AMBIENT ASSISTED LIVING, AAL

JOINT PROGRAMME

ICT-BASED SOLUTIONS FOR ADVANCEMENT OF OLDER PERSONS' INDEPENDENCE AND PARTICIPATION IN THE "SELF-SERVE SOCIETY"

D2.3

Final System Evaluation Report

Project acronym:	**ENTRANCE**
Project full title:	**ENabling elderly people TRAvel and iNternet acCEss**
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TABLE OF CONTENTS

1 EXECUTIVE SUMMARY 4
1.1 LINK WITH THE OBJECTIVES OF THE PROJECT 4
1.2 STATE OF THE ART 4
2 EVALUATION FRAMEWORK 5
2.1 VALUES IN ACTION (VIA) 5
2.1.1 Functional value 7
2.1.2 Epistemic value 8
2.1.3 Emotional value 8
2.1.4 Conditional Value 8
2.2 EVALUATION PROCEDURE 9
3 USER STUDY IN THE LAB 10
3.1 RESEARCH GOALS 10
3.1.1 Research Questions (RQs) 10
3.1.2 Methodological approach 11
3.1.3 Study Plan 14
3.2 PARTICIPANTS 14
3.3 RESULTS 16
3.3.1 Functional value 16
3.3.2 Epistemic value 26
3.3.3 Emotional value 27
3.4 CONCLUSION & IMPROVEMENTS 28
4 USER STUDIES WITH THE WRISTBAND 30
4.1 DESIGN OF THE HAPTIC WEARABLE 30
4.2 DESIGN OF THE LANGUAGE 32
4.2.1 Selecting the appropriate metaphors 33
4.2.2 Pattern design 36
4.2.3 Evaluation of produced patterns 37
4.3 RECOMMENDATIONS FOR DESIGNING HAPTIC NAVIGATION AIDS 42
4.4 CONCLUSION 43
5 USER STUDY IN THE FIELD 44
5.1 RESEARCH GOALS 44
5.1.1 Research Questions 44
5.1.2 Methodological approach 45
5.1.3 Study Plan 47
5.2 PARTICIPANTS 49
5.3 LIMITATIONS OF THE STUDY 50
5.4 RESULTS 52
5.4.1 Functional value 52
5.4.2 Epistemic value 60
5.4.3 Emotional value 63
5.5 CONCLUSION 67
6 OVERALL CONCLUSION 69
REFERENCES 70

TERMINOLOGY & ABBREVIATIONS

To assure coherent terminology and abbreviations across all documents inside the project, the specific terminology and abbreviations for this deliverable should be written here.

E.g.....Example given
HP.....Home Platform
MP .....Mobile Platform
SG.....Serious Game
RQs.....Research Questions
U .....Usability
UCD .....User-Centred Design
UX.....User Experience
UA.....User Acceptance
WB.....Wristband

1 EXECUTIVE SUMMARY

1.1 Link with the objectives of the project

Access to information is shifted steadily to online platforms, but older adults are often less likely to use digital services such as purchasing e-tickets or booking vacation packages. Within the Entrance project a system consisting of a home platform, a serious game, a mobile platform, and a haptic feedback device in form of a wristband was developed that supports older adults in trip planning as well as indoor and outdoor navigation. Navigation in this context means to plan and organize the itinerary to a certain destination. It also encompasses the actions undertaken to actually reach the destination (with or without technology). Furthermore, a self-paced tutorial on the home platform is implemented, which supports older adults in using the system and Internet services. As a starting point, older adults' requirements regarding outdoor and indoor navigation were assessed. Moreover, older adults' strategies in learning how to use technologies, experiences they have with tutorials and the motivation to learn have been investigated. This was done by means of interviews, workshops, and a survey with older adults and experts (see D2.1).

Based on these insights mock-ups and design sketches have been developed and were evaluated in user workshops. Afterwards, these first drafts were iterated and first prototypes were developed to be evaluated with experts. The iterated prototypes of the home platform (HP) with the serious game (SG) and the mobile platform (MP) with the wristband (WB) were again evaluated with experts before the lab study with 38 end users. The issues identified in that lab study were taken into consideration for subsequent versions, which have since then been focused on improving usability and related aspects. The iterated prototypes were again evaluated with experts before the field study with 26 end users. Additionally, several user studies were conducted for the development of the haptic feedback device.

The evaluation was iterative, i.e., there were separate evaluations for different components, as they are developed consecutively (from mock-ups and design sketches to prototypes). For the development and evaluation different methods were applied to investigate the value of the Entrance system. The concepts, guides and materials for the user studies were provided by PLUS or CEA, and adapted according to the project partners' feedback. The studies were then conducted by PLUS and 50plus in Austria as well as CEA and ALab in France. Afterwards, PLUS or CEA analysed the results and provided the evaluation reports to the technical partners. The results of the different evaluations formed basis for the iteration and development of the Entrance system (i.e., the HP, the SG, the MP, and the WB).

When evaluating the Entrance system in the field, we still investigated usability and acceptance, but the focus was shifted towards promoting technology competence in older adults and whether the Entrance system could successfully achieve this.

1.2 State of the art

All research efforts in the project are following a user-centred design (UCD) approach. UCD is a multidisciplinary design approach, which is based on the active involvement of users and refers mainly to the usefulness and usability of a product [Mao et al., 2001]. Thus, we have included end users into the requirements analysis and in the evaluation phase. The aim is to develop a system, which meets the users' needs at best.

2 EVALUATION FRAMEWORK

The goal of the evaluation is to provide a system for the older adults, which satisfies their needs and preferences. Thus, the results of the requirements analysis, in which the needs and preferences of the target group were identified, are the basis for the evaluation to define its foci. The evaluation of the Entrance system will be divided into two different parts:

1. An evaluation based on the enabling environments guidelines (T2.3), which allow to evaluate the systems with experts regarding the potential to support the users best, as enabling environments are considered ”to augment users’ initiative, autonomy, responsibility, reflective freedom of action and cognitive and relational skills“ (see the Entrance proposal for more details on enabling environments).
2. An evaluation based on the requirements analysis (T2.1) to see whether the users’ requirements are met with the systems and its parts.

The first part, i.e., the evaluation on basis of the enabling design guidelines, will be conducted in form of heuristic expert evaluations. The second part is an evaluation on basis of various values from the Values in Action (ViA) model. ViA covers a wide range of factors of Usability (U), User Experience (UX) and User Acceptance (UA) within one concept, without making basic assumptions on causality between the factors. Figure 1 provides the respective definitions for U, UX and UA.

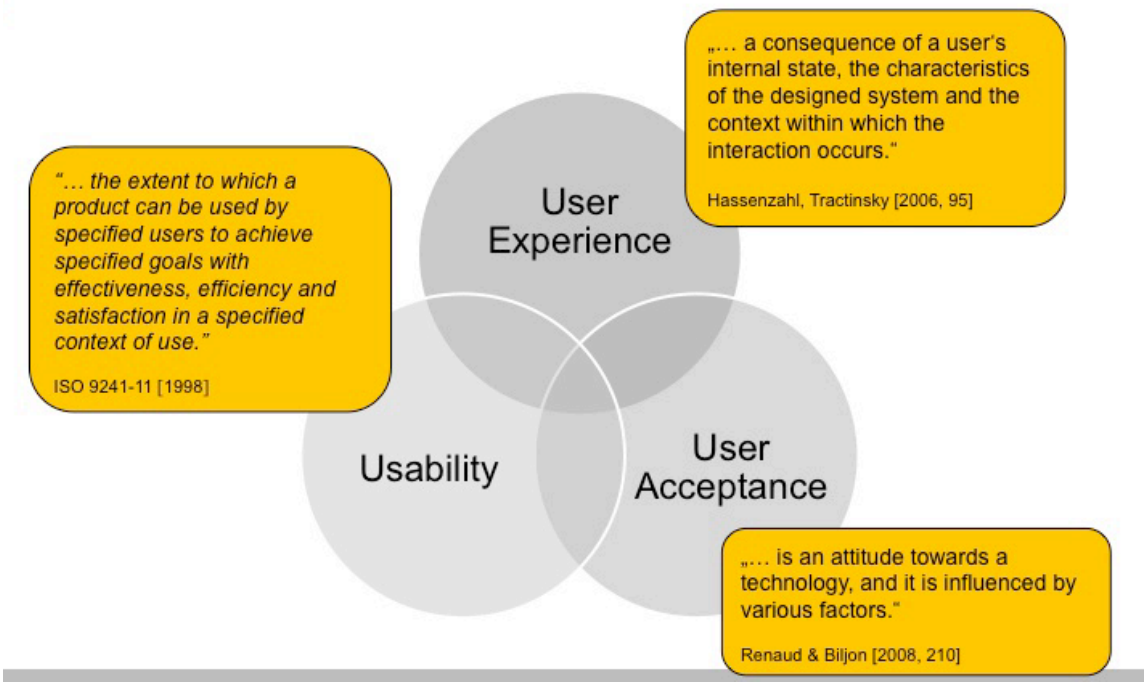


Figure 1: Definitions of Usability, User Experience, and User Acceptance

2.1 Values in Action (ViA)

Values might be described as goals and guiding principles in the life of a person [Schwartz, 1994]. They can affect multiple situations and guide the selection or evaluation of behaviours and events. Furthermore, people order their values by relative importance [Schwartz, 1992]. Values function as standards for judging and justifying actions and are acquired through socialization and individual learning experiences [Schwartz, 1994].

In this evaluation framework we consider values as concepts or beliefs, which direct human behaviour to specific action (e.g., to use a technology) and support to judge and justify actions. We see values as centred in people and referring to properties of objects (e.g., a technology) they desire, i.e., users seek to achieve their values, and the object needs to deliver[1] those. Regarding the model used for this evaluation framework this means that the technology addresses the users' values, which need to be recognized by the individuals and which correspond to the individual's beliefs and concepts. Furthermore, the values within this model address the potentially desired behaviours, goals or needs, which are perceived subjectively and motivate obtaining the technology/system/application [Fuchsberger et al., 2012].

In order to find out which values of the ViA to focus on the in the evaluation, the results of the requirements analysis were assigned to respective factors of U, UX, and UA, and then to the values of ViA. Initially, four researchers at PLUS assigned the results to the factors individually, afterwards they were merged and discussed in case of differences. However, in general the researchers assigned the results consistently. As an example, in the expert interviews the experts highlighted the importance of reassuring and encouraging the older adults when it comes to learning to use a technology; this finding was consistently assigned to the factor "motivation". Another example were the end users interviews, in which a main finding was that they would not find navigation systems useful; thus, this finding was assigned to usefulness, which needs to be evaluated in the Entrance system. Figure 2 presents the ViA model (adapted for Entrance), including those U, UX and UA factors, which are relevant for the target group in the project (according to the results of the requirements analysis).

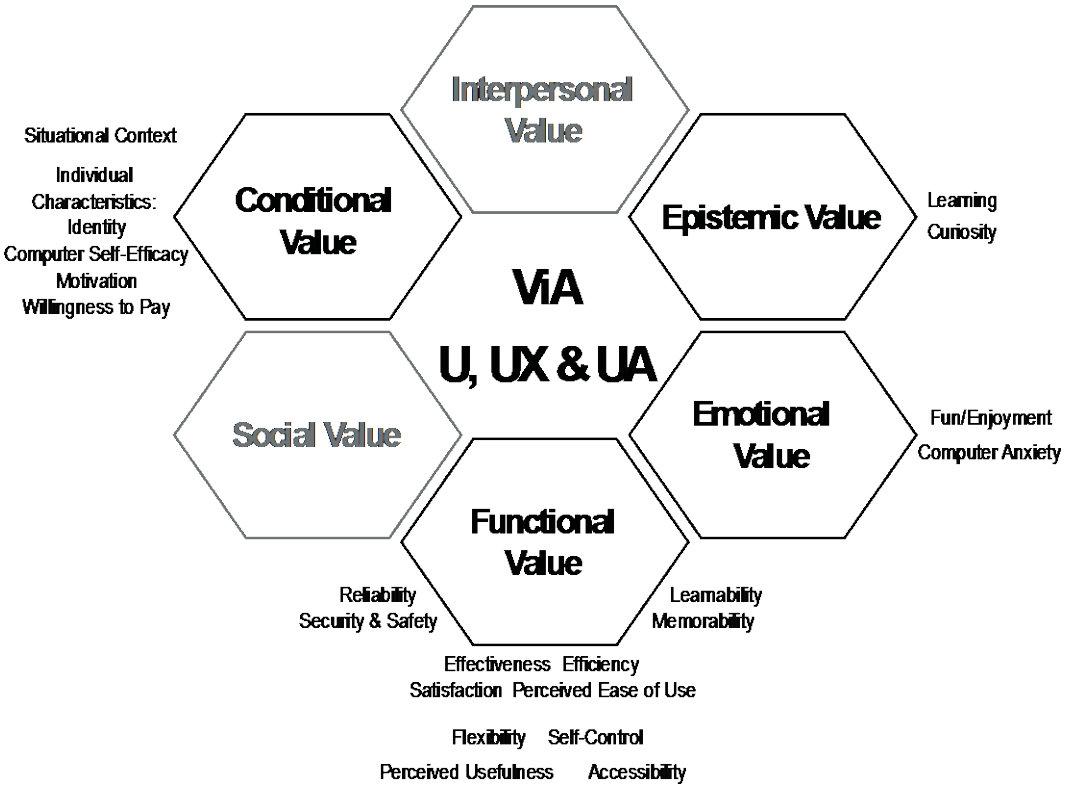


Figure 2: ViA model for Entrance

According to the results of the requirements analysis, the epistemic value, the emotional value, and the functional value need to be considered in the evaluation next to the conditional value (the social and interpersonal value are thus shown greyed out in Figure 2).

[1] "Deliver" is the used term in HCI for describing the role of the technology in supporting or satisfying values, thus we will use it here as well.

2.1.1 Functional value

Effectiveness is the "accuracy and completeness with which users achieve specified goals" [ISO 9241-11, 1998, p2]. Indicators of effectiveness include quality of task solution and errors. Some kind of usability issues may be especially related to the effectiveness of the system.

Efficiency is the relation between the accuracy and completeness with which users achieve certain goals and the resources expended in achieving them. Indicators of efficiency include task completion time and learning time [ISO 9241-11, 1998]. Some kind of usability issues may be especially related to the efficiency of the system. Usability issues will be detected within the heuristic evaluations, user studies and field studies.

Satisfaction is the users' comfort with and positive attitudes towards the use of the system and can be measured with attitude rating scales (e.g., SUMI or SUS) [ISO 9241-11, 1998].

Perceived ease of use describes the extent to which an individual believes that using a particular system would be free of physical and mental effort [Chutter, 2009]. The easier the use of a system, the more likely is an acceptance by the user [Davis, 1989]. As perceived ease of use has an impact on one's intention to use a system it is an important factor within our framework. However, perceived ease of use needs to be related to challenges, which users seek for, as for instance described in the concept of flow [Csikszentmihalyi, 1991].

Perceived usefulness is the extent to which an individual believes that using a particular system would enhance his or her job performance [Chutter, 2009]. As this factor was originally related to working environments, the wording used by Chutter [2006] and other authors refers to these environments. Here, job performance needs to be understood as task performance, i.e., any task a user wants to complete with a system.

Learnability is about the easiness for users to accomplish basic tasks the first time they encounter the design [Nielsen, 1993]. Linja-aho's perspective distinguishes objective and subjective facets: "Learnability signifies how quickly and comfortably a new user can begin efficient and error-free interaction with the system, particularly when he or she is starting to use the system" [Linja-aho, 2006, p203].

Memorability is about how easily users can re-establish proficiency, when they return to a design after a period of not using it [Nielsen 1993].

Accessibility means that users with specified disabilities or limitations can perceive, understand, navigate, and interact with the system in a specified context and thereby achieve certain goals with the same effectiveness, efficiency and satisfaction of use as non-disabled people or people without limitations.

Reliability is defined reliability as the consistency of performance and dependability (function preform right the first time) [Zeithaml and Berry, in Myers et al., 1997]. If the system is unreliable, users will avoid it regardless of how good it may be when it works [Gould, 1988]. Reliability addresses the maturity, fault tolerance, recoverability and reliability tolerance of a system [Abran, 2003].

Flexibility of a system means whether it can be adjusted and incorporated in existing systems, and it is largely connected to ease of use [Van Ittersum, et al., 2006]. Flexibility is a system inherent characteristic; the user perceives the system as adapting flexibly to her/his individual needs.

Security & Safety, i.e., feeling secure and experiencing a secure interaction need to be seen in the context of time, place, emotions, experiences, purpose of the interaction, other actors, or else [Mathiasen and Bødker, 2008]. Users base their security decisions on a mix of prior experiences [Mathiasen and Bødker, 2011]. In interface design, security issues are depending on whether the primary goal of the users is security (e.g., a firewall configuration), or whether it is a secondary goal (e.g., access to ebanking account). As users do not focus

on the secondary goal, they will not put much effort in understanding security issues, and perceive security as a system problem [Fidas et al., 2010].

2.1.2 Epistemic value

Learning is the basic outcome in the Entrance project: On the one hand, users are expected to learn how to navigate in unknown outdoor and indoor areas in the serious game, and on the other hand they are expected to learn managing the system by means of the tutorial on the home platform.

Curiosity / Interest / Preferences are similar concepts. The concept of epistemic curiosity, which can be defined as “desire for knowledge that motivates individuals to learn new ideas, eliminate information-gaps and solve intellectual problems” [Berlyne; Loewenstein; cited in Litman, 2008, p1586] or as a tendency to seek out opportunities for acquiring facts, knowledge, and ideas [Renner, 2006], will be an important factor in evaluating the Entrance system. The epistemic curiosity can be further distinguished into specific curiosity (i.e., the desire for certain pieces of information, and is initiated by variables such as novelty, complexity, or ambiguity) and diverse curiosity (i.e., motivated by feelings of boredom or a desire for stimulus variation) [Mussel, 2010]. Besides curiosity, we also seek to assess the users’ interest in the Entrance system and its parts, as well as individual preferences.

2.1.3 Emotional value

Fun / perceived enjoyment is the extent to which it’s enjoyable to use a specific system in its own right, aside from any performance consequences resulting from the usage of the system [Venkatesh, 2000].

(Technology) Computer anxiety is “the degree of an individual’s apprehension, or even fear, when she/he is faced with the possibility of using computers” [Venkatesh, 2000, p349 referring to Simonson et al., 1997].

2.1.4 Conditional Value

Situational context addresses possible influence on the interaction with the Entrance system. Dey [2001] introduces a vague definition of context: “Context is any information that can be used to characterize the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and applications themselves” [2001, p5]. Within this framework we refer to the context description model by Grill and Tscheligi [2011]. They distinguish the user or personal context and the application or system context. Additionally, they consider the concrete interaction context as well as the temporal context. Sub-contexts of the user context (i.e. the environmental, informational, social and task context) and of the application context (i.e. environmental, physical and social context) are defined.

Identity is the unity of a person’s self-concept, self-esteem, and the locus of control, which she/he evolves and continuously develops out of subjectively significant and subjectively concerned experiences via self-perception, self-assessment and personal control [Haußer, 1995]. These furthermore motivate a person to realize her/his self-claims (in needs and interests), to check reality and to establish her/his self-esteem as far as behaviour is concerned.

Computer Self-Efficacy is the belief that one has the capability to perform a particular behaviour [Compeau and Higgins, 1995]. Thereby, self-efficacy has three dimensions, i.e., magnitude, strength, and generalizability. Magnitude refers to the level of task difficulty, one believes is attainable, strength is the level of conviction about the judgment. Generalizability

indicates the extent to which perceptions of self-efficacy are limited to specific situations [Compeau and Higgins, 1995]. Compeau and Higgins finally define computer self-efficacy as the judgment of one's capability to use a computer, based on what could be done in the future.

Motivation can be the intrinsic and extrinsic motivation on basis of the self-determination theory [Ryan and Deci, 2000]. Intrinsic motivation is the inherent tendency to seek out novelty and challenges, to extend and exercise one's capacities, to explore, and to learn. Opposed to this, extrinsically motivated behaviours are the performed to satisfy an external demand or reward contingency [Ryan and Deci, 2000].

Willingness to pay is a crucial determinant of the Entrance system to be used also after the project period. In order to establish a business model, which is as realistic as possible, the financial context needs to be considered.

2.2 Evaluation Procedure

According to the UCD approach end users were involved in the evaluation phase. The development of the parts of the Entrance system was done iteratively, i.e., after an evaluation approach had been conducted, the parts were improved according to the results, before the next evaluation round was conducted.

The following iterative procedure was applied:

1. Development of design sketches, mock-ups and scenarios
2. **Workshops about design sketches, mock-ups and scenarios** (separated for the different parts of the system)
3. **First heuristic expert evaluation on the parts of the Entrance system** (separated for the different parts of the system)
4. Implementation of first functionalities (first prototypes)
5. Design of the language for the haptic wristband
6. **Second heuristic expert evaluation on the first prototypes of the Entrance system** (separated for the different parts of the system)
7. Improvement of the first prototype according to the results of the heuristic expert evaluation (second prototype)
8. **End user studies in the lab on the second prototype**
9. Testing of the haptic language with the older adults
10. Improvement of the second prototype according to the results of the end user studies
11. Evaluation of the designs of the wristband
12. **Final heuristic expert evaluation**
13. Last improvements (final prototype)
14. **Final testing of wristband and field study with the prototypes of the Entrance system**

In the following sections, we report the user studies in the lab and field.

3 USER STUDY IN THE LAB

3.1 Research Goals

The user studies in the lab aimed at evaluating the prototypes of the home platform (HP) with the serious game (SG) and the mobile platform (MP) with the wristband (WB) to identify usability problems and first insights from an end user perspective regarding their experiences and acceptance. The prototypes provided different functionalities that were evaluated to find out how well they satisfy users' needs regarding indoor and outdoor navigation. The user studies in the lab took place in Austria (organized by PLUS and 50plus) and France (organized by CEA and ALab) with 38 end users in total representing the personas George and Luise (see D2.1).

3.1.1 Research Questions (RQs)

Central research questions were defined. They are structured according to different values as well as usability (U), user experience (UX) and user acceptance (UA) factors (as described in the evaluation framework document) that were addressed.

Functional value:

U - Effectiveness

- RQ1: How accurate and complete can users perform a defined task on the system?

U - Efficiency

- RQ2: How much effort is it for the users to perform a task in relation to the accuracy and completeness?

