be noted that participants mentioned multiple things, so when a participant answered with "yes and no, because…" it was put under both the 'yes' and 'no' clusters.

The interpreted data was then content analyzed for commonalities within each prototype. This data is represented in visual overviews of word clusters (see figures 7.3 to 7.32); the words (or phrases) that are large, bold and centered are clusters that were often mentioned, and words that are small, thin and positioned away from the middle were least mentioned. The data from the rating questions was also checked for quantitative significance by using statistics.

7.4.7. Venue and Equipment

The study was held in a home-like situation, where the participants were in peace and at ease. There were no disturbances, and it was (far) away from their normal work place. The audio-video recording system of the room was used.

7.5. RESULTS

The results will be presented per prototype, starting with the pillow prototype for the inviting theme, then the labyrinth prototype for the mastery and control theme, and lastly the armrest prototype for the logically-linked theme. For each prototype, the results are split up into the separate parts of the user study, for readability and understanding. The results are shown as word clouds (wordles) with clusters of participant quotes. The smallest words away from the center are mentioned 1 to 5 times. The bigger words around the center are mentioned 5 to 10 times. The smaller bold words in the center are mentioned 10 to 15 times. Accordingly, the biggest bold words in the center are mentioned 15 times or more. Finally, the participants' preference for prototypes is discussed, and overall comments are made.

7.5.1. Pillow Prototype

Each part of the user study will be discussed in a separate section, but only the most important results are discussed.

7.5.1.1. Expectations on Functioning and Use

After being exposed to the prototype, the first question was asked to the participants on the expectation of the functioning of the prototype: How do you expect it will work/how do you expect to activate the functions?

The pillow prototype was always immediately recognized as a pillow. This even led to the misunderstanding that it was not a remote at all, or that the actual remote control was hidden underneath it. So for functional pleasant tactility, using a metaphor related to pleasant tactility should not be too extreme.

Figure 7.3: Participant Expectations on the Functioning and Use of the Pillow Prototype

Figure 7.3 clearly shows (size corresponds to frequency) that the squeezable characteristic of the pillow invited to press and squeeze the pillow (hugging was the power function). However, the participants expected all the functions to require pressing for activation. The softness and fluffiness of the textures did not dominate to make caressing more inviting or intuitive. Only a few participants expected a soft touch, rather than pressing. So inviting a caressing movement for functional pleasant tactility should be done in a clearer manner.

The contrast between the four different textures worked as an indication, for the participants, that they activated four separate functions. Many participants also realized that there was a function missing, and guessed that the power function might be activated in the center or middle of the four areas. This worked as well (although hugging the pillow was intended, but too the prototype was too fragile for it). So, clear contrasts work well for indicating separate functions.

A pillow also looks sturdy and invites playful handling for some participants. Many participants wanted to lift the pillow off the table, turn it around or put it on their lap. One participant assumed to throw it away in order to turn the power of the TV off. However, because of the fragile state of the prototype, none of this was unfortunately possible. It can be assumed as a principle of functional pleasant tactility that soft, light or bouncy, sturdy looking objects invite handling and playing with.

It was commented that there were no buttons visible. Participants did not know which function to expect where. Channels or volume could be left, right and diagonally, depending on which remote the participant was used to (volume and channels do not have a fixed position across different brands of remote controls). Here there is not one intuitive principle for the placement of functions, so a clarification is needed (in the form of indications, text, symbols, etc.).

7.5.1.2. Reflections on Functioning

On the topic of functioning, the second question was asked to the participants on the reflection of it in the prototype after using it: Did it work the way you expected it to?

Figure 7.4 shows how the participants reflected on the expected functioning of the pillow prototype after use.

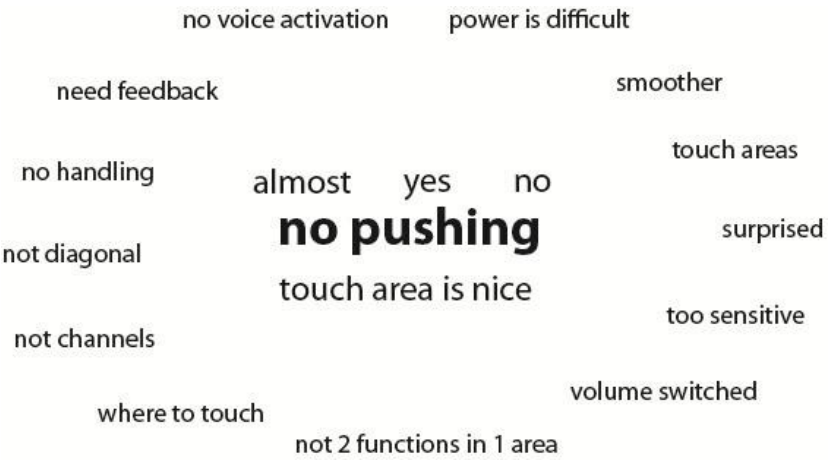


Figure 7.4: Participant Reflections on the Functioning of the Pillow Prototype

The answer to the question whether the prototype worked as expected was often "yes, except for…" where they named the aspect that did not work as expected. Some participants clearly said that it did not work as expected, with similar reasons, mentioned below.

Nearly all participants commented that they expected to push for function activation; however the activation worked on soft touch only. Most of them then mentioned that soft touch was nice, and maybe even better, more magical. The design principle of trial-and-error could be stronger here; in a way that pressing would create such an error (turning off for instance) that it is quickly replaced by soft touch.

Reflections on which square area corresponded with which function were also made. The design principle of exploring works well here, but it is not enough to remember the positioning of the functions; more indication is needed. Moreover, the up and down function of the volume was unintentionally switched around, so there was completely no logic in the placement of the functions. This was noticed as well. The design principle of logic mapping is needed in at least a small amount, to be able to remember function positioning.

The pillow prototype was over sensitive, because activation of the functions sometimes occurred before the pillow was touched at all. Participants commented on this as well, but realized that it was just a prototype. The same counts for comments on bugs and unstable behavior. Proper functioning is therefore probably more important than pleasant tactility.

Many participants were pleasantly surprised by the prototype. This was mostly because it was just a pillow, but now it worked as a remote control. Also the magic of the hidden functioning, and that it actually worked were reasons for surprise. Aiming for surprise is a good design principle for wanting to show it off to friends.

7.5.1.3. Expectations on Tactility and Use

The question that was asked on the expectation of tactility in the pillow prototype was 'How do you expect it will feel?' after being exposed to the prototype. This was combined with using the prototype to explore the expectations.

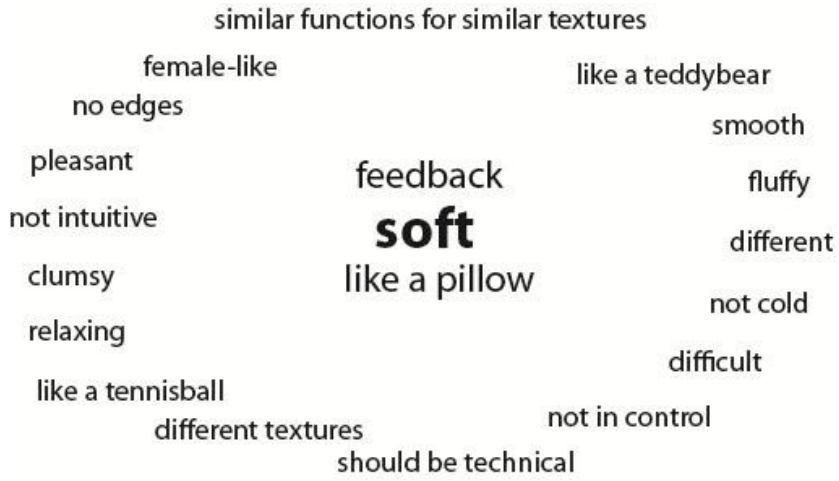


Figure 7.5: Participant Expectations on the Tactility and Use of the Pillow Prototype

The tactility that was expected of the pillow was clearly pillow-like softness and a different feel for the different textures (see Figure 7.5). This was intended, so the characteristics of the pillow were well expressed.

Some participants also expected tactual feedback after activation of a function. This was because there were no clear buttons, so they expected the activation to be clear through enhanced feedback. However, during use, the TV gave direct feedback by responding to the controls.

7.5.1.4. Reflections on Tactility

On the topic of tactility, the second question was asked on the reflection of it in the prototype, after having used the prototype: Did it feel as expected?

For this prototype the answer to the question whether it felt as expected, was mostly answered by "yes" (see figure 7.6). Some exceptions were mentioned, and some participants answered with "no" and explained why, with similar reflections.

The prototype indeed felt like a pillow (soft, warm, and with different fabrics), as expected by the participants. This was no surprise. However, the fluffy texture was made of small down feathers, and some of the ends were felt to be pointy. This was not expected, and also not intended, but a good finish cannot always be expected of a prototype.

One participant noted that it worked even before she understood how it worked. This is the trial-and-error principle that clearly works well for functional pleasant tactility.

Figure 7.6: Participant Reflections on the Tactility of the Pillow Prototype

7.5.1.5. Users' Enjoyment

As part of the reflection, the participants were asked whether they had enjoyed using the specific prototype. This was asked to find out if functional pleasant tactility had a positive effect on the user's enjoyment. Even though most participants had enjoyed using the prototype, they found the remote too extreme for everyday use compared to normal remotes; normal remotes were often preferred.

Figure 7.7: Participant Reflection on the Enjoyment of Use for the Pillow Prototype

Most participants had enjoyed using the pillow prototype, but some had not (see figure 7.7). The biggest reason that they enjoyed it was because they thought it was fun (the pillow prototype was most often mentioned as fun, compared to the other two prototypes). Other reasons for enjoying were that they found it nice, special,

surprising, magical, new, easy, and soft. This deals mostly with the interaction, which is usually a combination of functioning and tactility.

Reasons why it was not enjoyable included finding it too fuzzy (unclear), as if not in control, difficult, too big, impractical, not real, fragile, too different, missing feedback and too sensitive. Most of them relate to aspects that could be solved in a real product, compared to a prototype.

The exceptions were two participants (older females) that considered the pillow prototype to be dirty, because everyone would touch it. Here, reflections on the context were being made, which was never specified.

7.5.1.6. Fit with Bang & Olufsen

Because the prototypes were designed to fit with B&O, the participants were also asked to reflect on this. Though for the research this part is not very important, it is interesting for the company to know. First of all, it becomes clear what the employees of Bang & Olufsen consider as the B&O style. Secondly, it is interesting to know which aspects fit with this style, which do not, and which might in the future.

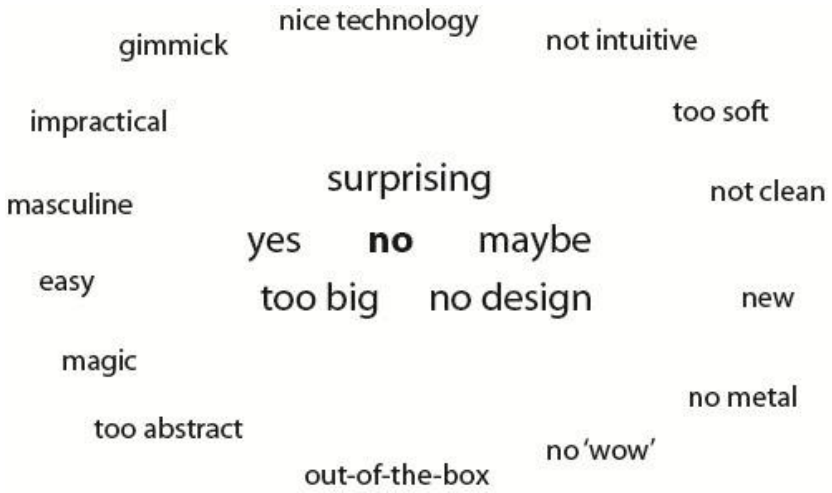


Figure 7.8: Participant Reflection on the Pillow Prototype's Fit with B&O

For the pillow prototype, the answer to the question whether it fits with the B&O style was mostly answered by "no", however "yes" and "maybe" were often mentioned as well (see figure 7.8). The biggest reason that it did not fit the B&O style was because the pillow prototype missed proper design and finish, which can be expected in prototypes. Other common concerns were that the pillow was not masculine enough for B&O, and that the pillow was too big for a B&O style remote control. The materials used were also thought not to fit with B&O, because metal (aluminum) is expected.

The participants also mentioned aspects that did fit with the B&O style, like new, magical, surprising and out-of-the-box, as well as being easy and nice in use, and

having an interesting technology. So, by improving the prototype into a real product, it might actually fit with B&O.

7.5.1.7. Rating on Presence of Themes

A statistical analysis has been performed for the rating questions. Because the 6-point rating scale was from negative to positive (but without a neutral point), it is here represented from -3 to 3. The zero is added as a mathematical middle (represented by the shaded area), but was of course never chosen. A complete overview of the ratings per theme can be found in the boxplot of figure 7.9. The outliers from the first boxplot are three participants that did not find a pillow the proper appearance for a remote control, and therefore rated it low on the presence of the inviting theme.

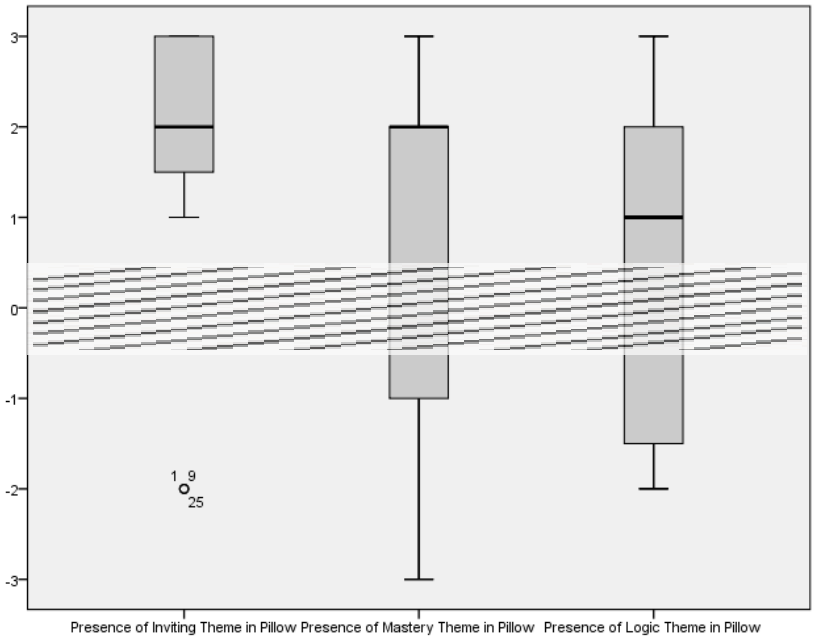


Figure 7.9: Boxplots of Ratings of Presence of All Themes for the Pillow Prototype (SPSS)

Each boxplot is split up into four segments (though not always visible) by horizontal lines, where each area represents 25% of the participants; the darker grey areas represent 50% of the data, and the bold horizontal splits this up equally.

The data was not normally distributed and could not be adjusted either. Therefore, non-parametric tests were performed. In order to conclude if one of the themes in this prototype was more present than another, a related-samples test was performed with Kendall's coefficient of concordance.

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The distributions of Presence of Inviting Theme in Pillow, Presence of Mastery Theme in Pillow and Presence of Logic Theme in Pillow are the same.	Related-Samples Kendall's Coefficient of Concordance	.009	Reject the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

Figure 7.10: Results of Related-Samples Kendall's Coefficient of Concordance for Pillow (SPSS)

For the pillow prototype, the statistic test concludes that the inviting theme is significantly more present than the other two (see figure 7.10), as intended. This means that the pillow prototype was effective in representing the inviting theme in a positive way.

7.5.1.8. User Experience Evaluation

The final question after use was to evaluate the user experience. Figure 7.11 shows how often the images of the User Experience Evaluation technique have been chosen by the participants. The images that were only picked once, were left out.

Clusters of how the participants evaluated the user experience of the different prototypes (in their own words), are shown in figure 7.12.

