Mobiles for mobility: Participatory design of a 'Happy walker' that stimulates mobility among older people

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F. Verhoeven, A. Cremers, M. Schoone, J. van Dijk. Mobiles for mobility: Participatory design of a 'Happy walker' that stimulates mobility among older people. Gerontechnology 2016;15(1):32-44; doi:10.4017/gt.2016.15.1.008.00 **Purpose** Existing solutions facilitating mobility among older adults mainly focus on supporting physical disabilities. However, solutions are more likely to succeed when current activities and capabilities serve as a starting point. Participatory design is a suitable approach to detect these. We investigated (i) how participatory design techniques can be applied to obtain insight into the daily activities and capabilities of older adults, and (ii) what the design implications are of taking these activities and capabilities as a basis for the development of a mobility-enhancing application. **Method** Research context was a three-year European project comprising health care managers, researchers, and designers from Belgium, the Netherlands, Italy, Spain, and Germany. Older adults were involved in each of the four-step iterative design process (participatory design sessions, scenarios, user requirements, and user evaluation). **Results & Discussion** (i) Reflection on the design process showed that particular issues should be considered in selecting participatory design tools (e.g., diaries and photo assignments are more suited than interviews) and organizing joint sessions (e.g., reserve more time for informal activities, address privacy concerns, and provide opportunity to ventilate doubts towards technology). The participatory design methods appeared suited to provide input for the application's functionalities based on activities and capabilities. (ii) A mobility-enhancing mobile application for older adults should apply (a) Demographics: validated user profiles as a basis, but enable personalization; (b) Cognitive and physical abilities: Facilitate activities close to the home of the older adults; (c) Safety perception: Support older adults cognitively during their activities outdoor, but also prior to and afterwards and foster social contact. **Future work** The results of the current study have been used as input for prototype development, which has been tested in a pilot study in Spain and The Netherlands.

Key words: Older adults, participatory design, mobility, mobile technology, capability

The mobility of older adults is seen as a fundamental prerequisite for independent living and societal participation. We define mobility as going outdoors and travel to reach people and places, such as going for walks, visiting friends, shopping and attending cultural events. Being mobile leads to psychological benefits of going out, in particular reduction of feelings of loneliness and risk of depression[1], exercise benefits to avoid muscle and bone deterioration[2], inclusion in the local community to strengthen the social network and increase overall well-being[3], and the empowering experience of knowing that one can (still) make a trip if one wanted to. These benefits promise to result in a better quality of life[1,4], a better physical and psychological condition and societal cost reduction of long term care[5].

However, as people grow older their mobility decreases, due to changes in (i) demographic variables (e.g., changing traveling needs); (ii) physical and cognitive abilities (e.g., not being able to walk long distances, loss of memory or sense of orientation); and (iii) safety perception (feeling vulnerable and becoming more anxious to be on the street)[6,7]. Existing aids such as the Dial-a-Ride service[8] and products like (smart) walkers[9], fall alarms[10], hip protectors[11], and electric mobility scooters[12] mainly focus on physical (walkers, mobility scooters) and incident support (fall alarms, alarm buttons). Although these products and services indeed support older adults to stay mobile, they do not sufficiently take into account demographic variables, cognitive abilities and safety perception. Moreover, current

solutions predominantly emphasize older adult's disabilities and fears, by compensating for limitations and solving problems caused by a users' disability. It may be argued that in some sense these products actually underscore or even actively sustain the disability rather than empowering the person in leading an independent life.

Mobile technology

Mobile applications for smart phones and tablets have a high potential to support older adults in carrying out activities outside of the home without the drawbacks of existing solutions[13]. Mobile applications offer a wide variety of functionalities, which can be used anytime and anywhere (both inside and outside of the home). Also, the functionalities and interaction can be entirely tailored to the demographic variables, cognitive and physical abilities, and safety perception of the individual user, without them being stigmatized as having a disability. Mobile applications are already playing an increasingly important role in health and well-being[14]. However, popular existing health applications (such as Nike+ and RunKeeper) are not always suited for older users and their activities, in terms of both functionality and usability (for example meaningless icons, insufficient contrast, and small font sizes)[15]. Even mobile apps specifically designed for older adults, such as apps that stimulate healthy eating behavior, show similar problems[16].

In a society where empowerment and self-reliance become ever more important, it is crucial for mobile technology to stress and strengthen all capabilities that older adults still have, rather than emphasize the ones they no longer have. This is in line with the Capability Approach[17], which builds, first, on the claim that freedom to achieve well-being is of primary moral importance, and second, that this freedom is to be understood in terms of people's capabilities, that is, their real opportunities to act within given the context and resources available in practical situations, and to be what they have reason to value[18]. In order to develop mobile technology to enhance mobility among older adults, it is thus essential to start from their current capabilities. These include people's existing activities, routines and skills, what people like and appreciate doing, what they are proud of doing, and what they no longer do but would very much want to do again in order to bring back lost meaning to daily life[19]. Also, it is important to know how people already recruit available resources in their environment to deal with mobility problems in improvised, creative ways[20,21,22]. However, there is no easy answer on what to design, in terms of both functionality and the interface, once the starting point is what people are already capable of and what they currently already do.