U, UX - Satisfaction

- RQ3: How satisfied are the users with the functions and usage of the system?

UA - Perceived ease of use

- RQ4: To which extent do the users believe that using the system will be free of physical and mental effort?

UA - Perceived usefulness

- RQ5: To which degree do users believe that the system would facilitate achieving their goals?

U - Learnability

- RQ6: How does the system enable the users to learn how to use it?

U - Accessibility

- RQ7: In what way does the system respond to age related limitations (e.g., cognitive, physical) in terms of understanding, navigation, and interaction with the system?

U - Reliability

- RQ8: How reliable is the system?

U - Flexibility

- RQ9: How flexible is the system regarding individual needs and preferences as well as contexts?

Epistemic value

UX - Learning

- RQ10: To what extent does the system support learning (1) to navigate, (2) to manage the system?

UX - Curiosity / Interest / Preferences

- RQ11: In what way does the usage of the system provoke the user's curiosity about and interest in the system and its content?

Emotional value

UX, UA - Computer Anxiety

- RQ12: To what extent does the system evoke computer anxiety?

UX - Motivation

- RQ13: To what extent does the system motivate to use it?

3.1.2 Methodological approach

We applied a formative user study, which is usually characterized as a method to investigate the usability of interactive systems in order to design the respective system suitable in the users' sense. The main distinction between a formative and a summative study is set in the iterative nature of formative testing and the overall goal to improve the system's design [Tullis and Albert, 2008]. In the following, questionnaires and models are described, whereof items were selected that are appropriate to answer the RQs and assess different factors.

System Usability Scale [Brooke, 1996]

The System Usability Scale (SUS) is a simple, ten-item scale giving a global view of subjective assessments of usability. Despite being a self-described "quick and dirty" usability scale, the SUS has become a popular questionnaire for end-of-test subjective assessments of usability. Scoring the questionnaire yields a usability score in the range of 0–100, i.e., 80 to 100 users likes the system, 60 to 79 users accept the system and 0 to 59 users dislike the system.

SUS

1. I think that I would like to use this system frequently
2. I found the system unnecessarily complex
3. I thought the system was easy to use
4. I think that I would need the support of a technical person to be able to use this system
5. I found the various functions in this system were well integrated
6. I thought there was too much inconsistency in this system
7. I would imagine that most people would learn to use this system very quickly
8. I found the system very cumbersome to use
9. I felt very confident using the system
10. I needed to learn a lot of things before I could get going with this system

Subjective Satisfaction [Nielsen, 1993]

Subjective satisfaction refers to how satisfying it is to use a system. The questionnaire is filled in after having tried out the system with real tasks.

Satisfaction items

1. It was very easy to learn how to use this system.
2. Using this system was a very frustrating experience.
3. I feel that this system allows me to achieve very high productivity
4. I worry that many of the things I did with this system may have been wrong.
5. This system can do all the things I think I would need.
6. This system is very pleasant to work with.

Epistemic Curiosity Scale [Koo et al., 2007]

Epistemic curiosity is defined as the extent to which the activity is perceived to provide learning experiences about new things, strategies, and trends.

Curiosity items

1. I learn a lot by playing online games.
2. Playing an online game makes me think a lot.
3. Playing an online game stimulates my curiosity.
4. I consider that playing an online game is a learning experience.
5. Playing an online game is a good method to learn what is new.

Intrinsic Motivation Inventory (IMI) [Deci and Ryan n.y.]

The inventory is a multidimensional measurement device to assess users' interest/ enjoyment, perceived competence, effort, value/usefulness, felt pressure and tension, and perceived choice after performing a given activity. The interest/enjoyment subscale is considered the self-report measure of intrinsic motivation; thus, although the overall questionnaire is called the Intrinsic Motivation Inventory, it is only the one subscale that assesses intrinsic motivation, per se. The perceived choice and perceived competence concepts are theorized to be positive predictors of both self-report and behavioural measures of intrinsic motivation, and pressure/tension is theorized to be a negative predictor of intrinsic motivation. However, only the subscales for interest/enjoyment and perceived competence are relevant for our study.

Interest/enjoyment items

1. I enjoyed doing this activity very much
2. This activity was fun to do.
3. I thought this was a boring activity. (R)
4. This activity did not hold my attention at all. (R)
5. I would describe this activity as very interesting.
6. I thought this activity was quite enjoyable.
7. While I was doing this activity, I was thinking about how much I enjoyed it.

Perceived competence items

1. I think I am pretty good at this activity.
2. I think I did pretty well at this activity, compared to other students.
3. After working at this activity for a while, I felt pretty competent.
4. I am satisfied with my performance at this task.
5. I was pretty skilled at this activity.
6. This was an activity that I could not do very well. (R)

Technology Acceptance Model (TAM) [Davis, 1989]

Ease of use and ease of usefulness both influence the behavioural intention, which finally leads to the actual system use. Both are operationalized in 6-item scales. The second version, evolved by Venkatesh and Davis [2000] is called TAM2. Recently, there has been a new version the TAM3. It extends the TAM2 by some new factors, which influence directly the perceived ease of use: Computer self-efficacy, perceptions of external control, computer anxiety and computer playfulness [Venkatesh and Bala, 2008]. For our user study selected item for perceived ease of use, perceived usefulness and computer anxiety are of relevance.

Perceived ease of use (TAM2) items

1. Learning to operate [the system] would be easy for me.
2. I would find it easy to get [the system] to do what I want to do.
3. My interaction with [the system] would be clear and understandable.
4. I would find [the system] flexible to interact with.
5. It would be easy for me to become skilful at using [the system].
6. I would find [the system] easy to use.

Perceived usefulness (TAM2) items

1. Using [the system] in my job would enable me to accomplish tasks more quickly.
2. Using [the system] would improve my job performance.
3. Using [the system] in my job would increase my productivity.
4. Using [the system] would enhance my effectiveness on the job.
5. Using [the system] would make it easier to do my job.
6. I would find [the system] useful in my job.

Computer anxiety (TAM3) items

1. Computers do not scare me at all.
2. Working with a computer makes me nervous.
3. I do not feel threatened when others talk about computers.
4. It wouldn't bother me to take computer courses.
5. Computers make me feel uncomfortable.
6. I feel a tease in a computer class.
7. I get a sinking feeling when I think of trying to use a computer.
8. I feel comfortable working with a computer.
9. Computers make me feel uneasy.

3.1.3 Study Plan

The user study setup is informed by the intended usage and learning of the Entrance system later on in the field. Therefore, the order of the tasks is not going to be changed.

Time	Process
	Pre Session
2 min	Introduction of moderator and assistant
5 min	Contact sheet
2 min	Introduction to Entrance Project, description of the study procedure and instructions for the user study, etc.
2 min	Permission for data collection
5 min	Pre-Interview
	HP & SG & MP Testing
10 min	Task 1: Registration & Tutorial - Scenario 1
10 min	Task 2: Play Scenario 2
5 min	Task 3: Play Scenario 3
	Questionnaire
	MP & WB Testing A, B, C, D and E need to be defined per location
10 min	Task 4: Plan a route on the HP from here (A) to B and then to C. Go with the help of the smartphone to B (but not to C).
5 min	Task 5: Go now to D with the help of the smartphone and then back to A
5 min	Task 6: Learning of WB patterns
5 min	Task 7: Go to E with the help of the smartphone and WB and then back to A
	WB Questionnaire
10 min	Task 8: Take a look at the other functions and try them out (contextual help)
	Questionnaire
	Post Session
10 min	Post-Interview
3 min	Debriefing

Table 1: Study plan

3.2 Participants

The 38 participants (15M/23F) were aged between 56 and 80 years (average age 66.03 years, SD = 5.77), whereof 20 participants (12M/8F) represent George (average age 65.75 years, SD = 4.30) and 18 participants (3M/15F) represent Luise (average age 66.33 years, SD = 7.18). The participants from Austria were slightly older than the participants from France (see Figure 3). More demographic data can be found in Figure 4 and Table 2.

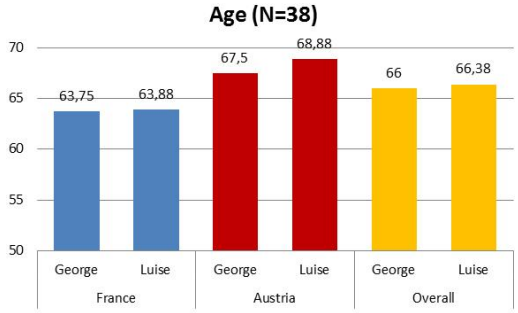


Figure 3: Mean age overall and per country

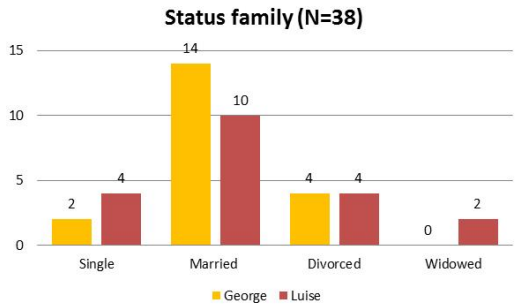


Figure 4: Family status of George and Luise

	France		Austria	
Personas	George (N=8)	Luise (N=9)	George (N=12)	Luise (N=9)
Gender	6M/2F	3M/6F	6M/6F	0M/9F
Age min.	61	56	61	60
Age max.	70	74	75	80
Average	63.75	63.88	67.5	68.88
SD	3.11	7.15	4.23	6.82
Family status (S/M/D/W)	2/6/0/0	1/6/1/1	0/8/4/0	3/4/3/1
Occupation	1E/7R	0E/9R	0E/12R	1E/9R

*M: male/F: female; S: single/ M: married/ D: divorced/ W: Widowed; E: employed/R: retired

Table 2: Distribution of personas: French and Austrian users

Figure 5 illustrates that all Georges have a computer with internet access and only one Luise has a computer without internet access as well as one Luise has no computer at all. The computer experience of George is mainly medium, but some have rather good or very good. Luise has also mainly medium computer experience, but some also have rather low computer experience.

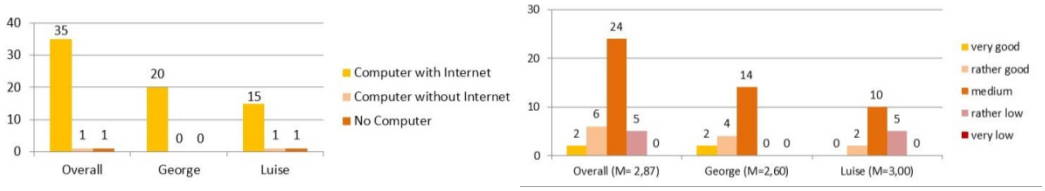


Figure 5: Computer and internet access as well as computer experience (N=37)

Figure 6 shows that three fourth of Georges have a mobile phone with internet and one fourth without internet, as well as more than two third of Luise have a mobile phone without internet and only 3 Luise have one with internet as well as one Luise has not mobile phone at all. The mobile phone experience of George is mainly medium, but some have rather good or very good. Luise has also mainly medium or good mobile phone experience, which is due to the fact that she mainly uses a normal mobile phone without internets.

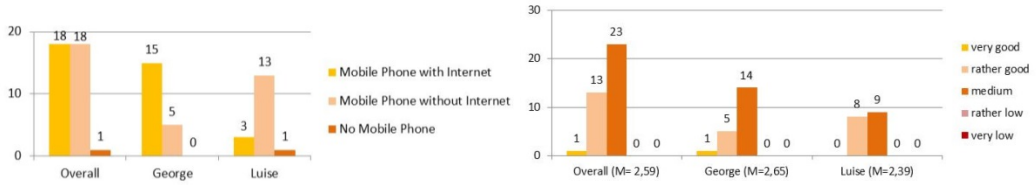


Figure 6: Mobile phone internet and mobile phone experience (N=37)

In the following the results are described for George and Luise, in order to illustrate possible differences for our target groups.

3.3 Results

The results are structured according to values of the ViA Model, which are concepts or beliefs that direct human behaviour to specific actions (e.g., using a technology/ system/application or refusing it), and support judging and justifying actions (e.g., the decision for a technology/system/application). Values are centred in people and refer to the properties of the objects (e.g., technology) they desire, i.e., users seek to achieve their values.

3.3.1 Functional value

The functional value, which is defined as the perceived utility for achieving a specific task or a practical goal, refers, for example, to the UX factor satisfaction, to the UA factor perceived ease of use and perceived usefulness, as well as indirectly too many usability factors, e.g., efficiency and effectiveness.

3.3.1.1 U - Effectiveness

RQ1: How accurate and complete can users perform a defined task on the system?

Task 1 - Registration & Tutorial – SG Scenario 1

Only George was partially able to finish the task without help. George and Luise needed either help of were even unable finish the task in time (see Table 3). During the registration the handling of the keyboard needed to be explained to nearly all of them, as it was not popping up automatically, the text was not written directly in the field and also the auto-correction caused some confusion. While playing the first scenario the movement in the SG needed to be explained to both of them, as well as the handling of the videos. Luise also needed support with handling the help section. George sometimes got confused why the SG is saying that he was lost when reaching a blue circle (but he was not lost). Both had problems in finding the elevator (e.g., they were missing signs in the parking garage; typically the elevator is next to the parking lots for handicapped people).

Task 2 - SG Scenario 2

George and Luise were partially able to finish the task without help, but more often they needed help (see Table 3). Again while playing the second scenario the movement in the SG needed to be explained to both of them (e.g., they wants to walk backwards, which is not possible, and do not understand why this is not possible) and they needed help with the navigation aid. Luise not being so familiar with smartphones needed also some help to find the actual position on the map. Gorge has problem to understand why the game is guiding him to the blue circle and not the shoe shop.

Task 3 - SG Scenario 3
George struggled more in this task due to orientation and navigation problems and for Luise it was even more difficult (see Table 3). For Luise again the movement in the SG needed to be explained and to find the actual position on the map. George also needed some more support regarding the movement in the SG and the video usage. George wanted to turn on the navigation aid in the SG and was wondering why this is not possible in the scenario. With regards to the video both were confused when watching the second video why it did not start with the main menu.

The effectiveness of the following tasks was most affected by the loss of the GPS signal.

Task 4 - Plan a route on the HP from here (A) to B and then to C. Go with the help of the MP to B
George struggled also in this task (see Table 3) due being unfamiliar with QR codes and not knowing how to start the navigation and for Luise it was even more difficult (she even struggled with the web interface and did not know what to do after having selected the places, or had problems with the small font for entering the name of the route on the MP). Both were tapping several times on the images instead of the check boxes and were missing proper information what to do.

Task 5 - Go now to D with the help of the MP and then back to A
Help was sometimes needed by Luise in order to find the place on the MP. George was wondering why it is not possible to plan a route on the MP. One major issue caused by the bad GPS signal was that the shown route was wrong (see Figure 7); George wanted an automatic realignment of it.

Figure 7: Wrong route on MP due to bad GPS Signal

Task 6 - Learning of WB patterns
Some of the participants had problems to adapt the WB to their hand because it was too rigid.

Task 7 - Go to E with the help of the MP and WB and then back to A
This task could be performed in Austria nearly without help for both of them (only sometimes help was needed to find a place on the MP).

Task 8 - Take a look at the other functions of the MP and try them out
The contextual help as only activated by mistake, when Luise was tapping too long on icons and then she became confused how to exit the help. Both really liked the my car function, however, the icons were not self-explanatory.

Task completion	Task 1			Task 2			Task 3			Task 4			Task 5		
	Overall	George	Luise	Overall	George	Luise	Overall	George	Luise	Overall	George	Luise	Overall	George	Luise
successful without help	6	6	0	12	8	4	8	7	1	8	7	1	28	18	10
successful with help	14	6	8	24	11	13	15	9	6	15	9	6	9	2	7
unsuccessful	18	8	10	2	1	1	15	4	11	15	0	11	1	0	1

Table 3: Task completion of task 1-5 (there was no task completion for task 6 and 8; task 7 was only carried out in Austria; therefore, they were left out in this table)

The MP & WB were in general effective to use for George and Luise, although Luise needed more help than George. The usage of two devices was for both in the beginning also not effective, but they got used to it. The HP & SG were partially not effective to use due to orientation and navigation problems in the SG, e.g.,

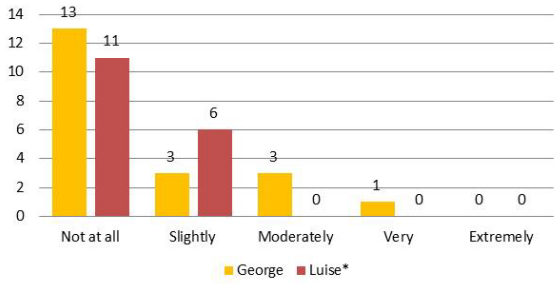
- creating a new profile and playing the first scenario in the SG was only possible for Luise with help or even impossible, and also George struggled and needed help.
- finding a place in the shopping mall was also only possible with help for Luise or even impossible and also George struggled and needed help.

George and Luise most of the time overlooked the video tutorials or had problems with them, the provided text made them tap in the SG instead of the MP, which exited the video (see Figure 8). George accidently clicked on the wrong "X" to close the help and closed thereby the whole game. Luise often believed that pressing on the "start" button would start the video and not the game. If there were several videos shown in the instruction, then Luise tended to believe the first video is a reminder one and started immediately with the second one. Both had problems to understand that the MP should be used to follow the video and were confused, if on the MP not the menu was shown as in the video (did not always know how to get there and Luise was unsure how to get one step back). They were also missing the possibility to go back in the video and watch a step again.

Figure 8: Problem with video tutorial in the SG

Another problem occurring several times, confusing George and Luise, was that the message destination reached was shown on the MP although this was not the case in the SG. This made in particular Luise unsure what to do in the game.

Regarding the WB, George and Luise consider that the patterns did not cause irritating sensation and only some felt slightly irritated by the patterns (see Figure 9). However, George and Luise had problems to distinguish front and right/left vibration pattern of the WB, as vibrators are too close together. Some participants complained about too many repetitions of the vibration patterns.



* indicates that one Luise did not respond to this question

Figure 9: Sensory perception – Irritability (N=37)

3.3.1.2 U - Efficiency

RQ2: How much effort is it for the users to perform a task in relation to the accuracy and completeness?

George and Luise could not efficiently navigate through the SG using the arrows, as they were missing a stop button and had problems to understand how far the game character is moving in the SG (see Figure 10). As Luise is not so familiar with touch interaction, she had more navigation problems than George. She, for example, pressed continuously on the arrow buttons in order to better control the character (which was not implemented). Whereas George is familiar with touch interaction and, therefore, he swiped over the touch screen to change the view or navigate into that direction or tried to zoom with two fingers (which is also not implemented).

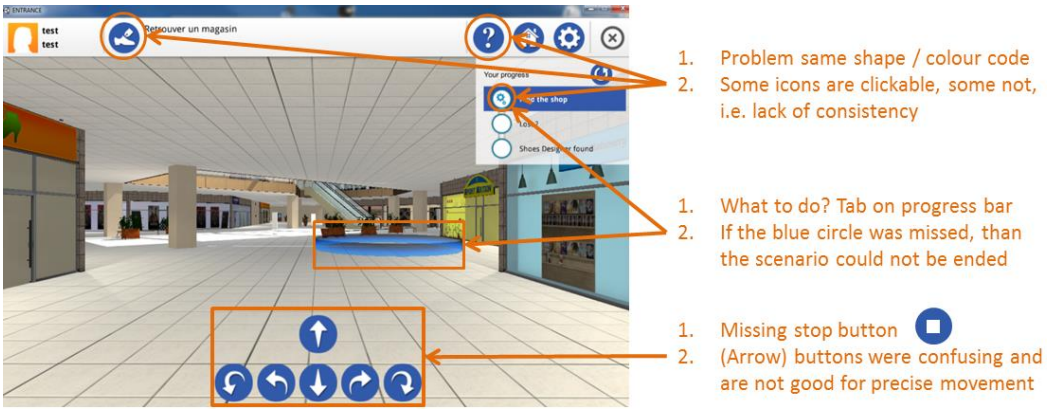


Figure 10: Problems while using the SG

George did not like that the game character was running into objects or walls (no one would do that in real) and, therefore, the navigation became really frustrating. George and Luise had the feeling of not being able to control the game character and that the game controls were not reacting fast enough. Luise mentioned several times that she was trying to avoid running into the wall, but does not know how. Both reported the problem of getting a proper orientation due to the too limited view in the SG (see Figure 10).

George and Luise had also orientation problems while using the map of the MP in the SG (see Figure 10 and Figure 12). The shape of the buttons/icons, which was too similar and caused a lot of confusion in terms of what is tapable and what is not (e.g., the progress bar in Figure 10). In the MP of the SG George and Luise had problems with recognizing the icons on the map (e.g., clock icon for elevator or T-Shirt icon for shoe shop). Problematic was also the position of icons on the MP, if the George or Luise used the map and zoomed in (see Figure 11), therefore, it happened several times that they walked into the wrong corridor in the SG. Additionally, the map was often upside down, which increased the cognitive load to process the information form the MP in the SG. Therefore, they sometimes rotated the

smartphone, which resulted in that the direction arrow was showing into the wrong direction form the new perspective. However, in the SG both often overlooked the direction arrow in the MP (e.g., as the contrast was not high enough). If it was not overlooked another problem appeared, when turning around in the game, the direction arrow was still showing in the old direction (this caused confusion). Whereas, in the MP outside the direction arrow was perceived not to be very trustworthy and efficient, as it was jumping a lot due to the bad GPS signal.

