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Hagethorn, F.N.; Kröse, B.J.A.; de Greef, P.; Helmer, M.E.

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Creating Design Guidelines for a Navigational Aid for Mild Demented Pedestrians

F.N. Hagethorn[1] and B.J.A. Kröse[1] and P. de Greef[2] and M.E. Helmer[2]

[1] University of Amsterdam, Kruislaan 403, 1098 SJ Amsterdam, The Netherlands
[2] Eindhoven University of Technology, P.O. Box 513, 5600MB, Eindhoven, The Netherlands

Abstract. In this paper we describe our project in which we study design options for a GPS-based navigation aid for elderly with beginning dementia. In a user centered approach we first studied problems of the target group. Results were used in the design of a WoZ prototype. The method proved to work very well in designing a prototype that is tuned to the needs of the user. This prototype was used in experiments in which we studied the performance of landmark vs. left right instructions in navigation. We found that landmark based instructions resulted in less errors and less hesitation with the users.

1 Introduction

Nowadays, finding the right way to a destination is getting easier because of the broad range of navigation systems on the market. The user can enter his desired destination and the system will point the user in the right direction. At every decision point, like a junction, the system uses verbal instructions and/or visual support on a screen, like directions on a map. Such systems are available for most people who take part in traffic, like motorists, cyclists and pedestrians. Currently research is focusing more and more on specific target groups. Studies have been done in order to explore the most effective form of auditive aid for the blind and the visually challenged [8, 15, 5, 9]. Another category that may benefit from such systems is the elderly pedestrian, especially the elderly pedestrian with mild dementia. Alarm systems exist that let the elderly get in touch with a caregiver when they are lost, for example the alarm medallion that with a press on a button can warn the caregiver who then will accompany the person to his or her desired destination. Prototype systems have been tested only for indoor navigation [11]. Andersen et al.[2] found that good support for pedestrians with mild dementia can lead to a better quality of life, especially in terms of independence and freedom to move around outdoors. The physical and mental fitness of a patient can also improve and the deterioration of the dementia process can be postponed [12]. With this extended independence and freedom the patient can continue to live at home for an endured period of time and medical expenses can be reduced as well as the work pressure of the caregiver.

We study the design considerations for a navigation system for the target group. We took a user centered approach because we feel that nobody better

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than the dementia patients themselves can indicate the problems they encounter while taking an independent walk outdoors. Next to the findings in literature it is essential to learn about the experiences in the field and needs the patients and their caregivers have in relation to wayfinding. For this we contacted several care centers in the Netherlands and undertook outdoor walks with patients who suffer from mild dementia. We had group discussions and interviews with patients and caregivers about their experiences with wayfinding and about the possible functionality of the aid. We also took several walks with a test system which we designed to find out what the patients thought about it and to see if walking with our system is helping them to find their way.

The goal of our study is to gain insight into 1) frequently made mistakes that people with mild dementia make in wayfinding, while taking an independent walk. 2) which functionalities a navigational aid for this target group should have or should not have 3) how the target group feels about such a navigational aid 4) test the difference between landmark based and left/right based instructions for navigation.

2 Dementia and wayfinding

The term dementia represents a number of illnesses which increasingly weakens the patient's memory functions and cognitive skills. This can lead to problems in wayfinding [4]. Dementia can affect the area of language (aphasia or the disability to use language correctly), the motor area (apraxia or the disability to execute targeted operations or movements correctly), the perception area (agnosia or the disability to recognize impressions of the senses) and/or the area for executing functionalities (planning, organizing and consecutive acting). The symptoms significantly contribute to impairments in social and professional handling and show a clear decrease in former cognitive level.

Wayfinding is the process that involves making decisions about which direction to choose while taking a walk [1]. It is heavily based on the memory and perception functions of a person. As discussed in the previous paragraph, these functionalities are the ones which deteriorate when the dementia progresses. A logical result is that patients with dementia perform worse at wayfinding and learning new routes [4, 1, 18]. They also more frequently fail to execute a planned wayfinding task than people who do not suffer from dementia. Patients also seem to get confused more easily by conventional navigation aids, like street nameplates [11], not so much because they do not know how to use these but because of problems with understanding language or sight. It was reported often that patients who suffer to dementia make use of salient objects in the surroundings, or 'landmarks', while taking a walk outdoors [1, 18]. Passini et. al [14] studied design criteria for indoor environments to let patients with Alzheimer's disease find their way better. Their study shows that performance of reaching a predefined destination depends on the structure of the building and the number of reference points. Examples of these reference points are spaces with a certain function, like the lobby, the living room or medical staffroom but also smaller

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objects like a clock. Deviations in form, function or meaning of an object in contrast to other objects in its surrounding form the characteristics of a reference point.

