Usability and User Experience Evaluation Model for Investigating Coordinated Assistive Technologies with Blind and Visually Impaired

University of Oulu
Faculty of Information Technology and Electrical Engineering / Degree programme in Software, Systems and Services Development in the Global Environment
Master's Thesis
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Abstract

The objective of this thesis is to examine how should usability and user experience of a cooperative assistive technology for blind and visually impaired be evaluated in a field setting. The target system in this study was developed by a doctoral student, who was also responsible for conducting an experiment in Pakistan. It is important to evaluate assistive technology for visually impaired because of poor adoption rates, while the number of visually impaired people needing them is going to increase.

The research includes literature review on development of assistive technologies, and existing usability and user experience methods. Theory is supported with qualitative and quantitative methods. Discussions with three experts in Finland were held and analysed. An experiment for eleven blind and visually impaired people was conducted in Pakistan. This included interviews, analysed observations, and a validation of a user experience questionnaire, meCUE 2.0. Discussions with the research team and consultations from usability and user experience experts were used to assess the results of the research and to develop an evaluation model suitable for the prototype system in specified setting.

The first main finding of this thesis is the developed model called *UUXCAT for VIP*. It can be used to evaluate cooperative assistive technology in a field setting. Development of the model was an iterative process and is based on synthesis of existing methods and available research. The second main finding is the extended contexts questionnaire. New contexts add dimensions that were missing from other methods. These contexts are trust and confidence, social, physical, and culture, and are relevant to visually impaired and the cooperative aspect of the system. The study is limited by Covid-19 as the planned experiment in Finland was not carried out that could further validate the model.

Keywords
assistive technology, blindness, cooperative, electronic travel aids, meCUE 2.0, SUS, usability, user experience, visual impairment

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Foreword

I would like to take this opportunity to offer my deepest gratitude to the research team working with me on this project. This includes Professor Petri Pulli, who was my supervisor early on and who influenced the direction of this work. Doctoral student Babar Chaudary with whom I worked very closely on this project. Babar is the builder of the prototype system and without him this thesis would not exist. M.Sc Eeva Leinonen who always found time to answer questions and provide support. PhD Pasi Karppinen who supported the work and helped to push forward the idea of writing the papers.

I would also like to offer my thanks to M.Sc Iikka Paajala for originally suggesting the topic for me and who also acted as an examiner for this thesis.

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Sami Pohjolainen

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Abbreviations

ASQ = After Scenario Questionnaire

AT = Assistive Technology

ETA = Electronic Travel Aids

GSM = Global System for Mobile communication

HAAT = Human Activity Assistive Technology

IoT = Internet of things

ISO = International Organization for Standardization

meCUE = Modular evaluation of the Component model of User Experience

PSSUQ = Post-Study System Usability Questionnaire

SUS = System Usability Scale

UEQ = User Experience Questionnaire

UI = User Interface

USE = Usefulness, Satisfaction, and Ease of use

UTAUT = Unified theory of acceptance and use of technology

UX = User eXperience

VIP = Blind or Visually Impaired Person / People

Contents

1. Introduction

Those who suffer from visual impairments face major challenges to their daily life, as they suffer from adverse effects to their performance in many situations (Manduchi & Coughlan, 2012; Bhatlawande, Mahadevappa, Mukherjee, Biswas, Das & Gupta, 2014). Projections show that there were around 38.5 million blind and 237.1 million people with moderate or severe visual impairment in 2020. These are expected to triple to 114.6 million and 587.6 million by 2050, respectively. This means that a significantly higher number of people will need Assistive Technology (AT) in the future. (Bourne et al., 2017). Improving mobility and navigation of Blind and Visually Impaired People (VIP) has and continues to be one of the main areas of research and development focus when it comes to AT. This is reflected with the fact that an important societal goal is to help VIP remain independent and integrated to the society, which in turn will improve their quality of life. (Calder, 2009; Bohwmick & Hazarika, 2017.)

The problem with AT for VIP in general has been that people are not keen to adopt them, while discontinuance rates are high (Riemer-Reiss & Wacker, 2000; Roentgen, Gelderblom, Soede & De Witte, 2008; Manduchi & Coughlan, 2012; Paajala & Keränen, 2015; Gori, Cappagli, Tonelli, Baud-Bovy & Finocchietti, 2016). One issue is that VIP are a very diverse group of people who suffer from various degrees of vision loss, but vary in terms ability (Manduchi & Coughlan, 2012). There are VIP who like to use the latest technology to help them in various tasks, but research has shown that many barriers and reasons exist why the acceptance for these technologies is so low. (Riemer-Reiss & Wacker, 2000; Roentgen et al., 2008; Manduchi & Coughlan, 2012; Paajala & Keränen, 2015; Gori et al., 2016.) The fact is that developing products for VIP is a continuing challenge. According the evaluations in academic research, developers have generally reported positive results from end users when testing new technologies including those meant for VIP. (Bhatlawande et al., 2014.) In contrast, Roentgen et al. (2008) reported that many these products fail to meet the needs of visually impaired. Calder (2009), and Riemer-Reiss and Wacker (2000) also outline some of the difficulties with development of AT products that would have staying power in the market. They highlight that it is very hard to match user requirements when the ecosystem of products is constantly evolving and VIP can have multiple disabilities, which can result in very specific and often niche needs. Varity of technology, such as type of sensors used, also adds to challenge of development AT with longevity. Advances in technology can make even proven solutions either obsolete or undesirable, which is illustrated very well by the arrival of affordable smartphones. (Roentgen et al., 2008; Manduchi & Coughlan, 2012; Islam, Sadi, Zamli & Ahmed, 2019.)

This thesis presents work done in research and development of an evaluation model called *UUXCAT for VIP*. The model can be utilized to assess usability and User eXperience (UX) of AT used cooperatively by VIP and their caretakers. AT is essentially an umbrella term that describes tools used by people with disabilities to accomplish variety of tasks. The evaluation model was developed for a very specific case of Electronic Travel Aid (ETA) with a goal to improve mobility and navigation of VIP. In this case, the technology also relied on cooperation and communication between VIP and their caretakers. While the case for development of the evaluation model is specific, it can be adapted to work in other settings as well. The thesis goes through the relevant work and provides a detailed examination on how the evaluation model was iteratively developed, why certain methods were chosen, and new ones needed to be added.

This introduction briefly explains the background and motivation for the research. It defines the research problem, outlines the research questions, and presents the study methods. Furthermore, the goal and scope of the study are considered, and the structure of the study introduced.

1.1 Background and motivation

The research for this thesis started with a need to evaluate a new AT developed in OASIS research unit at University of Oulu. It is a prototype level system of ETA developed for VIP and their caretakers by a doctoral student as a part of the dissertation research (Chaudary, Paajala, Keino & Pulli, 2017; Chaudary, Pohjolainen, Aziz, Arhippainen, & Pulli, 2020). A unique aspect of this system is that it relies on cooperation between users. It has a multimodal interface that works over the internet of things (IoT) relying on both haptic and vocal communication. Caretakers, which can include friends and family, use an application on a device that shows them the field of view of the VIP through smartphone camera that is placed on the chest of the VIP. Users can communicate vocally, but navigational assistance is mainly provided through haptic feedback to the white cane using a simple set of vibrations. In a case where the primary caretaker is unfamiliar with the area, they can request help from another caretaker, who can in-turn help the VIP to navigate through that.

The initial discussion about the evaluation needs for the system were outlined by the doctoral student and the professor of the research team. Implementation of the Unified Theory of Acceptance and Use of Technology 2 (UTAUT2) method was supported in these discussions. This method was considered because it was topically very close to the research that the doctoral student needed for the dissertation. It had also been used by Paajala and Keränen (2015) to study acceptance of AT among VIP in the Oulu area, Finland. Other outlined requirements included that the system needed to be tested with multiple participants cooperating with each other. The idea was that participants, including VIP and two caretakers, would use the system in the field and this would be evaluated using different methods, which at this point were yet to be determined. These experiments were originally planned for both Pakistan and Finland. Experiments in Finland were to take place in Jyväskylä, as they have a school meant for VIP operating under the Finnish National Agency for Education. However, after initial literature review, assessing the prototype system and its development needs, and other factors relating to the UTAUT2 model, it was decided that usability and UX evaluation methods might provide a better fit for the tests.

1.2 Research problem and methods

This section describes the research process and methodology used to develop the evaluation model, and the research problem and two research questions are introduced. Figure 1 provides an overview of the research methodology. The process shown illustrates how conclusions are reached, research questions answered, and material produced for this thesis.

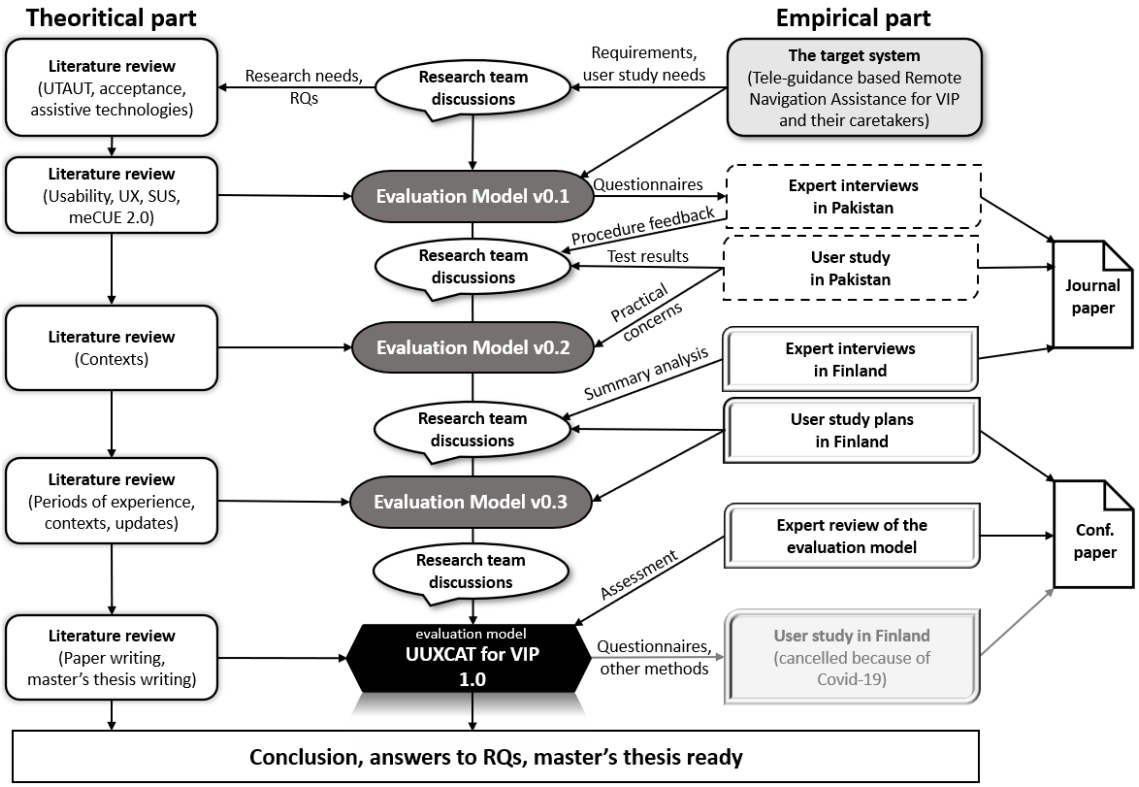

Figure 1. The research process and methodology for master's thesis.

This thesis develops an evaluation model for a specific case and explores the research problem:

How should usability and user experience of a prototype cooperative assistive technology for blind and visually impaired be evaluated in a field setting?

This is done by developing an understanding of the research area with literature review and empirical qualitative study combined with quantitative data from actual tests. This means that a mixture of qualitative and quantitative methods is used. It is also important to understand technology involved and specific needs of the users. While methods used in similar settings, provide a solid foundation on which the design and development of the evaluation model can begin. Therefore, a review and analysis of existing evaluation methods used in similar settings is required.

The research problem is divided into two research questions:

RQ1: What dimensions should be considered when evaluating usability and user experience of cooperative assistive technology for blind and visually impaired in a field setting?

RQ2: What kind of usability and user experience evaluation could be suitable for assessing assistive technology used cooperatively by blind or visually impaired with their caretakers?

The research philosophy in this thesis is somewhat pragmatic. The study mixes both qualitative and quantitative methods. Interviews and participant observations are the main qualitative methods used to identity different contexts. Discussions with the research team could also be categorised as qualitative interviews when considered in the context of the research problem and research questions for this thesis, but not when applied specifically

to the experiments of the system. The distinction being that the work for the thesis is done in parallel and in conjunction with the design and planning for the experiments. Quantitative data comes from questionnaires and analysis is done by the research team using statistical methods.

The theoretical part of the research is met with literature review of various subjects. Material for the literature review is collected from multiple sources. This includes using scientific search engines and full text databases. Google Scholar and Oula-Finna online library catalogue are the main search engines. The latter provides access to many relevant electronic journals and online databases including ACM Digital Library, IEEE Xplore, Science Direct, Wiley Online Library and EBSCO. Variety of search terms are used in different combinations, but few examples include “assistive technology”, “cooperative”, “electronic travel aids”, “user experience”, “usability”, “evaluation” and “visually impaired”.

One goal of the research team is to get multiple scientific papers written based on the planned research. At the time of writing this thesis, one journal paper and one conference paper has been written and submitted. The added goal to this study came from the doctoral student, as he wanted to get perspective on future development needs of the prototype system. This means that while research questions in this thesis address a more theoretical problem, the experiments are done to solve a practical problem as well. In other words, the developed evaluation model has a practical application in the field test setting, but also answers a theoretical problem presented as the research problem in this thesis.

The initial knowledge to answer RQ1 is presented in Chapter 2 but is also included in later chapters and Appendices. Chapter 3 describes the development process and Chapter 4 presents the findings to answer RQ2.

1.3 Objectives and scope of the thesis

The objective of this thesis is to provide knowledge on the development of an evaluation model. The model can be used to evaluate usability and user experience of cooperative assistive technology with blind and visually impaired, and their caretakers.

An empirical level this objective is met with the literature review, comparison of methods, tests, expert interviews, and discussions with the research team that consisted of topical experts. All methods contributed to the iterative development of the model. Three versions of the model are presented as iterations and the final evaluation model is presented in the findings. Considerations and decisions for the changes made in each iteration are explained in detail. Limitations of the developed model are also considered and future work on it is recommended towards the end of this thesis.

On a theoretical level, the objective of this study is fulfilled by presentation of the final evaluation model and extended contexts included in the model. While a lot of development of assistive technologies is done in both academia and industry, there did not seem to be many specific evaluation methods available for them. This was an opportunity to understand the needs and preferences of the user group in this setting. The evaluation model called UUXCAT for VIP and its questionnaires can utilized to assess cooperative assistive technology in a field test setting. It is also adaptable to other setting where a functional prototype or product in a market needs to be evaluated. The extended contexts provide extra dimensions to investigate specific issues relating to those who use AT and suffer from visual impairment.

Assistive technology is a category that includes a broad range of systems, services, and products, so it is not reviewed in depth. The focus was on ETA as it was the category of the prototype system the evaluation model was created for. In addition, the literature review related to acceptance of technology is limited, as the initial idea to use it in this study was abandoned relatively early on in favour of usability and UX focus.

Because of Covid-19 the scope of this thesis is narrower, as initially planned. The research team was unable to complete the experiments in Finland. These would have provided valuable qualitative and quantitative data to help validate the evaluation model.

1.4 Structure of the thesis

Chapter 2 of this thesis is a literature review and contains academic literature on AT for VIP in the context of this study. In addition, the chapter contains the review of evaluation methods, terminology, and closely related contexts important for the development of the model. Chapter 3 details the development process of the evaluation model. In Chapter 4, the final version of the development model and other relevant findings are presented. Chapter 5 provides discussion and implications of this study but includes answers to the research questions and considers future research options. Chapter 6 concludes the thesis.

2. Literature review

This chapter reviews the key literature used in this study. Section 2.1 explores the UTAUT model briefly, as it was outlined in early discussions regarding potential evaluation methods and was therefore explored. Afterwards, development related issues of ETA for VIP are considered in Section 2.2 and Section 2.3 more detailed look at various usability and UX methods is provided.

2.1 Unified theory of acceptance and use of technology

Understanding the acceptance and use of information systems is a mature research area in the information systems field and several theoretical models exist to study it (Chang, 2012; Dwivedi, Rana, Jeyaraj, Clement & Williams, 2019). The UTAUT and UTAUT2 are used to predict whether a user intends to use a system and what the subsequent usage behaviour will be like. The original model has four constructs. These constructs contain multiple variables created from many contributing theories on the subject. Performance expectancy is about the degree the user believes that his performance will improve, while effort expectancy is about the ease of use of the system. Social influence looks at how important the user think it is to be seen using the system. Facilitating conditions is about whether the user believes that the system is supported by the organisation and technical infrastructure. (Venkatesh, Morris, Davis & Davis, 2003; Venkatesh, Thong & Xu, 2012.)

