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Technology for mobility: A user-centered approach evaluating affinity for technology and requirements for a navigation assistant for people with cognitive impairment

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Abstract

Background: People with dementia experience problems to maintain autonomy and self-determined mobility. Assistive technology devices, if adapted to the specific needs of this user-group, may support people with dementia and help them maintaining daily functioning and independence.
Objective: This study aimed to examine the future users' perspective on function and design requirements for technical navigation assistants to support outdoor mobility in people with cognitive impairment.
Method: Within a user-centered design approach we conducted semi-structured interviews on mobility behaviour and technology affinity with 14 people with mild cognitive impairment or mild to moderate dementia. Qualitative content analysis as described by Mayring was used to analyse the data.
Results: Nearly all of the participants expressed the need for self-determined mobility and all participants used technical devices in their daily life. Five of 14 participants had experienced phases of disorientation outside their homes, resulting in discomfort and a reduction or avoidance of outdoor activities. The participants' requirements for a technical navigation assistant comprised the following features: Integration of safety services; customisable functions, a legible display, a small, unobtrusive design of the device (e.g., a smartphone or watch), and additional support for the selection of and adherence to compensation strategies. Despite previous experiences with navigation systems, participants did not use them. This indicates the need for innovations in this area.
Conclusion: People with dementia provide us with essential expert insights into dementia-related mobility constraints and requirements for the design of technical navigation assistants. These insights will help to improve usability and acceptance of such technologies by the intended users.

Keywords: Dementia, disorientation, assistive technology, spatial navigations, user participation

Introduction

People with dementia are at risk of loss of autonomy and need of care (McKhann et al., 2011). Physical activity is a resilience factor identified in dementia (Bherer, Erickson, & Liu-Ambrose, 2013 & Heyn, Abreu, & Ottenbacher, 2004). Independent mobility outside the home is important for maintaining the quality of life and preventing nursing home admission (Groessl et al., 2007). It is estimated that more than half of persons living with Alzheimer's disease experience orientation problems which may be alleviated with navigational assistance technology (Pai & Jacobs, 2004). Such assistance should be situation-adaptive so that it delivers interventions only in instances of need. This would allow the users to continue to rely on their cognitive resources as long as they are not critically impaired (Teipel et al., 2016). User involvement ensures adaption of technological devices to users' needs (Yatawara, Lee, Lim, Zhou, & Kandiah, 2017, Kwan, Cheung, & Kor, 2018 & Span, Hettinga, Vernooij-Dassen, Eefsting, & Smits, 2013).

There are no intelligent and situation-adaptive assistance systems that are able to recognize needs and propose interventions for the outdoor sector (Kan, Huq, Hoey, Goetschalckx, & Mihailidis, 2011). Current systems are limited to geofencing (i.e., setting up digital motion zones), helping

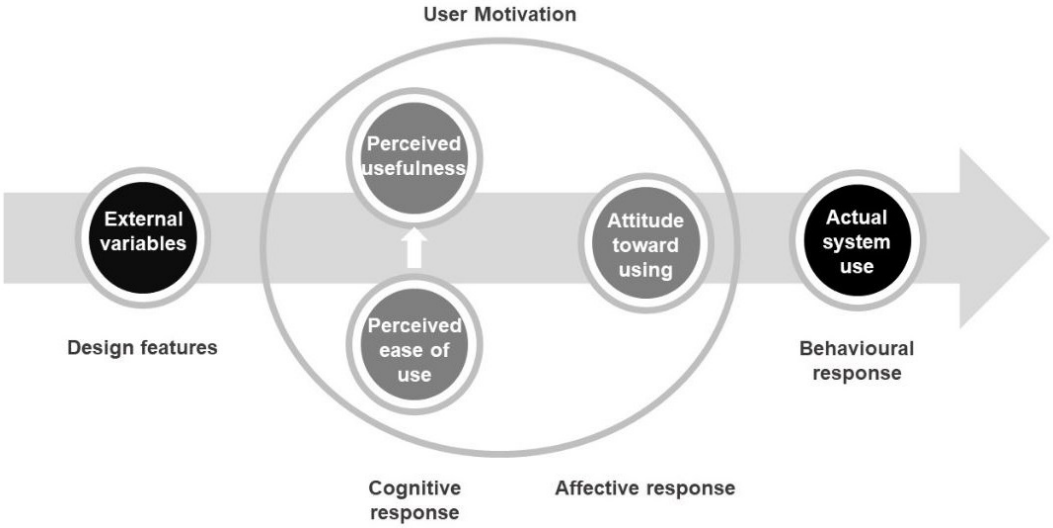

Figure 1. Technology Acceptance Model (original representation, based on Davis, 1985, p. 24).