It seems that 'landmark objects', or 'reference points' play an important role in the spatial cognition of dementia patients. In the following we will focus on our design procedure for our landmark-based navigation device for elderly with beginning dementia.

3 Design of a simple navigational aid

With the target group in mind, the interaction between the aid and the patient must be as simple as possible. This way the patient can more easily learn to handle the aid and is distracted by it as little as possible. We base the design on existing navigational aids that are used in cars, like TomTom, since we do not have urgent reasons not to do so, at this point in the study. To design such an aid using a user centered approach, we need to view the design in a few levels. The first level is that of the experienced problems and hindrance we try to aid with the system. The second level consists of the functionalities of the system. The third level consists of the dialog between the aid and the user and the fourth level consists of the physical form of the system itself.

Level 1: problems in wayfinding. To address the first level of the design, which covers the retrieval of information about what problems or hindrance the system may aid, we contacted different care centers in The Netherlands and spoke with mild demented patients and caregivers about their experiences with wayfinding. To gain more insight we also took several outdoor walks (as of now: "Introduction walks") with patients. The main goal of these walks was to gain insight into the reoccurring mistakes which people with mild dementia make while finding their way when taking an independent walk outdoors. We've paid close attention to the ability of the patient to find the correct way to a predefined destination and to problems that occur in relation to their independence. We also paid attention to the correct use of the rules in traffic by the patient. During the walks we recorded frequently made mistakes and hindrance the patients experience, by using observation and making conversation with every participant after the walk. While taking the introductions walks, no use was made of electronics to navigate. The routes we walked were not predefined. The patient chose the destination, for example the market place and the way that he or she thought was the correct one. Table 1 shows the demographic characteristics of the participants and the locations where the walks took place.

During the introduction walks we found that the most frequently made mistakes were: choosing the wrong direction at a decision point, not recognizing the destination, incorrect use of the rules in traffic and portraying dangerous behavior by, for example, not taking the rest of traffic into account while crossing the street. The hindrance pointed out most by the participants was the feeling of uncertainty or agitation while choosing a direction to go into. Also the sudden

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Table 1. Demographic characteristics of the participants and the locations the walks took place. Par.= Participant, M= Male, F= Female, Diagn.= Diagnose, AD = Alzheimer's disease, VD = Vascular Dementia

Par.	Sex	Diagn	Remark	Location
1	F	AD	-	Amsterdam
2	F	VD	Has difficulties with walking	Hilversum
3	M	AD	Has difficulties with walking	Hilversum
4	F	VD	Has difficulties with visual perception	Hilversum
5	M	AD	Young demented	Utrecht
6	M	AD	Young demented	Leusden
7	M	AD	Young demented	Leusden

loss of memory or understanding of their whereabouts is pointed out as being problematic. It must be said that the wayfinding performance during the walks greatly differ from patient to patient while for the most part the diagnosed disease was the same. In this part of our research we concentrate on the first stated problem; the decision making process involving the directions about the way in which to proceed a walk. If some kind of guidance is given, the user could feel less uncertain or agitated while choosing a direction.

Level 2: functionalities of the aid. In any case, the system is meant to aid the user in navigating to a predefined destination. However at this point, it is still undecided if the future system will use geographical maps to navigate with, just like navigational aids for cars do, or that the routes are specifically programmed for a certain user. In this particular part of our research, we've used predefined routes with a destination where the patient is navigated to. From the user's point of view, we can say that there are decision points along the way, like crossings, where the user has to decide in what direction he or she should proceed. A simple navigational aid will assist the user by giving instructions to go left or right when arriving at decision points. If the user doesn't follow up the instruction and makes a mistake, he or she will get the instruction to turn around, so the user will get back on the predefined route. If the user has reached the destination, he or she will be informed about that by the system.