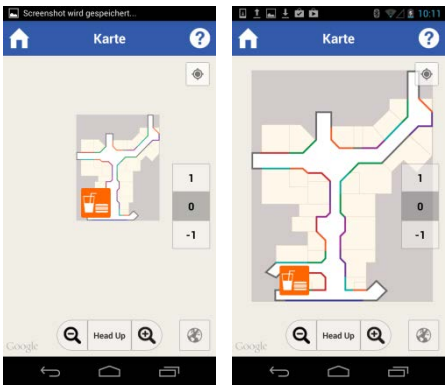


Figure 11: Problems position of icons on the map of the MP

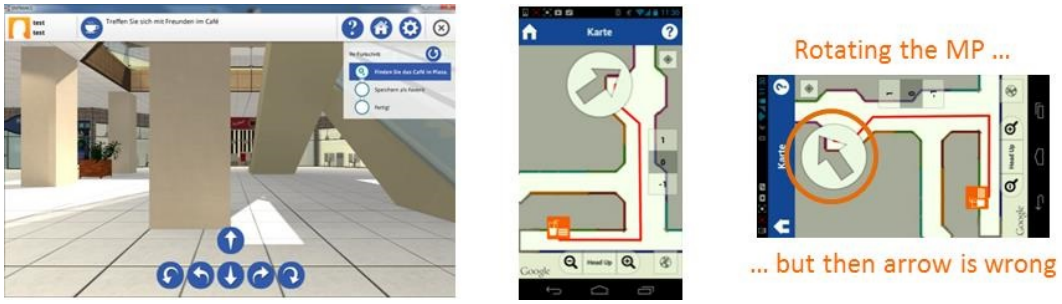


Figure 12: Orientation problems while using the SG and MP

Additionally, both got confused when they were turning the game and the blue dot on the map was not moving, as they believed they were moving into that direction in the game. Besides they did not like the small blue dot, which was easily overlooked, and would prefer a little man. On the MP also an arrow was shown instead of the dot, which was confusing when navigating outdoor. George was missing a labelling for the floors on the map (the meaning of 1/0/-1 was not clear at first sight).

3.3.1.3 U, UX - Satisfaction

RQ3: How satisfied are the users with the functions and usage of the system?

Overall, George is (very) satisfied with the Entrance system, but was not very satisfied in the beginning. Luise is also satisfied, however, she was more struggling with herself. The MP & WB satisfied George and Luise, although Luise needed more help than George. Both are satisfied with the usage of the MP & WB and are neither/nor (un)satisfied with the usage of the HP & SG (see Figure 13). George is less satisfied with the HP & SG than Luise, contrary Luise is less satisfied with the MP & WB than George (see Figure 13).

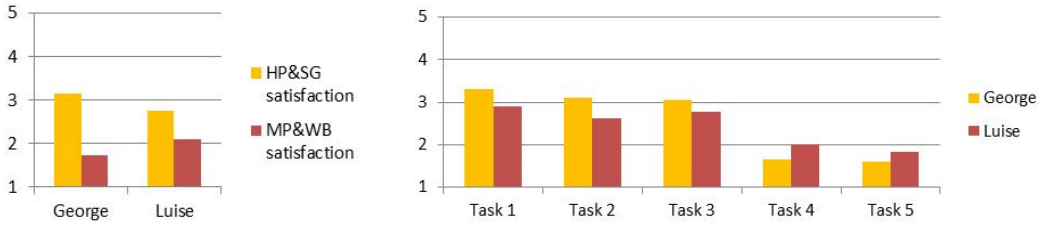
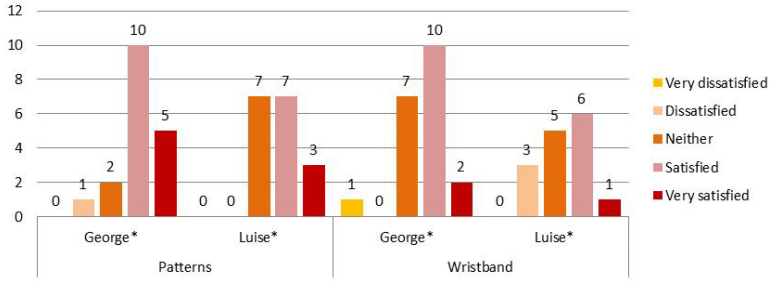


Figure 13: Mean task satisfaction rating (N=38)
(1 - very satisfied; 2 - rather satisfied; 3 - neither/nor; 4 - rather unsatisfied; 5 - very unsatisfied)

George was more satisfied with the patterns and wristband than Luise (see Figure 14). Regarding the wristband some participants are even dissatisfied with the design and made improvement suggestions like using a different wristband (e.g., for people with smaller and weakest wrist), positioning the vibrator more apart, or increasing the overall sensation and recognition of the patterns (for example, with adding a vocal assistance or increasing vibrations intensity). Additionally, four relevant criteria (i.e., vibrations intensity, wristband strength, wristband size and multimodality) were identified.



* indicates that one or more participants did not respond to this question

Figure 14: Pattern and wristband design satisfaction (N=35)

3.3.1.4 UA - Perceived ease of use

RQ4: To which extent do the users believe that using the system will be free of physical and mental effort?

George and Luise perceive the Entrance system as rather easy to use. Both perceive the MP & WB as more easy to use (see Figure 15). George and Luise also perceive neither/nor (in)competence to handle the system. However, George perceives significantly more competence regarding handling the MP & WB than Luise (see Figure 15). George also believes the Entrance system could also be interesting for other people, as it is easy to use.

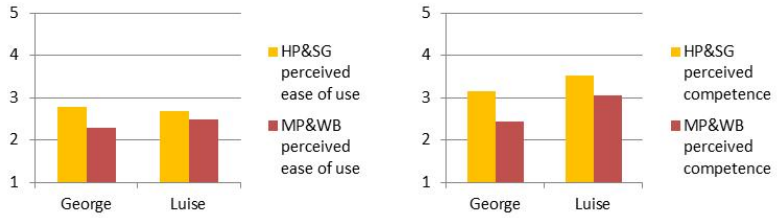


Figure 15: Mean perceived ease of use and perceived competence rating for HP & SG and MP & WB (N=38) (1 - agree; 2 - rather agree; 3 - neither/nor; 4 - rather disagree; 5 - disagree)

3.3.1.5 UA - Perceived usefulness

RQ5: To which degree do users believe that the system would facilitate achieving their goals?

George and Luise perceived the Entrance system as rather useful (see Figure 18), although they did not know what to do in the SG. Both perceive the MP & WB as more useful.

- George: "*Pedestrian GPS for indoor and outdoor navigation for unknown destinations*"
- Luise: "*Useful when learnt and once understood , useless if one needs to stop and take times*"

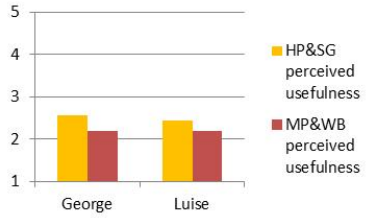
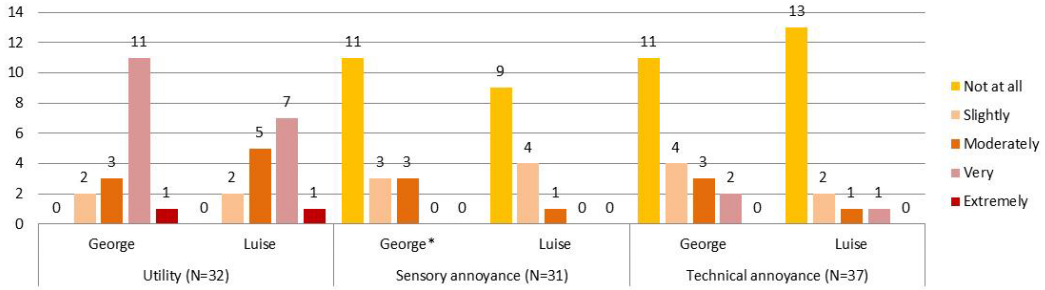


Figure 16: Mean perceived usefulness rating for HP & SG and MP & WB (N=38) (1 - agree; 2 - rather agree; 3 - neither/nor; 4 - rather disagree; 5 - disagree)

George was wondering where the system can be used and the data for the MP will come from. Both would not use it in familiar surroundings like their home town. However, as we live in a travel society, both believe the Entrance system can be very useful (e.g., for large cities). George and Luise found partially the satellite view very useful and would like to have alternatives routes displayed in case there are problems with the shown route. They believe that the WB can be useful for other users (e.g., bling people or people with dementia).

62% of respondents consider that the patterns are very (11 George and 7 Luise) or extremely (1 George and 1 Luise) useful to complement the information provided by the MP (see Figure 17). For eight other people (3 George and 5 Luise) the utility is moderate. The majority of them (11 George and 9 Luise) are not at all annoyed with feeling the patterns when using the mobile app (see Figure 17). Concerning a potential technical annoyance, the majority of respondents (11 George and 13 Luise) are also not at all annoyed with wearing an additional accessory (see Figure 17). Only three persons (2 George and 1 Luise) are very annoyed.



* indicates that one George did not respond to this question

Figure 17: Utility and usability of the WB (N=37)

43% of George and Luise would like the wristband to provide other types of information to ensure their safety (i.e., risks alerts, obstacles, differences in level, ways errors) and to support outdoor navigation (e.g., say if you are on the right way or if your objective is reached).

3.3.1.6 U - Learnability

RQ6: How does the system enable the users to learn how to use it?

For George the Entrance system can be easily learnt, but older adults would need training, if they are not used to such devices. George was also not always very patient when interacting with the Entrance system. Luise needs more time to learn how to handle the Entrance system and hesitated a lot. She also believes that she would have to use it more intensively in order not to forget how to handle it. For George and Luise the tasks on the MP & WB were very easy to learn and easy complete and on the HP & SG easy to learn and neither/nor easy/difficult and for Luise the tasks were slightly more difficult (see Figure 18).

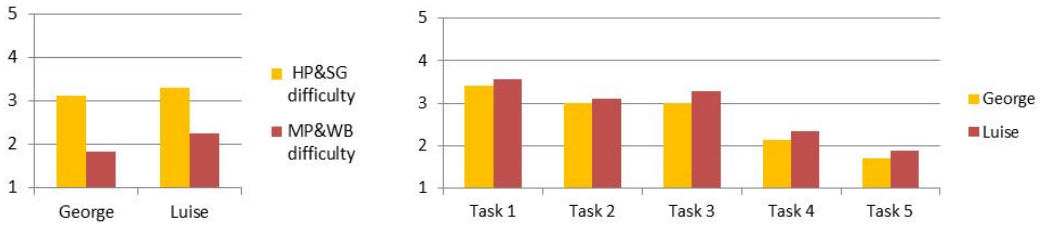


Figure 18: Mean task difficulty rating (N=38)
(1 - very easy; 2 - rather easy; 3 - neither/nor; 4 - rather difficult; 5 - very difficult)

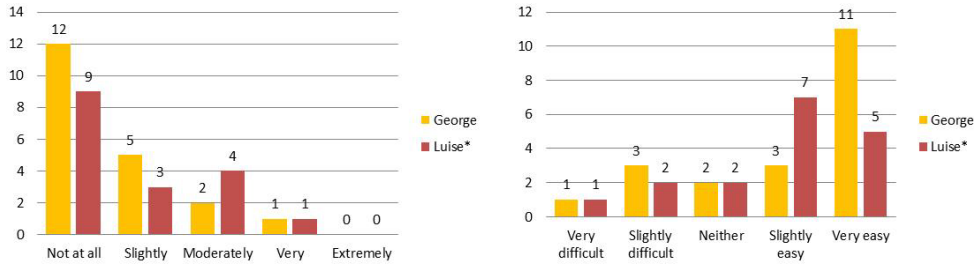
George and Luise had also problem with learning how to use the navigation aid. In the beginning it was displays and very often overlooked in the beginning and were confused after the second blue circle, as it seemed like the blue line disappeared, which was not the case, as it was displayed behind the player (see Figure 19).

Figure 19: Problems with navigation aid in the SG

Figure 20: Understandability problem in the icon design in the MP

George and Luise had problems with understanding the meaning of the icons (see Figure 20). Additionally, when a route was uploaded with a QR code both were not sure where to find the uploaded information, as it was not opened automatically.

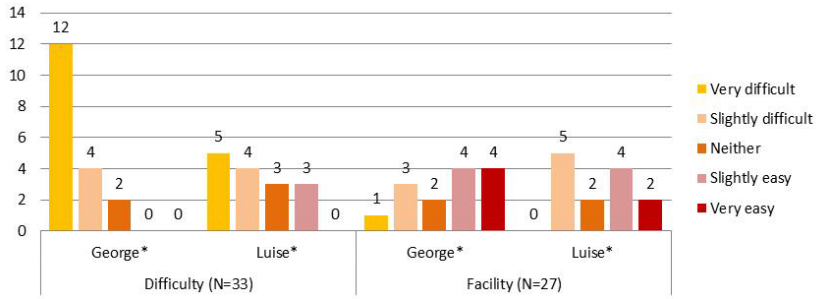
The learning of the patterns is not at all (12 George and 9 Luise) or slightly (5 George and 3 Luise) mentally demanding is very easy (11 George and 5 Luise) or slightly easy (3 George and 7 Luise) (see Figure 21). For the (4 George and 3 Luise) rest it was more difficult. The main constraints are concentration level and confusion caused by similar vibrations (see Figure 21). For George and Luise the WB does not require a lot of thinking, if the vibration patterns could be distinguished properly. However, both had problems learning to distinguish front and right/left vibration pattern of the WB, as vibrators are too close together (for example, between "right" and "go ahead"). Luise struggled even more with the distinction of the patterns.



* indicates that one Luise did not respond to this question

Figure 21: Cognitive load and learning level of WB vibration patterns (N=37)

75% of the participants estimated that the recognition of the patterns was mentally demanding when also using the mobile app (see Figure 21). For them, it is very difficult (12 George and 5 Luise) or slightly difficult (4 George and 4 Luise). During mobile app use, the recognition of the patterns is slightly (4 George and 4 Luise) or very easy (4 George and 2 Luise) for half of the respondents (see Figure 22). Both encounter difficulties to “recognize right and go ahead” and observe “distorted results if the wristband slides”.



* indicates that one or more participants did not respond to this question

Figure 22: Patterns recognition - difficulties and facilities (N=37)

3.3.1.7 U - Accessibility

RQ7: In what way does the system respond to age related limitations (e.g., cognitive, physical) in terms of understanding, navigation, and interaction with the system?

George and Luise perceive the system as rather accessible and both perceive the MP & WB as more accessible (see Figure 23). For both, the colours were well differentiable and the contrast between foreground and background was high enough. In particular, for George important information was neither/nor highlighted enough and warning signals were not helpful (as there were no) in the SG or MP. Luise was unsure about the needed amount of choices in order to reach a goal and the challenging interaction with the SG & MP.

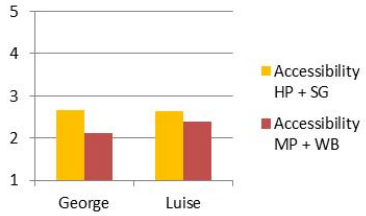


Figure 23: Mean accessibility rating (N=38)
(1 - very accessible; 2 - rather accessible; 3 - neither/nor; 4 - rather inaccessible; 5 - very inaccessible)

3.3.1.8 U - Reliability

RQ8: How reliable is the system?

The SG worked reliable (only Splashtop crashed several time), whereas the MP crashed often several times during one task and the GPS signal was also very bad (causing problems with the shown route). The WB had some connectivity problems with the smartphone.

3.3.1.9 U - Flexibility

RQ9: How flexible is the system regarding individual needs and preferences as well as contexts?

George like the flexibility when navigating in the SG with the two options (in particular, as the navigation with the arrows was not very efficient). He also enjoyed the flexibility of the MP and found different ways to solve the tasks. Luise rather used the in the SG learned function of the MP. She also had problems with entering places for the navigation from A to B, as it was not possible to click on in the search field or on the labels “FROM” / “TO” (see Figure 24).

Figure 24: Problem with navigation from A to B on the MP

Both liked the flexibility the WB can provide, but were unsure, if they would really use it.

3.3.1.10 Summary

George and Luise dislike the system functions (see SUS Score in Figure 43). Both did not feel confident while usage. Luise would have to learn a lot before using the Entrance system. The different factors of the functional value show that there is a lot of room for improvements.

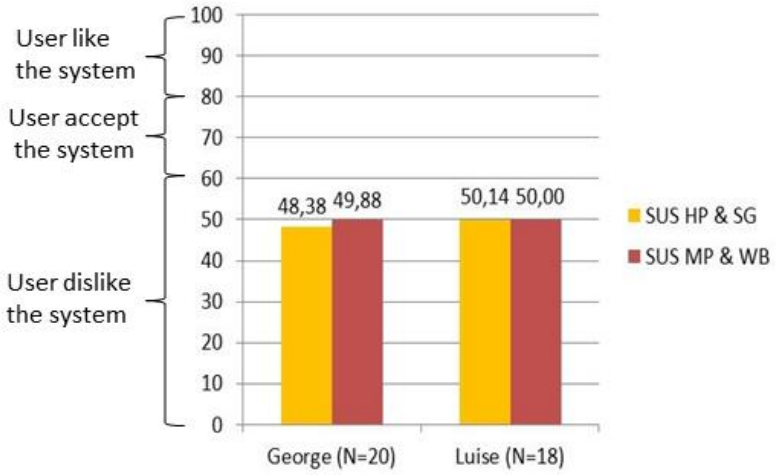


Figure 25: SUS Score (N=38)

Summing up, the SG was not very effective, efficient to use or easy to use, as a lot of help was needed or tasks could not be finished in time (e.g., due to navigation and orientation problems – the feeling of not being in control). George and Luise struggled to understand what the aim of the SG is and what they have to do in the SG. The video tutorials causing a lot of problems need to be improved in order to provide their full potential to the player. The icons caused problems in the SG (e.g., too similar were confusing is terms of what is tapable and what is not) and on the MP map (e.g., position and design of icons or meaning of 1/0/-1). Additionally, important information was not highlighted enough in the game. Luise is not so familiar with touch interaction and had, therefore, problems to learn the navigation (e.g., she pressed continuously on the arrow buttons in order to better control the character). Whereas George is familiar with touch interaction and, therefore, he swiped over the touch screen to change the view or tried to zoom with two fingers. George and Luise had the feeling of not being able to control the game character and that the game controls were not reacting fast enough (e.g., the game character was often running into walls). Therefore, both were neither/nor (un)satisfied with the usage of the HP & SG.

In general the MP & WB were effective and easy to use for both and they were satisfied with the usage. However, the sever GPS problems effected the user experience a lot. The contrast of the direction was too low and, therefore, it was overlooked often by both of them and also not very trustworthy when navigating outside due the GPS problems. Additionally, the map caused orientation problems in the SG, as it was not automatically aligned to the view of the user, the blue dot was not moving when turning and icons were not properly positioned on it.

George and Luise had problems to distinguish front and right/left vibration pattern of the WB, or complained about to many repetitions of the patterns. Otherwise, the WP patterns were easy to learn. George was more satisfied with the patterns and wristband than Luise. The WB did not cause irritating sensation and is useful to complement the information provided by the MP.

3.3.2 Epistemic value

The epistemic value, which is related to experiencing new products, captures the UX factors learning, curiosity, interest or preferences.

3.3.2.1 UX - Learning

RQ10: To what extent does the system support learning (1) to navigate, (2) to manage the system?

George believes the SG can offer the opportunity for learning how to handle the MP, but it needs to be improved and it should not be named gaming but rather training. Luise in particular experienced that she learned something about tablets and smartphones in general (the possibilities they can offer). In terms of navigation both learned how to use a pedestrian GPS by orientating where the own position is on the map and following the direction arrow to the destination. In the SG both rather tried to solve the task on their own, than to follow each of the instruction to learn something.

3.3.2.2 UX - Curiosity / Interest / Preferences

RQ11: In what way does the usage of the system provoke the user's curiosity about and interest in the system and its content?

George and Luise are interested in the usage of the whole system. Both are slightly more interested in the usage of the MP & WB.

- George: *"Interested to live and work with current technologies, maybe more interested in indoor navigation"*
- Luise: *"Interesting, if needed for unknown places, but would prefer paper maps"*

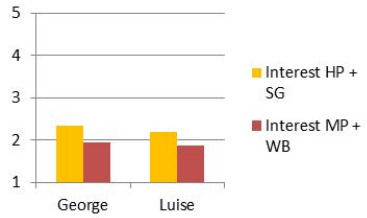


Figure 26: Mean interest rating (N=38)
(1 - agree; 2 - rather agree; 3 - neither/nor; 4 - rather disagree; 5 - disagree)

Additionally, George likes the possibility to plan routes in advance on the HP and to store the position of the car on the MP. Luise likes the possibility to navigation to places (also with the support of the WB), the support provided by the direction arrow on the map, or the navigation aid in the SG

3.3.2.3 Summary

George believes the SG can offer the opportunity for learning how to handle the MP, while Luise experienced that she learned something about tablets and smartphones in general, which made her interested. Luise was also interested in the usage of the WB.

3.3.3 Emotional value

The emotional value is the potential of the product to arouse emotions, which are believed to accompany the use of a product, taking UX factors like fun/perceived enjoyment or computer anxiety into account.

3.3.3.1 UX, UA - Computer Anxiety

RQ12: To what extent does the system evoke computer anxiety?

For Luise the usage of two devices in the SG was sometimes stressful and caused anxiety.

3.3.3.2 UX - Motivation

RQ13: To what extent does the system motivate to use it?

George and Luise are (rather) motivated to use the MP & WB and are neither/nor motivated to use the HP & SG. George is also slightly more motivated to use the MP & WB than Luise (see Figure 27). Both would feel more secure when using MP & WB for unknown destinations.

- George: "*Pedestrian GPS for indoor and outdoor navigation for unknown destinations*"
- Luise: *"To know how to navigate to unknown places"*

For George and Luise the usage of the SG was frustrating, which negatively affects the motivation.

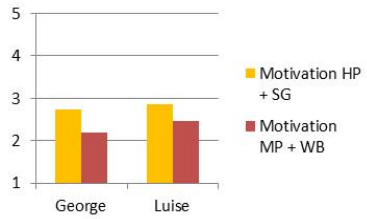


Figure 27: Mean motivation rating (N=38)
(1 - agree; 2 - rather agree; 3 - neither/nor; 4 - rather disagree; 5 - disagree)

3.3.3.3 Summary

George and Luise are rather motivated to use the Entrance system. However, the usage of the SG negatively affected their motivation.

3.4 Conclusion & Improvements

The user lab studies revealed interesting insights regarding the different values addressed by the Entrance system. The functional value revealed the most areas for improvement, whereas, the emotional and epistemic value already indicated slightly positive experiences of users while interacting with the system.