people to find their way back home or alerting a caregiver (Dröes et al., 2009 & Huang, Lin, Yu, Liu, Kuo, 2015 & Megges, Freiesleben, Jankowski, Haas, & Peters, 2017). The discrepancy between the users' need for autonomy and current systems' abilities suggests that people with cognitive impairment, including people with dementia, should be actively involved in the design of such technologies to incorporate their values and needs. User-centered development approaches (e.g., Value Sensitive Design, VSD) systematically capture the values and needs of future users to develop responsive and marketable technologies that meet their needs (Friedman, Hendry, & Borning, 2017). Qualitative user surveys play a central role in understanding the users' perspective as they allow complex and context-sensitive insights into individual demands on assistive technology beyond predefined answers (Aspers & Corte, 2019). Approaches focusing on the assessment of the values and needs of people with dementia are established in many contexts (Tsekleves, Bingley, Luján Escalante, & Gradinar, 2018), but have not been widely used with respect to an affinity for technology. The current work aimed to elicit necessary factors and design features for the development of a navigational assistive technology from people with cognitive impairment, including people with dementia, as the future users of such technologies. The catalogue of questions was based on Davis' Technology Acceptance Model (TAM), which specifies predisposition factors that are important to ensure user-acceptance (Davis, 1985): design features, sociodemographic characteristics, technological experience, the perceived ease of use, and the perceived usefulness (*Figure 1*) (Davis, 1985 & Venkatesh & Bala, 2008). To adapt future prototypes to the needs of people with dementia, information on their mobility behaviour and expectations of navigational assistive technology are required.

Accordingly, we examined the following questions:

I. Which mobility needs do people with mild and moderate dementia have?
II. How can these mobility needs of people with dementia be supported by navigational assistance technology?
III. How technologically incline is the target group?
IV. How must the device be designed to be accepted by the users?

Table 1. Sample.

Interview ID	Age*	Sex	MMSE*	Highest level of education	Technological education
X01	73	F	26	Vocational training	No
X02	73	M	27	Vocational training	Yes
X03	58	F	25	Higher Education	No
X04	59	M	17	Higher Education	Yes
X05	64	M	26	Higher Education	Yes
X06	82	M	28	Vocational training	Yes
X07	86	M	25	Higher Education	Yes
X08	58	F	26	Vocational training	No
X09	62	F	20	Vocational training	No
X10	76	F	25	Vocational training	No
X11	78	F	28	Vocational training	No
X12	73	M	27	Higher Education	Yes
X13	71	M	23	Higher Education	Yes
X14	81	M	24	Higher Education	No

*at time of interview

Methods

The user-centered approach was embedded within a qualitative research method using semi-structured interviews (see Procedure).

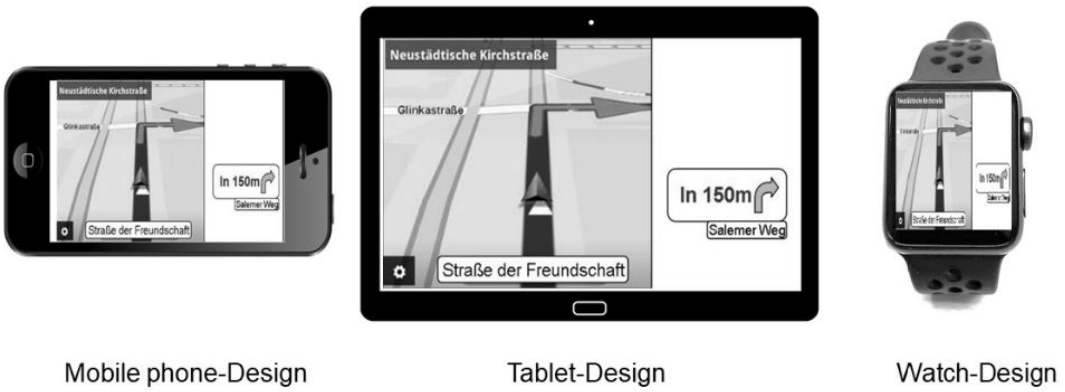

Figure 2. Examples of possible devices for navigational assistance technology (Source: https://pixabay.com/de & https://www.google.de/maps).

Sample

We interviewed 14 people with mild cognitive impairment or mild to moderate dementia due to clinically probable Alzheimer's disease, according to NIA_AA criteria (Albert et al., 2011 & McKhann et al., 2011). The inclusion criterion was the absence of other clinical causes of cognitive impairment in clinical examination, routine blood examination, and MR imaging and cognitive decline not more pronounced than moderate dementia (operationalized as a value of ≥15 in the Mini-Mental-Status-Examination (MMSE) (Folstein, Folstein, & McHugh, 1975). The mean age of participants was 71 years (range: 58-81 years) and the mean MMSE test value was 24.8 (range: 17-28) (*Table 1*). Fifty percent had received vocational training, fifty percent had undergone higher education. Seven of fourteen were technologically educated.

Procedure

Participants were recruited through the Memory Clinic of the University Medical Center and the Research Outpatient Clinic in Rostock, Germany. The interviews took place at the Research Outpatient Clinic or the participant's home. All patients or their representatives provided written informed consent. The interviewers ensured ongoing consents. The study was approved by the ethics committees of the University Medical Center Rostock (A 2013-0072) and conducted in accord with the Declaration of Helsinki (1975).