The original UTAUT model was typically used to study organizational behaviour, but the UTAUT2 model added in a consumer context with dimensions of hedonic motivations, price, value, and habit (Venkatesh et al., 2012). This version was used to study acceptance of navigation-related AT amongst Finnish VIP by Paajala and Keränen (2015). Hornbæk, and Hertzum (2017) in their comparative study of technology acceptance and UX found that there is currently limited amount of overlap between the research on these two concepts. The focus on technology acceptance remains on adoption and use of technology, while UX methods seek to improve a design by understanding user experiences better. However, some overlap does exist, as is show with a fact that intrinsic motivations have been incorporated in some technology acceptance models. (Hornbæk & Hertzum, 2017.)

2.2 Developing electronic travel aids for blind and visually impaired

The Human Activity Assistive Technology model (HAAT) shown in Figure 2 is a framework developed by Cook and Hussey (2002) that provides perspective on the place of AT in the lives of those who have disabilities. The model describes AT, as a system where a person (Human) uses AT to perform an Activity in some context (Cook & Hussey, 2002; Lenker & Paquet, 2003). The contexts are defined, as social, cultural, physical, and institutional (Cook & Hussey, 2002).

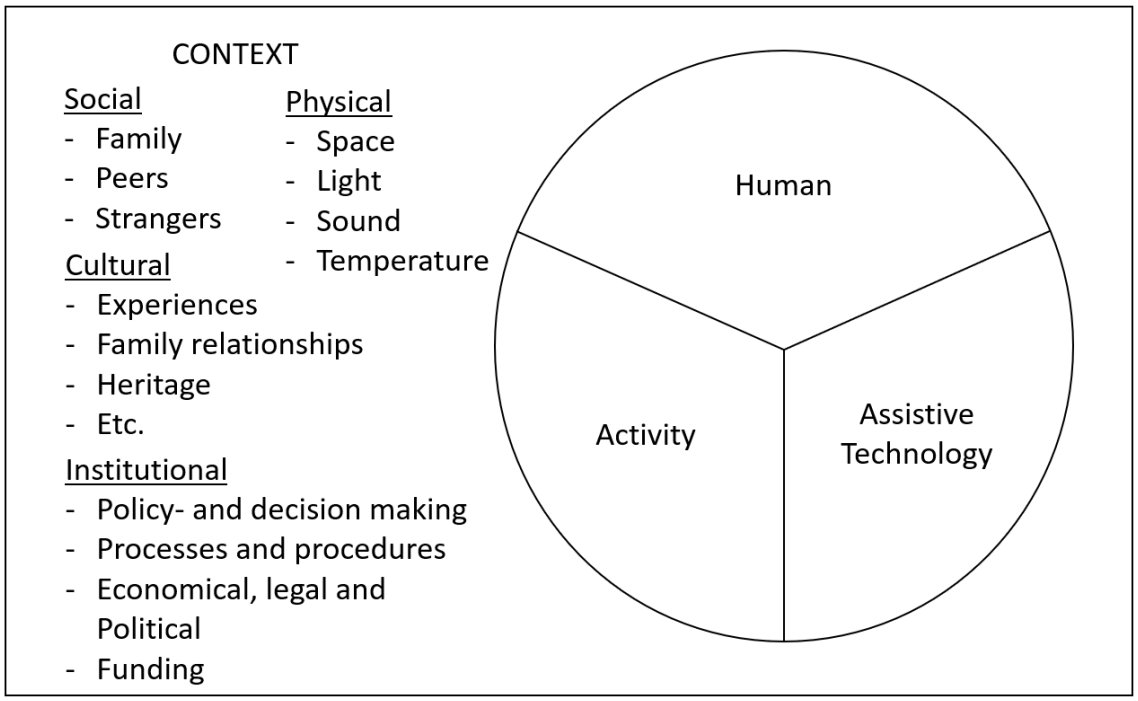

Figure 2. The Human Activity Assistive Technology Model (adapted from Cook and Hussey, 2002).

Cook and Hussey (2002) expect that when the four described factors of Human, Activity, Assistive Technology, and Context, are considered as a part of development process, it will improve acceptance and increase adoption of the final product. When it comes to VIP specifically, Bhowmick and Hazarika (2017) posit that the field of developing AT for VIP is rather complex. It can be approached from different angles and often requires considering physiological, psychological, and human factors related to those suffering from vision loss. They mention that the field of developing AT is multidisciplinary and over 3000 relevant scientific publication were made between 1994 and 2014. Manduchi and Coughlan (2012) claim that development of AT has traditionally been very technology-driven pursuit and many products have been designed by engineers rather than specialists from other areas. These AT products have not become that successful in the market, as they often do not address the actual problems or lack in performance when it comes to the actual use by VIP (Manduchi & Coughlan, 2012).

VIP mainly use two kinds of AT: primary and secondary. Primary technology includes more widely adopted products such as the white cane. Secondary technology consists of many product categories and includes ETA to help VIP with navigation, mobility, and sensing of the near environment (Loomis, Golledge, Klatzky & Marston, 2007; Cardillo & Cademi, 2019). ETA is the term generally used to define this category of products and was first presented by Blasch, Long, and Griffin-Shirley (1989). They define ETA, as "*devices that transform information about the environment that would normally be relayed through vision into a form that can be conveyed through another sensory modality*".

Islam et al. (2019) divide ETA into three categories of sensor-, computer vision- and smartphone-based. According to Islam et al. (2019) all categories have been very active in terms of product development, so there is a lot choice and variety. However, not all products are as far along in terms of development. Solving issues regarding indoor navigation and wayfinding were mentioned by Bhowmick and Hazarika (2017) as one particularly challenging development area. Today many VIP also own a standard

smartphone and can use variety of developed apps that also supplement their needs, such as BlindSquare, RightHear and Be My Eyes (Avila, Wolf, Brock & Henze, 2016; Be My Eyes, n.d.; BlindSquare, n.d.; RightHear, n.d.).

Over the years, there have been many barriers that have inhibited the adoption of ETA. The products used to be cumbersome, unreliable, expensive, and not widely available (Roentgen et al., 2008; Kim & Cho, 2013). Ongoing miniaturization, maturity and rapid advancements of technology, availability and lower costs have removed many of earlier barriers (Cardillo & Cademi, 2019). Another significant problem to overcome is that majority of VIP are elderly and often have other cognitive and physical disabilities. According to Ojamo (2018) estimated 69 percent of VIP in Finland are at least 65 years old or older and 57 percent are 75 years old or older. Elderly tend to be laggards in adoption of new technologies, but emerging young elderly are showing much higher adoption rates (Mostaghel, 2016). Research also indicates that younger people with disabilities are more willing to experiment with AT, as they are often very goal and task orientated, looking to improve their independence and performance (Ripat & Woodgate, 2017).

Roentgen, Gelderblom, and de Witte (2012) mention that individual needs and preferences are important factors determining the adoption and the use of ETA over time. Other factors that can act either as facilitators or barriers include goals and expectations, requirements, functions, functionalities, features of the product, and environmental factors. Research shows that many VIP are also willing to collaborate and communicate with other people when completing navigation or orientation related tasks (Balata, Míkovec & Slavík, 2012; Balata, Franc, Mikovec & Slavik, 2014). The Be My Eyes application is a good example of volunteer community-based AT that helps VIPs and is used widely (Be My Eyes, n.d.).

2.3 Usability and user experience

ISO 9241-210 (ISO, 2010) provides more formal, but also informative, definitions to both usability and UX. ISO (2010) defined usability as measuring effectiveness and efficiency the user has with a product, but also satisfaction the user feels about it. Meanwhile, UX is an umbrella term used to define many concepts that can also include usability (Majrashi, Hamilton, & Uitdenbogerd, 2015). But essentially it is about perceptions and responses that a user has resulting from the use and anticipated use of a product. (ISO, 2010). UX includes emotions, beliefs, preferences, perceptions, behaviours, psychological and physical responses that the user has. These can occur before, during and after the use of a product. During an interaction with a product, UX is also affected by various factors such as brand image, presentation, functionality, performance, interactive behaviour, and assistive capability. In addition, both internal and physical state of the user impacts UX. These can be influenced by prior experience, attitudes, personality, and the context in which the interaction takes place. (ISO, 2010.)

There are many valid definitions for usability and UX besides ISO 9241-210 (ISO, 2010). Majrashi et al. (2015) provide examples of traditional definitions from various sources and discuss how they overlap. It should be noted that different interpretations can lead to different scopes and measures, while different emphasis can lead to different concerns (Bevan, 2009). Vermeeren, Law, Roto, Obrist, Hoonhout and Väänänen-Vainio-Mattila (2010) are of an opinion that usability and UX are intervened and that UX subsumes usability. Arhippainen (2009) sees usability as an interaction experience that is surrounded by different contexts that contribute to the overall UX through the interaction.

Both Arhippainen (2009) and Vermeeren et al. (2010) indicate that UX evaluation methods should be augmented with usability dimension. Figure 3 shows an illustration that highlights differences and relationships between usability and UX (adapted from Majrashi et al., 2015).

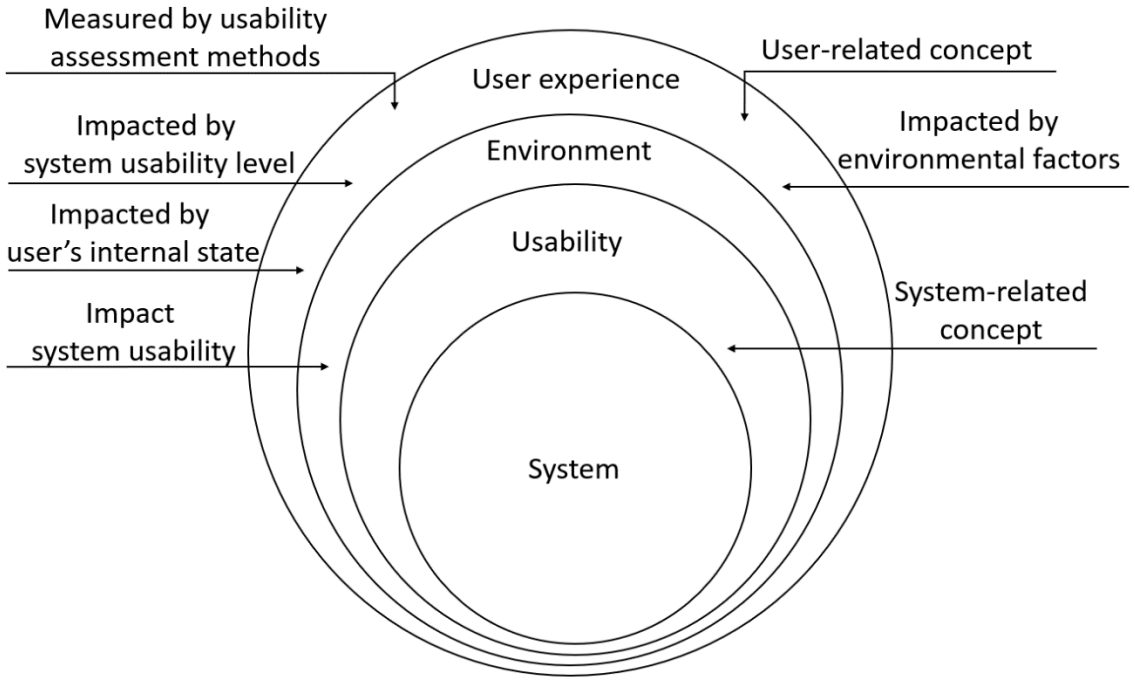

Figure 3. Difference and relationships between usability and UX (adapted from Majrashi et al., 2015).

Bevan (2009) explains that while he found no fundamental difference between measures of usability and UX at a time, different concerns are arrived at when an evaluation focuses on task performance or pleasure. He adds that in user-centered design usability and UX concerns tend to be different. Petrie and Bevan (2009) also reflect on emergence of UX as a concept, which happened when developers wanted to understand consequences of users interacting with a system that go beyond usability. Table 1 from Bevan (2008) provides those factors and dimensions that contribute to UX. It shows how a focus on usability would leave out important dimensions necessary to develop products with lasting appeal to users (Adikari, McDonald & Campbell, 2011).

Table 1. Factors and dimensions contributing to UX consequences (adapted from Bevan, 2008).

Quality characteristic	UX	Functionality	UI usability	Learnability	Accessibility	Safety
Product attributes	Aesthetic attributes	Appropriate functions	Easy to use UI	Learnability attributes	Technical accessibility	Safe and secure design
UX pragmatic goals	To be effective and efficient					
UX hedonic goals	Stimulation, identification, and evocation					
Actual User eXperience	Visceral	Experience of interaction				
Usability (performance in use measures)	Effectiveness and productivity in use			Learnability in use	Accessibility in use	Safety in use
Measures of UX consequences	Satisfaction in use: achieving pragmatic and hedonic goals					
	Pleasure	Likability and comfort				Trust

Arhippainen (2009) expands the UX conceptualization with the presented frame in Figure 4. It depicts that when a user interacts with a product that interaction is influenced by user, product, and then different contexts. All these factors and dimensions can impact the overall user experience. Usability, either good or bad, is present at a moment of use and is at the core of the frame. This frame expands UX concept further and links it up with the HAAT model shown earlier (Fig. 2). Both illustrate that social, cultural, and physical contexts have an impact on usability and UX for VIP (Cook and Hussey, 2002; Arhippainen, 2009).

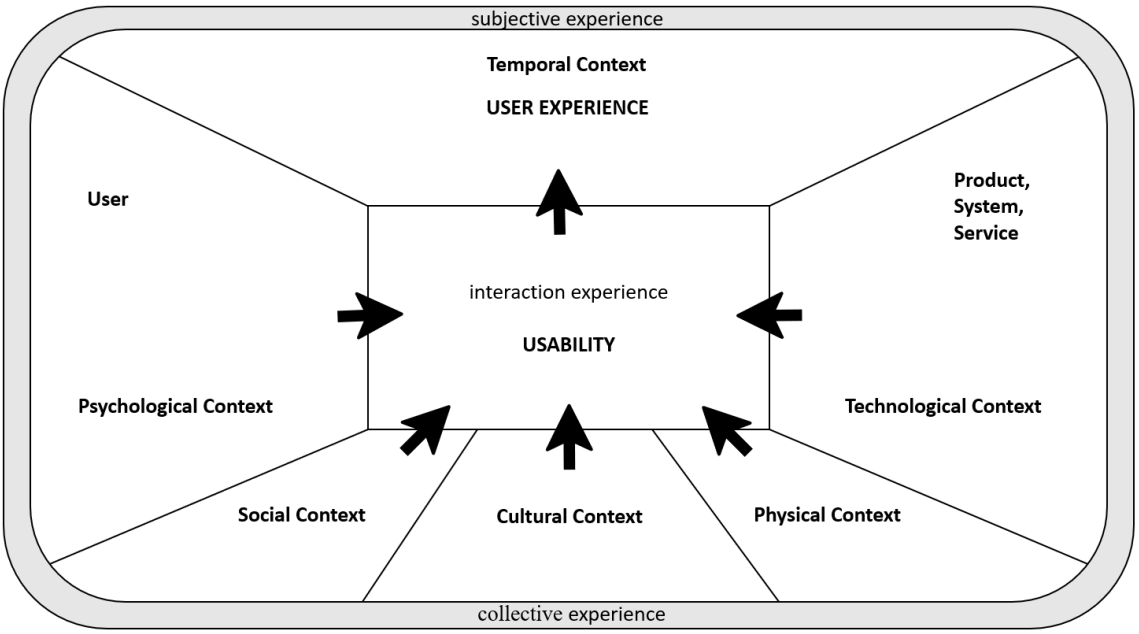

Figure 4. Usability and UX framework with additional contexts (adapted from Arhippainen, 2009).

2.3.1 Evaluation methods

Väänänen-Vainio-Mattila, Roto and Hassenzahl (2008) claim that usability is evaluated for three main reasons. Firstly, to test effectiveness, satisfaction, and efficiency. Secondly, to make UI and the product easy to use while also making it easier to learn. On the other hand, according to Bevan (2009), UX is evaluated to understand the user and what they do and what they want. He adds that gaining recognition, suggestions, and other emotional responses are also achievable aims of UX evaluation.

There are many usability and UX evaluation methods that can be used to investigate variety products from different angles. Methods include anything from measuring of a very specific task performance to asking about how the user felt after interacting with a product. (Roto, Obrist & Väänänen-Vainio-Mattila, 2009; Paz & Pow-Sang, 2015; Chung & Sahari, 2015.) Different methods can be used at different parts of design and development process. Some methods are specific to certain settings, while others are more universal. (Roto et al., 2009; Paz & Pow-Sang, 2015.) Usability evaluations can be used for different types of products, services, or systems. The aim is to assess the interaction between humans and machines. The interaction should result in user satisfaction, as they achieve their goals while using the product. (ISO, 2010; Paz & Pow-Sang, 2014.) The same is true for UX evaluations but providing engaging UX becomes more important when adequate usability and technical reliability has been reached. This becomes more important when a sector of industry matures. (Roto et al., 2009.)

A practitioner website founded in 2010 lists daunting 86 different UX evaluation methods, while another website on usability explain nearly 20 commonly used methods (All About UX, n.d.; Usability Body of Knowledge, n.d.) It is important for a practitioner, whether in academy or industry, to know, which methods are suitable in different contexts and that mixed methods are often used to gather richer data (Obrist, Roto & Väänänen-Vainio-Mattila, 2009; Roto et al., 2009). Using combination of methods is common and even recommended to capture wider or more detailed perspective (Roto et al., 2009; Díaz-Oreiro, López, Quesada & Guerrero, 2019).