HP & SG improvements:

- The user studies indicated a rather neutral attitude and revealed a lot of improvements
- The user studies revealed problems with curiosity and what to do with the game ⇨ provide introduction tutorial (one user know what to do the game it gets useful for them)
- The user studies showed navigation problems in the serious game ⇨ adapt the navigation input possibility (i.e., the character should not run into objects; enable swipe or zoom gestures for George) and explain them more properly (i.e., turning does not mean moving into that direction)
- The user study highlighted consistency problems regarding icon design ⇨ use same icon design as on the mobile platform (i.e., tiles)
- The user study showed problems with the interaction with the video ⇨ video should be easier to start and not end by accidently tapping on it instead of the MP
- The user studies showed that the synchronization between the SG and MP should be improved ⇨ do not show the message destination reached before the scenario is finished in the SG; send more messaged on the movement of the game character in order to enable an automatic realignment of the map on the MP; additionally, improve the placement of the icons on the map

MP improvements:

- The user studies indicated a general positive attitude and found it useful
- The user studies revealed problems with the planning of the route and the QR code scan ⇨ provide more instructions
- The user studies revealed problem with orientation on the map while navigation ⇨ improve interface elements for navigation and automatically realign the map according to the view of the user; improve the navigation arrow
- The user studies indicated big problems with the instable GPS signal ⇨ improve the navigation error so that is not switching so often and the displayed route should also automatically be updated
- The user studies revealed that the user like the my car function but that the icons were not self-explanatory ⇨ improve the icons and provide labels

WB improvements:

- The user studies revealed that learning the vibration patters was easy; however, while moving it was harder to distinguish them, therefore, the recognition of the patterns was mentally demanding
- The user studies showed problem with direction patterns ⇨ advance the hardware (e.g., sensors should be more separate, change the intensity of vibration) and the design

4 USER STUDIES WITH THE WRISTBAND

In the context of an ageing society, vibrotactile wearable devices can open up new avenues for assisting older adults in their daily lives. They can provide information and yet free the hands, ears and eyes, which can be crucial to safety. However, designing a wearable haptic navigation aid with intuitive informational vibrotactile messages for and with the older adults has seldom been investigated. The Entrance project enabled to provide different contributions in this area through various studies in relation to the design of the haptic wearable (i.e., wristband) and of the haptic language. The studies for each aspect will be described in the following sections.

4.1 Design of the haptic wearable

The vibrotactile wristband was developed at the Sensorial and Ambient Interfaces Laboratory at CEA. It was designed to provide basic navigational cues as well as other potentially useful or interesting information (e.g., points of interest). The wristband contains three actuators strategically placed around the wrist (left, right, and top), whereas the microcontroller and the power circuit are located under the watch face as displayed in Figure 28. Each actuator is composed of a commercially available coin motor (Precision Microdrives 310-113). As for the microcontroller, it not only regulates the actuation level and timing but also ensures the battery management and the Bluetooth communication with a mobile device. During the studies, a tablet running Windows 7 was used to control the messages delivered to the participants and record their answers.

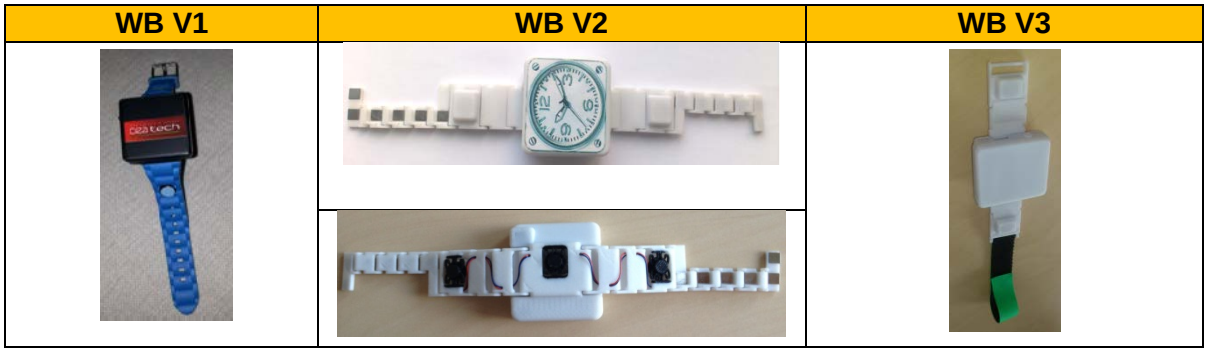


Figure 28: Evolution of the design of the wristband following users' feedback

The messages to convey were encoded into vibrotactile patterns using a combination of actuation parameters. These parameters were: 1) the vibration duration; 2) the pauses between the actuator activation; 3) the repetitions of a pattern; 4) the amplitude with six possible levels and 5) the position and number of activated actuators.

In parallel to the studies pertaining to the design of the language (described in the following section) and following the Entrance review recommendations, a pilot study was conducted to assess the design of the wristband as well as the preference for one or two devices, to remove any ambiguity concerning the identification of left and right vibrations. The pilot study lasted about 1h30 and consisted of two tasks: a recognition task (in static condition) testing the WB V1, V2 and 2 WBs V1 (see Figure 28) and a mobile navigation task with a treasure hunt comparing 1 versus 2 WBs V1 (see Figure 29). In both cases, a familiarisation phase was initiated for learning the patterns by repeating them 3 times with explanations, followed by a recognition task with 4 random iterations for each pattern and where repetitions of the messages were allowed. The messages tested were left, right, ahead, turn back, problem and arrival at destination. Their designs were adapted from previous studies with a wristband with 8 actuators and corresponded to the patterns used in the Entrance lab studies.

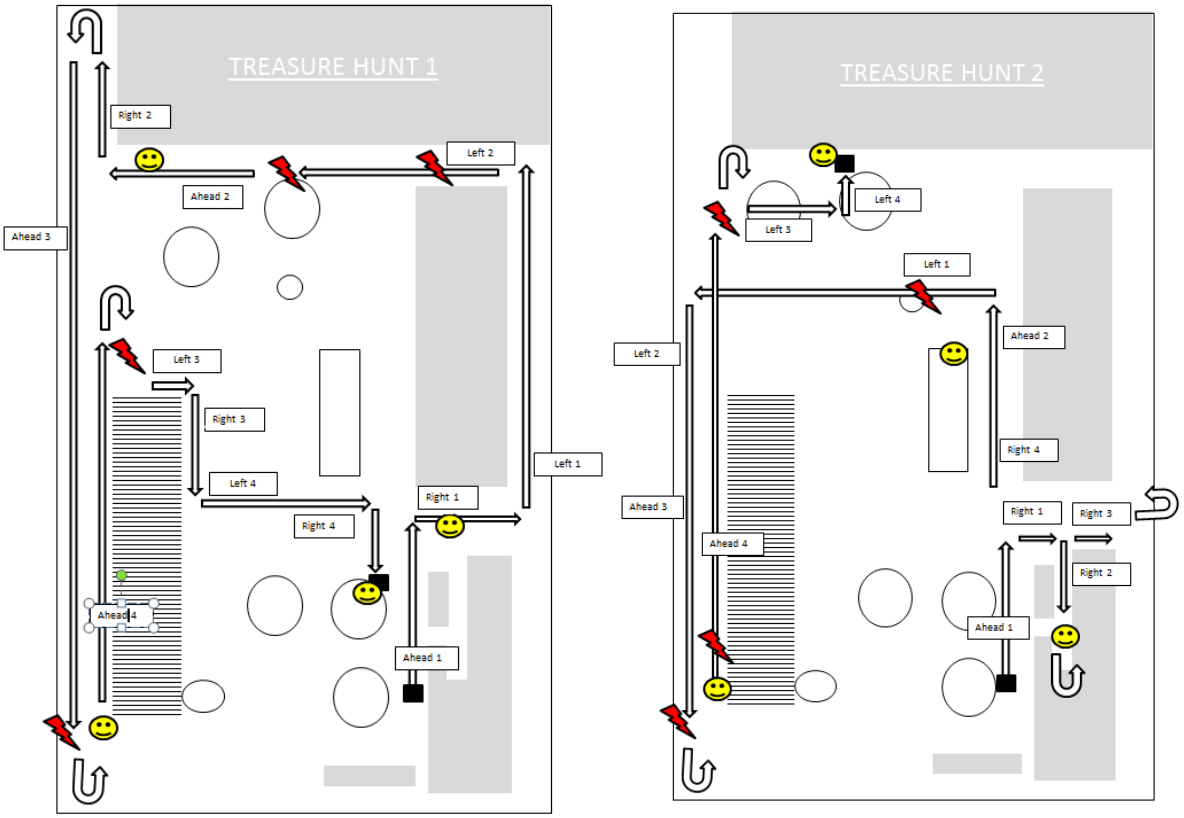


Figure 29: Maps of the treasure hunt and the messages indicated. The arrows indicate the directions whereas the smiley indicated arrived at a treasure point and the thunder icon indicates a problem.

At the end of the experimentation, semi-structured interviews were conducted with the participants evaluating the utility, acceptability and usability of the wristbands as well as the solvability of the market (preference of 1 vs 2 WBs, financial effort that the participants would be willing to provide to purchase the navigation device). For the static recognition task, 6 participants were recruited (4M/2F). The participants' demographics are described in the table below.

	Man	Female	Overall
Age Min.	16	28	16
Age Max.	24	65	65
Average	21,25	46,5	29,7
Family status (Single/Married/Divorced/Widowed)	1/3/0/0	0/2/0/0	1/5/0/0
Occupation (S= Student, R = Retired)	4S	1S/1R	5S/1R

Table 4: Demographics

The results indicate that the perception and discrimination of the patterns were more difficult with one WB V1 compared to a WB V2 or two WBs V1 according to the number of times the patterns needed to be repeated for its understanding. The number of repetitions is similar for WB V2 and two WBs V1. Regarding the recognition rates, similar results were observed. The recognition of patterns «left/right» was slightly better with 2 WBs but surprisingly not that different from having only one WB.

The navigation task was performed with two young male volunteers (24 and 16 years old). All patterns were correctly identified, with in particular the same recognition rates for the left/right directions. The only exception concerned the pattern “ahead” and “turn back”. Concerning the acceptability, two main questions were enquired:

- Design satisfaction: participants thought 2 WBs were a superior design, followed by WB V2 and finally WB V1 as perception was the best with 2 WBs, followed by WB V2 and then V1. Though, one participant (age 65 years) preferred WB V1 as it resembled more a commercial product.
- Perceived utility: in that case, having only one WB was judged more useful and appropriate than having 2.

Concerning the solvability of the market, participants mostly preferred having only one haptic wristband as they were not interested at all in having to purchase two wristbands instead of one. The average acceptable price for a haptic wristband would be 22 euros.

Overall, the identification of patterns was improved with WB V2 and the discrimination of left/right was slightly improved with two wristbands. However as participants clearly stated they preferred having only one wristband and were not willing to purchase two of them, we decided to choose WB 2 for the remainder of the project. However, during the evaluation outdoor, it was noted that it was quite difficult to attach WB 2 for the older adults. We, therefore, opted for a Velcro band for the field studies, as can be seen from WB V3 on Figure 28.

4.2 Design of the language

For most haptic applications older adults are not involved in the design of the vibrotactile feedback from the beginning of the design cycle but rather solely in the last stages through evaluations of the final prototype. However, older adults present different challenges than younger people that can impact the design and the perception of the vibrotactile cues such as different attitudes to new technology, sensory impairments, difficulties in extracting information, and difficulties in abstract thinking. In the navigation area, most applications have focused on conveying directions using simple intuitive mapping and thus the lack of involvement of the target users was not an issue. However, it can be problematic for other potentially useful non-directional information, often omitted, such as alerts for problems, leisure-related or social information, as it is more challenging to encode into vibrations. In this case the mapping is less straightforward than mapping directions and choosing the right mapping, suitable to the target audience, can impact the learning and recall.

In order to ensure the effective integration of haptic patterns into daily life applications, it is important to use stimuli that can assist in their interpretation and recall. One solution is to ground the design on semantic analogies or metaphors in order to strengthen the semantic link between the pattern and its corresponding message, and thus holds more potential for intuitiveness. In this case, the design of tactile patterns is supported by a symbolic representation shared by a wide range of people (e.g., danger is assimilated to screams, fire, sirens, etc.). The design success thus relies on the choice of metaphors. The choice of metaphors is often arbitrary and not defined by the target users themselves. Therefore, we have used an approach where the users are involved as co-designers not only for the definition of metaphors but also their associated patterns. The process consists roughly of two stages. First, metaphors corresponding to the different elicited messages are collected during face-to-face interviews. Second, patterns corresponding to each message are designed by users based on the collected metaphors and subsequently refined for a final set.

4.2.1 Selecting the appropriate metaphors

The goal of the first step was to collect sensory metaphors for the 7 messages chosen for a pedestrian navigation application (see Table 5 below). However, as metaphors can be a very abstract concept, the challenge consisted in finding the interview guide that was the most suited to the task while not bringing any bias.

M.1	**Reassurance** that it is the right way
M.2	Alert of a **problem**
M.3	Alert of the **arrival at destination**
M.4	Inform of a cultural or leisure-related or user-defined **point of interest (POI)**
M.5	Inform of **friends or relatives** nearby
M.6	Inform of **promotions** nearby
M.7	Alert the device is **connected** and functioning

Table 5: List of messages the haptic wearable could provide

4.2.1.1 Participants

In total, 26 participants (19F/7M) took part in the metaphor collection experiment (see Table 6 for their repartition). They were recruited through senior clubs or acquaintances. The average age was 73.54 years (60-92 years). They had a wide range of occupations, from bank employees, cemetery caretaker to head of an advertising agency. 7 participants had experience with navigation systems. Only 6 participants owned a smartphone; 17 had a "standard" mobile phone, mostly to enable their families to reach them or for emergencies, while 3 had none at all. 11 out 26 participants have used the vibration mode of their mobile phones to guarantee discretion.

Study 1	Study 2	Study 3	Occupation	Age range
6 (4F/2M)	5 (2F/3M)	15 (13F/2M)	2 working, 24 retired	60 - 92

Table 6: Demographic details

4.2.1.2 Procedure

In total, three interview guides for semi-structured interviews were subsequently employed and tested to collect the metaphors, until the right one was found to gather meaningful results. We further describe them and report on the limitations of the first two as they can help in the design of interview guides targeting the older adults.

STUDY 1 (6 PARTICIPANTS)
First, the participants were trained, through examples, to associate quickly a metaphor to messages presented verbally by the experimenter. For example, for the message "I feel good", they could propose: "a bubble bath" or "the sound of waves crashing on the beach". They were then presented with the 7 messages the device should convey (see Table 5) with a context describing the situation of future use of the message. The participant was asked to verbalize the metaphors (such as objects, melodies, etc.) that s/he spontaneously associated to the given message. The 7 messages were given in random order. The experiment lasted about 20 minutes.

STUDY 2 (5 PARTICIPANTS)
The training was the same, but the context was removed and solely the message with its description was provided (as in Table 5). The participant was asked: "what spontaneously comes to your mind for this message? It can be sensations, sounds, images, smells or else".

STUDY 3 (15 PARTICIPANTS)
It concretely asked for metaphors for each sensory modality. The new instruction was to provide as quickly as possible which analogies came to mind in relation to the messages for each sense. For each message and for each modality, the following question was asked: “To indicate the message [message], what would you like to [feel; see; hear; smell or taste] or what would you associate [tactually, at the body level; as images, signs; as melodies, sounds, noises, music; as smells or at the gustatory level]. A training phase provided examples for three messages (“feeling good”, “hurrying up” and “beware of danger”).

4.2.1.3 Results: general tendencies

STUDY 1
In most cases, participants were focused on the context and did not give answers that were generic enough. For instance, for the message concerning a problem (M.2), the context given presented the unavailability of the escalators, so an answer was “stairs”. In other cases, participants were not concrete or specific enough, for example for the message “arrival at destination” (M.3), a participant replied “caution”, while for “friends/family nearby” (M.4) a participant replied “trust, reassurance”. Therefore, out of the 39 replies collected, 11 were unsuitable metaphors (~28%). In the remaining cases, participants gave mostly auditory or visual metaphors.

STUDY 2
Consequently, the context was removed. However, this method led to even more general and abstract answers, due to the lack of any indications on the types of answer expected. Out of the 34 replies collected, only 6 were suitable metaphors (~18%). Moreover, participants would often provide personal replies, which was also observed with the first interview guide but was more exacerbated in this case. For instance for the message “friends nearby”, participants would often answer they currently have no friends or they would provide the name of an actual friend or relative (e.g., “my wife”). Participants were centred on their feelings (loneliness, disease) and behaviour (e.g,. reasoning and action for problems). These results, though interesting as they provide insights about what preoccupies them, were not really usable for the collection of metaphors.

STUDY 3
Overall, we realized that abstract concepts (i.e., providing generic yet concrete metaphors) were difficult to grasp, and that the task should be made as explicit and easy as possible while still avoiding bias. Furthermore, context should only be provided when answers directly related to this context are needed. Therefore, in the final interview guide, metaphors were directly asked for each sensory modality, while the message and context provided remained generic to avoid influencing the answers (as in Table 5). In this case, we obtained much more targeted answers, and it enabled the collection of metaphors for every dominant modality. The olfactory and gustatory metaphors raised more difficulty as they were often not appropriate to the message. In total, 354 answers were collected, of which only 11 were unsuitable metaphors (~3%).

4.2.1.4 RESULTS: METAPHORS COLLECTED

In total, 139 different metaphors were gathered. Figure 30 depicts the answers common to at least 3 people (i.e., same word or idea) and their proportion for each message and for each sensory modality through the size of the circles. We used an ad-hoc similarity analysis which allowed us to combine metaphors according to their similar meaning. The results integrate the results from all the groups. Overall, auditory and visual metaphors are the dominant modalities for common metaphors, not surprisingly as most of the world cues are based on these modalities. Except for M.6 (Promotions) (see Figure 30), all the messages could be related to some tactile metaphors, meaning these messages can be associated to tactile or body sensations. Apart from the gustatory/olfactory modality, the rest of the metaphors can

be used in any application using these messages: for example for M.5 (friends/family nearby), the presence of friends (like in Foursquare) could be indicated visually by smiles, auditory with happy songs and tactually with a pattern mimicking the sensation of joy (see Figure 30). For M.2 (problem), a problem could be indicated by a loud noise, a blocking sensation, a burnt or gas smell or a danger sign (see Figure 30). The collection of metaphors for each modality ensures a consistent design of cues for a given message within one or a set of applications.

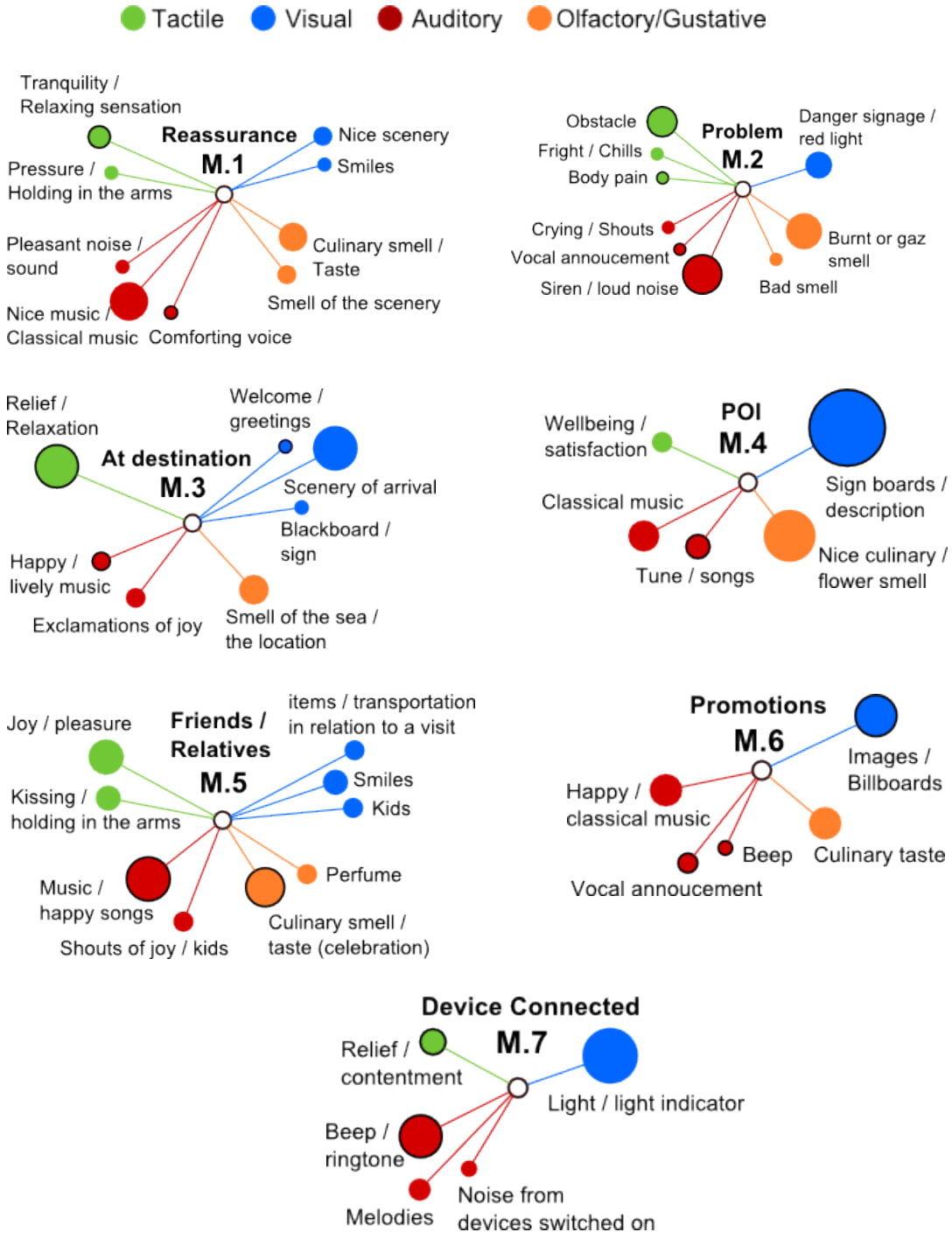


Figure 30: Summary of metaphors given by at least 3 participants. The circles proportionally represent the count of participants for that metaphor. A circle with a black contour indicates the answers from the other groups that were also included. The upper left quadrant shows the tactile metaphors, the upper right the visual ones, the lower left the auditory ones and the lower right the olfactory and gustative ones.

4.2.2 Pattern design

The next step consisted in involving older adults as co-designers for designing the vibrotactile patterns using the collected metaphors for the 7 messages as well as for directional messages (left/right/front/back).