Level 3: dialog with the user. Instructions could appear on a display, like text or a map, but the display for information about a route can also be in the form of auditive instructions. We choose to use the latter because it requires the least attention and offers the least distraction [7]. In this part of our research we have used the same syntax as used in car navigation. For example, the TomTom navigational aids have a speech display. Approximately 50 meters prior to a decision point an instruction is giving like: "In 50 meters turn [left/right]." It also has an instruction to turn around when going in the wrong direction and the arrival at the destination will also be announced. We did not use distance infor-

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mation, and in experiments reported later in this paper we compare left/right instructions to landmark based instructions.

Level 4: physical aspects of the aid. The navigational aid will be built in a small box that can be carried around easily. The auditive display will be realized with an earphone, a speaker system would be less discrete. We used a male voice for the spoken instructions. Our decision about the voice was based on a study by Lines and Hone (2006) [10]. They found that a male voice was preferred for spoken instructions.

4 Evaluating the design

To determine the effect of a simple electronic navigational aid, we need a working system that we can use to let participants perform tasks. At the time of this writing we do not have such a system. In user-centered design such a dilemma is dealt with using the Wizard of Oz approach.

4.1 Wizard of Oz approach

In a Wizard of Oz (WoZ) approach, a simulation of the future system is constructed. The system is not fully autonomous but some parts, often the reasoning part or the perception part, are carried out by a human behind the screen (the 'Wizard'). The WoZ system is evaluated by users as if it were a real working implementation of the system. In other projects on technology acceptance by elders we had a positive experience with WoZ approaches [6]. Figure 1 shows the Wizard of Oz approach we took to simulate a simple navigational aid. To perform the Wizard role accurately is a demanding job and requires prior training to get acceptable and consistent behavior [16]. Preparations for our Wizard of Oz walks consist of defining a route near the care centre of the participant, defining decision points within the route, defining the points in the route were the spoken instruction is given, recording the spoken instructions and practicing with the WoZ setup on site without participants because we didn't want to stress the patients while practicing.

4.2 Apparatus

The test system consists of a ASUS A636N PDA with Windows Mobile 5. This PDA has Bluetooth version 2 software with Advanced Audio Distribution Profile (A2DP). The earphones, the Jabra BT320s, can be connected to the PDA with A2DP. We used the Windows Mobile 5 Windows Media Player to play the spoken instruction sound files. We configured the PDA control buttons so we can play the sound files by using the buttons instead of having to use the stylus while walking. Using the stylus while walking could result in accidentally tapping the wrong sound file. Also, we muted all the theme sounds in Windows Mobile 5.

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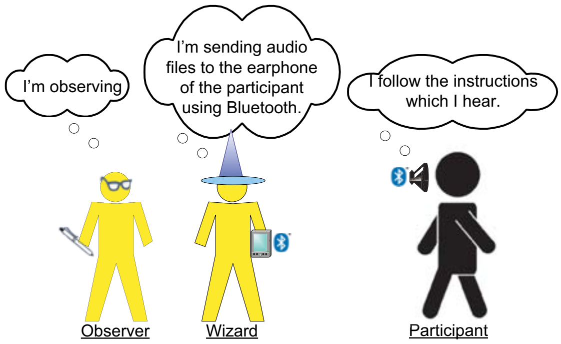

Fig. 1. Wizard of Oz method for the walks with a simple navigational test system.

4.3 Routes

Two routes were set out. One route went through the town of Leusden (from now on: Town-route) and the other went through a park in Leusden (from now on: Park-route). Both routes begin and end at the building of the care center for young demented patients. Both routes took approximately 50 minutes to walk, with an average speed of 3 kilometers an hour. The town-route holds 24 audio instructions and the park-route had 22 audio instructions.

4.4 WoZ walks with the participants

A total of four young demented patients took part in our WoZ-walks. Table 2 shows their demographic characteristics.

Table 2. Demographic characteristics of the patients who participated on the WoZ-Walks. P= Participant, S= Sex, M= Male, F= Female, D= Diagnose, AD = Alzheimer's disease, VD = Vascular Dementia, YD= Young demented

P	S	D	Walk Type	Remark	Location
8	M	VD	WoZ (park)	YD	Leusden
9	F	VD	WoZ (town)	YD	Leusden
10	M	AD	WoZ (park)	YD	Leusden
11	M	AD	WoZ (town)	YD	Leusden

We chose a group of young demented patients because this group can put in more effort and often has better vision and hearing that an older group of patients with mild dementia, apart from exceptions that is. Also, fourteen participants, including the participants shown in table 1 and 2, have taken part in the group conversations about our Audioguide study.

