Product Adoption Design of Ergonomic Aid Utilizing Eye Tracking Technology

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Approved	Examiner Claes Tisell	Supervisor Stefan Ståhlgren
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Abstract

Tobii Dynavox is developing a product called Ergo, which is an ergonomic aid utilizing eye tracking technology. Its purpose is to ease physical pain related to computer work by enabling the user to navigate their computer with their eyes. With this product, Tobii Dynavox is entering a new market and addressing new customers, therefore needing a better understanding of potential customer needs, behaviour and desires. The research questions investigated in the project are; What does the market of ergonomic aids look like? What does the customer journey with Ergo look like? Who are the potential users of Ergo and what are their needs? How should Ergo be designed and presented to facilitate adoption?

In order to understand how Ergo should be developed, a research of Ergo's context was conducted. The research consisted of a user study, a study of the brand identity of Tobii Dynavox and the market of ergonomic aids. It also consisted of a literature study where eye tracking technology, physical ergonomics, human-computer interaction, cognitive ergonomics and the market of technological innovation ware studied.

The research resulted in insights that were summarized in a list of guidelines. The guidelines are essential to follow in the development of Ergo in order for it to be user-friendly, profitable, more feasible and ready for market launch. The insights from the research also resulted in a list of problem areas, of which the problem of the users' difficulty in adopting eye tracking was chosen to work further with. The development of Ergo involved solving the chosen problem area. The solution is a product adoption design with a linear process of unpacking and installing the product. It further involves a new system of how to learn and adopt eye tracking as a tool in daily computer activities. The overall adoption design is guiding, comprehensive, friendly and intuitive while also communicating feelings of excitement and giving an impression of high-tech. The evaluation concluded that the design is beneficial for Ergo in order to facilitate user adoption and to succeed on the market. Finally, all results were summarized and discussed in the end of the project.

KTH Industriell teknik och management

Examensarbete MMK 2015:34 IDE 163

Användarcentrerad utveckling av eye-trackingprodukt för kontorsergonomi

Malin Daleke

Ida Nilsson

Godkänt	Examinator Claes Tisell	Handledare Stefan Ståhlgren
	Uppdragsgivare Tobii	Kontaktperson Malin Ivarsson

Sammanfattning

Tobii AB arbetar med en teknik kallad eye tracking, som syftar till att läsa av ögonrörelser. Tobii Dynavox, en del i Tobii AB, utvecklar för närvarande en ny produkt, kallad Ergo, som nyttjar den tekniken. Syftet med produkten är att minska fysisk smärta i samband med datoranvändning genom att låta användaren styra datorn med ögonen istället för med händerna. Produkten är riktad mot en ny marknad för Tobii Dynavox, en marknad med andra kunder och användargrupper än deras nuvarande. Med anledning av detta behöver Tobii Dynavox en större förståelse för Ergos blivande kunder. De frågor som undersökningen ämnar att besvara är följande: Hur ser marknaden för ergonomiska hjälpmedel ut? Hur ser kundresan med Ergo ut? Vilka är de potentiella kunderna och vilka behov har de? Hur bör Ergo vara designad och bli presenterad för att användaren lättare ska ta till sig produkten?

För att undersöka detta genomfördes en kontextuell undersökning av Ergo. Undersökning bestod av en literaturstudie, användarstudie, en studie av Tobiis företagsidentitet och marknaden av ergonomiska hjälpmedel. Undersökningen resulterade i insikter som sammanfattades i en lista med riktlinjer. Dessa riktlinjer är väsentliga i utvecklingen av Ergo för att få en produkt som är användarvänlig, lönsam för Tobii, mer trovärdig på marknaden och redo för marknadslansering. Insikterna resulterade även i en sammanställning av problemområden med Ergo, från vilket ett valdes ut för fortsatt utveckling. Det problem som valdes var användarnas varierande förväntningar av produkten och deras svårigheter att ta till sig produkten.

Utvecklingen av Ergo innefattade ett förslag för att lösa det valda problemet. Lösningen är en ny produktdesign som genom en linjär inlärningsprocess underlättar för användaren att ta till sig produkten och använda den i sitt dagliga arbete. Designen ska därtill vara mer ledande, intuitiv, lättsam och förmedla ett snällt men också spännande intryck. Slutsatsen från utvärderingen visade att den nya designen är fördelaktig för Ergo, då den underlättar för användaren att ta till sig eye tracking i dagligt arbete.

Acknowledgements

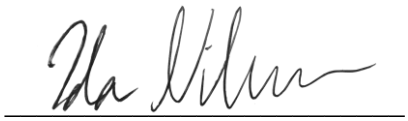
This master thesis concludes our studies at the Industrial Design Engineering track, held within the Master of Science programme Integrated Product Design at the Royal Institute of Technology in Stockholm. The thesis work was performed at Tobii AB, the world leading company of eye tracking, during the time period of January to June 2015.

Many people have supported our work throughout the project, and without their help this master thesis would not have been the same. First of all, we would like to thank the employees in the Ergo development team who have taken time to be interviewed and never failed to answer our questions. Thank you Ulrica Wikström, Fredrik Ruben, David Henderek, Simon Cicek, Ralf Biedert, Volodymyr Iakovenko and Åsa Broman. We would also like to show special gratitude to Malin Ivarsson, our supervisor at Tobii Dynavox, for always understanding and supporting our project and goals.

Additionally, we would like to thank all people who have been involved in the user study for taking time and contributing to our work. Your input has been extremely valuable. Also, we would like to thank Mia Hesselgren and Mats Magnusson for valuable discussions.

Above all, we would like to send our most sincere appreciations to our academic supervisor Stefan Ståhlgren for all guidance and support we have received throughout the project, and for the inspiration for our future careers.

Malin Daleke, June 2015



Ida Nilsson, June 2015

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1 Introduction

This chapter is an introduction to the scope of the master thesis project. The product in focus, Ergo, is briefly presented as well as the background, purpose, problem, research questions and delimitations of the project. The chapter also consists of essential terminology and nomenclature.

1.1 Problem background

Tobii AB, situated in Danderyd, Sweden and founded 2001, is working with a technology called eye tracking. Eye tracking is the process of identifying where a person is looking, normally with a device called eye tracker. The eye tracker investigated in this master thesis is visualized in Figure 1. The technology is rapidly adopted into different devices and services, both to understand human behaviour and enhance computer interaction (Tobii AB, 2015). The company consists of three divisions, each working with eye tracking in a specific way. Tobii Dynavox, one of the divisions, is developing medical aid for disabled people with limited communication abilities.

Figure 1. A remote eye tracker connected to a computer screen.

Tobii Dynavox is releasing a new product called Ergo in 2015. Ergo is the product investigated in this master thesis and has the purpose of giving the user the ability to navigate the computer with their eyes instead of their hands, hence easing physical pain related to computer work. The user's gaze point, the point where the eyes are looking, determines the position of the cursor. Clicking is performed by pressing a key board button. The product consists of a package with an eye tracker and software. With Ergo, Tobii Dynavox is entering a new market and addressing new customers with different needs than their current ones. It is their first product aiming for a broader market and a wider variety of users.

1.2 Purpose and problem definition

The purpose of the thesis work is to investigate the concept of using eye tracking technology in the field of physical ergonomics in computer work. The investigation will consist of a literature study, user study and market study. It involves the understanding of the potential user, how they

adopt eye tracking as a tool in daily computer activities and understanding the market of ergonomic aids. The product Ergo will be used as means for this investigation. The findings from the investigation will be used to develop Ergo.

The software and hardware of Ergo are developed to a great extent, but Tobii Dynavox needs to design the product with the user in focus. In order do this, they need a better knowledge of their potential customers; what their needs and desires are, and of how they can adopt eye tracking as a tool in their daily computer activities. This knowledge is essential to make Ergo suitable for the user, profitable for Tobii, more feasible and ready for market launch.

1.3 Research questions

The following questions will be investigated in the project.

- What does the market of ergonomic aids look like?
- What does the customer journey with Ergo look like?
- Who are the potential users of Ergo and what are their needs?
- How should Ergo be designed and presented to facilitate adoption?

The investigation and answers to these are presented throughout the report under different chapters.

1.4 Delimitations

Since eye tracking is a technology used in many different fields with a diverse range of users, the project is delimited by only investigating eye tracking when it acts as a tool in daily computer activities. These activities are ones carried out by frequent computer users who spend an essential amount of time in front of a computer in their daily lives. Adoption of eye tracking within other fields, such as scientific research and research for commercial intent, will not be investigated.

The project will exclusively look at the eye tracking technology of Tobii AB and their product Ergo when doing the investigation. The project is geographically delimited to Stockholm, Sweden and demographically limited to people working with computers in their daily occupations, hence excluding children and elderly.

The project is delimited by exclusively investigating the usage of Ergo and will exclude other parts of its product life cycle. Production, transportation and disposal will hence not be investigated and neither will environmental aspects.

The master thesis project is delimited to the time frame of twenty weeks. Due to this time frame, the test persons will participate in the beta program for three weeks only. The number of beta products available for the master thesis is also limited, and only seven will be handed out.

Tobii has an agile approach when developing the software of Ergo, so the software will be continuously improved and changed throughout the master thesis. The participants of the research has therefore experienced and tried different versions of the software. Furthermore,

since the software is under construction and not perfectly stable, it is incompatible with some computers and can sometimes not be installed. It can also cause other technical complications such as unwanted software updates or computer crashes. This issue has also limited the number of test participants.

The project includes a study of market strategy theory in order to understand the target market and the potential user of Ergo. The purpose of the project is however not to suggest a market strategy for Ergo, even if strategic conclusions can be drawn from the result findings.

1.5 Thesis outline

This section will describe the disposition of the master thesis report and briefly what is included in each chapter.

Chapter 1. Introduction - This chapter introduces the problem background and the product in focus for the master thesis. It also presents delimitations, research questions and problem definition.

Chapter 2. Methodology - This chapter describes what has been done in the project, and the methods used for conducting the master thesis work.

Chapter 3. Introduction to eye tracking - This chapter introduces the technology studied in the master thesis; eye tracking. It also presents the product, Ergo, which is used in the investigation.

Chapter 4. Theoretical framework - This chapter presents the literature that has been used to guide the investigation and development.

Chapter 5. Results from contextual study - This chapter presents the findings from the contextual study, including market study and a study of Tobii's brand identity.

Chapter 6. Results from user study - This chapter presents the findings from the user study.

Chapter 7. Research analysis and conclusions - This chapter presents the conclusions from the contextual study and the user study.

Chapter 8. Development of product adoption design – This chapter presents a design suggestion to facilitate adoption of Ergo, based on findings from a user study.

Chapter 9. Evaluation - This chapter evaluates Ergo and its developed adoption design.

Chapter 10. Discussion - This chapter discusses the final results of the master thesis and includes a reflection from the researchers.

1.6 Terminology

Eye tracker - The measurement device most often used for measuring eye movements is known as an eye tracker (Duchowski, 2007).

Eye tracking - The process of tracking where someone is looking, most commonly with an eye tracker device (Tobii AB, 2015).

RSI - Repetitive strain injury

Conceptual model - a mental model constructed by interpreting a perceived structure in order to try to understand how a device works and should be used (Norman, 2013).

Beta product – A pre-release version of a product that is given to potential users to try, in order to obtain feedback (Mohr, Sengupta, & Slater, 2005).

2 Methodology

This chapter presents the methodology of how the different phases of the project were conducted. It also provides an evaluation of the research quality.

2.1 Overview

The project consists of a research phase, followed by analysis and product development based on the findings. The phases of the project are visualized in Figure 2. There are three research phases; literature, contextual and user research, each marked with blue in the figure. The analysis of the research will provide guidelines for the development of Ergo, as well as a list of problems areas. These conclusions from the analysis will be the foundation of the development of Ergo. The final results will be reported and published. Overall, the process will be iterative in order to follow the agile software development of Ergo.

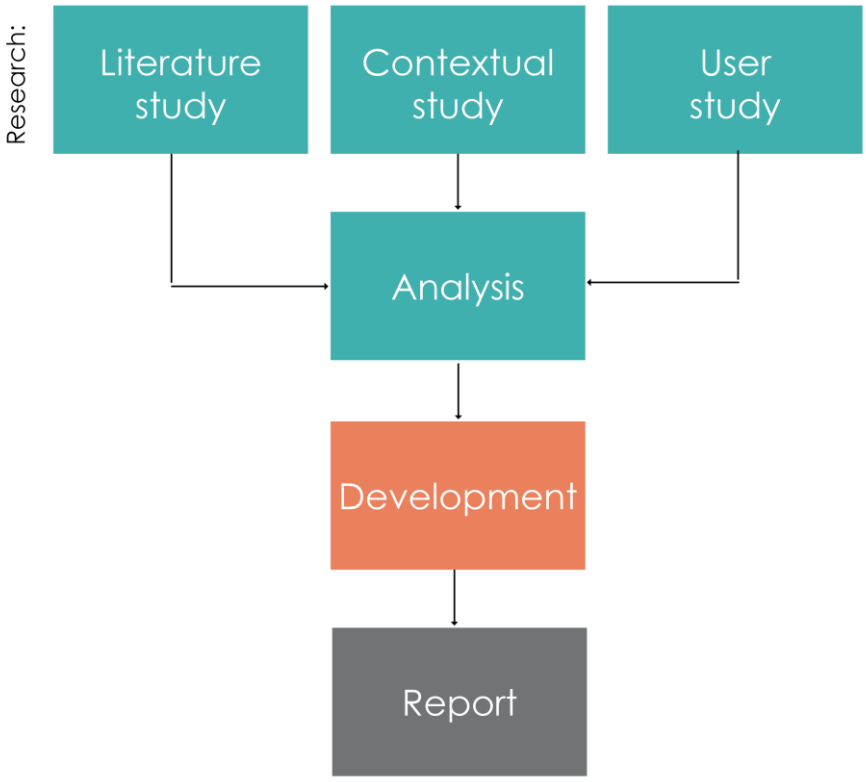


Figure 2. An overview of the different phases in the project.

2.2 Research: literature study

The aim of the literature study is to investigate what has already been studied within the areas that concern the project. It also aims to obtain knowledge within fields that concern the project and could be of importance when developing Ergo. The fields chosen to look into includes eye tracking technology, physical ergonomics in computer work, cognitive ergonomics, human-computer interaction and the market of technological innovation. The literature is presented in chapter 4; Theoretical Framework. The study of eye tracking is presented in chapter 3. The method used for the literature research is reading books while gathering relevant information

concerning the project. Furthermore, interviews with a market strategist, a design strategist and ergonomic experts have been conducted for guidance and advice.

2.3 Research: contextual study

Since the project will result in development of a Tobii product, it is important to look into the brand identity of the company. This research is small, but will be included to ensure that Ergo speaks the same design language as other Tobii products. The methods used to identify the brand identity are interviews with Tobii employees about visions and strategies, as well as a listing of hardware, software, packages, printing material, logotype and other graphic material developed and used at Tobii. This will be summarized in a collage to show the general visual expression. A competitor analysis will also be made by information retrieval through internet research. A potential distributor of Ergo, Rahmqvist, will also be contacted to gain understanding of their general requirements on products they distribute.

2.4 Research: user study

In order to investigate how Ergo is perceived by users and what type of aspects affect adoption, a thorough user study will be made. The aim of the user study is to identify problems throughout the entire journey that the customer experiences with Ergo. It also aims to understand the potential users and identify their different behaviours and needs. The methods used for this user study are presented in this section.

User study test groups

The data will be collected from five different types of test groups, presented in Figure 3. The total number of participants in the study is 67 people. The motive behind having different user groups is to cover and understand every stage of the customer journey. Every test group can provide information from different stages in the journey, which is why all participate in the study. Each group will be approached with different methods to properly retrieve the information needed.

The people participating in the beta study have been reached by contacting human resources divisions at big companies in Stockholm, Sweden. The division has then forwarded the request to eligible employees. The companies work within different fields to ensure a wide diversity of participants. Some participants have also been reached by contacts through the Royal Institute of Technology and by Tobii Dynavox, to further ensure a wide demographic range of people with varying interests. People with and without RSI have both been chosen to take part of the user study, to investigate what impact pain has on product adoption. Beta users without RSI or other ergonomic problems have however contributed with valuable data about the general use of Ergo and eye tracking.

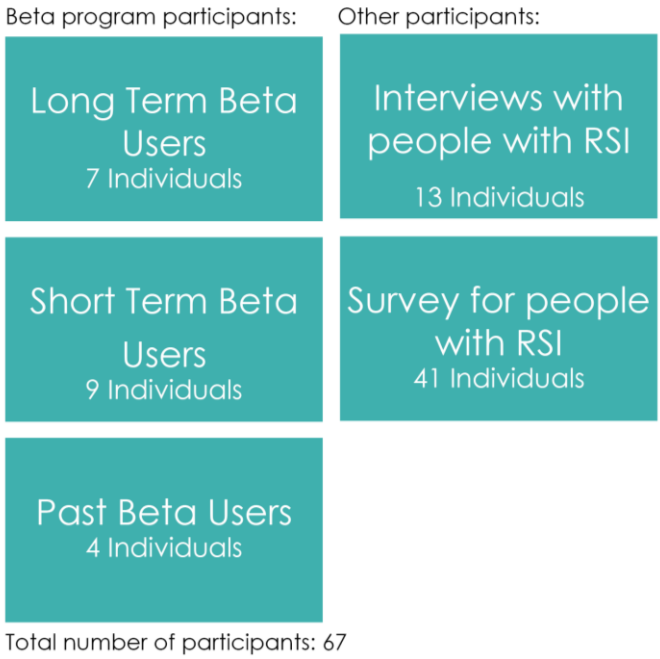


Figure 3. The different test groups of the user study and number of participants.

Long term beta users

The long term beta users will try Ergo at their own workplace for three weeks with continuous observations and interviews. The participants will be followed prior to, during and after testing Ergo in order to gain information about the entire customer journey with Ergo. Three meetings with each participant are set up where every meeting follows a premade interview guide. All questions are formulated so that factors of adoption and problems with Ergo are investigated. The detailed guides for each meeting can be found in Appendix A.

Short term beta users

Some participants will try Ergo under a short time under total observation of the master thesis students. This test group is called the short term beta users. These tests will be made on a computer provided by Tobii where Ergo is installed. The test persons will be interviewed prior to, during and after testing. Every interview follows the same interview guide detailed in Appendix B. The interviews will provide information of associations and feelings towards eye tracking prior to testing as well as first impressions of the technology. They will however lack to provide long term contextual experience of Ergo.

Past beta users

The test group of past beta users will be able to provide long term experience of Ergo. This group of users were on the past beta program, conducted by employees at Tobii Dynavox, before the master thesis project started. These beta users can therefore not provide valid data of expectations and associations of eye tracking prior to testing as they have already been using Ergo for a longer time. They can however provide long term experience with Ergo, and will be interviewed in order to gain this information. The interview guide for this test group is found in Appendix A. The short term users and past beta users will hence complement each other in data they provide.

Interviews and survey of people with RSI

The three previously stated test groups are chosen in order to understand how people interact with and adopt eye tracking and Ergo. However, in Ergo's context it is important to understand in what mental stage users enter the journey with Ergo. Their associations and previous experiences with ergonomic aids are important to investigate in order to understand the target market. Users with RSI will hence be interviewed and surveyed. The interview guide of these interviews can be found in Appendix C and the survey questions can be found in Appendix D.

User study methodology

The aim of the user study is to obtain qualitative data about the user. It aims to understand the user in terms of associations, expectations, perceptions and experiences, which of none can easily be measured or quantified. This data will hence be obtained through several qualitative data retrieval methods. Furthermore, qualitative research is a powerful tool in understanding customer motivation. The concept is based on searching for the real motivations that do not emerge from structured lists (Mohr, Sengupta, & Slater, 2005).

The long term, short term and past beta users will or have been participating in a beta program of Ergo. A beta program is a method used to obtain user feedback before a product has its market launch. A beta version of a product is a pre-release that the company gives potential users to try. In the test, the customer agrees to provide feedback that the developer can use to improve the product prior to its commercial release (Mohr, Sengupta, & Slater, 2005). The version of Ergo that is used in the beta program is hence fully functioning, but under development.

Contextual interviews are used as an interview method for the long term beta users. This type of interview is conducted in the environment, or context, in which the process of interest occurs. The technique allows interviewers to observe and investigate the behaviour they are interested in (Stickdorn, Schneider, & co-authors, 2011). This means, for Ergo, that the interviews of the long term beta users will be conducted at the environment in which they will interact with Ergo. It will therefore provide an understanding of the social and physical environment surrounding Ergo. The benefit of using contextual interviews is that it helps the interviewee to detect and remember details that often get lost in a traditional interview. Also, most people are more comfortable providing insights into their daily thoughts and behaviour when discussing this in a familiar environment. These insights can be both validated and expanded upon by the observations of the interviewer. "What people don't say is often just as valuable as what they do" (Stickdorn, Schneider, & co-authors, 2011).

Besides the observations made in the contextual interviews, observations are used as a general method in all encounters and meetings with research participants. More insights about customer behaviour can be obtained through observations, rather than exclusively collecting user data through oral information.

Traditional interviews will be conducted with short term beta users, past beta users and people with RSI. They are conducted either in person or by telephone. Both the traditional and the contextual interviews, will be of semi structure. A semi structured interview is an interview with a pre-planned guide with the freedom to deviate from. It normally contains a few subjects or

questions to discuss around, while still giving the interviewee the chance to direct the discussion. This type of interview provides a more systematic analysis of the results compared to unstructured interviews (Bohgard (red), 2011).

During all interviews, both traditional and contextual, a method called The Five Whys will be used. It was first described by Sakichi Toyoda, a former employee at Toyota. It is a root cause analysis that aims to investigate the occurrence until the single underlying cause is found (Norman, 2013). In practice, it means asking a chain of why questions to dig below the outward perception of a user experience in order to uncover the motivations that are at its root cause (Stickdorn, Schneider, & co-authors, 2011). This method will be used to find the root cause of the associations, expectations and perception of eye tracking in order to truly understand the user.

Two scenarios when surveying is a prominent way of obtaining information is firstly when data from a large number of people is needed under a short period of time, and secondly, when the primary focus group is difficult or expensive to find and reach (Bohgard (red), 2011). Both scenarios apply for people with ergonomic problems as the process of finding them is both time consuming and difficult. The traditional interviews with people with ergonomic aids will hence be complemented with a survey to support the validity in the interview findings. Conclusively, interviews will be the main method of information retrieval for the journey with ergonomic problems, and the survey acts as confirmation and validation of the responses.

An iterative process of gathering data

The user study will be an iterative process, Figure 4. This process differs from the traditional design process, which is more linear. A traditional design process can be divided into the following steps; product discovery, project planning, product definition, conceptual design, product development and product support, which can be further studied in (Ullman, D. (2010)). This process is commonly used in mechanical design, while the iterative approach is more commonly used in human centred design. Instead of a project going in one single direction with gates blocking transition between each project phase, the iterative process is circular. This gives the process the chance of continuous refinement, change, encouragement of backtracking and rethinking early decisions. (Norman, 2013) The iterative process is chosen in this project, since it aims to develop a product from a user perspective. Due to this, it is important to continually refine and update the interview guides as the insights and problems with Ergo emerge. An iterative method allows further investigation in findings from one iteration to another. Each iteration will include gathering of data from every test group followed by a summary and analysis of insights. When one iteration is saturated with data, the interview guides for the next iteration will be updated based on the insight analysis. The iterations will stop when the time frame does not allow for further data gathering and when sufficient amount of data is collected. When the last iteration is finished, a final summary of the insights is made in order to facilitate definition of problem areas.

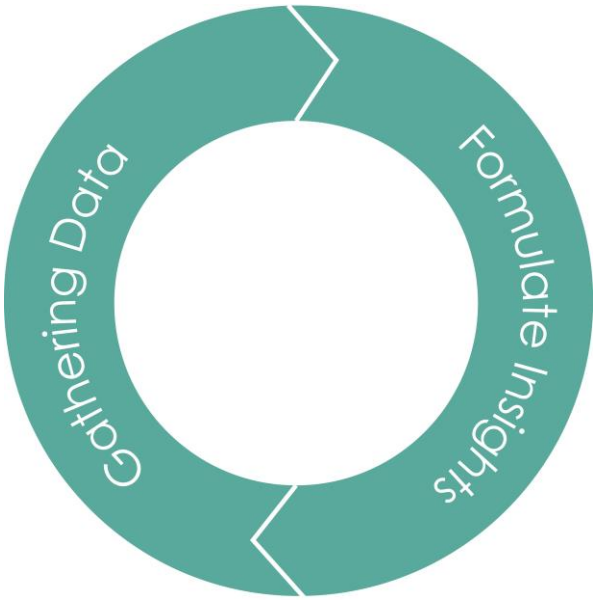


Figure 4. A basic iterative project process.

2.5 Research data analysis

To analyse and summarize the findings from the research, several methods will be used. In order to understand the user's whole experience of using eye tracking, customer journey maps will be made based on insights from the user study. A customer journey map provides a vivid but structured visualisation of a user experience. The touch points of interaction are used to construct a story based upon user experience (Stickdorn, Schneider, & co-authors, 2011). The story reveals the emotions the customer experiences, which is important knowledge in the development of Ergo. A customer journey map will be made for each participant in the user study. These will be analysed to find similarities and common patterns in the different customer journeys. Conclusively, one common customer journey map will be made illustrating the journey with Ergo, and another illustrating the journey with ergonomic problems. A template of a customer journey map is presented in Figure 5.

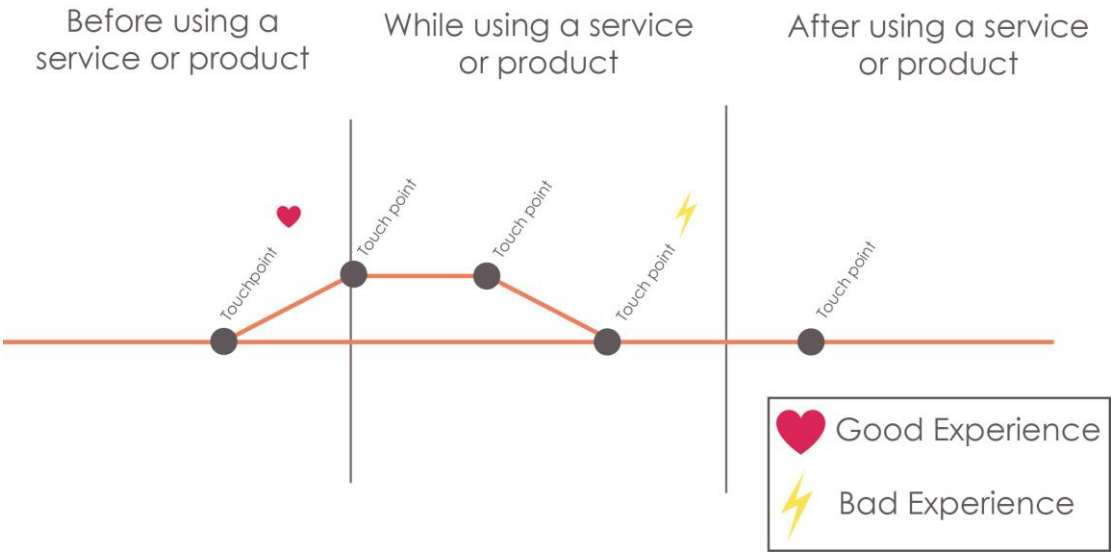


Figure 5. A template of a customer journey map.

Based on the customer journey map and insights from the user study, the market of potential users will be segmented into groups. The segmentation groups will be defined through a clustering session, see Figure 6. The segmentation will be based on variables that meaningfully distinguish between customers' needs, choices and buying habits. The customer profile within each segment will then be analysed. These are the first steps in a method used when selecting the target customer for a new product, described in Marketing of High-Technological Products and Innovations (Mohr, Sengupta, & Slater, 2005). It can however also be used to map the potential users in a market. The results of the segmentation will be visualized in a map of behaviour groups, see Figure 7. This visualization method to understand customer need is a variation to the more commonly used persona. Personas are fictional characters often developed to represent a particular user group with shared interests (Stickdorn, Schneider, & co-authors, 2011). However, the drawback of using personas is that the user focus often lays on gender, age and interest rather than need and behaviour. For the development of Ergo in the master thesis project, user need and behaviour, unrelated to age and gender, is more relevant which is why a map of behaviour groups is chosen as a method to understand and describe the potential users.

Based on the findings from the entire study, a list of problems areas with Ergo will be made. All insights and problems will be segmented and clustered to thoroughly understand them, see Figure 6. This type of clustering is done after each iteration in Figure 4.

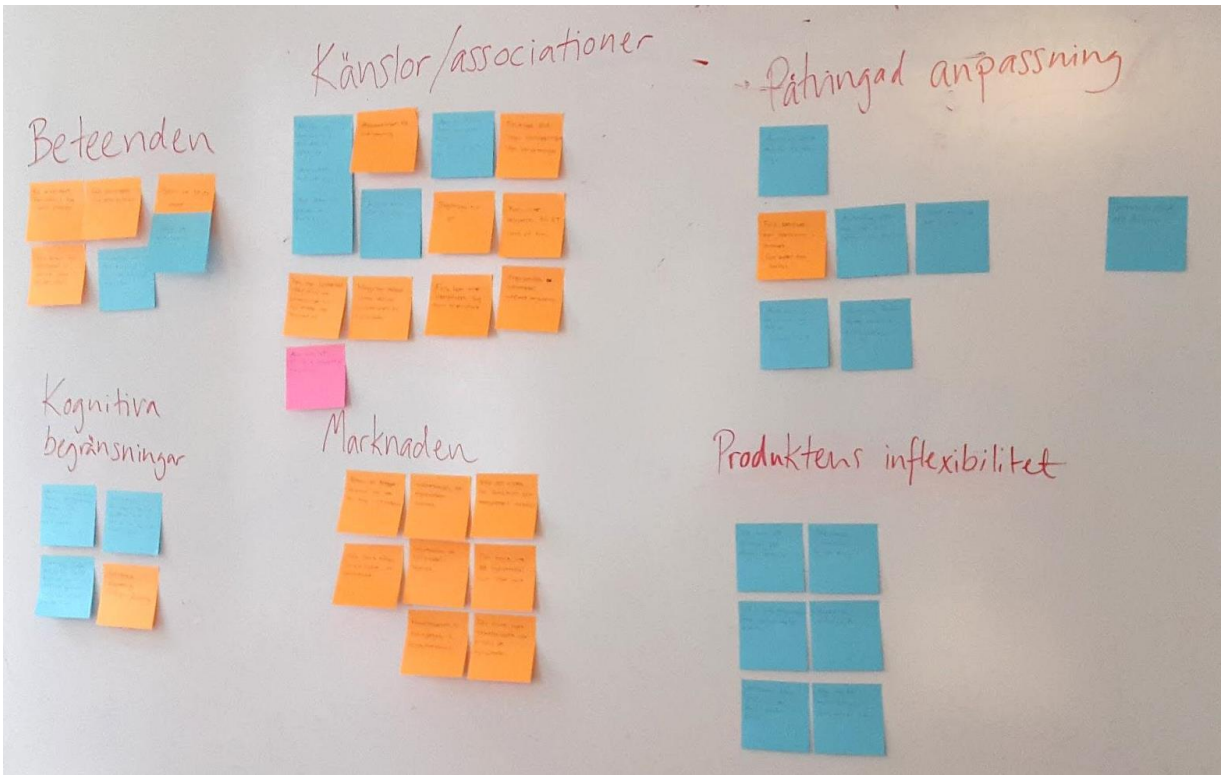


Figure 6. Clustering of user insights and problems with Ergo.

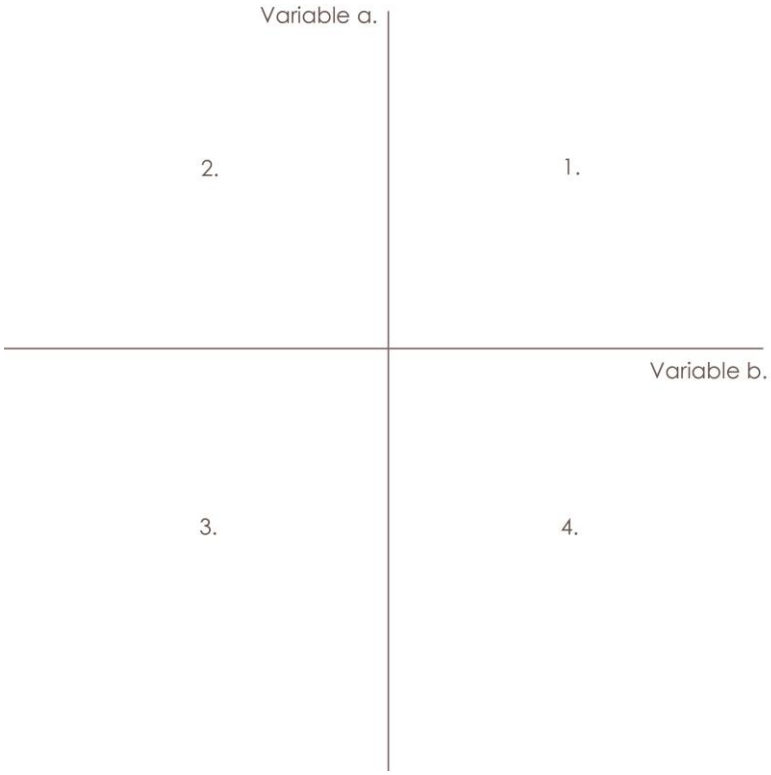


Figure 7. A template of a behaviour group map.

The problems areas that are found will be assessed in order to choose one to work further on. Furthermore, a specification of requirements will also be compiled based on all findings from every step in the research. These requirements will act as a guide when solving one of the problem areas with Ergo.

2.6 Product development

Ergo will be developed using the findings from the research as the foundation and guide. When the problem areas with Ergo are defined, brainstorming will be performed in order to define what actions are needed to properly solve them. The problem areas will be assessed so that one can be chosen to work further with. The evaluation will be based on importance for Ergo to function as a product, the interest of Tobii and the feasibility towards the master thesis guidelines. When this decision has been made, another brainstorming will follow. This brainstorming will involve the generation of specific solutions for the chosen problem area, keeping the specification of requirements in mind.

A mood board will also be made based on the findings from the user study. The mood board will be a guide to what the design of Ergo should convey so that it will appeal to the user.

Visualisation of the final concept as well as digital prototypes will be made. The purpose of doing this is to obtain feedback of the concepts in order to have a user centred development. The prototype will be tested and sketches will be shown to beta program participants to get their opinion. The concept will then be developed with their feedback in mind. The final design will be visualized using graphic design and rendered CAD-models.

Finally, the product will be evaluated with several methods. The evaluation will be based on the guidelines that were concluded from the research, methods from the theoretical framework in chapter 4, and feedback from beta test participants.

2.7 Research quality

This section contains an analysis of the master thesis based on research quality criteria. It discusses validity, reliability and generalizability of the findings as well as criteria of open system of thought and research ethics.

Open system of thought

The first criterion of good research quality proposed by Phillips and Pugh is having an open system of thought (Andersson, 2012). This project has no hidden agendas in politics, management, religion or marketing. The purpose of the project has not been related to any kind of direct profit for the test participants, which minimizes the bias. This also applies for the authors and cooperative company. In that sense, the project has been implemented with an open system of thought.

Critical reflection of research approach

The second criterion of good research by Phillips and Pugh (Andersson, 2012) is that the researcher examines data critically in order to obtain systematic, reliable and valid data. According to Bryman and Bell, reliability is connected with the consistency of the tool for measuring, while validity is concerned with the accuracy and truthfulness of findings (Bryman & Bell, 2007).

The primary tool of collecting data is contextual interviews, which is a qualitative information retrieval method. The motive behind doing a qualitative study rather than a quantitative is that the data of interest for the research cannot easily be measured. The study aims to understand the user in terms of associations, expectations, perceptions and experiences, which of none can easily be measured or quantified. A qualitative study is hence chosen in order to provide as valid and relevant results as possible. The data can hence be argued to be reliable as the primary data-retrieving tool has been consistent. The tool itself however, has drawbacks of research quality as the researchers' perceptions can interfere with the results. This has however been taken into consideration as every observation is made by two researchers and is discussed afterwards to ensure that both observations conform.

The validity of the research is also affected by the delimitations described in section 1.4. The number of test participants and the diversity of them are factors that affect the validity in the results. The number of people participating in the investigation was limited due to the time frame and limited number of beta products. A qualitative research is normally more time consuming than a quantitative one. The participants did however provide information in which obvious behaviour patterns and similarities could be found. Conclusively, the number of participants was sufficient enough to provide valid data. An increased number of test participants would however improve the validity. To further ensure the validity of the user study findings, some inappropriate survey responses were excluded from the analysis.