Two different researchers conducted the interviews. All fourteen interviews were digitally recorded, anonymized, and transcribed verbatim. The interview guideline contained four main categories:

A) Living conditions and socio-economic status.
B) Use of digital technology.
C) Need for help when navigating outside the home (need for support, purpose, significance, frequency, and range of mobility).
D) Requirements for the usability of a device to support outdoor navigation.

The technological sections (B & D) were based on the TAM. A priori, we deduced a category system based on the guideline. This category system was inductively supplemented during the evaluation of the interview material (Mayring, 2000). To ensure a consistent coding procedure, an intercoder check was conducted (Mayring, 2014). Two coders contributed to the evaluation process.

Material

To increase participants' imagination of a future navigational assistive technology the following examples were shown to all participants (*Figure 2*). In addition, a sample of display layouts for navigation information was given to all participants (*Figure 3*).

Analysis

The data was evaluated using qualitative content analysis as described by Mayring (Mayring, 2014). We divided the data into the following units: evaluation unit (all transcripts), context

Figure 3. Different versions of Google street views used as navigation aid for people with dementia (Source: https://www.google.de/maps).

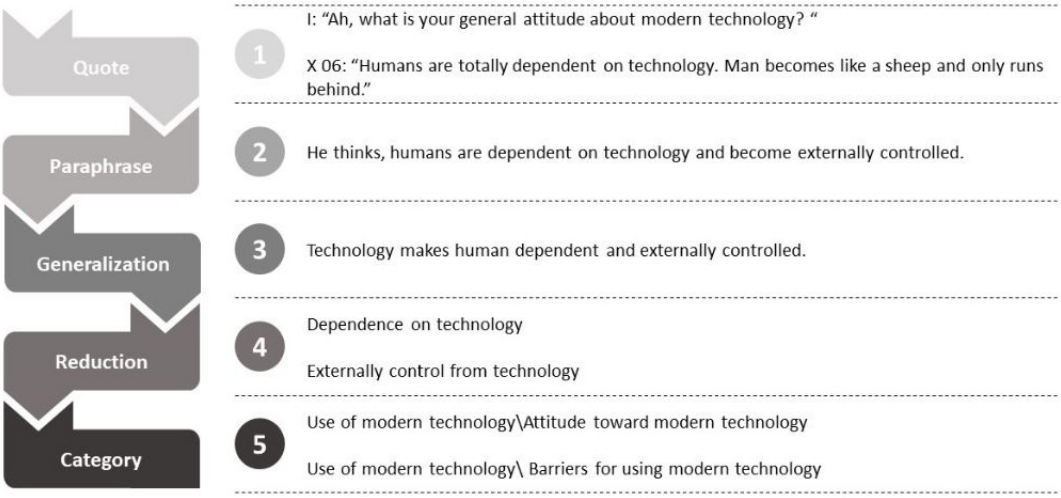

Figure 4. Process of reduction.

unit (sense sections), and coding unit (individual words/word groups) (Mayring, 2014). The coding unit was paraphrased, generalized, and reduced (*Figure 4*). The reduction was classified in the smallest existing (sub-)categories (deductive) or, if necessary, in newly built ones (inductive).

Besides, a coding guideline was developed to structure the coding process (coding rules) (Mayring, 2000). The coding guideline defined the meaning of subcategories and provided anchor examples for these definitions (*Table 2*). Further, the coding rules specified the content of answers and determined the manner how the answers should be coded in this category (i.e. values, yes/no, or reasons) (Mayring, 2014).

To structure, organize and summarize the data a qualitative data analysis software (MAXQDA 2018, release 18.2.4, VERBI software, Consult. Sozialforschung GmbH, Berlin, Germany) was used. After finishing all evaluations, the identical reductions in each (sub-)category were added up to present the priorities of the statements.

The affinity for technology features personal resources, personality, and the willingness to interact with new technology (Franke, Attig, & Wessel, 2019). To derive affinity for technology for each participant, we applied the Affinity for Technology Interaction Scale (Franke et al., 2019). We took the sum of all positive factors towards technology use (past and present use of landline phone and mobile or smartphone, tablet, personal computer, notebook, device for navigation; technological education; resources; coping strategies and personal benefit) and subtracted all negative factors (obstacles; barriers and problems). The sum built the ability to use modern technology and was set in relation to the attitude.

Results

In total, we extracted 1,432 codings in 115 subcategories. The amount of the codings per inter-

Table 2. Extract from the coding guideline.

Category 2: Use of modern technology (affinity for technology)	
Question:	Do you have any difficulties with electronic/technological devices that you use?
Subcategory 1	Difficulties during operation
Definition	All problems, obstacles and difficulties arising during the operation of technological equipment or constituting a barrier to operation.
Anchor example	"I: OK. And what electronic devices, would you say, //or technological devices, where you would say, "this is actually more difficult for me (.) to use"? X04: (...) But with the new devices, especially the one, the ones (...) uh, (..) the small computers//; (...) Tablets. Right. Uh, with these I had to work my way through, but once you've spent a bit of time with them and you understand how to use them better//
Coding rule	All answers to this question that indicate difficulties in operation were coded under this category, even if the interviewed person had strategies to overcome the difficulties.