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4.5 Procedure WoZ-walk

The Wizard of Oz enactment of the town-route and the park-route are equal to each other. The only difference is the route itself. The described procedure we describe in this paragraph thus applies to both types of WoZ-walks.

In consultation with the caregivers of the care center, two participants per WoZ-walk were asked to take part. The first participant gets a short briefing about what is going to happen, where emphasis is laid that the participant only has to follow up the instruction he or she hears, as best as he/she can. The earphone is placed in the participant's ear and we begin to walk. During the walk, the caregiver and the second participant walk behind the first participant at a short distance.

The researcher who controls the PDA, sending the audio instructions (the wizard) walks approximately two meters behind the participant who receives the instructions. This way the wizard can determine when to send the audio instruction and take action when the participant threatens get him or herself into a dangerous situation. When he participant gets confused while choosing a direction, the wizard can take action by asking the participant what the system told him of her over the earphone. The wizard will try to help by encouraging the participant to choose a direction which he or she thinks is the right one.

The observer also walks approximately two meters behind the participant who receives the audio instructions. This way he can hear remarks and see reactions better then walking further away. Halfway the first participant switches with the second participant who walked further behind with the caregiver. The short briefing is given to the second participant and the earphone is placed in his or her ear.

After the walks, both participants talk about their experience. One of the researchers summarizes what the participant told and asks the participants if he understood them correctly

4.6 Evaluation during and after the walks

The most frequent made mistakes while taking an independent walk, the hindrance one experienced and the attitude patients and caregivers have toward the audioguide were taken in stock in three ways. By having group discussions prior to the introduction walks and WoZ-walks, by observing during the introduction walks and the WoZ-walks and by having a discussion about the experience after both types of walks.

Group discussions. We have had several group discussions to clarify our goal and learn about the mistakes patients make and hindrances they experience while taking on independent walk outdoors. During these group discussions, we asked no explicit questions. We encouraged the patients and caregivers to ask us anything about the project and share their walking and wayfinding experiences with us and the other patients.

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Observation during the walks. We made observations during the walks to complement the information we gained from the group discussions, to learn which mistakes are made most frequently and which hindrances the patients experience while walking. We have looked at the behavior or impairment that has a negative effect on the patient's independence. We also observed if the patient acted out the rules in traffic for pedestrians correctly, mainly for the patient's own protection.

Discussion after the walks. To get an idea about what the participants think about the electronic navigational aid after they took part in the WoZ-walk, we had a short discussion with them. We asked them if they could tell us what they thought about the walk with the electronic navigational aid. Most of the participants started the conversation by themselves. When the participant was done sharing his or her story, one of the researchers would sum up the most important points according to the patient and asked if he had understood the patient correctly. In the end we always asked the patient to tell us if they have a positive or negative feeling about walking with an aid like this and if they are skeptical about such an aid.

5 Discussion

We have formulated three research questions prior to this study.

1. What are the frequently made mistakes and hindrances people with mild dementia experience while taking an independent walk?
2. Which functionalities and audio messages of the test system are and are not appreciated or missed by people with mild dementia and their caregivers?
3. How do people with mild dementia feel about the electronic navigational aid?

With the findings and information we described in the prior chapters we can answer these research questions.

5.1 Frequent made mistakes and experienced hindrance

As we expected based upon the discussed literature in the introduction and section 1, several patients were having trouble interpreting and using language. This showed during the walks when they tried to read or interpret street nameplates, house numbers and direction indicators. For the group of (mild) demented patients it is difficult to use conventional wayfinding aids to navigate from point A to point B. This combined with the feeling of anxiety to lose the way results in most of the patients always taking the same route when they decide to take a walk outside. Also, as can be found in literature, acts that are more frequently performed and are stored in the long term memory more easily performed then acts that are almost never performed [3]. These inabilities result in serious restrictions in the freedom of choice and independency of the patient. During our

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research we had a growing concern about the safety of the patients during the walks. A number of times we observed unsafe behavior, like crossing the street without paying attention to the traffic and pedestrian aids like traffic lights, level-crossings and sidewalks. A solution to this problem may be to equip the audioguide with safety warning instructions like "Pay attention to the traffic" or "Proceed using the sidewalks". During the group discussions several patients and the caregivers pointed out that this addition would be very preferable.