The fact that beta test participants made an active choice of taking part in the investigation, might also have affected the validity of the results. They had to take their own initiative to participate, which might indicate that they have some interest in the technology or product, affecting their overall experience. It can therefore be argued that people reluctant to the technology or product have been excluded from the research. However, this validity issue has been considered by involving other people, besides the beta users, in the study. These people have shown varying interests in Ergo, where some have been largely reluctant towards the product. In this sense, the study results can still be argued to be valid.

The research cannot be considered a fair test as it had more than one varying variable, as different test participants tried different versions of the product software. A fair test occurs when only one factor changes, while all others are kept the same (Olofsson, U. 2014). This can have affected the results making them less valid. This issue was however taken into consideration by the researchers when performing the tests so that the differences in the software versions would be of less interest and focus would lay on the general functions of the product.

Generalizability

Valid generalizations make it possible to apply knowledge in a wide variety of appropriate situations, which is the third and last criterion of good research according to Phillips and Pugh (Andersson, 2012). The main outcome of the master thesis is primarily applicable for the product Ergo developed by Tobii Dynavox. The findings can however be used in the development of other commercial products utilizing eye tracking technology in order for them to have a more user-friendly approach. Furthermore, the research can be valuable in the development of other technological innovations unfamiliar to the commercial market. In that sense, the findings and results are argued to be generalizable.

Ethical considerations

The results of this research are publicly accessible, thus available for everyone. Sensitive and private information about the test participants have therefore not been published. Other scientific misconduct such as fraud and plagiarism has been taken in consideration when compiling the master thesis report in order to have a high ethical standard. Furthermore, the references and theoretical framework used are public resources and are hence available for everyone. The master thesis has also been opposed upon by unbiased sources prior to publication. In that sense, the report is argued to have a scientific ethical standard.

3 Introduction to Eye Tracking

This chapter introduces a study of the technology in focus in the master thesis; eye tracking. It also presents the product called Ergo, which is the eye tracking product studied in the project.

3.1 Introduction to eye tracking

This study aims to investigate what technology is utilized in Ergo and what benefits and limitations it has. This information is important to consider when developing Ergo.

Benefits of eye tracking

A device that is equipped with an eye tracker has the ability to know where the user is looking. This makes it possible for humans to interact with computers using their eyes. This also makes it possible for the computer to register many things about the user that has not been understood before. It can track what information the person has seen or what it pays attention to. It also possesses the ability to indicate a person's presence, focus, drowsiness, consciousness and other mental states. The technology is used in many ways in different fields to serve different purposes. For example, it is used in market research to gain deep insights about customer behaviour. It is also used to design user interfaces, in computer games for instance. Furthermore, eye tracking is used together with computers as a new way of interaction. The technology is prominent for the gaming industry as well as in the transportation industry, and is adopted into various technical devices (Tobii AB, 2015).

There are three primary benefits of eye tracking, where the first is to understand human behaviour. The eye tracking technology has the ability to observe a person's fixations, saccades, pupil dilation and blinks. Saccades are rapid eye movements used in repositioning the centre of the eye to new locations in the visual environment (Duchowski, 2007). Fixations are eye movements that stabilize the eye over a stationary object of interest (Duchowski, 2007). By observing these eye movements, the eye tracker can obtain insights of user behaviour and from this, driving factors behind behaviour and actions can be derived and concluded. The second benefit of eye tracking is the enabling of hands-free interaction with computers. This facilitates interaction with computers when people are, for different reasons, unable to use their hands. The third primary benefit of eye tracking is the ability to create new user experiences and humanized interfaces. This is done by combining it with other input modalities, such as voice and touchpad commands. Interfaces like these creates new user experiences and innovative interfaces that are more intuitive, natural and engaging (Tobii AB, 2015).

How eye tracking works

The most common way of tracking the eyes is through optical technology. The optical eye trackers can either be remote or head-mounted. There are some differences in their systems, but the general technology is the same. Optical eye trackers contain two common components; a light source and an optical sensor. The light source is usually infrared and directed toward the eye. The optical sensor tracks the reflection as well as visible features in the eye, such as the pupil. (Eyetracking Inc, 2011) The light source is commonly a set of projectors or illuminators, and the optical sensor is one or a set of cameras. Furthermore, algorithms and mathematical calculations

for image processing is also needed for an eye tracker to function (Tobii AB, 2015). The data from the light reflection is used to extrapolate the eye rotation and gaze direction. This data is compiled into a file that is compatible with an eye tracking analysis software (Eyetracking Inc, 2011). Figure 8 illustrates a remote eye tracker and the basic principles of optical eye tracking.

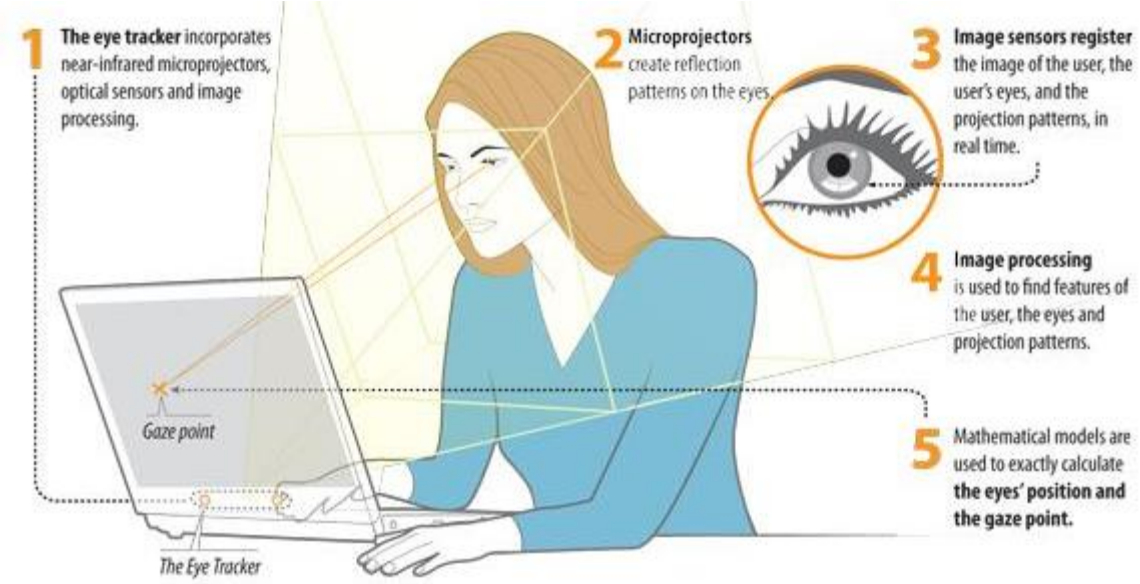


Figure 8. The basic principles of optical eye tracking.

3.2 Product description of Ergo

Ergo is under development, and will continuously be changed and improved by Tobii as the master thesis project proceeds. This section presents the version of Ergo that is used for all tests in the research.

Ergo comes in a package with several components, all presented in Figure 9. The package content is also listed and described in Table 1. The package has two layers where components 1-3 are in the first layer, while components 4-8 are in the second layer.

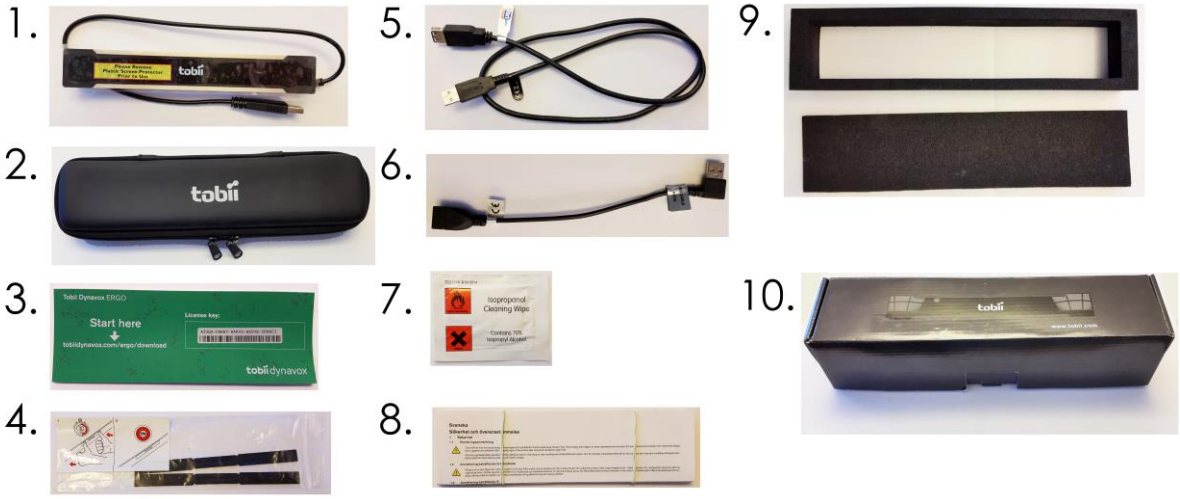


Figure 9. All components in the Ergo package.

Table 1. All components in the Ergo package.

Component in Ergo package	Description
1. Eye tracker	The eye tracker model Tobii X2-30. Comes with a plastic film covering the front surface.
2. Eye tracker case	The eye tracker is placed in its case when the package is open.
3. Green note	Provides a link to a website where the software is downloaded and pictures of mounting installation is shown. The note also provides an activation key.
4. Two mountings	Two mounting plates in a small plastic bag, also containing a short manual of safety instructions.
5. An extension USB cable	
6. Another extension USB cable	With an angled plug.
7. One cleansing wipe	Used to clean the surface where the mounting is attached.
8. Technical and safety manual	Held together with two rubber bands.
9. Foam parts	Two foam parts that divides the box in two layers.
10. Card board box	The package.

Hardware description

The eye tracker used in the beta tests in the master thesis project is a Tobii X2-30 eye tracker. It is a remote eye tracker using two sources of near-infrared light to track the eyes of the user. The eye tracker is places at the lower part of the screen. The technology behind it is previously described in section 3.1. Its technical specifications are shown in Table 2, and are further described in Appendix E.

Table 2. General technical specifications of Tobii X2-30, the eye tracker used in the beta tests.

Technical specification	Description
Dimensions	Length: 184X28x23 mm
Weight	200 g
Compatibility	Windows 7, Windows 8
Connectivity	USB 2.0
Mounting and Setup	Up to 25" screen. Minimum 1,3 mm flat and vertical surface right below the bottom of the actual screen.

Remote eye trackers has a track box, which is the three dimensional space in which the eye tracker can find the eyes of the user. If the eyes are outside the box or close to its edge, the eye tracker will lose gaze data. The distance from the eye tracker *d*, see Figure 10, can be calculated with basic trigonometry. By assuming the tracked area is half a circle and that the distance, *s*, from the centre of the screen to its top corner is its radius, the distance between the eye tracker and the eyes is calculated with Equation 1. Normally, the eye tracker Tobii X2-30 can track eyes with the distance interval 45-90 cm.

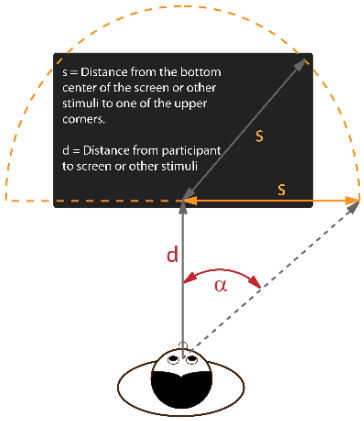


Figure 10. The distance interval of the eye tracker used in the tests.

$$d = \frac{s}{\tan \alpha} \qquad (1)$$

For best performance, the eyes should be 60-65 cm away from the eye tracker, although it can track the eyes if they are within the distance interval of the eye tracker. The distance interval is dependent on angle α in Figure 11. For optimal eye tracking, the angle α should not exceed 36° when the user is 65 cm away from the eye tracker. Conclusively this means that the eye tracker

can track a 25" monitor when the user is sitting 65 cm away from the screen, and allows for head movement 50 x 36 cm (Width x Height).

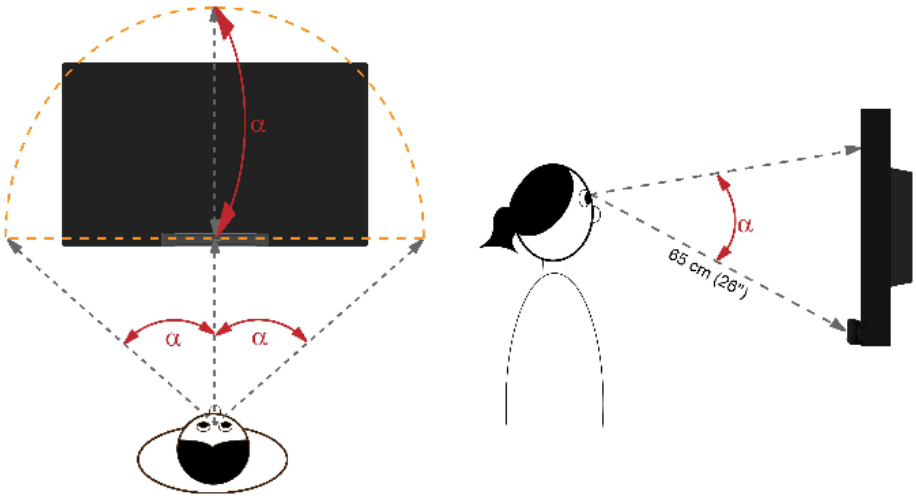


Figure 11. The distance interval of the eye tracker used in the tests.

Tobii X2-30 is insensitive to darkness and can track the users' eyes in dark environments. However, bright light environments and reflections are decreasing its performance as it is sensitive to such lighting conditions. The eye tracker has the ability to track the eyes of a user using glasses or contact lenses. It also has the ability to track one eye exclusively if the user has strabismus, squinting eyes.

Ergo comes with a thin metallic mounting that is permanently glued on the frame below the computer screen, on monitor or laptop. The mounting in the master thesis project is glued with a less permanent glue using a double coated adhesive tape. The eye tracker is attached to it by magnets and is put in the correct position with geometric lockings. The angle between the eye tracker and the computer screen is constant so the software can incorporate the angle between the imaginary surface of the screen and the surface of the eye tracker. The mounting must be placed with precision in the centre below the screen, as the eye tracker will perform less accurately with a badly mounted eye tracker.

The Tobii X2-30 is used in all the beta tests of Ergo, but will not be the eye tracker of the final product. This eye tracker is called Tobii EyeX and has close to the same compatibility and requirements on mounting and setup. It does however require USB 3.0 connectivity, uses three sources of near-infrared light, and has a wider and more slim design, as shown in Figure 12. The two eye trackers use the same technology and functions in the same way, but Tobii X2-30 is simpler and therefore chosen by Tobii to be part of the beta tests.

Figure 12. Left: Tobii X2-30, the eye tracker used in the beta tests. Right: Tobii EyeX, the eye tracker of the final product.

Software description

Ergo contains software that is communicating with the eye tracker to allow navigation of the computer. The software mainly constitutes of two programs, EyeX Interaction and Ergo. Both programs have desktop icons and need to be run in order for Ergo to function. EyeX Interaction allows communication with the hardware and user interaction, and Ergo allows additional interactions and features, listed and briefly described in Table 3. All user actions are performed by a combination of eye movement and physically pressing a keyboard button, where the eyes control the placement of the cursor.

Table 3. The features and functions of Ergo

Functions	Details
Right click	Allows the user to right click with their eyes.
Left click	Allows the user to left click with their eyes.
Double click	Allows the user to double click with their eyes.
Scroll	Allows the user to scroll with their eyes.
Drag and drop	Can be used to move items, highlight areas and adjust the size of open windows.
Mouse teleport	The cursor teleports to where the user is looking.
Features	
App switch	A quick way of switching between running programs and applications.
Shortcuts	A feature for the user to reach the programs and actions they frequently use.
Insights	A feature where the user can find data about their ergonomic behaviour.

When installing the software, the user has to interact with EyeX Interaction to calibrate the eye tracker and to set up a personal profile, Figure 13. This program can also be reached from the settings page in Ergo, as it is a partly hidden program. Ergo also includes a short tutorial of the interaction methods, that automatically starts after installation. Other interaction methods and features are not introduced to the user. The main page of Ergo is shown in Figure 14, where the settings can be reached. The feature called Insights, Figure 15, can also be reached from the main page.

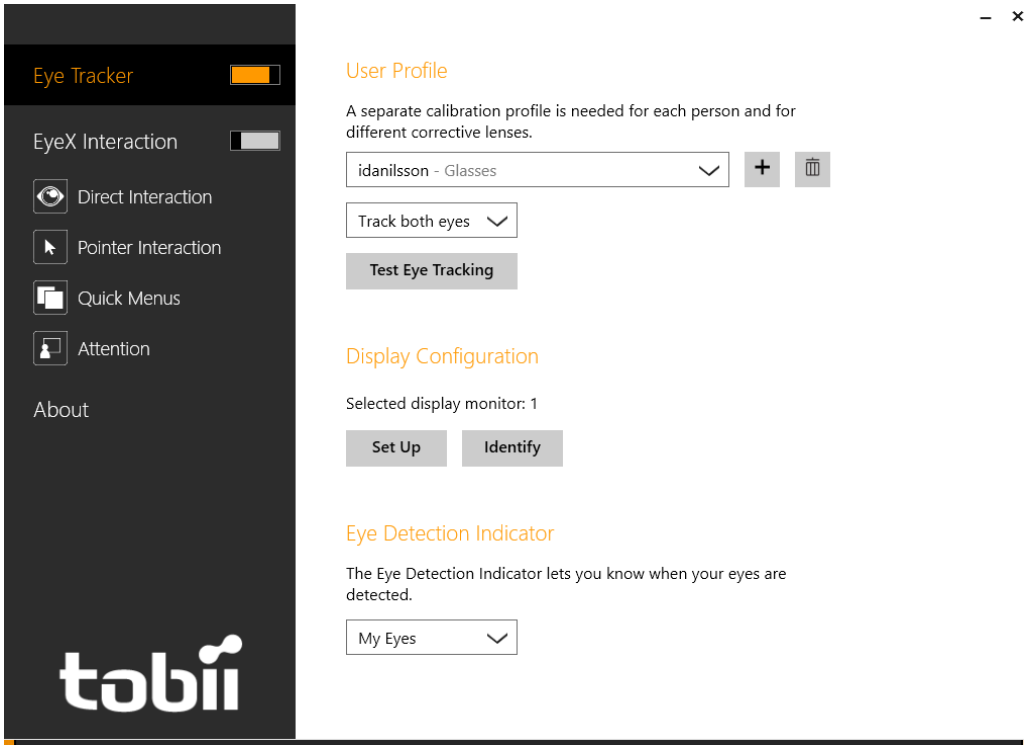


Figure 13. The main page of EyeX Interaction.

Figure 14. The main page of Ergo.

Figure 15. A visualization of the feature called Insights.

The software previously described is under development and will continuously change and be improved by Tobii as the master thesis proceeds. The main features and interaction actions will however remain the same.

4 Theoretical Framework

This chapter presents the literature that has been used to guide the study and development in the master thesis. To establish the context in which this project is implemented and to further gain understanding of it, a literature study of physical ergonomics, cognitive ergonomics, human-computer interaction and the market of technological innovation was conducted.

4.1 Physical ergonomics

This study aims to find general information and guidelines to follow when developing ergonomic aids. This information is important to have in mind when developing Ergo.

In the industrialized part of the world, physical pain is common at workplaces where the main tool is computers. In Sweden, 3,5-9 per cent of office workers and secretaries suffer from pain caused by work in front of a screen (Arbetsmiljöverket, 2014). About 4-7 per cent of office workers and secretaries claim to feel pain in their neck or the back of their neck, 6-10 per cent feel pain in their shoulders or arms, 2-3 per cent feel pain in hand, wrist or finger and 4-6 per cent feel pain in their back (Arbetsmiljöverket, 2014). A person who has recently started to feel discomfort is often unjustifiably optimistic about the situation (Bohgard (red), 2011). Other attitudes such as being too young to need help or considering pain a part of the job, may lead to no actions being taken to prevent and relieve pain among the employees. Women are being over-represented in the injury statistics, probably because of their tendency to do more monotone work, despite having the same title as men (Bohgard (red), 2011)..

The goal should be a job that does not cause physical strain, offers variation, physical mobility, room for recovery, freedom of action to some extent and capacity building (Bohgard (red), 2011). But, without introduction of more flexible strains during work and spare time, it is unlikely that repetitive strain disorders will be overcome (Bohgard (red), 2011).

Repetitive strain injury

The main factors associated with musculoskeletal conditions at work are force, posture, repetition, duration and stress (Bridger, 2008). These disorders affect the locomotion organs and are called RSI (repetitive strain injury), WRMD (work related musculoskeletal disorders) or CTD (cumulative trauma disorders). They have arisen in the industrialized parts of the world as a result of monotone and repetitive work, which are often caused by higher degree of specialisation (Bohgard (red), 2011).

Human muscle has excellent endurance up to 15 per cent of the maximum muscle strength (Bridger, 2008), but even low loads, at a level of two to five per cent of the maximum muscle strength, have been recorded to cause objectively verifiable disorders (Bohgard (red), 2011). The pain caused by the low intensive monotone loads that dominates many occupations is often ambiguous and is developed over a long time. This may lead to difficulties in attributing what type of strain is causing the problem (Bohgard (red), 2011).

Strains can be either global or local, where global strains affect large parts of the body's musculature and local strains affect only a delimited part. Local strains usually causes injuries in their own impact area, such as tennis elbow or mouse arm (Bohgard (red), 2011). In local muscle fatigue, lactic acid is piled up in a specific muscle group, often caused by choked circulation because of static contraction (Bohgard (red), 2011). The result is not acute symptoms, but there is a risk for development of a long lasting injury. In many occupations, these kind of long lasting static contractions are common, typically when handwriting, typing or other repetitive movements occur (Bridger, 2008).

Ergonomic issues in computer work

RSIs caused by continuous computer work often occurs in the trapezius muscle, that stabilises the shoulder blades, as there is a strain in the muscle at all times when the arms do not get support. Other body parts that are often affected by computer work are the neck, shoulders, arms, wrists and hands. The only factors for which there are firm evidence for causing neck pain are a sedentary posture and twisting and bending of the trunk (Bridger, 2008). Carpal tunnel syndrome, when the tendons and nerves running to the hand is being put under higher pressure than normal, is also reported for computer work (Bridger, 2008). Injuries caused outside of work, such as tennis elbow, can be worsened during computer work.

In everyday life, people rarely adopt static posture for any length of time and periods of movement are vital to activate the venous pump that assist the return of the blood from the lower limbs (Bridger, 2008). When sedentary, most people cannot sit erect in a 90° posture for long periods and they will soon adopt a slumped posture. When the job itself is physically constrained, which it usually is at offices, it requires maximum flexibility to be built into the workspace to compensate (Bridger, 2008). This could be in terms of adjustable furniture.

Managing RSI

Of particular interest in ergonomic workspace design is the reduction of postural stress in the shoulders, elbows and wrists as the control of finger movements depends on many small muscles which can easily become fatigued during prolonged work (Bridger, 2008). Important to take into consideration with RSIs are, besides posture, working techniques, work rate, satisfaction with the work, muscle strength, body measures, visual ergonomics, age and gender. Managing upper body RSI involves work design, education, training and job design.

Pain in the arm, hand and shoulder can be caused by using a conventional mouse (Bohgard (red), 2011) whereas conventional keyboards causes ulnar deviation and fatigue. However, using a mouse is a much more static and non-neutral strain situation for the hand and arm compared to using a keyboard, and gives rise to injuries that are usually referred to as mouse arm (Bohgard (red), 2011) (Bridger, 2008). The conventional mouse is far from having an optimum ergonomic design, but introducing better alternatives, such as the mousetrapper, is hard as the conventional one had a rapid impact (Bohgard (red), 2011) when it was released to the market. The same goes for the conventional QWERTY-keyboard. Dominant designs will be further discussed in section 4.3.

4.2 Cognitive ergonomics and human-computer interaction

The aim of this study is to find guidelines and suggestions of how to design for good human-computer interaction, so this can be applied in the development of Ergo.

Cognitive psychology can be described as the study of thinking, both intentional and emotional (Allwood & Jensen (red), 2012). Two of the main modern approaches to understand human cognition are *situated* and *distributed* cognition (Allwood & Jensen (red), 2012). They emerged during the 1980s when a group of scientists questioned the traditional approach, where human cognition is compared to computing. They argued that it is the interaction between an agent and their surrounding that is of interest rather than the agent's mental processes (Allwood & Jensen (red), 2012). Situated cognition describes the human cognition as always tied to a certain place, culture and time. In other words, cognition is dependent on a context and could never be described as an entity of its own. Similarly, distributed cognition describes cognitive processes as systems of people, tools and the surrounding environment. Knowledge of these two theories are used today when designing modern IT-products (Allwood & Jensen (red), 2012) in order to understand the user and in which context the products will be used. This area is called human computer interaction (HCI), and deals with developing IT-products to make them useable, which includes being purposive, effective, safe, learnable and giving the user a positive experience (Allwood & Jensen (red), 2012). Similarly, the design approach human centred design (HCD) focuses on human needs, capabilities and behaviour first and then design to accommodate those (Norman, 2013). Good design starts with an understanding of psychology and technology.

Learning how to use a new device

Learning can be defined as experiences or situations leaving a somewhat permanent trace in an individual, which at a later point will enhance the possibility for a certain reaction (Allwood & Jensen (red), 2012). The transfer, when what was learnt is applied in a new situation, can be either hard (remote transfer) or easy (close transfer) depending on how much time has passed between the two occasions, how much the new situation differs from the first one, what objects are involved and which feeling that dominates (Allwood & Jensen (red), 2012). Learning can be either active or passive, where the first can be in form of trial and error or insights and the latter in form of habit forming or conditioning (Bolstad, 1998). For active learning, trial and error is often used when learning a new skill and it is performed repeatedly until it can be done quite automatically and insights is about understanding a phenomena or a context, either suddenly or gradually. As for passive learning, habit forming is when a behaviour is repeated until it becomes part of a person and conditioning is learning that a certain action has a certain effect, like the prominent example with Pavlov's dogs.

When people have learnt how to use a product or system, they tend to get upset by change (Norman, 2013). Being introduced to a new product or system causes a violation to their conventions (a kind of cultural constraint). Conventions provide guidance in new situations and when they need to be altered, the merits of a new system or device is irrelevant as the change itself is upsetting. Because of this, consistency in design is virtuous, lessons learned in one system should be transferred into a new one. Incorporating old, familiar ideas into new technologies even though they no longer play a functional role (called skeuomorphic) help people reduce or overcoming their fear of the new.

How to design for good interaction

When interacting with a device, people construct a mental model by interpreting its perceived structure in order to try to understand how it works and should be used. Donald Norman calls this a conceptual model (Norman, 2013), and argues that it does not necessarily need to correspond correctly with how the device actually work in reality, as long as it helps the user to operate the device properly.

Norman argues further that the two most important characteristics of good design are discoverability and understanding. Users need to know what actions are possible in the current state of the device, where and how to perform them and how the product is intended to be used. With simple devices, these needs have to be fulfilled with the design of the product, but if the device is complex, people tend to accept that they require aid in form of manuals or personal instruction (Norman, 2013). Norman has summarized these needs that results with discoverability and understanding into six fundamental principles of interaction:

1. *Feedback*: There should be a full and continuous information about the results of actions and the current state of the device. After an action has been executed, it should be possible to determine the new state.
2. *Conceptual model*: The design should project all the information needed to create a good conceptual model of the system, a mental model of how the system works, leading to understanding and a feeling of control.
3. *Affordances*: The possible interactions between people and products should be able to accommodate the desired actions.
4. *Signifiers*: Effective use of signifiers ensures discoverability and that the feedback is well communicated and intelligible.
5. *Mappings*: The relationship between controls and their actions follows the principles of good mapping, enhanced as much as possible through spatial layout and temporal contiguity.
6. *Constraints*: Providing physical, logical, semantic and cultural constraints guides actions and eases interpretation.

When trying to determine how to solve a problem, like how to operate a new device, several cognitive processes are activated: memory processes, decision processes and different estimation processes (Allwood & Jensen (red), 2012). This causes a need for a combination of knowledge: knowledge in the world, such as perceived affordances and signifiers, the mapping and the physical constraints of what can be done, and knowledge in the head, such as conceptual models, cultural, semantic and logical constraints and analogies between the current situation and previous experiences with other situations (Norman, 2013). Knowledge in the world gives the user clues on what to do, whereas knowledge in the head provides solutions for previous, similar problems.

4.3 The market of technological innovation

As eye tracking is a novel innovation, little research can be found of eye tracking in the ergonomic field. General theories of market strategy of innovation is therefore studied in order to understand the context of Ergo. The aim of this study is to find guidelines and suggestions of how to market and design an innovation for the potential user and if this is applicable for Ergo.

Technology innovation diffusion

Technology innovation diffusion is the spread of a technology through a population. The technology tends to diffuse through population in an s-shape pattern. Initially, the diffusion is slow because the technology in unfamiliar. An acceleration of diffusion follows as the technology becomes more known, utilized and understood. Eventually, the diffusion rate declines as the market gets saturated. The pattern is explained as a process of different categories of people adopting the technology at different times, which can be further studied in (Schilling, 2013). The most common way of categorizing adoption was proposed by sociologist Everitt M. Rogers, who originated the diffusion of innovation theory. He categorized five different groups of adoption; innovators, early adopters, early majority, late majority and laggards (Rogers, 1983). His categorization is illustrated in Figure 16. It is important to understand each of these groups as the characteristics of them make them responsive to different designs and market strategies.

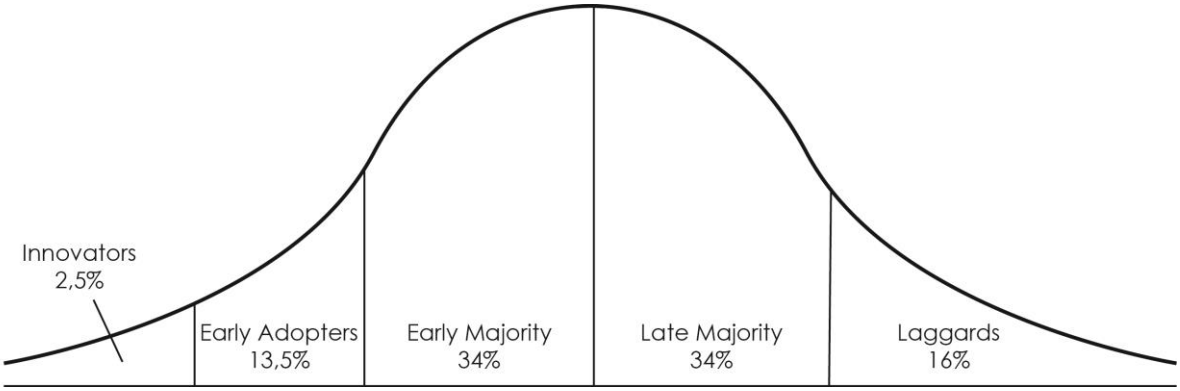


Figure 16. The innovation diffusion curve and its different categories of adoption groups.

Innovators are venturesome and very eager to try new ideas, making them the first to adopt new technologies. E.M Rogers estimates this group to be 2,5 per cent of the total market share. He further describes a typical innovator as one who desires the hazardous, the risky, the rash and the daring. They must be able to cope with technology uncertainty and setbacks when the new ideas prove unsuccessful. While innovators might not be accepted by the social system, they play an important role to innovation diffusion as they are the ones who introduce technology to the social system.

The second group to adopt an innovation is the early adopters. They are estimated to constitute 13,5 per cent of the total market share. Compared to the innovators, they constitute a more integrated and respectable part of the social system. They are localities who function as good missionaries for the new ideas. They are commonly looking for advanced technologies that offer a significant advantage or differentiation over competitors and previous solutions. They are willing to pay high prices and will accept some incompleteness in the product as they are aware of the expense and development difficulties of new high tech products. Complexity and uncertainty in the product is hence something they expect and they feel comfortable with. They are looking for products that offer a significant amount of technical content and that emphasizes the technology behind the innovation.

The third group in E.M Roger's categorization of innovation diffusion is the early majority. This group adopts a technology just before the average member of the social system and constitutes

34 per cent of market share. Before completely adopting a new idea, they commonly deliberate for some time. This deliberation differentiates them from the early adopter. They are also, in contrast to the early adopter, looking for products that communicate completeness, legitimacy, ease of use and consistency with the customer's way of life. These are hence factors in focus when designing and marketing a product for this diffusion group. Detailed technical information is of less importance.

Reaching the early majority is however not as easy as to market the product correctly. Many firms experience what is called the chasm, during the transition between selling to early adopters versus the early majority. While early adopters are enthusiastic about the technology features, the early majority may find the product too complex, expensive or uncertain. The chasm causes sales to drop because the early adopter market is saturated and the early majority market is not ready to buy. Therefore, the firm enters a period of time where they simultaneously must handle diminishing sales and increase in production capacity to prepare for the mass market launch. The difficulties of crossing the chasm can be further studied in (Moore, 2001).

The fourth group of innovation diffusion categories is the late majority. They adopt new ideas just after the average member of the social system and constitute 34 per cent of the total market share. E.M Rogers claims they approach innovations sceptically and and cautiously, and do not adopt until most of their peers have. Furthermore, almost all uncertainty about an innovation must be removed before they will adopt to the idea. Hence, they adopt products that express reliability, simplicity and cost-effectiveness. These factors are in focus when marketing and designing a product for the late majority.

The last group to adopt an innovation in the diffusion theory is the laggards. They are described as traditional by E.M Rogers and constitute 2,5 per cent of the market share. They adopt to innovation so late that the technology might already be superseded by a new generation. The innovation diffusion theory can be further studied in (Rogers, 1983) or (Schilling, 2013).

Dominant designs

If a single product or process architecture dominates a product category, usually 50 per cent or more of the market, it has a dominant design. A dominant design is a design that may not be officially enforced or acknowledged, but has become the standard of the industry. An example of a dominant design is the standard computer keyboard, which placement of keys is derived from the historical typewriter. The keys are not ideally placed and there have been other variations of key placement that encourage faster typing and more ergonomic hand posture. However, the standard keyboard has a dominant design on the market, meaning that the users have adopted that design and will likely prefer that one before others. Another reason why markets unite around one single design instead of a variety, is that many industries exhibit increasing returns to adoption. Therefore, a firm that is able to make its technology the dominant design of a market usually brings huge revenue and may dominate the product category through several product generations (Schilling, 2013).

Factors of innovation utility and components of value

When trying to reach the market with a new technology, it is important to understand its qualities of being useful. If a product lacks these qualities, it will be difficult to sell as few people invest in useless things. This type of product utility is discussed in (Kim & Renee, 2005). They argue that it is important to consider six stages of the buyer experience cycle, as well as six different utility levels, to understand an innovation's usefulness to a buyer. The six stages of buyer experience is purchase, delivery, use, supplements, maintenance and disposal. The six different utility levers are productivity, simplicity, convenience, risk, fun and image and environmental friendliness The stages and levers are commonly visualized in a utility map where each cell in the grid provides an opportunity to offer a new value to the user, see Table 4. The fundamental purpose of W.Chan Kim and R.Mauborgnes' strategy is to find product utility that offer customer value rather than battling competitors. The values can be found by looking at the entire user experience with the product and the proposed utility levers.

Table 4. A template for a utility map (Kim & Renee, 2005).

	Purchase	Delivery	Use	Supplements	Maintenance	Disposal
Productivity						
Simplicity						
Convenience						
Risk						
Fun and Image						
Environmental friendliness						

Customer value is further discussed by (Schilling, 2013). She argues that when users are comparing the value of a new technology to an existing one, they are weighing a combination of objective information, subjective information and expectations for the future. Objective information are value components like actual technological benefits or actual information on installed base. Subjective information are value components based on perception on the technological benefits or information on installed base, where the installed base is the number of users of a particular good. Expectations for the future bring anticipated value components. Schilling explains that firms can take advantage of the fact that users rely on both objective and subjective information in assessing the combined value offered by the technology. A technology with an actual small installed base, can achieve a large share if the installed base is perceived as big through heavy advertising. In addition, the users expectations of the future installed base can also be shaped through announcements of pre-orders, licensing agreements and distribution arrangements.