Table 3. Different attitudes toward modern technology.

ID	Quotation	
X01	"Yes. (.) Indeed. I absolutely want to stick to that too, because I think it´s an immense feeling of freedom"	positive
X02	"No. Not me. I'll get there // I won't get along with it. There I am // I'm not even interested in."	negative
X03	"Yes, yes, yes! So I want// And like I said, I've got it all figured out for the winter. So, I just realize that this is a different age group that can do it better. So it's easier for the younger ones."	positive
X04	"It's nice when something new comes."	positive
X05	"Yes, actually open. (…) Due to history."	positive
X06	"Humans are totally dependent on technology. Man becomes like a sheep and only runs behind."	negative
X07	"But otherwise, technological devices that // I'm not afraid of, let's say."	neutral
X08	"Not that good. No, this bells and whistles and if they have 1000 other things."	negative
X09	"Yes, great if you know how to do it. Yes, it is already, it is already beautiful." "Yes. And it will always go on. I don't need anything anymore. So what's new now."	positive
X10	"If that stays within limits. *Then it is OK?* Yes. But if all of life is based on technology, I don't think that's a good thing."	neutral
X11	"Well, if I can handle it, then it's fine// Yes. //but if I can't handle it, I'm avoiding it."	neutral
X12	"Positive, actually. And that then this general communication between people is indeed blocked by it."	positive
X13	"Well, I'm actually quite open-minded. Yes, you would also like to see how it goes on."	positive
X14	"Yes, I am amazed to see what the new times have in store. And when I'm gone, how it goes on. I'm making thoughts about that. And that's where I have ideas."	positive

view was independent from the MMSE-Score or age. The average interview duration was 30:55 minutes (range: 15:16 - 45:53 min) (Contact corresponding author to obtain supplementary materials written in German).

Living conditions and socio-economic status
Ten people lived with their partners, four lived alone. Eight of the 14 participants previously worked in the technological field, with nobody currently working (13 pensions/early retirement, one unemployed). Nine of the interviewees reported physical illnesses that might limit mobility behaviour: cardio-vascular diseases (n=1), visual impairment (n=4), degenerative changes in the musculoskeletal system (n=4), and balance disorders or faint (n=3).

Use of digital technology (affinity for technology)
Concerning the usage of technology, eleven participants had a mobile phone and eight used a car navigation device, in addition to the use of communication and kitchen appliances.

Obstacles and resources for technology use
Major obstacles for technology use arose from visual impairment, partially in combination with wrong prescription glasses, with fear of increasing impairment, the confrontation with unusual, new technology as well as from lack of perceived benefit and financial resources. Complex device operation was also described as problematic because it frustrated and overwhelmed the user: "*Oh, God, let me put it this way, I've decided not to burden myself with the latest technology. (.) Because that's beyond my ability now.*" (X14, L.1432-1437). When participants faced problems using technological devices they relied on the following strategies: (i) they read the instructions to solve problems, (ii) they took time to calm down before they tried again, (iii) or they used a different device instead (e.g., their microwave instead of their stove). Additionally, asking the children or spouse for help was named: "*And the washing machine, if, if I can do it and if I can handle it, I'll do it myself and otherwise my daughter will do it //*" (X11. L.200-202). At the same time, the spouses were a barrier for technology use relieving the operation of complex devices because the spouses did not think that the participants could manage these: "*(..) he always thinks he's doing something good for me if he helps me with everything. I don't want him to. I want to do as much as possible myself. (…) And it's all working out if he lets me.*" (X08, L. 537ff.). Some participants described inhibitions

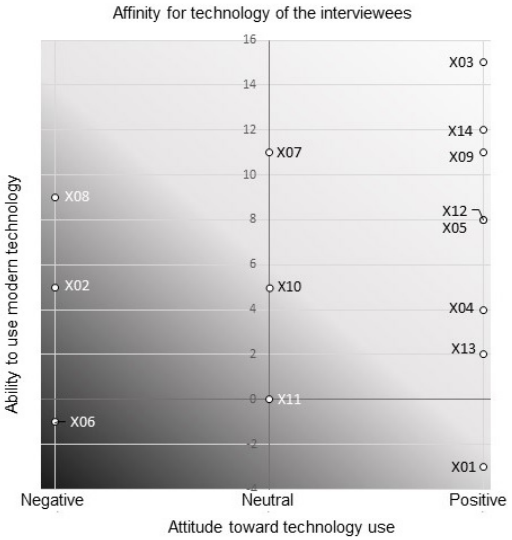

Figure 5. Affinity for technology of our interviewees derived by use of technology and attitude towards modern technology. Dark grey means not technologically inclined, light grey means neutral, and white means technologically inclined.

to ask their spouses for help; the participants felt ashamed or feared conflicts: *"And then I say// it's too embarrassing for me to say, 'get me maps in there', that I don't even ask that anymore."* (X01, L.675-676) and: *"Yeah, I'll do it myself, I'll read it again, and I'll try it out and what I need. If he tries to explain it to me, it's gonna be a cramp."* (X08, L. 332-334).