Both figures clearly show that for the pillow prototype the most important experience was the feeling of coziness and being relaxed. In images this was expressed as reading a book (while lying on a pillow), being home alone (sitting in a comfortable chair) and drinking tea (by the fireplace), but in the participants' own words it was found to be pillow-like, cozy, relaxing, comfortable and warm.

Figure 7.11: Chosen Images for User Experience Evaluation of the Pillow Prototype

Figure 7.12: Participant Evaluation of the User Experience of the Pillow Prototype

Feelings of not being in control, frustration and difficulty were also often mentioned, and expressed with the image of juggling. The target group evaluated the experience as attracting attention or showing off, because the pillow prototype was so different and new. The image of a dancing couple was even chosen five times, to express the easy, smooth moving, romantic and good feeling they experienced.

7.5.2. Labyrinth Prototype

Each part of the user study will be discussed in a separate section, but only the most important results are discussed.

7.5.2.1. Expectations on Functionality and Use

After being exposed to the labyrinth prototype, the first question was asked to the participants on the expectation of the functioning of the prototype: How do you expect it will work/how do you expect to activate the functions? This was immediately combined with using the prototype, to explore the functionality.

The labyrinth prototype was always recognized as a maze or labyrinth, although it was not always understood as part of the functioning (see figure 7.13). The general idea of a labyrinth is to move through it, to get to the exit (or functions, in this case). This is what most participants expected correctly. It also included the expectations of a long way (long time) to reach a function, and a certain level of challenge (difficult, complicated). However, some participants' expectations were dominated by the look of the handle, and expected functioning similar to a joystick (tilting). So as a principle of functional pleasant tactility, it is important that a design does not send out mixed messages.

Figure 7.13: Participant Expectations on the Functioning and Use of the Labyrinth Prototype

Many more comparisons were made by the participants, leading to different expectations of the functioning and tactility of the prototype. Many of those comparisons link to the playful character of the labyrinth prototype, like kid's toy, Pacman, joystick, ball tilting game, puzzle, game, computer game, plaything and toy. These comparisons led to expectations based on playing and having fun with the remote, which was intended. Also smooth movements and more focus on the remote were expected. The handle was also compared to the gear shift in a car, and led to the correct expectation of the feeling of a firm leather handle that needed to be moved to ends to activate functions. This all relates to the principle of close corresponding metaphors.

The text in the corners and in the middle of the labyrinth prototype were seen by most participants as indications as to where the functions should be activated. Following text indications was quite intuitive for the participants. It was however not considered logical to move through a labyrinth in order to activate TV functions. One participant therefore thought that the path toward the corner function was part of the function; the closer to the corner, the higher the volume would go. So the principle of game-like functioning should not be taken to the extreme.

During use, the participants could not activate the on function without help. This was because activation took only a short click, but when something does not work, people press harder or longer. Therefore, after trying a normal click, none of the participants tried a shorter click, only a longer and harder click. Here the principle of trial-and-error is not properly implemented.

7.5.2.2. Reflections on Functioning

On the topic of functioning, the second question was asked on the reflection of it in the prototype, after using it: Did it work the way you expected it to?

In the labyrinth prototype the answer to the question whether it worked as expected was mostly "yes" or "almost" (see figure 7.14), and then they noted the exceptions. This means that the labyrinth prototype was intuitive in its functioning.

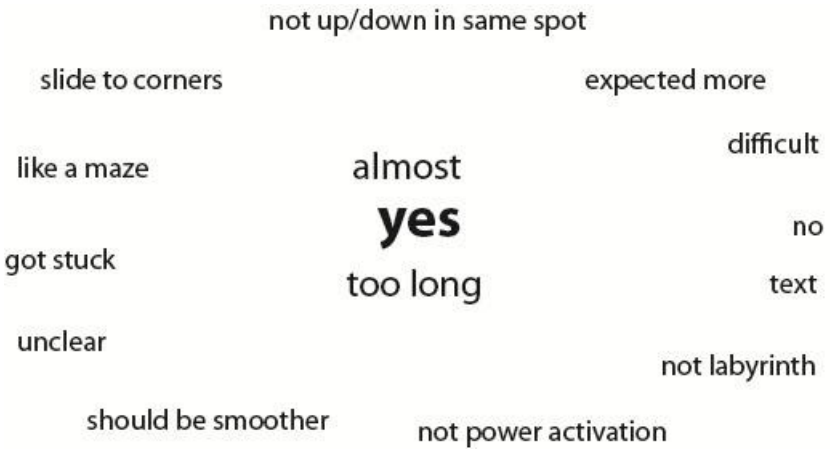


Figure 7.14: Participant Reflections on the Functioning of the Labyrinth Prototype

The text was mentioned as leading to the right expectations of functioning, although few participants did not expect the entire labyrinth to be part of the functioning (only a tilting motion in the corresponding direction).

Most participants mentioned that it took too long to get to the functions in the corners, which was often expected as well. Many also said it was complicated, difficult, unclear or too much like a labyrinth. The game-like principle was probably taken to its extreme, and did not work for a remote control anymore.

Some participants mentioned that the movement should be smoother, but that they sort of expected it because it was a prototype. Again, proper functioning is important for pleasant tactility to work.

7.5.2.3. Expectations on Tactility and Use

The first question on the expectation of tactility in the prototype was asked after being exposed to the prototype: How do you expect it will feel? This was combined with using the prototype to explore the expectations on the tactility of the labyrinth prototype.

The tactility that was expected of the labyrinth prototype was a near tie between smooth motion and wobbly or rough motion (see figure 7.15). This was because the participants considered a smooth motion to be important, but realized that it would not always be possible in a prototype. Here pleasant tactility is more important than functioning.

For the handle, most participants expected it to feel soft, ball-like, squeezable, tool-like, leather-like, comfortable, pleasant, like a joystick, or like a gear knob. This was intended, to clarify the functioning of holding the handle and keeping it comfortable.

The feel of the interaction was expected to be slow, game-like, boring, strange, nice, cheap, complex and difficult. These are all expectations that correspond with a labyrinth, and they were correct as well.

Figure 7.15: Participant Expectations on the Tactility and Use of the Labyrinth Prototype

7.5.2.4. Reflections on Tactility

On the topic of tactility, the second question was asked on the reflection of it in the prototype, after having used the prototype: Did it feel as expected?

For this prototype the answer to the question whether it felt as expected, was mostly answered by "yes", though sometimes followed by "almost" or "except for" (see figure 7.16). The participants that answered with "no" gave reasons and exceptions similar to the other participants.

The participants mostly commented on the motion being rough, wobbly and not as smooth as should be. It is important for functional pleasant tactility to be implemented properly; otherwise it will not be experienced as pleasant as intended.

The handle was only reflected on as hard (instead of soft) and feeling like leather. This was as expected, but so few comments on this positive aspect might be because problems are always more dominant.

Figure 7.16: Participant Reflections on the Tactility of the Labyrinth Prototype

The interaction was experienced as difficult, because it was a labyrinth, and the paths were not easy or straight forward. “Cheap”, “no finish”, “rubber-like” and “got stuck” were also mentioned once, because the feeling of quality was missing.

7.5.2.5. Users’ Enjoyment

As part of the reflection, the participants were asked whether they had enjoyed using the specific prototype.

The labyrinth was not so much considered as enjoyable (see figure 7.17). The biggest reason for that was that it was found to be too difficult. When it was thought of as enjoyable, it was often mentioned to be fun, like a game, but not for daily use as a remote control. Other reasons for this were that it took too long, was not practical, took too much work, had to think too much, got stuck and was unpleasant in use.

The positive aspects of the labyrinth prototype were that it was like a game (fun), interesting, surprising, different (or new), and the text was intuitive.

Figure 7.17: Participant Reflection on the Enjoyment of Use for the Labyrinth Prototype

7.5.2.6. Fit with Bang & Olufsen

Because the prototypes were designed to fit with B&O, the participants were also asked to reflect on this.

The labyrinth was not really considered as fitting with the B&O style (see figure 7.18). This was mostly because the labyrinth was thought to be too difficult. Other reasons were that the labyrinth was too childish and playful, too long, not intuitive, too crazy, not logical, unpleasant in use, not fast enough and missing design. Also, the material used was still not the B&O metal.

The aspects that did fit the B&O style, according to the participants, were that the labyrinth prototype was inviting, fun, new, magical, and surprising. One participant even mentioned that this prototype might prevent the annoying habit of constantly zapping through channels.

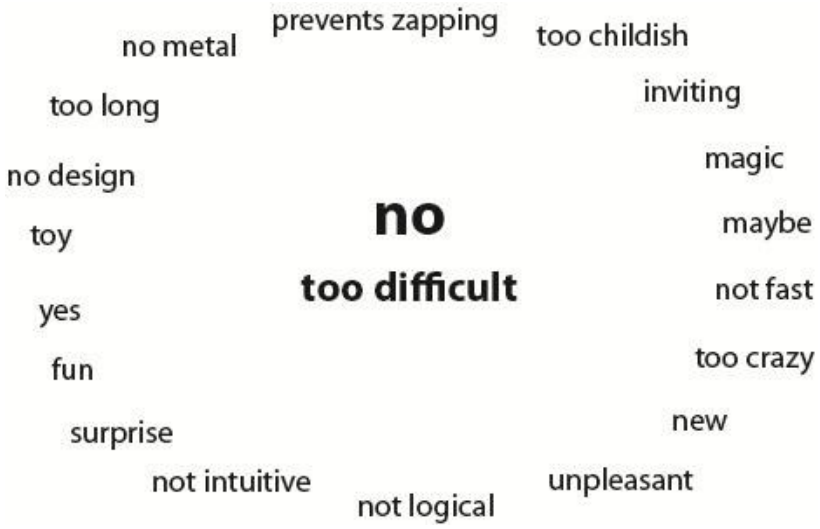


Figure 7.18: Participant Reflection on the Labyrinth Prototype's Fit with B&O

7.5.2.7. Rating on Presence of Themes

A statistical analysis has been performed for the rating questions. A complete overview of the ratings per theme can be found in the boxplot of figure 7.19.

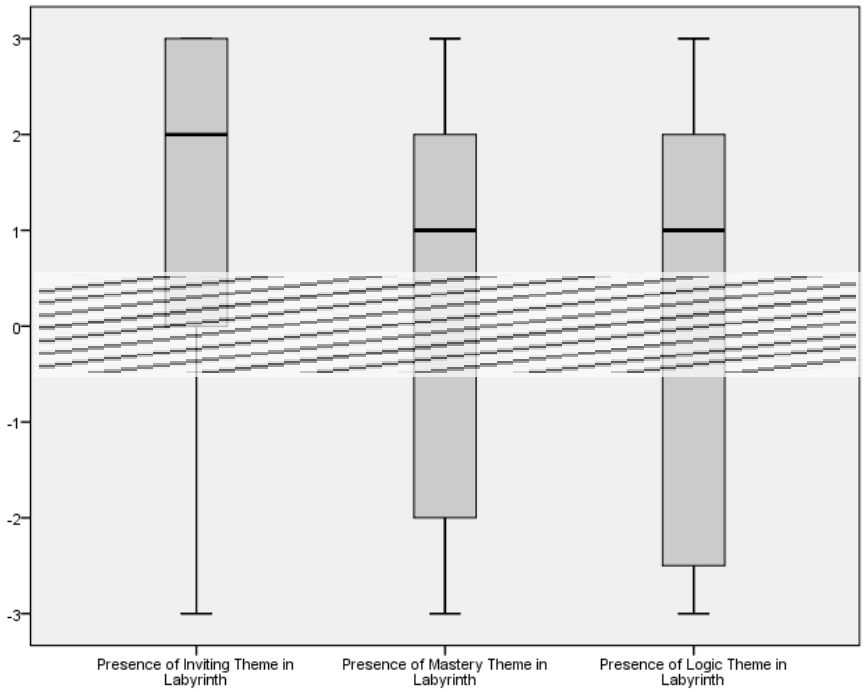


Figure 7.19: Boxplots of Ratings of Presence of All Themes for the Labyrinth Prototype (SPSS)

The data was not normally distributed and could not be adjusted either. Therefore, non-parametric tests were performed. In order to conclude if one of the themes in this prototype was more present than another, a related-samples test was performed with Kendall's coefficient of concordance.

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The distributions of Presence of Inviting Theme in Labyrinth, Presence of Mastery Theme in Labyrinth and Presence of Logic Theme in Labyrinth are the same.	Related-Samples Kendall's Coefficient of Concordance	.007	Reject the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

Figure 7.20: Results of Related-Samples Kendall's Coefficient of Concordance for Labyrinth (SPSS)

For the labyrinth prototype, the statistic test concludes that the inviting theme is also significantly more present than the other two (see figure 7.20), which was unintended. So, the labyrinth prototype does not represent the mastery theme of functional pleasant tactility. This is because the challenge aspect of the mastery theme was taken to its extreme; the labyrinth was too challenging and therefore too difficult. However, the playful aspect of the mastery theme was strongly present as well, and this made the labyrinth prototype very inviting. Thus, the playful characteristic of functional pleasant tactility belongs more to the inviting theme, than the mastery theme.

7.5.2.8. User Experience Evaluation

The final question after use was to evaluate the user experience. Figure 7.21 shows how often the images of the User Experience Evaluation technique have been chosen by the participants. Clusters of how the participants evaluated the user experience of the different prototypes (in their own words), are shown in figure 7.22.

The user experiences of the participants for the labyrinth prototype are mostly negative; the images of juggling and being in a traffic jam prevail. Both were mostly expressed as not having a choice, feeling stuck, taking too long, and being difficult. However, juggling was sometimes chosen to express fun and playfulness as well. The image of visiting an attraction park was also used to express fun and playfulness, as well as being inviting, and exploring new and special things.

The images of filling in a form, feeling locked up, being in a car crash and composing were also frequently chosen. Most of them were negative, again. Filling in a form was often chosen to express that it was a lot of work, required focus and felt like doing an exam, but it was also used to describe the hand motion performed with the handle. Feeling locked was of course used to express the feeling of going through a maze, and being restricted. The car crash was mentioned in relation to

being negatively surprised (loud volume) and wanting to throw out the remote control. Composing was used to express being active, doing something, and having limited options.

Figure 7.21: Chosen Images for User Experience Evaluation of the Labyrinth Prototype

The only real positive experiences with the labyrinth prototype dealt with it being different and new, and fun and playful. One participant described the movement through the labyrinth as dancing or ice skating.

Figure 7.22: Participant Evaluation of the User Experience of the Labyrinth Prototype

7.5.3. Armrest Prototype

Each part of the user study will be discussed in a separate section, but only the most important results are discussed. The size of the phrases in the wordles (word clouds) still corresponds to the frequency of mentioning by the participants.

7.5.3.1. Expectations on Functioning and Use

The first question was asked on the expectation of functionality in the armrest prototype, after being exposed to the prototype: How do you expect it will work/how do you expect to activate the functions? This was combined with using the prototype to explore the expectations.

For the armrest prototype the power function (on/off) was least expected (see figure 7.23). Participants often noticed the switch on the side, sometimes after prompting them for the position of a power function. Some participants expected a tapping on the touch area for the power function. A few could not figure out the power function at all, and a few did not explore any further and just assumed that the cover needed to stay on (hidden), which provided functioning similar to the pillow prototype, with squeezing or pressing for activation. However, none of the participants expected the cover to be the power function, unless they had opened the cover to explore, and the TV suddenly turned on. This design principle of logic (cause and effect) is perhaps not intuitive, but it is quickly understood and therefore works through trial-and-error.

Some participants quickly noted that they expected the armrest prototype to work in a simple way. They saw only few buttons, and there was no ambiguity in how to operate them. This might also be the reason why only one participant mentioned that moving up with the slider or on the touch area would be up in the functioning as well; it was so simple and logical that it might have been assumed as common sense. Simplicity is a good design principle as well.

The touch area was new in remote controls, and therefore not everyone expected a simple up and down movement for function activation. Some participants expected tapping gestures similar on smartphones, and others expected the touch area to be a display as well. A few participants had no idea what to expect of the touch area at all, or had not even recognized it. New technology should therefore be more explicit in expressing its use, but has more possibilities for implementation.

