Travelling with my SOULMATE: Participatory Design of an mHealth Travel Companion for Older Adults

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Abstract: Mobility is an important factor in the coming about of quality of life of older adults. In this article, we discuss the participatory design process of a mobile mobility aid for older adults (SOULMATE), which resulted in a service model and functional specifications. We conducted 12 design sessions in Austria, Belgium, and the Netherlands, in which we involved older adults and other stakeholders. The main values that older adults seek to satisfy, with respect to mobility, are comfort, speed, and affordability. They also experience a myriad of problematic situations while travelling, such as complicated ticketing systems for public transport. Participants' thoughts on the role of technology and their reactions towards existing applications resulted in a service model for SOULMATE that consists of four modules: Travel planning, assistance, discovery and training. Their functioning is detailed in a list of (non)functional requirements. As a next step, prototypes of the SOULMATE technology will be developed and tested iteratively.

1 INTRODUCTION

Mobility is an important factor in the coming about of quality of life of older adults. Being mobile allows one to travel to desired people and places, leads to the physical and psychological benefits of movement, allows for involvement in one's community, and leads to a sense of self-esteem when knowing that one is able to travel (Metz, 2000). However, due to degeneration on the physical and cognitive front, the mobility of older adults is often hampered over time (Visser et al., 2005, O'Connor et al., 2010). This manifests itself in difficulty with planning a trip and proper navigation and orientation during a trip (Tournier et al., 2016). For cognitively impaired older adults, wandering becomes a serious threat (Algase et al., 2001). In order to cope with the increasing demand on different forms of travel by an increasingly larger older population, new service models and technological innovations need to be developed (Alsnih and Hensher, 2003).

In recent years, a myriad of travel applications was launched for mobile devices, such as smartphones and tablets. The most well-known application probably being Google Maps. These apps focus on, for example, travel planning for public transport, wayfinding while traveling, or sharing rides. However, the functionality and visual design of these applications do not cater towards the needs and (cognitive and visual) disabilities of older adults (Rassmus-Gröhn and Magnusson, 2014). As a result, some dedicated applications for planning a trip and wayfinding on route have been developed. Gomez and colleagues (2015) created a travel planning and wayfinding application for older adults with cognitive impairments: AssisT-OUT. An evaluation showed

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that the application outperforms standard applications in allowing these older adults to reach and correctly identify their final destinations. A different smartphone application (AssisT-In) was developed to support people with cognitive impairments with wayfinding indoors. The app asked users to scan QR-codes throughout the building, so that an optimal route could be calculated and presented. A first evaluation showed that the designated end-users could indeed find their way while using the application (Torrado et al., 2016).

Other studies have taken a more fundamental approach and looked at the conditions that wayfinding technology for older adults will need to fulfil, or values it should satisfy. Sorri, Leinonen and Ervasti (2011) found that older adults with some form of dementia have difficulties with straying from predefined routes, finding the right door, and specific attractions like people or pretty views. They also found that supporting navigation by showing landmarks on a handheld device did not turn out to be as effective as providing precise and correctly timed advice (e.g., clearly stating "turn left" or "go straight ahead"). Boerema and colleagues (2017) studied the topic on a more abstract level and identified the values that older adults have when it comes to using mobility aids. Facilitating social interaction, fostering independence, and relaxation were the most important values in this.

However, in order to develop wayfinding technology that can aid older adults (with or without cognitive impairments) and that can collect the data that is necessary for identifying cognitive decline, design processes should highly involve prospective end-users (Pulido Herrera, 2017). Apart from these findings, the number of applications for planning a trip and wayfinding on route for elderly and the amount of evaluations that are published about these applications are limited (Bosch and Gharaveis, 2017).

In this article, we discuss the participatory design process of a mobile mobility aid for older adults, taking into account their diversity in terms of mobility profile, country of origin, and living environment. Section 2 explains the Soulmate project which forms the context of the development process. In Section 3, we elaborate on the participatory design methods we used to develop (1) a service model, and (2) functional specifications. Results are presented in Section 4, and discussed in Section 5.