Participatory design

In order to design truly useful mobile applications for older adults we suggest that intended users should be involved in the design process. In the tradition of participatory design creative techniques such as diary and photo assignments have been developed to obtain rich insight in the person's daily life activity. Design researchers and users collaborate in the design process, where users serve as experts of their own experience and design researchers as experts in translating user experiences to viable design opportunities[23,24]. Many participatory projects however focus quite straightforwardly on generating user requirements, for example to ensure basic usability given specific target groups. In our study we aimed to use these techniques to gain more deep insight into people's contextual, everyday experiences in order to design for capabilities, rather than disabilities. This raised several questions concerning the central focus of the participatory techniques we used and how certain techniques might be adapted to better cater our objective.

Method

Research questions

In what follows we introduce a participatory design case resulting in a mobile application (called 'Happy Walker') that stimulates an active lifestyle and thereby builds on people's capabilities in terms of demographics, cognitive and physical abilities, and safety perception. Our guiding focus pertained to what activities, in the context of outdoor activities, give meaning to people's everyday lives. We carried out this study as part of the European (Ambient Assisted Living[25]) 'Happy Walker'-project. The consortium consisted of ten partners (small and medium-sized enterprises, research institutions, and health care organizations) from five countries (Belgium, Germany, Italy, the Netherlands, Spain). The target group of our project was older adults over the age of 60, living independently at home, with possible mild physical and/or cognitive mobility limitations.

In the remainder of this paper we take lessons learned from our design case to discuss two main questions. First we ask how various participatory design techniques can best be applied to obtain sufficient insight into the daily activities and capabilities of older adults. Second, we explore what the design implications are of taking the older adults' activities and capabilities as a basis for the development of a mobility-enhancing application.

Design process

The participatory design process consisted of four phases: (i) Participatory design sessions, (ii) Scenarios, service selection and user requirements, (iii) Use case, user interface concepts and ser-

Table 1. Overview of the participatory process to design the 'Happy Walker' application

Objective & Result	Method	Participants
	PHASE (I): PARTICIPATORY DESIGN SESSIONS	
Rich descriptions of older adults' needs, wishes and capacities, their ideas for new mobility services and initial user requirements for the services including a technology assessment scan. Resulting in rich insight in activities, storyboards, personas, scenarios, initial requirements, and ideas for services.	*NETHERLANDS*: a. Session 1: Face-to-face introduction session with two groups (n=15; n=6) aimed at fostering participants' commitment and obtaining insight in their mobility; b. In-between activity: cultural probes (n=7). Cultural probes are a way of gathering information about people and their activities, based on self-report of users during a longer period. After session 1 participants received a cultural probe kit, consisting of activity cards, photo's, smileys etc. They were asked to fill in the booklet and make pictures to go with it. They had two weeks to do so; c. Session 2: One-to-one interviewing (n=7) with the group of the first two activities, aimed at gathering more in-depth information of activities. The participant chose one of the photos he/she made to determine the activity to discuss in five scenes: at home, on the way, at destination, way back, back home. This discussion led to creation of storyboards. Then, the actual participatory design started when the researcher and participant talked about a possible product that might support the older people outside the home; 4.Session 3: One-to-one interviewing (n=2) with people with mild dementia or mild cognitive impairment.	*NETHERLANDS*: Ages: 58-93; Living alone or in couple, most living independently in sheltered accommodation; Some had physical disabilities, others had mild memory loss.
	SPAIN: a. Session 1: Face-to-face introduction session (n=13) with similar aim as Dutch group; b. Online questionnaire about daily activity (n=13) during 15 days, aimed at getting an overall vision about their life style to try to detect their needs regarding mobility and to get a general idea to be refined during the second online questionnaire; c. Online questionnaire about daily activity (n=13), to obtain a more concise vision about their lifestyle and to understand specific aspects of their routines: movement, cognition, external support, and social.	*SPAIN*: Ages: 65+, but in the younger age groups; Living situation: alone/couple, living independently at home; None or mild physical disabilities and/or no or (very) mild memory loss or other cognitive problems (see further below).
	PHASE (II) SCENARIOS, SERVICE SELECTION AND USER REQUIREMENTS	
Scenarios representing the target group using the service at different points in life, leading to user requirements that specify what the user expect the application (software) to be able to do (e.g., "the application should help the user with navigation").	a. Scenario development: Workshop (March 5th, 2013). Based on personas, storyboards, initial services and requirements four scenarios were developed based on a template. Also, a feasibility assessment of the scenarios was made based on criteria (feasibility of the content/technology, organizational feasibility, economic feasibility and 'fit' with the project consortium); b. Service selection: Conference call (March 25, 2013). Project team synthesized core services of the application and discussed how to proceed from scenarios to user requirements via service selection; c. Use cases and user requirements: Workshop. After presentation of the four scenarios, services were selected, based on similar criteria as during scenario development.	Project team members: designers, software engineers, researchers, health care managers from Germany, Spain, Italy, Belgium, and the Netherlands. All meetings took place in the Netherlands. Project members from other countries participated through Skype.
	PHASE (III) USER INTERFACE CONCEPTS AND SERVICES SPECIFICATION	
Evaluated global user interface concepts, available on paper and non-interactive digital screens. Concepts include specifications for the three	a. Desk research and project meetings: Exploration of useful service concepts and discussion among project team about which services to deploy and technology to use;	User evaluation sample: Ages ranged from 49 to 93 yrs (mean: 68,5): four men and eight women. Minority had a mobile phone and/or a tablet.