Being the first mover of a product

There are different types of market entrants depending in which order they enter a certain market. The entrants are divided into three categories; first movers, early followers and late entrants. The first movers are the first to sell in a new product, the early followers are early to the market but not first, and late entrants enter when or after the product penetrates the mass market (Schilling, 2013).

Being a first mover may confer the advantages of brand loyalty, technological leadership and pre-emption of limited assets such as key locations, permits, access to distribution channels and relationship with suppliers. A first mover may also earn a lasting reputation as a technology leader in that industry. Such reputation can help sustain the company's image, brand loyalty and market shares even after competitors have introduced comparable products. Hence, the first mover also has an opportunity to build brand loyalty before the entry of other competitors. The technology leader also possess the ability to shape customer expectation about the technology's architecture, features, pricing and similar characteristics. Furthermore, once the buyer have adopted a good, they often have to face costs when switching to another good. This happens especially when the product is complex, since it takes long time for the user to become familiar with its operation. This time investment becomes a switching cost that discourage the buyer from switching to a different product (Schilling, 2013).

Customer uncertainty with new technology

A first mover may face customer uncertainty about what product features users will desire and how much they are willing to pay. When a new technology is developed, people may also find it difficult to relate to it and understand the role in their lives. Hence, both developers and customers struggle with understanding the importance of various features in the product. Some promising features might turn out to be unnecessary, and features that seemed unimportant may actually be crucial. If a firm releases the product too early and the values of the technology are not clearly communicated to potential users, there is a strong possibility of receiving an unenthusiastic welcome. Unfortunately, market research prior to release may be of little help for very new technologies. These customers have little or no idea of the value the technology would bring, which makes them difficult to approach in a market research. As a consequence, first movers may find that their early product offerings must be revised as the market begins to reveal customer preferences. Another factor that affects customer uncertainty is to which degree the new technology exceeds previous solutions. When the advantages are dramatic, it will more rapidly gain customer acceptance. This will in turn lead to less ambiguous feelings towards the technology (Schilling, 2013).

Gathering information prior to market release of technologically advanced products

Since the customer uncertainty is an important factor to contemplate when developing a new high-tech product, successful firms collect useful information about the user and market to guide decisions. Even if this may be difficult as previously described, there are some prominent methods that can be used to gather this information. What methods that are chosen depend on the type of product. However, for products containing software, beta testing is a common and popular method. A beta version of a product is a pre-release that the company gives potential users to try. In the test, the customer agrees to provide feedback that the developer can use to

improve the product prior to its commercial release. Furthermore, qualitative research is a powerful tool in understanding customer motivation. The concept is based on searching for the real motivations that do not emerge from structured lists (Mohr, Sengupta, & Slater, 2005).

Factors affecting customer purchase decision

When understanding the customer's decision in purchasing a product, it is important to study buyer behaviour. The purchase process model in Figure 17, is commonly utilized when describing a basic purchase process of a high-tech product (Mohr, Sengupta, & Slater, 2005).

Figure 17. A standard purchase process model.

It is also suggested in (Moore, 2001) that firms should look at different critical issues when assessing customers motivation of buying a technologically advanced product. Primarily, factors that affect customer decision must be looked into. These factors include relative advantage, compatibility, complexibility, trialability, ability communicate product benefits and observability, which are thoroughly described in Table 5.

Table 5. Factors affecting customer purchase decisions (Mohr, Sengupta, & Slater, 2005).

Factors affecting customer purchase decisions:	Detailed information
1. Relative advantage	The benefits of adopting the new technology compared to costs
2. Compatibility	The extent to which adopting and using the innovation is based on existing ways of doing things and standard cultural norms
3. Complexibility	How difficult the product is to use
4. Trialability	The extent to which a product can be tried on a limited basis
5. Ability to communicate product benefits	The ease and clarity with which the benefits of owning and using the new product can be communicated to prospective customers
6. Observability	How observable the benefits are to the customer using the new product, and how easily other customers can observe the benefits being received by a customer who has already adopted the technology

5 Contextual Study of Ergo

The contextual study aimed to find guidelines to which the design of Ergo should follow. The findings described in this chapter comes from interviews with employees of Tobii, internet information retrieval as well as information from participants in the user study. This chapter also investigates and presents an answer to the first research question; What does the market of ergonomic aids look like?

5.1 Tobii's brand identity

Tobii AB is strategically divided into three divisions; Tobii Pro, Tobii Tech and Tobii Dynavox. Tobii Pro focuses on using eye tracking technology within research and marketing. Tobii Tech is developing products for commercial use, such as the gaming industry. Tobii Dynavox is developing products used to facilitate life and communication for disabled people. The three divisions act as separate companies with different cultures, customers and visions (Ruben, 2015). What they have in common is that they all work with eye tracking technology, but in different fields. Their visual identity and logotypes also follow the same design code, Figure 18. Since Ergo is a product by Tobii Dynavox, their specific brand identity is further investigated.

Figure 18. The logotypes of Tobii.

Tobii Dynavox have a passion for people and are dedicated to help those in need. With the technology they possess they aim to facilitate life for disabled people. The main users of their products are hence severely disabled with communication disabilities who are in need of aids to facilitate communication with their surroundings. The users of the products commonly have cerebral palsy, autism, ALS and similar disorders that limits the mobility and ability to communicate. Tobii Dynavox offer them products that provide independence and quality of life. The products are commonly subsidized and distributed by different types of health providers. Besides the passion for helping people, the culture of Tobii Dynavox has partly derived from Tobii as a high technological start-up company. The combination of their competence and interest in technology with their devotion of helping disabled people is what signifies their culture (Ruben, 2015).

The focus when designing Tobii Dynavox products is user friendliness. As their users have varying special needs and varying mental and physical handicaps, their products speak different design languages, see Figure 19. They combine their hardware with different software to adjust the product for the user need (Wikström, 2015). Because the users are so different from one another, there is no obvious design language for all Tobii Dynavox products. However, the

hardware design of current Tobii Dynavox products is moving away from expressing handicap, due to user need and request. It is understood that people with communication disabilities also want attractive products without the handicap-product impression.

Figure 19. Products of Tobii Dynavox.

Since Ergo aims for users with no severe medical complication or mental disorders, it cannot be designed in the same way as other Tobii Dynavox products. Even if other products try to move away from giving a handicap-product impression, the interaction is still designed for handicapped people. However, the design of Ergo should still follow the most important focus of Tobii Dynavox design; user friendliness. It should also be marketed as an aid and a tool to facilitate life, just like the other products. In this way, it will express Tobii Dynavox and it will be recognized with the brand. Ergo should carry the logo of Tobii Dynavox, to imply that it is a product that helps people. If it exclusively carries the Tobii logo, there is a risk that it will be associated with research, gaming or other fields that Tobii is involved in.

5.2 Study of the ergonomic aid market

This report section describes Ergo's main competitors and the general ergonomic aid market.

Competitors

Even if Ergo is the first ergonomic aid utilizing eye tracking technology, there is still competition on the market. There are many established and common products that ease ergonomic pain and discomfort in computer work. There is a great variety of products designed to relieve pain in different body parts. A back support for example is very common for people experiencing discomfort in the lower back region. An ergonomic chair or foot rests are also common products that encourage a good posture and continuous physical movement. Furthermore, height adjustable tables are popular products that prevents ergonomic pain as it encourages the user to stand up and vary their position. There are also smaller products that prevent and relieves strain

in upper back, neck, shoulders, arms and wrists. These include different types of forearm supports, wrist supports, ergonomic designed keypads and mouses. Every product comes in many versions, designs and prices and are suitable for people with different needs.

Considering the large amount of ergonomic aids on the market, there are only a few that are competitors to Ergo. These aids are products that relieve the same kind of pain as Ergo does. Ergo enables the user to navigate the computer using eye movement instead of hand movement. This means that Ergo relieves pain that is related to any activity performed by the hands, wrists or arms. The aids that aim to ease this type of pain are presented in Figure 20. The six different aids are the mousetrapper, rollermouse, ergonomic mouse, ergonomic keyboard, forearm support and wrist support. Each of these come in a great variety of forms and designs and the ones presented in the figure are examples to visualize the general architecture.

Figure 20 further shows the common visual expression of many ergonomic aids. They commonly have organic shapes with few sharp edges. They are also commonly black and neutral in the colouring in order to blend in well in office environments. Many ergonomic aids follow these design characteristics, but there are also exceptions.

Figure 20. The competitors of Ergo; Mouse trapper, Roller mouse, Ergonomic mouse, Ergonomic keyboard, Forearm support and Wrist support.

The mouse trapper and the roller mouse are aids that relieve pain related to the usage of a standard computer mouse. Both encourage the user to keep the hands and arms in front of and closer to their body to prevent static strain in the arm. These two aids help people as they enable the user to navigate the computer from a more ergonomic posture. The only difference between them is that the cursor is controlled by a cylinder using the roller mouse, and a square mat using the mouse trapper. The biggest disadvantage of using any of these aids is that the cylinder and the mat have physical geometrical limits. This means that the user will not be able to move the cursor

freely when it has reached it physical geometrical limit. Furthermore, both aids are space ineffective and require a significant amount of space in front of the ordinary keyboard. Due to the long learning time, difficulty of breaking old habits and switching costs; these two aids are rarely used as preventative tools for RSI.

The Ergonomic mouse and Ergonomic keyboard are only architectural variations of the ordinary mouse and keyboard. They are designed to follow the natural anatomy of the human hand, where conventional keyboards cause ulnar deviation and fatigue. When using an ordinary mouse or keyboard, they are forced into an unnatural position causing strain in the muscles, as described in section 4.1. The ergonomic mouse and keyboard allows the user to have a relaxed and natural hand position preventing and relieving RSI.

Besides the previously described ergonomic aids, different types of physical supports are also common ergonomic aids. The forearm support is an effective aid for back, neck and shoulder pain. It is therefore an effective pain preventive and relieving aid and does not prohibit work effectiveness. Furthermore, smaller supports like the wrist support are used when a body part needs relief and support to keep to its anatomically neutral position. The supports are however commonly big and space inefficient.

All of the six previously described ergonomic aids are competitors of Ergo as they aim to relieve pain from the same body area. However, only three of them are aids that actually navigate the computer and the cursor. These three are the mouse trapper, roller mouse and the ergonomic mouse and are presented on the left side in Figure 20. Only these are the true competition for Ergo as they share the same fundamental function; navigating the computer by controlling the cursor. Learning a new way to control the computer takes time and can be frustrating, as described in section 4.2. Hence, if a user do not experience pain explicitly from navigating the cursor, there is little chance they would choose a new way of doing it. This is simply because it is easier to relieve pain with a physical support, than adopting a new way of controlling the computer.

Ergo's competitive advantages are that it has no geometrical limit like the rollermouse and the mouse trapper, and that the user needs less physical motion to control the cursor and navigate the computer. Furthermore, since Ergo is a combination of hardware and software, it possess abilities that its physical competitors lack. It has the ability to monitor, log and store data of the users ergonomic behaviour. It also has the ability to have cues and reminders to encourage ergonomic behaviour. These abilities make Ergo stand out as an ergonomic aid on the market, but whether this is wanted or needed by the user is further discussed in chapter 6.

5.3 Obtaining Ergo and other ergonomic aids

The theory of marketing a technological innovation proposes a basic model for user behaviour when purchasing a product, section 4.3. The user identifies their problem, search for information, evaluate alternatives and then makes a purchase decision. However, the results from the interviews and survey investigating the customer journey with ergonomic problems indicate that there is no standard way of obtaining an ergonomic aid, as further described in section 6.1. The theoretical way of looking for a product to purchase is hence not always the way people with RSI

obtain ergonomic aids. For the market this means that there is no standard way of selling and marketing an ergonomic aid either, since the customer does not turn to a specific source when searching for one. However, from the survey results it is also understood that most ergonomic aids are financed by the employer, no matter how it is obtained.

The different stakeholders of Ergo are presented in Figure 21 (Broman, 2015). It is important to understand each lead of the stakeholder map when designing a product to know who the product should be designed for. Ergo is developed by Tobii Dynavox, but will be distributed by resellers. The reseller will in turn sell it to companies whose employees are in need of an ergonomic aid. Each lead has different demands on Ergo, and they all need to be met in order to have a complete market chain.

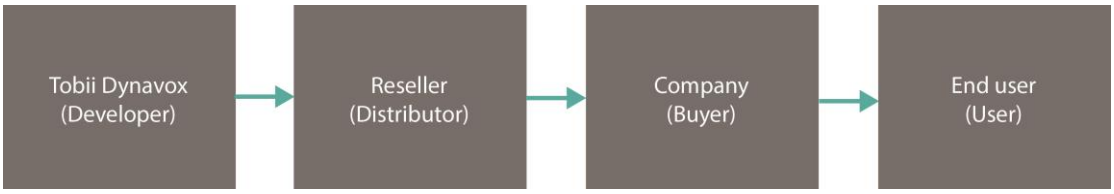


Figure 21. Stakeholder map of Ergo

Since Tobii Dynavox is the developer of Ergo they require that it represents their brand identity and brings revenue. The resellers are looking for products that solve their customers' problems and expresses uniqueness, quality and innovation. Other qualities they are looking for is an attractive and discreet design to fit in with other products in their collections, (Eriksson, 2015). Companies, that are the actual buyer of Ergo, require a product that facilitates work for their employees and represents professionalism. For large companies it is common to cooperate with resellers that distribute ergonomic aids. Resellers like these commonly visit the companies regularly, sometimes together with ergonomic specialists, to support and guide people in their choice of ergonomic aid.

The companies will cover the financial costs of obtaining Ergo, and are hence in need of a reasonable price. Comparing with standard computer products, ergonomic aids are quite expensive, see Table 6. As Ergo is not yet established on the market and contains much more advanced technology than its competitors, its price is higher. However, many companies see ergonomic aids as investments as they encourage a healthier work environment and provide healthier employees. The mouse trapper and the roller mouse costing around SEK3000 are standard aids at companies, and are commonly offered as first choice. Therefore, Ergo is aimed for users who can obtain it through their companies since it might be too expensive to buy privately. Companies are primarily looking for a product to help their employees, however it still needs to express professionalism to fit in a work environment.

Table 6. Market price of ergonomic aids. Prices retrieved May 18, 2015.

Ergonomic Aid	Market Price [SEK]
Mouse trapper	2500-3000
Roller mouse	2500-3000
Ergonomic Mouse	800-1200
Ergonomic Keyboard	600-1000
Forearm support	800-1200
Wrist support	100-300
Ergo	~5000

Conclusively, the resellers' and companies' opinion about Ergo's overall design matter as they distribute and buy the product. The most important factors for them are however that it solves the employees problems while expressing professionalism, uniqueness, innovation and has a discrete design. The user' opinion and requirements are described in chapter 6.

5.4 Defining the market of Ergo

Tobii Dynavox has chosen to develop Ergo as a side project to investigate the potential in a new market. It is currently developed to investigate if the commercial market is ready for this type of high technological product. Eye tracking is currently adapted into the commercial market where the users are gamers or have a great interest in technology. Ergo is on the contrary investigating a broader commercial market where users of eye tracking can be anyone, regardless technological interest. The strategic vision of Ergo is to prepare both the market and Tobii for a potential future where eye tracking is widely used and integrated in all kinds of electrical devices (Ruben, 2015).

To understand the potential market of Ergo, it is essential to look at the current users of eye tracking that have adopted eye tracking in their daily activities. There are two main user groups; commercial and disability. The customers in the commercial segment are early adopters of the technology as they show a great interest in technology and find it easy to adopt eye tracking. The other big user group of eye tracking are severely disabled people with communication limitations. The products for this user group are developed by the division Tobii Dynavox. This group of customers is small, yet the one most profitable for Tobii. The two user groups are presented in each end of the graph in Figure 22. Between these two groups are customers who are currently not reached by any product by Tobii. This is the market that Tobii wish to reach with Ergo (Henderek, 2015).

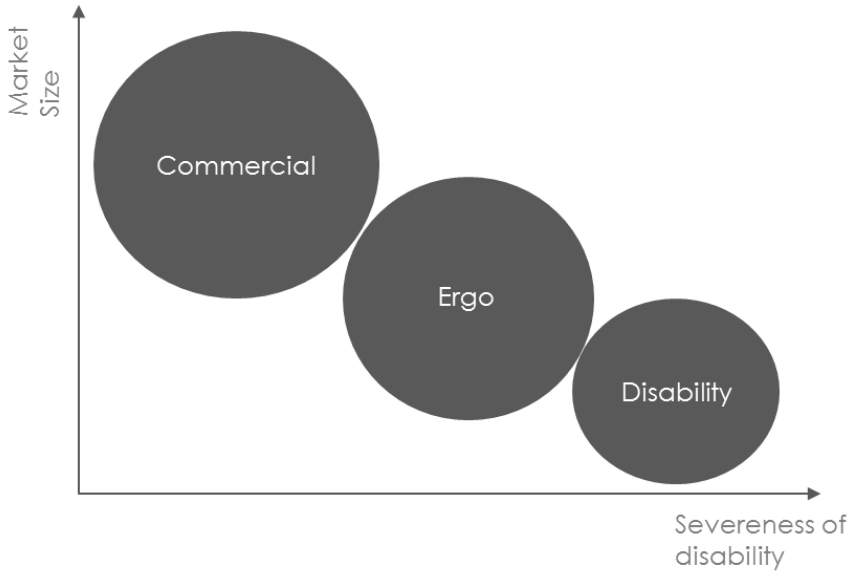


Figure 22. The user groups of Tobii Dynavox.

The target market

The target market of Ergo can however not be defined this easily as there are subgroups within this customer segment, that will respond differently to Ergo. Within this group, three subgroups are defined by severeness of mobility limitation, Figure 23. These three subgroups contain users with different needs and demands as they suffer from different grades of mobility limitations. They will therefore also have different needs and demands on Ergo. The first group is everyone who uses a computer and can use Ergo as a tool to prevent RSI. They are common people with no ergonomic problems. The second group are people who experience pain and discomfort when using a computer. The smallest group are people with severe inability to move or who suffer from injury, but are not however diagnosed with a syndrome or disease that limits their general communication abilities.

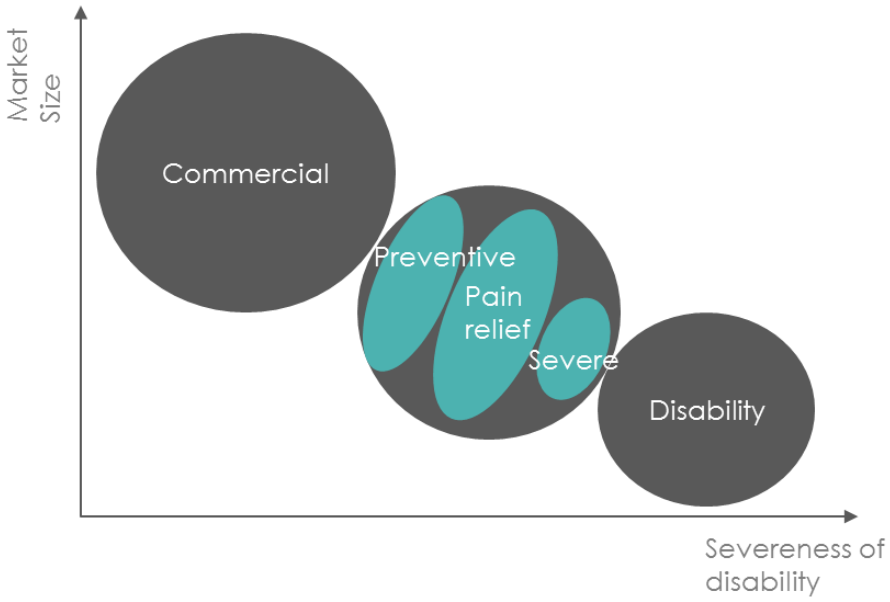


Figure 23. The target market of Ergo is divided in three subgroups.

Preventive market

The research has shown that people with no pain related to computer do not prefer Ergo as a tool to navigate their computer, see Appendix F. for detailed information. It makes them less efficient compared to using their ordinary tool, it is also difficult to break the old habit. Also, there will be no motive for an employer to finance such an expensive product if their employees do not have any work related problems. For a private user, Ergo might be too expensive to obtain. So as Ergo is today, it will not function as a preventative product. People with no pain also has higher demands of a plug and play product. This group should be aimed for later, when Ergo is more developed and perhaps integrated in computers. Tobii Dynavox also needs to establish a name and a reputation, which they can only accomplish by reaching their early adopters first.

Severe pain market

The research shows that Ergo requires more physical motion than what people with very severe pain and inability to move can handle, see Appendix F for detailed information. For them, it is still painful to have one button to press. The technology of Ergo allows a blinking function to click instead of using a button, however this would make Ergo even less effective and more similar to products Tobii already sell and develop. Tobii Dynavox has other fully developed and functional products that can help the people with more severe problems from injury or disability, which is why this customer group is not the market to focus on. However, there are a few people who fall in between the sectors and cannot be helped with any product developed by Tobii.

Pain relief market

The customer segment between the previously described user groups are people who experience some kind of physical pain or discomfort in computer work. The research shows that this user is the only one who continues using Ergo when the honeymoon phase has passed, see Appendix F for detailed information. This group is therefore the initial target group of Ergo. Even though this target group is big, everyone in it might not be potential customers. There are many different types of people with ergonomic pain in this market and all of them might not be ready to adopt the new technology. Aspects to why some people adopt Ergo and eye tracking and some not are further discussed in chapter 6.

6 User Study of Ergo

The user study aimed to investigate what the potential customers' previous experiences and associations to eye tracking and ergonomic aids in general are, consequently understanding their attitude towards the technology, their needs from ergonomic aids and how they behave when obtaining one. The study further investigated how the users behaved when using Ergo, finding positive and negative aspects regarding the product. The findings are translated into design and marketing guidelines that Ergo should follow to facilitate adoption from the potential customers. The findings and conclusions that are made are the result of in-depth interviews with people suffering from RSI, interviews with previous beta test participants, contextual interviews and observations of beta test participants and survey responses from people with RSI. The results from this study are presented in this chapter, and are based on insights from the interviews and the survey. The interview insights can be found in Appendix F. The survey responses from people with RSI can be found in Appendix G. The chapter also presents the answer to the second and third research question; What does the customer journey with Ergo look like? and Who are the potential users of Ergo and what are their needs?

6.1 Having ergonomic problems

The journey with ergonomic problems is often long and difficult to navigate, as there are many different ways to deal with the problem, see Figure 24. The journey in the figure can also be found in Appendix H. Usually, people who start to feel pain while working do not know where to start as they have little knowledge about how the market of ergonomic aids look like, as discussed in section 5.2. This leads to a long period of time when they are passive and do nothing, hoping that their problems will decrease. This user issue, among others related to having ergonomic problems, are presented in this section.

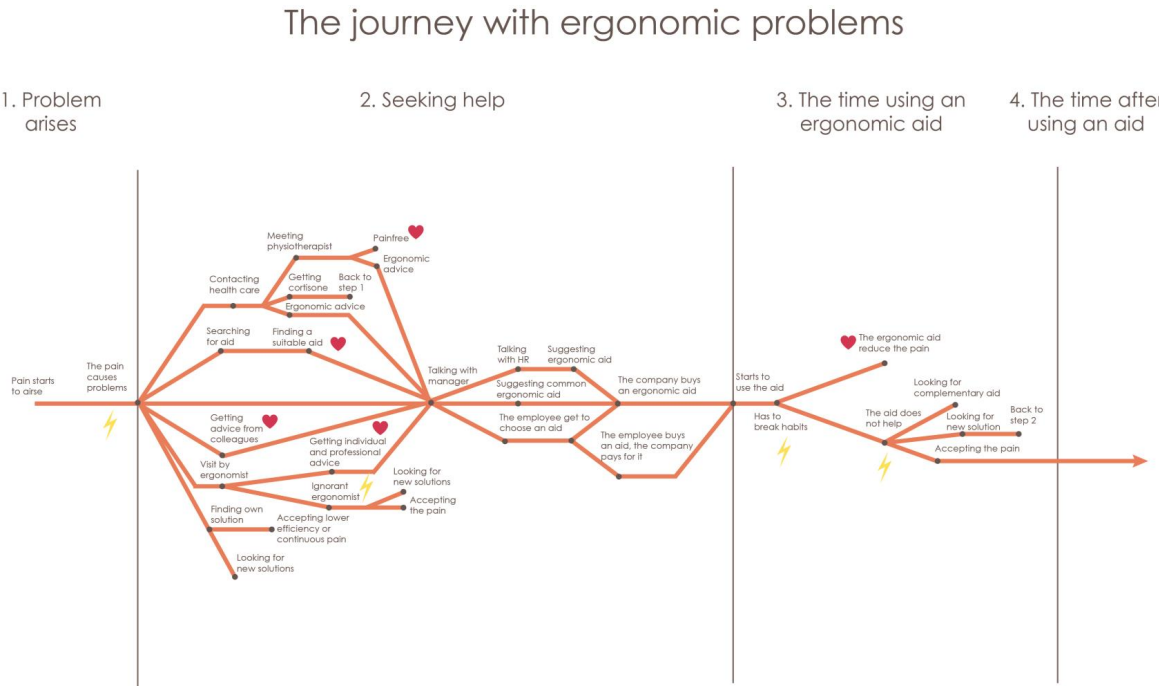


Figure 24. The journey with ergonomic problems.

Problem arises

The time before seeking help and before obtaining an ergonomic aid can be several years. It is not until the problems are starting to have too much impact on their everyday life and are intolerable that people start to look for ways to solve their problem.

Seeking help

There are six common but different ways to deal with ergonomic problems; contacting health care, searching for an ergonomic aid, talking with the manager, talking with colleagues, getting a company visit from an ergonomist or finding an own solution, see Figure 24.

Contacting health care

Few interviewees and survey respondents recounted having contact with health care in this matter, but those who had, had gotten cortisone injections to ease their pain. Two of them said that this was a very common treatment over a decade ago when they started to feel pain. Both of them were using a mouse trapper at the time for the interviews. Another one had recently gotten an injection, but was also looking for new aids in order to ease the pain. The effects of the injections eventually wear off commonly resulting in a returning pain. In this scenario, the patient either gets a new injection or looks for other possible solutions. One respondent had been given a referral to an occupational therapist by health care and they helped her to find a suitable aid. However, a larger number of respondents had taken personal contact with physiotherapists and got programmes with rehabilitation exercises, which in many cases helped them. Some claim to be nearly painless if they follow their programmes. Others had been in contact with chiropractors, with varying results. In order to prevent the pain rather than treating it when it has arisen, the health care could also advise the patient to look for ergonomic aids. Contacting health care is not usually the first step to take, but rather a step taken if the pain gets too severe.

Searching for an ergonomic aid

A common first step when pain arises is to research the internet for information about the problem and read reviews on different aids. People search for reviews from others with similar problems as many consider this a more trustworthy source, compared to information on a reseller website. Some people prefer finding information on their own instead of getting it directly from another person, as they might feel pressured to make uninformed decisions. If they manage to find an aid they would like to try out after the research, a conversation with their company manager follows. Some interviewees and survey respondents express that it facilitates the conversation with the manager if they have done research prior to the meeting.

Talking with colleagues

As ergonomic problems are rather common, many people who start to feel pain at work know others, often colleagues, who have similar problems. Getting advice from colleagues and other reliable people is common and can lead to the person trying the same solution. Interviewees and survey respondents accounted for needing some kind of trigger factor in order to do deal with their problem. If they do not experience any trigger factor, it might take years before they do something about their pain. In this stage, they might also find the pain too difficult to cope with. Colleagues, or other friends, can be that trigger factor and persuade the person with pain to take action.

Visit from an ergonomist or occupational therapist

As ergonomic problems receive more attention now than they used to, some companies invite ergonomists or occupational therapists to talk about ergonomic problems and what to do to prevent them. After the demonstration, it is often possible to sign up for a private session where the ergonomist or occupational therapist will go through the employee's individual problems and suggest workplace arrangements and different aids to try. These visits could also be a trigger factor, making it easier for the person in pain to finally act and ask for help and advice. Several interviewees and survey respondents recounted meeting with an ergonomist or occupational therapist through their work, the research therefore indicates that this is a rather common way to get help. The respondents have however had different opinions about ergonomists and occupational therapists. Some have felt seen and gotten valuable and individual help, while others felt like the ergonomists and occupational therapists had a "one-size-fits-all" approach and did not understand or care about their individual problem. They can also be perceived as sellers who force them to purchase products, which causes dissociation.

Finding own solution

Many participants in the user study show signs of procrastination of seeking help for their pain. Instead, they come up with their own solutions when the pain gets too severe. For example, people who experience pain in their right arm might start to use their left, and some will do other work tasks for a while when the pain arises. Eventually, some people will need to seek professional help if the situation is unsustainable, but some will accept this pain and their lower efficiency and continue with this behaviour for years.

Speaking to the manager

For some, the very first step of solving the problem with the pain is to speak to the manager. Also, for every way which results in obtaining an ergonomic aid, talking to the manager is a necessity in order to get an aid financed by the company. Even though a few interviewees expressed being reluctant to ask their manager for an aid because of the expense, all ways of obtaining an ergonomic aid intersect at this point, see Figure 24. What will happen next depends on the manager and what they will suggest. Some managers know from experience what aids are common and will suggest one of them to the employee. Some managers do not have previous experience in ergonomic matters and will tell the employee to find a suitable aid, which the company will order or retrospectively pay for. In some cases, most often at larger companies, there is a designated department, such as Human Resources, who handle these matters, and the manager will direct the employee to them. At this department, they usually have more experience and in some cases they have common ergonomic aids in a storage-room, ready to be collected.

Starting to use an ergonomic aid

When the employee has obtained an ergonomic aid for the first time, which can be several years after the point where the pain arose, there is an adoption process no matter how simple or complex the aid might be. This process involves learning and adopting the new aid into daily work and computer activities. It can be about getting used to arm rests being fastened to the table or re-learning how to navigate the computer by replacing the mouse. This period is usually very frustrating for the employee, as they need to break their old habits and lower their efficiency

while learning their new tool. Because people find this learning process difficult, they might be reluctant to getting into a new one later on if the first aid would not help. When they have used their new tool for some time and learnt how to use it in their everyday work, they will either feel that their pain has decreased, stayed at the same level, increased or arisen in another body part. If it has decreased, they will continue to use their aid and feel content with the situation. If they do not feel helped and content with their new situation, they either look for a new aid, go back to where they first started to look for help, look for a complementary aid if the situation is acceptable but could be improved, or they stop using their aid and accept their pain.

Attitudes and previous experiences

With these different previous experiences, people's attitudes towards ergonomists and ergonomic aids vary. Some people, in the user study, have good experiences and are pleased with their current aid or rehabilitation programme and have learnt how to use them efficiently. The people who are pleased with their ergonomic aids are however rather few, meaning that most people have negative experiences, causing them to quit using their ergonomic aid or forcing them to seek complementary aids or health care. The products not reducing their pain or making them too inefficient for work cause their negative experiences. Some people have had bad experiences with ergonomists and sellers as well, as they felt like the ergonomists and sellers did not care about them, did not understand their problem or being too assertive with them. Once someone has had a bad experience, it is unlikely that they will actively seek help again even if their problem continues for years.

Another attitude with high impact on the general attitude toward ergonomic aids is that people do not want to identify themselves as someone with pain and in need of help. People do not find ergonomic aids attractive, as they are associated with having problems. This arrogance and pride causes people to procrastinate seeking help and to identify ergonomic aids as unsuitable for them. Ergonomic aids are seen as an unwanted necessity.

Hopes and expectations of ergonomic aids

Some interviewees say that they wish to navigate their computer with their mind or having a secretary so that they would not need to use their arms at all. Others dream about more physical movement in their work rather than being sedentary like they are today. Interviewees have expressed that they would like to have aids that are designed in a way that works with how they naturally sit and that all of their aids would be compatible with each other, indicating that this is not the case with their current ones. One interviewee said that if she changed one parameter of her workspace, another one failed and gave the example of a failing chair when adding a roller mouse to her workspace. They would also like ergonomic aids to be simple, functional and easy to use and to feel natural rather than science fiction. Several interviewees also recounted that ergonomic aids are not as good as ordinary tools in terms of accuracy and effectiveness and would wish that they were. A few interviewees have also said that they would like a mobile solution as they work from different places. What people expect from ergonomic aids is however lower than their hopes, most interviewees and survey respondents have stated that they simply want something to ease their pain.

The design of the product is usually not something the interviewees mention, and they believe that function and ease of pain is more important. However, some interviewees express that they want an aid that is well-designed and does not look like anything out of the ordinary. Most people believe that ergonomic products today look soft, well-designed and a bit futuristic and something out of the ordinary.

Few interviewees and survey respondents talk about the cost of the products, but some say that they would like ergonomic aids to be cheaper as they hardly dare to ask their manager for aids because of the expense. Similarly, several interviewees have expressed that they would like to use a product on trial first and purchase it when they know that it works well for them. This is related both to the cost as well as the belief that ergonomic aids do not function as well as ordinary tools.

Behaviour groups

The different backgrounds, experiences, attitudes and knowledge cause people to behave differently towards ergonomic aids and have different needs from them. There are hence many variables that meaningfully distinguish between customer needs, choices and buying habits. Their different backgrounds will affect their choice of ergonomic aid and decision to try Ergo. Two high impact variables have been identified and are used to segment and describe the potential users, see Figure 25. The first variable is whether the potential customer is using an ergonomic aid or not at the present. The second is whether they have an active or passive state of mind when it comes to searching for aids and dealing with their pain. If the customer uses an aid at the moment or not, will implicate if they would feel the need to obtain another one or not. If they do not have an aid at present, chances are higher that they might be looking for one. However, it could also mean that they do not have knowledge about the ergonomic market and of how to obtain and aid. They could also lack about whether they need one or not. If the customer on the other hand uses an aid, chances are that they do not feel the need to look for a new one or have the energy to learn how to use another tool yet again. They, however, know how to obtain an aid as they have done so before. If the customer has an active or passive approach to this matter implicates how they will act to solve their problem. An active customer would be more independent and search for help and information on their own, whereas a passive customer would need a trigger factor or wait to act until the problem has gotten intolerable.

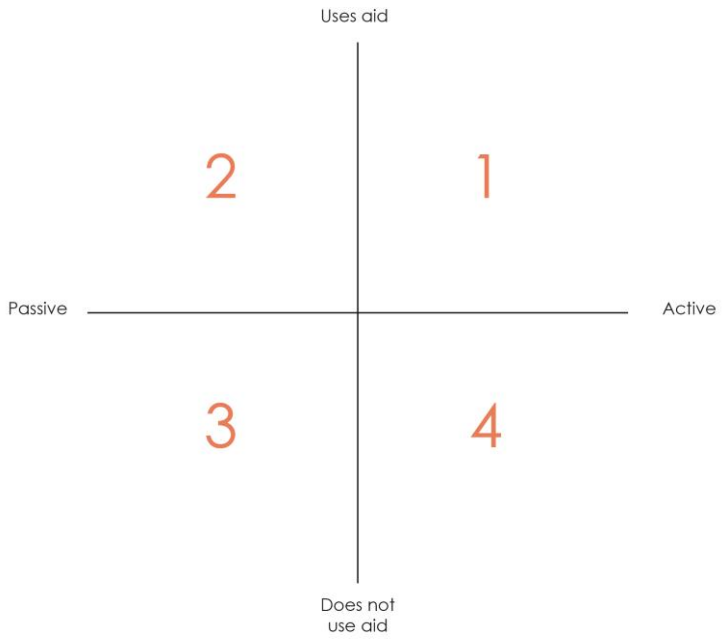


Figure 25. A segmentation of potential users based on the behavioural variables passive/active and uses aid/does not use aid.

Group 1. Uses Aid - Active
These users already have ergonomic aids, but they are not content with the situation and continue to look for other aids. They look for other aids either because they want to replace their current aid or because they want to have complementary aids as they are aware of the positive effects with having variation in posture. This group is independent, aware of and act on their problems, have knowledge about the ergonomic market and knows how to navigate it, take chances to try new aids when they get one, listens to recommendations, understands that no single aid can solve their problem.
Needs: Information about new products to become aware of their existence, flexibility and compatibility with their present work space and aids, facts to strengthen their arguments to the manager, added functionality.