Besides the independent exploration of devices at one's own pace, interest in technology, as well as constant use, were important for the handling of technological devices. The perceived benefit at home and in professional settings was named as important factors for using technological devices, as underlined by this quote: *"I: So, would you also say, that you are open to electronic devices, such as computers? X01: Yes. (.) Indeed. I absolutely want to stick to that too, because I think it's an immense feeling of freedom"* (I1, l.177ff.).

Despite that technological education being named as an advantage when using technology by the technologically educated participants (n=8), they did not use more often or more modern technology and did not report fewer struggles with it. Even interviewees with technological backgrounds had no personal computers or mobile phones for work because they had worked as mechanics or welders. In most cases, the crucial point for using modern technology was the need to handle digital devices, like personal computers or mobile phones in their previous work and a high degree of education itself.

Attitude towards modern technology

The attitude towards modern technology can be divided into positive, neutral, and negative by interviewees' answers to the question: *"What is your general attitude towards modern technology?"* (*Table 3*). Most of the participants were open-minded towards modern technology (8 positive, 3 neutral, 3 negative). Positive attitudes included anticipation, fascination, and progress. In contrast, disinterest, the feeling of dependence on technology, and worries about decreasing social interaction were facets of negative attitudes.

The attitude towards modern technology itself was not sufficient to infer technology use. A more precise picture was obtained from evaluating the affinity for technology for each participant (*Figure 5*).

The absence of affinity in the four least technologically inclined participants (X02, X06, X08, X11) may be explained by their backgrounds (*Figure 6*).

For the technologically inclined participants, there was a strong tendency to use several different devices, but their ability to cope with problems in use was different. All participants who were currently using a personal computer were considered technologically inclined and had previously operated it in their work-life; they had a positive attitude towards modern technology. However, not all participants with a positive or neutral attitude who had previously used a computer in their work-life were still using it at the time of the study. Further, the use of a mobile or smartphone was independent of their affinity for technology. X02 used his mobile phone only for calls and recognized the benefit in cases of disorientation. X08 used her mobile phone out of habit, but only for calls, SMS, and in case of emergency (emergency button). X06 and X11 did not have mobile phones. X13 did not own a mobile phone, reported not leaving his property, and thus perceived his landline phone as sufficient.

In summary, the affinity for technology depended on various, individual experiences and abilities and could not be strictly classified.

Need for help when navigating outside the home

Outside activities

One of the interviewees no longer left the property on his own. Ten of the interviewed persons reported going out by themselves at least twice a week. Three did not respond directly to this question but from their other answers, we inferred that they went out alone as well. Being accompanied by other persons increased the frequency of mobility outside the home in two interviewees. For four participants, the radius of movement was increased by the presence of another person.

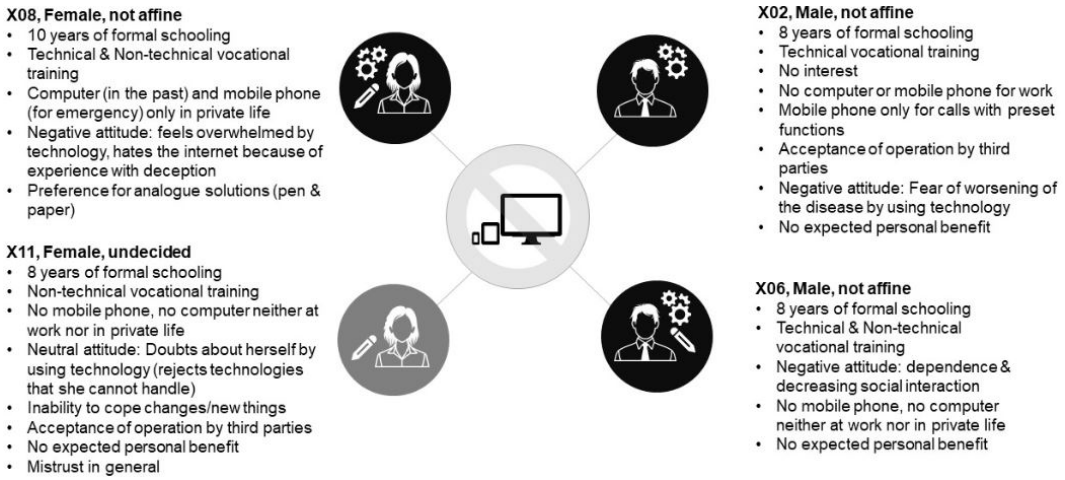

Figure 6. Characteristics of not technologically inclined interviewees.