The UX methods can be divided into four broad categories by type of method used, which development phase they are suitable for, at what period of experience, and what are the evaluator types it is used for. It should be noted that some methods are suitable for multiple different settings. These categories are shown in Table 2 (About UX, n.d; Roto et al., 2009; Roto, Law, Vermeeren & Hoonhout, 2011).

Table 2. The UX evaluation methods (About UX, n.d; Roto et al., 2009; Roto et al. 2011;).

Method	Field Studies	Lab Studies	Online Studies	Questionnaires / Scales
Development phase	Scenarios, sketches, or concepts	Early prototypes	Functional prototypes	Products on market
Period of experience	Before usage	During interaction	After usage	Over time, long-term
Evaluator or information provider	UX experts	One user at a time	Groups of users	Pairs of users

Research also show that it is important to capture UX over time, as views on UX tend to change as time passes (Karapanos, Zimmerman, Forlizzi & Martens, 2009; Roto et al., 2011; Marti & Iacono, 2016; Feng & Wei, 2019). Feng and Wei (2019) differentiate between first-time and long-term UX. Those product qualities that provided positive initial experience may not be those motiving for longer use. Familiarity, functional dependency, and emotional attachment are the main temporal forces that impact the experience over time. (Karapanos et al., 2009; Marti & Iacono, 2016). Roto et al. (2011) suggest four time periods when to capture UX. These are: Anticipated UX before the usage, Momentary UX while experience the use, Episodic UX when reflecting on the experience and finally Cumulative UX when recollecting memories from multiple periods of use. These are shown in Table 2, as period of experience. Evaluation methods for each period can be quite different. For example, standardized questionnaires can be used to capture at least Episodic UX and Cumulative UX (Marti & Iacono, 2016).

2.3.2 Standardized questionnaires

Standardized usability questionnaires such as SUS (System Usability Scale), and USE (Usefulness, Satisfaction, and Ease of use) have been around for a while and are quite popular in both academia and industry, as they have been found to be reliable and valid methods (Brooke, 1996, 2013; Lund, 2001; Paz & Pow-Sang, 2014; Chung & Sahari, 2015). As UX has gained popularity over the recent years, few standardized UX questionnaires have emerged that try to provide comprehensive and easy to use way of capturing key parts of UX. Some of these methods are free to use, while other require payment. The benefit of using standardized UX questionnaire is that they are easy to use and economical, while considered reliable and valid measuring methods. (Minge, Thüring & Wagner, 2017; Díaz-Oreiro et al., 2019).

AttrakDiff, User Experience Questionnaire (UEQ) and meCUE are standardized UX questionnaire currently used in academic research and Díaz-Oreiro et al. (2019) provided a systematic literature review for them. They noted that by far the most popular is AttrakDiff, as it was first to the market in 2003. However, UEQ has surpassed it in 2017 and 2018, while meCUE remains a relative newcomer. However, Díaz-Oreiro et al. (2019) conclude that in over sixty percent of the cases between one and five additional methods were used to complement a standardized questionnaire. SUS, the standardized usability questionnaire introduced by Brooke in 1996, was used often together with UX questionnaires (Díaz-Oreiro et al., 2019).

Module I: Perception of instrumental product qualities	Module II: Perception of non-instrumental product qualities	Module III: User emotions	Module IV: Consequences of use	Module V: Overall evaluation
Dimensions:	Dimensions:	Dimensions:	Dimensions:	Dimensions:
Usefulness Usability	Visual aesthetics Status Commitment	Positive emotions Negative emotions	Intention to use Product loyalty	Overall evaluation

Figure 5. Modules of the meCUE 2.0 questionnaire (adapted from Minge and Thüring, 2018).

AttrakDiff (Hassenzahl, Burmester, & Koller, 2003), UEQ (Laugwitz, Held, & Schrepp, 2008) and meCUE (Minge et al., 2017) all evaluate hedonic and pragmatic dimensions of

UX. In addition, meCUE considers emotional dimension and has a wider perspective on acceptance. MeCUE is also a modular approach to a standardized UX questionnaire, as seen in Figure 5. It is currently more comprehensive and has more dimensions than AttrakDiff or UEQ because it was developed with the latest research in mind, but UEQ has also been updated recently to expand it and a modular version of it exists as well (Minge & Thüring, 2018; Schrepp, & Thomaschewski, 2019b).

The purpose with meCUE was to make a single standardized questionnaire that would address key components of UX (Minge et al., 2017). MeCUE questionnaire is now on its second incarnation and has four modules that focus on different UX dimensions. First two modules focus on perception of instrumental and non-instrumental qualities, respectively. The third module is about user emotions and the fourth module focuses on consequences of use. The fifth module is used for overall evaluation. While the questionnaire is comprehensive, it is still missing certain aspects of UX. Missing dimensions include perceptions of acoustic and haptic quality, and trustworthiness of the system and received information. In addition, the questionnaire focuses on interaction with a technical device and does not consider interpersonal relations and social influences of UX. (Minge & Thüring, 2018.)

2.3.3 Additional contexts

Several UX contexts were identified that needed to be explored for VIP and collaborative situations, as they were missing from standardized questionnaires. The first context was the issue relating to trust, but also includes confidence. Forster, Hergeth, Naujoks and Krems (2018) show that trust is an important precursor of for acceptance of technology, while Petrie and Bevan (2009) consider safety and trust from usability perspective. Petrie and Bevan were concerned whether the system safety is about protecting the user or whether the user trusts the system to behave as intended. Schrepp and Thomaschewski (2019a, 2019b), when validating additional scales for the UEQ questionnaire, considered trust from more safety perspective and have dependability as a separate scale measuring trust in a similar manner defined by Petrie and Bevan (2009). UEQ+ is more recent version and a modular approach to UEQ (UEQ+, n.d.). The questionnaire introduces several new scales that are relevant measures for AT. Trustworthiness of content, haptics, acoustics, and adaptability of the product are measures that can provide insight to VIP using AT. (Schrepp & Thomaschewski, 2019a, 2019b).

Arhippainen (2009) presents several additional contexts that are missing from many current usability and UX evaluation methods (Fig. 4). According to Arhippainen (2009) and Schilit (1995), the culture context is about the habits and rules the user has, but also habits and rules of others, and even differences between people and environment from different countries. Social contexts are essentially about presence of other people, sharing the experience, and having to deal with distractions, such as phone calls during the interaction of the product. Physical contexts focus on environment itself where the interaction takes place. It can include aspects such as weather or differences between indoor and outdoor lighting. (Schilit, 1995; Forlizzi & Battarbee, 2004; Forest & Arhippainen, 2005; Arhippainen, 2009.)

3. Development of the evaluation model

This chapter describes development of the evaluation model. The evaluation model was developed iteratively and was influenced by the theoretical and empirical parts of the study (Fig. 1). The major iterations of the development model are presented in Figure 6 for a quick reference.

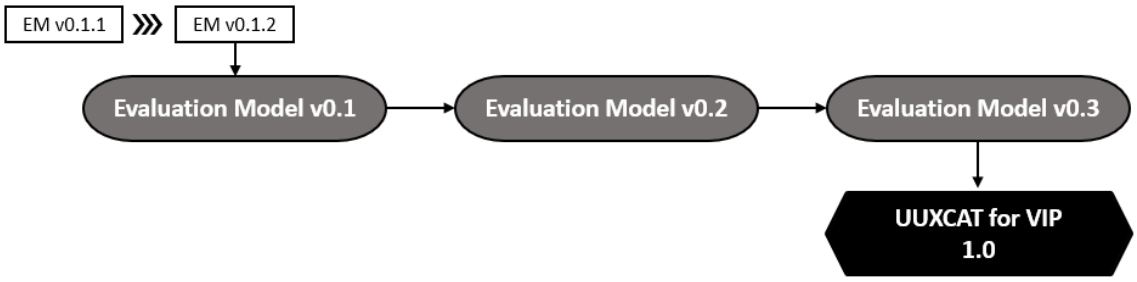

Figure 6. The major iterations of the evaluation model.

The target system, requirements and user study needs from the research team shaped the original direction of this study and are explained in more detail. It should be noted that discussions with the research team also provided significant contributions to the development of the model throughout the research process. In addition, each iteration of the development model is discussed at length. In between, the results from the first experiment in Pakistan are presented. A summary from expert interviews conducted in Finland is given. Certain elements of the plan for experiment in Finland are discussed including the evaluation setting procedure.

3.1 Requirements and user study needs

Figure 7 is a visualization of the early requirements and user study needs. These were expressed by the research team I worked with, but primarily came from the doctoral student who built the prototype system to be evaluated. The doctoral student had worked on different versions of the system and done testing on previous iterations of it. The aim for this study was to explore usability and acceptance of technology of the latest iteration of the system in specific settings. This included assessing the viability of the system, which meant finding out whether users like functionalities of the system. The acceptance of technology was to answer whether the users find the system too complex, intrusive, unnatural, or does it meet their needs. The UTAUT2 model was suggested for this evaluation. To address the future development of the system, aspects such as experience with the haptic and voice interaction modalities, personalisation, safety, security, usability, and general usefulness, were to be explored.

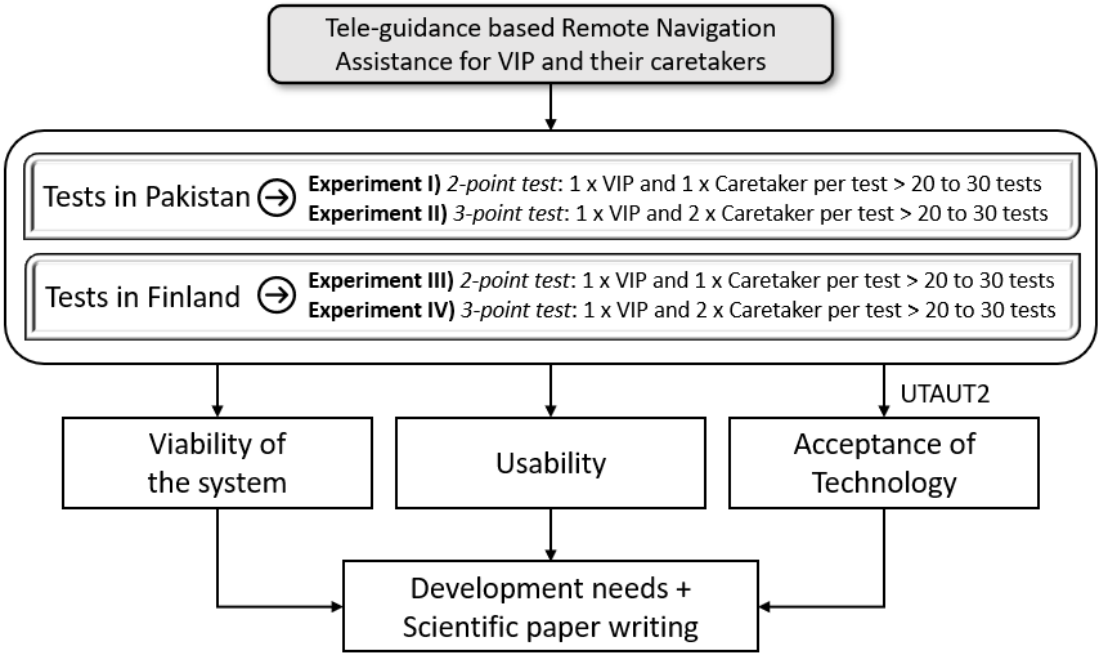

Figure 7. An early version of requirements and user study needs.

Two different type of experiments were planned, and both were to be carried out in Finland (Oulu, Jyväskylä) and Pakistan (Islamabad, Lahore). It should be mentioned that these requirements and user study needs were decided before I joined the team. The first type of experiment included two participants at a time working together with the system, a VIP, and a caretaker. This was referred to as the 2-point testing. The experiment could either involve professional or volunteer caretakers. In the 2-point testing, a remotely located caretaker would use the system to guide VIP through three scenarios. Each scenario would be done twice using two different haptic schemes. A smartphone would be placed on the chest of the VIP and it would transmit a field of view through its camera to the caretaker. Using this view, the caretaker could use haptic and voice modalities to guide VIP. The pair would then complete the three scenarios while being observed. The second type of experiment would be otherwise similar, but there would be two caretakers. The first caretaker could either be professional or volunteer, but the second one had to be a location expert. The aim of this experiment was to switch caretakers at certain points during a scenario. This was to test whether the system would work well when the caretakers would make a switch. In other words, the location expert would take over when the normal caretaker did not know how to guide the VIP in a location. The normal caretaker could still be able to watch and learn about the area from the location expert.

In both Finland and Pakistan, the idea was to recruit participants through personal contacts. Partnerships or at least plans for them were in place with VIP associations and schools. Initially the goal was to conduct at two experiments per location. One for the 2-point testing and another for the 3-point testing. This would have meant a high number of tests with a lot of participants. The 2-point testing at one location would include between 40 to 60 participants with 20 to 30 VIP and 20 to 30 caretakers. Each test was to take no more than two hours. This included instruction and orientation, traversing to test locations, filling out questionnaires and conducting interviews. In Finland, half of the test could be completed at the University of Oulu campus to reduce the number of days in Jyväskylä. This was mainly a budgetary concern, but at this point, the research team did not know exact number of participants and days that would be available in Jyväskylä.

3.2 The target system

This section described the prototype system that was to be evaluated. The longer name for the system is Tele-guidance based Navigation Assistance System for Blind and VIP. The system consists of the Smart Cane, Mobile Application and Web Server (Fig. 8). VIP participants will be provided with the Smart Cane, a smartphone, and a Bluetooth headset. Caretakers will use a 6.3-inch screen smartphone with the application installed. This screen will show the field of view transmitted from the smartphone placed on a chest of VIP.

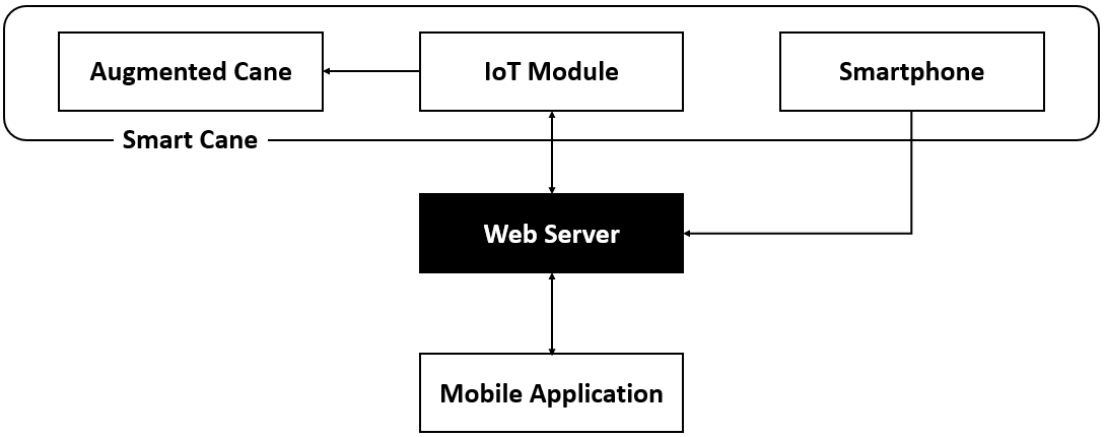

Figure 8. Block diagram of Tele-guidance based Navigation Assistance System for Blind and VIP (adapted from Chaudary et al., 2020).

Smart Cane includes haptic interface that gives out vibrations. Two different versions of this haptic interface were to be tested. The first one had one button using a specific set of vibrations, while the second one had two buttons. In addition to this modality, voice communication can be used between VIP and caretakers, but navigational assistance is mainly given through haptic feedback. Interfaces work over the internet of things (IoT).

Augmented Cane is an ordinary white cane with an enhanced grip that has the haptic vibrators installed. The vibrations patterns were made to match those used in Apple's Watch for maps, so that performance between them could be compared. The IoT module is also attached to Augmented Cane and provides connection to the web server. The smartphone is hanged in the neck of VIP with a necklet and sends real time video feed to the smartphone used by the remotely located caretaker. VIP can also use the Bluetooth earpiece to communicate with the caretaker.

Mobile Application used by the caretaker has a simple User Interface (UI) that is divided into two halves. The upper half show a video feed of the field of view from VIP. The lower half has two buttons that can be used to control the vibrators on Smart Cane. The application also enables voice communication on a separate GSM channel to remove delay in communication that may be caused by IoT. This results that the video feed may suffer from some lag, but the voice communication is in real time. The role of Web Server is to host the control logic of the communication between Mobile Application and IoT module.

3.3 The first iteration of the evaluation model

This section goes through the first iteration of evaluation model and explains why certain methods were chosen. There were three major iterations to the model before the final evaluation model was reached. Figure 9 shows the first two revisions of the evaluation model. These revisions have been combined into the same version, as they happened early in the research process.