Group 2. Uses aid - Passive
These users also have ergonomic aids at present but are passive either because they are satisfied with their current aid or because they are tolerating the current situation. This might be because they find it difficult to start a new process with looking for a new aid or because they are too lazy. This group needs a trigger factor in order to start looking for a new aid, they have some knowledge about the ergonomic market, knows how to obtain an aid, understands that no single aid will solve their problem, do not think it is worth the effort to start looking for a new aid.
Needs: A complement to their current aids, information about the benefits of using complements, something with news-value, added functionality, a trigger factor.

Group 3. Does Not Use Aid - Passive
This group is, according to the conducted user study, the largest one. They do not use aids and are tolerating the situation, either because they have bad experiences with aids that did not work, because they do not have the energy to start looking for help or because they do not want to

identify themselves as someone who needs help. Some people in this group have tried ergonomic aids before and believe ergonomic aids are the same they were decades ago. This group needs a trigger factor in order to obtain an aid, they do not have much knowledge about the ergonomic market, they also are generally conservative in a technological aspect. They have negative feelings towards ergonomic aids and it is a big step for them to start looking for an one. Furthermore, it is important for them that an ergonomic aid helps them completely and makes a big difference in their situation, if they choose to try one.
Needs: A trigger factor, something or someone reliable telling them what to use and giving it to them, references to someone in the same situation that has been helped, awareness of ergonomic aid's existence and usefulness, awareness of the seriousness with ergonomic problems.

Group 4. Does Not Use Aid - Active
This group consists of people who have recently decided to try an ergonomic aid, because their pain is getting intolerable. They are either completely new to the ergonomic market or they have gone from group 3 and become active. This group do not have much knowledge of the ergonomic market, they are independent, actively looking for solutions, they are conscious of their problems, are interested in ergonomic aids, are taking the chance to try something new when they get it.
Needs: Information about ergonomics, problems, products, a guide in how to solve their problems, help to find the right aid.

Conclusions
Conclusively, as there is no standard way to obtain ergonomic aids, all four behaviour groups are in need of information prior to purchase, whether that information is concerning new products on the market to become aware of their existence, benefits of complementary aids, what has helped others or about ergonomics in general. Ergo should therefore be easy obtain and retrieve information about, when the customer has made a decision to purchase it. When an employee has decided they need help, they will talk to their closest manager and what they decide depends on the manager's knowledge about the ergonomic market. If the employee has not found specific information about what they need, it is important that Ergo is known to managers, in order to be an alternative to the ordinary ergonomic aids, such as the mouse trapper.

As many people have a negative or passive attitude towards ergonomic aids, they are in need of something new that does not necessarily relate to other aids that they might have tried. Ergo should therefore be designed to bring new-value to the user. This is also important for the users who already have ergonomic aids, as they would only buy another aid if it added something new and gave them added functionality. As the largest behaviour group have a passive state of mind and are unsure about how to proceed when they are in need of pain relief, Ergo should be marketed and designed in a non-intimidating way in order to make it more attractive for the user to choose.

Tobii Dynavox may have the advantages of being a first mover of ergonomic aids utilizing eye tracking technology, but they are not the first mover of ergonomic aids. Hence, their customers have to face switching costs when switching from a competitor to Ergo. This switching cost contributes to the passive state of mind the common potential user has.

6.2 Hopes and expectations of eye tracking

The general hopes, expectations and associations to eye tracking found in the user study are presented in this section.

The findings from the user study indicate that eye tracking is a technology that most people find hard to relate to. Only a few, often with a high interest in technology in general, have read about it or seen it before. Others may have seen futuristic eye tracking technology in movies and TV-series, and can only relate to what they have seen there. Due to this, user associations are often related to science fiction and space. Some interviewees have been in contact with eye tracking in medical devices and some have been part of market research where eye tracking has been used. Other interviewees relate the word eye tracking to target advertising, surveillance and tracking other objects, such as a lost smartphone. Everyone in the user study agrees on eye tracking as cool, modern and futuristic. This appeals to many, but some express a feeling of being old and not keeping up with technology. As these are the associations people have, most of them find it hard to believe that they can use eye tracking in their everyday life. Primarily because they cannot relate to the combination of eye tracking and ergonomics, and secondly because they do not believe the technology is that far developed. Only a few people who took part in the user study can imagine themselves using eye tracking as a complement to their current navigation products.

Hardware

When the interviewees explain how they believe the hardware will look, most of them think it will look like a web camera and be mounted on top of the computer screen, where integrated web cameras generally are placed. Others believe that they will need eye tracking glasses, or some sort of sensor on their body or a helmet. Some people believe that there will be no need for an external hardware at all, and believe it will be the computer screen that will register their eye movements.

Interaction

When describing how the interaction will work, most people in the study say that they will be able to navigate their computer with their hands down in their lap. They believe the clicking will be performed with their eyes, perhaps by blinking. Some people believe that they will need to adjust themselves to eye tracking, that it will not be compatible with their computer programmes, that it will be hard to learn and that they need to focus so hard when looking at their computer screen that they worry about tension headaches. Others believe that eye tracking will be highly intuitive and easy to learn.

Conclusion

As eye tracking is unfamiliar and hard to relate to, people's hopes and expectations do not match. They hope that eye tracking will be like in movies, intuitive, easy to learn and efficient. They also hope that eye tracking used as an ergonomic aid will ease their pain. However, they believe that all of this is too good to be true, that eye tracking will slow them down and not be compatible with their type of computer work. Furthermore, the interviewees find it hard to understand how eye tracking could possibly work and find it hard to relate the technology to familiar knowledge. Therefore, it is hard for them to construct a conceptual model, which was described in section 4.2, at this stage. In order to facilitate adoption of eye tracking as a tool, Ergo needs to guide the

user into the unfamiliar world of eye tracking, providing the information and feedback that is needed to construct a correct conceptual model. Furthermore, Ergo should be designed in a non-intimidating way by enhancing the positive associations, like high tech and excitement, and diminish the negative ones, like surveillance and targeted advertising. Lastly, Ergo needs to be marketed as a well-functioning alternative to other tools, as no one in the research had ever thought of using eye tracking to ease their ergonomic pain.

6.3 Using Ergo

Using Ergo causes the user's feelings to fluctuate, and the interaction points that causes these positive and negative feeling are described in this section through two customer journey maps; one for the emotional journey and one for the touch points during the unpacking, installation and tutorial phase.

The emotional journey with Ergo

As discussed in section 6.2, users find eye tracking hard to relate to, with high hopes and low expectations, as can be seen in the customers' emotional journey in Figure 26. The figure can also be found in Appendix I. Their starting point when getting Ergo is positive, as their hopes are very high and they find eye tracking exciting even before they have tried to use it.

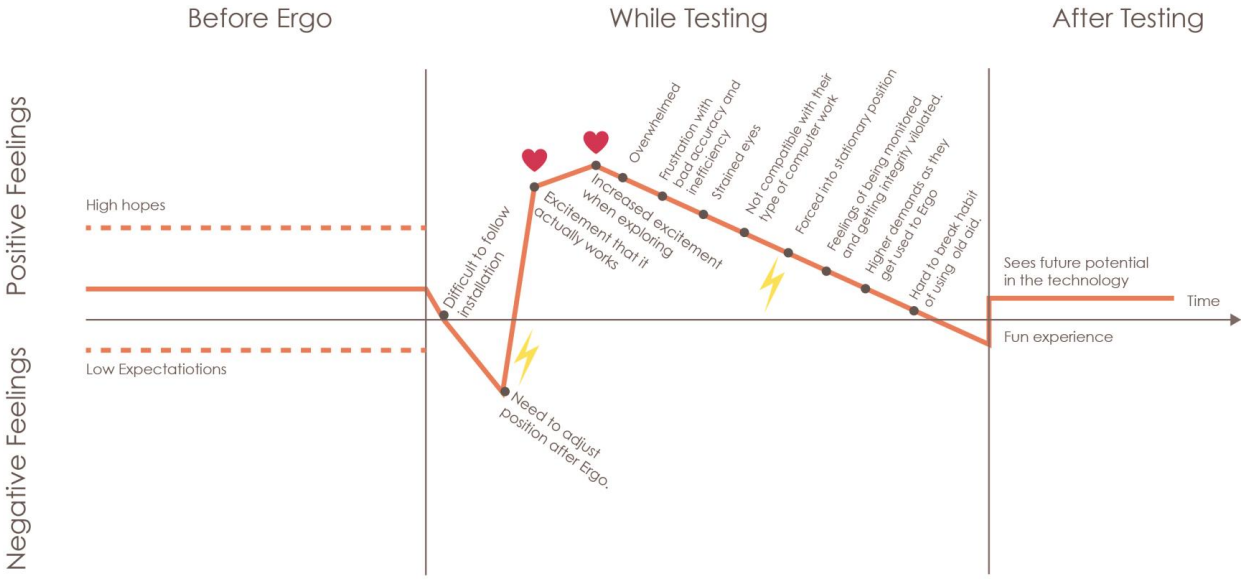


Figure 26. The emotional journey with Ergo

From there, the emotional curve decline as the installation process is difficult to follow. The curve is further declining when the users need to adjust their position and workplace after Ergo. This happened to all long term beta testers, because the eye tracking was unable to find the users' eyes while they tried to sit or stand in their usual position. This caused the users to position their screens unreasonably close to themselves, to sit very close to the desk, and to move document stands, see Figure 27.

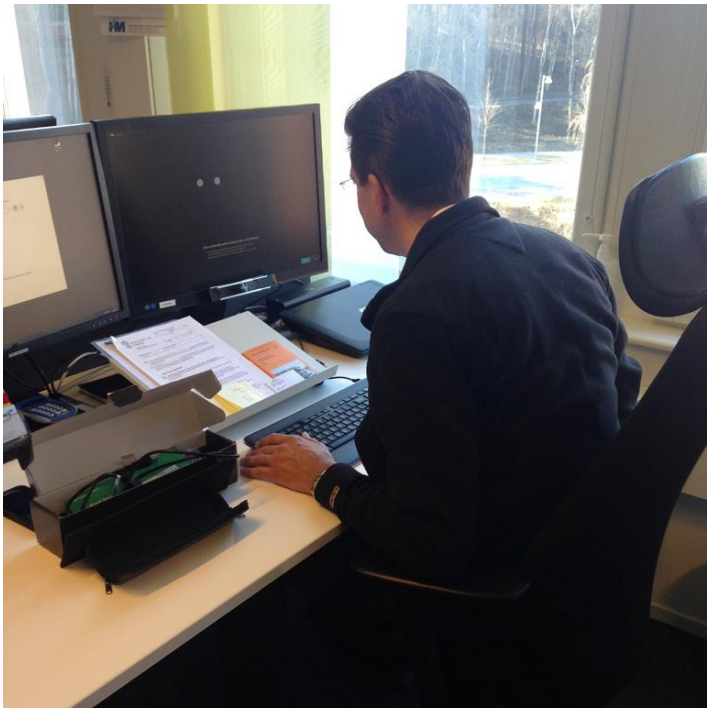


Figure 27. A test participants' position when trying Ergo.

In this stage of the calibration process, the user is advised to find a "comfortable position where your eyes can be detected", but several beta test participants commented that the position where the eye tracker detected their eyes was not comfortable. Several of the participants had to raise their desk considerably, and one commented that Ergo should come with an ergonomist who could help him make the right settings. However, when the unpacking and installation process is complete and they try eye tracking for the first time, every beta test participant has been excited because the technology works better than expected. This excitement continues as the user explores the possibilities with navigating the computer through eye tracking. After this phase, when they are supposed to use eye tracking as a tool, most users find it hard to relate what was learnt in the tutorial and what they wish to do when they are supposed to work. This causes an overwhelmed feeling, and one beta test participant referred to it as "being let off in a world you do not know how to handle". From the initial overwhelmed feeling, several others make the general feeling towards Ergo slowly decline. These factors are: frustration because of bad accuracy, strained eyes because of overexertion, bad compatibility with the software they use for work, being forced into a stationary position, feelings of being monitored and getting their integrity violated, difficulty in breaking habits and higher demands when they get used to eye tracking as a phenomenon.

When the beta test participants have finished their test period with Ergo, they have positive feelings towards the product and eye tracking in general. They see the testing of Ergo as a fun experience. They see potential in the technology and believe that it will be popular in the future, indicating that they might not want to use the technology at present.

The unpacking and learning experience

Today's customer journey with Ergo has been divided into three parts: unpacking, installation and tutorial, see Figure 28 and Appendix J. In the unpacking phase, the customer retrieves the

package, unpacks it and sees the case of the eye tracker. The eye tracker and the rest of the components are described in section 3.2. The look of the eye tracker impresses most users. Some relate the design of the eye tracker to those of video game consoles, which also use similar technology to track movement of the gamer.

In the second part, the installation phase, the customers take one of three different paths. Either they follow the instructions on the provided green note and go to the website for Ergo where they download the software, or they start with mounting the eye tracker on the screen frame right after they have picked it up, or they connect the eye tracking without mounting it first. Regardless of choice of path, the user will encounter different steps in the installation process where there is confusion about how to proceed.

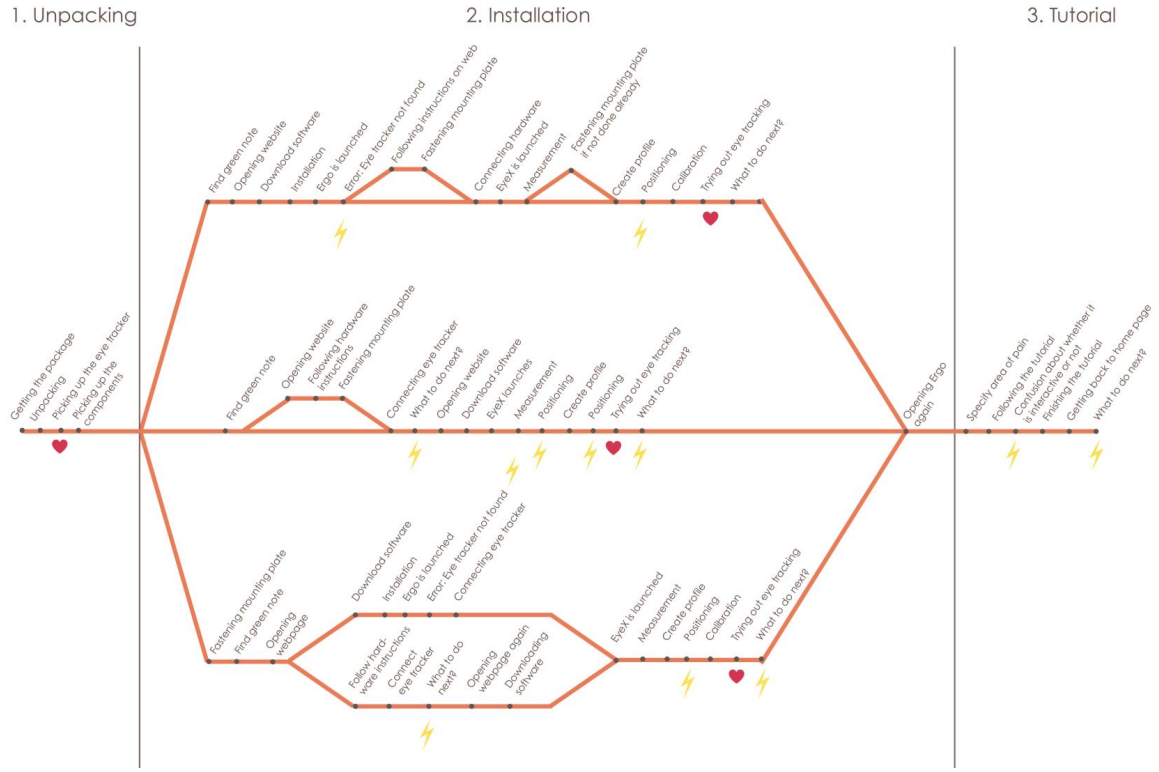


Figure 28. The unpacking and installation journey with Ergo.

Path 1: Downloading software first

Following this path, the user follows the instructions on the green note stating "start here", and type in the provided website link, see Figure 29. On top of the website is a download button and below pictures on how to mount the eye tracker to the screen. The users choosing this path will start by downloading the software and follow the installation procedure. When the installation is complete, the Ergo program is launched and the user is requested to type in the license key, which is also provided on the green note. Several beta test participants have been confused by the 0:s in the license key, wondering if they are 0:s or O:s. As the user has not connected the eye tracker yet, the next page will give an error-message stating that there is no eye tracker connected. At this stage there is frustration and confusion because the user seemingly followed the instructions and do not understand what they did wrong. The user has to start looking for clues and either the user opens the web page again to follow the instructions on how to mount the eye

tracker with the mounting plate or they connect in directly without looking for instructions. When the eye tracker is connected, the program EyeX will launch and start a settings guide. The first page shows a measurement tool, so the user can make sure the eye tracker is mounted correctly. However, if the user already has fastened the mounting plate, they cannot remove it due to the strong glue to correct the position of it. After this page the user is asked to create a profile, where they can choose if they wear glasses, lenses or nothing and if they want to track both eyes or only one due to strabismus. Some beta test participants did not believe the eye tracker would work when they wore glasses before they got to this stage. They were also confused by the option to track only one eye and could not imagine the reason for not tracking both eyes. When the profile is created, the next step is to calibrate the eye tracker to get the best possible accuracy. The program requests the user to sit comfortably where their eyes can be detected, whereupon several beta test participants have stated that they cannot find a comfortable position while the eyes can be detected. The program gives feedback in this stage in form of white circles on a black backdrop, imitating the user's eyes and moving forward (larger circles), backward (smaller circles) and sideways as the user does. After the initial stage of calibration, when the user has found a sufficient position, the user has to follow a circle moving around the screen with their eyes. After that, the user gets to try to use eye tracking for the first time, by highlighting different parts of the page when they are looking around. The beta test participants have gotten amazed at this stage by the fact that the eye tracker actually responds to their eye movement, despite knowing beforehand that it is supposed to. When they have looked around for a while on this page they will press the finish button and then the settings guide is closed. This causes confusion once again as they do not know what they are expected to do next. Eventually, they will realize they have to open the Ergo program again, from where the tutorial will start.

Figure 29. Today's customer journey with Ergo, with installation path 1 is chosen: downloading software first.

Path 2: Installing hardware first

If the user chooses the second path after the unpacking, connecting the eye tracker before downloading the Ergo program the journey will look different, see Figure 30. Either they follow the instructions for mounting on the website, which are displayed below the software download button, or they simply connect the eye tracker with the USB-cord without following instructions. When the eye tracker is connected before the software is downloaded, nothing will happen at this stage and this will cause confusion. The user will either look for instructions in the package or remember that they there is a website they can look at. Eventually they will find the download button on the website and install the program. When the eye tracker is connected to the computer when the software is downloaded, the EyeX program will launch before the Ergo program. The user will now follow the same procedure as stated above, measuring that the eye tracker is mounted correctly, and if it has not been mounted already do so in this step, and after that creating a profile and calibrate the eye tracker. When this settings guide is finished, the user will have to find their way to the Ergo program to move on to the tutorial.

Figure 30. Path 2: Installing hardware first.

Path 3: Fastening mounting plate first

If the user chooses the third and last possible path, to fasten the mounting first, the journey will take the shape presented in Figure 31. As the mounting plates are packaged in a small plastic bag with an instruction note, as seen in section 6.3, some users can choose to mount one of them on the screen before reading the instructions on the website. In this case they will open the website at a later point and from there choose to either fasten and connect the hardware (which can also be done without opening the website) or downloading the Ergo program. Either way, they will encounter the corresponding confusion touch points as in path 1 and 2 as described above. The major drawback with fastening the mounting plate before coming to the measurement instruction in the EyeX program is that the position cannot be corrected because of the strong glue.

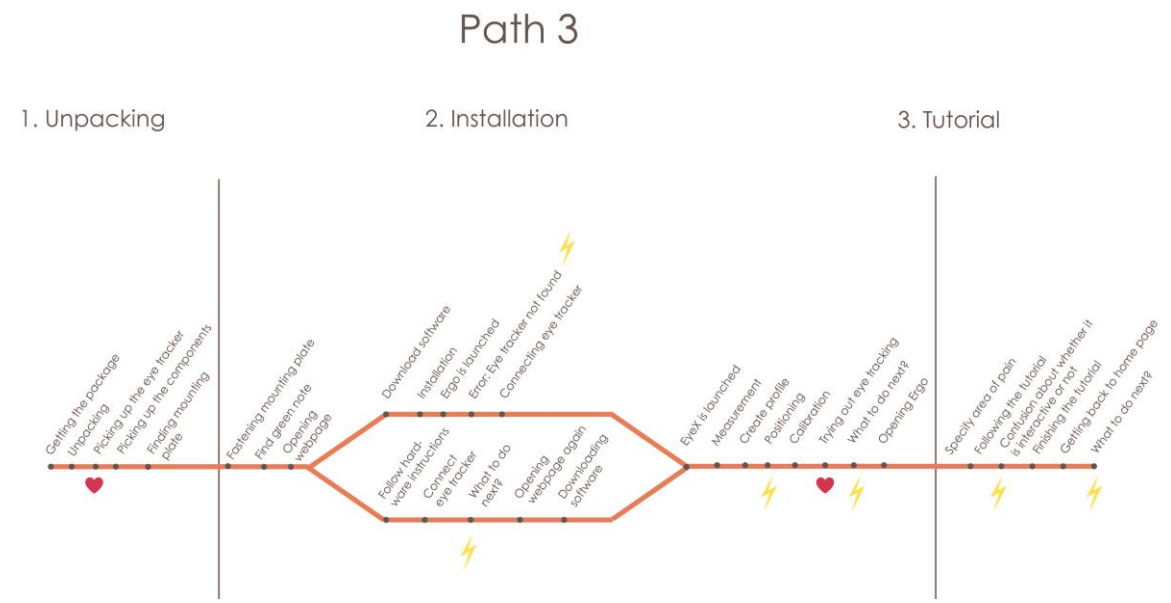


Figure 31. Path 3: Fastening mounting plate first

When the installation part is done, following one of the three paths described above, and Ergo is opened, the tutorial part begins. In the beginning of the tutorial the user gets to state where they feel pain, and their activation button will be chosen based on their answer. Then, when the actual tutorial of the functions starts, the first page presents the mouse teleport function and the users get confused and wonder whether it will be interactive or read only. The following pages are interactive and they users perceive them as fun. When the tutorial is finished however, the users feel confused once again and do not know how to proceed. One beta tester expressed a feeling of "being old" when he tried to use eye tracking in his work environment and another said felt like being "left in an environment I did not know how to control" after she had finished the tutorial.

Conclusions

The user's journey with Ergo contains both ups and downs emotionally. The users have very high hopes but low expectation, making their feelings towards the technology mixed and hard to relate to. The fact that they have both positive as well as negative associations to the technology beforehand adds to their mixed feelings. When they are first introduced to eye tracking, and have to install it on their computer, there are several touch points where the user gets confused and do not know how to proceed. In order to facilitate the installation and learning process, they should be designed in a more linear manner, guiding the user from the point of the unpacking until they are able to use eye tracking independently. Similarly, as the users feel overwhelmed by the complexity of the technology, Ergo should give them solid feedback and feedforward, as well as be designed in a non-intimidating way to further guide the user through the experience. The most important part to keep and enhance with Ergo is the users' feeling of excitement when they first try eye tracking. The most negative aspect of using Ergo, causing the most negative comments from beta testers; that they needed to adjust their position after Ergo and that the technology made them more stationary than before needs to be investigated further and improved by making sure that the user do not have to adjust their position after Ergo's track box.

7 Research Analysis and Conclusions

The research has provided sufficient information about the context of Ergo, as information about the user and the market has been obtained. This chapter summarizes this information into specific requirements for designing and marketing Ergo. The requirements are not quantifiable and act more as guidelines in the development of Ergo. The chapter also presents several problem areas with Ergo that the research has revealed. The problem areas are assessed and one is chosen to work further on.

7.1 Specification of requirements

The contextual study and the user study have provided essential information for Ergo to succeed as a product. This information is summarized in a list of specific requirements, Table 7. The requirements will act as guidelines in the development of Ergo, which is presented in chapter 8.

Table 7. Detailed requirements on Ergo based on the contextual study.

Requirements	Detailed Information
From contextual study:	
1. Ergo should follow Tobii Dynavox brand identity. *From 5.1*	Carry the logo of Tobii Dynavox. Follow the most important design focus of Tobii Dynavox; user friendliness. Should express facilitation of life.
2. Ergo's market competitive advantages should be emphasized. *From 5.2*	Navigating the computer without geometric limits. Navigating the computer with less physical motion. The hands and arms can be kept close to and in front of the body, encouraging a ergonomic posture and less static strain. The ability to have reminders that encourage ergonomically behaviour. The ability to monitor, log and store ergonomic behaviour.
3. Ergo should have a design that attracts the buyer and resellers. *From 5.3*	Unique, innovative, professional and discreet.
4. Ergo should be designed as an ergonomic aid to suit the market of pain relief. *From 5.4*	

From user study:	
5. Ergo should be easy to find and obtain. *From 6.1*	Available in Tobii's web shop for consumer products Information about resellers provided on the website High ranked in internet search results.
6. Ergo should bring news-value to the customer. *From 6.1*	Using another technology than common ergonomic aids.
7. Ergo should be well known to managers with staff liability. *From 6.1*	Marketing efforts aimed for managers.
8. Ergo should be designed in a non-intimidating way. *From 6.1, 6.2 and 6.3*	Friendly Intuitive
9. Ergo should emphasize the positive associations. *From 6.2*	High tech Exciting
10. Ergo should understate the negative associations. *From 6.2*	Surveillance Targeted advertising
11. Ergo should guide the user's conceptual model of eye tracking towards reality. *From 6.2*	Provide information, give feedback and feedforward.
12. Ergo should guide the user into the daily usage of eye tracking. *From 6.2 and 6.3*	Ergo should give feedback and feedforward. The installation process should be linear.
13. Ergo should be marketed as a well-functioning alternative. *From 6.2*	
14. Ergo should be adjustable to suit the user's position. *From 6.3*	The track box should be bigger.

7.2 User related problems

The problems related to the users and their relation to Ergo are presented and discussed in this section.

The users' passive state of mind

The fact that people tend to defer dealing with their ergonomic pain is a problem both for them, and for Tobii. They do not want to see themselves as people with problems, they do not prioritize their problems and do not understand the seriousness in deferral. Many people wait until their problems are very severe until they actually deal with their ergonomic issues. The findings from the user study also shows that many people who have tried one ergonomic aid that did not work for them, tend to give up without trying anything else. One bad experience with an ergonomic aid, a salesperson or an ergonomic expert can make them avoid any contact with the ergonomic market. This type of user becomes very judgemental and are not willing to try something new. What this results in is a passive state of mind where people accept living their problems. This means that few potential users of Ergo will actively look for it. This gives a small chance of them finding Ergo by themselves, and former bad experience with the market gives an even smaller chance of them wanting it.

To reach this potential user group, their needs and requirements on Ergo need to be met. The problem is however best solved by strategic marketing where Ergo is literally and physically given to them by someone they trust and consider reliable. Ergo can also be tried by potential users prior to purchase.

The users' expectations and conceptual model differ from reality

Since Ergo contains eye tracking technology that is new and unknown to almost all potential customers, they find it difficult to relate to it. They cannot identify themselves as users of something they do not even know exist. So when the users first encounter Ergo, they do not know what to expect. Their conceptual model of Ergo before using it differs so much from reality, which causes difficulty in understanding it. This issue makes it very difficult for them to install, learn and adopt Ergo and the eye tracking technology. They describe it as being left in a world they can not handle, which makes it easy for them to get lost, give up and fall back into their old habits of navigating the computer. Furthermore, the installation is hard to follow and the step from the tutorial to daily usage is very big. This leaves the user in an even more confused state where it is difficult to adopt eye tracking to the daily computer activities.

To tackle this problem, Ergo must be designed to be as easy to understand as possible. It must feel like one united product, with one straightforward and simple installation guide. The whole experience with Ergo, from unpacking it to using it in daily computer activities, must express friendliness and facility so the user feel comfortable and do not get confused. Furthermore, the interaction with Ergo must be designed so that the conceptual model gradually changes to match the reality without leaving users in a lost state.

The users' feelings of being monitored

The research shows that some users feel monitored by Ergo and that their integrity is being violated. Even if Ergo does not track or monitor things they believe it does, it is the perceived

feeling by the user that really matters. They know so little of the product and the technology behind it so they find it difficult to understand what it actually has the ability to do. The black screen on the eye tracker hides its content and gives the user free imagination of what is behind it. Since Ergo can track their eyes, which is an advanced phenomena to them, they start wondering what more it tracks. The feeling of being monitored is also increased with the flickering red lights on the eye tracker as it reminds them of monitoring devices like surveillance cameras.

With the increased trend of social media, sharing private life and free access to information through the internet, a greater awareness of integrity problems has arisen. The awareness has also increased due to widely spread information about society's, and companies', ability and authority to monitor, store and use personal information about behaviour. People show a general higher understanding of what power technology and the internet possess. Some users of Ergo have shown this type of awareness, making them afraid of having their integrity violated when using Ergo.

This user issue can be tackled by providing the user with sufficient information about Ergo, how it functions and what abilities it has, prior to using it. The information will give them knowledge that will prohibit the feelings to arise. Furthermore, the design of Ergo and the perception of the whole product can be amended to decrease these feelings. The red lights should not be as vivid and the overall design of the hardware should look less like a camera and monitor device.

Another way of tackling this issue is to enhance, rather than hide, everything Ergo can track and its ability to monitor and store data. There is a rising trend to have cloud-based phone applications and devices that store and track one's behaviour. Users of services like these want to track their own personal behaviour like calorie intake, running distance or carbon dioxide emission and consumption. With Ergo, they would be able to have control over and get feedback about their ergonomic behaviour in computer work. The enhancement of this ability would be appreciated by users who follow this trend. If this strategy of tackling the problem of users feeling monitored, Ergo should be marketed as a product that tracks and stores behaviour like similar services.

The users' need to adjust their position after Ergo

When using Ergo, people are forced into a stationary position that is not ergonomically ideal. Initially, the users need to adjust their position for their eyes to fit inside the track box. The position can vary from very uncomfortable to reasonable, depending on the environment and the user's anatomy. The position is however rarely the position they would naturally choose. This problem is mostly related to people using Ergo on their stationary monitors. When the user has found the best position so that the eyes can be tracked, they need to stay in this position. Staying in one position is the most important thing to avoid when preventing and relieving ergonomic problems, as described in section 4.1. This is a critical problem because Ergo, which is an ergonomic aid, forces the user into a behaviour that is not ergonomically sustainable. This contradicts the very fundamental purpose of the product.

The eye tracking technology needs to be further developed so that the tracking box can be enlarged. This would create a larger space in which the eye tracker can find the eyes, allowing the user to move around more freely. The ergonomic problems of sitting still would hence be avoided. Another solution is to complement Ergo with another mounting or stand that allows the eye tracker to be moved around. The eye tracker could hence be adjusted to suit the user's position, and not the other way around.

The users feel it does not suit them due to technical limitations

Some people who took part in the research feel that Ergo would not suit them due to its technical limitations. Ergo is not ideally compatible with some type of software and programs they use in their daily computer activities. The most common reason to this is that those programs require better accuracy in details than what Ergo can offer. CAD-programs is one example of software where Ergo is not ideal as a tool of controlling the computer. Another technical limitation that makes the user reject Ergo is its inability to function on double monitors. Some users are dependant on their both their screens and has a system of working where both are needed. Furthermore, some users have modern monitors and laptops that lack frames where Ergo can be mounted. They are rarely willing to change their entire laptop or monitor only to make it possible to mount Ergo. Finally, Ergo is only compatible with the operative system Windows hence excluding people who use other operative systems.

As Ergo is in a initial stage in its development, time and further development of Ergo and the eye tracking technology behind it will probably solve many of these problems. The compatibility with other operative systems for example, will be possible when Ergo has been tried on the market and has brought revenue for further development.

The immobility of Ergo

The research shows that people who have flexible jobs working from different places and different computers reject Ergo as a tool. People who work much from home or work as consultants are examples of people demanding a more mobile product. This is because they perceive Ergo as an immobile product that would not suit their mobile way of working. They complain about and that the software only can be installed once on one computer, however, the license key that comes with Ergo is valid five times and can hence be used on different computers. This multiple validity is not communicated to the user who instead perceives Ergo as an immobile product. They further complain about the permanent mounting which also makes Ergo perceive as immobil. Even if the eye tracker itself is removable and mobile, it cannot be used without the mounting which makes the total product immobile. Another drawback of having a permanent mounting is that some people will not be allowed to glue it to their computer. The computer might belong to the company or someone else who has restrictions of what they can do with it.

The problem of immobility can however be be tackled by informing the user of the number of license keys that Ergo contains. Also by designing a mounting that is not permanent or providing the user with the same number of mountings as the number of software licenses.

7.3 Market related problems

The problems related to the market are discussed further in this section.

The users' lack of knowledge

The potential user of Ergo lacks knowledge about many things concerning ergonomic aids and the market of work related ergonomics. The users need to be provided with information concerning the importance of dealing with ergonomic problems at an early stage. They also need information about how to obtain ergonomic aids and what aids are available on the market. Another need is information and recommendations of what ergonomic aid would relieve their specific type of problem. Furthermore, they lack knowledge about the advantages of using complementing aids to vary their working position and posture. The user also lacks knowledge of the existence of eye tracking in the ergonomic field. This general lack of knowledge is a problem for Tobii Dynavox as it makes it difficult for them to find and reach the potential users, and difficult for the user to find them.

The problem with the user's lack of knowledge can be tackled by providing them with information through different marketing channels.

The demographic variety of potential users

There is a wide demographic variety of potential users since anyone can get pain from using a computer, and a large number of people use computers. This is a problem since it is difficult to design a product for a user group that is very broad and diverse. It contains both genders of different ages, backgrounds, cultures and interests. This wide diversity leads to a high demand of Ergo to suit very many different people and needs. With a neutral design of Ergo that focuses on what the different customers have in common, ergonomic problems, the issue can be tackled.

The market competition

The final problem for Ergo is its market competition. The competitors like the rollermouse and mousetrapper are known and established aids that are often offered and chosen as first choice. They are cheaper, easier to adopt and familiar to many people. Furthermore, they are widely accepted and have helped many people with their problems. This market will be difficult for Ergo to enter as it does not have many advantages over its already established competitors.

The problem of tough market competition is best tackled by differentiating Ergo from its competitors through enhancing what Ergo does different.

7.4 Problem area assessment

All problems previously described in this chapter should be taken seriously as they all affect the possibilities of Ergo reaching the market and becoming a popular and favoured ergonomic aid. Some problems are however more serious and important to tackle than others. The following table, Table 8, is an assessment of which problems are the most important to tackle in order for Ergo to reach the market and succeed as a product. The problems are ranked 1,2 or 3 where 3 is the most severe. The ranking is based on how much they would affect the possibilities of Ergo to become a successful product.

Table 8. Problem assessment where each problem is ranked 1-3, with 3 being the most critical problem.

Problem area	Assessment
The users' passive state of mind	3
The users' expectations and conceptual model differ from reality	3
The users' feelings of being monitored	2
The users need to adjust their position after Ergo	3
The users feel it doesn't suit them due to technical limitations	2
The immobility of Ergo	1
The users' lack of knowledge	1
The demographic variety of potential users	1
The market competition	3

The problems rated the most severe are the user's conceptual model differ from reality, the users' need to adjust their position after Ergo, the market competition and the user's passive state of mind. The problem with the user expectations and difficulties of adopting Ergo is chosen to work further on. The motive behind this choice is that and the user study has provided fruitful information that could be the foundation of solving this problem. The solution would also involve development of the product, rather than market strategy, which corresponds more to the track of design engineering.

8 Development of Product Adoption Design

The focus in the development of Ergo has been to tackle the problem with the users' varying expectations and that their conceptual model differ from reality. The idea of solving this chosen problem area is a product adoption design. The design involves a linear process of unpacking, installing and introducing eye tracking. It also involves a new system of introducing functions and features to facilitate adoption. The specific requirements in Table 7, presented in the previous chapter, have acted as foundation and guidelines throughout the development. This developed design is presented in this chapter. The development is a design proposal that has been briefly tested and not been implemented in the product at the time of writing this report. Conclusively, the design presented in this chapter is a suggestion based on findings from a user study to facilitate adoption of Ergo. Thereby, the chapter also presents an answer to the last research question; How should Ergo be designed and presented to facilitate adoption?

The graphical design has not been in focus in the development. The focus has rather been on what the steps and details the learning process should consist of to facilitate adoption. The interfaces presented throughout this chapter has a graphical design (colours, logos and symbols) based on existing development by Tobii Dynavox.