4.2.2.1 Procedure

The metaphors collected during the first phase were used for this step for the “informational” messages, with the exception of taste and smell metaphors as they can be difficult to transfer to the vibrotactile domain. We continued using the participatory approach placing the participant at the centre of the design: in this case the participant had first to choose the most representative metaphor for him/her for a given message and then "program" the tactile sensation corresponding to this metaphor with the help of the experimenter by varying the actuation parameters in a graphical interface. The metaphors were represented on PowerPoint slides with images along with the title of the metaphor whereas the directions were represented by arrows. In this study, the wristband V1 was used. 25 retired older adults [9f – 16m] participated in this phase. The average age was 72 (64-87 years). They were mostly recruited through the association of retired CEA employees.

4.2.2.2 Results

According to the participants’ feedback during the metaphor collection and pattern generation phases, the following messages were considered irrelevant or not interesting: “Device Connected”, the direction “Front”, “Reassurance”, “Promotion” and “Friends nearby”. Indeed, the message "Front" was not considered as necessary, and instead added yet another message to learn and recall, as the lack of directional indication means by default to keep going straight. Participants expressed the same reservations about the message "Reassurance" with the same reasoning that the absence of messages or alerts means they are following the right route. In fact, an error in route following would be indicated by the turn back message or could be indicated by the message problem. Participants were rather repulsed at the idea of getting information about promotions as they were concerned it would turn into unwanted solicitation. As for the message “Friends nearby”, as the older adults interviewed did not use social networking and social localization applications, they did not see the point in receiving such information. Finally, the message "Connected Device" was considered redundant with the LED of the bracelet that already indicates visually that the device is switched on. Therefore, the analysis of patterns focused on the rest of the informational messages (problem, point of interest, arrival at destination) and the directions (right, left, back).

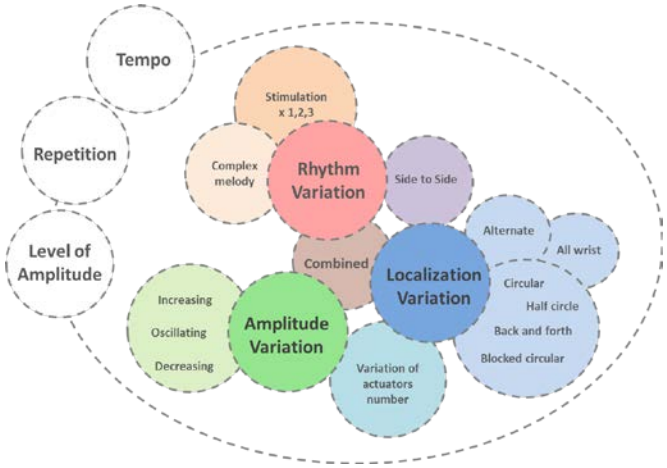


Figure 31: Classification of the most commonly used parameters for pattern design

The produced patterns and their corresponding parameters were analysed by identifying and classifying the patterns according to the rhythm, amplitude, localization, duration and repetitions used (using the classification summarized in Figure 31). The most common user designs per message - in most cases two - were selected. These were subsequently refined into two final pattern designs per message leading in total to the 12 most user representative patterns. They were then divided into two groups, Type 1 and Type 2, according to the following rules to ensure better discrimination (see Figure 32 for their description): within a group *Left* and R*ight* shall have the same symmetrical design; the designs of the directions should be as distinct as possible from the informational messages (e.g., if the directions are repeated, informational messages should preferably not be repeated or at least not the same number of times); and lastly similar rhythms for two different messages should be avoided (e.g., *Arrival* Type 1 and *Back* Type 2).

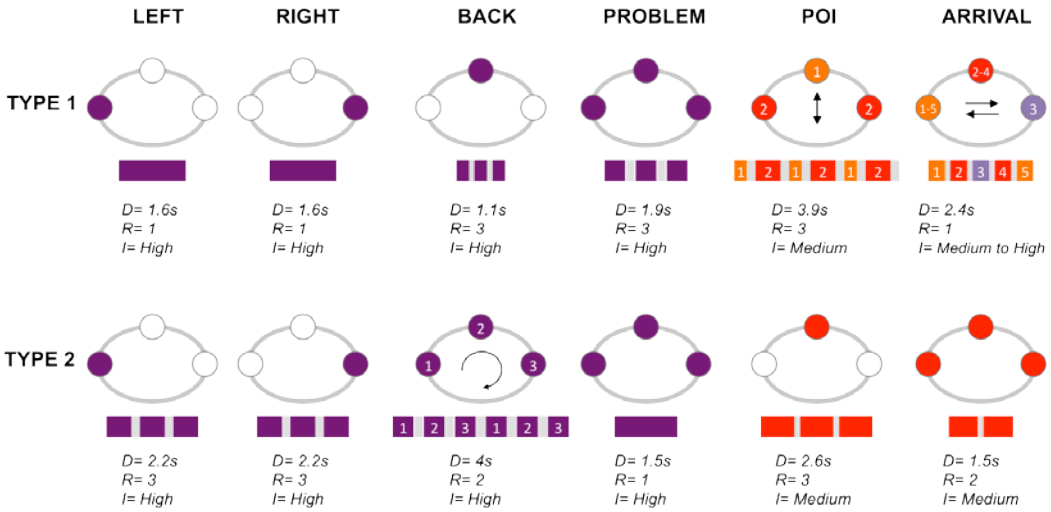


Figure 32: Description of the two most common user designs

4.2.3 Evaluation of produced patterns

4.2.3.1 Objectives and methodology

Our overall objective was to design discriminable, acceptable and intuitive vibrotactile messages for pedestrian navigation by involving older adults throughout the design process. The specific goal of the study described below was to assess the understanding and recognition of the haptic patterns designed during the initial participative design stage and thus to find the optimal final set for further experimentation. Therefore, we compared the recognition of the two resulting sets of messages during a pedestrian navigation task outdoors. Outdoor navigation presents particular challenges such as changes in weather and traffic conditions, noises, etc. All these factors may have a direct impact on pattern recognition. A secondary goal was to assess the acceptability of the haptic navigation aid.

4.2.3.2 Participants

Fourteen participants (7F/7M), with various backgrounds (e.g., a manual worker, an employee, an engineer), aged 63 to 78 years (Mean=72, SD=4.33), took part in the study. There were recruited through older adults' associations and they were not compensated for their participation.

4.2.3.3 Procedure

The evaluation lasted about two hours. Each participant started with a familiarization phase and then performed a navigation task. This process was repeated for each of the two sets of messages. In this study, the wristband V2 was used.

The familiarization phase occurred in a static seated position (e.g., on a bench outdoors). Each message was first played once along with a description of its meaning and parameters to help the user locate the actuators involved in the stimulation. Then, the message was repeated three times in order to help the participant memorize it. This process was repeated for each of the six messages. The participants could ask for an additional repetition if they judged it necessary.

During the navigation task, each participant had to walk two different outdoor routes (see Figure 33 and Figure 34), for about 20 minutes (depending on their walking speed and breaks). The participants wore the vibrotactile wristband on their right hand. One set of patterns was presented during one of the two outdoor itineraries. The presentation order of the two sets of patterns was counterbalanced between the participants, i.e., half of participants performed first route 1 with Type 1 patterns, while the other half performed it with Type 2, and inversely for route 2. For each route, all messages were presented five times. Participants were delivered the message and then asked to verbalize the message they recognized, which was immediately recorded by the experimenter through a graphical Python application. In order to ensure a relative ecological validity of the study, the messages were associated as much as possible to actual valid information in the environment. Obviously, directions were associated to the chosen itinerary, whereas points of interest corresponded to different landmarks (e.g., buildings) and similarly problems to potential dangers (e.g., ravines).

A questionnaire was administered after the navigation task. It was composed of 31 questions based on a 6-point Likert scale in order to avoid neutral answers. The questionnaire tackled the participant's demographics and navigation and orientation difficulties; their needs and expectations as far as vibrotactile navigation aids are concerned; their subjective appreciation of the vibrotactile patterns and device presented in this study.

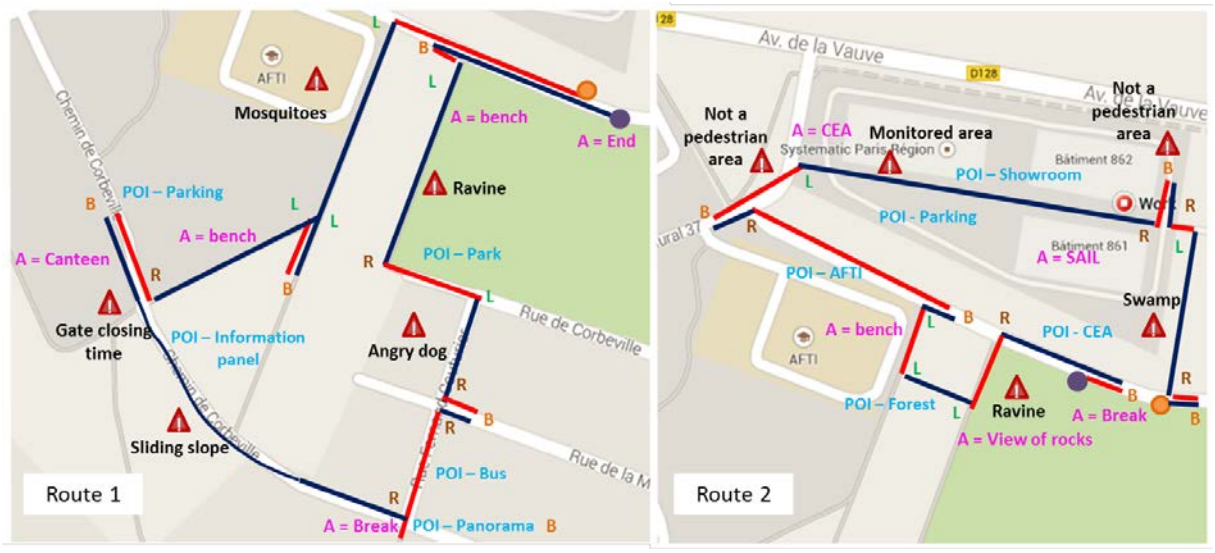


Figure 33: Routes description with the paths walked and the distribution of directional and abstract messages along the routes: *Left* (L), *Right* (R), *Back* (B), *Point of interest* (POI), *Problem* (⚠) and *Arrival* (A). The alternance of the route's colour indicates a change of direction, either by turning or going back. The light coloured circle indicates the start of the route whereas the dark coloured one indicates the end.

Figure 34: Participant testing the wristband outdoor

4.2.3.4 Results and discussion

During the study, both quantitative and qualitative results were collected. These results are presented below and organized in three subsections, where the first presents the quantitative results about the recognition rates and the last two describe the qualitative results about the patterns design.

Since most of the data failed to meet the normality criterion, within-group comparisons were performed using Wilcoxon signed-rank tests. The Likert responses were numerically coded using the 1–6 values and were treated as ordinal data by means of nonparametric statistics. For the frequency data (for instance, the preferred design), the chi-squared test was used to test the hypothesis of independence between participants' assessments. Percentages of responses were privileged when they appeared more informative or when a categorical approach focused preferentially on some responses (e.g., ''often'' and ''very often'' contrasted to the other responses).

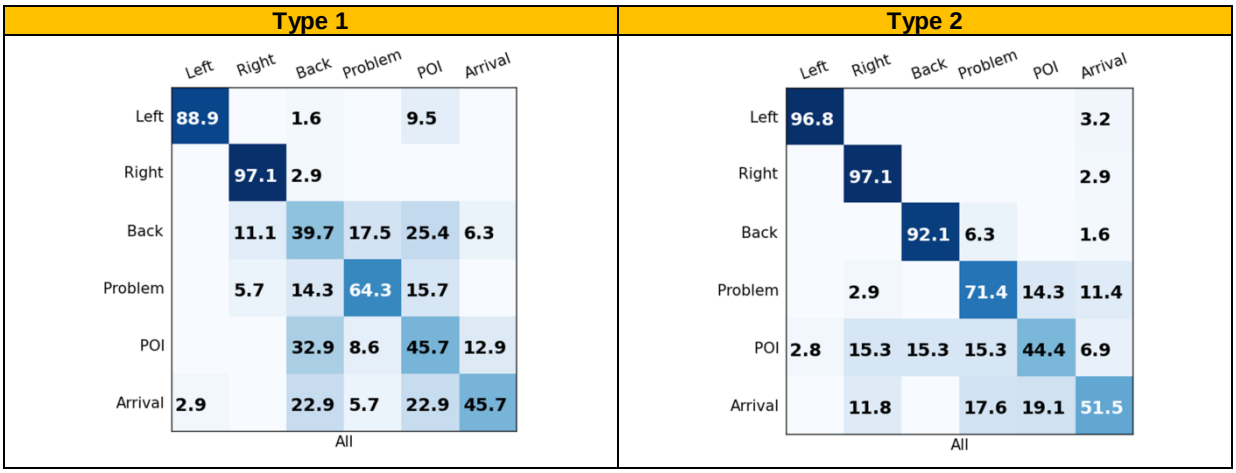


Figure 35: Confusion matrices with the average recognition rates for the two sets of messages (Type 1 and Type 2)

PATTERNS RECOGNITION

For both sets of messages (Type 1 and Type 2), the simplest messages (e.g., directional messages such as Right and Left) had the highest recognition rates (> 88%, see Figure 35). For these messages, the recognition rate was higher than for complex messages, no matter the design (only the comparisons between the simple message Left and the complex message Back for Type 2 is non-significant, T=4.00; Z=0.94; ns). Although Left and Right have the same recognition rate for Type 2 design, it differs significantly for Type 1 (T=0.00; Z= 2.02; $p<0.05$). Surprisingly, the message Left for Type 1 was not as well recognized as the similar message Right (T=0.00; Z= 2.02; $p<0.05$). Indeed, participants complained that the left actuator was not sensed as strongly as the right one for the same intensity. As this was not noted by all the participants, there could be different possible explanations. This could be due to anatomical differences on the wrist with the prominence of the ulna bone on the right side. Or perhaps it could be caused by an industrial dispersion of manufacturing between the actuators, thus impacting on vibration intensity. It could also be due to an unequal adherence of actuators on the skin. We hypothesized that this phenomenon is less pronounced for Type 2, due to the repetitions that could have increased the perception potential. In addition, we observed a high recognition rate for the Back message for Type 2 (92.1% versus 39.7% for Type 1; T=0.00; Z=3.06; $p<0.01$), which was based on a “turn around” metaphor imitating the movement of turning back. The Type 1 Back on the other hand was not designed using a metaphor-based approach, but rather by simple opposition to the Left and Right messages with an alerting property. This result suggests a positive impact of a metaphor-based design in helping the understanding and recognition of haptic information. Another well-recognized message was the message Problem (71.4% for Type 2 versus 64.3% for Type 1; T=16.05; Z= 0.21; ns) where a long continuous signal was presented (Figure 35). The metaphors involved here were based on alarms, with two possible designs, a continuous or a repeating one.

The two remaining messages (Point of Interest and Arrival at Destination) were poorly recognized and often mistaken with each other or with other messages that constitute possible subsets of the patterns. A possible interpretation of these relatively poor results could be that these messages are quite abstract and require longer learning to be memorized. These poor recognition results could also be due to a learning time too short for a large number of messages - participants learned 12 messages in total. Another explanation could simply be that the learning time of more complex messages was too short to allow participants to remember all the messages. Priority was given to what participants considered the most important messages, i.e., directions and problems. This is also confirmed by observations done by the experimenter and qualitative feedback further detailed in the following subsections.

PATTERNS PREFERENCE

At the end of the user study, the participants were asked which of the patterns they preferred for each message. Concerning the directional messages (Left and Right), there was no major difference in preferences, though Type 1 had a slight advantage compared to Type 2 (57% of participants for Type 1, $\chi2(1, 14) = 0.54$, ns; see Figure 36). Regarding the other messages, the preferences were more strongly pronounced. Participants largely preferred the second set of patterns (global comparisons between Type 1 and Type 2 $\chi2(4, 14) = 24.38$; $p<0.001$, with for Back, $\chi2(1, 14) = 28.00$, $p<0.001$, and for Problem, POI and Arrival, the same significant-different pattern of responses $\chi2(1, 14) = 20.57$, $p<0.001$; see Figure 36). It is noteworthy that all participants preferred the message Back which was based on the natural analogy with turning back on oneself (Type 2: vibrations in clockwise rotation) rather than the design relying on a simple opposition with directions. They found it more "intuitive".

For Directional or "simple" messages, more than half of the participants estimated that it is not necessary to repeat, within a given message, the vibrations for simple messages such as Right and Left (global comparisons of the 6 Likert scale's values, $\chi2(4, 14) = 22.54$, $p<0.001$; and comparisons between "1", "2", "3" responses meaning "no repetition" and "4", "5", "6" responses meaning "repetition": $\chi2(1, 14) = 14.28$, $p<0.001$). These participants thought that such a repetition would require more cognitive resources to process and memorize the haptic information. They were also afraid of confusions with more abstract and complex messages (i.e., informational messages). The participants required repetition "on demand", when judged necessary.

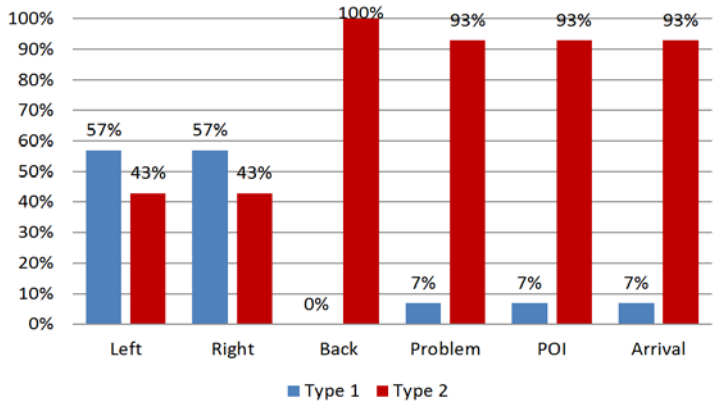


Figure 36: Haptic patterns preference for each message.

Similarly, for abstract or "complex" messages, though not significantly, more than half of the participants reported again that changes in the number of vibrations and internal repetitions caused memorization difficulties and confusion between abstract messages. Contrary to our expectations, repetition was not perceived as an aid to recognition; it makes messages "more complex". Moreover, 78% of participants considered that repetitions would be mainly useful in an emergency situation to emphasize the imminence or to stress a problem.

OVERALL ACCEPTABILITY QUESTIONS

The other questions enquired about the general acceptability of the haptic aid. First, concerning the learning and recognition of the messages and whether each was mentally demanding, the participants' feedback showed that Type 1 and Type 2 patterns were not significantly different concerning learning ($\chi2(20, 14) = 29.70$, ns). In contrast, it was for recognition ($\chi2(12, 14) = 29.16$, $p<0.01$) with Type 2 performing slightly better. However when enquired about the ease of learning and recognition, there was a significant difference for learning between Type 1 and Type 2 ($\chi2(16, 14) = 25.00$, $p<0.05$) but not for recognition ($\chi2(12, 14) = 15.84$, ns) with Type 2 leading to a better learning facility. Nevertheless, data showed it was still a rather easy and acceptable task. The difficulties participants faced stemmed primarily from the more complex messages (i.e., POI, Arrival and Problem).

When asked about the general satisfaction of the design of the messages for each type, only 14% of the participants were not satisfied with Type 1 design and no participant was unsatisfied with Type 2 design. The satisfaction degree did not differ significantly between the two designs ($\chi 2(12, 14) = 15.84$, ns). All the data indicated that overall participants were satisfied, particularly so with the second design, but left some room for improvement. In particular such improvement was suggested by recombining the two sets, according to the results presented in the patterns preference section.

As for the irritation caused by the vibrations, all participants but one did not find the sensation irritating at all. Furthermore, only 14% of the participants did not appreciate the sensation caused by the vibrations. Interestingly, 57 % of the participants found it useful to wear such an aid for navigation. They found it particularly useful for indicating directions and problems. Concerning the potential improvements, the suggestions tackled primarily missing functionalities such as the possibility to have a volume button (for discretion as well as perception purposes, 71% of the participants), a “repeat message” button (all participants) and a stop message (93% of the participants). The other improvements concerned the aesthetics (size of the wristband, a look more similar to a real watch) with 21% of participants, as well as the improvements of the design of the more complex informational messages.

Overall, participants reacted well to wearing the haptic wristband and its sensations and were not displeased with getting information haptically. On the contrary, they were satisfied and found it useful and securing. Their feedback highlighted the importance of designing simple messages with the worry of inattention and memorization issues and having a functional yet esthetical device.

4.3 Recommendations for designing haptic navigation aids

Haptic technologies can open up new avenues for assisting older people in navigation and orientation tasks. However, key factors for a successful haptic aid lies not only in the discrimination and intuitiveness of the haptic language but also its acceptability along with the one of the device. In this section, initial recommendations resulting from the study are described for designing vibrotactile navigation aids suited to the older pedestrians’ needs.

Recommendation 1: Design task-specific messages, on the basis of the priorities given by older adults. Thus, in this study, the older adults considered the directional patterns crucial for the navigation task, while the other patterns were considered of secondary importance. This could be influenced by the outdoor setting and the experimental conditions which did not offer and promote exploration through interesting points of interest or convey problems related to real dangers. Consequently, task-specific messages, in this case directions related to the primary task of navigation, should be designed as the most intuitive and easy to recall as possible. Also the design should be different between a set of messages considered as crucial to the primary task and others as of secondary importance.

Recommendation 2: The design of the important messages should be the simplest possible. In our study, the preferred and better recognized design involved continuous strong signals, without too many repetitions. Such patterns were considered “most intuitive”, requiring less memorization efforts. Therefore, various combinations of parameters (such as repetitions, as well as variations on the durations and the amplitude of the stimulations) should be avoided as much as possible for such messages. In general, for such messages, in our case directions, a single repetition with the highest possible amplitude was preferred.

Recommendation 3: Use “internal” repetitions of a sequence with care. We hypothesized, given attentional issues, potential memory declines and possible distractions from the environment, that having “internal” repetitions within a message would help its recognition. Indeed, even if the first signal were missed, the following signals would still enable its recognition. However, in a set containing at least 6 messages, each with

repetitions and different combinations, this brought confusion. By missing the first signal, participants were unsure of how much they had missed and could not discriminate properly amongst similar messages.