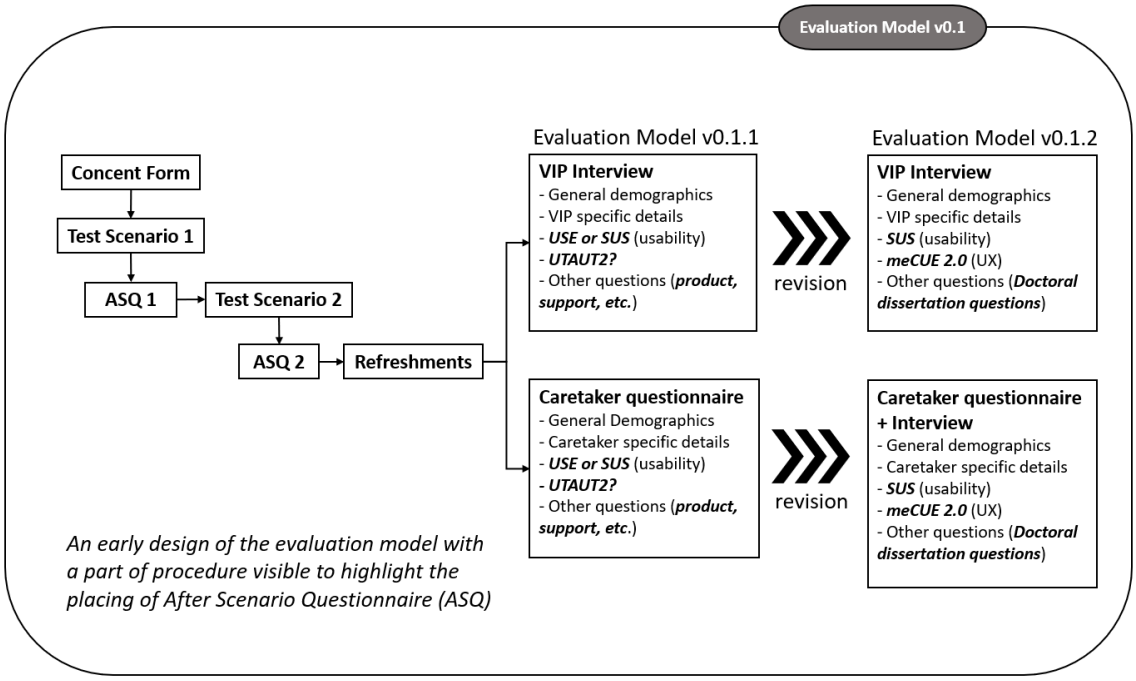

Figure 9. The first iteration of the evaluation model.

Initial requirements and user study needs influenced the selection of UTAUT2, as a potential method and was reviewed (Venkatesh et al., 2012). In addition, literature review was conducted on methods that would answer the usability aspect of the requirements (Fig. 7). Early work consisted adding the demographics part to the tests including specific details for VIP and caretakers, as they would be interacting with the system differently, while also having quite different backgrounds and needs. Other questions were also considered regarding the system and its support. However, it was decided that at this point additional questions should focus more on the doctoral dissertation.

There are many different usability methods available. Various methods were reviewed based on their suitability to the field test setting with the prototype system. Essentially, usability evaluation needed to cover three areas of inquiry. These were effectiveness, efficiency, and satisfaction (ISO, 2010). These aspects would have to be answered reliably and with validity. Because of the setting, a decision was made to look at usability questionnaires more closely. The questionnaire needed to be comprehensive, but with a limited number of questions, complexity also needed to be low, and it should be quick to complete, as there were going to be other evaluation methods as well. The other methods at this point were the UTAUT2 model from Venkatesh et al. (2012) and possibly After Scenario Questions (ASQ) from Lewis (1991). The idea for using ASQ was that it might be useful to ask few questions just after a test scenario and not wait until the end.

The top usability questionnaire contenders at this point were SUS from Brooke (1996), USE from Lund (2001) and Post-Study System Usability Questionnaire (PSSUQ) from

Lewis (2002). Each of these were considered and are considered reliable and valid. The selection of SUS came down to a few things. It is used a lot in various studies and secondly it contains only 10 questions whereas PSSUQ had 16 and the additional questions did not really provide a lot of extra meaning to this study. The USE is by far the most comprehensive of this lot and was a strong contender for a time. It was presented as a viable option early on but was discarded mainly because it is too comprehensive for the purpose of this study. In a sense, it was a choice between 10 and 30 questions. Another factor that favoured SUS was that it is used a lot in both academia and industry, so the results are comparable with many other studies.

The UTAUT2 model was also dropped after literature review of UX methods. While the UTAUT2 might be useful later, UX was considered to provide more interesting data at this point. The UTAUT models focus on understanding the intention to use and the subsequent behaviour of users. Surveys done with the UTAUT models are usually for a high sample size. The UX methods can typically be used for a smaller sample size and still provide interesting data. Also, understanding emotions and attitudes of participants towards the prototype system would be valuable for its future development.

Just like with usability, there are many types of methods that can be used to measure UX, but the questionnaire methods were considered suitable for this setting. At this point, a UX expert was consulted regarding the study. Study from Rajeshkumar, Omar and Mahmud (2013) also showed that UX is most often used for prototypes or products ready to be or already deployed. Review of various UX methods, led to three standardized UX questionnaires. These were AttrakDiff (Hassenzahl et al., 2003), UEQ (Laugwitz et al., 2008) and meCUE 2.0 (Minge & Thüring, 2018). While it was clear that both AttrakDiff and UEQ were popular and used by many researchers (Díaz-Oreiro et al., 2019), meCUE 2.0 was chosen because it was the most recent, appearing to be most comprehensive and had been developed with the most recent research in mind (Minge & Thüring, 2018). It was the only one that incorporated user's emotions to the evaluation. In addition, it was an opportunity to test this new method in this setting and see how well it does.

At the time when this phase concluded, the first experiment was conducted in Pakistan that was used to validate the meCUE 2.0 questionnaire. It was done with several VIP who carried out navigational tasks with the system and completed a translated questionnaire along with interviews. The SUS questionnaire was not used, but detailed examination of the methods showed that the questionnaires have very little overlap and supplement each other rather nicely. During this time, several expert interviews were also conducted in Finland.

3.4 Experiment in Pakistan

This section details the experiment done in Pakistan. The experiment in question is the 2-point testing marked as Experiment I in Figure 7. The viability of the meCUE 2.0 questionnaire was explored with the experiment and for the purpose of this thesis the results are important. Understanding the setting is also important, as it reflects on the development of the evaluation model. It also impacted the choices made for the experiments planned in Finland in terms of the setting and procedure. The doctoral student carried out the experiment in Pakistan.

The experiment in Pakistan involved using the 2-point testing mentioned earlier, which means using two participants in each test. A total of eleven blind and visually impaired participants along with a single sighted caretaker took part in the tests. This was nine VIP

short from the originally planned number and only one caretaker was used, who was also a part of the research team. The system used for these tests is described in Section 3.2. Each test session lasted around 45 minutes and included instruction and orientation, three navigation scenarios and a semi-structured interview that also covered the questions for the meCUE 2.0 questionnaire. All communication and data gathering were conducted in native language of the participants. The data gathering was based on field laboratory design recommendations by Høegh, Kjeldskov, Skov, and Stage (2008).

3.4.1 The evaluation setting

The evaluation setting is show in Figure 10. Additional personnel shown are Camera Operator and Safety Person. The former oversaw recording of the tests for later analysis and the latter was there to keep an eye on the VIP participant in case something goes wrong.

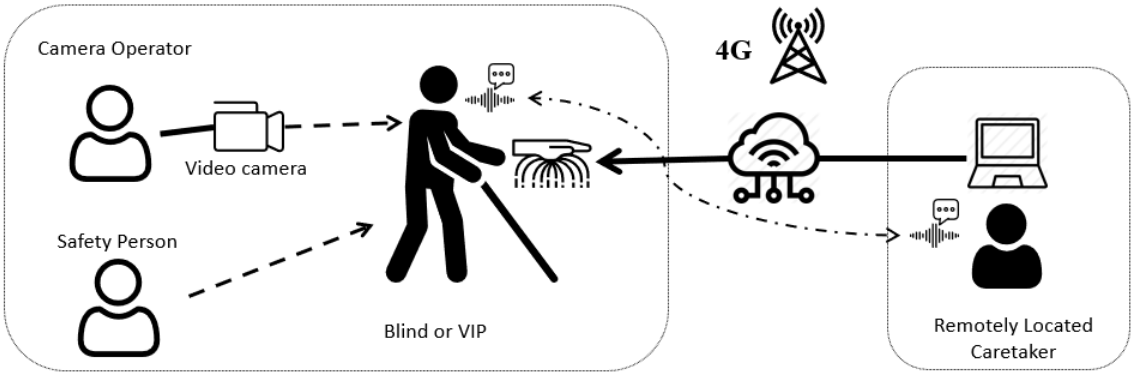

Figure 10. The evaluation setting for Experiment I in Pakistan

All tests were completed by the same caretaker who was placed in a remote location and navigated the VIP participant through a planned route. The aim of the study was to validate the design of the prototype system and more specifically to investigate two haptic-based vibration schemes. It was important to find out if they preferred the one with one or two buttons, and if there were differences between blind and visual impaired. In addition, feedback was gathered from VIP and the caretaker to get a better understanding of UX with the system.

The experiment was conducted both in indoor and outdoor environment. The outdoor testing place was in a public park where it was possible to do testing with less interference and hazards. The indoor route was a corridor in a building. The outdoor route had a total of 8 decision points while indoor had a total of 10 decision points. The length of the indoor route was around 46 meters and the outdoor route was around 76 meters.

3.4.2 The evaluation procedure

Before starting the testing session, participants were given an oral introduction about the system and test procedure. The Smart Cane was handed over to them to get a feel of it by touching and grasping. Any questions they had were answered. While at the start of the session, approximately 5 minutes were used for a test run of the system. Few tactile cues and voice commands were given to get test participant familiar with the system and to check that the equipment was working properly. Participants were also instructed on the use of vibration protocols.

The navigation scenario was tested with both haptic vibrations scheme separately. This means that a total of six tests were run per participant. All tests were video recorded for later observation. At a completion of each scenario, post-scenario questions were asked, and audio recorded, while the cumulative feedback from participants about usability and acceptance of the system was asked and audio recorded at the end of the test. Further interviews about UX were conducted using a meCUE 2.0 based questionnaire and their answers were marked on a paper sheet.

3.4.3 Results

Usability and user experience results from Experiment I in Pakistan are reported in (Chaudary et al., 2020). This section will mainly focus on the findings derived from the meCUE 2.0 questionnaire, as validating this method was important for the development of the evaluation model. This was the first time the research team used this method in the field. It should also be mentioned that the data for usability testing came from analysis of navigation videos, audio recordings of post-scenario questions, and from the cumulative participant feedback about the system. These were considered as good methods to gather this type of information even when the SUS method was not applied in Pakistan. In addition, group discussions were held after the tests, which could potentially be used in Finland as well, at least in Jyväskylä where all participants would be at the same location because it is a school. Observations also helped to uncover some specific problems that the VIP participants had, which could be used to refine the procedure for future experiments.

The meCUE 2.0 questionnaire uses the 7-point Likert scale. It also has an additional question about the overall experience uses a scale from minus five to plus five. Cronbach Alpha test was used to check the consistency of the meCUE 2.0 data. All values of Cronbach alpha reliability test results are ranging from 0.73 to 0.86. As the general rule of thumb is that a Cronbach's alpha of 0.70 and above is good. The reliability of meCUE 2.0 in this instance seems to be good at least with the small sample size. (Chaudary et al., 2020.)

Analysis of the UX data (Fig. 11) shows the way that meCUE 2.0 provides the assessment of each module. In this instance of eleven users, the feedback was very positive for the prototype system. They perceived the system as useful and usable (Module I). Visual Aesthetics, Status, and Commitment (Module II) was also appreciated, even though the system was in a prototype development phase. Emotions (Module III) were mainly positive. Two participants experienced negative emotions, because they felt that the system makes them tired, as using it was exhaustive. A single participant felt that the system makes him feel passive. Also, intention to use and product loyalty (Module IV) was rated quite high. For instance, all participants thought that they would use this system daily. In addition, 64 percent of all participants answered that they would not swap this product for any other. The overall evaluation (Module V) of the system was high with a mean value of 4,4. (Chaudary et al., 2020.)

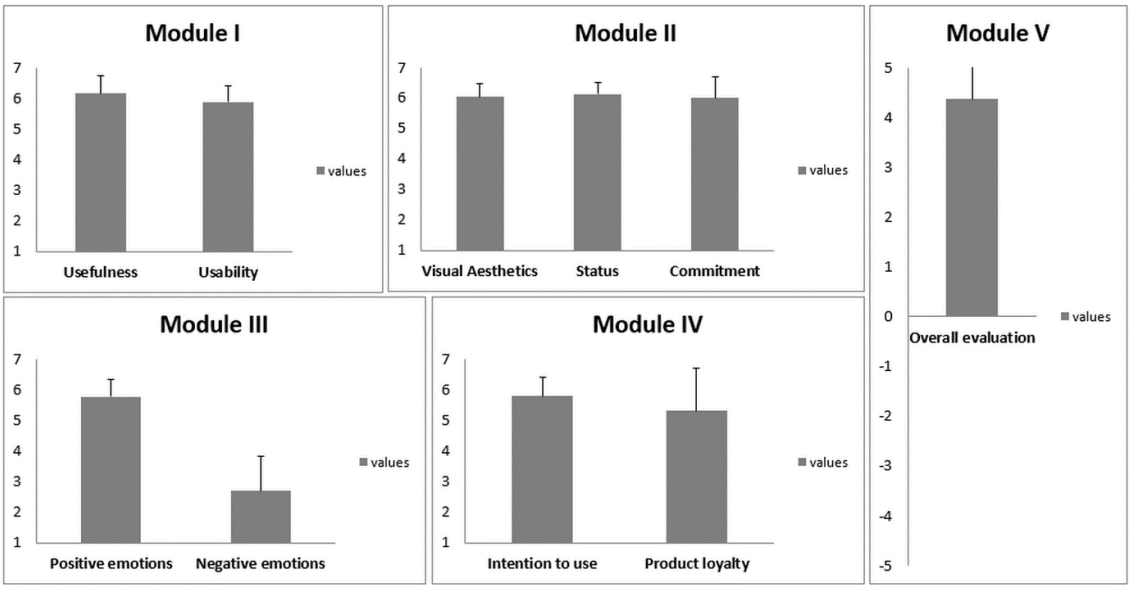

Figure 11. Mean values and standard deviations according to the meCUE 2.0 questionnaire from blind and VIP participants (n=11).

One concern that came up from this experiment was on the participant bias issue, as it has been known to produce significant amount of error (Dell, Vaidyanathan, Medhi, Cutrell, & Thies, 2012). Dell et al. (2012) argued that it is crucial to avoid this. For example, in the case of VIP, it might be possible to mention by the interviewee asking the questions that they are not a part of the research team, but only conducting these tests on their behalf. This could at least avoid some of the participant bias issue. Ideally, the whole questionnaire would be presented in Braille, so that VIP would not have to be asked questions verbally.

3.5 Expert interviews in Finland

Three semi-structured interviews were conducted with experts from Finnish Federation of the Visually Impaired (NKL, n.d.; PPNRY, n.d.). Interviewees were recommended by PPNRY, as they were known experts on VIP and AT. A total duration of the interviews was around 130 minutes. Interviews were informal discussions, but the prototype system was described to them in detail to probe their interest. In addition, several questions were asked to direct the discussion. Interviewees were only interrupted if there were misconceptions about the prototype system. Notes from these discussions were analysed and anonymised, and the key findings are presented below in a summary format. Table 3 provides details on participants.

Table 3. Participants in expert interviews.

ID	Gender	Expertise	Institute	Date	Duration of interview
1	F	VIP instruction	PPPNY	4.2.2020	30 mins
2	F	ICT, VIP instruction	PPPNY	4.2.2020	40 mins
3	F (VIP)	IT specialist	NKL	6.2.2020	60 mins

According to the interviewed experts, caretakers do not typically assist VIP with navigation related tasks. The main reason for this is the limited time they have allocated. A typical caretaker only has 20 hours per month, and this is often used to read mail, shopping, and other living-related tasks. In addition, most VIP want to be independent and not rely on others whenever possible. Finland is in a good position, as VIP over 40 to 50 years have been integrated to the society. They use white canes and have guide dogs when required. Some of them can use transport services. In other words, the state takes relatively good care of them. When they move in a new area, an instructor familiarizes them to the area. They go through the process of learning and memorizing the main routes and locales in the area, such as shopping malls and health services. One interviewee believed this is not the case in all countries. Nor do people get even the most basic AT, such as white canes or dogs, in some countries. Also, technology infrastructure is very good in Finland versus many other developing countries. In less developed countries, VIP often left to be taken care by their immediate family and friends rather than the state.

Interviewed experts were not overly enthusiastic about the new prototype technology when it was explained to them, as they felt it did not bring significant change to existing solutions in the market. One concern with this is that one must have a good approach when explaining new technologies for VIP. Especially with new technologies that can have major concerns related to safety and risk. For example, even when the traffic light is green who will want to take a risk and guide VIP through the crossing. In addition, if something goes wrong, who is responsible? One interviewee thought that this type of prototype system might be more useful indoors where there is need to access services, for example in shopping malls, where VIP need access to more feedback than just orientation and navigation related, such as special offers or menus.

Two interviewees mentioned that other solutions such as BlindSquare and Beacon-based technology provide similar functions, while Be My Eyes can be used for orientation and other information. Essentially, they felt that all that needs to be developed had already been, at least relating to this type of technology.

In addition, one interviewee saw the age as major inhibitor to adoption of new assistive technologies in Finland. She told that an average age of VIP is about 79 in Finland and that they tend to focus on proven routines and methods. She did mention that children and young people are keener to try out things, but that they are very goal and task orientated. They are quick to test and fast to abandon if the product is not good enough. The product needs to solve real problems for them. This is also true for those VIP who work.