8.1 Overview of product adoption process

This chapter section presents an overview of the developed product adoption design proposed for Ergo. It briefly presents the changes made to the installation learning process as well as feelings Ergo should express. A more detailed description of the development is further described in the following subchapters.

The linear process

The proposed development of Ergo is concerning the facilitation of adoption, based on the conducted research. This includes a re-design of the whole process from the unpacking experience to the independent usage of Ergo, see Figure 32 or Appendix K. The linear process is divided in three parts; Unpacking and installation, digital guide and continued learning. Focus is laid on making a guiding, friendly and linear installation and learning process of the novel experience of using eye tracking in daily work.

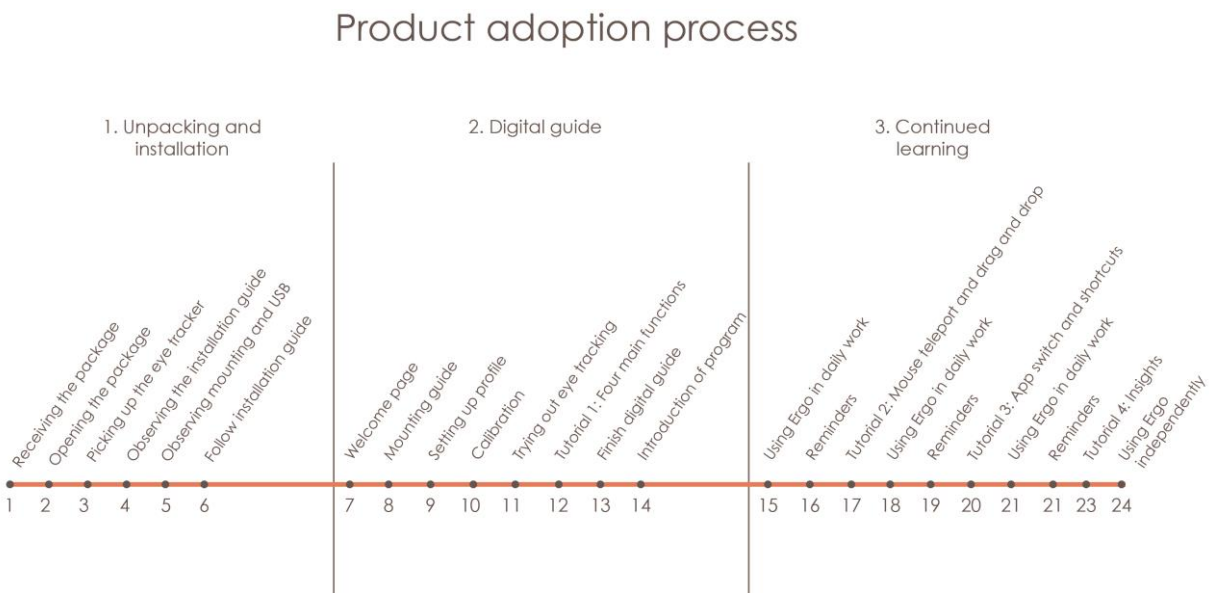


Figure 32. The suggested product adoption process.

The user would first encounter this linear process when opening the package, which is layered. The layered package should guide the user through the installation process by showing the components in the correct order. The unpacking and installation is a critical part as this is the user's first impression of the product, as this impression will have impact on the following steps in the process. In this step the product must be perceived as one unit, causing no confusion, even though there are two main components (hardware and software) that needs to be installed correctly to the computer. The user should have no doubt of how to proceed with the unpacking and installation, and from there be naturally led into the digital guide. The digital guide should help the user to make the necessary settings and form a correct conceptual model by providing information in a non-intrusive manner. A significant difference from the beta version is that the tutorial part of the digital guide will visualise how to use the functions on a computer desktop. This would facilitate the transition from tutorial to daily usage.

Another major difference from the beta version is the added step called *continued learning*. By adding this step, the tutorial will be separated into several parts, exclusively introducing the four basic functions of Ergo first. After some time of using the product, Ergo will introduce more functions and features to the user. The reason behind adding this step is that the beta test participants have felt overwhelmed by the complexity of the product. This has caused them to only use the basic functions, as they are the ones they remember. By introducing the whole extent of the program bit by bit, the user gets the chance to develop at their own pace. This added step would also prevent the users from growing tired of the product as it will grow with them over time, rather than staying the same, just like described in theory (Chapman, 2005).

This is the starting point on the path to independent usage of eye tracking, making it vital that the first impression of using the technology make the user want to continue to explore the possibilities. To facilitate learning and ease of use, a step called *continued learning,* has been added to the original process, which lets Ergo grow in the users' own pace. When the user has experienced and learnt all the different functions and features of Ergo bit by bit, they should feel confident enough to be able to use eye tracking independently in their computer activities.

Visual expression

The user perceive Ergo as unfamiliar, difficult to relate to and difficult to understand which leads to a state of confusion and a feelings of being left alone in a new world they cannot control. These factors have been highlighted to transform in the development. Transforming these factors would have high impact on how well the users adopt the product and be correspond to good user experience proposed in theory. The identified factors are transformed according to:

New, unfamiliar	➡	High tech, exciting
Difficult to relate to	➡	Self-explanatory, comprehensible
Difficult to understand	➡	Guiding, intuitive
Confusing, left alone	➡	Friendly

The user experience should therefore be characterized by an exciting, high tech, comprehensible, guiding, intuitive and friendly approach. Representations of these feelings have been assembled in a mood board, see Figure 33, to visualise a coherent approach for the development of the product. The mood board also present feelings based on requirements in Table 7, section 7.1.

Figure 33. Mood board for the product adoption design of Ergo.

How this idea of the product design is to be actualized in each step of the usage process, is further discussed in the following subchapters.

8.2 Unpacking and installation

The first six steps of the linear process in Figure 32 are part of the unpacking and installation of Ergo. The user is guided into one linear order of installing the different components, hence avoiding moments of confusion. The six different steps are presented in Figure 32, and thoroughly described and motivated through the chapter. The overall experience corresponds to the feelings represented and visualized in Figure 33.

Receiving the package

The first impression the user has of Ergo is when receiving the package. It is hence important that the feelings Ergo should represent, are expressed here. The package is a simple box so that the user does not get the feelings of complexity. Everything with the box is something they can relate to and has seen before. The one single box also mediates the impression of one united product, rather than a combination of eye tracker, mounting, software and so on. Everything the Ergo package contains is obtained from that one single box.

A dark design keeps the impression of space, high-tech and science fiction. Yet, the chosen colours of the box do not have high contrast as it should give a friendly and soft impression. It was chosen to exclude too many colours to keep the design clean, professional, easy to understand and suit many different kinds of people. Giving a professional first impression is important to attract the resellers and buyers, while what is inside the box is exclusively for the user. The research of the ergonomic market concluded that the package expressing Ergo's expense is of less importance and has hence not been in focus when redesigning the package.

The package is wearing the logo of Tobii Dynavox and the product name Ergo, according to another requirement in Table 7. It is also wearing the two connected dots in the Tobii logo as people in the user study seem to recognise that part of the logo most. It is however not wearing more details than these, so that the user can have an open mind of what to expect when opening the box. More labels, figures and texts might give Ergo a disunited impression hence confusing the user. The outside of the package is visualized in Figure 34.

Figure 34. The exterior of the Ergo package.

Opening the package

After receiving Ergo, the user will open the package. The fundamental thought of unpacking Ergo is to be presented to every part of Ergo in a friendly linear order. In this way, the user will be pleasantly and slowly guided from their conceptual model to reality. The user will meet different layers in the box, avoiding them from getting the feeling of being overwhelmed with too many components at the same time. The layered concept of the package will introduce them to each component in the right order to facilitate the installation of Ergo.

The user open the box by sliding the cover to the side, see Figure 35. This is a common way of opening a box, making the user feel they are in control and they understand what is happening. Sliding the cover gives the user a moment of excitement as the interior is slowly revealed.

Figure 35. The package is opened by sliding the cover to one side.

Picking up the eye tracker

The first thing the user sees when the cover has been removed is the eye tracker. It lays in a case that has the writing *This is your eye tracker* on the surface, Figure 36. The eye tracker is the most essential part of the whole product and is the component the user find hardest to relate to. This is the reason why they are exposed to the eye tracker before anything else in the package. As users enter their journey with Ergo with varying expectations of how the eye tracker will look like, their conceptual models must directly be met before the journey can continue.

Figure 36. The first layer of the Ergo package; eye tracker.

When picking up the eye tracker in its case, the user will immediately understand that what they are holding in their hand is the eye tracker. Having it in a case from the beginning gives the user the impression of the eye tracker being something valuable and fragile. It will also make the user understand that the eye tracker is mobile and something they can carry with them. This tackles the problem of Ergo being perceived as immobile. Furthermore, the text on the case also express that it belongs to them, which avoids the feelings of the eye tracker being unfamiliar and unrelatable. Instead, it gives them the control of the product as they feel it is something that belongs to them. Therefore, the text makes the eye tracker to be perceived as personal giving the user a friendly impression. The case is made of leather which is a material that is familiar to the user, it is durable and will protect the eye tracker while it still gives a sense of softness.

As the eye tracker is hidden in its case, apart from a small part sticking out, the user will feel encouraged and excited to remove the case and look at the eye tracker. It will have a transparent plastic film covering the front, indicating that it is a sensitive surface. If it is removed here or later does not matter for the process. It will however be communicated to the user later in the process that it must be removed before calibration, since it can interfere with the optics in the technology. The plastic film used in the beta tests had a big red and yellow warning sign on the surface telling the user to remove it. This sign is very conspicuous making it the first thing the user sees and experience when getting to know the eye tracker. A warning sign with these colours scares the user, rather than making them feel comfortable. The way of communicating the removal is hence moved to a latter part of the installation process. The eye tracker and its case is visualized in Figure 37.

Figure 37. The eye tracker and its case.

Picking up the installation guide

When the eye tracker in its case is removed from the package, the second layer is revealed. This layer constitutes an installation guide, see Figure 38. The guide is chosen not to cover the underlying layer completely as it still must feel like a guide that has something on the back.

Figure 38. The second layer of the Ergo package; installation guide.

The front of the installation guide has the text *Installation Guide* placed in the middle, together with the name of the product. The word guide is used instead of manual, as manuals are often associated with complexity. A guide feels more personal and something that does not leave you. Furthermore, the front of the guide contains two pictures of the eye tracker mounted on a laptop screen and a monitor. The motive behind putting these two pictures here is to make the user understand where the eye tracker should be mounted. The user may not consciously reflect over the placement of the eye tracker, they will however see the pictures and deviate their conceptual model towards reality. The user has already seen the eye tracker and will recognise it on the pictures. The front of the installation manual is shown in Figure 38.

Observe layer with mounting and USB

When the user has removed the installation guide, the third layer will appear. This layer includes the mounting and the USB-cord. Each of the two parts have explanatory texts describing what it is, see Figure 39.

Figure 39. The third layer of the Ergo package; mounting and USB cord.

When reaching this layer in the package, the user has two ways of proceeding. Either, they will lift the layer up and find the booklet with technical specification and have a look at it. This is the fourth and final layer in the package, see Figure 40. When finding there is no more in the

package, they will return to the installation guide that they have previously been introduced to. Or, they will go directly to the installation guide leaving the last layer. Which way the user proceeds does not matter and will not leave the user in a confused state as they are both straightforward.

Figure 40. The fourth and last layer of the Ergo package; technical specification.

Following steps in installation guide

After observing layer three and four, the user will return to the installation guide as it is the natural way to proceed. In the event of the user connecting the eye tracker or proceeding to steps ahead in the installation guide, they will be reminded to return to the guide. They have looked at it before and will hence naturally return to it. The installation guide is presented in Figure 41. It is divided into four steps that are differentiated by numbering and colours. The four steps are:

1. Take mounting from package, mount it
2. Attach and connect eye tracker
3. Download software from website
4. Follow guide on computer

The steps are read from left to right, as it is the intuitive way of reading. This helps the user to understand which step they should start with. In the unlikely event of the user starting with another step and hence faces confusion, they will always have the guide as a safe point to return to and follow.

Figure 41. The back of the installation guide.

The first step is a guide of how to connect the mounting on the screen. The mounting used in the beta version is not ideal, as discussed in chapter 7. It should preferably be removable and adjustable rather than permanent. It was however decided not to work further with this issue, the

illustration in Figure 41 hence shows the old mounting. The placement of the mounting is however very important as the eye tracker is sensitive to angle and position. The mounting needs to placed exactly in the middle of the screen for Ergo to function properly. An illustration like the one in Figure 41 might not be enough for the user to understand the importance of precision. The beta version uses a geometric guide in the software to indicate the centre, but this means the software needs to be installed before the hardware. As shown in Figure 30 this order of installing Ergo confuses the user. To avoid this confusion and to keep a linear installation process, it was decided to have the mounting as the first installation step despite the technical limitations. This decision was based on the fact that the mounting should be redesigned in the future as it has shown many drawbacks. In the redesign, it should adjustable so that the exact position can be altered later on in the process. Conclusively, the user will stick the mounting on the screen, close to the middle, and later in the installation process adjust it to the exact center following a guide in the software.

The second step in the installation guide involves connecting the eye tracker to the computer. This step should be fairly comprehensive for the user as it is a natural step after mounting the mounting. The combination of the text and the illustration, indicates the user to take the USB-cable from the package. The cable is easy to find as the user has previously been introduced to it. Plugging in a USB-cable into a computer is considered commonplace for computer users and is hence not further explained.

The third step in the installation process is downloading the software. It has been discussed whether to add a memory in the eye tracker where the software can be stored. This could theoretically be easier for the user as they would not need to go to a website to obtain the software. Technically, however, adding the software to a memory comes with many disadvantages and technical obstacles, which is the reason few developers do this. Firstly, few computers will allow direct installation of software when connecting a hardware since antivirus programs are close to standard. The user would hence most likely receive a warning when plugging in the eye tracker. A warning is not a friendly message and contradicts the feelings Ergo should express. Another problem is that the program would try to install every time the user replugs it, resulting in complications with the limited licence keys. The user would therefore have to open the eye tracker memory and transfer the installation file on to the computer memory. This would be confusing for the user as they would not expect the eye tracker to function as a USB memory. The primary problem of having the program on a memory in the eye tracker, is that it would not allow software updates. Every time the eye tracker is replugged, the software version on the memory will try to install. As software is developed more rapidly than hardware, software updates must be facilitated.

Due to the previously described problems of having the software on a memory in the hardware, the program is downloaded from a website. As the users are frequent computer users, downloading software from a website is commonplace and is not further explained in the guide.

When the program has been installed, the digital guide of Ergo will be launched on the computer. This is explained in the fourth and last step in the installation guide. This step also provides the activation key and informs of the multiple validity of it.

8.3 Digital guide

This section presents steps 7-13 in the linear process described in Figure 32. The interfaces presented throughout this chapter has a graphical design (colours, logos and symbols) based on existing development by Tobii Dynavox.

The digital guide is divided into two parts; settings and tutorial. The settings part guides the user to make the correct settings. The tutorial part is where the user learn how to use eye tracking as a navigation tool in their computer work. An overview of the digital guide can be seen in Figure 42. The whole guide is based on a friendly and personal note, in order to make the users feel confident and taken care of, rather than feeling lost and anxious. To deepen the feeling of control and confidence in using the technology, several overviews are provided and every page is giving both feedback and feedforward to the user. By doing this, the user is informed with what has been done and what can and should be done next. As eye tracking is a technology that is novel to most people, every step needs to be explained in order for them to get a correct contextual model of the program. All steps of the tutorial and continued learning phase are presented and explained in this section.

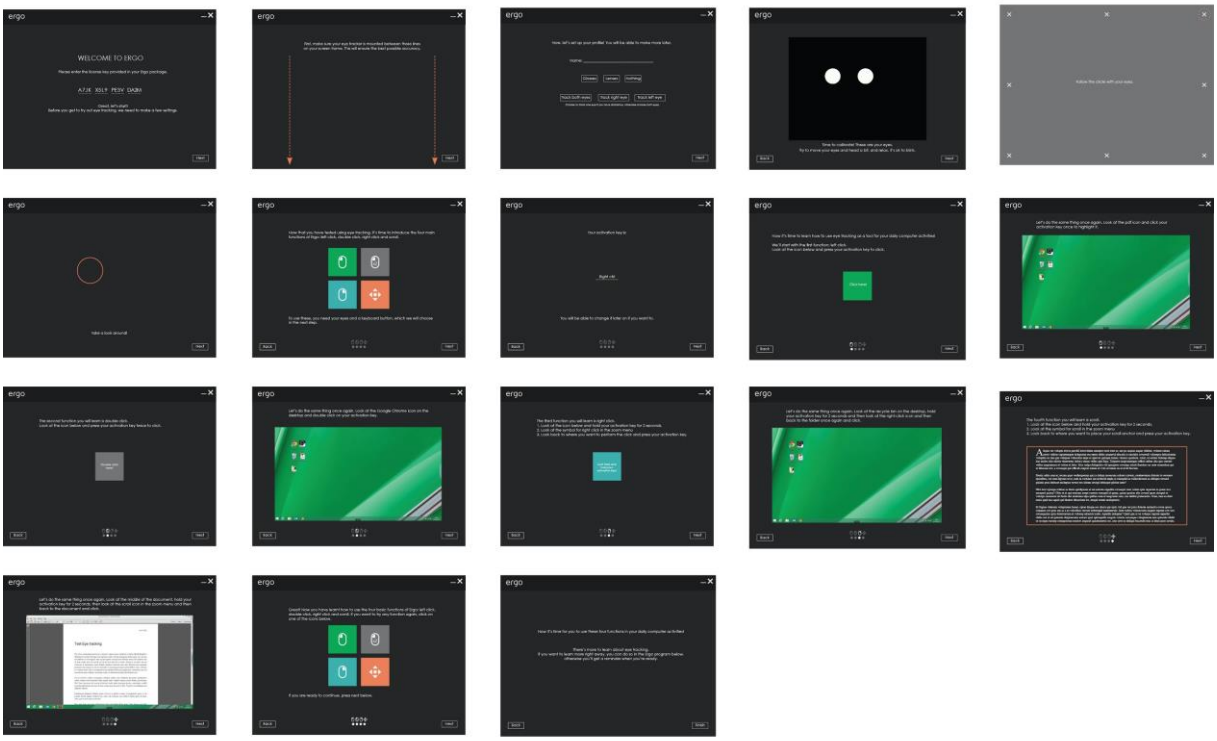


Figure 42. Overview of the digital guide.

Welcome, settings and calibration

The first page the user will encounter when the installation is complete is a welcome page. The user is asked to type in the license key provided in the package in order to continue. When the license key is entered, see Figure 43, a text under the license key will explain what the user can expect to happen next; making settings and then trying out eye tracking, before they ultimately can use the technology as a navigation tool on their computer screen.

The first part of the guide focuses on making the necessary settings for the eye tracker to work properly on the user's computer. This includes adjusting the position of the eye tracker if needed, making a user profile, calibration of the eye tracker and lastly giving the user their first experience of eye tracking. After this, the tutorial will begin. In the software version used in the beta tests, this part is passed through in a separate guide before getting to the welcome page and the tutorial of Ergo, causing great confusion. To make a more coherent and linear process, the settings and the tutorial will be part of the same digital guide, with the same graphical design. The settings starts with a page that asks the user to ensure that the eye tracker is placed in the horizontal centre of the screen and reminds them to remove the plastic film from the eye tracker, see Figure 44.

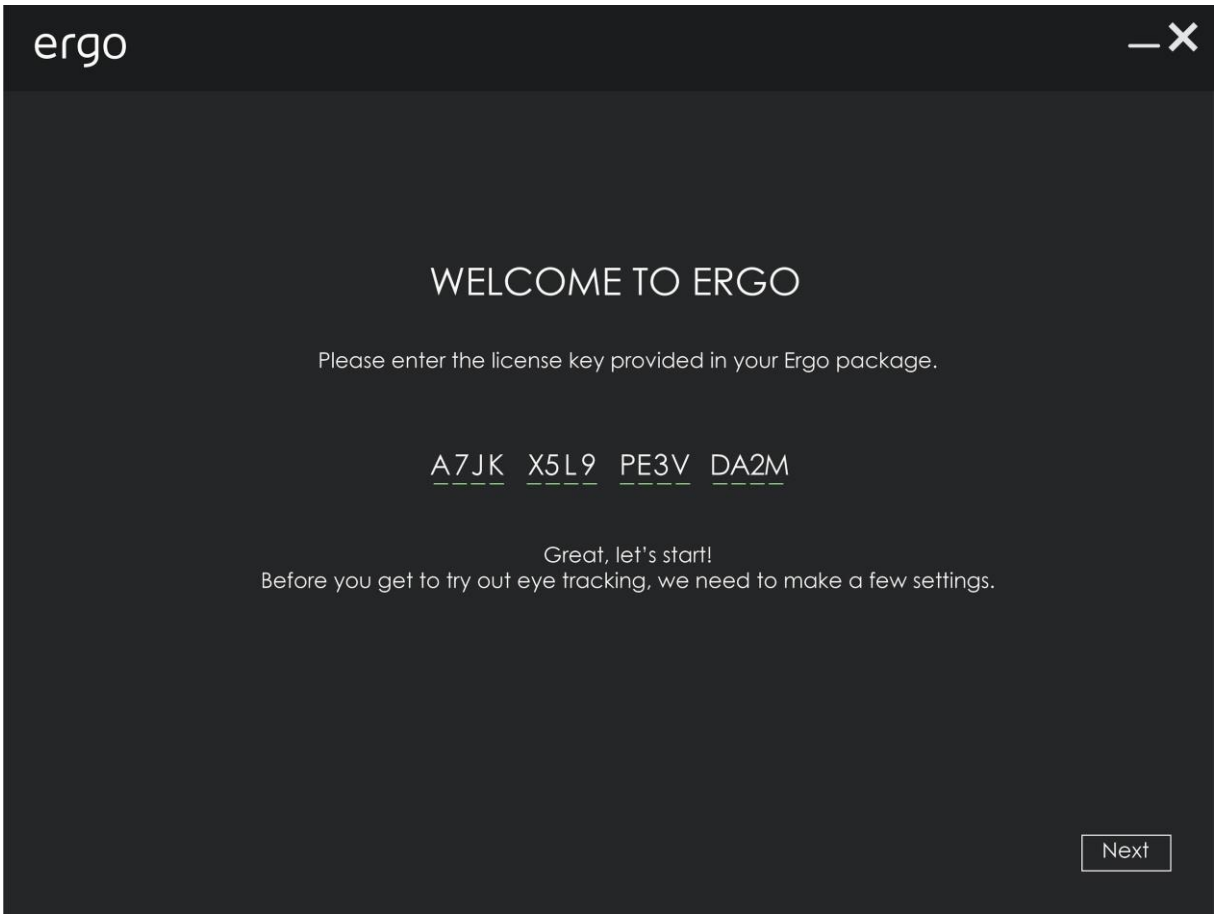


Figure 43. The welcome page of Ergo, where the license key is typed in.

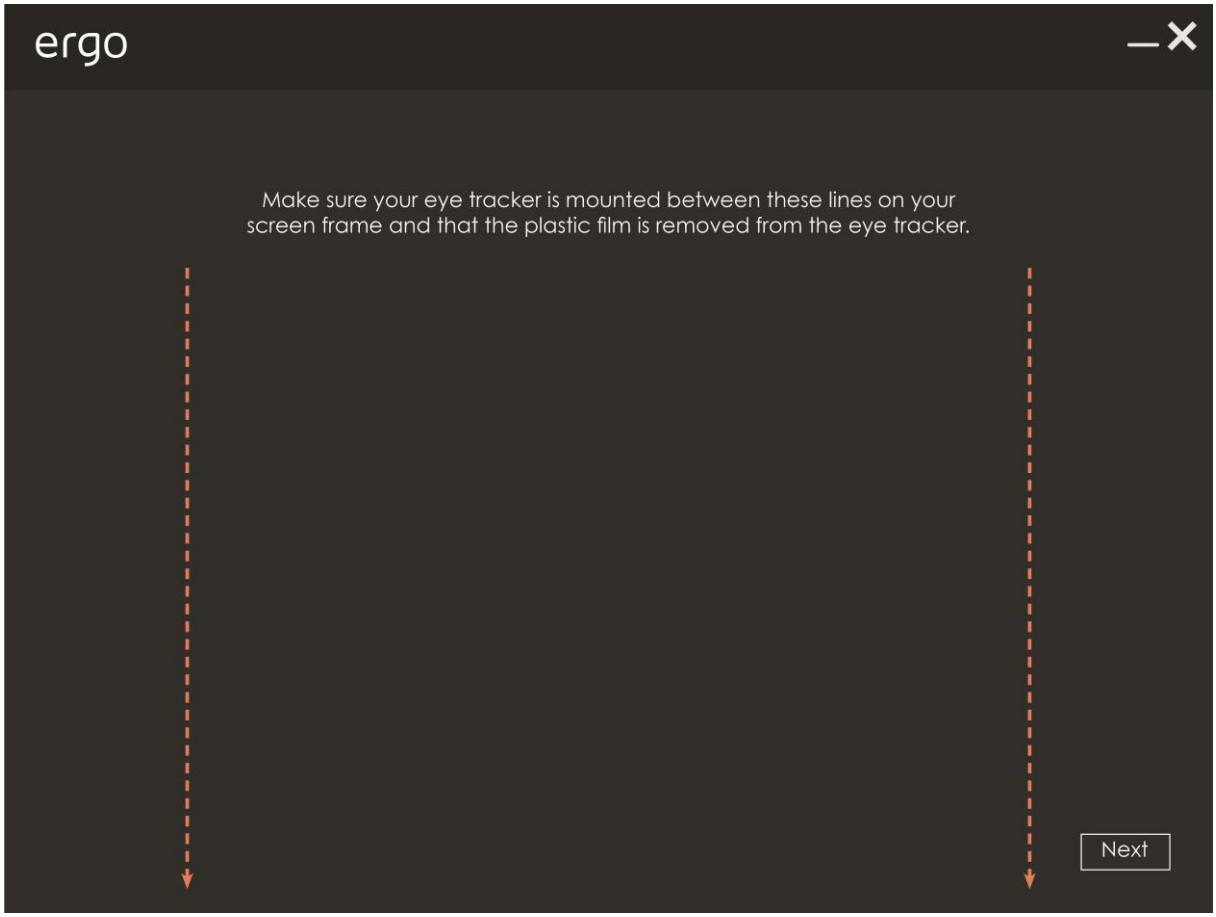


Figure 44. The user is asked to control their mounting of the eye tracker.

When the eye tracker has been correctly positioned, the user needs to create a profile where they choose if they are wearing glasses, lenses or nothing and if they want to track both eyes or only one, see Figure 45. This information should be provided in order to get the best possible accuracy. As some beta test participants have expressed confusion whether the technology functions at all when they are wearing glasses that information should be provided at an early state so that they consider being a user of eye tracking. It should also be explained that the reason for choosing to track only one eye is because it then can function for people with strabismus, as beta test participants expressed confusion for why there would be a reason for only tracking one eye.

When the profile is created, the user will get a chance to get familiar with eye tracking, and get feedback that the device responds to where they are looking, see Figure 46.

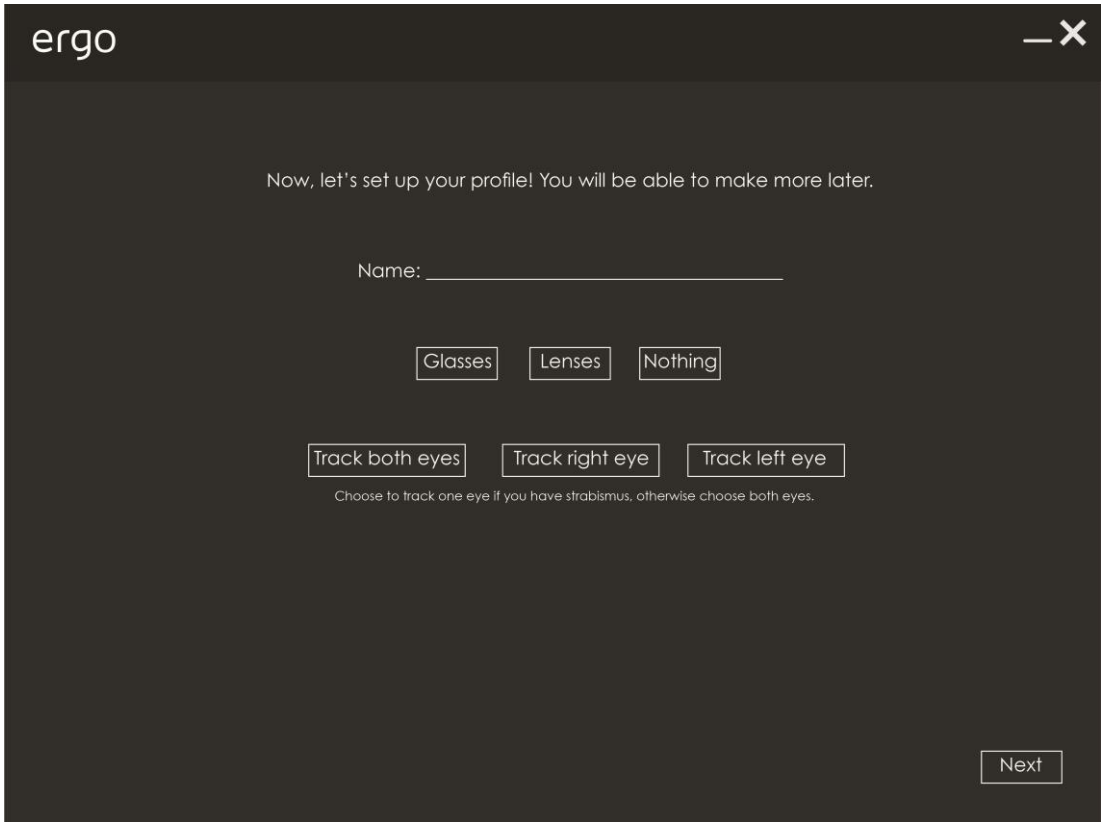


Figure 45. User profile settings in the digital guide.

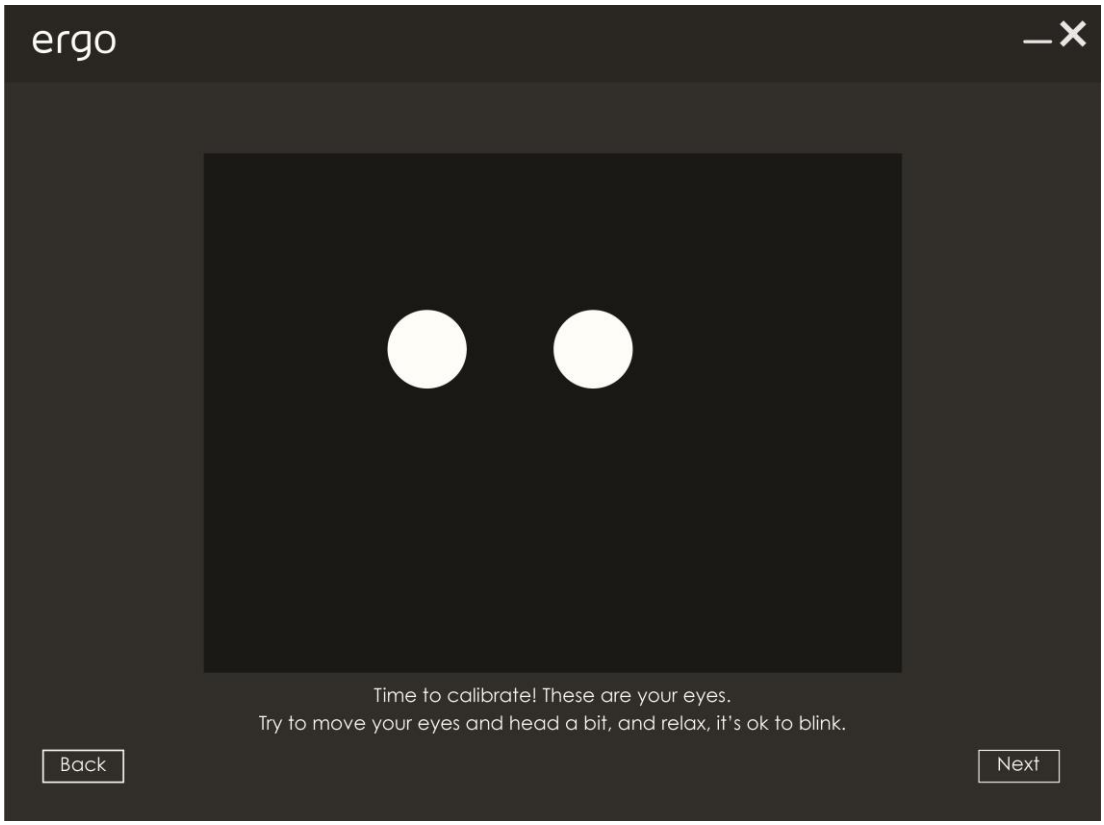


Figure 46. The user gets feedback on how well their eyes can be detected.

When the users feel ready, they can continue to calibration, which is a circle moving around the screen and fixating on certain parts, see Figure 47. The result from the calibration is used by the software to determine where exactly the user is looking, to ensure the best possible accuracy.

Figure 47. Calibration of the eye tracker. The user will follow a dot with their eyes to nine points on the screen.

The last page of the settings part is where the user can try to use eye tracking for the first time and see a circle follow their eye movements, see Figure 48. This is generally a part that excites the user as the experience often exceeds their expectations and they get instant feedback on how the settings and calibration worked. As this part was in a separate guide in the beta version, there was confusion about what to do next when the users felt ready to continue. They found it difficult to proceed from this page and find the tutorial.

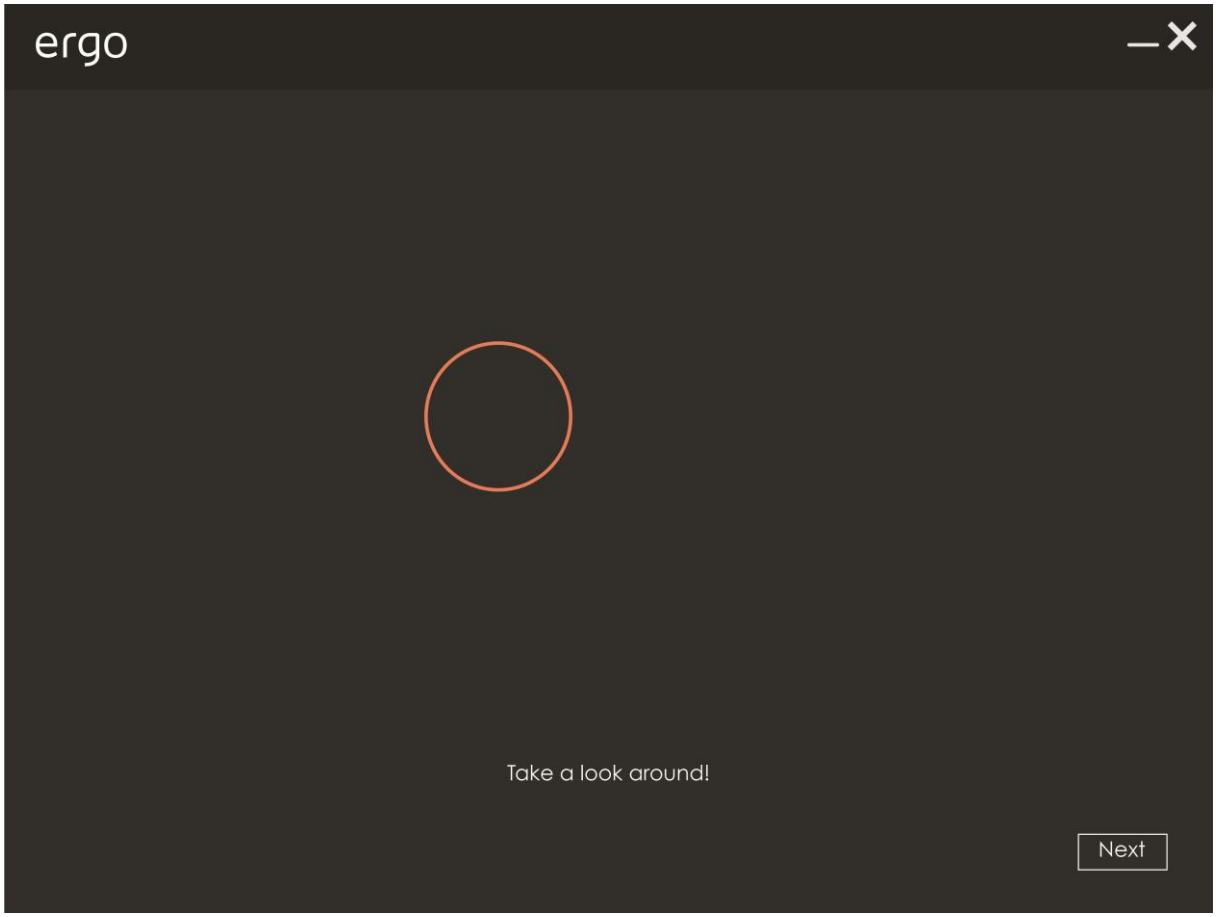


Figure 48. Trying eye tracking for the first time. The circle will follow the gaze point of the user.