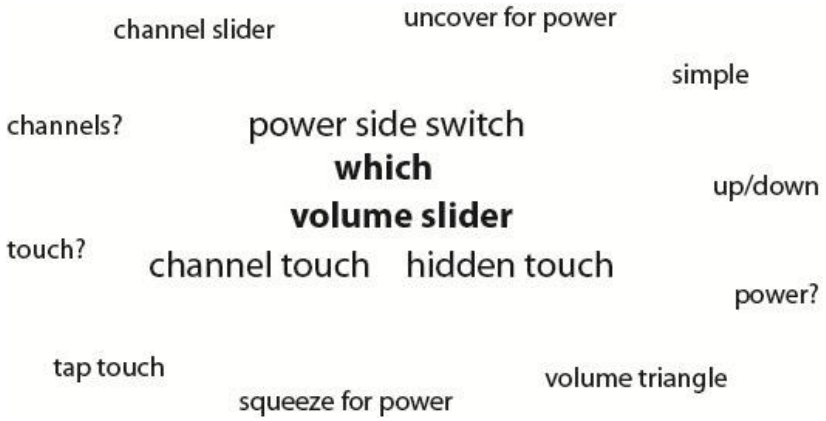


Figure 7.23: Participant Expectations on the Functioning and Use of the Armrest Prototype

Most of the expectations of the participants were about which button (slider and touch area) would activate which function (volume and channels). Most participants expected the slider to activate the volume. The biggest reason for this

was that the slider resembled a volume slider on an (old-fashioned) mixer board. This made the participants guess that the other button, the touch area, would automatically be the channel switch. Many of the participants also mentioned that those functions could be switched around. Only a few participants expected the touch area to be the volume function, because of the triangular shape that is often linked with volume. These were all males. Some of them would automatically assume that the slider would then be the channel function. Here, the triangle did not serve as a strong enough logical-link with volume to make the participants forget about the old-fashioned use of the volume slider. With the design principle of logical links, old-fashioned use and habits should be considered when re-using buttons for new functions.

7.5.3.2. Reflections on Functioning

On the topic of functioning, the second question was asked on the reflection of it in the prototype, after using it: Did it work the way you expected it to?

For the armrest prototype the answer to the question 'did it work as expected' was nearly as much "yes" as "no", with some saying "almost" (see figure 7.24).The cover was unexpected, but most participants thought it was nice, clever or even better than expected. So even though this function was not intuitive, it was quickly understood and even liked.

The functions of the slider and touch area were often switched in the expectations. This was therefore often mentioned as not expected. Through trial-and-error it was however quickly understood. The participants did mention that more feedback was needed in order to be more enjoyable (the channel function was defined as difficult). A clicking stepwise sensation (sound or touch) for the channel slider, or visual lines next to the slider were brought up.

Suggestions were given as well. One participant suggested keeping the buttons covered up, so the buttons would feel softer, and the functioning would be more magical. Another participant suggested using a channel wheel, so an infinite amount of channels could be programmed, without having to make the steps smaller. One participant thought the armrest prototype was too big, and suggested making it smaller. These suggestions could be considered in redesigns.

Figure 7.24: Participant Reflections on the Functioning of the Armrest Prototype

7.5.3.3. Expectations on Tactility and Use

The first question asked on the expectation of tactility in the prototype after being exposed to the prototype was: 'How do you expect it will feel?' This was combined with using the prototype to explore the expectations. As figure 7.25 shows, nothing was mentioned more often than 9 times.

The tactility that was expected of the armrest was mostly related to the material properties (and therefore mostly correct), like no texture, hard, cold, plastic, sharp edges, rough, cheap, soft (for the cover), like a (glass) touch pad and like a VHS tape. Plastic is apparently not seen is a qualitative material.

The interaction was expected to be clumsy, uncomfortable, tiring, difficult, sensitive (for the touch area), smooth, nice, in control, easy, comfortable and pleasant. The positive feelings dominated, but the negative feelings were mostly based on the size (too big) and the positioning of the buttons (too far apart).

Because the slider was known, a few participants expected it to feel "like a slider", or "normal". This was indeed the case. However, one participant expected to feel enhanced feedback. This was perhaps more like a wish than an expectation, but it has been revealed before that proper feedback is needed.

Figure 7.25: Participant Expectations on the Tactility and Use of the Armrest Prototype

7.5.3.4. Reflections on Tactility

On the topic of tactility, the second question was asked on the reflection of it in the prototype, after having used the prototype: Did it feel as expected?

For this prototype the answer to the question whether it felt as expected, was mostly answered by "yes" (see figure 7.26). This means that the tactility was clearly expressed by the prototype.

Some unpleasant aspects were mentioned about the armrest prototype by all target groups, which were mostly expected, like “plastic”, “cheap”, “hard”, “sharp edges”, “too big”, “not pleasant” and “square”. As mentioned before, plastic is not seen as a qualitative material. One participant stated, in other words, that it felt like a prototype. A related suggestion was to round off the prototype, like a computer mouse. Clearly, this prototype did not have a good finish.

The interaction was deemed to be smooth and easy, and the volume touch area was experienced as nice. One participant even mentioned that the size was comfortable, and another that it felt like a remote control. However, the channel slider was thought to be difficult to control, because it was missing stepwise feedback (needs feedback). This was mentioned in the functioning reflections as well, because here functioning and tactility overlap.

A few participants did not expect the cover to be lifted off, so they stated that the prototype was not as soft as expected. Finally, a participant noted that it felt like being a master, because the remote could only be controlled by one person. This was however not directly linked to tactility.

Figure 7.26: Participant Reflections on the Tactility of the Armrest Prototype

7.5.3.5. Users’ Enjoyment

As part of the reflection, the participants were asked whether they had enjoyed using the specific prototype.

The armrest was also considered enjoyable by most participants. The reasons that were most cited were that it was easy, practical and normal (like a real remote). This was of course intended, because it was supposed to be logical.

Other positive aspects were mentioned, like the touch area was nice, the interaction was intuitive, no thinking was required, and it was built-in, fun and relaxed.

Many negative aspects were also indicated, like the armrest prototype being large, rough, not mobile, old-fashioned, geeky, uncomfortable, not normal, clumsy, not intuitive, too simple, and not fun. Moreover, the channel slider was considered to be difficult in use. As mentioned before, stepwise tactile feedback could improve this.

Figure 7.27: Participant Reflection on the Enjoyment of Use for the Armrest Prototype

7.5.3.6. Fit with Bang & Olufsen

Because the prototypes were designed to fit with B&O, the participants were also asked to reflect on this.

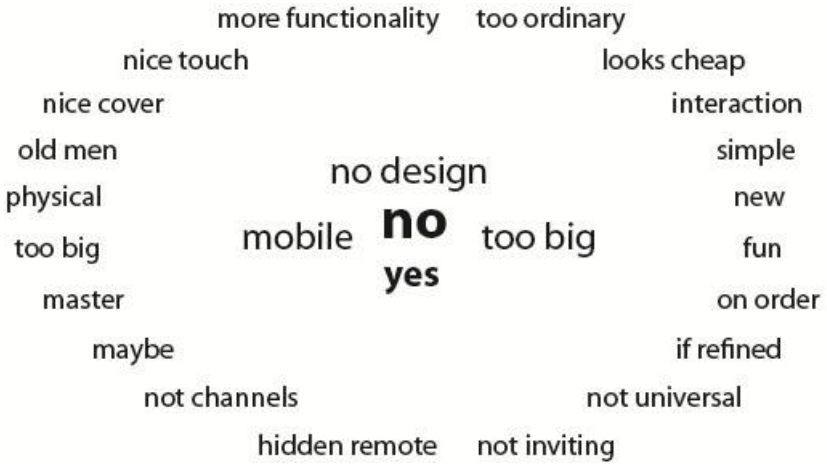


Figure 7.28: Participant Reflection on the Armrest Prototype's Fit with B&O

The armrest prototype, like the pillow prototype, was not completely fitting the B&O style, but many participants thought it could (see figure 7.28). The biggest concerns were that the armrest prototype was missing design, and it was not mobile. Other non-matching aspects were the large size, the channel slider, the cheap look, and that it is not universal. Two participants even believed it looked like a remote control for an old man.

The aspects that were considered to fit with B&O, if the prototype would be refined into a real design, were that it was simple, fun, new, physical, close by, and one could be the master controller. The volume touch area, cover function and interaction were thought to be nice as well. One participant mentioned that the remote control could be a special order directly from a client. The armrest prototype was nearly as much fitting to B&O as the pillow prototype.

7.5.3.7. Rating on Presence of Themes

A statistical analysis has been performed for the rating questions. A complete overview of the ratings per theme can be found in the boxplot of figure 7.29.

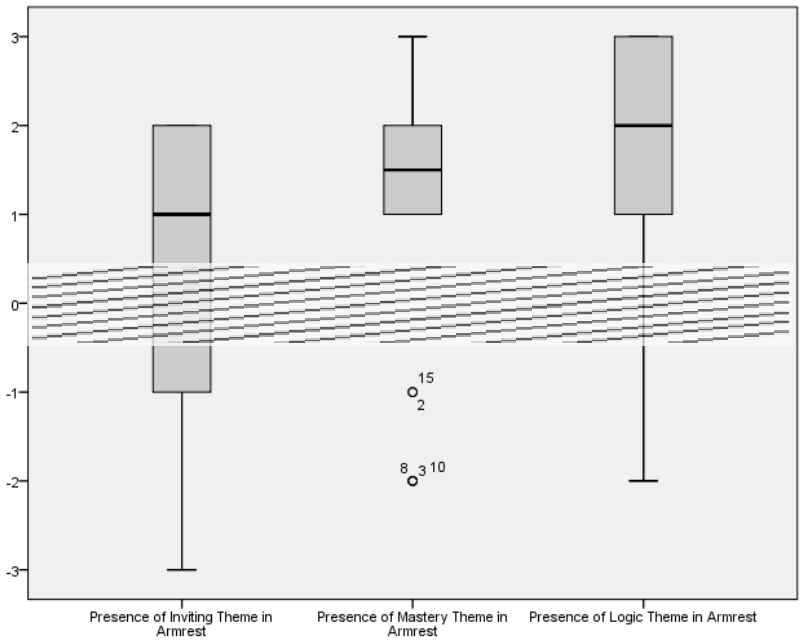


Figure 7.29: Boxplots of Ratings of Presence of All Themes for the Armrest Prototype (SPSS)

The 5 outliers of the presence of the mastery theme in the armrest prototype considered the challenging and playful aspects of the mastery theme to be missing, even though they did feel in control, and therefore rated this theme lower.

The data was not normally distributed and could not be adjusted either. Therefore, non-parametric tests were performed. In order to conclude if one of the themes in a prototype was more present than another, a related-samples test was performed with Kendall's coefficient of concordance.

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The distributions of Presence of Inviting Theme in Armrest, Presence of Mastery Theme in Armrest and Presence of Logic Theme in Armrest are the same.	Related-Samples Kendall's Coefficient of Concordance	.005	Reject the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

Figure 7.30: Results of Related-Samples Kendall's Coefficient of Concordance for Armrest (SPSS)

For the armrest prototype, the statistic test concludes that the logic theme is significantly more present than the other two (see figure 7.30), as intended. This means that the armrest prototype represents the logically-linked theme properly, so the characteristics of the theme were effective.

7.5.3.8. User Experience Evaluation

The final question after use was to evaluate the user experience. Figure 7.31 shows how often the images of the User Experience Evaluation technique have been chosen by the participants. Clusters of how the participants evaluated the user experience of the different prototypes (in their own words), are shown in figure 7.32.

The armrest was experienced mostly positive again. The participants chose the images of being home alone, being bored and attracting attention most frequently. They were used to mostly express the feeling of being relaxed, not having to think about what to do and standing out because of being the only controller (master), correspondingly. The simplicity of the armrest prototype was also often mentioned in both positive (easy) and negative (restricted) ways.

Figure 7.31: Chosen Images for User Experience Evaluation of the Armrest Prototype

The images of juggling and composing were often stated as well. They were both used for positive and negative feelings; juggling was used to express the doubt of using which button for what function, but also for being logical and coming naturally (when it works). That counts for composing too; it was used to express the feeling of being in control, as well as doing something difficult.

The armrest prototype was also experienced as being new, innovative and different, as well as old-fashioned and normal. These contrasts show that the experience of this prototype was very personal.

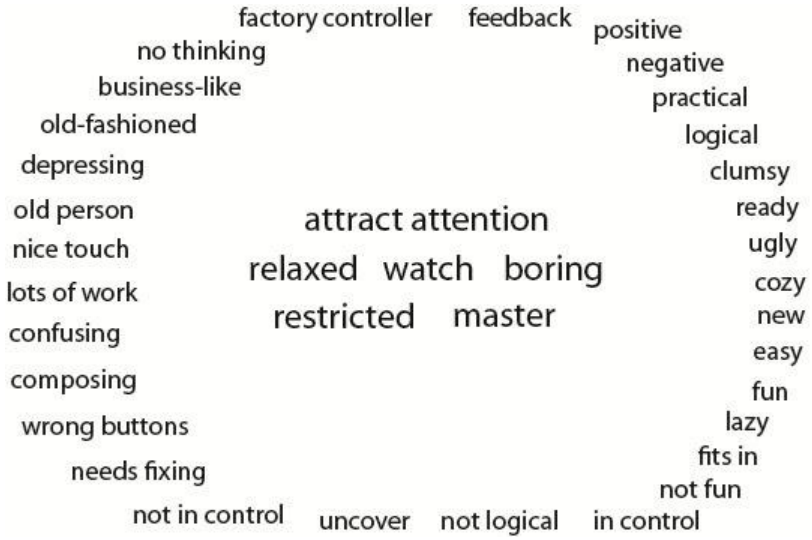


Figure 7.32: Participant Evaluation of the User Experience of the Armrest Prototype

7.5.4. Prototype Preference

After all the three prototypes were tested, comparisons were made by the participants. Figures 7.33 to 7.36 show how many participants preferred a specific prototype based on pleasantness, unpleasantness, enjoyable and not enjoyable.

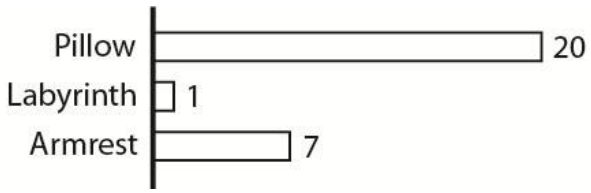


Figure 7.33: Participant Evaluation of Most Tactual Pleasant Prototype

The pillow is seen as most pleasant in tactility, because of its softness and magic (see figure 7.33). However, the armrest scores high as well, because of its simple and easy use. So again, simplicity is also important in functional pleasant tactility. Clearly, the labyrinth is not really thought of as having the most pleasant tactility.

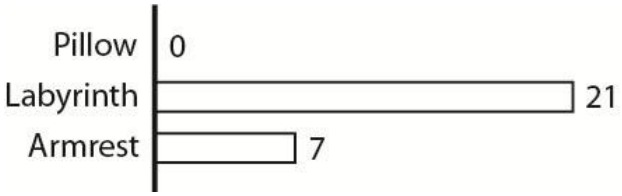


Figure 7.34: Participant Evaluation of Least Tactual Pleasant Prototype

The labyrinth is mostly seen as the least pleasant in tactility, because it often got stuck and was very cumbersome to move around (see figure 7.34). The armrest was also mentioned as unpleasant in tactility, because it was too simple and boring; the experience was not new.

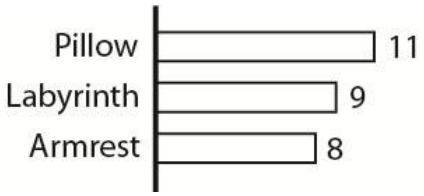


Figure 7.35: Participant Evaluation of Most Enjoyable Prototype

There is not one clear most enjoyable prototype (see figure 7.35); this is apparently very personal. However, the least enjoyable prototype can be seen as the labyrinth (see figure 7.36), even though it has often been mentioned as the most enjoyable prototype as well. The labyrinth was difficult and cumbersome in use, but it worked well and was fun and challenging; the remote was very extreme in different ways. So, depending on what the participant cared about more, the labyrinth was either enjoyable or not.