3.6 The second iteration of the evaluation model

Figure 12 represent the second major iteration of the evaluation model. The model changed visually as the procedural part was removed, but the major change was with the additional contexts that were considered. In addition, a clearer picture started to emerge on what the key findings and supporting findings were going to be from the experiments.

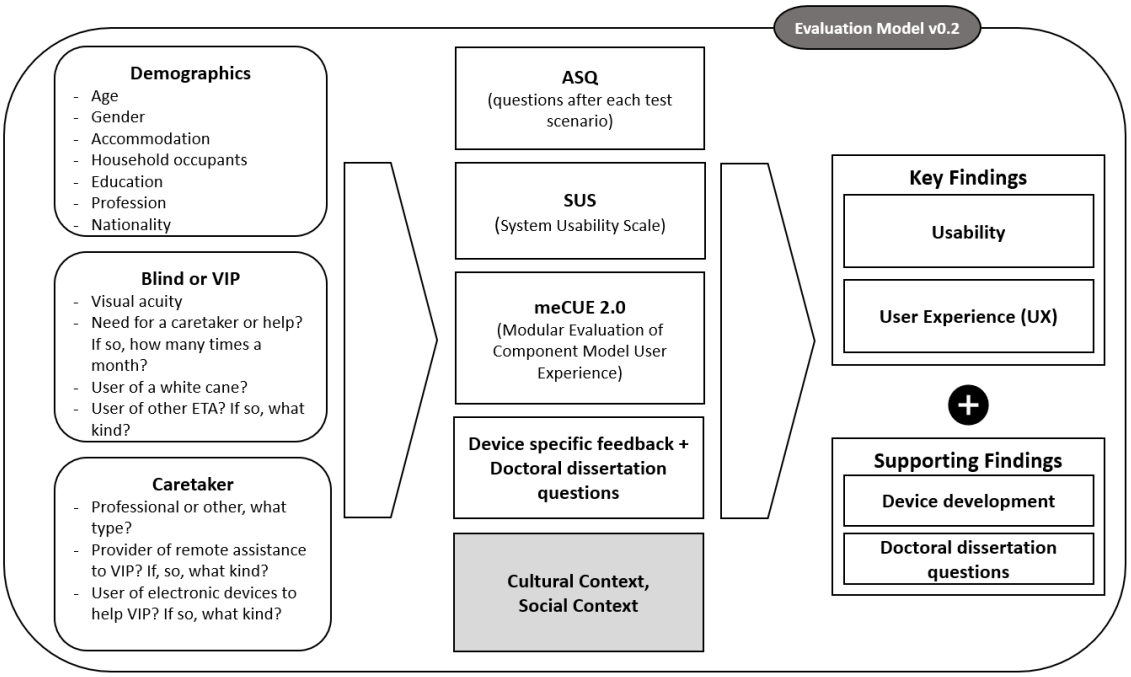

Figure 12. The second iteration of the evaluation model.

At this point, the research team had completed the first experiment in Pakistan. This gave us valuable insight, as also discussed in the journal paper (Chaudary et al., 2020). However, further research in the topics of usability and UX revealed that it would be prudent to extend our evaluation methods to capture more holistic understanding of specific needs and issues related to VIP and their caretakers. For example, the use of the system relies on cooperation of two or more people, so it was important for us to capture the impact that has on UX of all users. This was presented as a social context. In addition, culture was mentioned, as an important factor. Neither of these were covered in meCUE 2.0 or SUS but were of interest to the research team.

Based on research team discussions, first experiment, and its results from Pakistan and expert interviews in Finland, an extended literature review was carried to widen the scope of the study. While standardized questionnaires were useful, the study needed to capture other aspects of usability and UX as well. The focus was going to be on social and cultural contexts, but based on discussions, safety, security and trust related issues were also added to consideration at this point.

3.7 The third iteration of the evaluation model

The design of the evaluation model changed a lot in this iteration (Fig. 13), as several key concepts were added. The main change was that periods of experience were given an influential role in the model. This is because it is important to capture UX at distinct parts of the test, as how the participant feels about the system can differ a lot at different times. (Karapanos et al, 2009; Roto et al., 2011; Marti & Iacono, 2016.) Also, ASQ was removed at this point in favour of post-task questionnaires specifically designed for this study. In addition, two semi-structure interviews were added to capture Anticipated UX and Episodic UX. While observation of participants had always been in the plan, it was formalized to the evaluation model as well, as it was the most suitable method for this setting and had proven valuable in Pakistan. The idea was that all experiments will be video recorded from the VIP side and analysed later. It was important that the participants

were not interrupted during the test because they had to complete navigation scenarios in cooperation with each other, while interacting with an unfamiliar system. The experiment in Pakistan had shown that for some VIP the navigation with this system can be mentally taxing (Chaudary et al., 2020).

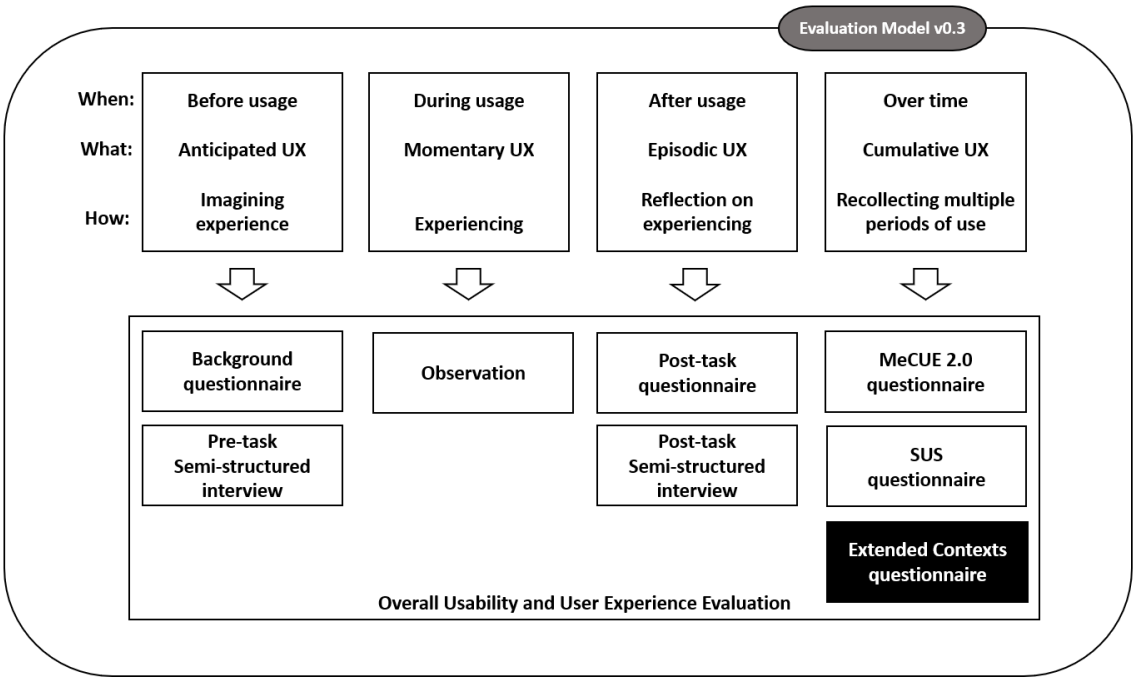

Figure 13. The third iteration of the evaluation model.

The other major change was that extended contexts had been added as a separate questionnaire. It contained four contexts at this point. Three were the social, physical and culture contexts. The name of the fourth one was still under consideration, but it contained aspects related to confidence, safety, security and trust. Social, physical and culture contexts were aligned with previous research from Cook and Hussey (2002) in their HAAT model, and from Schilit (1995) on context aware mobile computing, and finally from Forlizzi and Batterbee (2004) with collective experience aspect impacting on the interaction experience and therefore influencing the overall UX.

3.8 Planned experiment in Finland

The planned experiment in Finland was going to be for the 3-point testing marked as Experiment IV in Figure 7. This plan meant that all the questionnaires were translated into Finnish. This included meCUE 2.0, which was translated completely for both VIP and caretakers, as no previous translations were found (App. E). In addition, other questions were translated. This included going through previously translated SUS questionnaires and making sure that the translations were suitable for this experiment (App. D). VIP participants were going to be given a Braille-based 7-point Likert scale with a hope to increase variety in their answers, as the questions had to be asked verbally and they would have to rely remembering the Likert scale.

Two ethical committees, medical and humanist, were consulted about the experiment in Finland, but according to them there was no need to request the official approval, as our plans did not include those factors that would require it. However, it could be applied for if the research team thought it might be needed. Based on this feedback and the given

criteria from the committees, it was decided that these experiments did not require it. On the liability and risk side, advice was that a participant needs to be informed about the research and the experiment. This includes going through all the risks, which is a responsible conduct of research. If the participant chooses to sign a consent form after made aware of the facts, there should be no consideration that goes outside the norm associated with this experiment.

Unfortunately, the plans to tests the prototype system in Finland went through few changes over the course of this study. Initially, the plan was to pilot the experiment at University of Oulu and do Experiment III and IV at Valteri School Onerva located in Jyväskylä (Onerva, n.d.). These plans changed for two reasons. Firstly, the previous contact person had left the organization there and we had no new contact there. Secondly, the budget allocated for experiments had become very small and going to Jyväskylä was going to be too expensive at this point in time. However, the plan to go to Jyväskylä could be revisited if more funding became available.

These facts left the research team to change plans and arrived at a decision to do the tests at the University of Oulu campus and its surrounding area. The pilot and the actual experiment would be conducted there. In addition, a plan to consult an expert VIP regarding the test was added to the plan and was to be completed before any pilot test. The aim was to refine the procedure for the experiment and uncover any related issues prior to the pilot. The pilot would be done up to four times depending on the issues. The actual experiment would be conducted around 20 times at Oulu.

Towards the end, the possibility to visit Jyväskylä to conduct another experiment was reconsidered. The prototype system and our plans were explained to them in detail. The discussion continued, but on practical issues. Their concerns were mainly on how much time the students of the school would need for the tests and for how many days would be interrupted by these tests. The communication with Jyväskylä was temporarily ended in March 2020. They informed the research team that their institution would not able to participate in any tests for foreseeable future because of Covid-19.

3.8.1 The evaluation setting

This section takes a glance at the plans for the experiment in Finland by providing a look at the latest versions of the evaluation setting and the procedure. The experiment was postponed because of Covid-19. The planned Experiment IV was for the 3-point testing, which includes three participants per test. The methods, such as semi-structured interviews, were selected, as they were suitable for this test setting. Doctoral dissertation and device specific questions are included in those interviews and post-task questionnaires. The VIP participant uses a Braille-based 7-point Likert scale to select answers for verbally asked questions from questionnaires.

The planned evaluation setting for the experiment includes three participants and two observers (Fig. 14). The VIP participant and the Caretaker 1 are interacting with the system for the first time. Caretaker 2 can be somewhat familiar with the situation and the system but knows the location particularly well and acts as a location expert. Observer 1 conducts interviews with the VIP participant and acts as Video Operator responsible for recording navigation tasks and interviews with the VIP participants for later analysis. Observer 1 is also responsible for looking after the VIP participant during the experiment. Observer 2 is responsible for caretakers and conducts surveys and interviews with them.

The latter will also be voice recorded. A total of 20 tests were planned each taking around two hours with a short break in between.

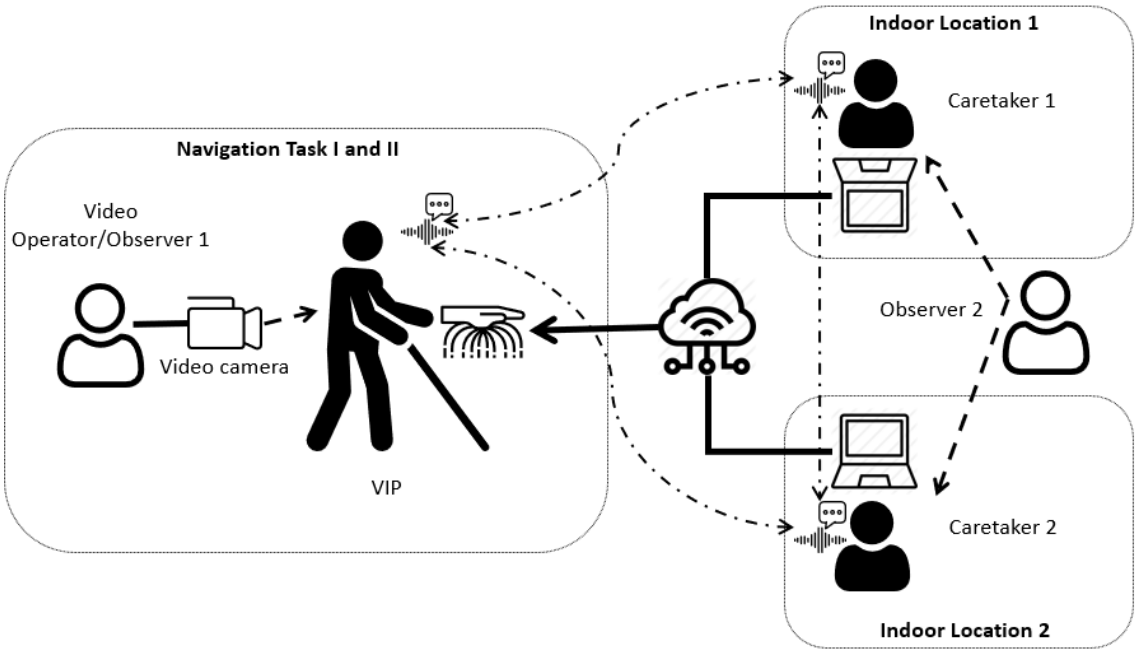

Figure 14. The planned evaluation setting for Experiment IV in Finland

3.8.2 The evaluation procedure

Figure 15 describes the planned evaluation procedure in Finland. All participants fill out the background questionnaire, consent form and are familiarized with the system. Before they start the orientation task, a short semi-structured interview is conducted. Participants then complete two navigational tasks. At the end of each task, questionnaire is filled, and a short semi-structured interview is conducted and recorded. After the tasks, participants will have a 20-minute break, which allows them to reflect on the experience before completing the post-test questionnaires and the end-of-test interview. Data is collected from all participants.

Evaluation procedure

1) Fill out a background questionnaire and consent form
   Introduce and instruct to the use of the prototype

2) Perform a pre-test semi-structured interview
   Provide orientation task to familiarize with the prototype

3) Conduct navigation task I
   Fill out a post-task questionnaire I
   Perform a semi-structured post-task interview I

4) Conduct navigation task II
   Fill out post-task questionnaire II
   Perform a semi-structured post-task interview II

   Break

5) Fill out post-test questionnaires: meCUE 2.0, SUS and Context Modules
   Perform the end-of-test semi-structured interview

Figure 15. The planned evaluation procedure for Experiment IV in Finland

This evaluation procedure was refined after Experiment I in Pakistan and additions from literature reviews. Another important change was that the person doing interviews should always mention that they are not the developer of the prototype system and only helping with the experiment. This is done to reduce the participation bias.

4. Findings

The aim of this thesis was to develop a usability and UX evaluation model that could be used in a field setting to assess a prototype cooperative AT meant for blind and visually impaired. This chapter presents the evaluation model developed through the research process. Extended contexts included in the model are also explained in more details in this chapter. Finnish translations for questionnaires including for the extended context questionnaire can be found in Appendices.

4.1 The UUXCAT for VIP evaluation model

Figure 16 shows the final version of the UUXCAT for VIP evaluation model (Usability and User Experience of Cooperative Assistive Technology for Blind and Visually Impaired People). The main contribution to this model is the Extended Contexts, but also the synthesis of the other usability and UX methods and concepts into this overall design. This model is suitable for the setting presented in this thesis but could be adapted to work in other laboratory or field settings when assessing either functional prototypes or products in the market. In other words, it is a modular model, which means that methods can be replaced with other methods. For example, instead of using meCUE 2.0 or SUS, they could be replaced with UEQ and USE, respectively.