Tutorial

When the settings are done, the tutorial starts. It is the part where user learns how to use eye tracking as a navigation tool through different interaction methods. The first page of the tutorial is an overview of the four main functions that the user will get to learn in this initial stage, see Figure 49. These four functions; left click, right click, double click and scroll, are the same operations that a conventional mouse allows. There are two more functions in Ergo, drag and drop and mouse teleport, and three features; the app switcher, shortcuts and the insights panel. These functions were part of the tutorial in the prototype, but are not introduced to the user in the tutorial in this concept. The features will also be presented in later tutorials. The beta test participants tended to be overwhelmed by the complexity of the program at this stage, which lead to them only remembering the basic functions and not learning and using the other functions and features. By that, they missed a large and convenient part of Ergo. In this proposed adoption design, the tutorial is divided into several parts, where this initial one is presented in the digital guide that is launched immediately after the installation and the other parts are presented when the user is using the four basic functions regularly.

By presenting the four basic functions in an overview, the user gets a better understanding of what the program can do and what they are expected to learn, in order to make them in control of the situation and not feeling overwhelmed. The four functions that are chosen; left click, double click, right click and scroll are the ones that are usually available on a conventional mouse, facilitating the transition from using a mouse to using an eye tracker, in accordance to interaction

theory presented in section 4.2. Below the symbols of the functions, the user is informed that they need to use their eyes and a keyboard button to operate the program, which is a necessity as many test participants expected to use only their eyes.

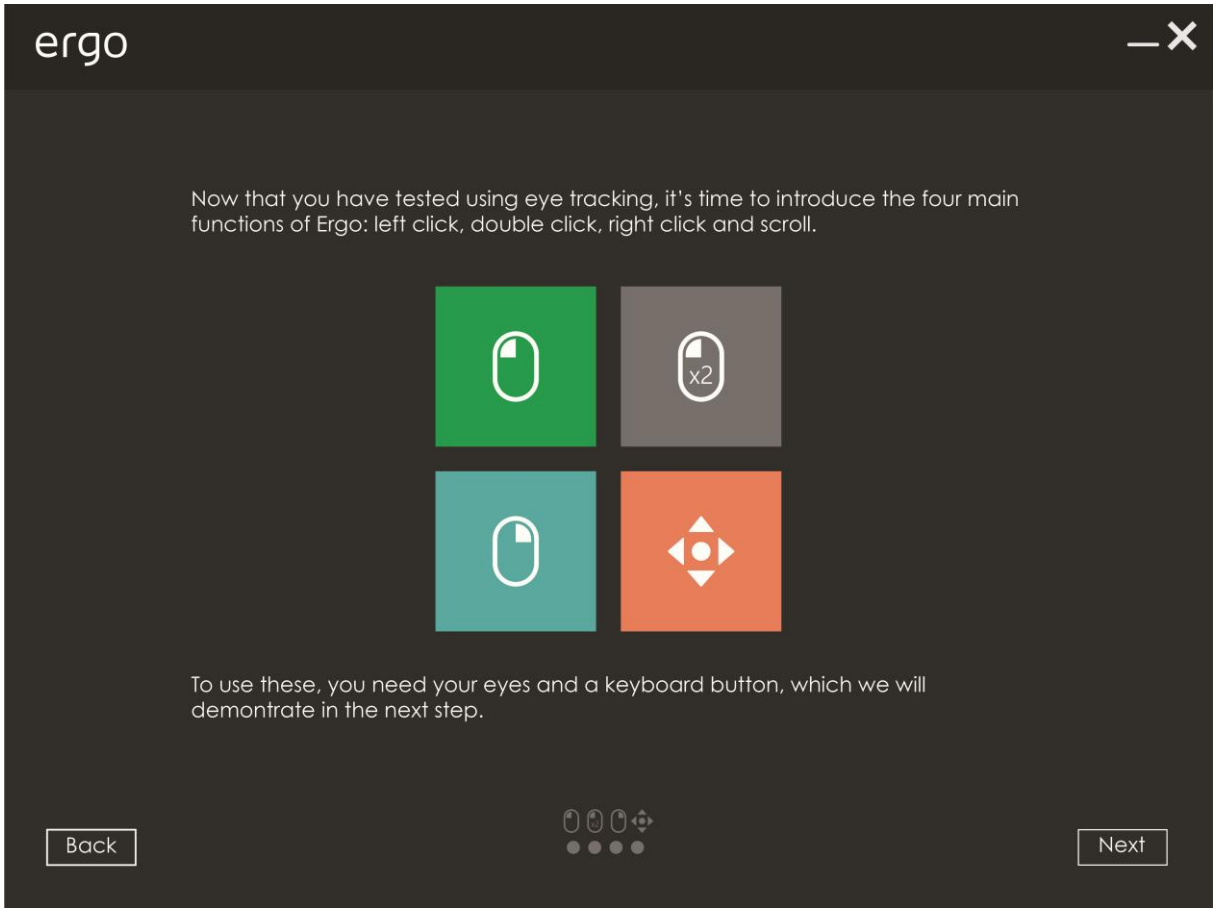


Figure 49. Overview of the four main functions of Ergo.

As stated in the overview page, the user will be given a keyboard button that will function as their activation key whenever they want to use eye tracking, see Figure 50. This key will override the other functions of it, and because of this, a commonly used key should not be chosen as the activation key for eye tracking. By choosing the key for the user at this stage, the tutorial will be simpler to follow and more linear, as the user cannot take any secondary tracks where they would need advice on how to choose a suitable key. Arguably, it could be useful to give the user a choice to change the key, especially because a few keyboards are not equipped with a right control-key, but the advantages from making the process linear for most of the users are on the other hand deemed more important. There are technical possibilities to use an external button as an activation key, which the user could hold in their hand or place anywhere, and this is something that some users have been asking for, as presented in section 6.3. This would also ease tension in the shoulders and arms of the user, according to section 4.1, as they could rest their hands in their lap. For users who need to type a lot in their work, an external button would most likely be irrelevant as they will need to use the keyboard anyways.

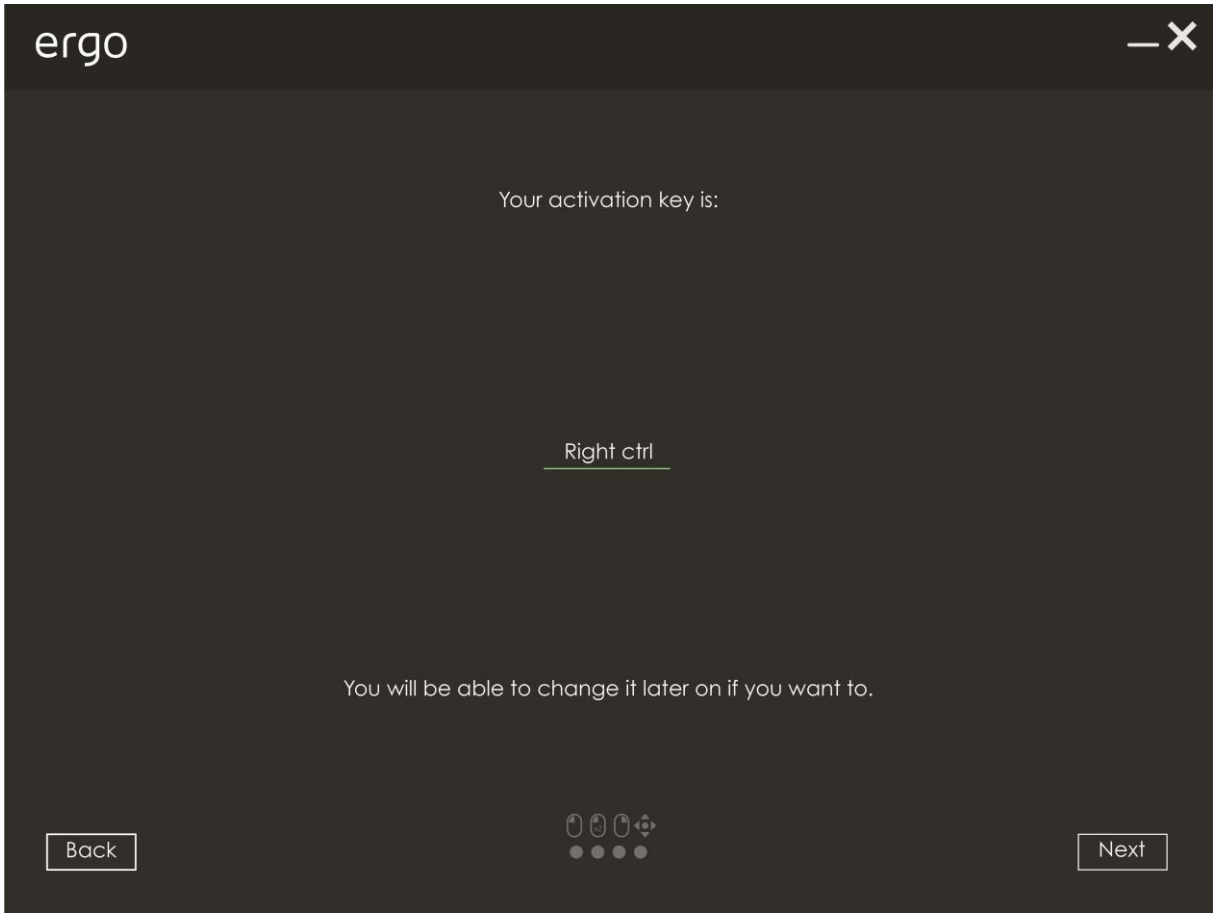


Figure 50. The activation key is presented.

After the overview and introduction of the activation key, the learning part of the tutorial starts. Each one of the four function has two interactive pages, which can be seen in Figure 51. On the first page the function is introduced and the user get to try it on an object with guidance and hints from the program. On the second page the user gets to try to use the function in a desktop environment in order to learn in what situations the specific function can be used. The second page is added as beta test participants expressed confusion of how to convert their knowledge from the tutorial into their working environment later on, as described in section 6.3.

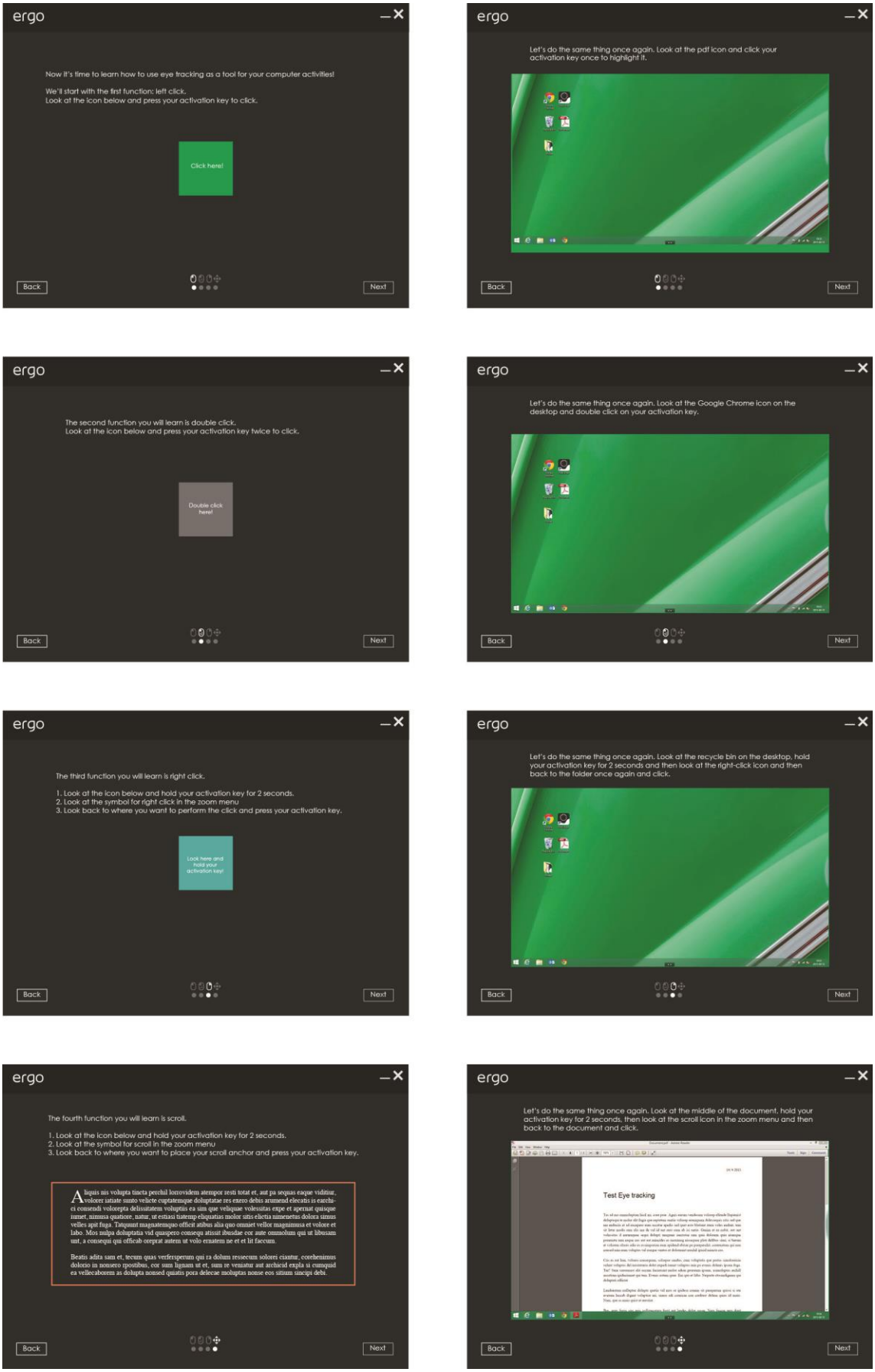


Figure 51. Overview of the tutorial for the four basic functions, left click, double click, right click and scroll.

When all four main functions have been presented, the user is once again presented with an overview of the four functions to provide feedback on what they have just learnt. They can now choose to try any of them again if they wish to practise, see Figure 52.

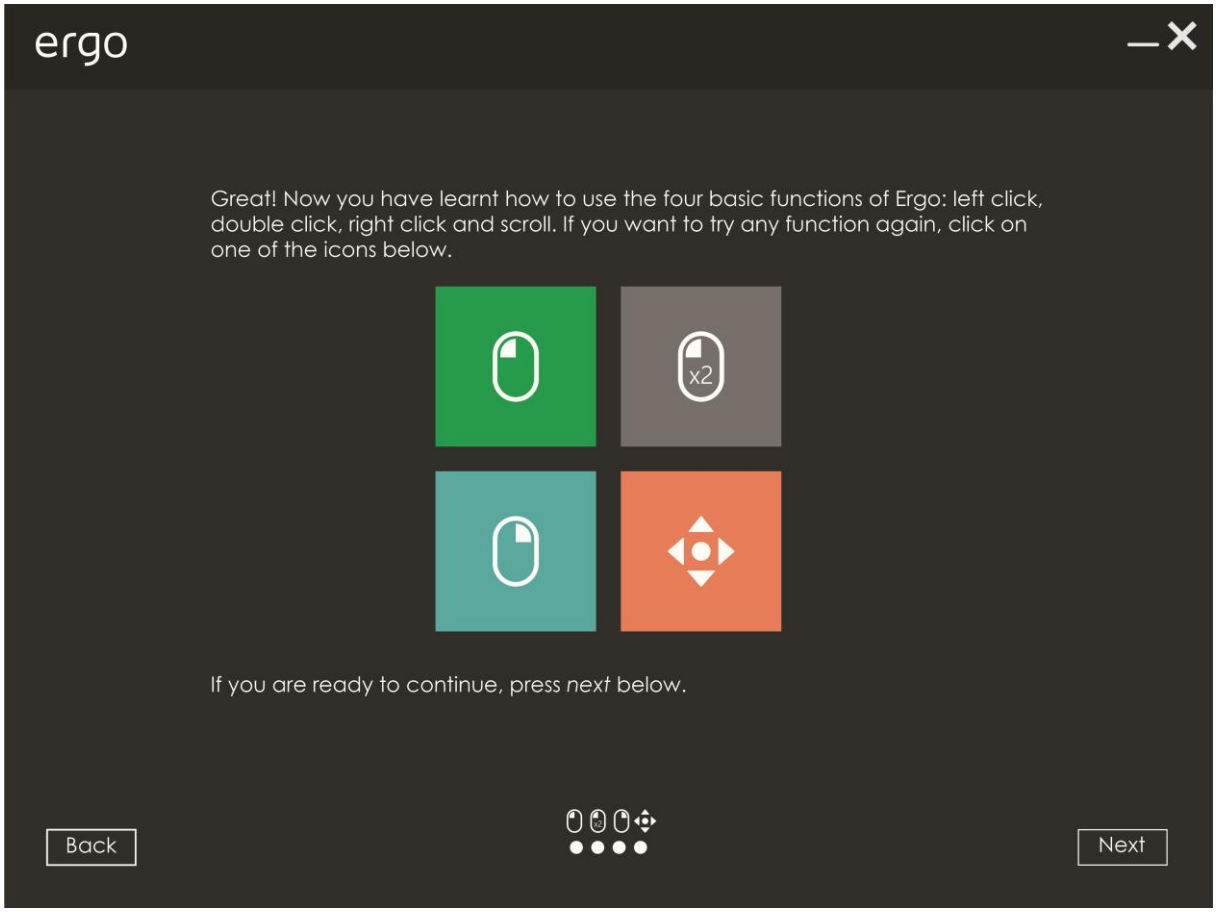


Figure 52. Second overview of the four basic functions of Ergo.

Finishing the digital guide

When the tutorial is finished, see Figure 53, the digital guide ends and the user is supposed to be comfortable enough with the technology to use the four basic functions as a tool. Some beta test participants expressed feelings of being lost when the tutorial ended, and to prevent that feeling it should be clear what has happened during the guide and what will happen next, when it ends. The user can now continue to use their computer, with eye tracking as a navigation tool, or open the program and change settings, recalibrate or learn more functions directly. When the user press *Finish*, they guide minimises into an icon on the taskbar, see Figure 54, from where the Ergo program later can be opened. By showing where they can reopen and return to the program they will further understand that Ergo contains a software, which will help convert their conceptual model towards reality.

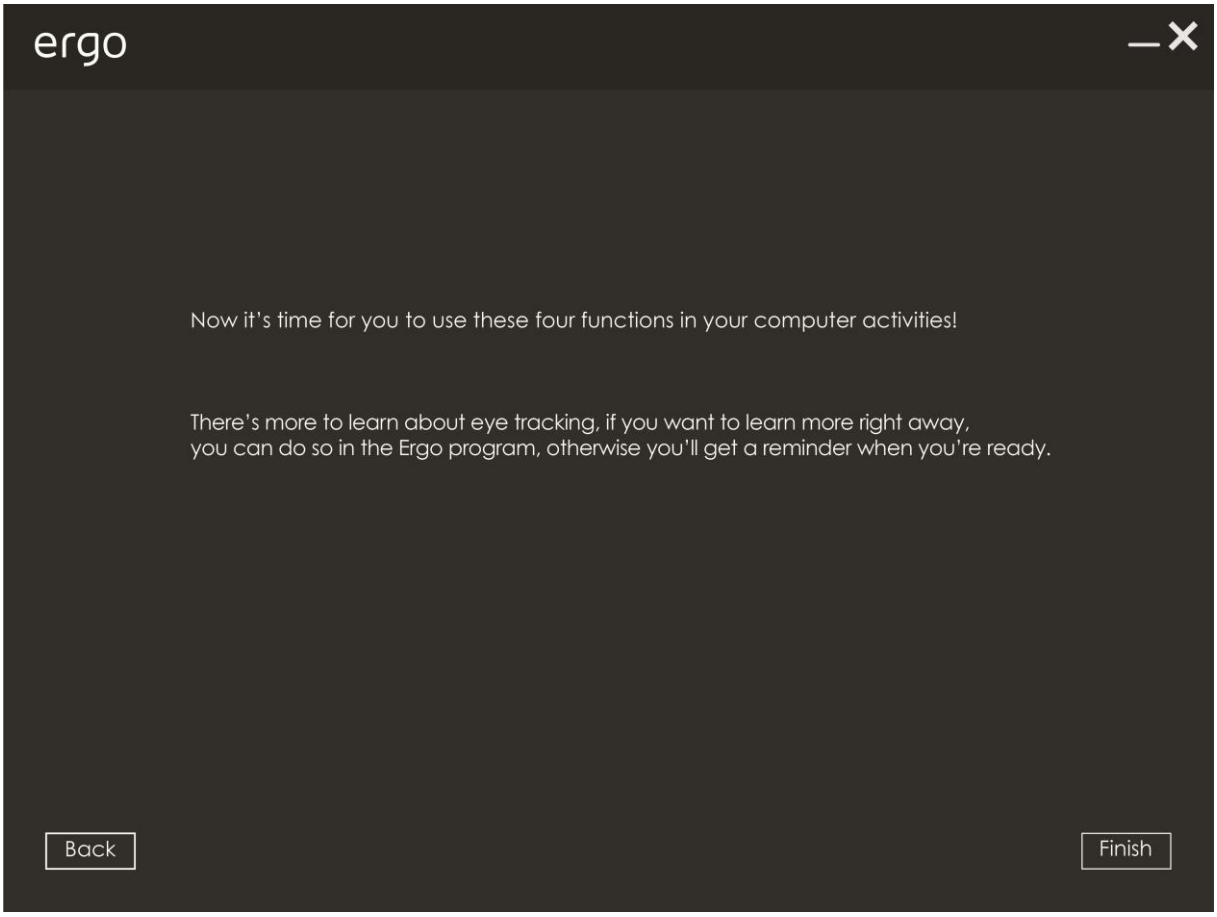


Figure 53. Final page of the digital guide.

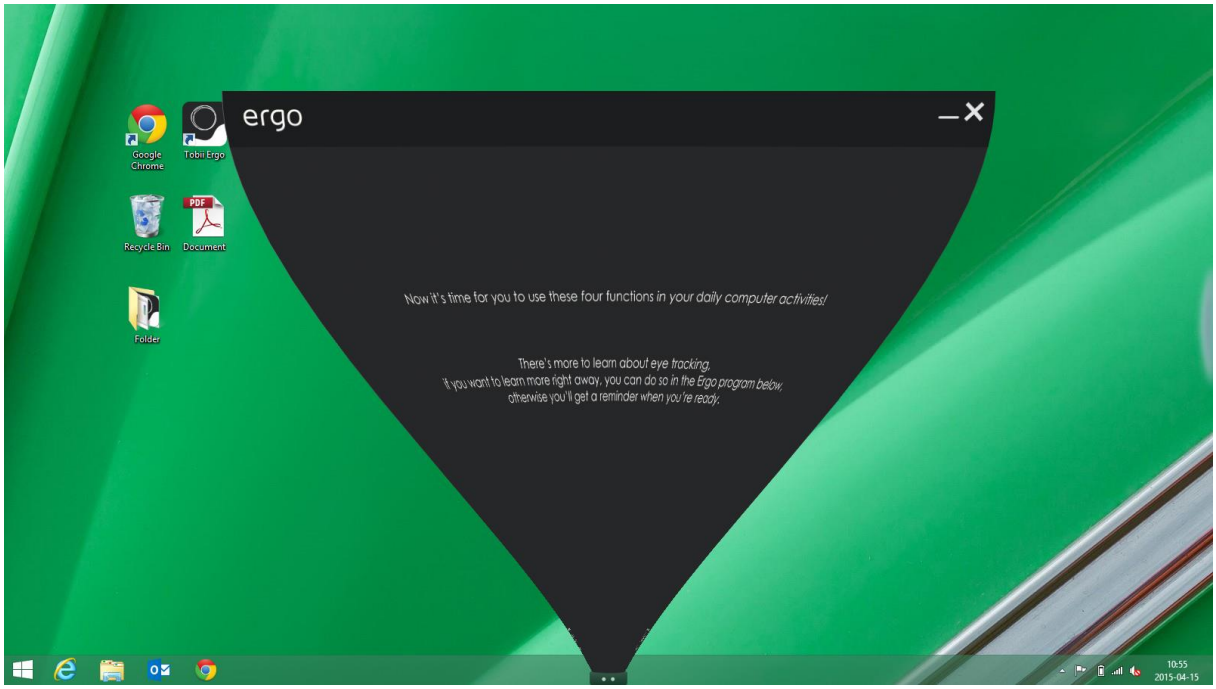


Figure 54. The digital guide minimizes into the task bar.

8.4 Continued learning and independent usage

This section presents steps 14-23 in the linear adoption design presented in Figure 32. The steps involve continued learning for the user with using Ergo in daily work. After the user has finished the tutorial in the beta version they are expected to know how to use eye tracking while working on the computer. However, many beta test participants found the transition from their previous navigation tool to eye tracking hard as they had to break their old habits. To help future users into forming a habit of using eye tracking as their primary navigation tool, the learning process will be gradual, where functions and features will be introduced to the user over a longer period of time. With this process they will be introduced to new functions or features when they are using those on their present stage regularly. The order of introduction is presented below, and corresponds to the steps in Figure 32.

16. Two additional functions: mouse teleport and drag and drop.
19. Two features: app switch and shortcuts
22. The last feature: insights

Some users might want to learn more functions immediately after the first tutorial. In this case, when they open the program, it will give them the choice between practicing on previous tutorial, change settings, or learn more. If they choose the latter alternative, they will be able to see the tutorials that are intended to be presented gradually directly.

However, it is expected that most users want to get accustomed to the four basic functions first and not choose to learn more directly. In this way, the users should be able to form a habit of using eye tracking. Some of the beta test participants expressed that if someone had reminded them they would have used eye tracking more. To encourage the users and remind them on a kind note to use eye tracking there will be notifications from the program if they are not using eye tracking regularly, see Figure 55. These notifications are supposed to not be imposing on the user and gradually become less frequent as the user increases the use of eye tracking. The reminders can be turned off in the settings menu in the program if the user wishes to.

When the users regularly use the four basic functions, which can take a few days or up to a few weeks, Ergo notifies them when they should add more functions to their knowledge. In this second tutorial, see Figure 56, they are introduced to the functions *drag and drop* and *mouse teleport*. These functions are not necessary to learn to use at first as eye tracking supposedly will be used as a complement in this stage of development, as it was preferred by the beta test participants in the user study. Drag and drop is used to highlight an object on the screen, i.e. an icon on the desktop, and then moving it. Mouse teleport is used to rapidly move the cursor from one point on the screen to where the user is currently looking. The tutorial for these functions will be based on the same principle as the first; the user gets information about the function and tests it on one page and then there is a test in a desktop environment to facilitate the transition of the knowledge later on.

Figure 55. Reminder about using eye tracking.

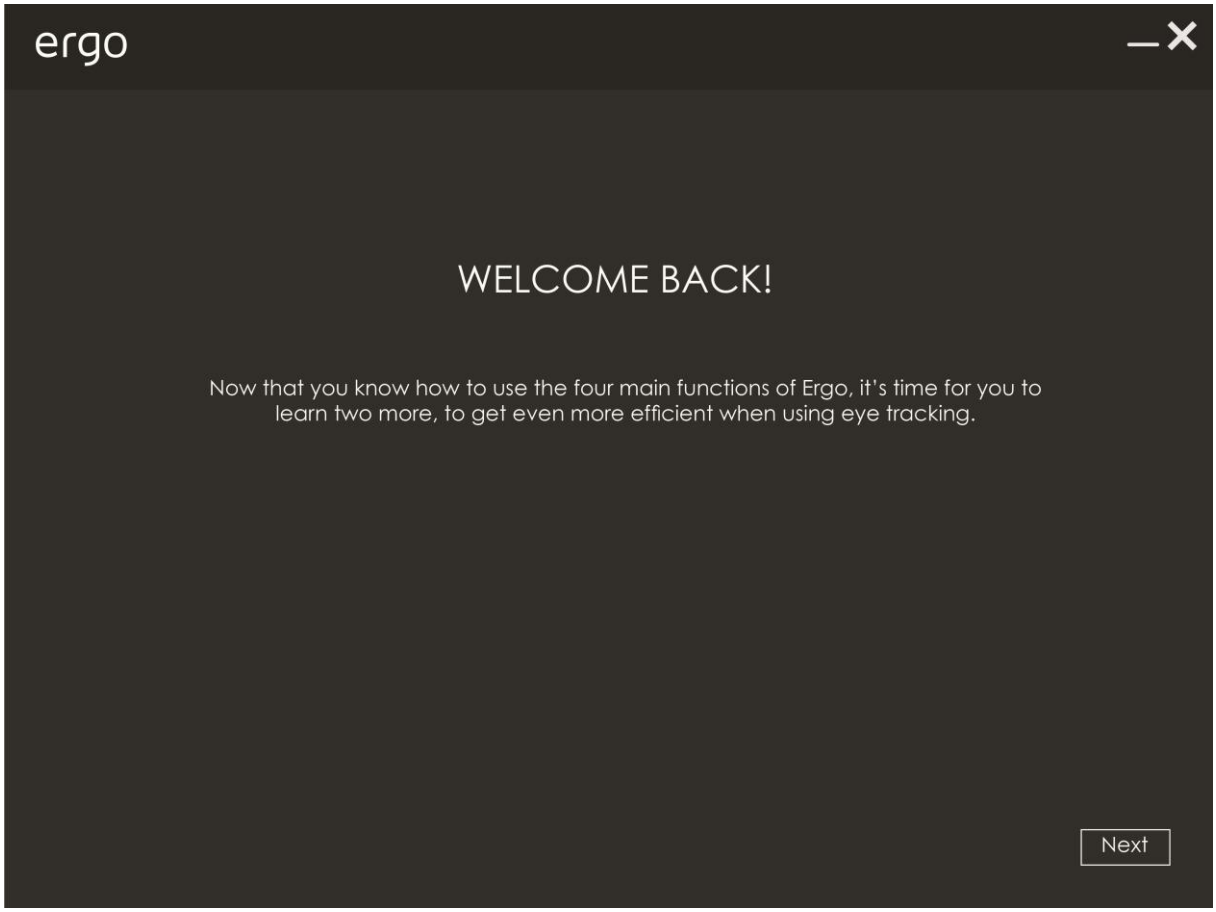


Figure 56. First page of the second part of the tutorial.

Following the same system as before, the user gets notifications with reminders to use these two functions if they forget them, which gradually becomes less frequent. The next features of Ergo to be introduced are *shortcuts* and *app switch*. Shortcuts opens a menu where the user can add actions or destinations (such as programs or files) that they commonly use. App switch opens a menu visualising all the programs that are being used to let the user quickly navigate to the desired one. As these are features and not functions of the program, they will not be presented in the same way as the functions have been. Rather than a tutorial, they will be introduced directly on the desktop. Information will be provided on the same guide platform as before, with directions on where to look on the desktop to activate the feature, see Figure 57.

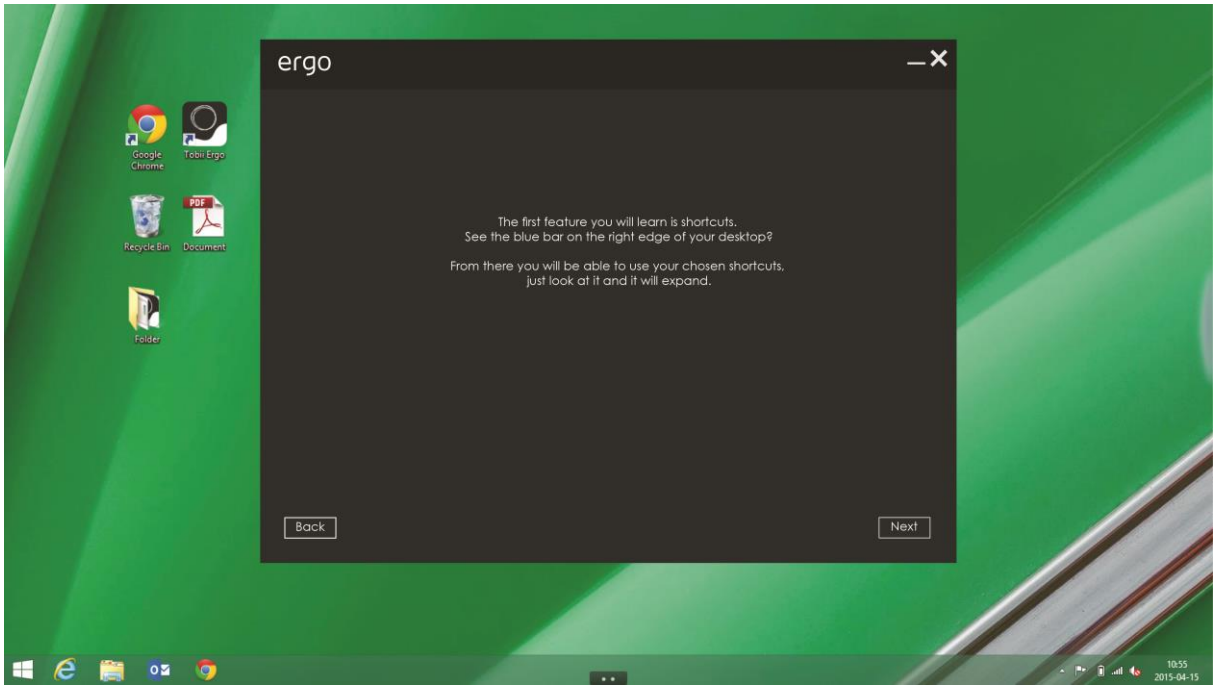


Figure 57. The tutorial of the shortcuts feature of Ergo.

The last feature to be introduced is the *insights panel*. The insights panel allows the user to log their ergonomic progress while using Ergo, based on how long they sit in front of the screen, how often they use eye tracking instead of the mouse etc. As some beta test participants expressed feelings of being monitored, the insights panel could contribute to increase that negative feeling and at this stage the user should be able to choose if this feature should be activated or not.

When the insights panel has been introduced, all of Ergo's functions and features have been presented for the user and they should with this gradual learning process now be ready to use eye tracking independently and form a habit of doing so. In the Ergo program the user can now find information about all the functions and features, change settings and follow their progress on the insights panel.

9 Results and Evaluation

This chapter summarizes the results from the project and presents an evaluation of Ergo and the developed adoption design. The evaluation is based on the requirements presented in 7.1, the theoretical framework in chapter 4, and feedback from beta test participants.

9.1 Summary of results

The contextual study of Ergo, as well as the user study resulted in a great number of insights about the product and its context. These insights were summarized in a table of guidelines, Table 7, that are essential to follow in the development of Ergo in order for it to be suitable for the user, profitable for Tobii, more feasible and ready for market launch. The compiled guidelines were taken into consideration in the development and were useful in the evaluation of the design.

The insights from the contextual study and the user study also resulted in a list of problem areas with the product and its context, section 7.2 and 7.3. These problem areas were both related to the potential user, the usage of Ergo and its market context. Due to the limited time frame of the master thesis, it was chosen to solve and work with one of the problems for the development of Ergo. The problem of the users' varying conceptual models and difficulty in adopting eye tracking as a tool in daily computer activities was chosen to work further with.

The presented solution to the problem is a product design of Ergo to facilitate adoption, described in chapter 8. It involves a linear process of unpacking and installing the product where the user's conceptual model is gradually met and guided towards reality. It further involves a new system of how to learn to use eye tracking as a tool in daily computer activities. The system starts with introducing the main functions of Ergo, while further features are added when the user is comfortable with the basic functions. In this sense, the product evolves with the user in their own adoption pace. The overall adoption experience is guiding, comprehensive, friendly and intuitive while also communicating feelings of excitement and high-tech.

All research questions presented in section 1.3 have also been investigated and answered throughout the project.