About a third of participants (n=4) were still mobile by car and regional trains, six participants used bicycles and seven participants used the local public transport or were front-seat passengers. All participants were mobile by foot.

Figure 7 provides an overview of outdoor activities, divided into independent and accompanying activities. Participants reported engaging in certain types of activities either on their own, with their partners, or both. Tendencies to one side represent the degree to which each activity is done more frequently alone or accompanied.

Reasons for and importance of outdoor mobility
Reasons for leaving the house included the need for self-sufficiency, good weather conditions, interest in the living environment, or exercise. In addition, maintaining social relationships as well as having time for oneself were mentioned: *"I'm always happy when I can get out on my own. That I could be without his exaggerated vigilance."* (X08, L. 612-613). Additionally, independent activities were crucial for the partnership because they provided new topics for conversation and reduced conflicts: *"And I'm always really happy when I come out. (…) Before you get arguing at home."* (X08, L. 655-659). Reported destinations varied from forests, neighbours, and locations in the city, like doctor's or therapist's office, flea markets, and shopping malls.

Independence and self-determination were of great importance to most participants: *"I put great importance on it, that I decide all this myself"* (X14, L. 831-832). Eleven participants felt that their independence was severely restricted by physical impairment, fear of crime, shame caused by a lack of affective control, dependence on local transport (with frequent changes), lack of leisure offers, accompaniment, and necessity. Sometimes, the partner played a role in this: *"I have a bike, but I haven't been riding for a while. My wife doesn't want to."* (X13, L. 458-459) and *"Well, going for a walk, my wife's not happy about it right now. Because we've also had times// I didn't come back."* (X13, L. 381-382). This participant was the only one who had neither coping strategies in case of disorientation nor a mobile phone.

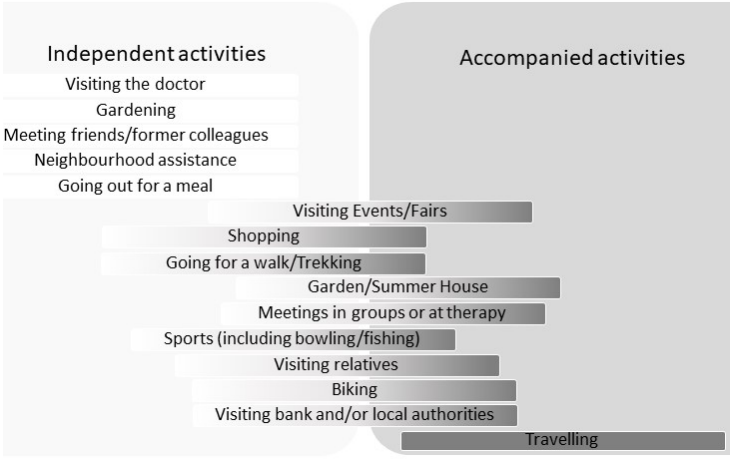

Figure 7. Independent or accompanied outside activities and degree of overlap.

Disorientation and coping strategies
In total, six participants reported situations of disorientation (*Figure 8*). The main factors for upcoming disori-

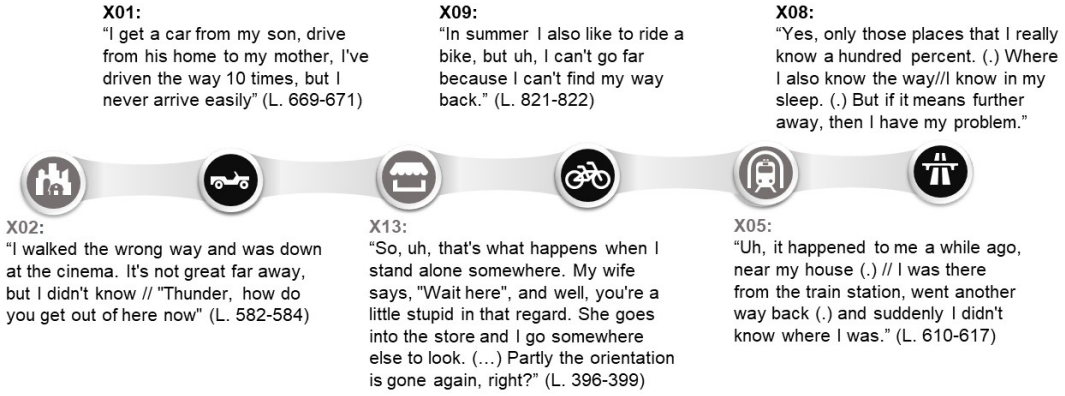

Figure 8. Reported situations of disorientation.

entation were unfamiliar, confusing surroundings, darkness, inattentiveness, lack of concentration, and high velocity i.e., by using the car. Disorientation was caused by struggling to relocate their bicycles or cars. Some participants described that their cognitive skills depended on their day-to-day psychological well-being.

To cope with disorientation, participants used different strategies, such as exact planning of the routes with the public transport departure times; using familiar, already learned routes; asking passers-by for direction; going accompanied and carrying a mobile phone as an emergency call possibility.