5.2 Functions and audio instructions for an electronic navigational aid

We have asked the patients and caregivers which functions they think a future pedestrian navigational aid must have. With the development of an interface for this aid, the following matters should be kept in mind:

- The aid must have only a few buttons that can be used to control it. This because of the deteriorating perception of the patient.
- The buttons on the aid must be big. This because of the deteriorating motor skills of the patients.
- The aid must be easy to use. The patient should be able to select or program a route himself.
- It would be appreciated if the patient could make a "free" walk. By free walk we mean a walk where the patient can randomly choose a direction but will be directed back to his or her starting point if they ask for it, or get to far away from where they initially came from.
- The aid must have an alarm function so the patient can call for help when needed.
- The aid must have a tracking function for the caregivers to see where their patient is.

The patients pointed out that an aid without these functions would not be that interesting to have. In the matter of the audio instructions, patients and caregivers wanted additional information about landmarks in the instructions. They feel that this would give them extra confirmation in choosing the right direction at a decision point. Also, the timing in which the instructions are given must be correct. It would be confusing and cause agitation and disorientation for the patients, if the instructions follow each other in a fast pace.

5.3 Attitude towards an electronic navigational aid

We have had very positive reactions from the patients and caregivers to the idea of an electronic navigational aid. They pointed out that it would increase their freedom and independence if they would have an aid like the intended Audioguide. We must point out that one must bear in mind the used sample of young demented patients. Although this group of young demented patients does not have many differences in comparison to an older group of demented

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patients, the young age of the group might have influenced the attitude towards an electronic navigational aid. None of the patients in the group were older than 65 years and might have gotten more used to using of technology in their daily life then an older group of demented patients. So it could very well be that these findings about attitude towards the aid cannot be generalized to the general group of demented patients in the Netherlands, but to the smaller group of young mild demented patients.

6 The use of visual landmarks

Current pedestrian navigation systems predominantly use distance-to-turn information and directional information to enable a user to navigate. However, [4] showed that dementia patients performed better on recognition of landmarks compared with recognition and recall of spatial layout. Studies have been carried out on the quality of landmarks [13, 17]. Here we focus on the performance of such a navigational system for elderly and defined the following research question:
Does the use of landmarks lead to better performance of using a navigation system and a better acceptance of the system by the elderly patient with beginning dementia?

We present an experiment which is carried out to compare landmark based navigational instructions with navigational instructions based only on left/right turn information.

6.1 Set-up

Conditions and routes We compare the following conditions:

- Navigation information is given as directional (left/right/straight) instructions on decision points
- Navigation information is given as directional instructions augmented with landmark information.

We have set out two routes in the vicinity of the day care centre, each approximately 750 meters long. Each route had 13 decision points at which navigational information had to be given. Both routes are as similar as possible with respect to difficulty and the number of instructions. Both contain a shopping area, residential area and a park-like area. In the first route we used only directional information. In the second route we used directional information augmented with landmark based instructions.

Instructions The instructions were as short as possible, and spoken by a male voice. The instructions are 'pre-recorded speech', and not computer generated. The use of a landmark is always an addition to the directional information, where

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Fig. 2. Left: typical decision point. Right: participant with earphone.

the landmark was always used at the end of the sentence [4], e.g. 'Turn left at the IKEA'. Given the limited number of participants it was not possible to use elderly patients to find the best names for the landmarks, as was suggested by [3].

Participants and design We used participants with beginning dementia from a day care centre, 4 males and 2 females. Each walked both routes in a random order.

Performance measure We compared the two conditions on the navigation performance and on the attitude of the users. During the walk we registered at each decision point whether an error was made, and whether the participant was sure about its direction or hesitated. A navigation error is counted if the participant takes the wrong direction and has to be corrected by the wizard. He does this by giving an audio instruction 'Please try to turn around'. When the participant sees that he or she is going wrong before the correction instruction is given, this is not counted as error. We also measured the hesitation of the participant by observation (0 points for no hesitation, 1 for a little and 2 for much hesitation). At the end of each route we also measured the acceptance and the participant's attitude toward the navigational system. We used a small questionnaire with 10 questions with a 7-points Likert scale. The questionnaire was taken after the first part of the tour, and again after the second part.