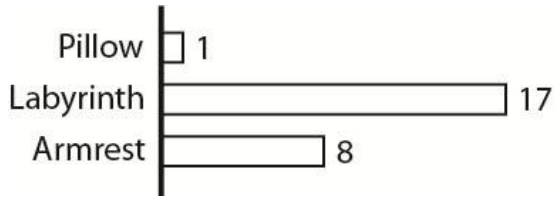


Figure 7.36: Participant Evaluation of Least Enjoyable Prototype

The pillow prototype could be seen as the most enjoyable one, because it was not the least enjoyable prototype (see figure 7.36). For the armrest prototype it is completely unclear whether or not is was enjoyable. The participant's taste influences this decision greatly.

7.5.5. Overall Remarks

To the question whether pleasant tactility makes the user experience better, all participants answered positively. Many participants used the example of the Beo4 remote as the example of a remote that works as it should, but has the extra feature that it feels nice as well; the remote is quite heavy, which gives the feeling of quality and control. The remote also has a long small shape that easily fits in the hand, and the buttons all lay in the proximity of the thumb. Moreover, a core is used in the Beo4 remote that keeps the outside cool (not cold), so it never gets sweaty.

Some participants gave the example of a cheap plastic remote as the opposite of pleasant tactility; unpleasant tactility, which should be avoided. Most participants actually explained that a remote should not feel unpleasant; the lack of pleasantness is not the same as the opposite of pleasantness. Therefore, what they meant was that a remote should not feel unpleasant, because that makes the user experience worse. This does not always mean that pleasant tactility makes the user experience better.

Finally, some participants mentioned that pleasant tactility is a nice bonus, but the remote should at least work. Functionality, in their eyes, was more important than pleasant tactility; if a product does not work properly, pleasant tactility is not going to make the user experience better. This can be concluded from many of the previous sections as well, and means that functional pleasant tactility is thus a desired combination.

7.5.6. Conclusions

Creating insights from this user study was done by answering the research questions, so a final design could be concluded. Each research question can be answered with a part of the data gathered.

7.5.6.1. In what way are the prototypes pleasant in tactility?

The results of the expectation question about tactility and the reflection question about tactility clearly show that the pillow prototype was pleasant in tactility through the use of soft, squeezable and warm materials, as well as by having an easy and smooth interaction.

For the labyrinth prototype the only aspect that was pleasant in tactility was the leather feel of the handle, and the playful character of the labyrinth (fun). However, because the playful character was too extreme for a remote control, that should not be taken into consideration. The movement of the handle through the labyrinth could only be pleasant in tactility if it was not as rough.

For the armrest prototype, pleasant tactility could be found in the nice volume touch area, as well as in the smooth and easy interaction. Also, having the remote control close by (right where it is needed) was considered to contribute to pleasant tactility. The channel slider could only have been pleasant in tactility if there was (enhanced) stepwise tactile feedback. Tactile feedback was mentioned for all the prototypes to have a positive effect on the pleasantness of tactility.

It should be noted that improper functioning for all prototypes in some cases also diminishes the pleasant tactility, depending on the context and person.

7.5.6.2. Is pleasant tactility in the prototypes perceived as a positive quality?

The results of the question about whether pleasant tactility makes the user experience better answers this question in an overall matter. The answer was yes, but if the product did not function properly, then pleasant tactility could not overcome that. At least the opposite was completely agreed upon; when a product does not feel pleasant, it makes the user experience worse.

More specifically, the pillow prototype was positively judged on its softness and magical interaction, so there pleasant tactility was perceived as positive.

The labyrinth prototype was unfortunately not as smooth in maneuvering as intended, so that made the user experience worse. The handle in the labyrinth prototype was deemed pleasant in tactility, but this did not dominate; therefore, the pleasant tactile handle was not mentioned as being unpleasant, but it was not (often) cited as being pleasant either.

The armrest prototype was pleasant in its easy and logical controls. Especially the touch area was perceived is being nice in tactility. Here, pleasant tactility was perceived as a positive quality as well.

7.5.6.3. Are the interactions based on functional pleasant tactility perceived positively?

The interaction deals with the link between pleasant tactility and the functioning of the prototypes. In the pillow prototype the interaction was perceived positively (when it worked), because it was new, magical and smooth; touching a soft pillow to activate functions was said to be nice.

The labyrinth prototype was mentioned to be fun and enjoyable (for the first time use), because it was like a game. However, the link to the functions was not perceived positively, because a remote control should be simple and fast in its interaction, whereas the labyrinth was challenging and required skill. So the interaction of the prototype did not fit with the expected interaction of a remote control.

In the armrest prototype, the link between pleasant tactility and the functioning was mostly perceived positively, because the interaction was simple and logical, as expected of a remote control; opening the cover to turn the TV on was stated as surprisingly nice, and the volume touch area was thought to be a good idea as well. However, enhanced tactile feedback for the channel slider was thought to be missing; participants meant that a channel control should be stepwise, and not continuous.

7.5.6.4. What user experience do the prototypes bring about?

The results from the evaluation task answer this question per prototype. The pillow prototype was experienced very positively by the participants (when it worked); the most frequent experiences were the feelings of coziness and being relaxed.

The experiences of the participants for the labyrinth prototype were not so positive; taking too long and not having a choice prevailed. However, the playful aspect of the labyrinth often led to being a fun experience.

The armrest was mostly positively experienced by the participants as well, because the remote control led to feeling relaxed, not having to think about what to do, and attracting attention because of being the master controller.

7.5.6.5. Do the prototypes fit with Bang & Olufsen?

The results from this directly asked question show that some aspects of the prototypes could fit with B&O, namely being new, magical, inviting, fun, surprising and out-of-the-box, as well as being easy, simple and nice in use, practical, physical, and having an interesting technology. Obviously, the opposite of those aspects would not fit with B&O.Of all three prototypes the pillow prototype was considered the best fit with B&O, closely followed by the armrest prototype.

7.5.6.6. Were the themes effective?

The reflection question about rating (Likert scale) the magnitude of the themes present in each prototype showed how much overlap there was in themes, and that each theme was not represented equally strong by each prototype.

For the pillow prototype the inviting theme was rated most present and for the armrest prototype the logic theme was rated most present, as intended. The mastery theme was probably interpreted more as 'being in control' rather than 'achieving something difficult'. Therefore, the labyrinth prototype was not rated high on mastery, because participants did not feel in control; the challenging aspect of the mastery theme was too extreme. The pillow and armrest prototypes were, however, rated quite high on mastery, because they were both considered easy to control.

From the comments of the participants it can be concluded that the logic theme is the most important theme for remote controls, because it needs to function easily; mastery is then automatically included as being in control. A side-note to the logic theme is that when something is logical, it cannot be surprising too. Therefore, the challenge will be to keep it inviting, because this theme is important for people to want to use it in the first place.

7.5.7. Final Concept Proposition

Finally, insights on each separate design proposition were distilled from the answers to all the research questions, which served as the basis for combining the three themes into a final design concept. The final design concept was therefore developed by the author, as a designer, through combining the positive aspects of the individual prototypes into one final design proposition.

The final design concept looks like a wallet from the outside (see figure 7.37). Its use is illustrated in the user scenario (figure 7.38). The following sections will explain, per theme, how the themes have been applied to the final design, without having their negative aspects.

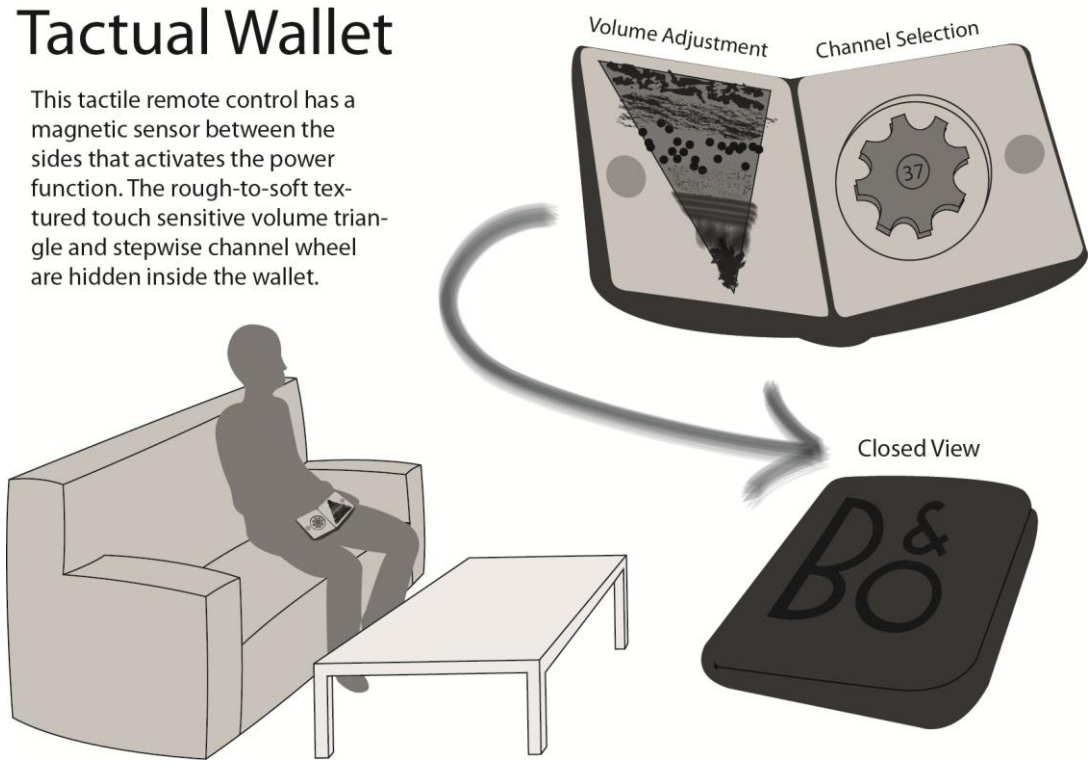


Figure 7.37: Final Design Concept: The Tactual Wallet

The Inviting Theme

The appearance of the final design, a tactual wallet, makes people want to open it, to find out what is inside; this was a positive aspect of the inviting theme. The inside of the wallet is made of two aluminum plates, which give a certain desired weight to the remote control. This was often mentioned, in the end of the user study, as an aspect of tactual pleasantness; it gives a feeling of quality, which invites re-use. Also, aluminum fits with the B&O style, according to the participants. The volume and channel controls are sunk into the plates, so the wallet can close properly. Moreover, there is no plastic used in the remote control at all, because this was perceived as cheap (a negative aspect of pleasant tactility).

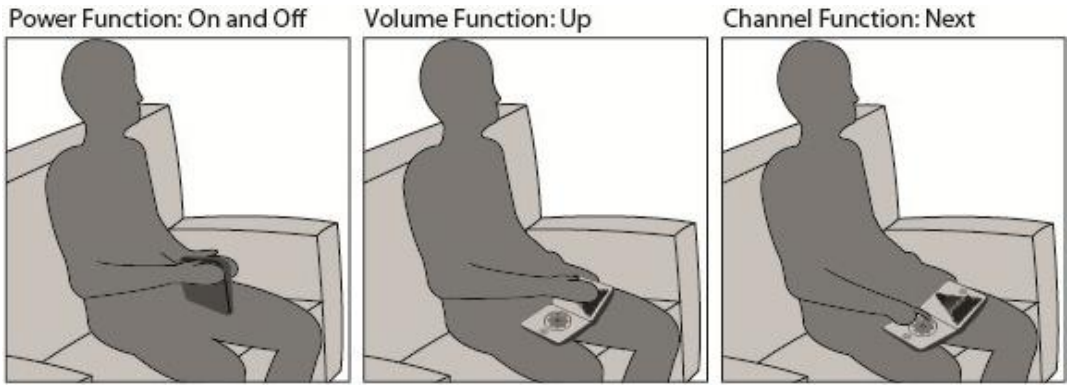


Figure 7.38: User Scenario of the Final Design Concept

Between the leather and the plates, a somewhat flexible filling is used to create a certain thickness and avoid feeling the hardness of the plates. This was done because softness was a pleasant aspect of functional pleasant tactility. Furthermore, all the corners of the plates are rounded off, because sharp edges (and hardness) were tactually unpleasant and uninviting, according to the participants.

What came out of nearly all questions of the user study was that softness was tactually very pleasant, inviting and enjoyable. This is implemented in the volume control area, where different textures are integrated into one surface, from more rough textures at the top, to more soft textures at the bottom. Moreover, the different textures in the triangular surface do contrast each other, which was also an appreciated characteristic of the inviting theme.

The negative aspect of the inviting theme, which was the squeezable characteristic that invited unintended pushing, was avoided in the final design by adding the metal (not-squeezable) plates.

The Mastery Theme

The outside of the tactual wallet is made of leather, with the B&O logo on it, because leather was perceived as a qualitative material with a good grip and pleasant tactility; it gave the feeling of being in control. The large size of the remote controls was often criticized as well, so this remote control has the size of a wallet to fit in the hand comfortably and not to be perceived as clumsy (not in control).

The channel wheel has notches that indicate the wheel can be turned stepwise, by putting a finger in the indentations. Stepwise tactual feedback, like a click, will also be present when a new channel is reached. This enhances the feeling of control as well.

In the middle of the wheel a fixed display is present, on which the number of the channel can be seen; a display was sometimes mentioned as desirable, because a TV does not always clarify which channel is on. The wheel has a playful character as well, because it can be turned quickly and when it is released, the wheel will go slower and eventually stop. This playful character was judged as an important part of the mastery and control theme, but should not be implemented in the extreme (like in the labyrinth prototype). Therefore it is implemented here as a side-function; it does not have to be playful.

The whole remote control is quite easy and smooth in its usability, which were desired properties of the mastery and control theme as well. The functioning of the entire remote control was stated by many participants to be more important than pleasant tactility; therefore simple controls were chosen which cannot easily fail. This is also to avoid the challenging aspect to get too big, which was a negative aspect of the theme.

The Logic Theme

Opening the wallet is what activates the power function. It resembles the uncovering of the armrest concept, which was very positively received because of its mysterious yet interesting and logical character.

The volume area also has positive aspects of the logic theme; moving over the surface in the direction of the rougher textures (and wider area) will make the volume go up, and moving in the direction of the softer textures (the smallest area) will make the sound softer. The continuous movement of caressing the textured surface matches with the continuous control of adjusting the volume. Also, the touch sensitive technology was perceived as new for remote controls, and therefore positively experienced. The triangular shape reminded people of a volume control, during the user study, so this positive aspect of the logic theme was kept.

The channel control of the armrest prototype was often misinterpreted by the participants, because it reminded them of a volume slider and the continuous character of a slider does not match with the stepwise character of a channel control. Therefore, a physical channel wheel with clear notches is designed. The channel wheel has another advantage: it can turn an infinite amount of times, so it does not matter how many channels the TV-system has (the opposite was criticized for the channel slider, which is why a wheel was suggested).

7.6. CHAPTER CONCLUSIONS

This chapter concludes with what was learned from the final phase of the case study, and what this means for the entire research.

From the results of the user study, it seems that themes can be implemented in both positive and negative ways; the mastery and control theme had negative aspects of being too challenging and too playful in the labyrinth prototype. The negative aspects should of course be avoided, which is one of the reasons that a user study is so important.

The other reason why the user study is important to perform, is to combine the most enjoyable aspects of the themes of functional pleasant tactility; even if all aspects of the implemented themes were pleasant in tactility, it does not mean that the resulting prototype was enjoyable to use.

Furthermore, it could be the case that only one or two of the three themes resulted in positive user experience. In that case, it would be preferable to design the final concept with only the one or two themes.

Finally, the user study was very extensive and gave a lot of insights into the effectiveness of the three themes and the perception of functional pleasant tactility. For the design strategy the user study could be made less extensive, because only insights for the final design concept are required.

CHAPTER 8

DESIGN STRATEGY FOR TACTILITY

8.1. CHAPTER INTRODUCTION

The vision on how to design for functional pleasant tactility (see Chapter 4: Design Vision for Functional Pleasant Tactility) described the envisioned competence that designers were missing, based on knowledge, insights, skills and attitude. It was implemented for the specific context of Bang & Olufsen TV-system remote control, by using pre-defined themes (see Chapter 5: Exploring Functional Pleasant Tactility) to come up with three different design propositions, work them out into prototypes (see Chapter 6: Designing and Prototyping), test them with users and use the results to design a final concept (see Chapter 7: User Experience of Design Propositions).