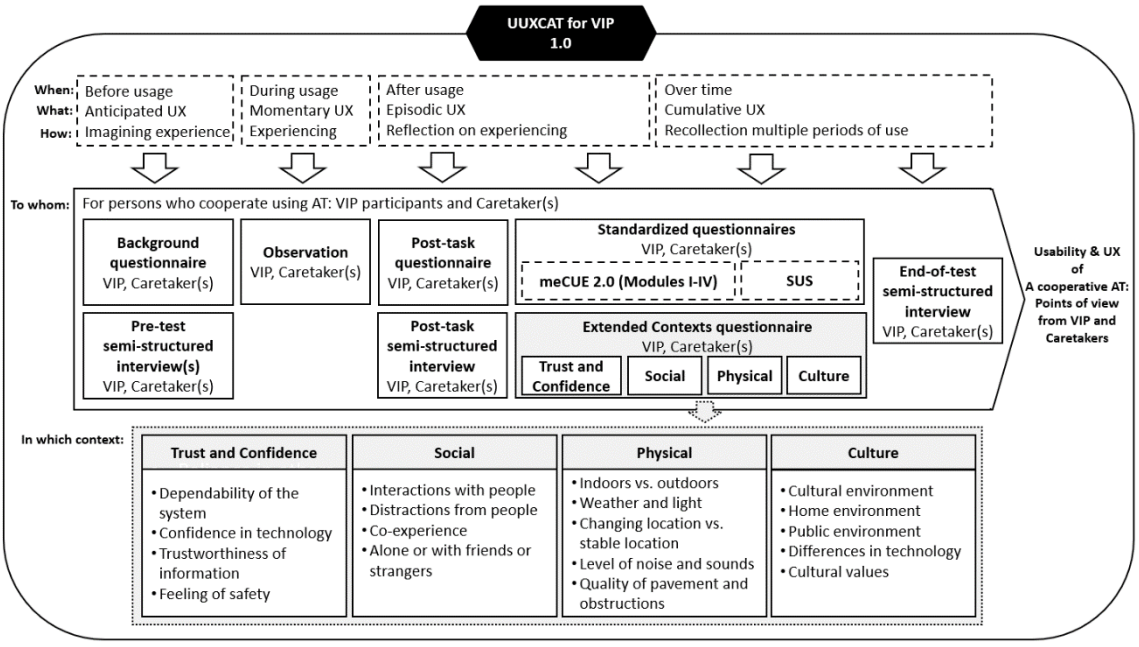

Figure 16. The UUXCAT for VIP evaluation model.

The dotted lines represent models and methods developed by other researchers. The model incorporates periods of experience from Roto et al. (2011). It includes the SUS usability questionnaire from Brooke (1996) and the standardized UX questionnaire meCUE 2.0 from Minge and Thüring (2018). Several additional methods have been added to evaluate usability and UX in this specific setting. Semi-structured interviews are used at certain points during the experiment to capture Anticipated UX, Episodic UX and Cumulative UX. Interviews given at different period of experiment have different content, but include questions related to the prototype system, its usability and doctoral dissertation related elements. Post-task questionnaires are used to capture Episodic UX and include some questions related to doctoral dissertation. While standardized

questionnaires and extended contexts questionnaire are used to capture Episodic UX and Cumulative UX.

The arrows from the periods of experience indicate those methods that are used to capture specific time of use. In the model, observations are used to capture Momentary UX because in this setting it is not a good idea to interfere with the participants when they are using the system. Experiment is also rather short in duration, so capturing Cumulative UX is rather limited. There is a short break in between, but the duration between Episodic UX and Cumulative UX is short.

The final version of the model was assessed by a UX expert from University of Oulu. This was an overall assessment and to check for any systematic errors that might have been missed.

4.2 Extended contexts

This section goes through the research and development of the final set of the extended contexts (Fig. 16). The findings from the literature review, expert interviews, results from Pakistan, and discussions with the research team led to development of these contexts. The aim was to capture dimensions that were either missing or presented in too limited fashion in standardized questionnaires. Minge and Thüring (2018), for example, are very open about the limitations of meCUE 2.0.

The development of these contexts started during the second iteration of the evaluation model. Eventually, the model settled on four separate contexts. Each context includes additional dimensions that were chosen because they were associated with VIP or coordination between multiple users of a system. All dimensions in each context contain two additional questions focusing on UX.

These contexts could be expanded further, but a choice was made for specificity rather than comprehensiveness. There was also a need to limit the number of factors to avoid too many items in the questionnaire. The most relevant dimensions were added to each context based on requirements, user study needs and the research. Questionnaires for each contexts and related dimensions can be found in Appendix F.

4.2.1 Trust and Confidence context

The dimensions that lead to the development of the context of trust and confidence started to emerge early in the research process. The doctoral student had listed safety and security as points to address for the future development needs. The trust and confidence context contains the following dimensions (main sources have been referenced):

- Reliance in other users (Blois, 1999; Corritore, Kracher, & Widenbeck, 2003)
- Dependability of the system (Jian et al., 2000; Laugwitz et al., 2008)
- Confidence in technology (Hakobyan, Lumsden, O'Sullivan & Bartlett, 2013; Schrepp & Thomaschewski, 2019a)
- Trustworthiness of information (Jian et al., 2000; Schrepp & Thomaschewski, 2019a)
- Feeling of safety (Jian et al., 2000; Petrie and Bevan, 2009; Dakopoulos & Bourbakis, 2009).

Corritore et al. (2003) proposed a model to measure trust, which consider that externals factors along with perceptions of credibility, ease of use and risk impact the trust. They consider that trust is an important social lubricant for cooperative behaviour. Petrie and Bevan (2009) see trust as a measure of the extend the user is satisfied that the product will behave as intended. They also see safety from more usability perspective, but this could also be considered as a measure of trust the user has that the system is protecting them from dangerous conditions and undesirable situations. Trust context is concerned with the trust between the users and whether they have trust in the system itself. Forster et al. (2018) show trust as a separate from user UX and refer to the method developed by Jian, Bisantz, and Drury (2000) that is often used to measure trust between people and systems. They consider trust, as prerequisite for acceptance of technology. While this is the case, this model considers trust from the UX perspective and present it here more as a category of similar items rather than as a measure itself. For example, it is possible to rely on someone else without trusting them (Blois, 1999), but to this study we wanted to know, if there was a level of trust involve in that reliance. Therefore, the context of trust and confidence groups thematically similar items together that try to answer specific questions related relevant dimensions.

In the study, it was important to understand, if VIP feels that they can safely use the system to navigate from one location to another or whether a caretaker thinks that the system is dependable enough to help them guide VIP in their destination. We also wanted to know whether the users felt safe using the system and how much confidence they had in technology employed. The system should also feel dependable and trustworthy. So that VIP does not stumble on obstacles because of delays in communication or turn in a wrong direction when receiving information. Trustworthiness of information and dependability of the system are similar described by Schrepp and Thomaschewski (2019a).

4.2.2 Social context

The social context was considered important early in the study, as the prototype system was relying on cooperation between two or more people. It was also used in an environment that could prompt interactions and distractions from non-users as well. Notably, the social aspects were missing from the SUS and meCUE 2.0 questionnaires, so there was a need to capture that data with other methods. The social context contains the following dimensions (main sources have been referenced):

- Interactions with people (Schilit, 1995; Cook and Hussey, 2002; Arhippainen, 2009)
- Distractions from people (Kane, Jayant, Wobbrock, & Ladner, 2009; Greifeneder, 2011)
- Co-experience (Forlizzi & Battarbee, 2004; Battarbee & Koskinen, 2005)
- Alone or with friends or strangers (Schilit, 1995; Cook and Hussey, 2002; Arhippainen, 2009).

Schilit (1995) identified three environmental categories that impact the interaction of a product. The first two deal with social conditions, such as being alone or with others and changing social situation. The third one is about physical environment where the interaction occurs. Nicólas and Aurisicchio (2011) explained that five types of contexts are often mentioned in research: physical, social, cultural, situational, and temporal. In this study, we decided to use three of those contexts: social, physical, and cultural.

Social context is about differences when experiencing an interaction with products in the presence of others or alone (Nicólas and Aurisicchio, 2011). Interactions with people and various social distractions can have significant effect on UX. People also create, elaborate, and evaluate experiences together with other people. This UX can be different from that they would have alone. Co-experience aims to capture important interactions and collaborations between people, as a part of expanding UX evaluation. (Forzilli & Battarbee, 2004; Battarbee & Koskinen, 2005)

4.2.3 Physical context

Physical context deals with UX in the physical environment and when there is change in locale. The physical context contains the following dimensions (main sources have been referenced):

- Indoors vs. outdoors (Cook & Hussey, 2002; Arhippainen, 2009)
- Weather and light (Schilit, 1995; Cook & Hussey, 2002; Arhippainen, 2009; Kane et al., 2009)
- Changing location vs. stable location (Forest & Arhippainen, 2005; Arhippainen, 2009)
- Level of noise and sounds (Schilit, 1995; Cook & Hussey, 2002; (Arhippainen, 2009; Boos & Brau, 2017)
- Quality of pavement and obstructions (Kane et al., 2009; Strumillo, 2010).

Traditionally computers were used in rather unchanging office environment, but this has changed with mobile computing (Schilit, 1995). Physical environment can hamper the use of a product. For example, the quality of pavement or many obstructions can make it difficult for VIP to traverse the terrain. Noises and sounds can reduce the user attention on the product. Weather conditions and different seasons can change the UX considerably. Level of lighting or temperature might make it difficult to use a product and therefore make the use experience worse. (Forlizzi, 2008; Nicólas & Aurisicchio, 2011.)

4.2.4 Culture context

Culture context is about users having different backgrounds, values, habits, and rules that can influence the UX of a product. The culture context contains the following dimensions (main sources have been referenced):

- Cultural environment (Forest & Arhippainen, 2005; Arhippainen, 2009; Ripat & Woodgate, 2011)
- Home environment (Forest & Arhippainen, 2005; Arhippainen, 2009; Interviews)
- Public environment (Forest & Arhippainen, 2005; Arhippainen, 2009; Interviews)
- Differences in technology (Forest & Arhippainen, 2005; Arhippainen, 2009)
- Cultural values (Hofstede, 1997; Cook & Hussey, 2002; Forest & Arhippainen, 2005; Arhippainen, 2009; Sunny, Patrick & Rob 2019).

According to Ripat and Woodgate (2011) some AT users may identify with a disability culture that can contain a shared set of beliefs, values, and behaviours. While users have their own habits and rules, it is important to consider the larger view that considers differences between work or organizational cultures, current level and availability of technology in a country, what type of products are favoured, and more general acceptance products in culture or sub-culture. (Arhippainen, 2009; Nicólas and Aurisicchio, 2011.)

5. Discussion and implications

This chapter combines the findings from the previous chapter with the theoretical part presented in Chapter 2 as literature review, and the empirical part explored in Chapter 3 with the development and in Chapter 4 with the presentation of the final version of the evaluation model.

5.1 Answers to the research questions

RQ1: What dimensions should be considered when evaluating usability and user experience of cooperative assistive technology for blind and visually impaired in a field setting?

The answers to this research question came mainly from the theoretical part of the study, but the findings from the theory were supported with discussions with the research team, expert interviews, and results from the first experiment in Pakistan. The more universal UX dimensions came from the meCUE 2.0 method. The details of these dimensions can be read from a questionnaire design in Appendix E. New dimensions that were specific to this study were added into four appropriate contexts. As an answer to this research question, the dimensions are presented in the extended context questionnaires (App. F). Additionally, we identified few dimensions that are not a part of the four contexts, for example haptics, was included in semi-structure interviews and post-task questionnaires.

Five dimensions were identified in trust and confidence context. These were reliance in other users, dependability of the system, confidence in technology, trustworthiness of information and feeling of safety. For example, did the reliance on others inhibit the use or was it a positive experience. Confidence in technology is about having confidence that the technology will not fail during the use. While feeling of safety is important to both blind and visually impaired, and their caretakers, when considering that the prototype system in this setting is used cooperatively.

Under social context four dimensions were identified. These dimensions depend on the setting, but the prototype system we had to evaluate was to be used in social situations. Therefore, interacting with people was important as the prototype system was used cooperatively. Then it was important to know, if the distractions from other people would have an impact on the use experience. Co-experience was about whether other users interacting with the system created positive experiences.

A total of five dimensions were also identified under physical context. This context again depends on the setting. We were testing an ETA-type device that could be used in both indoors and outdoors. Understanding differences in usability and UX in those locations was important. These dimensions included weather, level of light, sounds and noise, quality of pavement and obstructions. It should be noted that the level of light does not affect all VIP.

Another five dimensions were identified relating to the culture context. Cultural environment is about whether the use of system would be seen as acceptable in a culture. One dimension is about the impact of habits and rules at home environment or in public environment on usability or UX. Differences in technology is mainly about availability of required supporting technology. Finally, cultural values are about how the use would be regarded in the culture. Hofstede's cultural dimensions were also considered as a part

of values, these included short-term and long-orientation, femininity and masculinity, and individualism and collectivism.

RQ2: What kind of usability and user experience evaluation could be suitable for assessing assistive technology used cooperatively by blind or visually impaired with their caretakers?

The first determination here must be on what is tested. AT for VIP is also a broad product category. Variety usability and UX methods may be utilized for different types of technology and services. Some usability and UX methods are more suitable for certain development phases than others. Early concepts would require different approach than functional prototypes. Also, in this setting, where cooperation is assessed, a consideration needs to be given on whether the assessment takes place in a laboratory or in a field setting and whether it will include groups of users or just a pair of users. A lab test is more controlled environment, so it probably does not give as accurate results on the cooperative aspect as a field test would. This is because the environment can have significant impact on how a VIP is able to experience the use of AT.

If assessing a functional prototype or a market product, a holistic approach is probably the best. The duration for the assessment should be determined, as a short duration lab or field experiment requires different set of methods than a longer field study. This means that while observation might be a good way to assess AT in a short duration test, it will be quite impractical for longer studies in the field, where a diary approach might be more suitable for example. This applies to many methods related to different periods of experience, as each need to be considered before used in the setting.

The most important consideration should be on how to capture the cooperative aspect between VIP and their caretaker. While standard questionnaires can be applied, additional methods and questions need to be applied capture social, culture and physical contexts that are not covered in them but are important for VIP and their caretakers. For example, physical environment can impact the ability of VIP to function significantly. In addition, dimensions related to safety, security and trust are important when dealing with cooperative technology in general, but especially when dealing with VIP and technology related to mobility.

The UUXCAT for VIP model presented in Chapter 4 is a usability and UX evaluation that can be utilized to assess assistive technology used cooperatively by blind or visually impaired with their caretakers. This can be considered as an answer to the second research question, as it presents a kind of evaluation that can be used. Related questionnaires can be found in Appendices.

5.2 Limitations of the study

The biggest limitation to this study was that the experiment in Finland was not carried out because of Covid-19. The final assessment of the model was therefore done by an UX expert. The plan was to validate the model through pilot tests and finally with the experiment in Finland, but these were impossible to complete under these circumstances.

Another limiting factor was that the experiment setting was rather restrictive due to requirements and user study needs from the research team. This means that the evaluation model was developed for this specific setting. This impacted the choice of methods and

overall design of the model. Usability and UX methods that fall outside the setting were not explored in as much detail.

The study excludes UX evaluations that deal with differences between work and leisure activities or between goal- and action-mode. This was also because of the restrictive setting and there was no practical way to implement these aspects to the experiment.

The meCUE 2.0. questionnaire was not used in an experiment where there would be several caretakers, which impacts the assessment of its suitability. Caretakers interact with a different UI and use the system for different purposes than VIP. This would have been valuable to capture, so that design choices for the evaluation model could have been assessed.

5.3 Practical implications

This thesis provides a usability and UX evaluation model, UUXCAT for VIP. The model can be used to assess cooperative AT with VIP and their caretakers. The thesis also provides a questionnaire set for the model that were translated into Finnish in Appendices. In addition, the detailed exploration of developing the model can be viewed as a case. While it is a very specific case and its applicability to other areas might be limited, it can be adapted. The iterative process described can be followed and other method considerations made. The model itself is modular, so other researchers or practitioners can tailor it for their own purpose.

The provided model also adds a practical element to current usability and UX research because it has real world application. It is likely that these type of setting specific models are needed more in near future. Firstly, there are not many of them around and current standardized usability and UX methods do not cover social, culture, physical and trust related contexts in sufficient detail (Brooke, 1996; Hassenzahl et al., 2003; Minge & Thüring, 2018; Schrepp & Thomaschewski, 2019a, 2019b). The demand is predicated on facts that there will be a significant increase in the number of VIP, the field of developing AT for VIP is mature and active, current AT suffers from poor adoption rates, advances made and lower cost of AT related technology makes it easier to develop new products, and there actually is need for better products that address specific needs, preferences and problems of VIP (Manduchi & Coughlan, 2012; Roentgen et al., 2012; Bourne et al., 2017; Bhowmick & Hazarika 2017). In addition, there seems to be a trend towards more modular usability and UX evaluation methods, which means that developing additional contexts or modules for them can become practical (Minge & Thüring, 2018; Schrepp & Thomaschewski, 2019b).

5.4 Theoretical implications

This thesis provides a broad examination of usability and UX methods suitable for the setting. The presented evaluation model is synthesis of different research and methods. Adding periods of experience provides a view that is often neglected in current research because there is a tendency to focus more on a specific moment of interaction.

Extended contexts have been explored before (Schilit, 1995; Cook & Hussey, 2002; Arhippainen, 2009), but many standardized UX questionnaires currently do not implement social, culture, physical or even trust contexts in any meaningful manner. This study considers views represented by Cook and Hussey (2002) and Arhippainen (2009)

and applies them to a specific setting and extend the view from other sources that are relevant to the setting, for example from Schrepp and Thomaschewski (2019a, 2019b).

Currently, UEQ+ and meCUE 2.0 have approached the standardized questionnaires with a more modular structure (Minge & Thüring, 2018; Schrepp & Thomaschewski, 2019a, 2019b). The extended contexts described in this thesis can be considered as modules that can be researched further. It is with this acknowledgement that these add comprehensiveness to otherwise quite specific, or universal, standardized UX methods. While trust and confidence context might not be applied in all cases, social, and culture contexts contain dimensions that do apply more universally to a similar setting with different types of users.

As a part of this study, meCUE 2.0 was used and evaluated by the research team. The questionnaire was easy to use in the field once the questions had been translated. The method does provide a comprehensive way to assess UX and is suitable for this type of experiment, as shown from results in Pakistan (Chaudary et al., 2020). It works well as a part of suggested evaluation model in this thesis, as it can be used to investigate the more common UX dimensions.