Requirements for the usability of a device

Mobile phone usage

There was high variability in how participants used their mobile phones. About three quarters of participants with mobile phones (9/11) used their phones to make calls, two of them limited the use to emergency calls. Out of the eleven, four used messaging services such as SMS, WhatsApp, E-mail, weather apps, Google Maps, the alarm clock, and the camera function.

Difficulties in operation arose from small touch screens, complicated menus, problems seeing the screen in sunlight and difficulties remembering the password/PIN to unlock the phone. Seven interviewees indicated that these problems prevented them from using mobile phones.

Readiness and design requirements for a navigational assistive technology

Despite the difference in affinity for technology, all participants provided ideas for the development of navigational assistive technology. Further, twelve of the interviewees were interested in using such a device: *"Yoah, I think that at some point you will be ready again. They are always working on something like that, but I am already// would be interested in something like that." (X02, L. 807-809)*. The two non-interested participants refused it due to a lack of necessity (X10, no disorientation experienced), mistrust, or a preference for non-technological assistance (X11). The interviewees reported that they would be interested in using assistance systems to support their health, well-being, and sense of security. In addition, independence, the maintenance of independence as well as mobility were highlighted.

Nine interviewees stated that they would prefer their navigational assistive technology to be on a smartphone, six preferred the format of a watch and one stated that the format of a tablet would be most convenient (participants named more than one device). The smartphone was chosen because of its size, the watch because it does not attract attention and can be worn at all times. Interestingly, two participants suggested that a device in form of a pendant on a necklace would be handy.

Nine interviewees stated that they would prefer using their assistance via a touch screen and three said they preferred a key panel. Two participants opted for voice control and one reported preferring pen control. One interviewee recommended adapting the display format based on the dementia stages and the associated cognitive problems. In addition to the design, interviewees listed further system functions they viewed as important: a reminder function, emergency calls, calendar, timetable for public transport and location display, watch, navigation, GPS, notes, and alarm function.

Clear functions, a large display, easy operation, robust construction, and audio support were also emphasized. The possibility to try out the device was important as the interviewees could not imagine its usability and benefit due to a lack of experience.

When presented with samples of display layouts there was some variation with respect to participants' preferences. One person opted for version 1 of the sample layouts, five persons each

Table 4. Quotations that express the feeling of shame and coping ideas.

Feeling of shame	Ideas to cope with shame
"I mean, if someone knows that I have dementia, well, it's, uh, sometimes problematic, because then they think, I'm stupid and have to talk to me like a mental patient, but, uh, that's ignorance and I can't do anything about it, no." (X01, L. 891-894)	"That's, uh, uh, first of all, uh, the environment is interspersed with it, because people are all running, whether young, whether old//it's of course different things that they perceive and music or something like that//So, so that wouldn't bother me" (X07, L. 837-840)
"You have to keep in mind that we know (…) the dementia patient is aware that he is noticeable everywhere. And if we assume so, then he's not going out in the public road with a device like that." (X06, L. 910-919)	"They might think I'm a foreigner or something. (…) That's mine, my navigation system. I don't know my way around here, I'm not from here." (X09, L. 1746-1769)
"Well, I'm a little embarrassed then, right?" (X03, L. 1548-1549)	
"Nah, you can see that. Then the other people know" (X09, L. 1430)	

for version 2 and 3, and three for version 4. A third of interviewees (n=4) addressed feelings of shame and fear of stigmatization when using navigational assistive technology (*Table 4*).

As a result, it was recommended to use commercially available navigation functions with audio support via headphones. This would facilitate the use of assistance systems by providing an important degree of discretion in public.

Discussion

The results of this qualitative research show that people with dementia are in a position to voice their needs and preferences and that their experiences and perspectives contribute key aspects to the development of future navigational assistive technology. This highlights the value of qualitative approaches allowing researchers to examine questions outside the boundaries of predefined questionnaires, which is especially important for the development of new support systems. Our sample of participants represented a diverse group with respect to demographic and cognitive variables (e.g., age, cognitive impairment, gender). This allowed us to examine views from a diverse group of individuals with varied needs and preferences. Based on data saturation, a sample size of 14 was deemed sufficient in our study. Moreover, similar previous studies examining users' needs to assistance technology for dementia had a similar sample size (Span et al., 2013).

The results show the importance and value of self-determined mobility and independence in daily life. They provide important information with respect to preferred device designs, the means of transport used, and the consideration of environmental factors, for example, darkness, that lead to disorientation.

The results of this qualitative research also support the findings of other studies and show that participants' statements are valid despite their cognitive impairment. Numerous inductively formed categories show the broad response spectrum of the participants and underline the added value of the qualitative research approach for device development.