2 THE SOULMATE PROJECT

In the SOULMATE (Secure Old people's Ultimate Lifestyle Mobility by offering Augmented reality Training Experiences) project, a consortium of research organizations, end-user organizations and SME's collaborate to develop a personalised, customizable smartphone-based mobility solution for older adults (Neven et al., 2018). The goal of the Soulmate project is to develop a digital solution that caters for the different mobility needs that older adults have fitting their physical and cognitive abilities. It should evolve alongside the end-user's life stages and needs (e.g., starting out as a healthy older adult that just stopped working, to a senior with some problems walking which impairs self-confidence, to an older adult with mild or moderate cognitive impairments). The SME's involved bring in a set of mobility solutions for older adults with a wide range of mobility-related needs: Route training by means of a virtual training environment (Memoride), passive monitoring of trips to enable geofencing and travel coaching by an informal caregiver from a distance (Viamigo), indoor and outdoor route planning and assistance during a trip (Ways4all), and finally, a panic button for emergency assistance while travelling.

3 METHOD

During the design phase of the SOULMATE technology, a participatory approach was used, in which prospective end-users and stakeholders collaborated with researchers. In total, 12 design sessions were held in two rounds. In the first round, sessions focused on making an inventory of problems that older adults encounter while travelling, and on creating a service model for the Soulmate technology. Sessions in the second round aimed at eliciting functional and non-functional requirements, and at assessing end-user acceptance of the individual Soulmate technologies that the participating SME's brought in.

3.1 Participants

Participants of the design sessions needed to be at least 65 years old, willing to provide informed consent and able to discuss the topics on the table. Since older adults of 65 and over is a very diverse group, we applied a stratified recruitment strategy.

See Table 1 for the different groups that were recruited.

Table 1: Participant groups in the design sessions.

Country	Group 1	Group 2
Austria	Native inhabitants	Immigrants
Belgium	Mobile	Mobility impaired
Netherlands	Urban	Rural

For each group, a design session was held in the first round and in the second round, which makes for a total of 12 design sessions. Mobile participants were defined as older adults that could travel without assistance; participants with a mobility impairment were recruited from an assisted living facility. Besides older adults, representatives of secondary end-users (e.g., family members or informal caregivers) were also invited, as well as representatives of tertiary end-users like informal caregivers. These 'additional' participants were treated like the primary end-users and asked to collaborate in developing technology.

3.2 Round 1

The design sessions in the first round (which focused on making an inventory of problems that older adults encounter while travelling, and on creating a service model for the Soulmate technology) consisted of the following parts:

1. Introduction of the session moderators and goals
2. Introduction of the participants. They were asked to state their name, and some basic demographics.
3. Value elicitation. By using the fictitious story of Martin (who explained what he valued while travelling), we questioned the participants about their values and asked them to rate these values on importance, by placing them on a radar (less important on the outside, more important near the center).
4. Inventory of troublesome situations. We provided the participants with two typical journeys (going to the grocery store, visiting family) and created a visual overview of these travels. Different travel modalities were used in these overviews (walking, cycling, public transport, car). We asked the participant to mark where they normally have problems.
5. Potential role of technology. In pairs, participants received the same overviews as in part 4, but were asked to put stickers of different technologies (e.g., wayfinding app, panic button) on it at the places where they thought this technology would be beneficial. They could also think of technologies, besides the predefined stickers and write these down on the overviews. Then, the pairs were asked to present their work in plenary, and the group discussed the results.

All sessions were audio-recorded and transcribed, except for the Austrian ones, which were transcribed while being conducted. Pictures were made of the products that the participants made. Parts 2, 3 and 4 were closely scrutinized and similar answers were counted. Part 5 served as input for the service model design. Here, we combined the needs and wishes that the participants expressed and the technical solutions that could be, realistically, developed, and the economic viability of the solution (as viewed by the participating SMEs).