Table 1. (Continued)

final services of the application.	b. Extensive use case based on an active user, able to use all functionalities, describing highly detailed the interaction between user and the application; c. First (non-working) user interface concept: paper-based sketches and thoughts of screens and contexts of use (made by project team), providing a first idea of how the different functions and services could be organized on the screen; d. Interactive interface mock-ups; interactive user interface mock-ups for three contexts of use (at home, in action and at rest during action), developed with InVision-software by project members; e. User evaluation (the Netherlands, n=12): Respondents were interviewed one-to-one or in groups to get a first idea about perception and appraisal of the user interface concept. They were shown screen shots of the prototype, made with InVision software, on paper or on a laptop and were asked whether they understood, liked, would use, or would change the functionalities. Limited interaction was possible with the mock-up.	
	PHASE (IV): USER EVALUATION	
Interactive, working prototype, evaluated with users regarding usability and functionality, in order to deliver a prototype that could be tested quantitatively.	Mock up testing through user evaluation (the Netherlands, n=9; Spain: n=4). Topics for evaluation were set among the project members during teleconferences. Respondents came together in joint sessions. Functionalities were explained based on the scenario in Figure 3. To test the user interface, the mock-up was demonstrated on a 4.8 inch-screen. It was imported so that the mock-up looked like a real application on the smart phone. Subsequently, participants ran through a series of assignments like: "Find your way to..", "Look up the address of..", etc. Wearability was improved in the Netherlands during a creative session with several sample materials (pouches, straps, belts, elastic bands, clamps, etc.) to try out different ways of wearing the device.	*NETHERLANDS*: Three female, six male. All between 60 and 70 years old (mean approx. 65). Four still working, but near retirement and other five retired less than 5 years ago. Six participants are/ were using computers intensively and are using modern media like (smart)phone, navigation, tablet, etc. *SPAIN:* Two males and two females (couples) between 60 and 80. All retired since at least 5 years.

vices specification, and (iv) Interactive prototype and user evaluation. *Table 1* provides a detailed overview of the four phases, in terms of objectives, participants, methods (both qualitative and quantitative) and results. To get rich insight in the activities of older adults in The Netherlands, we used qualitative methods that literally displayed the participants' daily life: cultural probes including photo assignments, followed by interviewing and storyboarding. In order to make existing methods better suited for older adults, we adjusted presentation (e.g., large font size) and content (e.g., limited number of assignments). Also, we reserved session time to explain things more often if necessary, and sent more reminders than we usually would have done. In Spain, we used an online questionnaire to get insight into daily activities of the participants. This questionnaire allowed us to obtain quantitative data collected over a longer period of time. Qualitative user evaluation sessions were held in both countries. All sessions were conducted by researchers from the Dutch and Spanish organizations involved in the project consortium.

Participants

In the first phase of the process, people were approached by the health care organizations involved in the project consortium (in The Netherlands and Spain) and participated voluntarily. We tried to select a wide range of older persons, in terms of age, living condition and abilities. Participants in The Netherlands were all living in a semi-independent sheltered accommodation, located on the grounds of the health care organization in a small town. Participants in Spain were all living independently in a large city. In comparison, Dutch participants were older and more fragile, some of them suffering from mild dementia, whereas the Spanish participants were younger and more active. In phases (iii) and (iv) of the process, the same participants were approached again and new participants

were recruited to enlarge the group if necessary. This reflects a basic principle in participatory design to work with a small committed group of users rather than strive for a representative sample.

Analysis

The qualitative material gathered in The Netherlands in the first and second phase was analysed using cluster analysis. This involved grouping data in such a way that objects in the same group are more similar to each other than to those in other groups. The results of the on-line questionnaire obtained in Spain were analysed quantitatively. User evaluation outcomes were described and ordered according to functionality and interaction categories. For each phase, a report was made, illustrated with examples from the collected materials. Reports served as input for the next phase (*Table 1*).

Results

First phase

Rich insight in activities

The introductory sessions in The Netherlands (session 1) and Spain (session 1) and the on-line questionnaires in Spain (sessions 2-3) revealed rich insight in activities, in terms of demographics, cognitive and physical abilities, and safety perception. Older people primarily appeared to go outside by foot for housekeeping and shopping activities, family visits or health purposes (walking). Most frequently visited locations were the supermarket and other shops, garage/parking, residential care home, theatre, bus stop, and post office. The main means of transport was public transport (bus and metro). The car and bicycle were used much less frequently, because most activities take place in the areas where the older people live. If they have to travel to or around the city, it is more convenient to use public transport. Factors impeding mobility involved both physical (limited ability to travel/carry goods (shopping), visual problems, body pain: knees, back) and cognitive (loss of memory, orientation, anxiety and concentration) aspects. The participants did not use many devices for mobility support, but when they did, walking sticks were used most. Determinants in terms of safety of the performed activities appeared to be time of the day, distance to go, weather forecast, emotional state (e.g., at ease in the street, fear of having to go alone and unknown surrounding, irritation about traffic jam), and objects to take (e.g., scooter or bicycle, mobile telephone).