Recommendation 4: Using a metaphor-based design is a promising lead. Indeed, the recognition rates were rather high for the messages Back of Type 2 based on the movement of turning back and for Problem where the underlying metaphor is an alarm (either repeated or not). On the contrary, for the messages where the metaphors were less significant, i.e., intuitive and natural (POI and Arrival), the recognition rates were quite poor, less than average in fact. Such a methodology has proven effective for a younger targeted population and should be further investigated and applied for older adults where strengthening the link between the vibrations and the signification of the message is of outmost importance for recall.

Recommendation 5: For any success of a haptic aid, its acceptability should be tackled as seriously as the development of the language itself. Given some reticence of the older adults towards technological accessories, it is important to take into account the aesthetics, comfort and portability of the navigation aid. We chose the form factor of a wristband resembling a watch to aid its acceptability. Through the qualitative answers, this design choice has proven fruitful as participants did not reject this design and felt comfortable with the device.

4.4 Conclusion

With the goal of ensuring acceptability of a haptic wristband communicating informational messages, a UCD approach was adopted for the design of the haptic language in the context of a navigation application targeting older adults. This approach involved the older adults in the design of these vibrotactile patterns by collecting the most common user-elicited metaphors for their definition. The different steps undertaken until reaching a suitable methodology highlighted the difficulties encountered with such an abstract notion to collect meaningful results. In particular, devising the protocol should carefully take into account the impact of introducing “example” contexts and should try being as explicit as possible in the task without introducing bias. The most common metaphors enabled to gather representations in every sensory modality for each message and could be used to create feedback in other modalities. The next stage implicated the user for the design of the patterns, leading to a refined set of 12 patterns, for the 6 most useful messages (Right, Left, Back, POI, Problem and Arrival at Destination), that is representative of the most common user designs. These patterns were subsequently evaluated in ecological conditions with older adults to assess the recognition and the understanding of haptic patterns for a navigation task. The other goal was to identify successful combinations of the parameters to reach intuitive and pertinent messages for the elderly. The various findings concerning the usage of a metaphor-based design or repetitions within a message highlighted the necessity to take into account the specific needs of this targeted population, for whom for instance focus should be given to simplicity and messages considered crucial to the task. These findings are summarized into recommendations for designing an efficient aid accepted by the older adults.

This approach and the related studies are a first step in designing and validating efficient haptic aids for older adults. In particular, the patterns will be further refined and evaluated for testing long-term recall and acceptability. Differences with younger users will also be investigated to further highlight the possible design differences stemming from different needs and population specificities. Finally, the integration of such a navigation aid into the current smartwatch trend will be explored along with other useful haptic information that can be provided (e.g., information from calendars or health-related alerts).

5 USER STUDY IN THE FIELD

5.1 Research Goals

The study aimed at evaluating the Entrance components (HP, SG, MP and WB) over six weeks within guided end user workshops. Starting with a general assessment of participants' attitudes towards technology in general and their first impressions of the Entrance system, individual workshop sessions were conducted for each component, together with an excursion to further evaluate the MP. In the final session, participants' attitudes towards Entrance and changes in their level of competence and technology self-efficacy were assessed. The field studies took place in Austria with 17 participants (organized by PLUS and 50plus) and in France with 9 participants (organized by CEA and ALAB) representing both personas Luise and George. 3 participants were excluded (1 from 50plus and 2 from ALAB) as they only participated in the first week.

5.1.1 Research Questions

In the following, the central research questions were defined. They are structured according to different values as well as usability (U), user experience (UX) and user acceptance (UA) factors that are going to be addressed.

Functional value:

U - Usability

- RQ1: How easy/difficult is it for older adults to perform tasks in the system?

U, UX - Satisfaction

- RQ2: How satisfied are the users with the functions and usage of the system?
- RQ3: What attitudes do the users have towards the system?

UA - Perceived ease of use

- RQ4: To which extent do the users believe that using the system will be free of physical and mental effort?

UA - Perceived usefulness

- RQ5: To which extent do users believe that the system would facilitate achieving their goals?

U - Learnability

- RQ6: How does the system enable the users to learn how to use it?

Epistemic value

UX - Learning

- RQ7: To what extent does the system support learning (1) to navigate, (2) to manage the system?

UX - Curiosity / Interest / Preferences

- RQ8: In what way does the usage of the system provoke the user's curiosity about and interest in the system and its content?

Emotional value

UX - Fun/ Enjoyment

- RQ9: To what extent does the system provoke fun/enjoyment?

UX - Motivation

- RQ10: How competent do the end users feel in using the Entrance system?

5.1.2 Methodological approach

We conducted a series of workshops with free exploration phases in order to evaluate the different components. In the following, questionnaires and models are described, whereof items will be selected that are appropriate to answer the RQs and assess different factors.

System Usability Scale (SUS) [Brooke, 1996]

The System Usability Scale (SUS) is a simple, ten-item scale giving a global view of subjective assessments of usability. Despite being a self-described "quick and dirty" usability scale, the SUS has become a popular questionnaire for end-of-test subjective assessments of usability. Scoring the questionnaire yields a usability score in the range of 0–100, i.e., 80 to 100 users likes the system, 60 to 79 users accept the system and 0 to 59 users dislike the system.

SUS

1. I think that I would like to use this system frequently
2. I found the system unnecessarily complex
3. I thought the system was easy to use
4. I think that I would need the support of a technical person to be able to use this system
5. I found the various functions in this system were well integrated
6. I thought there was too much inconsistency in this system
7. I would imagine that most people would learn to use this system very quickly
8. I found the system very cumbersome to use
9. I felt very confident using the system
10. I needed to learn a lot of things before I could get going with this system

Subjective Satisfaction [Nielsen, 1993]

Subjective satisfaction refers to how satisfying it is to use a system. The questionnaire is filled in after having tried out the system with real tasks.

Satisfaction items

1. It was very easy to learn how to use this system.[2]
2. Using this system was a very frustrating experience.
3. I feel that this system allows me to achieve very high productivity
4. I worry that many of the things I did with this system may have been wrong.
5. This system can do all the things I think I would need.
6. This system is very pleasant to work with.

Epistemic Curiosity Scale [Koo et al., 2007]

Epistemic curiosity is defined as the extent to which the activity is perceived to provide learning experiences about new things, strategies, and trends.

[2] Greyed-out items denote items that are part of the original scale or construct but were *not* integrated into the field study questionnaire(s).

Curiosity items

1. I learn a lot by playing online games.
2. Playing an online game makes me think a lot.
3. Playing an online game stimulates my curiosity.
4. I consider that playing an online game is a learning experience.
5. Playing an online game is a good method to learn what is new.

Intrinsic Motivation Inventory (IMI) [Deci and Ryan n.y.]

The inventory is a multidimensional measurement device to assess users' interest/ enjoyment, perceived competence, effort, value/usefulness, felt pressure and tension, and perceived choice after performing a given activity. The interest/enjoyment subscale is considered the self-report measure of intrinsic motivation; thus, although the overall questionnaire is called the Intrinsic Motivation Inventory, it is only the one subscale that assesses intrinsic motivation, per se. The perceived choice and perceived competence concepts are theorized to be positive predictors of both self-report and behavioural measures of intrinsic motivation, and pressure/tension is theorized to be a negative predictor of intrinsic motivation. However, only the subscales for interest/enjoyment and perceived competence are relevant for our study.

Interest/enjoyment items

1. I enjoyed doing this activity very much
2. This activity was fun to do.
3. I thought this was a boring activity. (R)
4. This activity did not hold my attention at all. (R)
5. I would describe this activity as very interesting.
6. I thought this activity was quite enjoyable.
7. While I was doing this activity, I was thinking about how much I enjoyed it.

Perceived competence items

1. I think I am pretty good at this activity.
2. I think I did pretty well at this activity, compared to other students.
3. After working at this activity for a while, I felt pretty competent.
4. I am satisfied with my performance at this task.
5. I was pretty skilled at this activity.
6. This was an activity that I could not do very well. (R)

Technology Acceptance Model (TAM) [Davis, 1989]

Ease of use and ease of usefulness both influence the behavioural intention, which finally leads to the actual system use. Both are operationalized in 6-item scales. The second version, evolved by Venkatesh and Davis [2000] is called TAM2. Recently, there has been a new version the TAM3. It extends the TAM2 by some new factors, which influence directly the perceived ease of use: Computer self-efficacy, perceptions of external control, computer anxiety and computer playfulness [Venkatesh and Bala, 2008]. For our user study selected item for perceived ease of use, perceived usefulness and computer anxiety are of relevance.

Perceived ease of use (TAM2) items

1. Learning to operate [the system] would be easy for me.
2. I would find it easy to get [the system] to do what I want to do.
3. My interaction with [the system] would be clear and understandable.

4. I would find [the system] flexible to interact with.
5. It would be easy for me to become skilful at using [the system].
6. I would find [the system] easy to use.

Perceived usefulness (TAM2) items

1. Using [the system] in my job would enable me to accomplish tasks more quickly.
2. Using [the system] would improve my job performance.
3. Using [the system] in my job would increase my productivity.
4. Using [the system] would enhance my effectiveness on the job.
5. Using [the system] would make it easier to do my job.
6. I would find [the system] useful in my job.

Additional Perceived ease of Use items

1. I learned a lot while using the system.
2. Using the system made me think a lot.
3. I consider using the system as a learning experience.
4. Using the system was a good method to learn what is new.

Attitude Toward Using Technology from the UTAUT [Venkatesh, 2008]

The UTAUT is an acceptance model aiming to explain user intentions and user behaviour. Attitude is defined as an individual's positive or negative feeling about performing the target behaviour (e.g., using a system). For this study we selected items from the construct “Attitude Toward Using Technology”, of the three subscales attitude toward behaviour, affect towards use, and affect.

Attitude Toward Behaviour (UTAUT) items

1. Using [the system] is a bad/good idea.
2. Using [the system] is a foolish/wise idea.
3. I dislike/like the idea of using [the system].
4. Using [the system] is unpleasant/pleasant.

Affect towards use (UTAUT) items

1. [The system] makes work more interesting.
2. Working with [the system] is fun.
3. [The system] is okay for some jobs, but not the kind of job I want.

Affect (UTAUT) items

1. I like working with [the system].
2. I look forward to those aspects of my job that require me to use [the system].
3. Using [the system] is frustrating for me.
4. Once I start working on [the system], I find it hard to stop.
5. I get bored quickly when using [the system].

5.1.3 Study Plan

Within six week six different workshops each lasting for 1,5 hours were organized that are outlined in the following table.

Time	Process
Week 1 – Introduction	
5 min	Welcome
10 min	Pre-Experiences (tablet, serious games, windows 8, navigation, etc.)
15 min	Introduction to Entrance project (aim, scope, etc.)
15 min	Expectations & anticipated user experiences (questionnaire)
15 min	Break
25 min	General introduction to tablet usage & Free try out phase
5 min	Overview of next week sessions
Week 2 – HP & Tutorials	
5 min	Welcome
5 min	Introduction to HP & Tutorials
30 min	Free try out phase (HP & Tutorials) with tasks
10 min	Questionnaire
15 min	Break
20 min	Discussion
5 min	Summary
Week 3 – SG & HP Tutorial	
5 min	Welcome
5 min	Introduction to SG
30 min	Free try out phase (SG & HP Tutorial) with tasks
10 min	Questionnaire
15 min	Break
20 min	Discussion
5 min	Summary
Week 4 – MP & WB	
5 min	Welcome
5 min	Introduction to MP
30 min	Free try out phase (MP) with tasks
10 min	Questionnaire
15 min	Break
20 min	Discussion
5 min	Summary
Week 5 – Excursion with GeoMobile to commercial centre	
5 min	Welcome
10 min	Introduction GeoMobile
30 min	Guided try out phase (MP) with tasks
40 min	Coffee & Discussion
5 min	Summary
Week 6 – Summary/Reflection	
5 min	Welcome & Introduction
10 min	Questionnaire for overall System
15 min	Summit conclusion for HP Tutorials
15 min	Summit conclusion SG
15 min	Coffee
15 min	Summit conclusion MP
10 min	Participation in course/workshop serious
5 min	Summary

Table 7: Study plan

5.2 Participants

The 26 participants (7M/19F) were aged between 55 and 76 years (average age 65.85 years, SD = 4.839), whereof 16 participants (6M/10F) represent George (average age 65.25 years, SD = 5.385) and 10 participants (1M/9F) represent Luise (average age 66.80 years, SD = 3.882). More demographic data can be found in Figure 37.

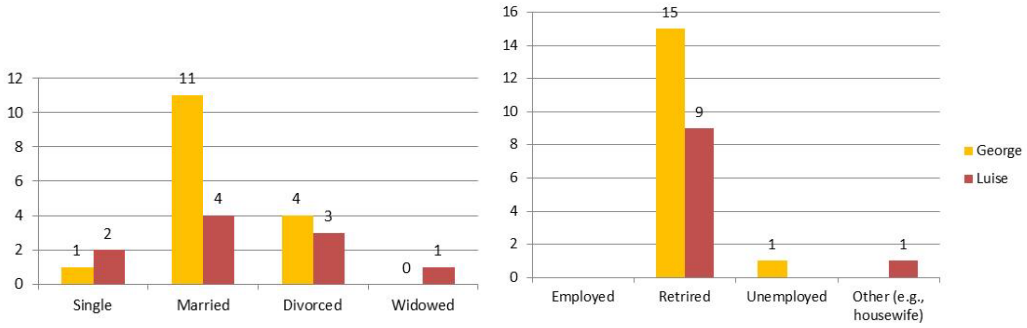


Figure 37: Family status and occupation of George and Luise

Figure 38 illustrates that all Luise and George have a computer with internet access except one George, who has no computer at all. The computer experience of George is mainly medium, but some have rather good or even very good experience. Luise has also mainly medium computer experience, but some also have rather low experience.

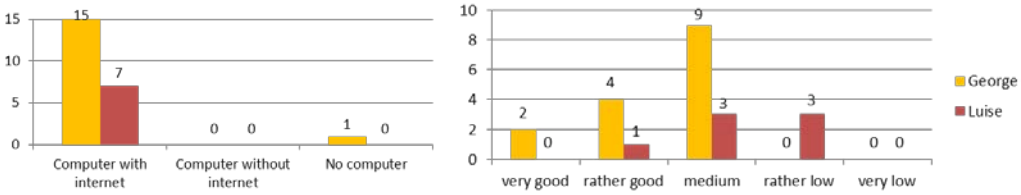


Figure 38: Computer and internet access as well as computer experience (N = 26)

Figure 39 shows that most George participants have a mobile phone with internet and only two without internet or one even has no mobile phone. Half of Luise participants have a mobile phone with internet and half without internet. The mobile phone experience of George is mainly medium, but some have rather good or very good experience. Luise has mainly medium or lather low phone experience.

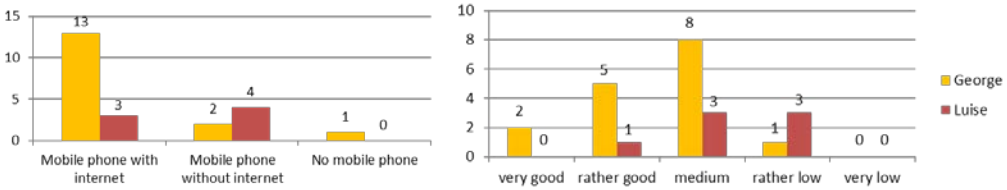


Figure 39: Mobile phone internet and mobile phone experience (N = 26)

Figure 40 illustrates the familiarity of participants George and Luise with touch devices. The touch experience of George is mainly medium, but some have rather good or even very good experience. Luise has also mainly medium touch experience, but some also have rather low experience.

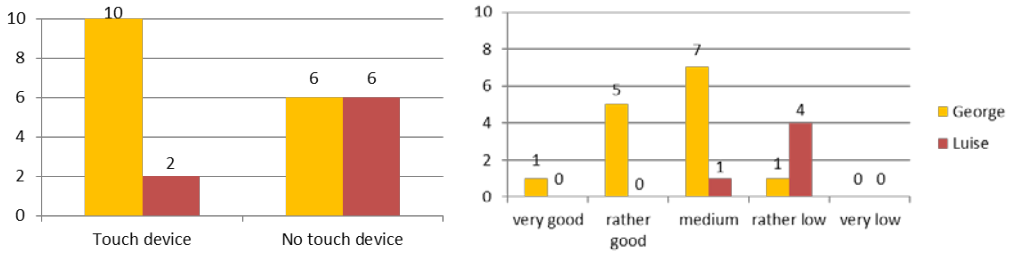


Figure 40: Touch device access as well as touch experience (N = 24)

Figure 41 shows that George has some pre-experience with Android and uses it quite regularly. Luise hardly has any pre-experience with Android.

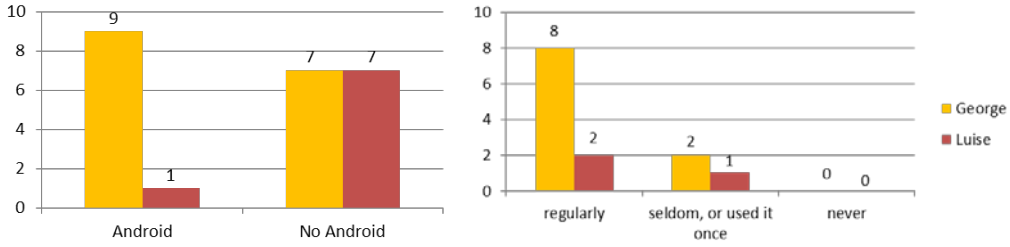


Figure 41: Android access as well as usage (N = 24)

Figure 42 shows that George has some pre-experience with Windows 8 and seldom uses it. Luise hardly has any pre-experience with Windows 8.

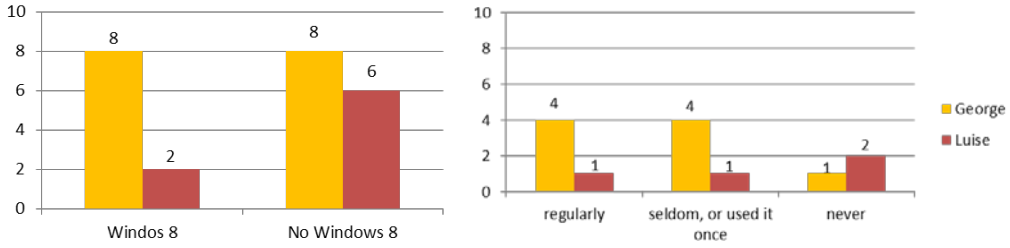


Figure 42: Windows 8 access as well as usage (N = 24)

The demographic data shows that the two EUOs successfully recruited participants that represent our two personas. George is in general interested in technologies and is part of the more technical affine target group, whereas Luise is rather interested and less experienced. In the following the results are described for George and Luise, in order to illustrate possible differences for our target groups.

5.3 Limitations of the Study

The following problems occurred during the study and have to be considered in the final results, as they affected the usage of the different system components. In the following, for each system component the associated limitations that reduced the usability of the system will be described.

Country	Limitations
Week 1 – Introduction	
Austria	• Replaced one HP that was not functioning and there was not have enough time to connect the tablet to the HP • Try out only with the tablets (not connected to the HP)
France	• Difficulties in connecting to internet and using the skype application. This task was skipped. • Problems with icons on the tablet: they “disappeared” and it was necessary to save them on the screen again. • Handling issues with the Home Platform and RDP (created confusion and problems of disconnection by pressing twice the RDP button).
Week 2 – HP & Tutorials	
Austria	• HP did not have an internet connection most of the time, therefore, no connection with the tablet was possible. • Could not work with the HP, therefore, the participants were not able to go through the tasks, instead print outs of the tutorials were handed out and other apps of the tablet were used (e.g., “Bing”).
France	• Some setup issues at first, due to the highly secured internet connection at ALAB, but SDS helped install and workout everything.
Week 3 – SG & HP Tutorial	
Austria	• Not all tablets connected with the MP, only 3 systems were running. • After some minutes the SG stopped and the start screen disappeared.
France	• The SG was not fluid.
Week 4 – MP & WB	
Austria	• Main problem was the rain, tried to navigate with the WB indoor
France	• GPS signal was very bad and inaccurate. • Did not manage to connect the WBs to the phones for the first group. • Also bad weather conditions with rain.
Week 5 – Excursion with GeoMobile to Shopping Mall	
Austria	• Sometimes PLAZA failed, i.e., the navigation did not work properly. • Not all participants came to the shopping mall, George was more interested.
France	• Bad GPS inside the commercial centre and the image of the map was of too low quality to be able to localize oneself. • Did not do much of the actual walking around with “indoor localization”. • Mostly a discussion of the aspect of indoor localization, if it were ideally working
Week 6 – Summary/Reflection	
Austria	• Most participants did not come, therefore, interviews with participants of group 1 and 2 were conducted instead of a discussion.
France	• -

Table 8: Study limitations in Austria and France

5.4 Results

The results are structured according to the values of the ViA Model, which are concepts or beliefs that direct human behaviour to specific actions (e.g., using a technology/ system/application or refusing it), and support judging and justifying actions (e.g., the decision for a technology/system/application). Values are centred in people and refer to the properties of the objects (e.g., technology) they desire, i.e., users seek to achieve their values.

5.4.1 Functional value

The functional value, which is defined as the perceived utility for achieving a specific task or a practical goal, refers, for example, to the UX factor satisfaction, to the UA factor perceived ease of use and perceived usefulness, as well as indirectly too many usability factors, e.g., efficiency and effectiveness.

5.4.1.1 U - Usability

RQ14: How easy/difficult is it for older adults to perform tasks in the system?

George and Luise still dislike most of the system functions (see SUS Score in Figure 43). George slightly accepts the MP & WB and Luise almost accepts the HP.