3.3 Round 2

The design sessions in round 2 (which focused on eliciting functional and non-functional requirements, and on assessing end-user acceptance of the individual Soulmate technologies) consisted of the following parts:

1. Introduction of the session moderators and goals.
2. Introduction of the participants. Similar to the introduction round of round 1.
3. Co-design activity. In pairs, participants created their own mobile travelling companion. More specifically, they were given handouts of blank mobile phones, colouring kits, ballpoints, etc. to create an interface (or set of interfaces) for three tasks: Preparing a trip, dealing with changes during a trip (e.g., a delay while travelling by train), and calling for help during a trip. These tasks were chosen as they turned out to be perceived as troublesome by the target population during round 1. Since this was a creative, and perhaps difficult task, session moderators helped the participants continuously (e.g., by asking questions that could guide design: "What kind of information do you need here?", "Which button would you like to see here?").
4. Plenary discussions of co-designs. All pairs showed their designs to the group and explained their design decisions. Other participants were encouraged to provide comments or suggest improvements.
5. Acceptance of Soulmate technology. The different technologies that are provided by the Soulmate SME's were demonstrated. Then, participants were asked about their first reaction and whether they thought a technology was useful or not.

Again, all sessions were audio-recorded and transcribed, or transcribed on spot (Austria); pictures were made of the co-designs. Demographics were counted. Results of the co-design activity (drawings and discussion) were scrutinized for relevant functionalities or interface/interaction attributes and then translated into a requirement. Prevalence was not an important issue here, as an idea provided by a single participant could be just as relevant as a functionality desired by the far majority. Each requirement was categorized using FICS categorization (Functions & events, Interaction & navigation, Content & structure, Style & aesthetics) and prioritized via the MoSCoW method (Must have, Could have, Should have, Won't have). Furthermore, the participating SME's indicated whether each requirement could be incorporated in the Minimum Viable Product (MVP), a version 2.0, only in a later version, or not at all. This way, we could grasp the technical feasibility of each request.

4 RESULTS

4.1 Round 1

In total, 42 older adults participated in round 1, with a mean age of 72 years. In the Netherlands, four persons that lived in a rural area took part, while six persons that lived in an urban area were present. In Belgium, 14 mobile persons frequented a session, followed by four less mobile older adults. In Austria, finally, six native Austrians were present in a session, while eight immigrants visited the next session. Besides these end-users, stakeholders also participated in the co-design meetings. In Belgium, one psychologist/gerontologist and one mobility volunteer were present. In Austria, two representatives from the participating SOULMATE SME's participated in both sessions. Sessions lasted about two hours.

4.1.1 Values

The values that were mentioned at least five times in total by the different participants in the different sessions are listed in Table 2. The table shows that comfort, speed, affordability, safety, and independence were mentioned most.

4.1.2 Troublesome Situations

During the workshops the participants were shown (or asked to create) two trips and asked to indicate problematic situations that could occur during such trips. Per mode of transportation, the following situations were mentioned.

Walking. Not many problems were experienced while walking. Limited physical fitness was mentioned in combination with the possible travel distance and walking uphill.

Table 2: Travel-related values mentioned by participants (at least five times).

Value	The Netherlands		Belgium		Austria		Total
	Urban	*Rural*	*Mobile*	*Less mobile*	*Native*	*Migrant*	
Comfort	3	3	3	1	4	2	16
Speed	3	2	6	1	1	1	14
Affordability	3	7	2		1	1	14
Safety			6	1	4	1	12
Independence	1	4	3	2	1	1	12
Social contact	3	1	3	2	1	1	11
Having information while travelling	2	3	1	1	2	2	11
Having information before travelling	1	1	1	2	2	2	9
Reliability, punctuality			5	1	1	2	9
Distance to public transport	2	2	2	1	1		8
Transportation of luggage	1	3	2		1	1	8
Little physical activity	2			1	3	1	7
Physical activity		3		1	1	1	6
Avoid traffic congestions		1	4		1		6
Not being rushed			3		2		5