Storyboards

Based on the activity insights, a storyboard format was constructed in the form of a timeline (see Figure 1 for an example), to obtain visually enriched 'stories' representing typical activities in the context of mobility. The format comprised the activity's goal and description, underlying value, key characters, temporal order of events, and possible obstructions and objects involved. The storyboards were created cooperatively by researchers and participants during the one-to-one interviewing (The Netherlands, session 2). The three resulting storyboards were entitled: (i) 'Go for a walk with the dog in the woods', (ii) 'Buy groceries at the supermarket' (*Figure 1*), and (iii) 'Go to a party by car'.

Personas

Based on the activity insights and the storyboards, four qualitative personas were created by the researchers. A persona is a fictional character constructed to be representative of specific user segments[26]. In our study, the personas were representative of the participants, each mentioning one or more technologies they had suggested. Also, each persona comprised information about demographics, cognitive and physical abilities, and safety perception: (i) 'The inseparable couple' (an older couple, one needing help from the other, (ii) 'Bon vivant' (a quite old but active older person, who needs to become more aware of risks), (iii) 'Home bird' (an older person without any physical problems, but with a mental threshold to go outside), and (iv) 'Mild dementia' (an older person with mild dementia).

User requirements

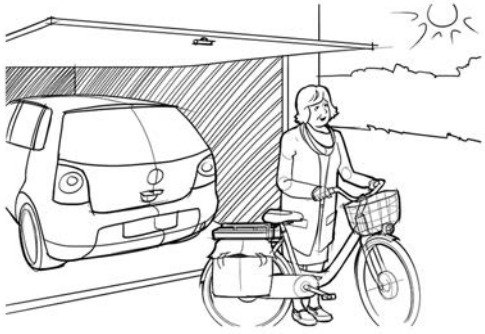
The research in this phase resulted in nine initial ideas for mobility-enhancing services and fourteen accompanying functional requirements (*Table 2*, four left-most columns). The requirements included demographic information regarding activities (traveling needs), safety perception, as well as cognitive and physical abilities. Service ideas mentioned by older adults were meant for use either prior to or during activities, or general services. Requirements reflected a strong need for cognitive support, both prior to going outside (b, d, f) and during their activities outdoors by foot or public transport, fairly close to the home (e, g, h, i, j). In general, one would like the services to foster social contact in order to decrease safety fears (requirements a, c, k, l) and to have a good usability (requirements m, n).

Conclusion on activities

This phase was helpful in identifying (rich insight) and depicting (storyboards) typical activities among older adults, representing the wide array of users and their perception of mobility (personas), and identifying initial services ideas and functional requirements. Although superficially these results could be seen as too general to generate concrete design requirements, this was actually the value of this first phase: it forced designers in the team to become aware and acknowledge how everyday ac-

Buying groceries at the supermarket

At home, preparing to leave (1)
I am Mrs. Emma Johnson. Here I look at the grocery list that is always on the small desk next to the kitchen. Whenever something's finished, me and my husband write it up here. I call to my husband, who is a heart patient and sitting in his chair. I ask whether he is feeling ok for me to leave now. He says: "Remember to get some paracetamol (pain killers), but buy them at the pharmacy, those at the supermarket are too hard to squash!" I check whether I have all my stuff, the list, wallet on elastic cord, cane, shopping bag, water, sugar (I am a diabetes patient). I have my keys- and spare keys attached to my top, below my clothes for emergencies. I consider asking Nancy, the neighbor, to buy the paracetamol, so I would not have to visit the busy street in the center. But as it is a nice day with good weather, I decide I can do it myself.



On the way (2)
I take the electric bike out of the garage. It is fueled up. I need to go through a tunnel that has bad concrete to drive on. This is always a bit of a hassle, especially when motor cyclist pass close by, with all the noise. Before leaving I put the newspaper in the neighbors' postbox. I check my watch: there is enough time to do the shopping and be back in time for lunch. It is important to keep my sugar level stable. I try to take the bike as much as possible, but when it is really bad weather, or icy in winter, I take the car. Luckily I have a drivers license, unlike my sister, who relies on public transport if she cannot bike. There are several places that cannot be easily reached by public transport and it is more of a hassle.

Figure 1. Storyboard 'Local shopping' as used in the first phase of the design process

tivities give meaning in people's lives, and to design product concepts on the basis of that understanding. Our next phase was to translate our rich insights into more extensive scenarios and use cases.

Second phase

Scenarios

For each of the four personas extensive scenarios were written, which reflected the storyboards (activities), initial services and requirements from the first phase. The fact that older adults required technological assistance not only during travel, but also prior to travelling, formed the basis of the scenario format. Also, since they had indicated to be very keen on looking back at the activity afterwards and sharing their experiences with others, ideas for support after the activity were added. Each scenario comprised the user activities, the requirements for the application, the accompanying service, and the required technology. *Table 3* illustrates the scenario related to the second persona.