9.2 Requirements

The requirements presented in Table 7 should be considered for the overall development and marketing of Ergo. The development of the product adoption covers 9 of 12 of the requirements. These nine requirements are presented below, followed by a description of how each requirement has been followed.

1. Ergo should follow Tobii Dynavox brand identity.
This has been considered through the chosen package design as it carries the logo of Tobii Dynavox. The whole product also expresses user friendliness and the purpose of the product is to facilitate life for the user, as it relieves their ergonomic pain.

3. Ergo should have a design that attracts the buyer and re-sellers.
The package is discreet and gives a professional impression with its clean design. The product expresses uniqueness as it is the only ergonomic aid on the market utilizing eye tracking technology. Also, the technology behind it has an innovative value, giving the product an innovative impression.

4. Ergo should be designed as an ergonomic aid to suit the market of pain relief.
This guideline has not been in focus, but has yet been considered when developing the product adoption design. Since Ergo is an ergonomic aid, the design has followed the general visual expression of ergonomic aids presented in Figure 20 in section 5.2. It has a dark, clean and professional design approach and is therefore suitable for a diverse group of people.

6. Ergo should bring news-value to the customer
This guideline is followed as Ergo uses a technology with news-value to the customer. It offers a method of navigating the computer that is brand new to many people with ergonomic problems.

8. Ergo should be designed in a non-intimidating way
The product adoption design has followed the design of the mood board presented in Figure 33. The focus of this design is to express a friendly and intuitive mood, which are both ways of describing a non-intimidating product.

9. Ergo should emphasize the positive associations
The positive associations of eye tracking; excitement and high-tech is naturally emphasized through the news-value eye tracking brings to the user. The product adoption design also emphasize excitement with the layered design of the package. The layered unpacking experience brings excitement to the user as different components are slowly revealed at different times. The excitement also follows in the digital guide as moments of excitement have been integrated, as presented in Figure 42.

10. Ergo should understate the negative associations
This guideline has been partly considered in the development of the product adoption design of Ergo but has not been in focus, as it deals with another problem area than the chosen one in chapter 7. The friendly and intuitive guide is however decreasing these negative associations as it gives the user a feeling of being calm and in control.

11. Ergo should guide the user's conceptual model of eye tracking towards reality.
This guideline has prominently been followed when developing the adoption design of Ergo, as this address the solution of the chosen problem area. Firstly, this has been considered in the unpacking experience as the eye tracker is the first component of Ergo is introduced. This directly gives the user the idea of what an eye tracker looks and feels like. Secondly, the front

page of the installation guide provides two vivid pictures of where the eye tracker is supposed to be on the computer. Furthermore, each step in the installation guide provides images of how the hardware works and looks like. Continuing, the digital guide initially introduce the actions the user normally does with their mouse. This is because they believe that these are the functions that Ergo will provide. More functions and features are introduced when their conceptual model has changed to more reality based. The user's conceptual model is further guided towards reality as the tutorial presents desktop visualizations of how the interaction works in reality.

12. Ergo should guide the user into daily usage of eye tracking

This is the guideline that the adoption design follows the most. The total experience with unpacking, installation, tutorial and learning system is designed to be guiding for the user. The linear process described in Figure 32 is a straightforward guide for the user to avoid moments of confusion and being lost in the adoption of eye tracking into daily computer activities. The system of introducing the basic functions first, and adding more features as the user adopts to the technology also acts as a friendly guide of learning how to use eye tracking. Additionally, the digital guide uses feedback and feedforward information to guide the user through their first experience of eye tracking.

9.3 Evaluation based on theory of physical ergonomics

According to the theory of physical ergonomics presented in 4.1, the main factors associated with repetitive strain disorders at work are force, posture, repetition, duration and stress. These factors will be used when evaluating Ergo from a physical ergonomic perspective, see Table 9. The factors that Ergo affect positively, are marked with green, the factors that are the same compared to general competitors are marked with yellow, and the factors that Ergo affect negatively are marked with red.

Table 9. Evaluation based on physical ergonomics. It shows a comparison between Ergo and a conventional mouse.

	Use
Force	
Posture	
Repetition	
Duration	
Stress/strains	

Relatively to a conventional mouse, which Ergo is aimed to replace, the main advantage is that using a mouse causes a static and non-neutral strain situation for the hand, which is not the case for keyboards. Keyboards do have their disadvantages as well as they cause ulnar deviation and fatigue. The force that the user needs to apply on a key on the keyboard to activate eye tracking is in the same order of magnitude as applying force on a conventional mouse. The same goes for

repetition as the same amount of clicks need to be made with Ergo as with a conventional mouse. Duration is another factor that will not be affected by using Ergo relative a mouse or other navigation tool as this is a factor that is not influenced by the tools themselves. What Ergo makes worse than when using a conventional mouse however, is the user's posture as it removes the small freedom of movement that the user has when using a mouse. When sedentary, most people cannot sit erect in a 90° posture for long periods and they will soon adopt a slumped posture, but due to the space limitation of the track box, they cannot use eye tracking while leaning back. This forces the user into a certain posture. Furthermore, when the job itself is physically constrained, which it usually is at offices, it requires maximum flexibility to be built into the workspace to compensate and Ergo is rather the opposite, making the users feel more stationary.

Conclusively, Ergo helps the user to reduce strain in their hands as they will use a keyboard instead of a mouse. In this sense, it is a useful tool for people with mouse arm and other ergonomic complications related to the physical movement of the hands and arms. However, the fact that Ergo causes its users to be more stationary makes it a non-suitable tool according to the posture aspect. As physical ergonomics has not been the focus in this master thesis project, there are no conclusions made on whether Ergo is better or worse in total than using a conventional mouse.

9.4 Evaluation based on theory of interaction design

According to the theory of cognitive ergonomics, people will use two kinds of knowledge to solve a problem; knowledge in the world and in the head. Knowledge in the world, in form of perceived affordances, signifiers, mappings and physical constraints, gives the user clues on what to do. Whereas knowledge in the head, such as conceptual models, cultural, semantic and logical constraints provide solutions for previous, similar problems. As users tend to be upset by change due to the violation it causes to their conventions, a product needs to be designed in order to help the user into understanding the new product. This is done by providing sufficient knowledge in the world, which the user can combine effectively with their knowledge in the head. This could be also be done by incorporating old, familiar ideas into new technologies such as eye tracking to help people to understand the new device and overcome their fear of the new.

As eye tracking is a new technology, it will cause violations to people's conventions and the best way to make them comfortable with using eye tracking is to let them be in control of the situation by providing sufficient feedback and information so they can construct a conceptual model. In the design to facilitate product adoption, Norman's six fundamental principles of interaction have been considered, see Table 10.

Table 10. Evaluation based on interaction theory.

	Use
Feedback	
Conceptual Model	
Affordances	
Signifiers	
Mappings	
Constraints	

The development of the unpacking experience and learning process has focused on understanding what constraints the users normally have when navigating their computers in order to be able to provide necessary feedback and signifiers to the user so they in turn are able to construct a useful conceptual model of Ergo. The linearization of the usage process is a result of this focus, to give the users less possible actions and making those actions possible easier to detect. The possible actions themselves, the affordances, should match the desired actions as they provide the same functionality as any other navigation tool, like the mouse. They have, however, not been further developed from what they were in the beta version. Mapping is concerning the relationship between controls and their actions. As this is mostly revolving around the interaction of performing the functions, not learning them, it has not been in focus either in this project. This part has been proved rather difficult for the beta test participants, as there are no natural mapping between looking at a spot, pressing a key and what will happen by doing so. However, they can understand it by conventions, if a click is performed on a desktop folder, it will open. Understanding what conventions and constraints people usually have when navigating a computer resulted in the fact that they should be presented with Ergo's four basic functions at first, as they correspond with the functions of a mouse. This helps the user to make the transition from using a mouse to using eye tracking as their computer navigation tool easier to overcome. When the users are comfortable with the use of these four functions, they are presented with other functions and features. To further give them the feeling of control, and guiding them into usage of eye tracking, signifiers and feedback have been used continuously. Examples of signifiers are that in the package, it is clearly displayed what component does what and in the digital guide it will be communicated what function that could and is supposed to be used at each page. Feedback will be provided similarly in the digital guide, communicating to the user when they performed a function correctly and otherwise giving them hints to help them. By ensuring discoverability this way, revealing the full extent of the program bit by bit, communicating and guiding in accordance with their previous conventions and also by letting them have time to perform trial and error in order to learn, the users should get sufficient information in order to construct a correct conceptual model. By ensuring that the fundamental principles of interaction

are in focus in the design, it should guarantee that the user's experience of the product will be positive and therefore making Ergo a successful product.

9.5 Evaluation based on theory of the market of technological innovation

In theory, it is said to be important that people can relate to Ergo and understand what role it would play in the customers' lives, and will otherwise be difficult to succeed on the market. In this sense, the developed adoption design is of great value for Tobii as it guides the user into understanding how they will use it as a tool in everyday life.

Ergo is in the beginning of the innovation diffusion curve. The theory suggests that the early adopters of innovation are willing to pay high prices, will accept some incompleteness and expects complexity and uncertainty in the product. The user study however indicates that the diffusion of Ergo may look slightly different. The user study participants have shown signs of avoiding to adopt Ergo if it is too complex or uncertain. The test participants might however have been people that in reality would belong to the early majority. The diffusion curve of Ergo may also slightly differ from theory because the users' will not always be the person deciding to obtain it. The buyer, normally managers of the companies, or the resellers may be the ones deciding to obtain Ergo for an employee. In this case, the user may not be similar to the early adopters described in theory. The design proposed in chapter 8 is appealing for this kind of user group as it expresses friendliness and facilitation of life rather than complexity. The first users to make the decision by themselves are more likely to be people who actively look for ways of dealing with their ergonomic problems. This behaviour group in described in chapter 6 and Figure 25 is more similar to the early adopter category described in the innovation diffusion theory. They will however also appreciate, according to the results from the user study, the developed adoption design presented in the previous chapter.

As the theory suggests, users will rely on both subjective and objective information when assessing the overall value of Ergo. This has been seen in the user study as both perceptions and anticipations of eye tracking and Ergo matter if they like the product or not. Theory also suggests to study the whole user experience with Ergo from different utility levers in order to find other factors of customer value. Of all phases in the user experience described in section 4.3, the project was delimited to only focus on usage. In this stage, all six utility levers can be looked at to evaluate what value Ergo brings to the customer, see Table 11. The utility lever environmental friendliness is however delimited from the master thesis and will therefore not be evaluated.

Table 11. A utility map for Ergo to evaluate customer value. Only the phase of usage has been evaluated.

	Use
Productivity	
Simplicity	
Convenience	
Risk	
Fun and Image	
Environmental friendliness	–

The developed product adoption design offers the customer simplicity, as it makes a rather complex product feel linear. Fun is another utility lever that that brings customer value, as many participants end their journey with positive feelings towards eye tracking, Figure 26, and describes the testing as a fun experience. Convenience is another value that Ergo succeeds to bring to the customer. Enabling people with physical ergonomic pain to navigate their computer with less physical motion is convenient for the user. The developed product adoption design also creates convenience for the user as the product is easier to learn and use. Furthermore, the primary risk a customer is taking when deciding to use Ergo, is the time consumption of adopting a new tool for computer navigation. This risk is reduced by the adoption design and can therefore be argued to bring customer value. On the contrary, the utility lever productivity can however be argued not to bring customer value with Ergo, as many participants in the user study expressed feelings of being less efficient and productive. Even if they experienced pain relief, their productivity was decreased. Conclusively, the utility map shows that Ergo with its developed product adoption design creates customer value hence creating higher chances of succeeding as a product.

The theory further argues that customers look for compatibility, complexity, relative advantage, trialability, benefits and observability in products to potentially obtain. In the development of the adoption design, the first two factors have mainly been in focus as the remaining are primarily related to marketing. Compatibility in this context means to which extent adopting and using the innovation is based on existing ways of doing things and standard cultural constraints. This is considered in the project when working with the user's conceptual model. Their cultural norms and standard way of perceiving things has created their conceptual model of how they believe Ergo will look like and function. The developed adoption design therefore contributes to making Ergo more compatible, hence more attractive for the user. Furthermore, the design also reduces the complex perception and will hence also make Ergo more attractive to obtain.

Since Ergo is the first of its kind on the ergonomic market, it does not have a dominant design to beat or follow. This insight concluded in more freedom when developing the product adoption design.

9.6 User feedback

A functional prototype of the digital guide, a 3D-model, rendered pictures and sketches were presented to three users who took part in the beta study, in order to obtain user feedback. The responses were positive and only minor changes were suggested to the overall design. The users felt that the layered package, installation guide and digital guide were intuitive and friendly. The adoption process of starting with introducing the basic functions of Ergo was also appreciated.

10 Discussion

This chapter discusses the chosen methods of conducting the project, as well as suggestions of improvements and further work. The researchers' own reflections on the project are presented in the end of the chapter.

10.1 Methodology Discussion

The project was divided into three major parts: research, analysis and development. The research phase, which was the largest, has been based on an iterative process. This has proven to adapt well to the agile working environment at Tobii Dynavox, as it has given the possibility to update the tools along with the process. With a major software update during the beta tastings, some participants have used the old version and some the new. Because of this, the results have at times been difficult to interpret. However, if the approach had not been iterative, interesting insights would have been left out. The beta testing was the most essential part of the research, but it was necessary to complement with other data retrieval methods; short term beta tests, interviews and a survey. Together, the methods have provided a comprehensive picture of the context of Ergo. The user study resulted in important insights, which would have been hard to obtain through other methods. One method that however could have been added to the beta testing is a discussion with a focus group of beta users, which may have resulted in further and deeper insights.

The transition from the research phase to the analysis phase was natural, as the research phase was saturated with insights. There was hence no need for further iterations. By doing an analysis of the research findings, problem areas were defined and requirements were specified. After the analysis, the development phase was conducted. However, it would have been valuable to conduct workshops in this transition, primarily with the development team at Tobii Dynavox, but also with beta test participants. By doing this, other ideas and concept may have evolved due to the different backgrounds of the participants.

The development phase was also conducted with an iterative approach, meaning that brief brainstorming sessions were carried out continuously throughout the process. This resulted in many different concepts of details in the adoption design. However, as the chosen problem area is very specific and well defined, there was no need to develop several different concepts for the overall design. Due to the substantial need of user insights at the product development stage in which this project started, the development phase was chosen not to be the greatest part of this project.

The chosen methodology has proven to give valuable results in both the research phase and the development phase. The choice to use qualitative methods in the user study is argued to have had a major impact on the result of the whole project. The findings by using these qualitative methods could not have been obtained through quantitative methods. Similar stages of other development projects are also likely to benefit from a qualitative study, especially when developing a product of high novelty such as Ergo. Unfortunately, qualitative studies seem to not be prioritised and thus missing out on the root cause of problems connected to a product.

10.2 Improvements and further work

The master thesis has resulted in useful and novel information about eye tracking in the ergonomic context. However, improvements of the research can be done. Primarily, the delimitations of the project should be decreased in order to increase result validity. A greater number of people from a more diverse group should participate in the research. This requires a larger number of available beta products and more people with ergonomic problems willing to participate in the beta program. The test participants should also use Ergo for a longer time to investigate and ensure the long term user experience with Ergo. Furthermore, to ensure a fair test, the software used in the investigation should be more stable and the same version should be used by all participants. Also, the eye tracker decided by Tobii to be part of the Ergo package should have been the one investigated in the tests.

For further work, all problem areas described in section 7.2 and 7.3 should be further investigated and looked more into in order for Ergo be suitable for the user, profitable for Tobii, more feasible and ready for market launch. The remaining three problem areas assessed to be the most critical should be prioritized to solve. Furthermore, a more thorough investigation of other stakeholders of Ergo, such as resellers and buyers, should be conducted. An investigation of other parts of the product life cycle, such as production, transportation and disposal as well as environmental aspects can also be part of future work.

The adoption design developed in the master thesis can also be further worked with. It should primarily be tested by a large number of people with ergonomic problems in order to retrieve more user feedback. The feedback can be used to change and improve the design further. The development should also be improved and worked with by graphical designers to create a more user friendly graphical interface, since this has not been in focus in the master thesis. The proposed design should also be evaluated from a feasibility aspect by Tobii, as they face difficulties with combining hardware and software developed by different parts of the company. Finally, the design should be tested and evaluated by the US division of Tobii in order to investigate its feasibility in the American market. An investigation of Ergo from a global perspective can further be made and be part of future work.

Since the study in this project aimed to find the underlying problems and the users' experience with this novel product, it was chosen to have a qualitative conducting approach. But now when the problem areas and insights about eye tracking in the ergonomic field has been revealed, a quantitative study can be made to further validate the findings.

10.3 Researchers' reflections

The master thesis has largely evolved around making a technical driven product development process more design driven by putting the user in focus. Working with a company and in a team that has a different approach of product development has been both challenging and educational. Managing a product design process in an ever-changing agile work environment has been one of the greatest challenges we had to face in the project. The knowledge about product development obtained from our education has proven very applicable in the project, however, a standard development process was difficult to follow in this environment. We have therefore naturally been encouraged to create our own development process to manage a design process in agile

development. This insight and experience has been educational and enlightening for us, as it has provided knowledge of how product development can look like in reality.

Being situated at the company together with the software development team has had many benefits. We have been able to follow the development of the software and the changes and decisions made for Ergo's future. We have also been able to work close together with software developers and experts within the field of eye tracking. This has given us important information that otherwise easily could have been missed or overlooked. Working close to the development team has also shown us the value of having a supportive, sensible and experienced academic supervisor who has the ability to follow the project from the outside. It is easy to get caught up in the mind-set of other developers when situated with them, and hence difficult to keep a questioning attitude towards their decisions. The academic supervisor, not being equally involved in this process, could hence guide us well throughout the project by providing a different point of view.

The project has involved working with an exciting and innovative technology that is unknown and unexperienced by many. Applying this type of technology in a new field is a factor that has made the project extra fun and interesting to manage. The novelty of the research has however also brought some challenges. It proved to be difficult to find theory and existing research of the topic eye tracking in the ergonomic field. We therefore had to broaden and generalize our literature research in order to find useful information to the project. This resulted in a theoretical framework mainly based on literature rather than research papers, as research papers commonly provide specific rather than general information.

Another great challenge we had to face in the project was the managing of qualitative data. Through a great number of observations and contextual interviews, the holistic picture of the potential user and Ergo's context emerged. To validate the findings, both of us have been present in all observations and we have continuously been discussing our observations to make sure they conform. This type of data is further difficult to present as it is not quantifiable and have only been briefly introduced in our education. We therefore had to make a research of methods of how to collect and manage qualitative data.

We have felt it has been fun and valuable for us to work with such a novel product in our master thesis, and see a great potential in the technology. The project has introduced us to the world of eye tracking which we believe is a technology that is waiting for the mass market to get ready. Ergo is a product that can prepare both the market and Tobii for a potential future where eye tracking is widely used and integrated in all kinds of electrical devices.

References

Allwood, J., & Jensen (red), M. (2012). *Kognitionsvetenskap: en introduktion.* Lund: Studentlitteratur. (in Swedish)

Andersson, Ö. (2012). *Experiment! Planning, Implementing and Interpreting.* Chichester: John Wiley & Sons.

Arbetsmiljöverket. (2014). *Work-related Disorders 2014.* Sveriges officiella statistik .

Bohgard, M; Karlsson, S; Lovén, E; Mikaelsson, L; Mårtensson, L; Osvalder, A; Rose, L; Ulfvengren, P (red). (2011). *Arbete och teknik på människans villkor* (2nd ed.). Stockholm: Prevent. (in Swedish.)

Bolstad, A. (1998). *Handbok i lärande.* Lund: Studentlitteratur . (in Swedish)

Bridger, R. S. (2008). *Introduction to Ergonomics.* London: CRC Press.

Broman, Å. (2015, 01 27). Product Manager at Tobii Dynavox. Interview.

Bryman, A., & Bell, E. (2007). *Business Research Methods* (2nd ed.). New York: Oxford University Press.

Chapman, J. (2005). *Emotionally Durable Design.* London: Routledge.

Duchowski, A. T. (2007). *Eye Tracking Technology* (2nd ed.). London: Springer-Verlag .

Eriksson, I. (2015, 05 08). E-mail. Conversation with product designer at Rahmqvist.

Eyetracking Inc. (2011). *What is eye tracking?* Retrieved 2015, from Eyetracking: http://www.eyetracking.com/About-Us/What-Is-Eye-Tracking

Henderek, D. (2015, 02 18). Global Product Manager at Tobii Dynavox. Interview.

Kim, W. C., & Renee, M. (2005). Blue Ocean Strategy - How to Create Uncontested Market Space and Make Competition Irrelevant. Boston: Harvard Business School Press.

Mohr, J., Sengupta, S., & Slater, S. (2005). *Marketing of High-Technology Products and Innovations* (2nd ed.). Upper Saddle River, New Jersey: Pearson Education Inc.

Moore, G. A. (2001). *Crossing the Chasm - Marketing and Selling High-Tech Products to Mainstream Customers* (Adobe Acrobat E-Book Reader v1 ed.). New York: HarperBusiness.

Norman, D. A. (2013). *The Design of Everyday Things.* London: MIT Press.

Olofsson, U. (2014, 11 05) *Science inclined to experiment, Scientist, engineers and other poets.* Lecture in Research Methodology in Machine Design MF2072. KTH. [online], [retrieved 2015, 05 27] http://www.kth.se/polopoly_fs/1.222329!/Menu/general/column-content/attachment/Lecture2_HT2011.pdf

Rogers, E. M. (1983). *Diffusion of Innovation* (3rd ed.). New York: The Free Press.

Ruben, F. (2015, 02 16). President at Tobii Dynavox. Interview.

Schilling, M. A. (2013). *Strategic Management of Technological Innovation* (4th Edition ed.). New York: McGraw Hill .

Stickdorn, M., Schneider, J., & co-authors. (2011). *This is Service Design Thinking.* Hoboken, New Jersey: John Wiley & Sons Inc.

Tobii AB. (2015). *This is eye tracking.* Retrieved from www.tobii.com: www.tobii.com/en/what-is-eye-tracking/

Tobii AB. (n.d.). *User's Manual: Tobii X2-30 Eye Tracker.* Retrieved from http://www.tobii.com/Global/Analysis/Downloads/User_Manuals_and_Guides/Tobii_X2-30_EyeTrackerUserManual_WEB.pdf

Ullman, G. (2010). *The Mechanical Design Process.* (4th ed.) New York: McGraw Hill .

Wikström, U. (2015, 01 27). Rnd Manager at Tobii Dynavox. Interview.

Figure 1
Tobii. Retrieved 06 02, 2015, from http://images.gizmag.com/hero/tobii-rex.jpg

Figure 8
Tobii. Retrieved 05 25, 2015, from http://www.tobii.com/en/about-tobii/what-is-eye-tracking/

Figure 12
Tobii. Retrieved 05 21, 2015, from http://www.tobii.com/ImageVaultFiles/id_2723/cf_60/Eye_Tracking_System_Tobii_Image_Tobii_X2_Eye_Track.jpg

Mynewsdesk. (2015). Retrieved 05 21, 2015, from http://d20tdhwx2i89n1.cloudfront.net/image/upload/t_next_gen_article_large_767/zmzms1d5fceegqwnumgi.jpg

Figure 19
Shopify. (n.d.). Retrieved 05 18, 2015, from http://cdn.shopify.com/s/files/1/0238/2031/products/Tobii-M-Series-Hero_With_Keyguard_MG_9515_1024x1024.jpg?v=139763391

Smartbox Assistive Technology. (n.d.). Retrieved 05 18, 2015, from http://www.smartboxat.com/wp-content/uploads/2013/05/I-Series-with-Symbol-Talker-A-copy.png

Smartbox Assistive Technology. (n.d.). Retrieved 05 18, 2015, from http://www.smartboxat.com/wp-content/uploads/2015/01/Untitled-21.png

Tobii Dynavox. (n.d.). Retrieved 05 18, 2015, from http://www.tobiidynavox.com/wp-content/uploads/2014/08/tobii-S32-428x278.jpg

Figure 20

Amazon. (n.d.). Retrieved 05 18, 2015, from http://ecx.images-amazon.com/images/I/71lYOLMZdWL._SL1500_.jpg

Amazon. (n.d.). Retrieved 05 18, 2015, from http://ecx.images-amazon.com/images/I/41pb8zbSH%2BL._SY300_.jpg

Contour Design. (n.d.). Retrieved 05 18, 2015, from , http://www.contour-design.co.uk/img.ashx?img=%2Fmedia%2F46085%2FContour_RollerMouse_Pro2_black_top_300dpi.jpg&width=235

Ergocanada (n.d). Retrieved 05 18, 2015, from http://ergocanada.com/ec_home/products/armpalm_rests_1.html

Microsoft. (n.d.). Retrieved 05 18, 2015, from http://www.microsoft.com/hardware/_base_v1//products/sculpt-ergonomic-keyboard/mk_SED_otherviews01.jpg

Mousetrapper. (n.d.). Retrieved 05 18, 2015, from http://www.mousetrapper.se/ElemImage/advance_700x255%281%29_700.jpg

Figure 33

DNV GL AS. (2015). Retrieved 05 18, 2015, from https://www.dnvgl.com/Images/Touchscreen552x320pxl_tcm8-13045.jpg

Fotosearch. (n.d.). Retrieved 05 18, 2015, from http://sr.photos2.fotosearch.com/bthumb/CSP/CSP992/k14493734.jpg

Global Toy News. (n.d.). Retrieved 05 18, 2015, from http://static1.squarespace.com/static/51b3dc8ee4b051b96ceb10de/t/53bed040e4b0bbf5aa443842/1405014080723/baymax-speaks-in-big-hero-6-teaser

Inmagine . (2015). *Man showing milkyway to little boy* . Retrieved 05 18, 2015, from http://images.inmagine.com/400nwm/iris/photononstop-063/ptg01497161.jpg

Leonhard, G. (2004, 10 15). Retrieved 05 18, 2015, from http://gerdleonhard.typepad.com/.a/6a00d8341c59be53ef0147e114fee6970b-800wi

SolarPhoton. (n.d.). *Power: Minimalistic theme for Rainmeter*. Retrieved 05 18, 2015, from DeviantArt: http://solarphoton.deviantart.com/art/Molecular-Simple-theme-for-Rainmeter-300607588

SolarPhoton. (n.d.). *Molecular: Simple theme for Rainmeter*. Retrieved 05 18, 2015, from DeviantArt: http://solarphoton.deviantart.com/art/Molecular-Simple-theme-for-Rainmeter-300607588

The networking and information technology research and development program (NITRD). (n.d.). Retrieved 05 18, 2015, from www.nitrd.gov: https://www.nitrd.gov/nitrdgroups/skins/vector/images/hciim.jpg

Table 6

Retrieved 05 18, 2015, from https://www.dustinhome.se/

Ergohuset. (n.d.). Retrieved 05 18, 2015, from http://www.ergonomi.se

Kontorsgiganten. (n.d.). Retrieved 05 18, 2015, from http://www.kontorsgiganten.se

Office Depot. (n.d.). Retrieved 05 18, 2015, from http://www.officedepot.se/

Appendix A. Interview guides for long term and past beta users

Guide: First meeting *(Long term beta users)*

Före installation

Namn, ålder, yrke.

Har du några ergonomiska problem i dagsläget när du använder en dator?

- Vad har du för ergonomiska problem .
- Vad har du för förväntningar på ett ergonomiskt hjälpmedel?
- Vad förknippar du med ett ergonomisk hjälpmedel? Vad är ett ergonomisk hjälpmedel för dig? Förutfattade meningar.
- Vad har du för önskemål/krav på ett ergonomisk hjälpmedel?
- Hur skulle ditt drömhjälpmedel vara? Spåna fritt.
- Har du några hjälpmedel? Vad tycker du om det? Har du testat olika? Vad har funkat/inte funkat?
- Hur länge har du haft problem?
- Vilka har du varit i kontakt med för att lösa problemet? (HR, ergonomer etc.)

Hur ser ditt dagliga arbete ut? Vad använder du din dator mest till?

Vad vet du om eye-tracking? (Har du varit i kontakt med eye-tracking tidigare?)

Vad förknippar du eye-tracking med? (Leta förutfattade meningar)

Vad vet du om Tobii?

Vad har du för förväntningar på Ergo?

Observation

- När de får paketet i handen
- Vad händer när de öppnar paketet. Reaktion? Vad tittar de på först? Vad tar de i först?
- Hur hanterar de lappen med installation av mjukvara?
- Hur fungerar montering av fästet?
- Hur fungerar installation av hårdvara?
- Första reaktioner av att testa programmet
- Vad upplevs svårt? Enkelt?
- Vad fungerar bra? Dåligt?

Efter installation

Hur upplevde du installationen?

Vad är din spontana reaktion av Ergo?

Guide: Second meeting *(Long term beta users)*

Användande och lärande

Hur har det gått?
Hur har det gått att lära sig att använda eye tracking?

Ergospecifika funktioner

Hur ofta har du använt den? Till vad? Vad har fungerat bra/dåligt? Hur upplever du interaktionen?
Vad är det här för någonting? (visa Hugo)
Vad tycker du om tipsen? (visa på Ergos startsida)
Vad tycker du om insights? (är det pålitligt?)

Interaktion med hårdvaran

Hur känns det att använda en produkt utan att ta på den?
Hur upplever du hårdvaran? Är den som du förväntade dig?
Inställning, associationer
Vad är din inställning till eye tracking? Har din inställning till eye tracking förändrats från att vi var här första gången?
Om du skulle beskriva produkten för en kompis/vän/kollega, hur skulle du beskriva den då?

Ergonomiska problem

Om ergonomiska problem, känns det bra, bättre, sämre?
Hur upplever du att din position varit när du använt ET?

Avslutning

Tror du att du kommer vilja fortsätta använda den? Varför?
Varför valde du att vara med och testa Ergo?

Guide: Third meeting *(Long term and past beta users)*

Användande och lärande

Hur har det gått att lära sig ET? Hur skulle du önska att det var?
Hur ofta har du använt den, har användandet ökat eller minskat? Varför?
Har du använt den till något annat än du gjorde först?

Customer journey

Beskriv din resa med Ergo: Vad har varit höjdpunkterna, vad har varit besvikelserna?

Inställning och associationer

Vad är din inställning till eye tracking nu? Har din inställning till eye tracking förändrats från att vi var här första gången?
Skulle du rekommendera Ergo till en kompis/vän/kollega? Vem skulle du rekommendera den till och varför?
Uppfattar du Ergo som ett professionellt hjälpmedel?
Uppfattar du Ergo (och insights) som pålitligt?

Har du tänkt på det röda flimret? Irriterad?
Vad skulle krävas för att du skulle byta ditt vanliga ergonomiska hjälpmedel mot Ergo? Hur skulle du gå till väga?
Har du känt dig övervakad eller upplevt ET som läskigt?
Har du tänkt/ varit nyfiken på vad som hännder "bakom den svarta skärmen"?

Ergonomiska problem

Om ergonomiska problem? Känns det bra, bättre, sämre?
Tror du att du kommer vilja fortsätta använda den? Varför?
Har du kunnat sitta som du vill?

Interview guide of past beta users

Namn, ålder, yrke.
Vad är dina intressen?
Varför valde du att vara med och testa Ergo?
Hur länge har du testat?
Har du några ergonomiska problem i dagsläget när du använder en dator? Hur påverkar de ditt vardagliga arbete?

- Vad har du för ergonomiska problem.
- Har du några hjälpmedel? Vad tycker du om det? Har du testat olika? Vad har funkat/inte funkat?
- Hur länge har du haft problem?
- Vad har du för förväntningar på ett ergonomiskt hjälpmedel?
- Vad förknippar du med ett ergonomisk hjälpmedel?
- Vad har du för önskemål/krav på ett ergonomisk hjälpmedel?
- Hur skulle ditt drömhjälpmedel vara? Spåna fritt.
- Vilka har du varit i kontakt med för att lösa problemet? (HR, ergonomer etc.)

Hur har det gått? Vad är dina spontana tankar?
Hur ofta har du använt den? Till vad? Vad har fungerat bra/dåligt?
Hur har det gått att lära sig att använda eye tracking?
Vad är din inställning till eye tracking? Har din inställning till eye tracking från innan du testade den?
Om du skulle beskriva produkten för en kompis/vän/kollega, hur skulle du beskriva den då?
Om ergonomiska problem? Känns det bra, bättre, sämre?
Tror du att du kommer vilja fortsätta använda den? Varför

Appendix B. Interview guide for short term beta users

Initial questions

Namn, ålder, yrke.

Hur ser ditt dagliga arbete ut? Vad använder du din dator mest till?

Vad vet du om eye-tracking? (Har du varit i kontakt med eye-tracking tidigare?)

Vad förknippar du eye-tracking med? (Förutfattade meningar?)

Vad vet du om Tobii?

Vad har du för förväntningar på att testa eye tracking?

Hur tror du att eye trackern ser ut?

Ergonomiska problem

Har du några ergonomiska problem i dagsläget när du använder en dator?

- Vad har du för ergonomiska problem ?
- Vad har du för förväntningar på ett ergonomiskt hjälpmedel?
- Vad förknippar du med ett ergonomisk hjälpmedel? Vad är ett ergonomisk hjälpmedel för dig? Förutfattade meningar.
- Vad har du för önskemål/krav på ett ergonomisk hjälpmedel?
- Hur skulle ditt drömhjälpmedel vara? Spåna fritt.
- Har du några hjälpmedel? Vad tycker du om det? Har du testat olika? Vad har funkat/inte funkat?
- Hur länge har du haft problem?
- Vilka har du varit i kontakt med för att lösa problemet? (HR, ergonomer etc.)
- Hur reagerar de på att testa? Verkar det intuitivt?

Efter test

Hur upplevde du användandet av eye tracking? *Läskigt? Roligt?*

Vad är din spontana reaktion av eye tracking? (Fortfarande samma som tidigare?)

Vad tänker du att eye tracking kan användas till? (Tänker de att det kan användas i deras arbete?)

Kan du tänka dig att använda eye tracking i ditt arbete? Varför, varför inte?

Uppfattar du Ergo som ett professionellt hjälpmedel?

Har du känt dig övervakad eller upplevt ET som läskigt?

Appendix C. Interview guide for people with RSI

- Namn ålder yrke
- Vad har du för ergonomiska problem.
- Vad har du för förväntningar på ett ergonomiskt hjälpmedel?
- Vad förknippar du med ett ergonomisk hjälpmedel? Vad är ett ergonomisk hjälpmedel för dig? Förutfattade meningar.
- Vad har du för önskemål/krav på ett ergonomisk hjälpmedel?
- Hur skulle ditt drömhjälpmedel vara? Spåna fritt.
- Har du några hjälpmedel? Vad tycker du om det? Har du testat olika? Vad har funkat/inte funkat?
- Vad gick du på när du valde ditt första hjälpmedel?
- Vad skulle få dig att byta eller komplettera ditt hjälpmedel?
- Hur använder du datorn, aktiviteter.
- Hur länge har du haft problem?
- Vilka har du varit i kontakt med för att lösa problemet? Fanns några riktlinjer? (HR, ergonomer etc.)

Appendix D. Survey questions

1. Enkät om ergonomiska problem vid datoranvändande
   1.1 Ålder
   1.2 Kön
   1.3 Yrke
   1.4 Får du ont i kroppen av datoranvändande?
   Om ja - gå vidare till *2. Får ont*
   Om nej - avsluta enkät

2. Får ont
   2.1 Var får du ont?
   Hand
   Handled
   Underarm
   Armbåge
   Överarm
   Axel
   Nacke
   Rygg
   Annat
   2.2 Hur ont har du en vanlig arbetsdag?
   Skala 1-10
   2.3 När kände du av problemet första gången?
   Mindre än 1 år sedan
   1-2 år sedan
   2-5 år sedan
   5-10 år sedan
   Över 10 år sedan
   2.4 Använder du ett ergonomiskt hjälpmedel idag?
   Om ja - Gå vidare till *3. Använder hjälpmedel*
   Om nej - Gå vidare till *4. Använder inte hjälpmedel*

3. Använder hjälpmedel
   3.1 Vilket/vilka hjälpmedel använder du idag?
   Ergonomisk mus
   Ergonomiskt tangetbord
   Mouse trapper
   Roller mouse (rulle under tangentbordet)
   Stöd för handled eller arm
   Fotstöd eller ergonomisk matta
   Egen lösning
   Annat
   3.2 Vad fick dig att ta tag i problemet?
   3.3 Hur gick du till väga för att ta tag i problemet?