Biking. The participants felt vulnerable and sometimes unsafe while riding a bicycle. They felt threatened by cars and other cyclists who do not pay enough attention. Some persons told of an accident, which made them avoid cycling. Safety was only mentioned by participants living in an urban environment in the Netherlands and by both types of participants in Austria, not in Belgium. In the Netherlands an unsafe feeling was also caused by the inconsistency in priority rules for Dutch roundabouts.
Driving a Car. Traffic congestions were considered an annoyance while travelling by car. Participants experienced stress while finding a parking spot or finding directions on busy roads. When asked about the possibility of being picked up or dropped off by a friend or family member, several participants indicated that they try to avoid this because they do not want to burden other people.
Public Transport. All participants thought that the public transport system, and the ticketing system in particular, was confusing. To them, it was unclear where or how tickets can be purchased and what the difference between the types of tickets and pricing is.
Trains and Train Stations. In train stations, the fast and inaudible information and lack of, or unclear, signage leads to confusion. In the Netherlands, problems were experienced with the accessibility of the stations and platforms. In Belgium and the Netherlands, the lack of information in general when travelling by train was often mentioned. Situations where a trip deviates from the normal, or planned, itinerary (change of route or platform) were considered stressful and led to fear of taking the wrong train. The short transfer times and limited boarding time gives a feeling of being rushed. Finally, the crowdedness, possible lack of a seat and anti-social behaviour of other passengers were also reasons for concern.
Busses and Bus Stops. The lack of up to date travel information at bus stops and unreliable schedules were often mentioned in all countries. The lack of seating and high entry of the bus were experienced as troublesome, due to a lack of balance and physical limitations, caused by older age. The distance to and from the bus stop was mentioned as being too long, depending on the preferences and level of physical fitness of the participant.

4.1.3 Potential Role of Technology

The participants introduced and discussed several general functionalities of technology that could support them while travelling.

Route Training. Some participants stated that when travelling to unfamiliar places, technology like route training might be helpful to recognize landmarks. They could imagine checking exits at train stations and other important places before embarking on a trip. However, most of the participants thought that such functionalities would not be very useful, as they would forget what they have seen while travelling. Participants liked to view pretty views (like buildings) or routes on the map, but could not imagine training a route themselves.
Travel Planning. Travel planning was already used by a lot of participants (e.g., Google maps, Quando). It helps to know how long a trip will take, what they will encounter en route, and what type of transport to take. People wanted to know how much time they would have for transferring between trains/ buses, and to create a forecast of potential difficulties (roadworks, delays, short transit times), so that they could be prepared.
Real Time Travel Updates. Participants liked to receive information about the remaining time a trip would take and unforeseen events. Technology should provide practical advice on how to deal with such events. Besides, participants would like to receive information about the history of the destination and its local events. Finally, they would like to know where the nearest restroom is at all times.
Route Security. Participants indicated that the older one becomes, the more important it is to have other people know where you are, as something might happen. Participants saw the potential of such services for other older people, but not for them.

Based on the inventory of troublesome situations and the participants' view on the potential of technology, we created a service model for the Soulmate service (see Figure 1). This service model also took into account which technologies the participating SME's thought ready and interesting to the market. The main premise is that the technology is divided in four modules with a similar look and feel. The reason for this is that the participants did not express an overall wish for a set of services, but linked these towards the physical and cognitive capabilities of the end user (divided into healthy older adults, mild cognitive impairments, moderate cognitive impairments). Each module reflects a product brought in by an SME, participating in SOULMATE. The travel exploration and training modules are the exception here. These modules are basically the same, but are marketed differently. Healthy older adults did not feel they need to train their travelling, but were fine with exploring their destinations. Each older adult can select the modules