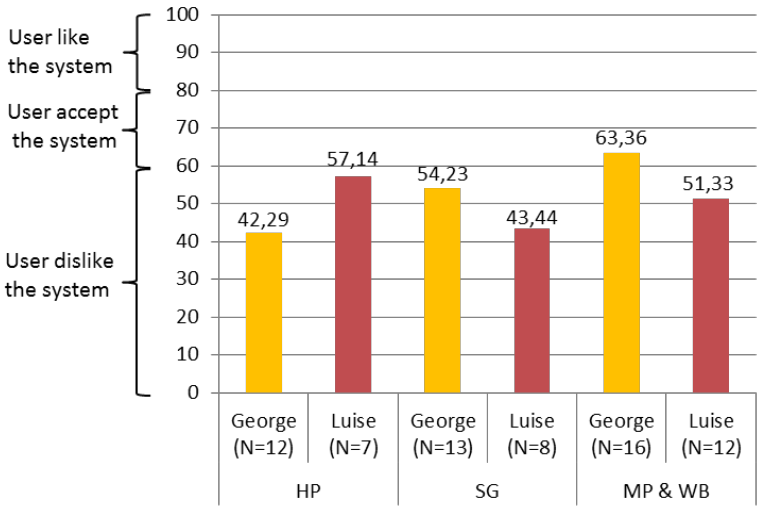


Figure 43: SUS Score [Booke, 1996]

Table 16, Table 10 and Table 11 describe the rating of the different questionnaire items for all participants, George and Luise. Overall most of the items were rated neither/nor, therefore more attention should be given Table 10 and Table 11.

	Overall					
	HP		SG		MP & WB	
	Mean	SD	Mean	SD	Mean	SD
I think that I would like to use this system frequently.	3,26	1,327	3,48	1,030	3,46	1,170
I found the system unnecessarily complex.	2,58	1,170	2,95	1,117	3,00	1,333
I thought the system was easy to use.	3,16	1,425	2,95	1,071	2,89	1,100
I think that I would need the support of a technical person to be able to use this system.	3,42	1,261	3,00	1,378	3,07	1,245
I found the various functions in this system were well integrated.	3,11	0,994	2,76	0,625	3,00	0,816
I thought there was too much inconsistency in this system.	2,37	0,895	2,81	0,814	2,86	1,239
I would imagine that most people would learn to use this system very quickly.	3,05	1,177	2,90	1,044	3,11	0,916
I found the system very cumbersome to use.	3,26	1,327	3,33	1,238	3,39	1,166
I felt very confident using the system.	3,11	1,197	3,00	1,140	3,14	0,932
I needed to learn a lot of things before I could get going with this system.	3,16	1,068	3,05	1,322	3,46	1,105

Table 9: Questionnaire items for the different system components [Booke, 1996]

For George the usage of the HP was unnecessary complex and inconsistent. Therefore, he would rather not like to use the HP frequently. The SG was rather easy to use for him and the functions were rather well integrated. The MP & WB were also rather easy to use and not very cumbersome for him and he also felt rather confident when using it. Therefore, he didn't need to learn a lot of things in order to use it. For more details see Table 10.

	George					
	HP		SG		MP & WB	
	Mean	SD	Mean	SD	Mean	SD
I think that I would like to use this system frequently.	3,75	1,357	3,23	1,013	3,25	1,125
I found the system unnecessarily complex.	2,50	1,382	2,85	1,214	3,31	1,448
I thought the system was easy to use.	3,33	1,614	2,69	0,947	2,44	0,964
I think that I would need the support of a technical person to be able to use this system.	3,42	1,165	3,46	1,330	3,56	1,094
I found the various functions in this system were well integrated.	3,50	1,000	2,69	0,751	2,94	0,929
I thought there was too much inconsistency in this system.	2,17	1,030	2,92	0,954	3,44	1,209
I would imagine that most people would learn to use this system very quickly.	3,50	1,243	2,85	1,144	3,00	0,966
I found the system very cumbersome to use.	3,08	1,443	3,31	1,316	3,75	1,291
I felt very confident using the system.	3,25	1,138	2,85	1,068	2,75	0,775
I needed to learn a lot of things before I could get going with this system.	3,08	0,900	3,46	1,127	4,06	0,929

Table 10: Questionnaire items for the different system components [Booke, 1996] (1 Agree – 5 Disagree)

Luise found the HP rather easy to use but also unnecessary complex. However, she can imagine that most people would learn to use the HP quickly. She would rather like to use the HP frequently as she found the function rather well integrated. She would rather need support and learn a lot of things before she could use the SG or the MP & WB. Therefore, she rather would not like to use the SG or the MP & WB. She thought there was also too much inconsistency when using the MP & WB and the system was unnecessary complex. For more details see Table 11.

	Luise					
	HP		SG		MP & WB	
	Mean	SD	Mean	SD	Mean	SD
I think that I would like to use this system frequently.	2,43	0,787	3,88	0,991	3,75	1,215
I found the system unnecessarily complex.	2,71	0,756	3,13	0,991	2,58	1,084
I thought the system was easy to use.	2,86	1,069	3,38	1,188	3,50	1,000
I think that I would need the support of a technical person to be able to use this system.	3,43	1,512	2,25	1,165	2,42	1,165
I found the various functions in this system were well integrated.	2,43	0,535	2,88	0,354	3,08	0,669
I thought there was too much inconsistency in this system.	2,71	0,488	2,63	0,518	2,08	0,793
I would imagine that most people would learn to use this system very quickly.	2,29	0,488	3,00	0,926	3,25	0,866
I found the system very cumbersome to use.	3,57	1,134	3,38	1,188	2,92	0,831
I felt very confident using the system.	2,86	1,345	3,25	1,282	3,67	0,888
I needed to learn a lot of things before I could get going with this system.	3,29	1,380	2,38	1,408	2,67	0,778

Table 11: Questionnaire items for the different system components [Booke, 1996]

5.4.1.2 U, UX - Satisfaction

RQ15: How satisfied are the users with the functions and usage of the system?

Home Platform

George had the feeling that he spent a lot of energy on this for nothing, that's the reason why he is quite disappointed and dissatisfied with the HP. He doesn't see the point in using the new system, as he would rather use an already existing system he is familiar with. George does absolutely not feel overwhelmed nor incompetent, but in his opinion he could solve the task faster with another already existing system. Luise had also difficulties with the different terms such as Google, Bing, as she found them confusing. In her opinion the HP makes things more complicated and this was not satisfying for her. She doesn't believe that this platform is designed for people who aren't that skilled because it is too complex.

Serious Game

George agreed that games are learnable and depends on training. The motivation to use the SG to receive the information he can get otherwise was not satisfying. He thought there wasn't enough action and "adventure" in the game. Another point was the one-dimensional space, it would be more logical to him, if he could play in the real world. He felt that he did not make any progress. Luise liked experimenting with the game, she only needs more training. It was hard for her to memorize what she can do, so she'd prefer doing it under real conditions. Furthermore, it was hard for her to understand the purpose of the game, which was not satisfying for her. She felt a little overwhelmed when working with two devices and the introduction because she couldn't find what she wanted.

Mobile Platform & Wristband
George did not feel overwhelmed at all and was very satisfied. However, he mentioned that it is a bad tool and with a bad tool he can't do a good job, as the arrow and GPS were not reliable enough and he needed help all the time. Nevertheless, he thinks in an unknown city the MP would have helped him. George had the idea of a scan station in the parking house. So he can scan the parking position and afterwards the system can tell him where the car is. Luise is not sure whether she is competent or not, which is unsatisfying. Though she did not feel overwhelmed, the device is too complex, too gimmicky and not reliable for her. She also had the feeling that she did not learn much. It was rather fun for her to try it out, but she also needed some help, especially with the GPS.

RQ16: What attitudes do the users have towards the system?

Overall, the attitude towards using the Entrance system is rather not positive (see Table 12). For George the system is rather ok for some tasks, but not the tasks he wants. Otherwise, both are rather not motivated to use the Entrance system (e.g., the interaction with the system was rather frustrating or once they started working with it, it was not hard for them to stop) (see Table 13).

	Overall		George		Luise	
	Mean	SD	Mean	SD	Mean	SD
Week 6	3,22	0,693	3,21	0,595	3,25	1,532

Table 12: Satisfaction comparison in week 6 [Venkatesh, 2008]

	Overall		George		Luise	
	Mean	SD	Mean	SD	Mean	SD
The system makes my tasks more interesting.	3,57	1,284	3,58	1,240	3,50	2,121
The system is okay for some tasks, but not the tasks I want.	2,85	1,068	2,73	1,104	3,50	0,707
I look forward to those tasks that require me to use the system.	3,79	1,051	3,83	0,937	3,50	2,121
Using the system is frustrating for me.	3,77	1,423	3,73	1,489	4,00	1,414
Once I start working on the system, I find it hard to stop.	4,14	0,864	4,17	0,835	4,00	1,414
I get bored quickly when using the system.	3,43	1,555	3,50	1,446	3,00	2,828

Table 13: Satisfaction questionnaire items in week 6 [Venkatesh, 2008]

5.4.1.3 UA - Perceived ease of use

RQ17: To which extent do the users believe that using the system will be free of physical and mental effort?

Overall, the Entrance system was neither difficult nor easy to use (see Table 14). For George the MP & WB were easier to use than the SG and the HP (see Table 15), whereas for Luise the HP was easier to use than the SG and the MP & WB.

Overall					
HP		SG		MP & WB	
Mean	SD	Mean	SD	Mean	SD
2,96	0,917	2,92	0,735	2,88	0,695

Table 14: Perceived ease of use overall factor comparison [Davis, 1989]

George						Luise					
HP		SG		MP & WB		HP		SG		MP & WB	
Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
3,17	1,052	2,88	0,800	2,59	0,312	2,64	0,581	3,00	0,659	3,27	0,838

Table 15: Perceived ease of use George and Luise factor comparison [Davis, 1989]

Table 16, Table 17 and Table 18 describe the rating of the different questionnaire items for all participants, George and Luise. In particular, George and Luise agree that using the MP & WB or the SG was a good method to learn what is new. For Luise using the HP tutorials was a very good method to learn what is new. Trying out the different system components was a good learning experience for both of them. Using the different system components made George think a lot. Luise perceived that it was rather easy to get the HP to do what she wanted it to do and that the interaction was clear and understandable.

	Overall					
	HP		SG		MP & WB	
	Mean	SD	Mean	SD	Mean	SD
Learning to operate the system was easy for me.	2,94	1,110	2,95	0,999	2,749	0,980
I found it easy to get the system to do what I wanted it to do.	3,11	1,278	3,00	0,858	3,137	0,991
My interaction with the system was clear and understandable.	3,00	1,188	2,90	1,252	2,944	1,209
I found the system flexible to interact with.	3,28	1,179	2,80	1,056	3,036	1,167
It was easy for me to become skillful at using the system.	3,00	1,317	2,94	1,056	2,942	1,221
I found the system easy to use.	3,17	1,249	2,95	1,024	3,044	1,268
I learned a lot while using the system.	3,33	1,085	3,15	0,875	2,781	1,081
Using the system made me think a lot.	2,65	0,996	3,29	1,263	3,472	1,181
I consider using the system as a learning experience.	2,35	1,057	2,47	0,964	2,444	0,804
Using the system was a good method to learn what is new.	2,56	1,199	2,45	1,356	2,213	1,169

Table 16: Perceived ease of use questionnaire items [Davis, 1989]

	George					
	HP		SG		MP & WB	
	Mean	SD	Mean	SD	Mean	SD
Learning to operate the system was easy for me.	3,00	1,095	2,92	0,996	2,309	0,807
I found it easy to get the system to do what I wanted it to do.	3,36	1,362	2,92	0,900	2,709	0,884
My interaction with the system was clear and understandable.	3,27	1,272	2,69	1,251	2,355	0,746
I found the system flexible to interact with.	3,45	1,214	2,54	1,050	2,600	0,615
It was easy for me to become skilful at using the system.	3,09	1,375	2,75	,965	2,364	0,806
I found the system easy to use.	3,36	1,362	2,85	1,068	2,400	0,771
I learned a lot while using the system.	3,64	1,120	3,15	,987	2,764	0,676
Using the system made me think a lot.	2,40	0,699	3,33	1,073	3,745	0,919
I consider using the system as a learning experience.	2,60	1,265	2,42	1,084	2,482	0,784
Using the system was a good method to learn what is new.	3,09	1,221	2,50	1,567	2,082	0,952

Table 17: Perceived ease of use questionnaire items for George [Davis, 1989]

	Luise					
	HP		SG		MP & WB	
	Mean	SD	Mean	SD	Mean	SD
Learning to operate the system was easy for me.	2,86	1,215	3,00	1,069	3,313	0,708
I found it easy to get the system to do what I wanted it to do.	2,71	1,113	3,13	0,835	3,688	0,836
My interaction with the system was clear and understandable.	2,57	0,976	3,29	1,254	3,714	1,065
I found the system flexible to interact with.	3,00	1,155	3,29	0,951	3,604	1,327
It was easy for me to become skilful at using the system.	2,80	1,304	3,33	1,211	3,688	1,280
I found the system easy to use.	2,86	1,069	3,13	0,991	3,875	1,213
I learned a lot while using the system.	2,86	0,900	3,14	0,690	2,813	1,453
Using the system made me think a lot.	3,00	1,291	3,20	1,789	3,125	1,431
I consider using the system as a learning experience.	2,00	0,577	2,57	0,787	2,393	0,889
Using the system was a good method to learn what is new.	1,71	0,488	2,38	1,061	2,375	1,475

Table 18: Perceived ease of use questionnaire items for Luise [Davis, 1989]

5.4.1.4 UA - Perceived usefulness

RQ18: To which extent do users believe that the system would facilitate achieving their goals?

At the beginning of the workshop series George and Luise thought that using the Entrance system could be useful for them (see Table 19 and Table 20). After getting to know each of the components, the perceived usefulness decreased and is rated now as neutral (see Table 19 and Table 21).

	Overall		George		Luise	
	Mean	SD	Mean	SD	Mean	SD
Week 1	1,86	0,713	1,92	0,721	1,75	0,729
Week 6	3,38	0,940	3,42	0,944	3,13	1,237

Table 19: Factor comparison week 1 and 6 [Davis, 1989]

	Overall		George		Luise	
	Mean	SD	Mean	SD	Mean	SD
I think the system would be useful for me.	1,88	0,680	2,00	0,655	1,67	0,707
Using the system would make it easier to navigate indoor and outdoor.	1,78	0,736	1,79	0,699	1,78	0,833
Using the system for navigation would enable me to navigate indoor and outdoor more quickly.	1,82	0,795	1,77	0,832	1,89	0,782
Using the system would improve my performance in navigation.	1,78	0,951	1,86	0,949	1,67	1,000

Table 20: Questionnaire items week 1 [Davis, 1989]

	Overall		George		Luise	
	Mean	SD	Mean	SD	Mean	SD
I think the system would be useful for me.	3,43	1,016	3,42	1,084	3,50	0,707
Using the system would make it easier to navigate indoor and outdoor.	3,15	0,987	3,18	0,982	3,00	1,414
Using the system for navigation would enable me to navigate indoor and outdoor more quickly.	3,31	1,182	3,36	1,206	3,00	1,414
Using the system would improve my performance in navigation.	3,42	0,996	3,50	0,972	3,00	1,414

Table 21: Questionnaire items week 6 [Davis, 1989]

5.4.1.5 U - Learnability

RQ19: How does the system enable the users to learn how to use it?

Although, George had problems with handling the tablet and doing the exercises in week 1, he was very interested and motivated. He found it useful to learn by doing. Sometimes the available materials were too complex and too long to read (i.e., he would prefer flash massages and button to go back to zero if he gets lost). Tutorials are useful and helpful but one still has to try it by oneself. George did not see the difference between Entrance and a navigation system, which he is used to. He admits that he is thinking too complicated, but the system is logical to use. Losing the shyness and learning about RPD function are some examples of what he has learned. He had little trouble with touch interaction and felt sometimes surprised because it was not what he was expecting. Generally speaking, he felt confident in using the tablet.

Luise had problems when installing Skype, not seeing things on the tablet (due to bad eyesight), unlocking the tablet, finding anything, not understanding the words and general problems with the surface (using a pen). She tried to get around the difficulties and use the system, although she would prefer a human being instead of a computer as well as picking up a book and searching for a while. She would like to have some basic notions as well as a simpler system, and the system should reassure her. A desired feature is an assistant. Tutorials were important for her and helped her a lot in handling the tablet and get to know the different functions. She had a lot of positive experiences, got more confidence, was amused and interested, and learned about applications in general. There are still many things to explore according to her but now she knows how to use a tablet and it felt good to do some exercises. In France Luise was less satisfied.

Overall, the Entrance system does neither/nor support a good learnability (see Table 22 and Table 24). George would rather not need help or learn a lot before using the MP & WB or the SG (see Table 23 and Table 25). On the contrary, Luise would rather need help and learn a lot before using the SG or the MP & WB (see Table 23 and Table 26).

Overall					
HP		SG		MP & WB	
Mean	SD	Mean	SD	Mean	SD
3,29	1,160	3,03	1,368	3,27	1,183

Table 22: Overall factor comparison [Brooke, 1996]

George						Luise					
HP		SG		MP & WB		HP		SG		MP & WB	
Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
3,25	1,032	3,50	1,251	3,81	1,030	3,36	1,393	2,31	1,250	2,54	0,977

Table 23: George and Luise Factor comparison [Brooke, 1996]

	Overall					
	HP		SG		MP & WB	
	Mean	SD	Mean	SD	Mean	SD
I think that I would need the support of a technical person to be able to use this system.	3,42	1,261	3,00	1,414	3,07	1,245
I needed to learn a lot of things before I could get going with this system.	3,16	1,068	3,05	1,356	3,46	1,105

Table 24: Questionnaire items for the different system components [Brooke, 1996]

	George					
	HP		SG		MP & WB	
	Mean	SD	Mean	SD	Mean	SD
I think that I would need the support of a technical person to be able to use this system.	3,42	1,165	3,50	1,382	3,56	1,094
I needed to learn a lot of things before I could get going with this system.	3,08	0,900	3,50	0,905	4,06	0,929

Table 25: Questionnaire items for the different system components [Brooke, 1996]

	Luise					
	HP		SG		MP & WB	
	Mean	SD	Mean	SD	Mean	SD
I think that I would need the support of a technical person to be able to use this system.	3,43	1,512	2,25	1,165	2,42	1,165
I needed to learn a lot of things before I could get going with this system.	3,29	1,380	2,38	1,408	2,67	0,778

Table 26: Questionnaire items for the different system components [Brooke, 1996]

Home Platform Tutorials

George had different opinions about the tutorials on the HP. On the one hand, the tutorials provided good instruction before using an application and they could answer lots of questions. On the other hand, they were too complicated, so it was better to just try out the application. The tutorials were perceived to be most of the time useless and not user friendly. He thought a home button was missing in the tutorials.

For Luise the tutorials are very good in general but they might confuse beginners. It is good for beginners to support them in using new devices, but Luise would prefer to try out things instead of reading the tutorials. The font was too tiny, so she did not want to read the tutorials.

Serious Game Tutorials

As George is more the learning by doing type, he found the tutorials are good so that users can re-read, if there are any problems during the game. However, the tutorials were perceived to be useless, not interesting, not clear and not simple enough, as they were written in a too technical way and the translation was bad.

Luise perceived that the tutorials had too much information in it. She could not remember all the instructions and sentences, as they were written in a too complicated way and, therefore, she needed to re-read them. She also got lost between the tutorial and the practical part afterwards.

Mobile Platform Tutorials

George agreed that the available materials were sufficient for learning to successfully use the mobile platform. Nonetheless, the tutorials were too long and needed to be shorter.

For Luise, the available materials were helpful and there were no problems with them. It was a little bit complicated, as the things on the MP were not self-explanatory. Luise found the internal “home” button confusing, because the same symbol exists within the mobile phone. For Luise the lack of knowledge made it hard to understand the system, and so the whole thing was a bit confusing. The positive outcome was that Luise is not afraid anymore in trying out new things.

5.4.1.6 Summary

Overall, the attitude towards using the Entrance system is rather not positive. In week 1 George and Luise thought that using the Entrance system could be useful for them. However, in week 6 the perceived usefulness decreased and was rated as neutral. George and Luise are rather not motivated to use the Entrance system (e.g., the interaction with the system was rather frustrating or once they started working with it, it was not hard for them to stop), but they agreed that using the MP & WB or the SG was a good method to learn new things.

For George the usage of the HP was unnecessary complex and inconsistent, whereas the SG was rather easy to use for him and the functions were rather well integrated. For George the tutorials on the HP were too complicated, so it was better to just try out the application. The tutorials were too long and not user-friendly. However, George found that the tutorials in the game were good as the users can re-read them if there are any problems during the game. The MP & WB were also rather easy to use (i.e., not very cumbersome for him) and he also felt rather competent when using it. Therefore, he also didn't need to learn a lot of things in order to use it. However, using the different system components made George think a lot.

For Luise the HP was rather easy to use but also unnecessary complex (in terms of the length of tutorials). She would rather like to use the HP frequently as she found the function rather well integrated. The HP tutorials were a very good method to learn what is new in general but they might confuse beginners. She would like to try out things instead of reading so much. However, she would rather need support and learn a lot of things before she could use the SG or the MP & WB. Therefore, she rather would not like to use the SG or the MP & WB. She thought there was also too much inconsistency when using the MP & WB and the system was unnecessary complex. Luise perceived that the tutorials in the SG had too much information in it. She could not remember all the instructions and sentences, as they were written in a too complicated (technical) way so she had to re-read them and got lost between the tutorial and the practical parts. Regarding the MP, for Luise the available materials were helpful and there were no problems with them. It was a little bit complicated to use, as the functionalities on the MP were not self-explanatory. For Luise the lack of knowledge made it hard to understand the system, and so the whole thing was a bit confusing.

5.4.2 Epistemic value

The epistemic value is about experiencing new technologies and refers, for example, to the UX factor learning (something new) and the UX factor curiosity / interest /preferences about the system.

5.4.2.1 UX - Learning

RQ20: To what extent does the system support learning (1) to navigate, (2) to manage the system?

Home Platform

As the system did also not work properly, it was hard for him to answer this question. George learned how to handle a tablet and that is a feeling of success. However, he had the feeling that he did not learn anything new and he had to do simple things in a more complicated way. George was not sure, if the tutorials are useful, as he would rather prefer learning by doing. For him the device is really funny, if he sees it from a playful side. For him it was something new to try out and as he has a tablet at home he would not try out more things. Especially, George in France seemed to be very unhappy with the system and totally disagreed on the fact that the home platform supports learning.

Luise thinks the usage is faster with the help of a tutorial. According to her the home platform is very helpful for people with no experience, but not for advanced computer users since they already know how to handle it. Luise learned how to handle a tablet and some of the many possibilities it offers. In general, she would prefer to look things up instead of using the tutorials. Also the font was too small so she could hardly read the tutorials.