5.5 Future research

This study provided few interesting topics that could be explored. The main suggestion for future research is about using the UUXCAT for VIP model in a real field situation to validate it. While the model is likely to provide rich data, practical factors when applying it in the field are not well understood. The Extended Contexts and its dimensions should also be explored further and validated during the experimentation with the model.

Another important suggestion for future is that developing context specific modules for different type of evaluation methods might be useful. Adding extra dimensions that could be used with standardized questionnaires might help both researchers and practitioners. It would be very helpful, if researchers and practitioners could just pick and choose specific contexts or dimensions to tailor a suitable questionnaire for their needs.

Experts interviewed in Finland were not keen towards new AT technology for VIP. It is unknown at this point whether this was just for this technology or is it more common thing amongst instructors of VIP that might also be limiting the adoption of these technologies. A study could explore this with more interviews that could go beyond the borders of Finland.

Cultural context requires further study. This thesis identified several new dimensions related to culture, but many were also left out. Researching these dimensions and other cultural dimensions with VIP should provide valuable information to developers of AT. According to interviews in Finland, VIP in some other countries are often left to be taken care by their immediate family and friends rather than the state. This can impact the availability and quality of services for them. The fact is these dimensions are not well understood in this space. Other contexts and their dimensions could be expanded on similarly either to validate or increase comprehensiveness.

Understanding different types of caretakers and additional situations might also be valid research directions. For example, instructors or teachers of VIP who know AT well, might be used in a caretaker role. Different settings could include a work or leisure type of

scenario or short, but intense, navigation route. In addition, some tests could only use friends of VIP as caretakers, while other tests would only use strangers.

The issue of participant bias came up with this study. This is an issue when questions are posed vocally to VIP. Other research has indicated that bias exists especially when VIP thinks that interviewers are also developers of the product tested. While participant bias is well understood and studied, in this context it is probably not considered often when doing evaluations in field for VIP.

Another potential research direction would be to do evaluations with a combination of usability, UX, technology acceptance and extended context methods to get richer data. There are few examples where technology acceptance and UX methods have been applied in a same study, but there seems to be only very few of them.

6. Conclusions

The study in thesis was conducted to develop a usability and user experience evaluation model called UUXCAT for VIP. This was done for assessment of a prototype cooperative assistive technology system build by a doctoral student. The model would be used in experiments to test the system with blind and visually impaired, and their caretakers. The aim was to get usability and UX results, but also to find out any development needs. These results would provide material for doctoral dissertation, scientific papers, and this thesis. As the thesis proposes a new model, its development process and the different iterations are explained in detail.

The research problem was about finding out how a system like that should be evaluated using usability and user experience methods in a field setting. Theoretical and empirical research was used to gain insight and solutions to this problem. These included literature review, expert interviews, an experiment and its results, discussions with the research team and an expert evaluation of the developed evaluation model.

As the first main finding, this thesis presents the *UUXCAT for VIP* evaluation model for cooperated assistive technology. It is usable with a prototype system and can be used in a specific field setting. It is synthesis of evaluation methods from other researchers, while extending contexts from other researchers and through empirical findings. The development process of the model was iterative combining both theoretical and empirical explorations.

The development of this type of models is important because the number of blind and visually impaired is going to increase significantly in the future, and current assistive technology is suffering from poor adoption rates. This does not correlate with the high evaluation scores given by blind and visually impaired for the new products, which could be an indication that the current standardized evaluation methods are not looking at all important dimensions. This was considered as an indication that there may be contexts that are missing when evaluating assistive technology with blind or visually impaired.

As the second main finding, the UUXCAT for VIP model includes four extended contexts and relevant questionnaire. These contexts aim to get richer data and therefore better results when assessing products with blind or visually impaired. The four added contexts are trust and confidence, social, physical and culture. Each context contains several dimensions that are backed up with previous research. These contexts should be further explored in future and make them into separate modules, so that they can be used by other researchers and practitioners as a part of their assessments. These contexts also add extra dimensions to existing standardized user experience questionnaires.

To better validate the evaluation model and the extended contexts, the model should be tested with a field experiment. The overall model should be assessed and the data from extended contexts analysed. It was not possible to conduct the experiment in Finland at the time of this study because of Covid-19.

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Appendix A. Info for UUXCAP for VIP Questionnaires

This appendix provides general information on questionnaire design and research considerations. Two terms of note are Blind or Visually Impaired Person (VIP) and Caretaker (CT).

Model	**Description**	**Number of questions**
Background questionnaire	Various background and demographics related questions.	9 + 9 (VIP) + 5 (CT)
Post-task questionnaires	Questions to be asked after navigation tasks.	8 (VIP) + 8 (CT), plus an open question for each
SUS	The System Usability Scale is a tool for measuring the usability.	10
meCUE 2.0	A Modular Tool for Measuring User Experience (UX).	33+1
Extended Contexts Questionnaire	A questionnaire for trust and confidence, social, physical, and culture contexts.	38
End-of-test questionnaire	Few open questions related to doctoral dissertation.	Not provided.

All usability and user experience questionnaire will use a psychometric scale to rank participant's judgements.		
The meCUE 2.0 uses a 7-point scale, while SUS typically uses a 5-point scale. The 7-point Likert scale is used to make the answers more uniform, and according the SUS it is not uncommon to use it.		
The 7-point Likert Scale		
Assigned values	**Options in English**	**Options in Finnish**
7	Strongly Agree	Vahvasti samaa mieltä
6	Agree	Samaa mieltä
5	Somewhat Agree	Jokseenkin samaa mieltä
4	Neither Agree nor Disagree	En samaa enkä eri mieltä
3	Somewhat Disagree	Jokseenkin eri mieltä
2	Disagree	Eri mieltä
1	Strongly Disagree	Vahvasti eri mieltä

Changes to translations	**Original**	**Change**
All questionnaires	product or system	device (laite)

Appendix B. Background Questionnaire

These VIP (Blind or Visually Impaired Person) and CT (Caretaker) questions are same for both. BG = Background.

ID	English /Finnish	Format (e/f)
01.BG	Age Ikä	Number Numero
02.BG	Gender Sukupuoli	Male, Female, Do not want to say Mies, nainen, en halua sanoa
03.BG	Marital status Sivilisääty	Married, single, other what? Naimisissa, naimaton, muu?
04.BG	Type of accommodation Asumismuoto	Sheltered housing, own house or apartment, rented house or apartment, something else? Palvelutalo, oma-asunto kerrostalo tai omakotitalo, vuokra-asunto kerrostalo tai omakotitalo, joku muu?
05.BG	Including yourself, how many people live in your household? Kuinka monta asuu taloudessasi sinut mukaan lukien?	Number Numero
06.BG	Do you live in 1) urban or 2) rural area? Asutko 1) kaupungissa vai 2) haja-asutus alueella?	Number Numero
07.BG	Education Koulutus	1. Less than comprehensive school or equivalent. 2. Comprehensive school (grades 1-6), primary school. 3. Comprehensive school (7-9 / 10). middle School. 4. High school, undergraduate or professional degree. 5. College or university degree. 6. Licentiate or doctoral degree. 7. Nothing 1. Vähemmän kuin peruskoulun ala-aste tai vastaava. 2. Peruskoulun ala-aste (1-6 luokat), kansakoulu. 3. Peruskoulun yläaste (7-9/10). keskikoulu. 4. Lukio, ylioppilas- ai ammatillinen tutkinto. 5. Opisto- tai korkeakoulututkinto. 6. Lisensiaatin tai tohtorin tutkinto. 7. Ei mitään
08.BG	Profession Ammatti	Open Avoin
09.BG	Nationality Kansallisuus	Open Avoin

These VIP (Blind or Visually Impaired Person) and CT (Caretaker) questions are separate for both.

VIP	**English / Finnish**	**Format (e/f)**
01.VIP	What is your visual acuity? Mikä on näentarkkuutesi?	0,5 - 0,00* 0,5 - 0,00*
02.VIP	How long have you had this problem? Kauan sinulla on ollut ongelmia näkösi kanssa?	Number of years Määrä vuosissa
03.VIP	Do you need navigational help from a caretaker when in unfamiliar grounds? Tarvitsetko apua kun navigoit tuntemattomissa paikoissa?	Yes, no Kyllä, en
03.1.VIP	If yes, how many times a month? Jos tarvitset, niin kuinka usein kuukaudessa?	Number Numero
04.VIP	Do you use white cane? Käytätkö valkoista keppia?	Yes, no Kyllä, en
05.VIP	Do you receive remote help from your caretaker? Saatko etäapua avustajalta?	Yes, no Kyllä, en
06.VIP	Do you accept new technologies easily? Otatko helposti käyttöön uutta teknologia?	Yes, no Kyllä, en
07.VIP	Have you used other electronical navigational aids? Oletko käyttänyt muita elektronisia navigointiapuvälineitä?	Yes, no Kyllä, en
07.1.VIP	If yes, what kind? Jos olet, niin minkälaisia?	Open Avoin
**When visus drops below 0.3, it is considered as a visual impairment, either visual impairment (visus 0.05- 0.3) or blindness (visus below 0.03).* ** Kun visus laskee alle 0,3:n, on kyseessä näkövamma, joko heikkonäköisyys (visus 0,05–0,3) tai sokeus (visus alle 0,03).*		

CT	**English / Finnish**	**Format (e/f)**
01.CT	Are you a professional caretaker? Oletko ammatiltasi avustaja?	Yes, no Kyllä, en
02.CT	If not, what is your relationship with the VIP? Jos et, niin mikä on suhteesi sokeaan tai heikkonäköiseen henkilöön?	Open Avoin
03.CT	Do you provide remote assistance to the VIP? Annatko etäapua sokealle tai heikkonäköiselle henkilölle?	Yes, no Kyllä, en
03.1.CT	If so, what kind? Jos kyllä niin minkälaista?	Open Avoin
04.CT	Have you used other electronical assistance devices to help the VIP? Oletko käyttänyt elektronisia apuvälineitä sokeiden tai heikkonäköisten auttamiseen?	Yes, no Kyllä, en

Appendix C. Post-task Questionnaires

IDs for Post-task questionnaires: For example, PT1V-1b. PT1 means Post-task 1(we had two separate navigation tasks), V stands for VIP, 1a is the first questionnaire question followed by 1b, which is an open question.

ID	English	For VIP	Format (e)	Format (f)
PT1V-1a	I easily completed this task	Suoriuduin tästä tehtävästä helposti	Yes, no	Kyllä, ei
PT1V-1b	If not, why not?	Jos ei, niin miksi ei?	Open	Avoin
PT1V-2a	Vibrations were easy to discern	Värinät oli helppo tunnistaa	Yes, no	Kyllä, ei
PT1V-2b	If not, why not?	Jos ei, niin miksi ei?	Open	Avoin
PT1V-3a	Voice communication was easy to hear	Ääniviestintä oli selkeää	Yes, no	Kyllä, ei
PT1V-3b	If not, why not?	Jos ei, niin miksi ei?	Open	Avoin
PT1V-4a	I trusted the device to work as intended	Luotin, että laite toimii niin kuin pitäisi.	Yes, no	Kyllä, ei
PT1V-4b	If not, why not?	Jos ei, niin miksi ei?	Open	Avoin
PT2V-1a	I easily completed this task	Suoriuduin tästä tehtävästä helposti.	Yes, no	Kyllä, ei
PT2V-1b	If not, why not?	Jos ei, niin miksi ei?	Open	Avoin
PT2V-2a	Vibrations were easy to discern	Värinät oli helppo tunnistaa	Yes, no	Kyllä, ei
PT2V-2b	If not, why not?	Jos ei, niin miksi ei?	Open	Avoin
PT2V-3a	Indoor navigation was easier than in the outdoor navigation.	Sisätehtävä oli helpompi kuin ulkotehtävä	Yes, no	Kyllä, ei
PT2V-3b	Why so?	Miksi niin?	Open	Avoin
PT2V-4a	It was easy to trust the other person guiding me	Oli helppo luottaa henkilöihin, jotka opastivat minua	Yes, no	Kyllä, ei
PT2V-4b	Why so?	Miksi niin?	Open	Avoin

IDs for Post-task questionnaires: For example, PT1C-1b. PT1 means Post-task 1(we had two separate navigation tasks), C stands for Caretaker, 1a is the first questionnaire question followed by 1b, which is an open question.

ID	English	For Caretaker	Format (e)	Format (f)
PT1C-1a	I easily completed this task	Suoriuduin tästä tehtävästä helposti	Yes, no	Kyllä, ei
PT1C-1b	If not, why not?	Jos ei, niin miksi ei?	Open	Avoin
PT1C-2a	The video quality was good enough for this task	Videon laatu oli riittävä tehtävästä suoriutumiseen	Yes, no	Kyllä, ei
PT1C-2b	If not, why not?	Jos ei, niin miksi ei?	Open	Avoin
PT1C-3a	Voice communication was easy to hear	Ääniviestintä oli selkeää	Yes, no	Kyllä, ei
PT1C-3b	If not, why not?	Jos ei, niin miksi ei?	Open	Avoin
PT1C-4a	I trusted the device to work as intended	Luotin, että laite toimii niin kuin pitäisi	Yes, no	Kyllä, ei
PT1C-4b	If not, why not?	Jos ei, niin miksi ei?	Open	Avoin
PT2C-1a	I easily completed this task	Suoriuduin tästä tehtävästä helposti.	Yes, no	Kyllä, ei
PT2C-1b	If not, why not?	Jos ei, niin miksi ei?	Open	Avoin
PT2C-2a	I felt confident guiding the person with the device	Olin luottavainen, että pystyn ohjaamaan henkilöä laitteella	Yes, no	Kyllä, ei
PT2C-2b	Why so?	Miksi niin?	Open	Avoin
PT2C-3a	Indoor navigation was easier than in the outdoor navigation.	Sisätehtävä oli helpompi kuin ulkotehtävä	Yes, no	kyllä, ei
PT2C-3b	Why so?	Miksi niin?	Open	Avoin
PT2V-4a	Sending out correct vibration feedback felt easy	Oikeanlaiset värinät oli helppo lähettää	Yes, no	kyllä, ei
PT2V-4b	If not, why not?	Jos ei, niin miksi ei?	Open	Avoin

Appendix D. System Usability Scale (SUS)

SUS is typically used with 5-point Likert Scale, but as meCUE 2.0 is used with 7-point scale, it will be adapted to reflect that.

D	English Original	For VIP	For Caretaker
SU.01	1. I think that I would like to use this system frequently	Luulen, että haluaisin käyttää tätä laitetta usein	Luulen, että haluaisin käyttää tätä laitetta usein
SU.02	2. I found the system unnecessarily complex	Mielestäni laite oli tarpeettoman monimutkainen	Mielestäni laite oli tarpeettoman monimutkainen
SU.03*	3. I thought the system was easy to use	Pidin laitteen käyttämistä helppona	Pidin laitteen käyttämistä helppona
SU.04	4. I think that I would need the support of a technical person to be able to use this system	Luulen, että tarvitsen teknisen henkilön tukea, jotta voisin käyttää laitetta	Luulen, että tarvitsen teknisen henkilön tukea, jotta voisin käyttää laitetta
SU.05	5. I found the various functions in this system were well integrated	Mielestäni laitteen eri osat toimivat hyvin yhteen.	Mielestäni laitteen eri osat toimivat hyvin yhteen.
SU.06	6. I thought there was too much inconsistency in this system	Mielestäni laitteessa oli liian paljon epäjohdonmukaisuuksia.	Mielestäni laitteessa oli liian paljon epäjohdonmukaisuuksia
SU.07	7. I would imagine that most people would learn to use this system very quickly	Luulen, että useimmat oppivat käyttämään laitetta erittäin nopeasti	Luulen, että useimmat oppivat käyttämään laitetta erittäin nopeasti
SU.08	8. I found the system very cumbersome to use	Mielestäni laitteen käyttö oli erittäin vaivalloista	Mielestäni laitteen käyttö oli erittäin vaivalloista
SU.09	9. I felt very confident using the system	Tunsin itse hyvin varmaksi, kun käytin laitetta	Tunsin itse hyvin varmaksi, kun käytin laitetta
SU.10	10. I needed to learn a lot of things before I could get going with this system	Minun piti oppia paljon asioita, ennen kuin laitteen käyttö alkoi sujua	Minun piti oppia paljon asioita, ennen kuin laitteen käyttö alkoi sujua
** Combines with meCUE 2.0 question.*			

Appendix E. meCUE 2.0

Module I: Perception of instrumental qualities

Contains two dimensions (D) plus some overlap with SUS: Usefulness (F) and Usability (U).

D	English Original	For VIP	For Caretaker
U.1, SU.03*	1. The product is easy to use.	Laitetta on helppo käyttää	Laitetta on helppo käyttää
F.1	2. The functions of the product are exactly right for my goals	Laitteen toiminnot ovat juuri sopivia päämääriini	Laitteen toiminnot ovat juuri sopivia päämääriini
U.2	3. It is quickly apparent how to use the product	Laitteen käyttö on nopea omaksua	Laitteen käyttö on nopea omaksua
F.2	4. I consider the product extremely useful	Pidän laitetta erittäin hyödyllisenä	Pidän laitetta erittäin hyödyllisenä
U.3	5. The operating procedures of the product are simple to understand	Laitteen toimintatavat on helppo ymmärtää	Laitteen toimintatavat on helppo ymmärtää
F.3	6. With the help of this product I will achieve my goals	Tämän laitteen avulla saavutan tavoitteitani	Tämän laitteen avulla saavutan tavoitteitani
* *Combines with SUS question.*			

Module II: Perception of non-instrumental qualities

Contains three dimensions (D): Visual aesthetics (A), Status (S) and Commitment (C). Together Status and Commitment form a Social Identity dimension.