The outcome, the final design proposal, is a fitting and creative remote control with the interaction based on functional pleasant tactility. This shows that the envisioned process that was followed (or the strategy) can provide good results in the context of B&O remote controls. It can be suggested that, even though this has not been tested, the strategy might be effective for other companies and similar contexts as well. This is founded on the successful use of founding design concepts on pre-defined themes, and evaluating design concepts through prototyping and user studies, throughout design education (and the profession).

Therefore, the envisioned design strategy for the specific context of B&O TV-system remote control will here be presented as the strategy on how to design for functional pleasant tactility in the broader context of industrial design. This strategy is also the answer to the main research question of this study: How can pleasant tactility be implemented in the functioning of products?

Furthermore, it is hoped that this thesis report, its public presentation and the accompanied poster will create awareness of this previously-lacking-competence, for designers, so the strategy can yield profit.

8.2. DESIGN STRATEGY

Similar to the design vision, the design strategy will be presented as a competence, with its four elements of knowledge, insights, skills and attitude. Different to the design vision, this strategy will not focus on a specific product or company, so it can be used in the broad context of industrial design.

8.2.1. Knowledge

Knowledge is the element of knowing. In designing for functional pleasant tactility, besides basic design knowledge, explicit knowledge on functional pleasant tactility, the chosen product context, and the company is expected.

Basic Design Knowledge

The basic design knowledge that is expected of designers for designing functional pleasant tactility involves knowledge of research, design and production methods, and what they imply. This is needed for recognizing which methods are used, and possibly choosing comparable methods. Knowledge about new and existing technologies in the product context is also important, to be able to facilitate creative interactions.

Functional Pleasant Tactility

Of course, knowledge about the topic functional pleasant tactility is needed, in order to design for it (see Chapter 2). An exploration in context is what will provide the specific knowledge of functional pleasant tactility in the context of the product and company: the three themes that will result from the exploration, including the characteristics of each theme (because they will become the design principles). For each theme, the corresponding actions, as the combination of the object or material property, the pleasant movement and the matching function, need to be known (see Chapter 5 for examples) in order to design the interactions.

Product Context

Naturally, the to-be-designed object or product needs to be known; its definition is essential. Also, knowledge about the context, functioning, use, existing interactions, differences and similarities, and existing models is desired.

Company

Knowledge about the company is logically required as well. Knowing the company's mission statement, product portfolio, recourses, production capabilities, and intended style, target group and interactions is necessary to design for that company.

8.2.2. Insights

Insight is the element of understanding. Understanding the basic process is very important for designing functional pleasant tactility. The design process is obviously very similar to the entire research presented in this thesis report, because that is an example (case study) of how designing for functional pleasant tactility works. A graphical overview of the design strategy can be found in figure 8.1.

First, knowledge is required (Gathering Information), as described above. Then the exploration on functional pleasant tactility in the context (Exploring Context) is performed to find the three themes and their characteristics from the explored actions. Using the pre-defined themes to base design propositions on (Designing Propositions) and to prototypes those concepts (Prototyping Concepts), will follow then. Performing a user study with those prototypes and the intended target group (Testing prototypes) will lead to one design concept (Concluding Design).

Insights into the process of this strategy are necessary to perform it oneself; knowledge of the process is not enough, understanding is needed to draw the proper conclusions, make the right decisions and color the basic process with personal insights.

8.2.3. Skills

Skill is the element of doing; experience is often involved. The basic designer skills are necessary, like collecting information, analyzing data, performing user studies, combining design propositions, visually presenting design concepts, etc.

Some specific skills for designing functional pleasant tactility are required too. The most important one is designing through research; a design concept is created, but the specifics of the design are not known yet, because the feel and interaction of the prototypes are more important than their looks, and those are hard to predict. Therefore, the prototypes are made while constantly checking (researching) and adjusting the feel and interactions.

Another specific skill that is needed is creativity, and how to facilitate creative sessions. Participatory design is a useful way to explore many creative options, because in participatory design multiple people are involved, and multiple people can do more than one person. Performing participatory design requires a good facilitator that can guide the group through a creative session, so the participants only have to focus on creativity.

8.2.4. Attitude

Attitude is the element of the way things are done; the manner. A hands-on attitude is required in designing for functional pleasant tactility; exploring, designing, prototyping and evaluating functional pleasant tactility can only be done by touching actual objects or materials. Tactility is all about the feel and interactions, which can only be correctly imagined by touching real examples. This familiarizing oneself with tactility (sensitizing) is important to become more aware of tactility, and thus to be able to design better tactile solutions.

8.3. PRESENTATION

The strategy can be visually represented in a poster (see figure 8.1), so it can be distributed to create more awareness. The poster is also a summary of this entire thesis report, because the research done to come to this design strategy is in itself an example of the design strategy; the study of finding out how pleasant tactility can be implemented in the functioning of a product followed the envisioned strategy of designing for functional pleasant tactility.

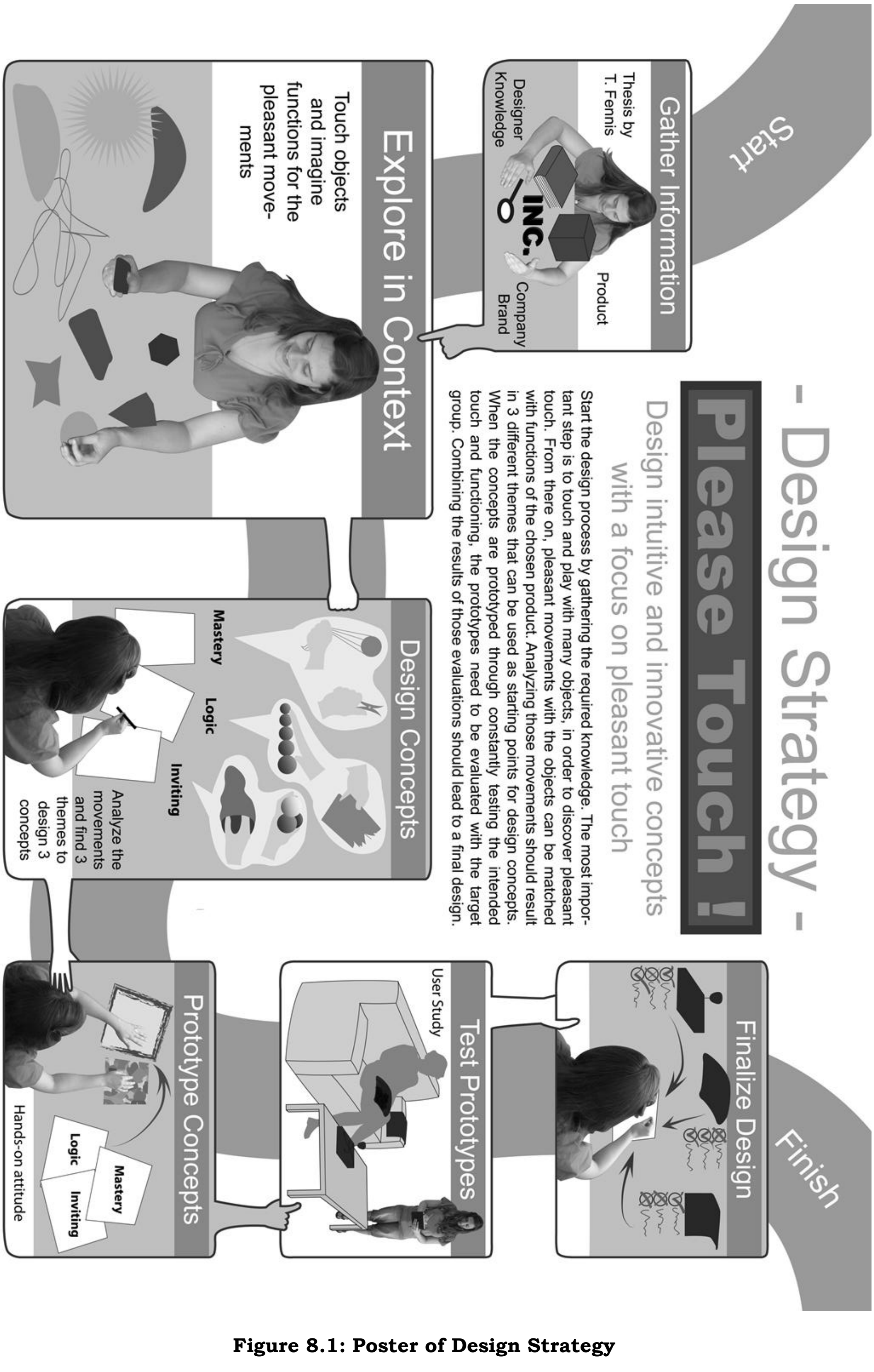


Figure 8.1: Poster of Design Strategy

8.4. CHAPTER CONCLUSIONS

In conclusion, the four elements of competence (knowledge, insights, skills, and attitude) that were envisioned, to design for functional pleasant tactility in the specific context of B&O TV-system remote control, are also applicable to the broader context of industrial design. Because this strategy needed to be verified, the previous chapters showed in detail an example of the implemented strategy.

The ***knowledge*** that is required is basic design knowledge, as well as explicit knowledge on functional pleasant tactility, the product context and the company. The basic knowledge should be known by any designer through education. Knowledge on functional pleasant tactility can be found in this thesis, but the explicit knowledge of functional pleasant tactility in the context of the chosen product and company should be explored through workshops. Knowledge of the context of the product and company brand can mostly be found on internet, or should be provided by the employer.

The ***insights*** that are needed are related to understanding the design process, from exploring and using pre-defined themes to prototyping and testing them in order to come to one final design concept. The design process is clearly presented here, but advanced designers can personalize the process by using different (yet similar) methods.

The ***skills*** that are necessary, besides basic designer skills, are designing through research, and facilitating creative sessions. These skills can only be acquired through experience, in for instance education, or experimenting with the techniques in itself.

The ***attitude*** that is essential for designing functional pleasant tactility is a hands-on attitude, by touching actual materials or objects to get sensitized. This attitude is easily brought to action by gathering a lot of objects with various material properties, and touching them whenever possible.

So with this design approach, industrial designers can create inviting and intuitive products with a focus on pleasant touch.

CHAPTER 9

CONCLUSIONS

9.1. CHAPTER INTRODUCTION

In this final chapter, first the answers to the main research questions will be presented, then the design strategy will be discussed and the limitations of the study will be reflected upon. Finally, recommendations for further research will be offered.

9.2. REVISITING MAIN RESEARCH QUESTIONS

The main research questions that lead to finding out how pleasant tactility can be implemented in the functioning of products, have been answered throughout this thesis report. Here the answers will be summarized.

9.2.1. What is Functional Pleasant Tactility

Tactility refers to all the qualities that can be felt through the sense of touch, including skin senses, muscle strength and tendon position. Pleasant tactility focusses on movements that people perform when they try to decide whether something feels pleasant (affective tactile movements). Those movements can be linked to functions of a product (like caressing something soft to adjust the volume), which can be called 'functional pleasant tactility'. Further details can be found in Chapter 2. When designed, functional pleasant tactility could have a great potential to improve user experience (by decreasing frustration) and product differentiation, yet designers lacked a clear strategy to design it; research was required.

9.2.2. How and in What Products Is Functional Pleasant Tactility Currently Used

The specific concept of functional pleasant tactility cannot easily be found in literature, but one example of a music player design based on scratching a textured surface is a good example. Pleasant tactility, or at least tactility, is implemented in more products; examples are push buttons or digital buttons that have tactile enhancements; they show the importance of 'real' tactile feedback. Other implementations can be found in tangible (graspable) user interfaces (TUIs); they show the importance of physicality in the interface. These examples, which can be found in Chapter 2, form a basis for functional pleasant tactility. What the current implementations of tactility lack, is often a focus on pleasantness, or the implementation in a different aspect than the functioning.

9.2.3. What Is Currently Known about Designing for Functional Pleasant Tactility

In the field of design for tactility, some toolkits and guidelines have been created. Heuristics like logical mapping and using metaphors are useful, as well as adding softness and extreme characteristics. In the overlapping field of TUI design, some helpful examples can be found that really show the physicality of tactility design. Furthermore, a material selection tool with a focus on tactility was found. Finally, examples of design for tactility courses had useful aspects in them, like learning from existing products and keeping a hands-on attitude. Some of those findings have been incorporated in the design strategy, and others have been left out because they were not relevant for functional pleasant tactility. Methods, techniques and approaches from the design education have also been incorporated in the design strategy, because they have been proven to yield successful results in various areas of design.

9.2.4. What Is Functional Pleasant Tactility in the Context of a B&O TV Remote

During the exploration with real objects, many actions were explored by the participants. Those actions are specific to the context, and are made up of an object (or material property), the pleasant movement that is made with it, combined with the imagined function for the remote control. Those specific actions are the representation of functional pleasant tactility in the context of a B&O TV remote, and can be found in Chapter 5. The actions were very intuitive and creative, for very basic functions. This suggests that functional pleasant tactility in other contexts is represented by intuitive and creative actions as well.

9.2.5. What Are the Underlying Themes of Functional Pleasant Tactility in the Context of a B&O TV Remote

Analyzing the resulting actions of the exploration concluded in three themes (inviting, mastery and logic) with corresponding characteristics that represent those themes; those three themes are the aspects of functional pleasant tactility in TV-system remote control. The *inviting* theme is based on characteristics that are nearly irresistible to touch. The *mastery* theme is based on challenging oneself to do tricky actions and staying in control. The *logic* theme is based on pleasant tactile movements that are logically linked to the function they control. Details of the themes can be found in Chapter 5. It might be the case that very similar products, like house phones or microwave ovens, could end up having similar themes as well. However, exploring very different products, like bicycles, are expected to result in very different themes, because they are used with very different intentions.

9.2.6. How Can the Themes Be Used in Designing a B&O TV Remote

The themes from the exploration phase are then used as starting points to design three different remote controls with functional pleasant tactility. This is done by implementing the characteristics of each theme in design concepts, through the

process of a participatory design session with designers. This creative session resulted in multiple design ideas that were used as inspiration for the actual design concepts. Those concepts were then worked out into prototypes (details can be found in Chapter 6), by constantly evaluating the intended tactility and functioning (design through research). Because the focus of the designs was functional pleasant *tactility*, the way of designing needed to be very physical. Therefore, objects were available during the creative session, and the design through research approach was used. It can be concluded that this hands-on attitude should be incorporated in any design for tactility strategy.

9.2.7. What Will Be the Result of Implementing the Themes in a B&O TV Remote

The three design concepts were worked out into prototypes through the use of design through research. This approach implies that throughout the process of prototyping, the prototypes are tested to verify the intended functioning and tactility, and to make adjustments accordingly. Each prototype then represents one of the three themes: A pillow remote for the inviting theme; a labyrinth remote for the mastery theme; and an armrest remote for the logic theme. Details can be found in Chapter 6. The resulting prototypes were of course very dependent on the author as a designer. However, implementing a theme into a prototype, based on the theme's characteristics and corresponding actions, is always expected to result in intuitive and creative concepts, because it is inherent to the design strategy.

9.2.8. How Do People Respond to the Resulting B&O TV Remotes

A user study is held with the three prototypes to find out that the user experience is mostly positive, although not always fitting with the company style. Also, conclusions were drawn on which aspects of the themes are most pleasant in tactility, like softness to invite and playfulness for mastery. The insights from the conclusions were used to combine the three prototypes into one final design concept with the best aspects of all: A Tactual Wallet. Details can be found in Chapter 7. It could have been the case that one (or more) of the themes was completely experiences as negative. In that case, the theme would have been completely left out of the final design concept. The analysis of the exploration could also have been repeated, because it might be the case that an unimportant theme was selected, or that the characteristics of the theme were too open for interpretation.