Service selection

The activities and services from the scenarios formed input for twelve use cases (*Table 2*, second-right column). During a workshop with project partners, use cases were grouped into three clusters of services, each representing a stage in the travel process (*Table 2*, right-most column). 'Happy Preparing' (prior to travel) involves the promotion of social and outdoor activities, provides reminders and checklists for preparation, and dynamic planning. 'Happy Traveling' (during travel) contains dynamic route navigation, support for doing things together, and safety features. 'Happy Memories' (after travel) includes the possibility to collect memories from the activities, share memories with friends and become motivated for future activities. Two remaining general categories comprised the interaction and technological requirements. Finally, a feasibility check was performed for each of the three selected service clusters among all project members of the 'Happy Walker' consortium, based on four criteria: (i) content-related feasibility (agreement regarding functionality of services), (ii) organizational feasibility (sufficient and adequate personnel and resources available within the consortium to develop services), (iii) economic feasibility (innovation sufficiently distinctive and underpinned by a business model), and (iv) consortium fit (compliant with vision and aims of 'Happy Walker' consortium). The three services scored sufficient on these criteria and therefore, we decided to continue with the selected services.

Table 2. Two design phases and 12 use cases results as grouped into three service clusters (last column) during a workshop with project partners

	Phase (i)			Phase (ii)	
Stage	**Initial service idea**	**Initial requirements**	**Cognitive / physical**	**Use cases**	**Service clusters**
Prior to activity	I Agenda service (appointments, suggestions for activities)	a Increase the opportunities for face-to-face social interaction: cultural or sport events, courses, et cetera	Both	1 Activity service (Do something)	Happy Preparing
		b Remind of appointments or activities, suggest activities	Cognitive	2 Calendar service	
	II Service to promote social inclusion, reaching users via phone or webpage for company	c Build up social / meeting community	Both	3 Social contacts/inclusion	
		d Helping not to forget things before going outside	Cognitive	4 Checklist/ preparation/ organization service	
		e Helping to keep orderly arrangement of things and outside activities	Cognitive		
		f Helping keeping track of what is needed for the activity (e.g. shopping list)	Cognitive		
During activity	III Service for transport or visiting the usual shops (such as food) IV GPS services and navigator V Public transport service VI Navigator service	g Helping with navigation	Cognitive	5 Navigation and (public) transport service (get there)	Happy Travelling
		h Improve orientation while moving	Cognitive		
				6 Information/ reminder service (on the way)	
	VII Forgotten key service (enter the house)	i Helping coming back home safely (dark	Both	7 Safety service (stay safe)	
	VIII Alarm for emergency situations when walking outside (woods, not busy pathways) or driving	outside, no more bus) / feeling of security	Both		
		j Helping against potential attack /thief when being alone outside			
	IX New social network that allows to remote control, for people living far away from their caregivers	k Tool to help elderly with the task of being carers of other elder people	Both	8 Informal care service	
		l Reduce needed effort to transport groceries or goods from the shop to home	Physical	9 Specific activity service	
After activity				10 Recording/memorizing activities service (learn something new)	Happy Memories
General		m Make use of the technology the elderly already used (e.g. iPad)	Both Cognitive	11 Interaction (software requirements)	
		n Avoid/reduce the lack of concentration			
				12 Technology (technical requirements)	

Table 3. Scenario 1 for female 'Bon Vivant' persona: Going shopping; Happy Walker (HW) personal is empowering the older adult

Activity:	Shopping at the a shopping Centre (for example buying present for grand-son and something for herself)
Persona:	Bon Vivant, active and has a slight urinary incontinence problem
Version:	15/3/2013
Moment:	Preparation at home; central theme: WELL PREPARED

Activities (Not necessarily in that order)	**Functional requirements (Not necessarily in that order)**	**DO SOMETHING SERVICE (planning)**	**Technologies**
-Checklist: Take keys, telephone, travel card (OV-chip card), medicine, money/bank card -Check amount of money on travel card -Select potential shops to visit (route planning) -Figure out how to get to those shops and plan a departure time (route planning)	-Not forgetting things before going outside -Knowing when to leave in order to arrive at a specific time	-Departure alert service, i.e. warn x minutes before departure where x changes based on local conditions. Reminder service (Giving signal when forget to take HW device) -The number x can change based on the weather [in icy conditions you may wish to leave earlier], actual train and bus times [if the train is running late, you can leave later], or even whether you have enough money in the electronic wallet of your travel card -The number x will be changed based on how fast the user walks; the service learns from experience -What to take service: according to weather umbrella, lots of water	-Interface on TV screen or laptop to plan the trip -Alert device -Physical activity device -Intelligent stick -Intelligent sensor door -Synchronization home device (e.g. laptop) to mobile devices (e.g. telephone)

Detailed requirements

As a final step in the second phase, the initial user requirements were further specified by the project team. This implied that, using the scenarios as input, for each use case specific functional requirements (54 in total) were written and used to create a first mock-up prototype. Generally, functional requirements were expressed as 'system must do <requirement>'. For instance, the first use case 'Activity service', part of the 'Happy Preparing'-service, should:

(i) Include a search function for activities;
(ii) Increase opportunities for face-to-face social interaction: cultural or sport events, courses, etc.;
(iii) Remember names and facts of other expected guests;
(iv) Give user a positive image of the destination (familiarization);
(v) Take away obstacles (mental and physical);
(vi) Enable user to look at photos of the destination or previous similar visits;
(vii) Suggest and select presents for the persons to visit (birthday or thank-you presents).