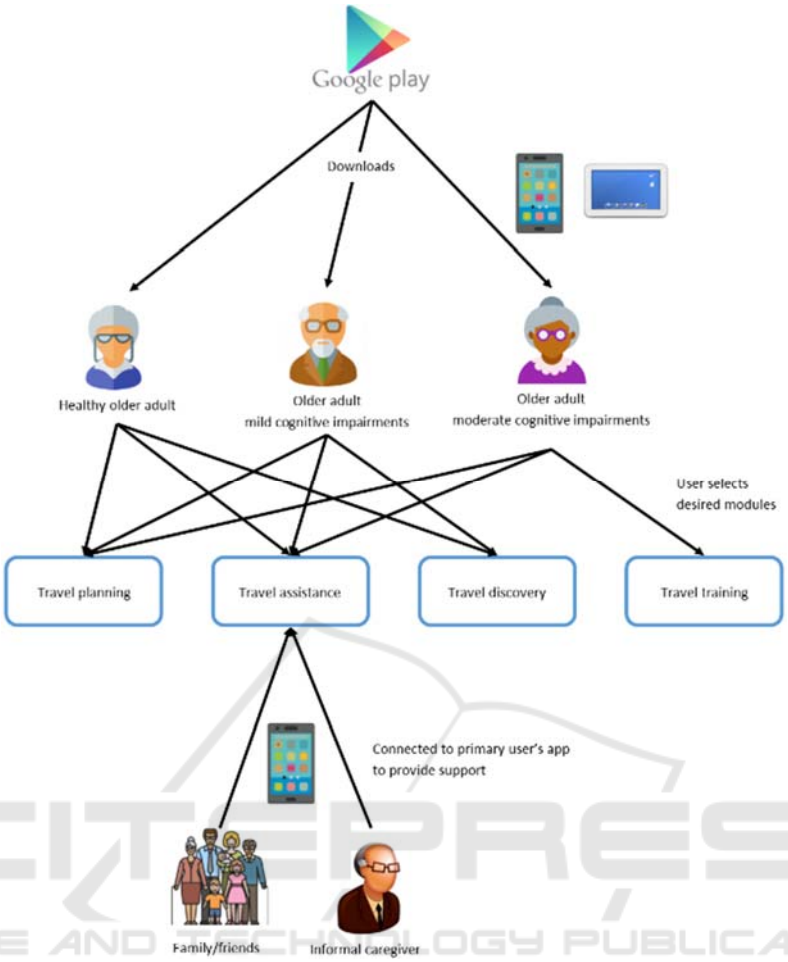

Figure 1: SOULMATE service model.

that s/he would like to use. Whenever the Travel assistance module is selected, secondary end-users (friends, family, care professionals) become relevant and can be linked to the individual end user, so that they can assist them during their travels.

4.2 Round 2

In total, 40 older adults took part in round 2, with a mean age of 71 years. This time, in the Netherlands, five persons that lived in a rural area participated and another five persons that lived in an urban area were present. In Belgium, 13 mobile older adults participated and six less mobile persons took part. In Austria, finally, five native Austrians participated, as well as five immigrants. Next to these potential end-users, a coordinator of an elderly service center and a mobility volunteer participated in Belgium. In Austria, six representatives from one of the participating SOULMATE SME's were present. The sessions lasted about two hours.

4.2.1 Requirements

The participants made a lot of co-designs for the SOULMATE app to support them in the tasks of preparing a trip, dealing with changes during a trip, and calling for help during a trip. Figure 2, 3 and 4 provide examples of such designs. In Figure 2, the participants created functionality for travel planning. They wished to insert a destination address, select their travel modality, and specified what they would like to see as output (travel duration, distance, obstacles, etc.). In Figure 3, participants specified what they would like to receive from the mobile app during a trip, like a map where the restroom and the current location of the end-user is specified. Figure 4, finally, shows that this pair of participants liked to have a simple alarm function in which a list of names was available, and that (video)calling a specific person should be able with one click.

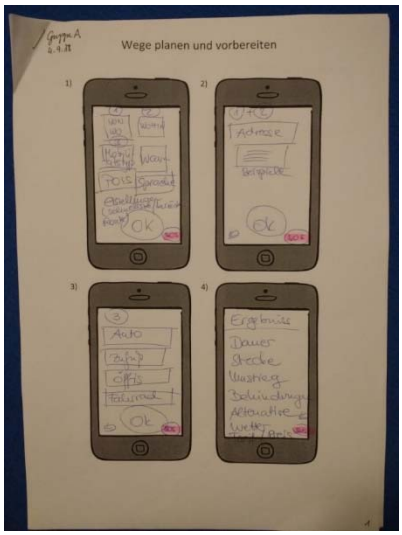

Figure 2: Co-design of travel planning functionality.