9.2.9. What Does this Mean for the Design Practice

The implementation of the design vision through the case study, and the resulting final design concept, show that the envisioned competence can be seen as a design strategy on how to design for functional pleasant tactility; this report is an example of the process described in the design strategy (the case study). It can be suggested that the design strategy is not only successful for the specific context of B&O TV-system remote control, but also for other companies and similar products. This is because the basics of the strategy have been proven to work in many areas throughout design education. It means that designers can now use the presented design strategy in order to improve or design new concepts with intuitive and creative interactions that provide for a positive user experience.

9.3. DESIGN STRATEGY

The design strategy is one of the most important outcomes of this study; an attempt to develop a strategic/methodological approach to design for functional pleasant tactility. The design strategy is suggested to be used by industrial designers to guide designing for functional pleasant tactility. The four elements of competence (knowledge, insights, skills, and attitude), that were envisioned to design for functional pleasant tactility in the specific context of B&O TV-system remote control, are also applicable to the broader context of industrial design. However, there might be products that do not easily lend themselves for this design strategy, like products that do not need to be touched to function: a speaker box.

Furthermore, attention should be paid to analyzing the results of both the exploration and the user study; it takes a lot of time. Therefore, the amount of exploratory workshops should be kept to a minimum, and the participant groups should not exceed 5 participants to avoid chaos, which is difficult to analyze. Also, the user study should be kept as simple as possible, and it is preferable to have a second researcher present (if possible) that immediately makes notes of the entire study. Though these points of attention are based on the specific case of the B&O remote control, it can be expected to apply in general, because analysis is always time consuming.

Moreover, the results of the exploration can be greatly influenced by the types of products that are used. Therefore, it is important to have a great variety of products that not only differ in visual and material properties, but also in the movements that they invoke. It could be possible to use a tactility toolbox for this.

Finally, it is advised to perform a test with the final design concept as well, to make sure that the product concept works as intended.

9.4. REFLECTION

The biggest limitation of this study is that the design strategy is only tested for one specific product category and company; it is uncertain if the strategy will yield successful results for other product categories and companies. However, the basics behind the design strategy suggest that it works for similar products and different companies as well.

Furthermore, the final design concept that resulted from implementing the design strategy has not been tested with the intended target group. It can thus not be certain that the design concept is pleasant in tactility and provides a positive user experience. Therefore, it is also not certain that the design strategy is successful, although it can be expected because the argumentation of the design concept is sound.

Moreover, the user study was performed with only 28 participants with similar backgrounds, so the resulting final design concept might not be relevant for the complete target group.

Finally, the proposed design strategy is based on the interpretations of the author as a researcher and also as a designer. It is therefore a strategy with subjective aspects, and might not always work for every designer. However, the basic ideas behind the strategy have been used throughout design education, so if designers personalize the strategy but keep the basics, that might solve the problem.

9.5. RECOMMENDATION

It is recommended to follow up on this design strategy by testing the resulting final design concept with the intended target group, as well as testing the design strategy for other companies and with other product categories. The design strategy could also be expanded upon with different possible methods and perhaps a set of objects, as a tool box, that can always be used for the exploration phase.

Furthermore, with this design strategy contributions have been made to the field of research through design, because the final design concept demonstrated how a successful design strategy could be achieved through user research and research through design. Therefore, playing two roles as a researcher and a designer, the subjective approach might have influenced the designs, but what was objective was the way the collected 'objective' data informed the design. It is a good example of how research could influence design and how design could inform research.

REFERENCES

Aoki, R., Maeda, A., Watanabe, T., Kobayashi, M., Abe, M. (2010). Twist&Tap: Text Entry for TV Remotes Using Easy-to-Learn Wrist Motion and Key Operation. IEEE Transactions on Consumer Electronics, Vol. 56, No. 1, p 161-168.

Archer, B. (1995). The Nature of Research. Co-design, interdisciplinary journal of design, January 1995, p 6-13.

Bang&Olufsen (2012). The Company Bang & Olufsen: Values and Vision. http://www.bang-olufsen.dk/en/the-company/heritage/our-values, retrieved 18 July 2012.

Bech, S., Mortensen, D. (2010). Identification of perceptual attributes constituting the user's experience of mechanical switches. Presented at Perceptual Quality of Systems conference in Dresden, September 6 – 8, 2010 and Haptic Audio Interaction Design Conference in Copenhagen, September 16 – 17, 2010.

Bermudez, J. L., Marcel, A., Eilan, N. (1995). The body and the self. London: The MIT Press.

Brewster, S., Chohan, F., Brown, L. (2007). Tactile Feedback for Mobile Interactions. Proceedings of CHI 2007, San Jose (California), USA.

Business Dictionary, (2012). Business Dictionary: Over 20.000 Terms. http://www.businessdictionary.com/, retrieved 18 July 2012.

Cambridge University Press (2011). Cambridge Dictionaries Online: American English. http://dictionary.cambridge.org/dictionary/american-english/competent?q=competence, retrieved on 18 July 2012.

Charmaz, K. (2006). Constructing Grounded Theory: A Practical Guide through Qualitative Analysis. London: Sage Publications, Ltd.

Classen, C. (2005). The Book of Touch. Berg Publishers: Oxford, New York.

Dankers-van der Spek, M. (2008). Studieloopbaanontwikkeling: Van stage naar afstuderen. Benelux: Pearson Education.

Dewey, J. (1938). Experience and education. New York: Touchstone.

Dictionary (2012). Dictionary.com. http://dictionary.reference.com/, retrieved 18 July 2012.

Dirken, H. (1997). Product Ergonomics. Delft: Delft University Press.

Essick, G. K., McGlone, F., Dancer, C., Fabricant, D., Ragin, Y., Phillips, N., Jones, T., Guest, S. (2009). Quantitative Assessment of Pleasant Touch. Open Source.

Fields, T. (2003). Touch. London: The MIT Press.

Finnegan, R. (2002). Communicating: The multiple modes of human interconnection. London, New York: Routledge, Taylor & Francis Group.

Fitzmaurice, G. W., Ishii, H. and Buxton, W (1995). Bricks: Laying the foundations for graspable user interfaces. Proceedings of CHI'95, 442-449.

Flanagan, J. R., Johansson, R. S. (2002). Hand Movements. Encyclopedia of the Human Brain, Vol. 2, p. 399-414.

Gallace, A., Spence, C. (2010). The science of interpersonal touch: An overview. Neuroscience and Biobehavioral Reviews 34 (2010) 246–259.

Gallace, A., Spence, C. (2011). Tactile aesthetics: towards a definition of its characteristics and neural correlates. Social Semiotics, 21:4, 569-589.

Gibson, J. J. (1962). Observations on active touch. Psychological review, 69(6), 477-491.

Han, J. Y. (2006). Multi-Touch Interaction Wall. Proceedings of SIGGRAPH 2006: Emerging Technologies ACM, New York (NY), USA.

Harrison, C., Hudson, S. E. (2009). Providing Dynamically Changeable Physical Buttons on a Visual Display. Proceedings of CHI 2009, Boston (MA), USA.

Holmquist, L. E., Redström, J., Ljungstrand, P. (1999) Token-Based Access to Digital Information. Proceedings of HUC ’99, Karlsruhe, Germany, September 1999.

Ijsselsteijn, W., Nap, H. H., De Kort, Y., Poels, K. (2007). Digital Game Design for Elderly Users. Proceedings of FuturePlay 2007, November 14-18, 17-22.

Ishii, H., Ullmer, B. (1997). Tangible Bits: Towards Seamless Interfaces between People, Bits and Atoms. Proceedings of CHI '97, March 22-27, 1997.

Klatzky, R. L., Lederman, S. J., Metzger, V. A. (1985). Identifying objects by touch: An “expert system”. Perception & Psychophysics, 37, 299-302.

Klatzky, R. L., Peck, J. (2011). Please Touch: Object Properties that Invite Touch. IEEE Transactions on Haptics.

Korhonen, H., Montola, M., Arrasvuori, J. (2009). Understanding Playful User Experience through Digital Games. In: International Conference on Designing Pleasurable Products and Interfaces, DPP109, October 2009, France.

Koskinen, E., Kaaresoja, T., Laitinen, P. (2008). Feel-Good Touch: Finding the Most Pleasant Tactile Feedback for a Mobile Touch Screen Button. ICMI'08, October 20–22, 2008, Chania, Crete, Greece.

Lederman, S. J., Klatzky, R. L. (1998). The hand as a perceptual system. *In K. J. Connoly (Ed.), The Psychology of the Hand.* London: Mac Keith Press.

Matell, M . S., Jacoby, J. (1972). Is there an optimal number of alternatives for Likert scale items? Effects of testing time and scale properties. Journal of Applied Psychology, 56 (6), 506-509.

Merrill, D., Raffle, H. (2007). The Sound of Touch. CHI 2007, April 28 – May 3, San Jose, USA.

Montagu, A. (1971). Touching. New York: Columbia University Press.

Mortensen, D. H., Bech, S., Begault, D. R., Adelstein, B. D. (2009). The relative importance of visual, auditory, and haptic information for the user's experience of mechanical switches. Perception, v.38, p 1560-1571.

Murray-Smith, R., Williamson, J., Hughes, S., Quaade, T. (2008). Stane: Synthesized Surfaces for Tactile Input (Rub the Stane). Proceeding of CHI 2008, Florence, Italy.

Nashel, A., Razzaque, S. (2003). Tactile Virtual Buttons for Mobile Devices. Proceedings of CHI 2003, Ft. Lauderdale (Florida), USA.

Norman, D. A. (1988). The Psychology (Design) of Everyday Things. New York: Basic Books.

Norman, D. A. (2004). Emotional Design: Why We Love (or Hate) Everyday Things. New York: Basic Books.

Norman, D. A. (2007). The Design of Future Things. New York: Basic Books.

Pedgley, O. (2010). Invigorating Industrial Design Materials and Manufacturing Education. METU Journal of Faculty of Architecture, Vol. 27, No.2, pp. 339-360.

Polyani, M. (1967). The tacit dimension. Garden City, New York: Doubleday.

Poupyrev, I., Maruyama, S. (2003). Tactile Interfaces for Small Touch Screens. In UIST '03, Vancouver (BC), Canada.

Poupyrev, I., Maruyama, S., Rekimoto, J. (2002). Ambient Touch: Designing Tactile Interfaces for Handheld Devices. Proceedings of UIST '02. ACM 2002: p. 51-60.

Raffle, H. S., Parkes, A. J., Ishii, H. (2004). Topobo: A Constructive Assembly System with Kinetic Memory. CHI 2004, April 24–29, Vienna, Austria.

Rozendaal, M. C. (*forthcoming*). User Experience Eliciting through Image Selection (working title). Delft University of Technology.

Ryokai, K., Marti, S., Ishii, H. (2004). I/O Brush: Drawing with Everyday Objects as Ink. CHI 2004, April 24–29, Vienna, Austria.

Saladin, K. S. (2001). Anatomy & Physiology: the unity of form and function. New York: McGraw-Hill Higher Education.

Sharlin, E., Watson, B., Kitamura, Y., Kishino, F., Itoh, Y. (2004). On tangible user interfaces, humans and spatiality. In: Personal and Ubiquitous Computing: 8, 338–346

Sleeswijk Visser, F., Stappers, P., Van der Lugt, R., Sanders, E. (2005). Contextmapping: Experiences from Practice. CoDesign, 1(2), 119–149.

Small, D., Ishii, H. (1997). Design of Spatially Aware Graspable Displays. Proceedings of CHI 1997, March.

Someren, M. W., Barnard, Y. F., Sandberg, J. A. C. (1994). The Think Aloud Method: A practical guide to modeling cognitive processes. Published by Academic Press, London.

Sonneveld, M. H. (2007). Aesthetics of tactual experience: About the body language of objects. Unpublished dissertation of Delft University of Technology.

Sonneveld, M. H. (2010a). Tactile aesthetics: An additional perspective on comfort and discomfort (translated from Dutch). Tijdschrift voor Ergonomie, 35(4), 15-19.

Sonneveld, M. H. (2010b). The Meaning of Non-Functional Touch. In: International Conference on Kansei Engineering and Emotion Research, Paris (France), March 2010.

Sonneveld, M. H. (*forthcoming*). Aesthetic Movements to Explore the Tactual Pleasantness of Objects (working title). Delft University of Technology.

Spence, C., Gallace, A. (2011). Multisensory Design: Reaching Out to Touch the Consumer. Psychology & Marketing, Vol. 28(3): 267–308.

Tassoul, M. (2009). Creative Facilitation. VSDD, Delft, The Netherlands.

Tempelman, E., Pilot, A (2008). Strengthening the link between theory and practice in teaching design engineering: an empirical study on a new approach. Open Source.

Farlex (2012). The Free Dictionary. http://www.thefreedictionary.com/, retrieved 18 July 2012.

Vander, A. J., Sherman, J., & Luciano, D. (2001). Human physiology: The mechanisms of body functions. New York: McGrawHill.

Van der Lugt, R. (2005). Visual Communication for Designers: Infographics and More… Reader ID4216: Context and Conceptualization, TU Delft, 2005.

Van Kesteren, I. (2010). A User-Centered Materials Selection Approach for Product Designers. METU JFA 2010/2, p321-338.

Vavik, T., Kourennayia, D. (2006). Exploring and Teaching Tactility in Design. Working paper, Nordecode Oslo, May 2006.

APPENDIX A

SET OF IMAGES USED IN USER EXPERIENCE EVALUATION

Figure A.1: Set of Images Used in User Experience Evaluation (Rozendaal, *forthcoming*)

Figure A.1: Set of Images Used in User Experience Evaluation (Rozendaal, *forthcoming*) (continued)

Figure A.1: Set of Images Used in User Experience Evaluation (Rozendaal, *forthcoming*) (continued)

Figure A.1: Set of Images Used in User Experience Evaluation (Rozendaal, *forthcoming*) (continued)

Figure A.1: Set of Images Used in User Experience Evaluation (Rozendaal, *forthcoming*) (continued)

APPENDIX B

PROTOCOL, DATA COLLECTION, AND VENUE OF EXPLORATION

Protocol

The workshop was designed as a creative session, where the participants were first introduced to each other using an icebreaker. (5 min, no data)

Icebreaker
Throw a ball to each other, while mentioning a word that starts with the first letter of your own name, and then a word with the second letter of your name, etc.

Then the participants were shortly introduced to the topic of touch, followed by touching all the objects available and discussing what is pleasant touch. (5-10 min, video record movements)

Touch Introduction
Now you can start touching. You can grab objects and do whatever you want with them. Nothing is stupid or wrong. You can talk about it, if you feel like it. Maybe you can even imagine things you would never do with an object. Also try to explore what feels pleasant, and what not.

Those ways of touching were then used to imagine creative TV-system remote control functions. The participants were introduced to a future scenario and asked to explore creative functions through touching the objects. (10-15 min, video record exploration)

Future Scenario Introduction
Home entertainment systems are going to focus more on pleasant touch in the future. So the movements that you've just explored can become creative TV-system remote control functions. Everything is possible; think of 'connectivity' (everything is connected to each other), every surface can be a screen (like with projectors), and a remote doesn't have to be a black rectangle with buttons anymore (futuristic images of remotes can be shown). An example can be that, to enlarge your screen, you pull something elastic with two hands, and push it to do the opposite.

The participants then presented their results in front of the camera (5-10 min, video record presentation). They received a small gift, thanking them for their participation.

The pilot proved that the protocol worked, and the total amount of time was between 30 to 45 minutes. Since nothing changed after the pilot, the results of the pilot study were seen as the first workshop results, and used for analysis as well.

Data Collection

Data collection during the workshops was done by video recording the participants exploring different ways of implementing functional pleasant tactility. The results (movements with specific objects and their matched function) were presented in front of a camera by the participants, to make the participants reflect on their exploration.

Venue

The study was held in a separate room, where the participants were in peace and at ease (Studio Home at the Industrial Design Engineering faculty of DUT). There were no disturbances, and proper lighting was available. The objects were laid on a large table that the participants could stand around (active position) and get creative.

APPENDIX C

THE PARTICIPATORY DESIGN SESSION

Protocol

Creative techniques were used to go through all the phases of the participatory design session.

Icebreaker (5-10 minutes)
To get creative it is important to use both the left and right side of the brain. To do this, an icebreaker can be used. However, because everyone came in at a different moment, and the table was quite small, a group icebreaker would have been too difficult. Instead, there were objects (from the set of the preliminary research) lying on the table, and everyone could play with them to get the creativity flowing.