Conclusion on requirements

The creation of scenarios was an essential intermediate step in which rather raw information from the previous step was merged into a useful form, combining textual with visual elements. The scenarios subsequently provided sufficient input to invent services and associated functional requirements that were further developed in the design process together with potential users. In addition, this step enabled the project consortium to reach shared understanding and agreement on the services and functionalities. Ultimately, the second phase led to specific input for the third phase in which users were involved again to create and evaluate a mock-up.

Third phase

Extensive use case

Before user interface concepts were drawn, an extensive use case was developed, which showed in detail the interaction between the user and the application. *Table 4* presents the use case accompanying the scenario related to the second persona.

Table 4. Use case for the 'Bon vivant' persona

Mary, a 68-year-old bon vivant elderly person with a slight urinary incontinence problem, is visiting a friend Ben. As she doesn't want to go there empty-handed, she wants to buy a cake first.
9h13: **Mary is at home**, sitting in her favourite chair. She wants to prepare her trip. She takes the BIG SCREEN (touch display) and starts the happy walker application. The screen provides three options: Happy preparing, Happy travelling and Happy memories.
Choose Happy preparing. The happy preparing application is loaded.
Choose activity > add new item > visit friend > Search in list:
Communication with server - user profile database: update local friend list
Generate local friend list
Choose Ben > Add time: 14h00
Look in local calendar: no existing calendar items at 14h00
Item added in local calendar: time: 14h00 - place: Ben's - Comment: Visit Ben
Communication with server: Ben's private profile: Identity - address
Calculate route on foot: 58 km distance: private profile: too long for Mary
Public transport line available on route
Look at timetable public transport
Public transport line available: 500m on foot: private profile: ok for Mary
Ask Mary for agreement – travel by public transport? > **Mary confirms OK**

First paper-prototype

Based on the extensive use case, we constructed a first user interface concept, integrating the three services, and focusing on active older users, such as the second persona. This global concept contained paper-based sketches and thoughts of screens and contexts of use and gave a first idea of how the different functions and services could be organised on the screen in an intuitive and user-friendly way. The idea of a calendar for planning activities as a basic concept was accepted. It was then used to organize the user interface by integrating the three services 'Happy Memories', 'Happy Travelling' and 'Happy Preparing', referring, respectively, to past, present and future activities. One important consequence of our focus on people's everyday activities in design was the interface decision to not decouple navigation cues to guide travel from other functionalities like planning a trip beforehand or reflecting on the experience afterwards (e.g. storing and organizing photos). For our participants, these are strongly interrelated aspects that all add to what is perceived as meaningful about the activity as a whole. An impression of the global concept is given in *Figure 3*.

Interactive interface mock-up

The paper-based concept was then developed further into partially interactive user interface mock-ups for three different contexts of use (at home, in action and at rest during action). These contexts were chosen, since they were thought to require different types of functionality and interaction. For example, the system should account for the fact that when at rest during action the user is able to devote more attention to the system than when in action. *Figure 4* shows one of the screens.

User evaluation

We evaluated the mock-up with twelve Dutch older, but active users, recruited through the personal network of the researchers. Although the participants commented on various problems pertaining to the usability of our concepts (e.g. the meaning of icons and use cues), they were generally very positive about the preparing-traveling-memories concept and understood the main functions. Almost all indicated that it would help them to be more mobile. As a critical note, they indicated they would not like to always carry a smartphone or tablet. Our recom-

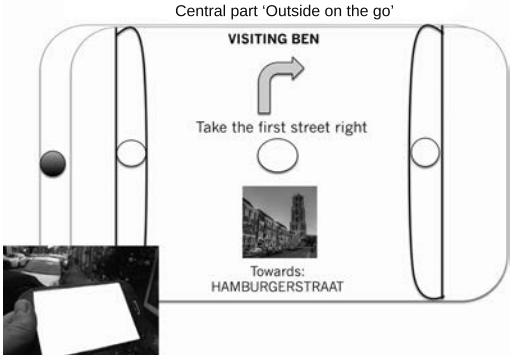


Figure 3. Impression of first user interface concept for 'Happy Walker'

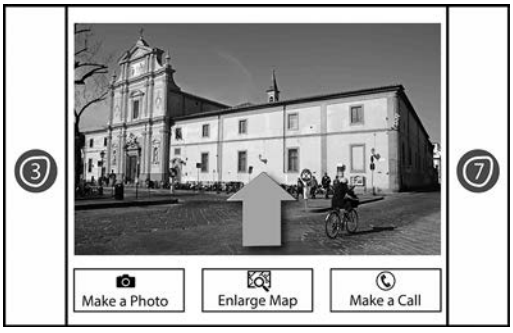


Figure 4. Impression of an interactive interface mock-up screen

mendation would be to use an eight-inch tablet instead, which would also solve some of the usability issues, such as text size.

Conclusion on mock-ups
In the third phase, we started with paper prototypes prior to creating a working mock-up. The sketches served as an easily accessible means for capturing, sharing and discussing the rich insights of the first and second phase among the project team, as well as a common starting point for the design of the first mock-up. In order for our user group to be able to make sense of the design concept we had to present it in a tangible, concrete presentation. However, the details of the presentation chosen may have stood in the way of getting to the question whether the product as a whole fits in with people's everyday lives and practices. Fortunately, although older active users experienced some usability problems during the evaluation, they liked and understood the concept. No testing with less active persons and persons with mild dementia took place in this point in the project. For these groups the prototype would probably require major alterations.