Serious Game

George had different opinions whether the SG helped learning to navigate or not. Those in favour of the game mentioned that the blue spot was helpful concerning the navigation in order to see how the user moves in the game, also that in general it might be helpful in every-day life to find something specific and it can be good to change habits. Others claimed that it was too complicated and not convincing (they felt the game was not finalized and, therefore, a waste of time). He learned that there are more possibilities than information tables in a shopping mall and that the navigation help is learnable. George in France had the feeling that he learned nothing, as the system is too complicated for him.

Luise agreed the SG supports learning to navigate (e.g., how to orientate oneself in a shopping mall and search for shops). However, she would prefer one device to work and play with because two devices were confusing, overwhelming and stressing for her. In Luise's opinion, the game should also be finalized and the in game tutorials improved as they were more of an obstacle and slowing down the game play. In her opinion some information was missing, such as the distance remaining to the shop – it's only shown in the MP. Playing on a tablet was perceived as enjoyable and fun. Also Luise in France had the feeling that she didn't learn anything.

Mobile Platform & Wristband

In general, the MP is a good idea and George learned how to use it as well as to navigate. He thought that the tutorial was helpful but not needed, as the MP was self-explanatory. He fears that the MP might be a regress, because people can lose the ability to navigate on their own. Insecurity increased when George was unsure if he arrived at the destination. The parking function was considered great as well as the little pictures of the points of interest. George suggested that it would be a good idea to insert bus or metro stations. The MP might also be interesting in a hospital or when he would be late and in a hurry. George thinks the system provides pleasure trips but it is not essential. George advised keeping the overall system simple, as a smartphone is enough. However, he liked the wristband and found it was a really welcoming add-on. He thinks that having one's eyes glued to a screen can be dangerous and also strangers could steal the smartphone. The watch is more discrete and can be hidden under the clothes. George also suggested using two wristbands that vibrate on the side you have to turn. This kind of system would be good for people with poor sight. A strong haptic feedback on the smartphone/tablet is necessary so you cannot miss the keyboard.

Luise found the MP good, but would prefer to ask people about the way to a destination. It seems faster for her and she likes the social contact. The system confused her a little bit and raised more doubts and questions than before. In general, Luise was really fascinated, but would like to have some more time to train and test the system in real conditions. Learning how to navigate and how to use the QR code is the main new thing she learnt.

5.4.2.2 UX - Curiosity / Interest / Preferences

RQ21: In what way does the usage of the system provoke the user's curiosity about and interest in the system and its content?

George is very curious and interested in the software as well as in the idea of connecting it with many devices. His first impression of Entrance was that it is a slightly improvement of a regular GPS with the ability to go into buildings. It could be used like a navigation system in the car or even for bicyclists. It is necessary that the system takes into account all different human senses so it is accessible to all, even for deaf people, people with sight or hearing problems. He believed that the idea behind the system is to reassure people and help them to be more autonomous, but technology should not inhibit ability or create dependence. Although he fears surveillance and that indoor navigation is not mature, it might be a very helpful and time saving assistant for people from abroad to find their way in a foreign hospital, libraries or airports. Generally, he was in favour of the wristband. In France George had a more negative attitude concerning the tutorials and the system. The tutorials had too much text and lacked clarity. He would not want to use the system, as one get discouraged by such a system, it can be off-putting and stressful.

Despite some doubts concerning her eyes, getting lost with a GPS or people getting frustrated with a computer and the costs of this application, Luise was very interested, curious and really wanted to know how to use a tablet as well as what was the difference with a computer. Luise was not sure if the workshops would fulfil her expectations, but she was looking forward to the experience. She never really used a GPS before or only in a car.

Overall, George and Luise were curious in the beginning (week 1) about modern technologies (see Table 27 and Table 28). After having used the Entrance system, George and Luise are neither curious about using the platform (see Table 27 and Table 29). George believes that using the Entrance system for navigation would enable him to navigate more quickly and rather make navigation easier (see Table 29). Luise believes that the Entrance system would improve her performance in navigation but would not make the navigation easier for her (see Table 29).

	Overall		George		Luise	
	Mean	SD	Mean	SD	Mean	SD
Week 1	1,46	0,419	1,49	0,369	1,40	0,510
Week 6	2,91	0,931	2,88	0,779	3,10	2,121

Table 27: Factor comparison week 1 and 6 [Koo et al., 2007]

	Overall		George		Luise	
	Mean	SD	Mean	SD	Mean	SD
I learn a lot by using modern technologies.	1,50	0,511	1,67	0,488	1,22	0,441
Using modern technologies makes me think a lot.	1,50	0,511	1,53	0,516	1,44	0,527
Using modern technologies stimulates my curiosity.	1,42	0,584	1,40	0,632	1,44	0,527
I consider that using modern technologies is a learning experience.	1,38	0,576	1,33	0,488	1,44	0,726
Using modern technologies is a good method to learn what is new.	1,50	0,590	1,53	0,516	1,44	0,726

Table 28: Questionnaire items week 1 [Koo et al., 2007]

	Overall		George		Luise	
	Mean	SD	Mean	SD	Mean	SD
I think the system would be useful for me.	3,36	1,008	3,33	0,888	3,50	2,121
Using the system would make it easier to navigate indoor and outdoor.	2,86	1,027	2,67	0,888	4,00	1,414
Using the system for navigation would enable me to navigate indoor and outdoor more quickly.	2,64	1,082	2,58	0,793	3,00	2,828
Using the system would improve my performance in navigation.	2,71	0,994	2,83	0,937	2,00	1,414
I think the system would be useful for me.	3,00	1,359	3,00	1,206	3,00	2,828

Table 29: Questionnaire items week 6 [Koo et al., 2007]

5.4.2.3 Summary

George and Luise were curious in week 1 about modern technologies, but after week 6 George and Luise are neither interested nor uninterested in using the platform.

As George is more used to a computer, he would prefer a computer instead of a tablet. He was trained on how to handle a tablet and that was a feeling of success, but he did not learn anything new. George in France seemed to be very unhappy with the HP. George had different opinions whether the SG helped learning to navigate (helpful to learn navigating with the blue dot vs. too complicated and not convincing), but George in France had the feeling that they learnt nothing new. Regarding the MP George learnt how to use it as well as to navigate.

Luise learnt how to handle a tablet and some of the many possibilities it offers. Luise agreed the SG supports learning to navigate, but would prefer using only one device and the in-game tutorials need to be improved. Luise in France had the feeling that they learnt nothing new. Regarding the MP Luise learnt how to navigate and how to use the QR code. She found the MP good and was fascinated, but would prefer to ask people about the way to a destination.

5.4.3 Emotional value

The emotional value is the potential of the system to arouse emotions, which are believed to accompany the use, and refers, for example, to the UX factor fun / enjoyment and the UX factor motivation.

5.4.3.1 UX – Fun / Enjoyment

RQ22: To what extent does the system provoke fun/enjoyment?

Overall, George and Luise in the beginning (week 1) thought that they would enjoy using the system (see Table 30 and Table 31). After having used the Entrance system, George and Luise are not sure whether they would enjoy using the system (see Table 30 and Table 32).

	Overall		George		Luise	
	Mean	SD	Mean	SD	Mean	SD
Week 1	1,97	0,550	2,04	0,520	1,87	0,610
Week 6	2,96	0,888	3,00	0,812	2,69	1,679

Table 30: Factor comparison week 1 and 6 [Deci and Ryan n.y.]

George and Luise believed in week 1 that they would enjoy using the system, it would not be boring or frustrating, it would be interesting and fun to use (see Table 31). After week 6 George was neither nor sure about the same statements whereas Luise was slightly more positive (see Table 32).

	Overall		George		Luise	
	Mean	SD	Mean	SD	Mean	SD
I would enjoy using the system very much.	1,83	0,717	1,93	0,730	1,67	0,707
Interacting with the system would be fun to do.	1,70	0,635	1,71	0,611	1,67	0,707
I think using the system would be boring.	4,30	0,703	4,07	0,730	4,67	0,500
I would describe using the system as very interesting.	1,96	0,767	2,00	0,784	1,89	0,782
Using this system would be a very frustrating experience.	4,23	1,020	4,21	0,975	4,25	1,165
I worry that many of the things I would do with this system may be wrong.	4,00	0,798	4,00	0,784	4,00	0,866
This system can do all the things I think I would need.	2,70	0,974	2,71	1,069	2,67	0,866
This system seems like it would be very pleasant to use.	2,09	0,750	2,21	0,802	1,88	0,641

Table 31: Questionnaire items week 1 [Deci and Ryan n.y.]

	Overall		George		Luise	
	Mean	SD	Mean	SD	Mean	SD
I would enjoy using the system very much.	3,07	1,072	3,17	0,937	2,50	2,121
Interacting with the system would be fun to do.	3,00	1,038	3,08	0,900	2,50	2,121
I think using the system would be boring.	3,38	1,261	3,36	1,206	3,50	2,121
I would describe using the system as very interesting.	3,21	0,802	3,25	0,754	3,00	1,414
Using this system would be a very frustrating experience.	3,71	1,267	3,67	1,303	4,00	1,414
I worry that many of the things I would do with this system may be wrong.	3,58	1,379	3,40	1,430	4,50	0,707
This system can do all the things I think I would need.	3,62	1,193	3,55	1,214	4,00	1,414
This system seems like it would be very pleasant to use.	3,38	1,193	3,36	1,120	3,50	2,121

Table 32: Questionnaire items week 6 [Deci and Ryan n.y.]

5.4.3.2 UX - Motivation

RQ23: How competent do the end users feel in using the Entrance system?

George estimated that he rather would have the competence to interact with the Entrance system in week 1, but after having used it he was not sure anymore. Luise was unsure from the beginning on whether she had the competence to interact with the system and remained unsure even after using the system (see Table 33, Table 34 and Table 35). George felt he was competent handling the tablet, he lost his shyness. In earlier times he thought he would break things if he wasn't careful enough. Luise knew how to use a tablet after week 1, but there were still many things to explore for her. However, with the exercises it felt good to try the tablet.

	Overall		George		Luise	
	Mean	SD	Mean	SD	Mean	SD
Week 1	2,41	0,525	2,23	0,544	2,71	0,333
Week 6	3,10	0,685	3,12	0,736	2,98	0,318

Table 33: Factor comparison week 1 and 6 [Deci and Ryan n.y.]

	Overall		George		Luise	
	Mean	SD	Mean	SD	Mean	SD
I think I would be pretty good in using the system.	1,88	0,680	2,00	0,655	1,67	0,707
After working with the system for a while, I would feel pretty competent.	1,78	0,736	1,79	0,699	1,78	0,833
I would be satisfied with my performance while using the system.	1,82	0,795	1,77	0,832	1,89	0,782
I would be pretty skilled in using the system.	1,78	0,951	1,86	0,949	1,67	1,000
I won't be able to use the system very well.	1,88	0,680	2,00	0,655	1,67	0,707

Table 34: Questionnaire items week 1 [Deci and Ryan n.y.]

	Overall		George		Luise	
	Mean	SD	Mean	SD	Mean	SD
I think I am pretty good in using the system.	3,43	1,016	3,42	1,084	3,50	0,707
After working with the system for a while, I feel pretty competent.	3,15	0,987	3,18	0,982	3,00	1,414
I am satisfied with my performance while using the system.	3,31	1,182	3,36	1,206	3,00	1,414
I am pretty skilled in using the system.	3,42	0,996	3,50	0,972	3,00	1,414
I cannot use the system very well.	3,43	1,016	3,42	1,084	3,50	0,707

Table 35: Questionnaire items week 6 [Deci and Ryan n.y.]

Overall, the George and Luise participants were not sure if they had the competence to handle the Entrance system (see Table 36 and Table 38). After using the different system components, George had the feeling that he might be able to handle the MP & WB but was unsure about the SG as well as the HP (see Table 37 and Table 39). Whereas Luise was always unsure whether she had the competence to interact with the different system components (see Table 37 and Table 40).

Overall					
HP		SG		MP & WB	
Mean	SD	Mean	SD	Mean	SD
3,14	0,878	3,09	0,962	2,91	0,906

Table 36: Overall factor comparison [Deci and Ryan n.y.]

George						Luise					
HP		SG		MP & WB		HP		SG		MP & WB	
Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
3,20	0,912	2,88	0,912	2,52	0,842	3,06	0,885	3,43	1,002	3,43	0,770

Table 37: George and Luise Factor comparison [Deci and Ryan n.y.]

Table 38, Table 39 and Table 40 describe the rating of the different questionnaire items for all participants, George and Luise.

	Overall					
	HP		SG		MP & WB	
	Mean	SD	Mean	SD	Mean	SD
I think I am pretty good in using the system.	3,18	0,883	3,10	1,021	3,19	1,144
After working with the system for a while, I feel pretty competent.	3,06	0,748	3,00	1,000	2,70	0,920
I am satisfied with my performance while using the system.	3,00	1,000	3,20	1,056	2,86	1,087
I am pretty skilled in using the system.	3,12	1,111	3,20	1,005	3,14	1,086
I cannot use the system very well.	3,06	1,110	3,17	1,339	3,26	1,515

Table 38: Questionnaire items for the different system components [Deci and Ryan n.y.]

	George					
	HP		SG		MP & WB	
	Mean	SD	Mean	SD	Mean	SD
I think I am pretty good in using the system.	3,10	0,994	2,92	0,996	2,600	0,907
After working with the system for a while, I feel pretty competent.	3,00	0,667	2,77	0,927	2,282	0,823
I am satisfied with my performance while using the system.	2,90	0,738	3,00	1,044	2,500	0,878
I am pretty skilled in using the system.	2,80	0,789	2,75	0,866	2,664	0,952
I cannot use the system very well.	2,55	1,036	3,36	1,206	3,350	1,734

Table 39: Questionnaire items for the different system components [Deci and Ryan n.y.]

	Luise					
	HP		SG		MP & WB	
	Mean	SD	Mean	SD	Mean	SD
I think I am pretty good in using the system.	3,29	0,756	3,38	1,061	3,938	0,995
After working with the system for a while, I feel pretty competent.	3,14	0,900	3,38	1,061	3,250	0,786
I am satisfied with my performance while using the system.	3,14	1,345	3,50	1,069	3,313	1,223
I am pretty skilled in using the system.	3,57	1,397	3,88	0,835	3,750	0,955
I cannot use the system very well.	3,86	0,690	2,86	1,574	3,125	1,388

Table 40: Questionnaire items for the different system components [Deci and Ryan n.y.]

George felt absolutely confident in using the tablet. He thought there was too much information on the tablet. According to him, there should only be the necessary icons when you turn on the screen and a quick tutorial. It should be intuitive as well. He also had some problems with touch interfaces. He didn't feel overwhelmed but surprised because he wasn't expecting that. Luise felt a little less confident. She was sceptical concerning the usage of the tablet with her bad eyesight. Furthermore, she also expected something much simpler and didn't want to spend all afternoon on it. She preferred using her computer instead of the tablet.

An interesting fact is that George felt less confident using the HP than Luise did. He only felt rather confident when using the SG and competent when using the MP & WB. Whereas Luise did rather not feel competent or confident when using the MP & WB (see Figure 44).

Figure 44: Subjective competence and confidence rating for the different system components

George was slightly frustrated but felt confident, because he learnt something new with the HP. In his opinion the design of the HP was too complicated and made for computer-literate people. His suggestion was to design simple interaction elements that brought you straight to the interface you wished. The tutorials should be improved or there shouldn't be any tutorials. Another suggestion was to design the logos to be more cheerful (not blue) rather than using a cold colour, to make it less Microsoft-oriented and to use other search engines. Luise was slightly frustrated after using the HP, as there were more difficulties than she thought. She

gained some confidence, although she thought it was not that accessible. Sometimes she felt a bit overwhelmed.

On the one hand George still feels confident or more confident than before using the SG. Some more time to train would be good. On the other hand George was very unhappy with the design of the game. He got irritated by the fact that he could not cope with the SG. He advised to make it far simpler. Nevertheless, he did not feel overwhelmed. George in France was unhappy with the whole system, whereas George in Austria was confident. Sometimes the connection on Luise's device was really bad so she had no joy in testing it and got frustrated. This was also due to not having the feeling of success. When the connection was good she gained some confidence.

For George spending two hours with the MP was too long. George in AUSTRIA felt rather confident, but George in ALAB didn't feel confident at all. He felt slightly overwhelmed and needed some more time to practice, which he did not have. George complained about the complexity of the tutorials as well as the system, he would prefer a quick start guide, a simplified system, and the reading material shortened. It should be instantly understandable, without the need to go through a long and complex learning process which is more of a deterrent. In his opinion it was easier to find his way without that system. George claimed that the MP did not work well and he neither learned anything nor made any progressions.

Luise was not very happy about the fact that the MP did not work properly. She would feel more confident with a more functional MP and she could have probably done it without support. Nevertheless, she thought it was fun to try it out. She realized that she could not damage anything. Therefore, she is more secure now in using devices like this. In general she felt more confident.

5.4.3.3 Summary

George estimated that he rather would have the competence to interact with the Entrance system and that it would be fun in week 1, but was no longer sure after week 6. Specifically, George had the feeling that he might be able to handle the MP & WB as well as the HP but was unsure about the SG. Luise thought that using the system would be fun, but was unsure from the beginning whether she would be competent to use the different system components and remained unsure even after using the system.

5.5 Conclusion

Before using the system George and Luise were curious and believed the system was useful and fun for them, but after using it they were less curious and it was more or less useful for them. George believed that the idea behind the system was to reassure people and help them to be more autonomous, but technology should not inhibit ability or create dependence. After getting to know each of the components, the perceived usefulness decreased and was rated as neutral. Both are also rather not motivated to use the Entrance system (e.g., the interaction with the system was rather frustrating or once they started working with it, it was not hard for them to stop). In comparison to the lab studies George and Luise still disliked most of the system functions and the attitude towards using the Entrance system was rather not positive. However, George is slightly more motivated to use the platform than Luise. In the following, summaries are provided for the different system components.

Home Platform

Luise would rather like to use the HP frequently, whereas George would rather not like to use it. For George and Luise the usage of the HP was unnecessary complex and inconsistent. However, Luise found the HP in general rather easy to use, although she had more difficulties than she thought in the beginning. Luise perceived that it was rather easy to get the HP to do what she wanted it to do with the help of the tutorials and felt, therefore,

confident in handling it. For both, the provided tutorials were useful and helpful (i.e., answer lots of questions), but one still had to try it by oneself and one would not read such lengthy tutorials. On the one hand, Luise can imagine that people with no previous experience would learn to use the HP quickly with the tutorials, as she found the function rather well integrated. She had a lot of positive experiences, got more confidence, was amused and interested, and learned about applications in general. On the other hand, George had the feeling that he spent a lot of energy on learning how to use it with the tutorials, in the end for nothing. Sometimes the available tutorials were too complex and too lengthy to read (i.e., he would prefer flash massages and a button to start over again, if one gets lost). That was the reason why he was quite disappointed and dissatisfied. George did not feel overwhelmed or incompetent, but he was unsure about handing it and, therefore, did not feel confident. In his opinion, he could solve the task faster with another already existing system (e.g., a computer), which he would prefer to use.

Serious Game

George and Luise believe that the game can be a good opportunity to learn how to navigate and to learn what is new (although they learnt nothing new). For Luise it was hard to understand the purpose of the game and for George the motivation to use the SG to receive information he could get otherwise was not satisfying. He thought the action and the "adventure" was lacking in the game. As George is more the learning by doing type, he found the tutorials were good so that users can re-read them if there are any problems during the game. However, for both of them, the content was perceived to be not very important, interesting, clear nor simple, as they were written in a too technical way and there were issues with the translation. For George the SG was rather easy to use and he felt confident as the functions were rather well integrated. However, he felt that he did not make any progress and Luise would rather need support and learn a lot of things before she could use the SG (e.g., it was hard for her to memorize what she can do). She felt a little overwhelmed when working with two devices. Although, she liked experimenting with the game, she rather would not like to use the SG, as also got lost between the tutorial and the practical part afterwards.

Mobile Platform & Wristband

In general, the MP is a good idea and the WB a nice add-on (e.g., in an unknown city), but George fears that the MP might cause a regress, because people could lose the ability to navigate on their own. George thinks the system provides pleasure trips but it is not essential. He did not feel overwhelmed at all and was very satisfied. For George the MP & WB was also rather easy to use and not very cumbersome and he also felt rather confident when using it. Therefore, he didn’t need to learn a lot of things in order to use it, but as the GPS was not reliable enough he needed assistance all the time. For George and Luise the available materials were sufficient for learning to successfully use the MP, though they were too long and a quick start guide would be preferred. Luise found the MP good and was fascinated, but would prefer to ask people about the way to a destination. It was fun for her to try out the system, but she was not satisfied, as the system did not work properly. But she would rather need support and learn a lot of things before she could use the MP & WB, as the system was unnecessary complex, not self-explanatory and not reliable. As she was not sure whether she was competent and did not feel confident, she rather would not like to use it.

6 OVERALL CONCLUSION

The project consortium faced several severe problems during the development and, therefore, no real mature prototypes could be developed. As described before in the field user studies sections several issues were faced while conducting the studies, which definitely influenced the final outcomes of the user evaluation. Overall, the different Entrance system components hold potential to be useful for older adults, but substantial improvement are needed before they can be brought to the market. Potentials include, for example:

- that both George and Luise found the tutorials in general useful and helpful to support learning. These could be improved by being shorter and perhaps embedded in an interactive way into the corresponding applications.
- that the game can facilitate learning, if people are willing to engage with the game. The game could be improved both at the tutorial level and at the gaming level with a more engaging and playful content.
- that for George the MP was self-explanatory and useful in foreign cities or for large buildings (like hospitals). The indoor localization potential feature and the parking functionality were found particularly interesting and beneficial.
- that Luise in general was fascinated using new technologies like the MP or a tablet, and would potentially use them so as long as they are easy to use
- and that the WB is a nice add-on for the MP.

Dealing with the gap between Luise and George skills was quite challenging in order to provide a system that would accommodate both without being over complicated for one or over simplified for the other. The Entrance project enabled to gain more knowledge on how to design such solutions to reach the widest audience possible. The conclusion is that existing systems should be kept as some users are already familiar with them and thus additional layers such as tutorials should be integrated to facilitate their use, preferably embedded within the applications. Therefore, learning would be at disposal without hindering the actual use of the application. Concerning the mobile application, the additional functionalities missing in today's navigation applications, i.e., indoor localization and finding one's car, and to a lesser extent points of interest, were particularly interesting. The navigation application should, therefore, include these functionalities while providing the same level of services as the ones present on the market, and with the same reliability.

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