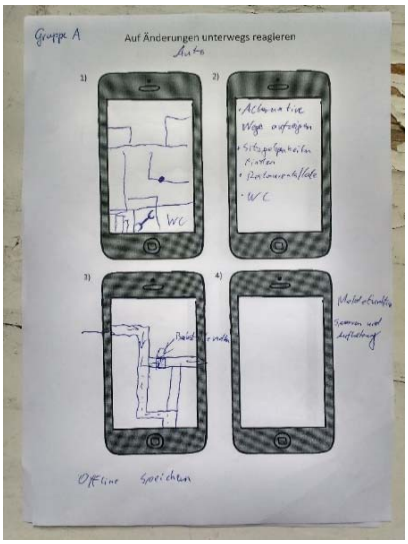

Figure 3: Co-design of travel assistance functionality.

Based on the co-designs and the participants' presentation of their work, 58 requirements were drafted. These 58 requirements were prioritized, based upon the urgency with which the participants mentioned a wish. Subsequently, the design team discussed with the participating SME's which requirements were feasible for the MVP.

In relation to travel planning, the service must:

- allow end-users to choose a location on a map as the place of destination;
- clearly show transfer times when travelling with public transport;
- allow end-users to select different transport modes when planning a trip (e.g., bike, car, public transport);
- make very clear what the start and the end of a trip is;
- allow the end-user to define a route with multiple stops;
- provide a clear overview of the planned trip.

Wishes that were estimated to be too complicated for inclusion in the MVP were transferred to version 2.0. These include showing the altitude of a route (relevant in Austria), providing a checklist of things that people need to bring on a trip, or indicating when a trip is made in the dark or not (as the participants indicated they want to prevent this).

With regard to travel assistance, the service must:

- only display real-time travel updates when travelling by public transport, car, or bike
- show alternative routes in case of a calamity (delay, traffic jam, road closure)
- notify an end-user when going the wrong way

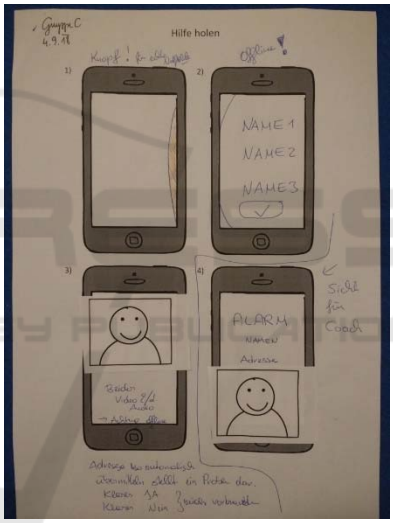

Figure 4: Co-design of alarm functionality.

- allow an end-user to store where they parked the car or bike, or where they got off the bus
- provide information about the accessibility of the transport options and destination
- not overload the end-user with information
- provide a map of stations and airports and their places of interest (escalators, exits, etc.)
- share personal information with a person that is being called in case of an emergency (including location)
- provide a panic button that can be activated by one push
- allow the end-user to choose between text and speech feedback

- provide the option to establish a video-chat in case of an emergency.

Wishes that were transferred to version 2.0 include the option to provide a summary of a trip when reaching the destination (e.g., kilometres travelled, height covered), continuously sharing the current location of the end-user with a predefined friend or family member, or indicating when a person needs to get off a bus, tram, or train.

With respect to travel discovery and training, the co-designs did not generate any input for the formulation of requirements. The participants thought that this functionality was not of relevance for them. As a result, the design team decided to integrate these modules as a technology push. In general, the service must have a clear and easy privacy statement, must be battery-friendly, and must clearly show the current location of the end-user on a map.

4.2.2 Gauging Acceptance

Finally, we gave demonstrations of the current versions of the to-be integrated SOULMATE technologies (i.e., the versions that were available before the design sessions), and questioned the participants about their acceptance.

Route Monitoring. This service (Viamigo, www.viamigo.be) offers real-time monitoring of trips by a remote coach. In short, it is determined whether a person strays too far from a predefined route, in which case the coach is alerted. Reaction to this solution were mixed. Some participants thought that if you need such a solution, you should probably not travel at all. Others said that it would give comfort to the family of the user, and might motivate people to go out. Finally, participants were worried that learning to use such technology might be difficult in case you need it, due to cognitive impairments.