Introduction (5-10 minutes)
Figure 5.3 shows three depictions that represent the three different themes. This image was printed and shown to introduce the design propositions, in combination with the following text.

Inviting
The inviting theme is made up of actions that are focused on being nearly irresistible to touch. Characteristics of this inviting theme can be: clear contrasts, colors, mysterious materials, extreme softness, hand-sized shapes, hints for more (partially hidden), unpredictable looks, etc.

To create the product identity 'inviting', things to consider are an open or welcoming character, with a low threshold to use (touch). Also, clear usability cues and immediate feedback are important.

Most of the inviting character will be visually noticeable, because when inviting to be used, the product isn't actually in use yet, and is therefore not being touched yet. However, because it invites to be touched, it should have visual aspects that make people assume that touching the controller will be pleasant. The inviting visual aspects therefore have to point out pleasant tactile aspects. The inviting character will also be present in the tactile aspects, to invite continued use.

Mastery/Control
The mastery/control theme is made up of actions that are focused on challenging oneself to be able to achieve something tricky. It can involve exerting a large amount of force, as well as fine coordination or perseverance.

For the theme of mastery or control, it is important to have this playful character that makes people want to challenge themselves to prove themselves. The pleasant tactility should be in the form of doing something tricky. It can be about exerting a large amount of force, as when stretching a training-elastic as far as possible or squeezing a (hair-) pin as hard as possible. It can also deal with fine coordination, like playing with a coin through the fingers or balancing a ball (sports related). It can also be something that is not too difficult, but done for a really long time (perseverance).

Logically-Linked
The logically-linked theme is made up of actions that are focused on the logic connection between the action and the function. This theme can involve metaphors and similar movements, as well as being based on the (old-fashioned) mechanics of the function.
In the theme of logically-linked functions, it is important that the function that is linked to the pleasant movement can be expected. The function should be predictable before or during the movement made.

Metaphors can be used to make this logical link. Those metaphors should be based on a similar goal, like paging through a book could be the function to page through channels. Many metaphors would be possible.

The interaction can also be linked by similar movements, like moving a mouse to the right will also move the cursor to the right. This can also be seen as linked to the movement of the (old-fashioned) mechanics behind the function, like with turning the wheels of a VHS tape to rewind the movie.

Understanding the Opportunity (15-20 minutes)
To show what the participants already knew about the topics, and what they had understood from the introduction, three mind maps were made. They were made on large sheets, where the topic was put in the middle, and around it, like a flower, sub-topics and related aspects were written or drawn (see figures c.1, c.2 and c.3). This was done through group discussion.

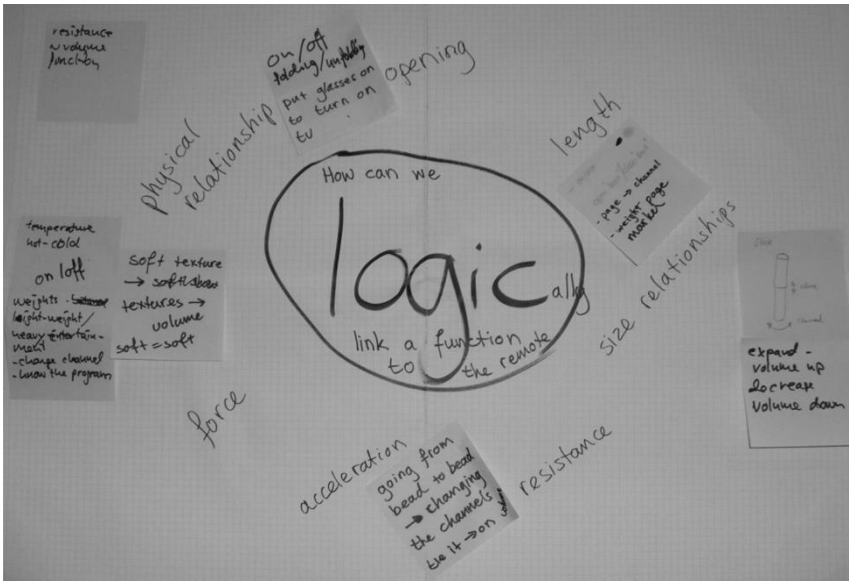


Figure C.1: Brainstorm Sheet of Logic Theme

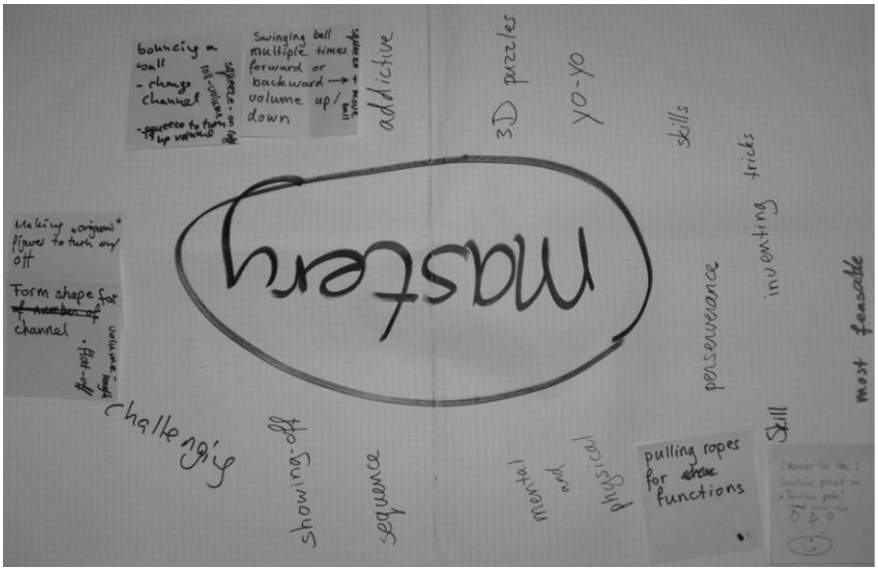


Figure C.2: Brainstorm Sheet of Mastery Theme

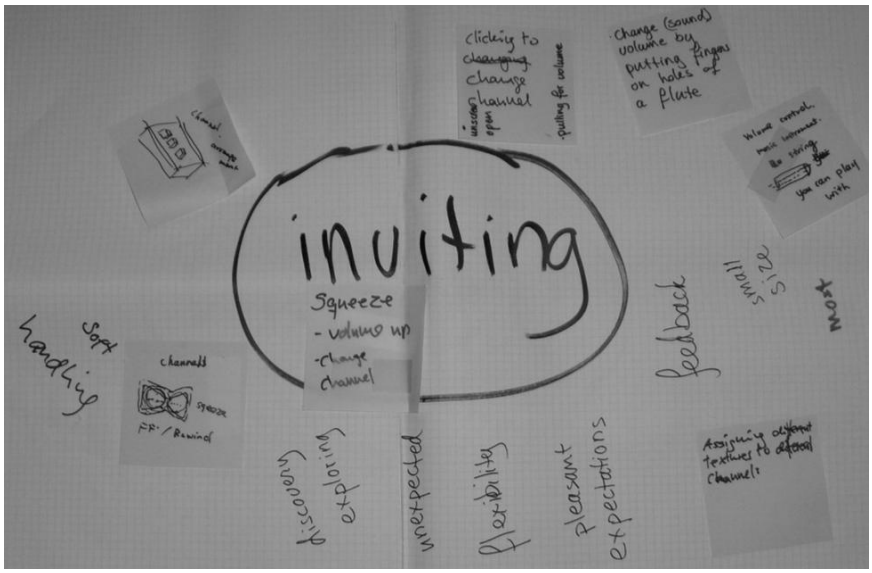


Figure C.3: Brainstorm Sheet of Inviting Theme

The next step was to turn these three opportunities into proper questions, so they could be used as starting points for idea generation. This was done with one of the topics, but it became clear that it was not necessary.

<u>Creating Ideas (diverging) (25-30 minutes)</u>
With the three topic sheets on the table, the participants started coming up with ideas for the three major functions (on/off, volume up/down, next/previous channel), by discussing them and noting them down on sticky-notes. This part was

called ‘shedding the known’, and provided the more common ideas, that might not have been very creative yet.

Then the actual creative part started, where random stimuli were being introduced, as inspiration, to associate on and to be used as a new angle for generating ideas. Those random stimuli were the images of existing (partial) solutions and the drawings of the actions from the preliminary research, mentioned in the tools section.

The ideas were drawn or written on sticky-notes again. The random stimuli were topic specific, but everyone could still work on all sheets at the same time, since the table was small enough.

Break (5-10 minutes)
When everyone seemed to be empty of ideas, a small break was introduced with drinks and snacks.

Reorganizing Ideas (15-20 minutes)
With a fresh look, the ideas were then sorted into a sequence of ascending order per topic. This was done by discussing the criteria for arrangement first. It was noted that some ideas did not include all functions, so those ideas were expanded on first. From the discussion it was clear that feasibility for prototyping should decide the order, so per topic the ideas were sorted from least feasible to most feasible.

Selecting ideas (converging) (5 minutes)
From those sequences, the three most feasible ideas of each topic were taken, and everyone was allowed to vote on them. The sticky-notes with the colored dots are the ones that were voted on. The three ideas with the most votes were selected. In two cases there was a tie, so the one person that did not vote on either one of them, was now allowed to vote again, making the final selection.

Conceptualizing Ideas (10-15 minutes)
The participants were split up into three groups which will all worked out one of the ideas into an A3 concept: Catchy title, sketchy drawing of idea, text explaining the concept in two to three sentences, and finally the three points of IPA: aspect that is Interesting, aspect that is Positive, aspect that needs Attention (not optimal yet). The visuals of the concepts were left out, because they were very unclear.

In total, the workshop took exactly 2 hours.

Data Collection

The interim results, ideas and final concepts were on (large) papers, so photos were made of that visual data, so it is possible to work with it digitally.

Additionally, the entire workshop was video-recorded, so as to have a record of the related discussions that were being held during the workshop; this could lead to interesting insights.

Venue and Equipment

The workshop was held in a separate room, where the participants could be noisy when necessary. There was a table to work around and get creative. There were ways to hang the papers (on the wall). A photo camera and built-in video-recording system were used.

Analysis

The analysis that has been done for the purpose of inspiration is based on full immersion into the data (reference). By being part of the workshop, direct contact with the data was already established.

Immersion
Directly after the workshop, when everything was still fresh in the mind, the paper data was spread out over a table and thoroughly studied. The ideas and reflections during the analysis were noted down immediately, and can be found in the following conclusion paragraph. From this immersion (Sleeswijk Visser, et al., 2005), three design concepts were derived, which can be found in section 6.3.3. Design Concepts.

All three concepts were discussed with a prototyping expert, in order to find the best way to work them out into detail (see Chapter 6: Designing and Prototyping).

Workshop Critics
By having taken another look at the recordings of the workshop, some points were concluded.

Audio: Somehow, after testing the video-recording system when everything seemed to work properly (in a test recording), the actual recordings had no (useful) audio data. This was a major disappointment, but too late now.

Time: It might have been beneficial for the results of the workshop to take more time for it, because there was still a pile of random stimuli left, and with more time, more ideas could have been generated. It was however not possible to keep the employees from their work longer than those 2 hours.

Space: The table had quite a small surface area (see figure 20), and its height was too low for standing around it. More (appropriate) space could have helped with being more creative, because of less limits and a more active environment.

Involvement: By being part of the workshop myself, as well as facilitating it, I focused on the content rather than the flow of the workshop. Because of this I might have missed opportunities to inspire others to be creative, where instead I was focused more on being creative myself. On the other hand, because it is my project, and they are just there to help me out, it wasn't appropriate not to join.

Creativity: The level of creativity wasn't very high. This was because I was afraid that they couldn't handle too much out-of-the-box techniques, and thus worked with more traditional techniques. I might have been wrong, because there was a good atmosphere and an already existing group bond. Also, extremely creative

techniques require more time to get back to feasible ideas, and my project was in a phase where the topics were already creative and feasible ideas were required now.

Similarity: This brainstorm was unexpectedly very similar to the preliminary research workshops, even though the results from those workshops were used in this brainstorm; objects were felt and played with, related issues were discussed and actions were imagined. The difference was that only a few objects were present, the related issues discussed were more underlying matters rather than experiences, and the actions that were imagined were additions to the ones found before and were focused on those three major functions combined in one remote control idea.

Additions to Design Propositions

From the discussions it was concluded that memory should also be part of the mastery or control topic, like large force, fine coordination and perseverance. This is because remembering how to do something, not just with the mind, but also with the body, gives that same feeling of being in control and mastering something. More related issues for mastery were found, taken from the mind-map: getting skilled, showing off, inventing tricks, being addictive, remembering a sequence, and being both a physical and mental challenge.

For the inviting topic it was found that characteristics like flexibility (not just as a material property, but also in the sense of having many possibilities), handily size, and exploring and discovering are closely related as well. Also feedback was considered to be important, and squeezable objects were deemed very pleasant.

In the logic topic it became clear that there is a certain physical relationship between the function and the control. Therefore, gradual controls (based on force, acceleration, length, temperature, position, etc.) work best for gradual functions like volume adjustment. Similarly, state controls (open/closed, present/absent, in/out, etc.) work best for state functions like turning the power on or off. Changing channels can have a control that has multiple levels, each corresponding with a channel.

Additional Metaphors

Many new metaphors have been brought into the workshop through the random stimuli, and some were spontaneously added throughout the brainstorm. For the topic of mastery a few interesting ones that can be named are: the art of Origami, pulling ropes like a puppeteer, solving 3D puzzles, way-finding in a labyrinth, and playing with a yo-yo. Inviting actions were the constant clicking of putting the cap on a marker, and discovering music instruments. Finally, in the logic topic, where metaphors are most appropriate, the following metaphors were mentioned: glasses to turn on visuals, rolling something over a surface for volume adjustment, manipulating an hour glass to fast-forward, rewind or pause, and a very interesting idea of linking material properties to show-types: weight (light show is comedy, heavy show is news), temperature (hot topic or cold show), and texture (soft or hard texture for soft or hard shows, like the division in drugs and porn).

Multi-Modal Feedback

During the brainstorm workshop, as in the preliminary research workshops, it was noted that tactility is not the only sense that is used in controlling devices; sounds and smells can be very inviting or give good feedback as well.

Combination
The participants all agreed that a good remote control probably has a combination of all three design propositions, because a remote control should be inviting to be picked over another, logically-linked to avoid frustration and provide for fast learning, and mastery or control keeps it interesting to use.

Concluding Design Propositions

All the information gathered in the previous sections of this chapter conclude to the following design propositions.

Inviting
The inviting theme is made up of actions that are focused on being nearly irresistible to touch. Characteristics of this inviting theme can be: clear contrasts, colors, mysterious materials, extreme softness, hand-sized shapes, hints for more (partially hidden), unpredictable looks, flexibility, and exploring and discovering.

Mastery/Control
The mastery/control theme is made up of actions that are focused on challenging oneself to be able to achieve something tricky. It can involve exerting a large amount of force, getting skilled, showing off, inventing tricks, being addictive, remembering a sequence, and being both a physical and mental challenge, as well as fine coordination, memory or perseverance.

Logically-Linked
The logically-linked theme is made up of actions that are focused on the logic connection between the action and the function, like the action of leafing through a book to change the channel. This theme can involve metaphors and similar movements, as well as being based on the (old-fashioned) mechanics of the function. The physical relationship between the function and the control is important, which means that gradual controls (based on force, acceleration, length, temperature, position, etc.) work best for gradual functions like volume adjustment. Similarly, state controls (open/closed, present/absent, in/out, etc.) work best for state functions like turning the power on or off. Changing channels can have a control that has multiple levels, each corresponding with a channel.