The fourth phase
Interactive prototype
In order to be able to test functionality and usability more extensively, a more detailed interactive prototype was developed, focusing again on active users (*Figure 5*).

Real-life context
In this user evaluation the prototype was tested in a real-life setting. Thirteen older active adults, recruited form the personal network of researchers, tested the working mock-ups at home and outdoors accompanied by a researcher, and commented on functionality and usability (user profile, user interface and wearability).

Functionality
Participants were not likely to carry an extra dedicated device, so 'Happy Walker' should be integrated on their regular smart phone. Using their own phones would also strengthen their own routines, rather than impose a new product that would have to be learned to use and potentially would emphasize a person's disability or stigmatize the person. Added value may come from creating 'marked' routes: safe, with resting places, toilets, nice shops, et cetera. Most preferred functionalities were 'Happy Preparing' and 'Happy Travelling'. 'Happy Memories' was marked as a "nice to have", but would not be used frequently. However, given a limited view on what is needed for people to go outdoors, it is likely that users do not see the added value of making and storing photographs. An 'emergency button' was also perceived as nice, but only to call a professional emergency service, not relatives.

User profile
A long list of possible information that could be part of the user profile was assembled. Most important was that participants did not want too many alarms and reminders. To offer added value, either the user should give the system input about what s/he wants to be reminded of or the system should learn about the habits of the user and make suggestions based on these patterns.

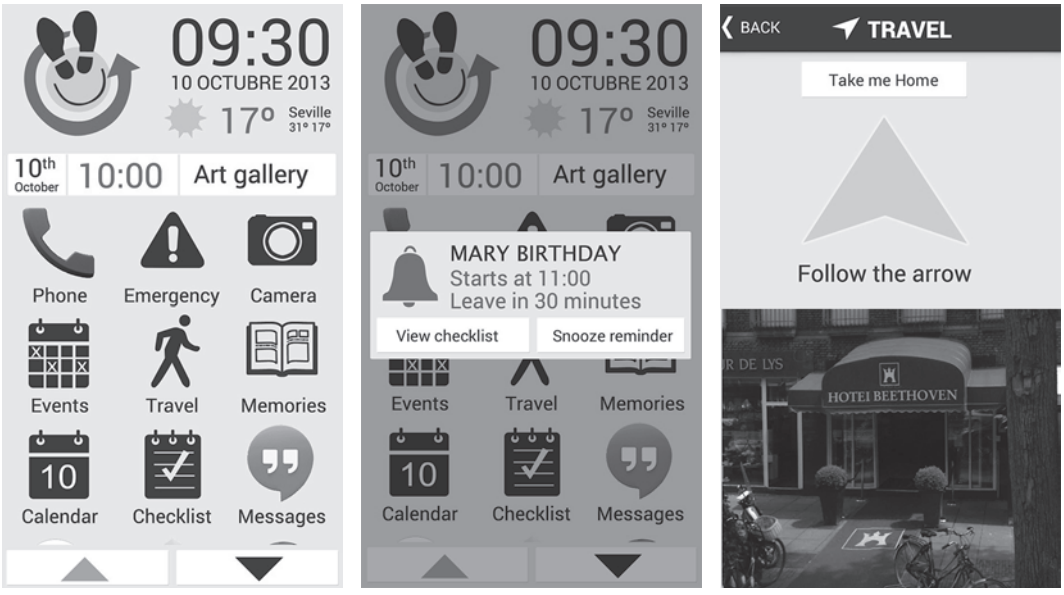


Figure 5. Screenshots of the interactive 'Happy Walker' mock-up

User interface
Single tasks could be performed easily based on intuition, but more complex tasks, requiring more steps to be taken, were difficult for participants, most prominently when planning a trip. Here, the number of steps should be minimized. Comments on the interface involved for instance: some icons looked very similar and could be mixed up easily. A lot of unnecessary information was presented: two or three available icons at a time was suggested to be the ideal design choice rather than showing the entire menu. Font size needed to be increased and voice recognition should be considered to ease the process of inputting addresses.

Conclusion on real-life
The user evaluation provided insights in functionality, user profile and usability issues the project team would not have noticed without involving the target group. Taking into account the recommended design revisions, technological development of the Happy Walker prototype started.

Discussion

Based on our lessons learned during the case study we now discuss our main questions: First, how, as part of the participatory design process, we could obtain better insight in daily activities and capabilities of older adults. Second: what the implications were of taking the older adults' activities and capabilities as a basis for the actual design of a mobility-enhancing application.