6.2 Results

Table 3 summarizes the results for the conditions. The landmark condition resulted in a lower number of errors then the left/right condition. The amount of hesitation was lower for the landmark condition then for the left/right condition. The attitude of the participants toward the system was only slightly more positive for the landmark condition. Under both conditions an overall high positive evaluation of the system was given

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Table 3. Results for the 6 participants

	Errors		Hesitation		Attitude	
Participant	Left/right	Landmark	Left/right	Landmark	Left/right	Landmark
P1	1	0	2	1	67	69
P2	2	1	7	0	48	58
P3	1	0	0	1	68	68
P4	1	1	0	1	67	67
P5	1	1	1	0	69	69
P6	2	1	1	3	65	62
Total	8	4	11	6	64	65.5

6.3 Discussion

A further analysis of the data learned that the 4 errors in the landmark condition were made at the same decision point, where the route instruction was not optimal. The instruction was to turn left at the landmark, while the landmark itself was placed after the decision point. For landmark based navigation, a careful formulation of the instructions is needed. In the final discussion with the participants the overall consensus was that the system is very helpful indeed. Even the use of earphones was not considered a problem.

7 Conclusion

After the findings of this study, we can conclude that an electronic navigational aid (our 'Audioguide'), can be a very valuable supplement in the lives of patients who suffer from mild dementia. The feeling of freedom and independence could be effected positively by offering the patient the possibility to go outside and take an independent walk with an aid like the intended Audioguide. The aid should prevent the patient from getting lost and it is maybe possible to let the patient live at home for a longer period of time before he or she gets transferred to a care center. Also, with this aid even the caregiver's job can be made a bit easier. The most important conclusion is that by involving the target group, in this case the young mild demented patients, in the preliminary research and evaluation of a new system, one can create an aid that is exactly tuned to fit the needs of the future user, which will be appreciated. On a small sample of participants we showed that landmark based navigation causes less errors and less hesitation then left/right navigation.

We are aware of the fact that the design of a future Audioguide will not eliminate all the problems and hindrance in a patients' life. We are also aware of the fact that not all of the patients in the target group with the same diagnose of dementia also experience the same problems. The main goal of this Audioguide project is to design a navigational aid that makes an independent walk for people with individual impairments possible. No matter if errors are made, the person should be able to reach his or her destination in a safe and reliable fashion. This

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means that the system should be designed in a way that the individual problems can be preempted as well as possible. Having a form of dementia brings a lot of stress, doubts and insecurities in the lives of the patients and if aids like the Audioguide can help to reduce these feelings while the patients is taking an independent walk, then our goal is for the better part fulfilled.

Performing a study with a sample of mild demented patients has not always been easy. Like we pointed out before, we had difficulties finding participants that were diagnosed with a form of dementia and which were physically fit enough and had well enough motor and perception skills. Because we had difficulty finding the right participants, we choose to look for young mild demented people, which is a smaller group of demented patients in the Netherlands. This group was also difficult to find because not all of the young mild demented patients have joined a care centre. Nevertheless, it seems wise to further study the design of a navigational aid for a bigger group of mild demented patients. The participants in this study were very enthusiastic about the test system they walked with. It gave them freedom, independence and it made the job of the caregiver a little less hard. They stated that an Audioguide like the intended test system, could be a good solution to the wayfinding issue.

In further studies one could concentrate on adding safety and warning instructions to the default left and right instructions of the current navigational aids for pedestrians. However, it should be taken into account that the length of an instruction cannot be too long, this could cause confusion.

It is also important to study the technical aspects of an Audioguide system. For example, more study is needed to find out what the user interface for the patient and caregiver should look like and how it should function in an user friendly fashion. Also, the Audioguide needs to have a robust GPS-signal in order to work with the precise location of the patients whereabouts. With this one should for example keep in mind that a GPS satellite fix is lost when one walks through a tunnel. The power supply is also very important. Studies should be done on how to manage the power of a Audioguide system. And last but not least, other studies can point out what exciting technology can added to the Audioguide system, like alarm and /or tracking functions.

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