Route Training. This service (Memoride, www.memoride.eu) offers people the possibility to train a route on home trainers or while sitting, by displaying a route (created from Google street view images) on a large screen or tablet. Most of the participants saw this solution as a 'fun thing', but not for real training purposes. They did see the possibilities for people who are not able to travel anymore. For them, it could be a fun and health exercise device. Most participants did not see the value of this service for training a route. They thought that the fun of travelling is in the unknown; to see things for the first time. Even when they would train the route, they said, they would probably not remember it when making the actual trip. Finally, they indicated that if they were in a situation where they had to train a route, they would probably not travel at all, as they would feel too insecure.

En Route Assistance. This demo showed the Ways4all application (ways4all.at), which aims to support active navigation. It provides indoor and outdoor navigation, provides route information (obstacles, elevators, restrooms) and takes into account personal preferences and characteristics while navigating (providing the shortest route, or one without stairs). It can signal help (e.g., to a bus driver when a person needs to be aided to disembark), and it also provides a help button, which activates a connection with a preselected person and conveys the traveler's location and planned route. Participants responded positively towards this solution. Especially in Austria, participants liked to communicate with public transport personnel, and would also use the video help function.

5 CONCLUSIONS

In this article, we have discussed the co-design process of a mobile travel solution for older adults, either with or without cognitive and/or physical impairments. This process resulted in a service model and a set of (non)functional requirements. Together, they will be the foundation of the SOULMATE service.

The SOULMATE service model offers older adults the possibility to select one or multiple travel modules, focused on travel planning, travel assistance, and travel discovery/training. The targeted end-users (and purchasers) of the service are older adults of 65 years and above. Such a broad target group was chosen to ease the transition from healthy, active senior towards a senior with physical and/or cognitive impairments. An older adult can choose to use the travel planning module only when in good shape, but can choose to extend the SOULMATE service later on with a travel assistance module (and panic button), when physical and/or cognitive degeneration leads to a situation in which the traveler does not feel as secure as s/he used to feel. Participants in the design sessions indicated that they thought many options were 'not for them, but for people that are actually old'. Previous research has acknowledged that older adults cannot imagine using or purchasing an assistive technology when there is no direct personal need (Peek et al., 2017). And when there is a need, issues like privacy, costs, stigma, and factors related to usability and a need of training can hinder uptake (Yusif et al., 2016). By offering SOULMATE as a 'normal' travel app to older adults

first, and to extend the service when the need arises, the barriers of stigma, usability and need for training can be tackled.

The requirements which were derived from the design sessions specify how a mobile travel service for older adults (with or without cognitive impairments) needs to have specific features to cater for these end-users. Being able to notify a bus driver that a person with mobility needs has to disembark, storing the location where one parked a car, or information about the nearest restroom are examples of functionalities that make such a technology interesting for older adults, and that allow them to remain mobile when facing the consequences of becoming older.

The SOULMATE requirements elicitation and design approach were highly participatory. The use of these design methods is slowly becoming common practice when creating innovations for older adults (e.g., van Velsen et al., 2015, Šabanović et al., 2015). We found that during our sessions, older adults were enthusiastic to collaborate. Unlike other projects, we decided not to use the co-designs that the participants made as a blueprint for the SOULMATE design. Instead, we elicited the rationale behind their design decisions and used these to draft (non)functional requirements. Then, and in close collaboration with the participating SME's, we decided which functionality to implement or not, also taking account what is technically feasible and makes sense from a business perspective.

5.1 Limitations

Like any study, this work has some limitations. First, the sample of older adults that participated in the design sessions had a slight overrepresentation of healthy older adults. As a result, the participants' views on assistive technology for people with cognitive decline may be too negative. Or, they might not have thought they might need or use the technology at the moment, thereby giving a somewhat biased image of the participants' intention to use the technology. Second, we did not have the opportunity to conduct a full stakeholder analysis (including mapping, determining salience). As a result, we opted for including stakeholders that were willing and able to participate.

5.2 Future Work

The next step in the SOULMATE project will be to develop prototypical versions of the technology. These prototypes will enter a series of iterations in which technical reliability, usability, and acceptance will be tested and improved. Then, the MVP will be evaluated in a real-life study with a focus on mobility, quality of life and informal caregiver burden. In the meantime, the participating SME's will work out a value proposition, business model and exploitation strategy.

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