Participatory design

Involving older adults in the design process enabled us to focus on older adults' activities and to emphasize their cognitive and physical capabilities, support safety perception and demographics in technological functionalities, leading to an application that empowers rather than stigmatizes the need for support. Reflection on the participatory design process generated lessons learned. The main conclusion was that for making products that really fit the older adults' daily life and capabilities, effectively integrating these users in the design process is an essential condition. In order to do that, it should be clear among both the entire project team and the target group what participatory design entails:
(i) The aim is to gain rich insight into daily activities of the participants, and not to gather representative data about the entire target group. Additional gathering of data may take place separately, for example with on-line questionnaires or literature surveys;
(ii) It is based on the assumption that if this rich insight is gained, the designed product or service will better meet the needs and wants of the users. However, this does not mean that individual wishes of participants will always be met;
(iii) The target group is considered a member of the design team and collaborates with the designers and researchers. Consequently their role is rather active; instead of only answering questions they can be leading in determining the topic of interest;
(iv) It is characterized by quick iterations of designing, testing, and improving again, which involves rather frequent involvement of the target group and close cooperation between designers and software developers. However, it may take a lot of time for the older adults to get acquainted with and committed to the topic and the project team, and to understand the way of working. The group synergy would benefit from the participatory design team consisting of the same members throughout the entire process, rather than involving new members for each iteration.

Also, when actually carrying out participatory design sessions with older adults, the following practical issues should be considered:
(i) Reserve time for participants to get to know each other and to chitchat about other topics than the project at hand. Be aware of the fact that participation in the sessions is a social activity in itself;
(ii) Respect privacy of participants by emphasizing the caution with which gathered data will be treated;
(iii) Be patient as a design researcher and expect having to explain some tasks multiple times;
(iv) Older adults may be sceptical towards new technology. Participants should thus be allowed ample time to talk about their doubts, reservations and experiences with technology. However, if persons remain too sceptical, they may impede group synergy and creativity. In that case, consider not inviting these participants for upcoming sessions;
(v) Having to talk about technology may scare off older adults, since they may feel it is too difficult. Therefore, rather than asking for needs and wants of a technological product, it is more effective to focus on their daily activities first. This also stimulates discussion about capabilities instead of disabilities;
(vi) Rather than asking questions about their life, it can be more fruitful to have older adults perform a creative activity, e.g., fill in a diary, take pictures, or draw something (a storyboard) and let them talk meanwhile;
(vii) Prototypes enable discussion about a tangible service or product and make technology more concrete, especially for less technology-savvy participants. Prototyping should thus start early in the project.

Activities and capabilities

We have learned that starting from older adults' activities and capabilities, we were able to come up with a service and user interface concept that reflects the actual context of planning activities ('Happy Preparing'), carrying them out ('Happy Travelling') and reflecting on them ('Happy Memories'). In this solution, practical navigation cues during activities are not decoupled from functionalities like planning a trip or storing and organizing pictures of the activity afterwards.

In addition, we have learned that a mobility-enhancing mobile application for older adults should take the following into account:

(i) *Demographics:* Start designing for broad use groups such as active older persons, but allow personalization through a user profile, while at the same time limiting the number of possible settings;

(ii) *Cognitive and physical abilities:* Facilitate/stimulate activities close to the home of the older adults; it should be possible to reach destinations either by foot or public transport. The application should take capabilities (things the older adults is able to do) (in line with the Capability Approach[13]) as a basis, rather than disabilities;

(iii) *Safety perception:* Provide cognitive support to older adults during their outdoor activities (navigation support), but also prior to (checklist) and afterwards (pictures) and foster social contact (e.g., a service that would offer social company for activities). In addition, offer physical safety fall-back, such as an emergency button or fall detector;

(iv) *Usability:* The application should not necessarily be offered on a smart phone. An eight inch tablet would be more suitable, but would be less easy to carry around. The interface should be entirely adapted to older adults to the highest level of detail, e.g., understandable icons and use cues and large font sizes. Learn from users but also from existing design heuristics[14,27,28]. Design heuristics based on evidence are essential to apply when designing a solution for this target group. They should already be applied early on in the design process, and adapted later based on results from user evaluations.

Limitations

The participatory design process was part of a large international project. A separate work package at the start of the project was devoted to participatory design, followed by system architecture design, design and implementation, trials and evaluation, exploitation and dissemination. This sequential project structure hindered the project team to optimally benefit from the participatory design approach. First, participatory design should not only serve as a starting point, but users should be intensely involved during the entire design and implementation process. Although older persons were involved in evaluations at two later stages, their involvement became less frequent as the project progressed. Second, the project imposed several deadlines, implying that sometimes sessions had to be organized although data from the previous phase were not entirely analysed yet. Third, technical engineers did not cooperate in the participatory design process. In order to reach commitment among partners and shared understanding, it would have been better to include system engineering from the beginning in joint sessions with users, designers and researchers and have them witness user evaluation sessions. One of the most difficult challenges was how to make sure initial insights were not lost somewhere during the process. The particular form of the prototypes and intermediary products can have great influence on whether and how the right sorts of information about the user is retained and attended to by designers in various later stages of the project.

Future research

The research reported only concerns the first year of a three-year project. After the described participatory design process, a working prototype of the 'Happy Walker' system was built. The working prototype has been tested in a trial in Spain and The Netherlands, involving two groups of elderly: one with no limitations and one with mild functional and cognitive limitations. Also, a business case for the system has been written, investigating the market position of 'Happy Walker' among other new solutions, such as ASSISTANT, that aids older adults in using public transport anywhere[22]. If the 'Happy Walker' system would become a product, it could provide proof in practice for the theoretical claims of the Capability Approach[13].

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