APPENDIX D

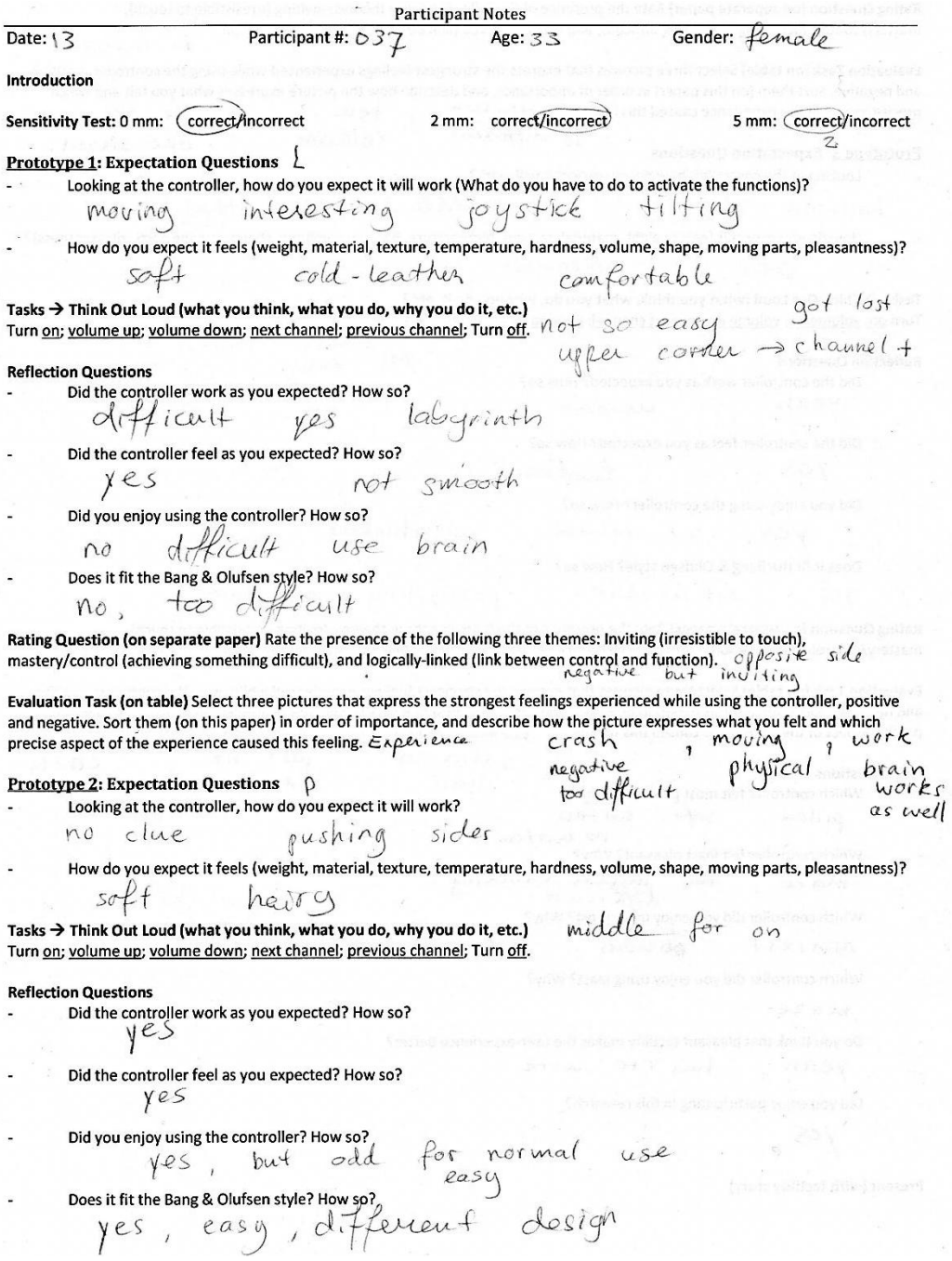
INTRODUCTION FOR PARTICIPANTS OF THE USER STUDY

I want to thank you for volunteering to join my research. The session should take about 30 minutes and will be made up of five parts; the first part will be a small test to find out if your finger-tips are touch-sensitive; this will take only a minute. The second, third and fourth part will be similar in content and will each take about 5 minutes; you will be shown a random prototype of an innovative TV system controller and be asked about your expectations before testing. Then you will be following some tasks to test the prototype, and finally you will be asked some questions and do an evaluation task. This will be done two more times with the other two prototypes. The fifth part will involve some final questions about all three prototypes and in the end you will receive a present for your participation. You are free to leave whenever you do not feel comfortable continuing. The entire session will be video-recorded for analysis purposes, and will only be used in the context of this study, never with personal information.

Please note that the prototypes are not complete products, and have only the three major functions of on/off, volume up/down and next/previous channel.

APPENDIX E

EXAMPLE OF PARTICIPANT NOTES



Participant Notes

Date: 13 Participant #: 037 Age: 33 Gender: female

Introduction

Sensitivity Test: 0 mm: (correct)/incorrect 2 mm: correct/(incorrect) 5 mm: (correct)/incorrect

Prototype 1: Expectation Questions L

- Looking at the controller, how do you expect it will work (What do you have to do to activate the functions)?
  moving interesting joystick tilting
- How do you expect it feels (weight, material, texture, temperature, hardness, volume, shape, moving parts, pleasantness)?
  soft cold - leather comfortable

Tasks → Think Out Loud (what you think, what you do, why you do it, etc.)
Turn on; volume up; volume down; next channel; previous channel; Turn off. not so easy got lost
upper corner → channel +

Reflection Questions

- Did the controller work as you expected? How so?
  difficult yes labyrinth
- Did the controller feel as you expected? How so?
  yes not smooth
- Did you enjoy using the controller? How so?
  no difficult use brain
- Does it fit the Bang & Olufsen style? How so?
  no, too difficult

Rating Question (on separate paper) Rate the presence of the following three themes: Inviting (irresistible to touch), mastery/control (achieving something difficult), and logically-linked (link between control and function). opposite side
negative but inviting

Evaluation Task (on table) Select three pictures that express the strongest feelings experienced while using the controller, positive and negative. Sort them (on this paper) in order of importance, and describe how the picture expresses what you felt and which precise aspect of the experience caused this feeling. Experience crash , moving , work
negative physical brain
too difficult works as well

Prototype 2: Expectation Questions P

- Looking at the controller, how do you expect it will work?
  no clue pushing sides
- How do you expect it feels (weight, material, texture, temperature, hardness, volume, shape, moving parts, pleasantness)?
  soft hairy

Tasks → Think Out Loud (what you think, what you do, why you do it, etc.) middle for on
Turn on; volume up; volume down; next channel; previous channel; Turn off.

Reflection Questions

- Did the controller work as you expected? How so?
  yes
- Did the controller feel as you expected? How so?
  yes
- Did you enjoy using the controller? How so?
  yes, but odd for normal use
  easy
- Does it fit the Bang & Olufsen style? How so?
  yes, easy, different design

Figure E.1: Example of Participant Notes

Rating Question (on separate paper) Rate the presence of the following three themes: Inviting (irresistible to touch), mastery/control (achieving something difficult), and logically-linked (link between control and function). inviting in control

Evaluation Task (on table) Select three pictures that express the strongest feelings experienced while using the controller, positive and negative. Sort them (on this paper) in order of importance, and describe how the picture expresses what you felt and which precise aspect of the experience caused this feeling. attention , tea , home alone
so different relaxing one person

Prototype 3: Expectation Questions

- Looking at the controller, how do you expect it will work?

built-in chair on-middle sides-others

- How do you expect it feels (weight, material, texture, temperature, hardness, volume, shape, moving parts, pleasantness)?

soft pleasant

Tasks → Think Out Loud (what you think, what you do, why you do it, etc.) doubt
Turn on; volume up; volume down; next channel; previous channel; Turn off. channel slider
not easy

Reflection Questions

- Did the controller work as you expected? How so?

yeah uncover

- Did the controller feel as you expected? How so?

yes feedback

- Did you enjoy using the controller? How so?

yes, sit relaxed no thinking

- Does it fit the Bang & Olufsen style? How so?

yes not in chair possibility on chair

Rating Question (on separate paper) Rate the presence of the following three themes: Inviting (irresistible to touch), mastery/control (achieving something difficult), and logically-linked (link between control and function). quite positive

Evaluation Task (on table) Select three pictures that express the strongest feelings experienced while using the controller, positive and negative. Sort them (on this paper) in order of importance, and describe how the picture expresses what you felt and which precise aspect of the experience caused this feeling. home alone , composing , tea
sittin in chair just sit move hand cozy

Final Questions

- Which controller felt most pleasant? Why?

pillow, soft surface no buttons

- Which controller felt least pleasant? Why?

maze, too much thinking difficult

- Which controller did you enjoy using most? Why?

armrest, most obvious

- Which controller did you enjoy using least? Why?

maze

- Do you think that pleasant tactility makes the user-experience better?

yeah, has to work

- Did you enjoy participating in this research?

yes

Present (with tactility story)

Figure E.1: Example of Participant Notes (continued)

APPENDIX F

EXAMPLE OF RATING QUESTIONS

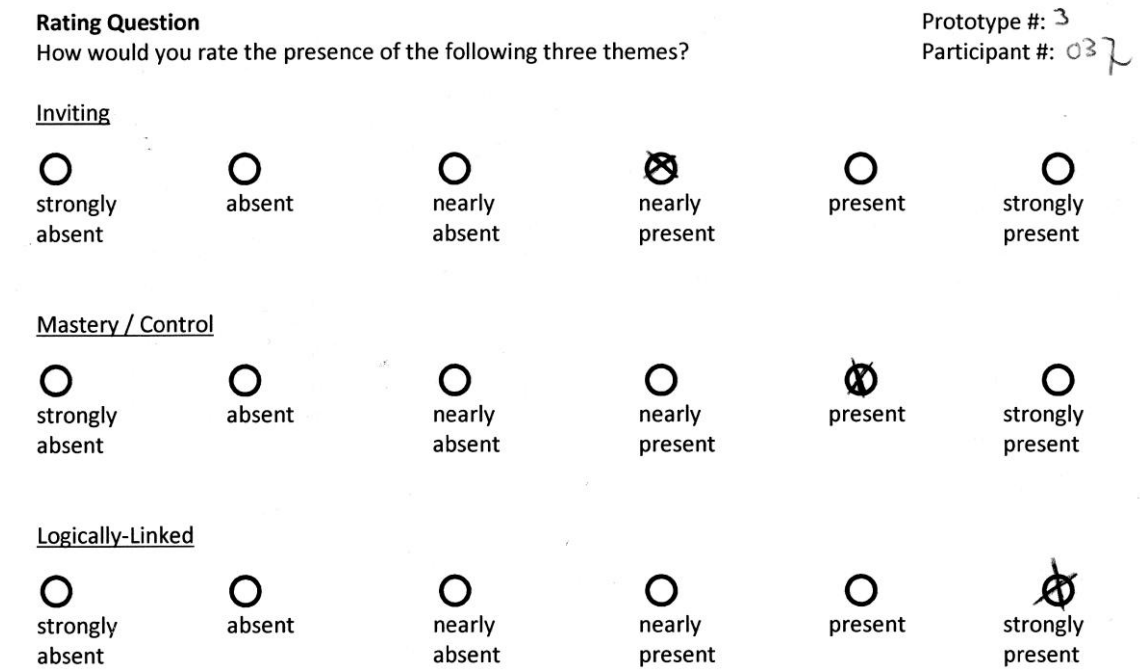


Figure F.1: Example of Rating Questions

APPENDIX G

PART OF SPREADSHEET WITH RESULTS OF USER STUDY

Particip ant #	Gend er	Age	Sensit ive	Orde r	Pillow										
					Expected functioning	Expected feel	Tasks	Reflection functioning	Reflection feel	Enjoyable	B&O style	Rating	Comments	Images	Evaluations
005	m	35	y	apl	if I know it has functions, then 4 different areas have the functions; on/off in middle	similar textures have similar functioning; soft, pleasant, not in control	something happened; too sensitive; don't have to push it	almost, I thought it would be more like pushing than just touching	yes, except for the controlling then	not that much; too fuzzy, not in control	no, too abstract; no design; it's a pillow to put your head on	I-2 M-3 L-2	not inviting for a remote; really different than what you expect	form; crash; spill	think too much about it; feeling out of control; I looked stupid
006	m	35	y+	apl	it's a pillow; I see the IR; 4 different areas for the functions, but I miss 1 button	it feels like a pillow; some sort of feedback, like sound or feel	ah ok, you don't have to press it	no, it's not stable	yes, like a pillow	it's really special, not fond of it personnally	yes, I believe so; could be B&O; new, superising, fits the mission	I1 M-1 L1	could be inviting, not working 100%, not stable	tea; juggle; apartment	cozy, relaxing; exciting; fits in environment
013	m	34	y	apl	not sure, maybe touching / squeezing the ends; one or two pushes	looks soft, fluffy; could be pleasant	puts it on lap; turned it off accidentally; TV bugs	kind of; wasn't easy to figure out not to press it	yes	more fun than pleasant; wasn't sure about functioning	maybe the concept of surprise, but not the design	I2 M3 L-2	knowing that it's a controller; still a prototype; inviting and showing off	attention; apartment; reading	touching a pillow to change the TV; fits in environment; appearance, looks like pillow
015	m	27	y	lpa	push these areas, something will happen; don't know what	soft, like a teddy bear	softly pushes; very sensitive	pretty much, yes; more sensitive than expected	yeah	yes, it was fun	no, I don't see our customers buying this	I3 M2 L1	very inviting, mostly in control, pretty logical	campfire; holiday; dancing	warm, cozy; new, different; soft, have to b gentle
018	m	27	y	pal	don't know; don't think it will work; press the squares	soft	touched the areas really fast; off in the middle	some of it, you have to touch it; little special	yes	yes, was quite funny	no, too big; too special; not intuitive	I2 M-2 L-2	mostly inviting, looks funny; not in control, not logical	traffic jam; juggling; being bullied	that's hard; frustrating; wasn't good at it; you knew how to use it, and not me
019	m	31	y	lpa	corners of pillow have functions, opposite corners; power function in the middle	soft, maybe pleasant	pressing opposite corners, then horizontal;	no, I was pressing instead of stroking; and functions weren't diagonal	yes, soft, fluffy; but the feather are pointy	no, not in control; not precise, more like chance	no, not the material; lack of aluminum	I1 M-3 L-1	not as inviting as labyrinth; not in control; more logical than labyrinth	reading; bored; locked	sleeping, pillow; gets boring; not that in contr
023	m	25	y	pal	fast reaction; not press too much for volume; basic functions near the thumb	weight is good quality; smooth edges, not too cold	so this is the remote, oh; tried to lift it; thought the remote under it	it's a really cool idea to just touch it; not expected it at all; normally you push	no, not at all; warm, soft, could be head rest	yes, really fun; didn't work properly, prototype; but really fun	no; B&O style is totally not like this; but could be new way	I3 M2 L2	really inviting; icons on it would be easier; show it off, tricks	juggling; attention; park	just for fun, play, could g either way; different, unexpected; try something different
028	m	34	y	lap	like 4 buttons on the different textures; where is the fifth one; and which is what	soft, different textures, like a cushion	nearly touches 2 areas all the time; it worked	some of it; expected to push; channels were normal; volume was switched; power button was struggle	yes, but feathers are a bit pointy; soft as it looks to be	yes, for the test; it's a gimmick; not daily, too big, difficult	probably not, too much a gimmick; should be more grown up	I1 M2 L2	rather logical; fun is inviting	reading; tea; bored	cushion part; cozy pictur after hours of use, get bored, gimmick
010	m	45	y	pal	4 areas with different functions, no idea which is which	soft, maybe a clicking button inside	pressing at first; found channel; turned it off accidentally	no, I was surprised; I expected pressing	yes, like a pillow; different fabrics	it's funny; I could get used to this; not very male	no, B&O is more masculine	I1 M1 L-1	not so logical, show it off a little	reading; tea; home alone	pillow in picture, relaxe same; quiet materials
011	m	50	y	alp	poke and press in some places	like pressing a soft tennis ball	puts it on lap; needs explanation (reset 4 times) too sensitive	no, I thought I should press it; idea is good	yeah	yeah, could be nice	yeah, could be	I3 M3 L2	very positive; details need to be worked out	tea; traffic jam; home alone	relaxed; stuck because prototype; cozy (also weird to touch a pillow)

Figure G.1: Part of Spreadsheet with Results of User Study