3.4 Vad var viktigt för dig i val av hjälpmedel?
3.5 Hur nöjd är du med ditt hjälpmedel?
Skala 1-10
3.6 Beskriv varför du känner dig nöjd eller missnöjd
3.7 Vad skulle få dig att testa något annat och varför?
3.8 Om du har testat något annat hjälpmedel som du inte längre använder, varför slutade du med det?

4. Använder inte hjälpmedel
4.1 Hur kommer det sig att du inte använder något hjälpmedel idag?
4.2 Har du testat något hjälpmedel tidigare? Vad?
4.3 Vad skulle få dig att testa ett hjälpmedel idag?
4.4 Vad är det första du skulle göra för att ta tag i problemet?

Appendix E. Extracts from the user manual of Tobii X2-30

3.1.1 General use

The Tobii X2 Eye Tracker is best kept in dry conditions at room temperature. The recommended range for temperature and the humidity value for the device is as follows:

- **Temperature**: 0°C to 40°C (32°F to 104°F)
- **Humidity**: Max 70% (no condensation on the device)

3.1.2 Transportation and storage

For transportation and storage, the recommended range for temperature and the humidity value for the device is as follows:

- **Temperature**: -40°C to 70°C (-40°F to 158°F)
- **Humidity**: 20% to 70% (no condensation on the device)

The Tobii X2 Eye Tracker is not waterproof or water resistant. The device should not be kept in excessively humid, damp or wet conditions. Do not submerge the device in water or in any other liquid. Be careful not to allow liquids to be spilled upon the device.

3.4 Disposing of the Tobii X2 Eye Tracker

Do not dispose of the Tobii X2 Eye Trackers in general household or office waste. Follow your local regulations for the disposal of electrical and electronic equipment.

4.1 Prerequisites

Before starting to mount and use your Tobii X2 Eye Tracker, you need to make sure that:

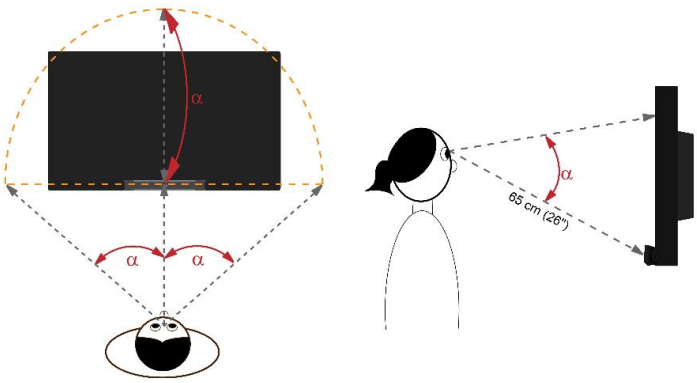
- Your computer is compatible with the software that you are going to use (Tobii Studio or other eye tracking software). The latest version of the Tobii System Requirements and Recommendations document is available on the Tobii website at www.tobii.com.
- You have administrator rights for the computer that you are using in order to be able to install and run the installation and configuration software.
- The screen used for presenting the stimuli has a proper size and form factor to be used with the eye tracker that you have. Please read *Appendix B Recommended Display Sizes, page 28*
- You are using either Windows 7 or Windows 8 as an operating system.
- The firewall(s) that you might have on the computer allow access for the eye tracking software.
- You are using USB 2.0. The Tobii X2 Eye Tracker does not support the USB 3.0.
- Always try out the Tobii X2 Eye Tracker before attaching it permanently to the screen in order to make sure that it works properly in conjunction to your screen.

6 Positioning

The distance from the participant's eyes to the eye tracker should be approximately 60–65 cm (23–26″) for best performance. However, the eye tracker can still track eye movements as long as the participant stays within the distance interval from the eye tracker mentioned below. If the eye tracker is too close or too far away from the participant there is a risk of losing some of the gaze data.

When the Tobii X2 Eye Tracker is used in a setup where it is not attached to a screen, it should be placed below the monitor (or below the surface that is to be used for presenting the stimuli) without covering the bottom of the display area for the participant watching the stimuli.

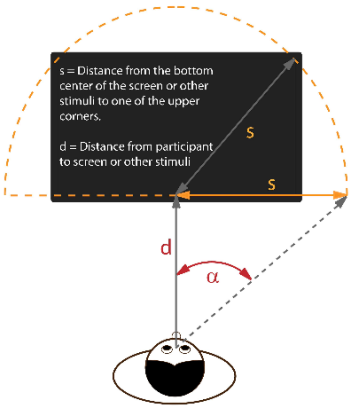
For optimal tracking, the eye tracker should be placed so that the gaze angle (α) illustrated below will not exceed the 36° for Tobii X2 Compact Edition when the participant is located ~65 cm (26″) from the eye tracker.



It is very important to have the correct distance to the monitor or the tracked object. Otherwise the eye tracker cannot track the entire area. If the monitor or object is placed too close to the participant there is a risk that the gaze data for the corners of the display area of the monitor will not be collected.

The correct distance can be calculated by using basic trigonometry (see image below). By assuming that the tracked area is a half circle and that the diagonal from the center of the screen or other stimuli to its top corner constitutes the radius of that half circle, it is possible to calculate the distance needed between the participant and the stimuli using the following formula:

$$d = \frac{s}{\tan \alpha}$$



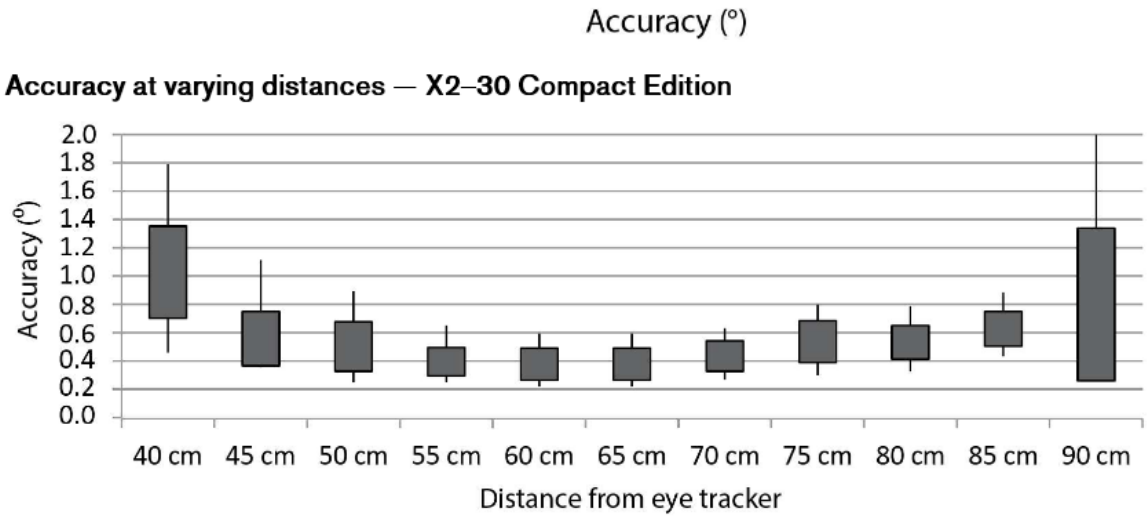
If you place the test participant farther away from the object you can track larger objects, if you place the test participant closer to the object you can track smaller objects. If you place a test participant at 65 cm (26″) you can track a 25″ (16:9) monitor. Regardless of the distance to the object the eye tracker should always be placed approximately 65 cm (26″) from the participant. For more information about supported monitor sizes please see *Appendix B Recommended Display Sizes, page 28*

6.1 Freedom of Head Movement

The Tobii X2 Eye Tracker allows for extensive head movement. Once the Tobii X2 Eye Tracker is properly calibrated and placed in front of the user, no further adjustments are required.

The Tobii X2 Eye Tracker allows for head movements of 50 x 36 cm (20 x 14″) (Width x Height) at the distance of 70 cm (27.5″) from the eye tracker. Depending on factors such as droopy eyelids, visual aids and other characteristics of the eye, the optimal distance between the participant and the eye tracker varies. The typical tracking distance limit from the center of the eye tracker is 45–90 cm (15.7–33.5″) for the Tobii X2 Eye Tracker.

In order to be tracked properly, the participant that is being eye-tracked needs to have at least one eye in the track box at all times.



Eye Tracking Specifications		Tobii X2-30 Eye Tracker Compact Edition
Sampling rate[1]		30 Hz (std. dev. approx. 2 Hz)
Total system latency		50–70 ms
Time to tracking recovery		For blinks: immediate
Head movement[2]	Freedom of head movement at 70 cm (width x height)	50 x 36 cm (20 x 14″)
	Operating distance (eye tracker to participant)	40–90 cm (15.7–33.5″)
Recommended screen size		up to 25″ (16:9)
Data sample output		Timestamp, eye position, gaze point, pupil diameter, validity code

1. As the Tobii X2-30 Eye Trackers have a variable and low sampling rate, they are not suitable for detailed studies of the onset or durations of fixations, saccades or other measures requiring high temporal and stable sampling precision.
2. Freedom of head movement describes the volume in front of the tracker in which the user must have at least one of the eyes. The numbers are specified parallel/orthogonal to screen surface, assuming the eye tracker is at a 20 degree angle to the screen.

Eye Tracking Unit	Tobii X2-30 Eye Tracker Compact Edition
Eye tracker processing unit	Embedded, no external eye tracking host necessary
Connectors	USB 2.0
Weight	200 g (7.1 oz)
Size	184*28*23 mm (7.2 * 1.1* 0.9″)
Mounting solutions	Adhesive Mounting brackets for monitors, laptops and tablets. Desk Stand Accessory package for Tripods and desks

The full guide can be retrieved from http://www.tobii.com/Global/Analysis/Downloads/User_Manuals_and_Guides/Tobii_X2-30_EyeTrackerUserManual_WEB.pdf

Appendix F. Insights User Study

Insights: Before using Ergo

Insights from first meeting with long term beta users, meetings with short term beta users and interviews with and survey responses from people with RSI.

Lärande och användande

- Man måste anpassa sin position efter ET
- Att ET inte funkar för två skärmar begränsar arbetet
- Förvirrad om man ska titta på skärmen eller ET
- Viktigt att kunna öva upp sin snabbhet med ET
- Att använda ET går långsamt
- Hög inlärningströskel, man måste lära sig att använda ET
- "De borde skicka med en ergonom"
- Man vill gärna ta på saker fysiskt för att förstå dem.
- Reklam- och mediebranschen är medvetna om vad ET är från undersökningar

Upplevelser

- Tror att det är henne det är fel på och inte Ergo - under installationen
- Förvirring kring begreppen Tobii, EyeX, Ergo - vad är vad?
- "Det här är så himla roligt faktiskt"
- Upplever ET som läskigt
- ET känns "lite otäckt" på grund av integritet.
- Upplever som skumt, främmande

Tankar, associationer, förväntningar

- Förknippar ET med handikapphjälpmedel
- Kopplar ET till saker de sett i film och serier
- Gamers: Ganska likgiltigt inställda till ET
- Förväntar sig något coolt, nytt
- Förväntningar på coolhet uppfylldes
- Förväntar sig något surrealistiskt och häftigt
- Tror att mindre teknikkunniga kan uppleva ET som läskigt
- Förknippar ET med riktad reklam
- Tror att det kommer fungera dåligt
- Det känns för komplicerat för att fungera bra
- Förväntar sig att den ska vara knepig och svår att installera
- Skeptisk till om ET funkar till deras typ av datoranvändande
- Skeptisk till om det kan hjälpa ergonomiskt
- Förväntar sig att ergonomiska hjälpmedel drar ner produktiviteten och accepterar det till viss del
- Förväntade sig att hårdvaran ska vara mindre.

- Förväntar sig att man klickar med ögonen
- Positiv till idén av eye-tracking.
- ET känns futuristiskt
- ET kan uppfattas som en leksak och inte som ett professionellt hjälpmedel (datatekniskt kunniga)
- Programmerare: kan tänka sig att ha ET för att det är kul.
- När effektivitet krävs i arbetet finns ett intresse för eye tracking för man tror att det kommer gå snabbare.
- Det finns en medvetenhet om att det är dåligt att sitta still vid datorn.
- Arbetsplatsens kultur och ekonomiska situation spelar roll för om man vill be om ett hjälpmedel eller inte.
- Har man ett flexibelt arbete är det svårt att använda ett hjälpmedel.
- Vissa (särskilt unga) vill inte identifiera sig som personer med ergonomiska problem.
- Man går ofta till sjukgymnast och naprapat som första steg.
- Byte av jobb påverkar situationen.
- Folk har okunskap om marknaden och hur den fungerar.
- Folk tar sig inte tid att ta tag i sina problem.
- Folk gör inget åt tillfälliga problem.
- Många som har testat hjälpmedel har slutat använda dem.
- Folk litar inte på säljare.
- Många vill testa hjälpmedel, men förutsättningslöst.
- Det finns en efterfrågan på ett mobilt ergonomiskt hjälpmedel.
- Oftas är det andra som tar tag i problemen (vän, kollega, chef, ergonom)
- De flesta är missnöjda med sina hjälpmedel.
- Experter (Sjukgymnaster, ergonomer, läkare) anses trovärdiga i fråganochmansöker efter deras råd.
- Ergonomiska hjälpmedel som tar plats är ett problem.

Installation

- För hoppig
- Start up/tutorial-upplevelsen är förvirrande
- Tutorialen är förvirrande i början
- Kul med interaktiv tutorial

Hårdvara

- Gamer: identifierar hårdvaran med Wii-tracker
- Hårdvaran upplevs som stilig
- Uppfattas som enkel och stilren
- Uppfattas som fin
- Fästet: förvirring kring var det ska sitta
- Fästet: gillar inte att det sitter permanent

- Fästet: vill kunna justera vinkel
- Fästet: tror att det ska monteras på skärmen
- Hårdvaran sitter i alldeles fel vinkel
- Monteringen av fästet känns stabilt
- Fodralet till REX signalerar att det är något ömtåligt inuti
- Paketet känns använt
- Inte självklart att det finns en våning till i paketet
- Tror att skyddsplasten indikerar att det är klister på ytan under
- "Trodde den skulle se ut som en liten webkamera."
- Förståelse för utformning av eye-trackern.
- Tror på intergation i datoskärm.

Mjukvara

- Om insights: roligt men opålitligt
- GUI:t upplevs som snyggt
- Dåligt att det inte fungerar på mac.

Positiva överraskningsmoment

- Magnet
- Scroll

Önskemål och krav

- Önskar sig en guide som fortsätter efter tutorialen
- "Det känns som att man blir avsläppt i en värld man inte riktigt hanterar"
- Förstår inte att Hugo indikerer att ET är aktiverat
- Vill ha feedback på vart man tittar
- Ergo måste vara kompatibel med arbetsplatsen och övriga hjälpmedel.

Insights: While using Ergo

Insights from second meeting with long term beta users.

Lärande och användande

- ET tvingar en att sitta på ett särskilt sätt - möte 1 och 2
- Ergo gör att de sitter mer still än innan
- Vill helst använda musen pga vana
- "Löjligt att man trodde att det skulle vara ett stort trappsteg när det funkar såhär bra"
- Lärandet begränsas av vanan att använda musen
- Tycker inte att ET funkar för sitt vanliga arbete (precisionen avgörande)
- Gamer: Lätt att ta till sig tekniken
- Dålig precision
- Tycker om ET för vanliga funktioner i Windows
- Tycker att det går för långsamt när man använder ET

- Det tar 2-3 dagar att lära sig.
- Personer som inte har ergonomiska problem tar inte till sig Ergo lika lätt.

Upplevelser

- "Man känner sig lite cyber"
- Känner sig iakttagen av Hugo och det röda ljuset
- Om ett problem ligger hos personen själv (långsam) är det acceptabelt, men inte om det ligger hos produkten
- Man har mer tålamod när man vet att användandet inte är långsiktigt och problemet övergående.

Tankar, associationer, förväntningar

- ET upplevs som coolt fortfarande
- Tror att ET är bättre för de som inte är lika vana vid ett särskilt sätt att använda datorn
- Fungerar bättre än förväntat i dagligt arbete
- Ser potential i tekniken
- Är man inte i behov av ET kommer man inte vilja använda det
- Tror att ET passar andra men inte en själv
- Tror att ET kan bli stort när man slipper använda händerna

Hårdvara

- Upplever det röda ljuset som irriterande

Önskemål och krav

- Behöver påminnelser om att använda ET
-

Insights: After using Ergo

Insights from third meeting with long term beta users and interviews with past beta users.

Lärande och användande

- Fungerar dåligt i det dagliga arbetet
- Känns som en uppstartsträcka varje gång man kommer till datorn
- I början har man inga krav, men blir mer kräsen eftersom
- Jobbigt att bryta vanan
- Lätt att lära sig, bara en knapp
- Använder musen för att det är mest bekvämt
- Har man en dålig touchpad kan man tänka sig att kombinera den med Ergo
- Det finns en viss grad av tolerans för att det tar tid att lära sig (och vänja sig) vid något nytt.
- Folk tror att det skulle vara bekvämt att slippa använda händerna.
- Otekniska personer tycker att den är pedagogisk och lättanvänd.
- Personer som inte har ergonomiska problem tar inte till sig Ergo lika lätt.

- Personer med ergonomiska problem tar lättare till sig Ergo.
- Personer med väldigt allvarliga ergonomiska gillar inte Ergo eftersom den fortfarande kräver att man fysiskt klickar på knappar.
- Endast personer med ergonomiska problem vill fortsätta använda Ergo efter testtidens slut.

Upplevelser

- Upplever att Ergo försämrar hennes ergonomi
- Gillar Ergo för att man får mindre ont. (Karpaltunnelsyndrom)
- "Företelsen att ögonstyra är kul som idé"
- "Kul att ha även om den inte gör nytta."
- Personer som har för ont för att klicka kräver annan interaktion av Ergo.

Tankar, associationer, förväntningar

- Svårt att bryta vanan att använda musen
- Känns fortfarande häftigt och coolt
- Skulle kolla upp ET som ett alternativ vid ergonomiska problem i framtiden
- Andra hjälpmedel tros ha lika hög lärandetröskel, men bättre precision
- Hade förhoppningar som inte besannades
- Skulle rekommendera ET till de som inte kan använda musen
- Lättare att lära sig än förväntat
- Orolig för sin integritet - undrar vad Ergo registrerar
- Förväntar sig att pekaren ska följa efter blicken
- De som är nyfikna på teknik kan tänka sig att testa Ergo
- De som redan har ett hjälpmedel som fungerar bra skulle förmodligen inte ta egna initiativ för att testa något nytt
- "Om någon hade tvingat mig att använda Ergo hade det gått skitbra"
- En person tycker att precisionen fungerar sämre än väntat
- De med lindriga problem tror att Ergo passar bättre för de med allvarliga problem och de med allvarliga problem tror att det passar bättre för de med lindriga problem
- Vid lindriga problem: Använder man en mousetrapper tillför inte ergo mer lindring.
- Intresserad avatt se vart ETutvecklingen tar vägen.
- Folk tror att tekniken kommit länge än den har.

Hårdvara

- Irriterande med rött flimmer
- Hårdvaran känns tung och stadig, inget plastskit
- "Känns som röda ögon som iakttar mig"
- Ergo upplevs som stationärt (problem för en konsult)
- Hårdvaran behöver inte nödvändigtvis fästas på skärmen - kan vara ett stativ

Mjukvara

- Tipsen i dagens Ergo uppmärksammas inte

Önskemål och krav

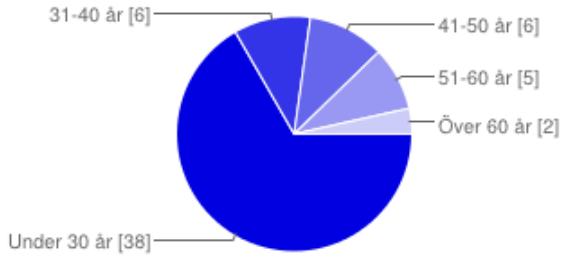
- Vill kunna klicka med ögonen
- Vill ha en mer slim och tunn design på hårdvaran.

Appendix G. Survey Response Summary

The responses of questions asking for qualitative data have been summarized. The most common responses are presented.

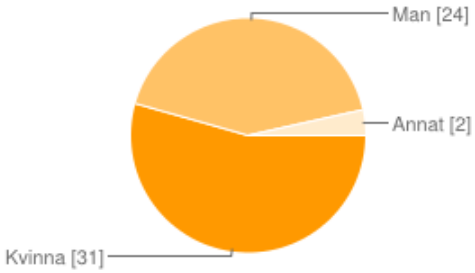
Summary

Ålder?



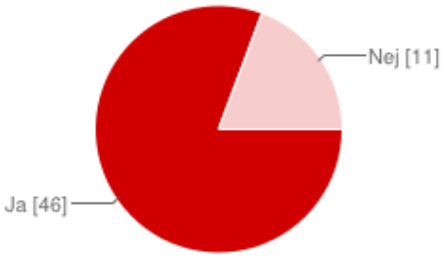
Under 30 år	38	66.7%
31-40 år	6	10.5%
41-50 år	6	10.5%
51-60 år	5	8.8%
Över 60 år	2	3.5%

Kön?



Kvinna	31	54.4%
Man	24	42.1%
Annat	2	3.5%

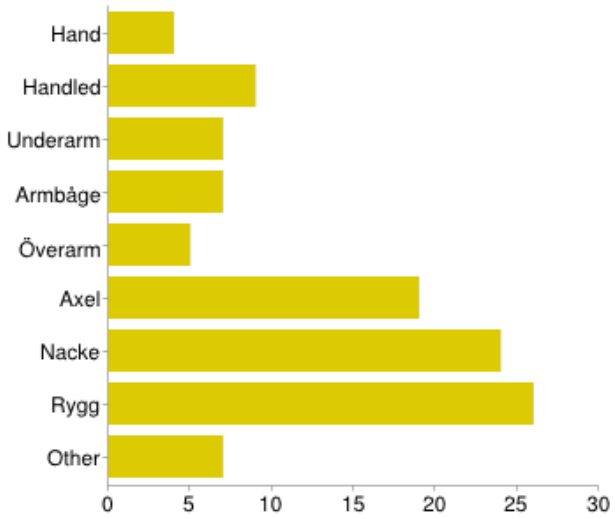
Får du ont i kroppen vid datoranvändande?



Ja	46	80.7%
Nej	11	19.3%

Eleven individuals do not experience pain or discomfort when using a computer and will hence not take further part of the survey. The number of participants contributing to data is 46 individuals. Five of these 46 individuals did not follow the survey properly nor answered the questions with manner and were hence excluded from the data. This results in 41 valid respondents in total.

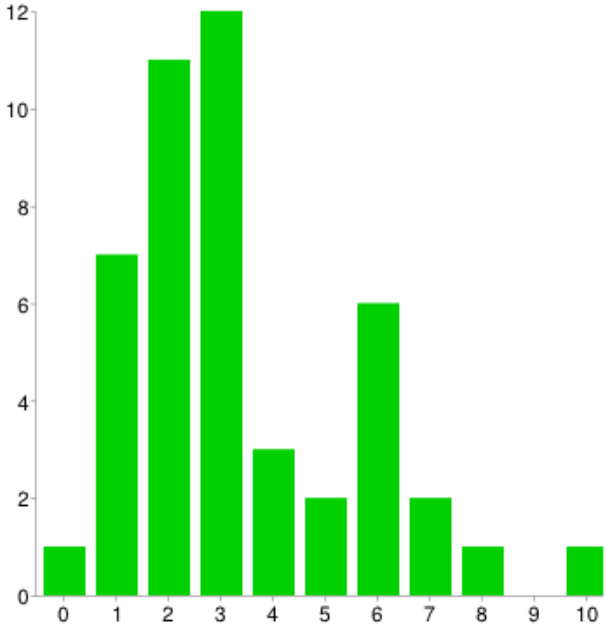
Var får du ont?



Hand	**4**	7%
Handled	**9**	15.8%
Underarm	**7**	12.3%
Armbåge	**7**	12.3%
Överarm	**5**	8.8%
Axel	**19**	33.3%
Nacke	**24**	42.1%
Rygg	**26**	45.6%
Other	**7**	12.3%

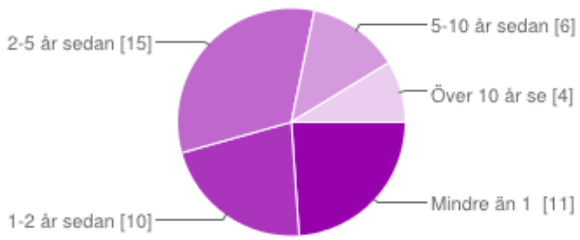
The most common place of pain or discomfort is the shoulder, back and neck area.

Hur ont har du en vanlig arbetsdag?



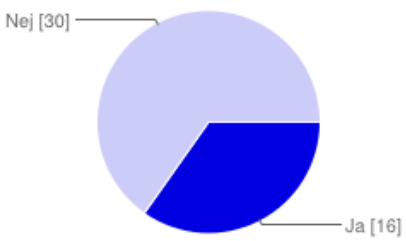
0	**1**	1.8%
1	**7**	12.3%
2	**11**	19.3%
3	**12**	21.1%
4	**3**	5.3%
5	**2**	3.5%
6	**6**	10.5%
7	**2**	3.5%
8	**1**	1.8%
9	**0**	0%
10	**1**	1.8%

När kände du av problemet första gången?



Mindre än 1 år sedan	**11**	19.3%
1-2 år sedan	**10**	17.5%
2-5 år sedan	**15**	26.3%
5-10 år sedan	**6**	10.5%
Över 10 år sedan	**4**	7%

Använder du något ergonomiskt hjälpmedel idag?



Ja	16	28.1%
Nej	30	52.6%

Individuals not using ergonomic aid:

How come you don't use an ergonomic aid today?

I lack knowledge of existing ergonomic aids.
My problems aren't severe enough.
The existing ergonomic aids are not enough mobile for my type of work.
I was recommended exercise or posture adjustment by a physiotherapist.

Have you tried any ergonomic aid before? What?

~25% Have not tried
Mousetrapper or roller mouse
Height adjustable table
Back pillow

What would make you try an ergonomic aid today?

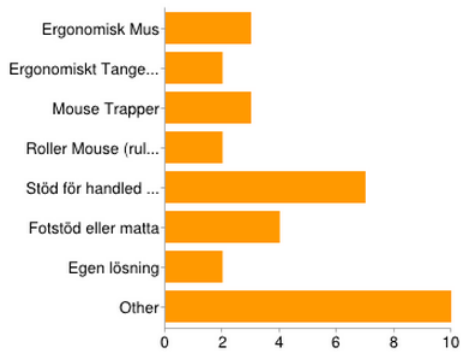
If an expert suggested what is best for me.
Free testing without the pressure of buying.
If my problems got worse.

What would be the first thing you would do to tackle your problems?

Contact reliable expert and ask for advice (doctor)
Google, find information by my own

Individuals using ergonomic aid:

Vilket/Vilka av följande ergnomiska hjälpmedel använder du idag?

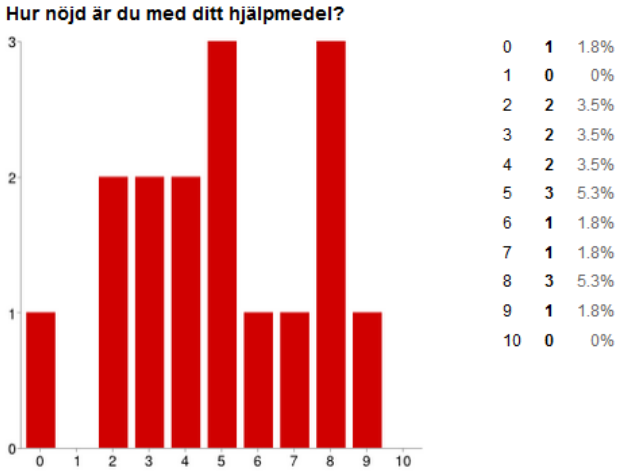


Ergonomisk Mus	3	5.3%
Ergonomiskt Tangentbord	2	3.5%
Mouse Trapper	3	5.3%
Roller Mouse (rulle under tangentbordet)	2	3.5%
Stöd för handled eller arm	7	12.3%
Fotstöd eller matta	4	7%
Egen lösning	2	3.5%
Other	10	17.5%

What made you tackle your problems?
The pain got too bad
A colleague, boss or work environment encouraged it.

How did you approach dealing with your problems?
Googled for solutions
Tried different things to combine an effective solution.
Spoke to different experts.
(Every respondant had different ways to aquire aid and deal with their ergonomic problems.)

What were important factors when choosing your ergonomic aid?
Availability
Shouldn't feel limiting
That it is adjustable and suitable for me
Shouldn't affect my way of working

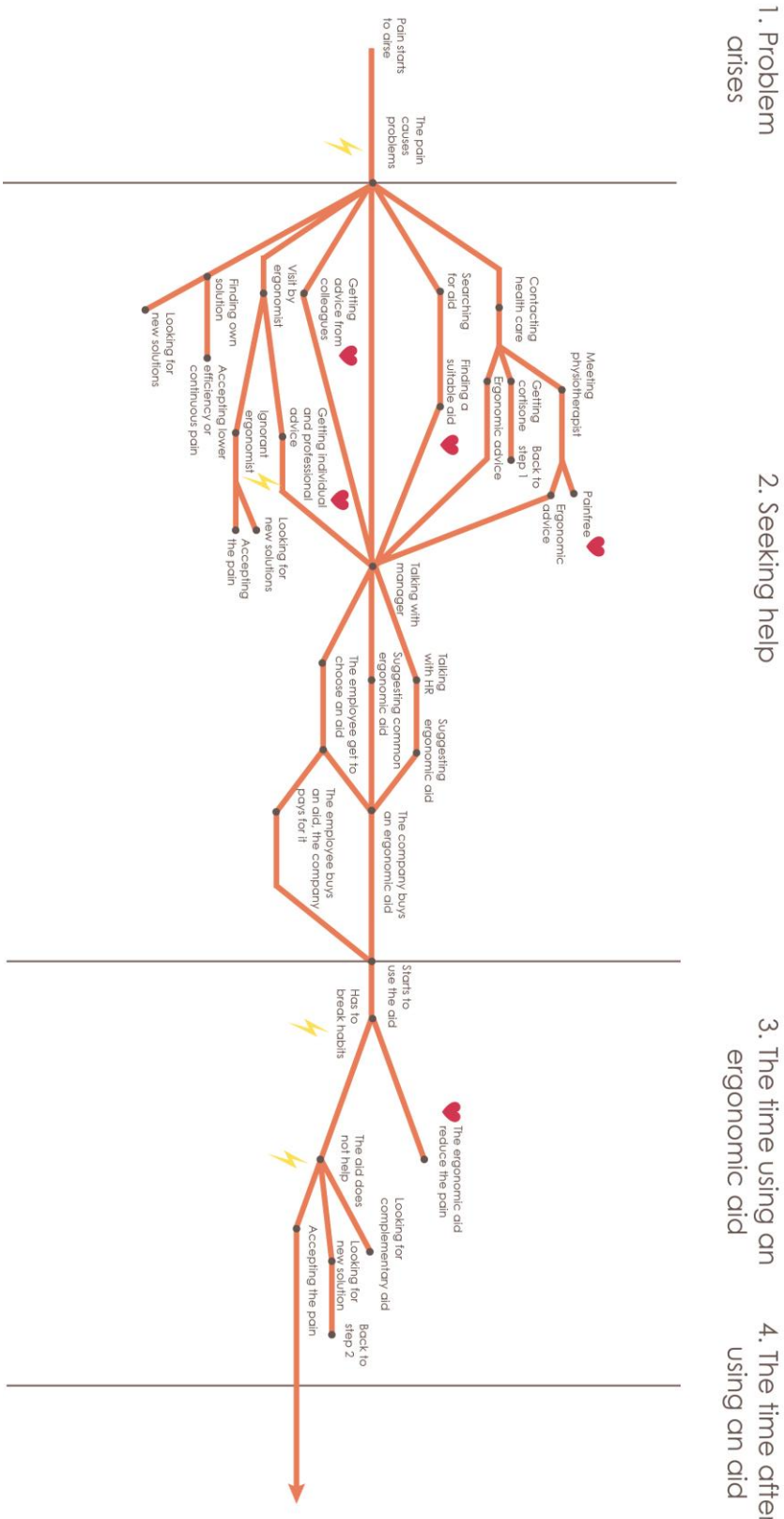


Explain why you feel happy or unhappy with your aid
Positive feelings:
Relieve Pain
Negative Feelings:
Takes too much space on the desk

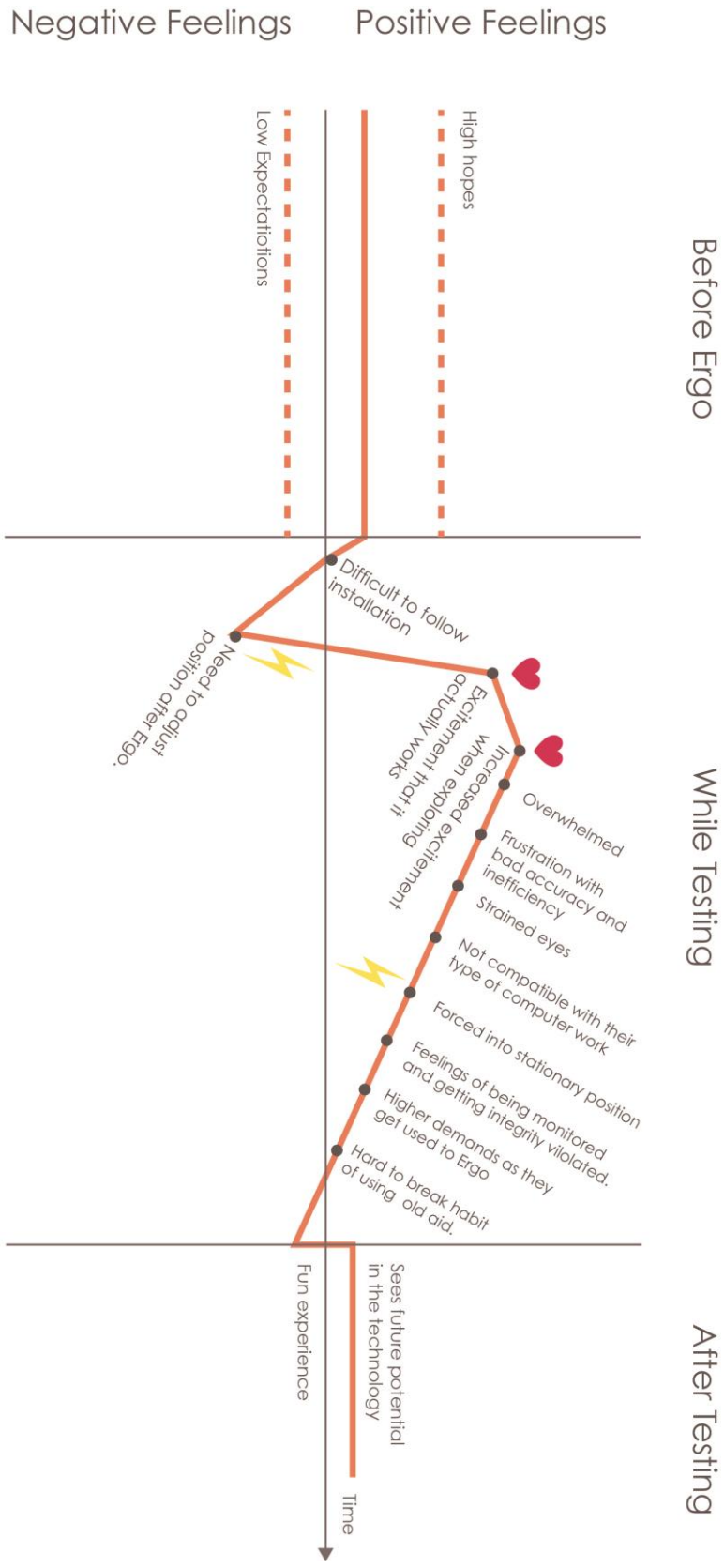
What would make you try something new and why?
Accessibility
If something encourages me to sit right and build my own muscles.
Free testing without the pressure of buying.
If the ergonomic aid was mobile
If the ergonomic aid removed all my pain

If you have tried an ergonomic aid that you're not still using, why did you stop using it?
Takes too much space on the desk
It didn't' relieve the pain
I got pain or discomfort somewhere else

Appendix H. The journey with Ergonomic problems



Appendix I. The emotional journey with Ergo



Appendix J. The customer journey with Ergo

Appendix K. The linear adoption process