D	English Original	For VIP	For Caretaker
A.1	7. The product is creatively designed	Laite on suunniteltu luovasti	Laite on suunniteltu luovasti
S.1	8. The product would enhance my standing among peers	Laite parantaisi asemaani vertaisteni keskuudessa	Laite parantaisi asemaani vertaisteni keskuudessa
C.1	9. I could not live without this product	En pystyisi elämään ilman tätä laitetta	En pystyisi elämään ilman tätä laitetta
A.2	10. The design looks attractive	Laitteen suunnittelu näyttää houkuttelevalta	Laitteen suunnittelu tuntuu houkuttelevalta
S.2	11. By using the product, I would be perceived differently	Käyttämällä laitetta minut huomioitaisiin eri lailla	Käyttämällä laitetta minut huomioitaisiin eri lailla
C.2	12. The product is like a friend to me	Laite on kuin ystävä minull.	Laite on kuin ystävä minulle
A.3	13. The product is stylish	Laite on tyylikäs	Laite on tyylikäs
C.3	14. If I ever lost the product, I would be devastated	Laitteen kadottaminen järkyttäisi minua	Laitteen kadottaminen järkyttäisi minua
S.3	15. I would not mind if my friends envied me for this product	En välittäisi, jos ystäväni kadehtisivat minua, jos minulla olisi tämä laite	En välittäisi, jos ystäväni kadehtisivat minua, jos minulla olisi tämä laite

Module III: User emotions

Contains two dimensions (D) each divided into two categories: Positive Emotions (PA, PD) and Negative Emotions (NA, ND).

D	English Original	For VIP	For Caretaker
PA.1	16. The product exhilarates me	Laite riemastuttaa minua	Laite riemastuttaa minua
ND.1	17. The product makes me tired	Laite väsyttää minua	Laite väsyttää minua
NA.1	18. The product annoys me	Laite ärsyttää minua	Laite ärsyttää minua
PD.1	19. The product relaxes me	Laite rentouttaa minua	Laite rentouttaa minua
ND.2	20. When using this product, I feel exhausted	Kun käytän tätä laitetta, tunnen uupumusta	Kun käytän tätä laitetta, tunnen uupumusta
PD.2	21. The product makes me feel happy	Laite saa minut onnelliseksi	Laite saa minut onnelliseksi
NA.2	22. The product frustrates me	Laite turhauttaa minua	Laite turhauttaa minua
PA.2	23. The product makes me feel euphoric	Laite tekee oloni euforiseksi	Laite tekee oloni uforiseksi
ND.3	24. The product makes me feel passive	Laite saa minut tuntemaan passiiviseksi	Laite saa minut tuntemaan passiiviseksi.
PD.3	25. The product calms me	Laite rauhoittaa minua	Laite rauhoittaa minua
PA.3	26. When using this product, I feel cheerful	Kun käytän laitetta, tunnen itseni iloiseksi	Kun käytän laitetta, tunnen itseni iloiseksi
NA.3	27. The product angers me	Laite vihastuttaa minua	Laite vihastuttaa minua

Module IV: Consequences of use

Contains two dimensions and overall judgement on the experience: Intention to use (IN), Product Loyalty (L) and Overall Experience (O).

D	English Original	For VIP	For Caretaker
IN.1	28. If I could, I would use the product daily	Jos voisin, käyttäisin laitetta päivittäin	Jos voisin, käyttäisin laitetta päivittäin
L.1	29. I would not swap this product for any other	En vaihtaisi tätä laitetta toiseen	En vaihtaisi tätä laitetta toiseen
IN.2	30. I can hardly wait to use the product again	Voin tuskin odottaa, että voisin käyttää laitetta uudelleen	Voin tuskin odottaa, että voisin käyttää laitetta uudelleen
L.2	31. In comparison to this product, no others come close	Verrattuna tähän, muut laitteet eivät yllä lähellekkään	Verrattuna tähän, muut laitteet eivät yllä lähellekkään
L.3	32. I would get exactly this product for myself (again) at anytime	Ottaisin täsmälleen tämän laitteen uudelleen milloin tahansa	Ottaisin täsmälleen tämän laitteen uudelleen milloin tahansa
IN.3	33. When using the product, I lose track of time	Kun käytän laitetta, menetän ajan tajun	Kun käytän laitetta, menetän ajan tajun
O.1*	+1. How did you experience the product as a whole?	Kuinka koit laitteen käyttökokemuksen kokonaisuutena?	Kuinka koit laitteen käyttökokemuksen kokonaisuutena?
** The extra question about the overall experience does not use a Likert Scale, but -5 to +5 measurement of the overall experience a person had when testing the product. (from all good to all bad)*			

Module IV: Overall Evaluation

Used for overall evaluation of meCUE 2.0.

Modules and Scale	Proportions of explained variance	Cronbach's alpha
Product perceptions: Non-instrumental qualities (Module I)		
Usefulness		
Usability		
Total		
Product perceptions: Instrumental qualities (Module II)		
Aesthetics		
Social identity: status		
Social identity: commitment		
Total		
User emotions (Module III)		
Positive emotions		
Negative emotions		
Total		
Consequences of use (Module IV)		
Product Loyalty		
Intention to use		
Total		

Appendix F. Extended Contexts Questionnaire

The first version of the Extended Contexts Questionnaire. It includes four contexts: Trust and Confidence context, Social context, Physical context, and Culture context.

These questions will be used with 7-point scale to make it more uniform with SUS and meCUE 2.0. Questions are done for a device, but it was a choice, but a product or system could be used here as well.

Module A: Trust and Confidence Context

Contains five dimensions (D): Reliance in other users (RO), Dependability of the system (DS), Confidence in technology (CT), Trustworthiness of information (TI) and Feeling of safety (FS).

D	English	For VIP
RO.1	Relying in other users did not inhibit the use of the device	Muihin käyttäjiin turvautuminen ei estänyt laitteen käyttöä
RO.2	Other users were positive influence when using the device	Muut käyttäjät vaikuttivat positiivisesti laitteen käyttämiseen
DS.1	I was able to depend on the device to work, as intended	Pystyin luottamaan, että laite toimii niin kuin on tarkoitettu
DS.2	I felt in control when interacting with the device	Tunsin hallinnan olevan minulla kun käytin laittetta
CT.1	I had confidence that the technology would not let me down	Luotin siihen, että teknologia ei pettäisi minua
CT.2	I was prepared to act without technology if the device let me down	Olin valmistautunut toimimaan ilman teknologiaa jos laite pettäisi minut
TI.1	I was able to rely on the information from the device	Pystyin luottamaan laiteesta saatuihin tietoihin
TI.2	I felt that the device provided accurate information	Minusta tuntui, että laite antoi tarkaa tietoa
FS.1	I felt safe using the device	Tunsin oloni turvalliseksi kun käytin laitetta
FS.2	The device made me feel secure in my actions	Laite sai minut tuntemaan oloni varmaksi toimissani.

D	English	For Caretaker
RO.1	Relying in other users did not inhibit the use of the device	Muihin käyttäjiin turvautuminen ei estänyt laitteen käyttöä
RO.2	Other users were positive influence when using the device	Muut käyttäjät vaikuttivat positiivisesti laitteen käyttämiseen
DS.1	I was able to depend on the device to work, as intended	Pystyin luottamaan, että laite toimii niin kuin on tarkoitettu
DS.2	I felt in control when interacting with the device	Tunsin hallinnan olevan minulla kun käytin laittetta
CT.1	I had confidence that the technology would not let me down	Luotin siihen, että teknologia ei pettäisi minua
CT.2	I was prepared to act without technology if the device let me down	Olin valmistautunut toimimaan ilman teknologiaa jos laite pettäisi minut
TI.1	I was able to rely on the information from the device	Pystyin luottamaan laiteesta saatuihin tietoihin
TI.2	I felt that the device provided accurate information	Minusta tuntui, että laite antoi tarkaa tietoa
FS.1	I felt safe using the device	Tunsin oloni turvalliseksi kun käytin laitetta
FS.2	The device made me feel secure in my actions	Laite sai minut tuntemaan oloni varmaksi toimissani.

Module B: Social Context

Contains four dimensions (D): Interaction with people (IP), Distractions from people (DP), Co-experience (CO) and Alone or with friends or strangers (AS).

D	English	For VIP
IP.1	Interaction with people not using the system did not negatively impact the use of the system	Vuorovaikutus sellaisten ihmisten kanssa, jotka eivät käyttäneet järjestelmää, ei vaikuttanut negatiivisesti läitteen käyttöön.
IP.2	Interaction with people not using the system made me focus more on the device	Vuorovaikutus sellaisten ihmisten kanssa, jotka eivät käyttäneet järjestelmää, sai minut lisäämään keskittymistä laitteeseen
DP.1	It was easy to keep focus on the device when other people were around	Oli helppoa pitää keskittyminen laitteessa kuin muita ihmisiä oli ympärillä
DP.2	Movement of other people did not distract me from the use of the device	Muiden ihmisten liikkuminen ei häirinnyt laitteen käyttöä.
CO.1	Interacting with other users was a pleasant experience while using the system	Laitteen käytön aikana vuorovaikutus muiden käyttäjien kanssa oli miellyttävää
CO.2	Interacting with other users enhanced the experience using the device	Vuorovaikutus muiden käyttäjien kanssa paransi laitteen käyttökokemusta
AS.1	It was more comfortable to use the device when there were no other people around	Oli mukavampaa käyttää laitetta kun muita ihmisiä ei ollut lähellä
AS.2	It does not matter to me whether I use the device with a person I know or a stranger	Minulle ei ole merkitystä käytänkö laitetta tuttavan tai vieraan kanssa

D	English	For Caretaker
IP.1	Interaction with people not using the system did not negatively impact the use of the system	Vuorovaikutus sellaisten ihmisten kanssa, jotka eivät käyttäneet järjestelmää, ei vaikuttanut negatiivisesti läitteen käyttöön.
IP.2	Interaction with people not using the system made me focus more on the device	Vuorovaikutus sellaisten ihmisten kanssa, jotka eivät käyttäneet järjestelmää, sai minut lisäämään keskittymistä laitteeseen
DP.1	It was easy to keep focus on the device when other people were around	Oli helppoa pitää keskittyminen laitteessa kuin muita ihmisiä oli ympärillä
DP.2	Movement of other people did not distract me from the use of the device	Muiden ihmisten liikkuminen ei häirinnyt laitteen käyttöä.
CO.1	Interacting with other users was a pleasant experience while using the system	Laitteen käytön aikana vuorovaikutus muiden käyttäjien kanssa oli miellyttävää
CO.2	Interacting with other users enhanced the experience using the device	Vuorovaikutus muiden käyttäjien kanssa paransi laitteen käyttökokemusta
AS.1	It was more comfortable to use the device when there were no other people around	Oli mukavampaa käyttää laitetta kun muita ihmisiä ei ollut lähellä
AS.2	It does not matter to me whether I use the device with a person I know or a stranger	Minulle ei ole merkitystä käytänkö laitetta tuttavan tai vieraan kanssa

Module C: Physical Context

Contains five dimensions (D): Indoors vs. outdoors (IO), Weather and light (WS), Changing location vs. stable location (CS), Level of noise and sounds (LS) and Quality of pavement and obstructions (OS).

D	English	For VIP
IO.1	It was more comfortable to use the device indoors	Oli mukavampaa käyttää laitetta sisätiloissa
IO.2	I did not have to be as careful with the device when outdoors	Minun ei tarvinnut olla yhtä varovainen laitteen kanssa ulkona
WS.1	The level of light did not bother me when using the device	Valon määrä ei haitannut laitteen käyttöä*
WS.2	The weather did not affect me when using the device	Sääolosuhteet eivät vaikuttaneet laitteen käyttöön
CS.1	Changing a location did not make me feel uncomfortable using the device	Paikan vaihtuminen ei vaikuttanut negatiivisesti laitteen käyttämiseen
CS.2	It was better to use the device in a stable place that did not change during the use	Oli parempi käyttää laitetta vakaassa paikassa, joka ei muuttunut käytön aikana.
LS.1	Other noises did not bother me when using the device	Muu melu ei häirinnyt minua, kun käytin laitetta.
LS.2	Other sounds did not affect the use of the device	Muut äänet eivät vaikuttaneet laitteen käyttöön.
OS.1	The quality of pavement did not affect the use of the device	Kävelyalustan päällysteen laatu ei vaikuttanut laitteen käyttöön
OS.2	It was easy to spot obstacles while using the device	Esteitä oli helppo havaita laitetta käytettäessä
* *Not relevant to those fully blind*		

D	English	For Caretaker
IO.1	It was more comfortable to use the device indoors	It was more comfortable to use the device indoors
IO.2	I did not have to be as careful with the device when outdoors	I did not have to be as careful with the device when outdoors*
WS.1	The level of light did not bother me when using the device	The level of light did not bother me when using the device
WS.2	The weather did not affect me when using the device	The weather did not affect me when using the device
CS.1	Changing a location did not make me feel uncomfortable using the device	Changing a location did not make me feel uncomfortable using the device
CS.2	It was better to use the device in a stable place that did not change during the use	It was better to use the device in a stable place that did not change during the use
LS.1	Other noises did not bother me when using the device	Other noises did not bother me when using the device
LS.2	Other sounds did not affect the use of the device	Other sounds did not affect the use of the device
OS.1	The quality of pavement did not affect the use of the device	The quality of pavement did not affect the use of the device
OS.2	It was easy to spot obstacles while using the device	It was easy to spot obstacles while using the device
* *Caretaker can operate the device indoors or outdoors*		

Module D: Culture Context

Contains five dimensions (D): Cultural environment (CE), Home environment (HE), Public environment (PE), Differences in technology (DT) and Cultural Values (VA).

D	English	For VIP
CE.1	I feel that using this device would be appropriate in my culture	Minusta tuntuu, että tämän laitteen käyttö olisi sopivaa kulttuurissani
CE.2	I would like to use this device in my country whenever I need to	Haluaisin käyttää tätä laitetta kotimaassani, aina kun tarvitsen
HE.1	I feel that using this type of device supports my routines in my home environment	Minusta tuntuu, että tällaisen laitteen käyttö tukisi rutiinejani kotiympäristössäni
HE.2	I feel that using this type of device would help my activities in my home environment	Minusta tuntuu, että tämän laitteen käyttö helpottaisi toimintojani kotiympäristössä
PE.1	I feel that with this device I could act as expected in public environments	Minusta tuntuu, että laitteen avulla voisin toimia julkisten paikkojen tapojen mukaisesti
PE.2	I feel that using this type of device would help my activities in public environments	Minusta tuntuu, että tämän laitteen käyttö helpottaisi toimintojani julkisilla paikoilla
DT.1	I feel that the technology used in this device would not be reliable in my country	Minusta tuntuu, että laitteessa käytetty tekniikka ei olisi luotettava kotimaassani
DT.2	I feel that the technology used in this device might not work outside metropolitan area in my country	Minusta tuntuu, että laitteessa käytetty tekniikka ei ehkä toimisi kotimaani pääkaupunkiseudun ulkopuolella
VA.1	I would not stand out when using this device in my culture	En erotu joukosta, kun käytän tätä laitetta kulttuurissani
VA.2	I would not want to use this device unless others had access to it as well	En haluaisi käyttää käyttää tätä laitetta, ellei muille ole sitä saatavilla

D	English	For Caretaker
CE.1	I feel that using this device would be appropriate in my culture	Minusta tuntuu, että tämän laitteen käyttö olisi sopivaa kulttuurissani
CE.2	I would like to use this device in my country whenever I need to	Haluaisin käyttää tätä laitetta kotimaassani, aina kun tarvitsen
HE.1	I feel that using this type of device supports my routines in my home environment	Minusta tuntuu, että tällaisen laitteen käyttö tukisi rutiinejani kotiympäristössäni
HE.2	I feel that using this type of device would help my activities in my home environment	Minusta tuntuu, että tämän laitteen käyttö helpottaisi toimintojani kotiympäristössä
PE.1	I feel that with this device I could act as expected in public environments	Minusta tuntuu, että laitteen avulla voisin toimia julkisten paikkojen tapojen mukaisesti
PE.2	I feel that using this type of device would help my activities in public environments	Minusta tuntuu, että tämän laitteen käyttö helpottaisi toimintojani julkisilla paikoilla
DT.1	I feel that the technology used in this device would not be reliable in my country	Minusta tuntuu, että laitteessa käytetty tekniikka ei olisi luotettava kotimaassani
DT.2	I feel that the technology used in this device might not work outside metropolitan area in my country	Minusta tuntuu, että laitteessa käytetty tekniikka ei ehkä toimisi kotimaani pääkaupunkiseudun ulkopuolella
VA.1	I would not stand out when using this device in my culture	En erotu joukosta, kun käytän tätä laitetta kulttuurissani
VA.2	I would not want to use this device unless others had access to it as well	En haluaisi käyttää käyttää tätä laitetta, ellei muille ole sitä saatavilla