Outdoors, our participants moved within the expected range for people with dementia (Tung et al., 2014). But two of them also went for regular walks in a forest. A sufficient strength of the GPS-signal to localize the persons in this special area must be ensured. The results of our study for participants' orientation difficulties support the findings by Pai & Jacobs (2004). Our interviewees were able to reliably report on situations of disorientation despite their cognitive problems. Although eight participants previously worked in a technological profession and most of those had experience with navigation systems (n=6), all interviewees stated that they did not use such systems to compensate for their orientation problems. This might point to deficits in the usability of currently available systems for people with cognitive impairments. Therefore, the following recommendations can be considered:

Increasing perceived benefit

We found that maintenance of self-determination, autonomy, and safety were crucial motives for people with dementia to use navigational as-

sistive technology. Against this background, an autonomy-focused system should respect the prioritized needs to ensure users' acceptance (Venkatesh & Bala, 2008). The functions need to be adaptable to serve individuals' needs, abilities, and circumstances.

The participants had difficulties identifying the benefits of using assistive technology devices. Furthermore, the ability to manage technological devices in daily life decreases for people with MCI or dementia (Malinowsky, Almkvist, Kottorp, & Nygård, 2010). In our interviews, the crucial factor for technology use was the affinity for technology, not MMSE or age. Therefore, to increase the habitual use of technological devices and a positive attitude, practical testing and training are necessary to examine and address barriers and incorporate facilitators. Our interviewees expressed their interest in such training programs. Also, Megges and colleagues, demonstrated the benefit of testing devices to examine the motivation to use an assistance prototype (Megges et al., 2017). For the future development of navigational assistive technology, we strongly recommend including people with dementia as co-designers to optimize outcomes and impact of such investigations (Tsekleves et al., 2018 & Teipel et al., 2016). Also, the interest in technology and its benefit should be promoted especially for people with a neutral attitude toward modern technology by offering public workshops or support courses. For the three non-technologically inclined participants, technological assistance may not be suitable. But the boundaries between technologically inclined and non-technologically inclined persons are fluid and the affinity might be changed by an individualized consultancy.

It cannot be determined if the negative attitude leads to a lack of using modern technology or the other way around. Future people living with dementia may experience a heightened inclination towards technology because of the increasing need to use it at work and leisure (Statista, 2019). Also, the relatives play a central role for using or avoiding technological devices. Thus, the relatives need to be included in the training and promotion efforts.

Increasing usability

Moreover, the technological navigation assistance should be usable and maintained independently by the person with dementia to increase motivation and confidence. Similar results were found by Megges and colleagues (2017). Increased training opportunities for individuals to use technological devices may reduce the barriers identified in this study, thereby increasing the use of assistance systems. Besides the implementation of training opportunities, individual compensation strategies should be promoted. Consistent with the simplicity of the devices' control, interviewees commented that the display panel (10 interviewees selected versions 2 & 3) should be more abstract, i.e., contain fewer details.

Removing barriers

According to our results, and consistent with earlier reports, barriers for use were high costs, difficult and unsuccessful handling of the device, and the lack of perceived added benefit (Boger, Quraishi, Turcotte, & Dunal, 2014). In line with this, our results highlighted the need for low costs, ease of use, familiarity, and portability as well as opportunities to strengthen and ensure acceptance by a perceived benefit. The fear of stigmatization and the users' sense of shame also played a role in our and the previous study (Boger et al., 2014). Moreover, there were device aspects, such as sufficient size, which Span and colleagues had also reported before (Span et al., 2013). In summary, the aim should be a simple, intuitive operation with a focus on the needs of the users in mind.

Strengthening self-efficacy and confidence by mobility

Local transport is a crucial part of participants' mobility. Problems often arose by frequent changes of train or bus. A navigational assistive technology should regard this problem and secure the usage of the most direct connection and a smooth change-process.

Disorientation reduces the life space of people with dementia if they have no eligible coping strategies. Relatives increase participants' life space as well as their independent mobility i.e. by committing their loved one to use a mobile phone. Along the same lines, relatives' exaggerated surveillance and fear of their spouses getting lost may limit the independence and self-determination of the people with dementia. Therefore, also training for relatives which provide technological and non-technological coping strategies for their spouses getting lost are useful.

Their mentioned fears of unfamiliar routes and disorientation could be addressed with the help of the navigation assistant. The assistant should support the individual to maintain independence, promote mobility and, if necessary, inform the partner if help is needed.

Strengths and limitations

Qualitative approaches allow an in-depth examination of participants' daily mobility and reasons towards or against technology use which may apply to similarly characterized groups of people with dementia. Many challenges for modern technology use were pointed out which may be

overcome by individual training offers and long-term technological support.

Interviews offer the advantage of compensating for disease-specific symptoms by paraphrasing or clarifying specific questions. In qualitative research, the researcher is seen as an instrument (Patton, 2002). The quality of the interview guideline, depth of participants' answers, and valid interpretation of the data depend on the interviewers' experience.

The interview guideline was based on the TAM and mainly focused on technology use. In the future, the affinity for technology should be put more in the foreground, i.e. by using the recently published Affinity for Technology Interaction Scale (Franke et al., 2019). Since affinity for technology is not uniformly defined (Franke et al., 2019) a clarification of the term and an explanation to the interviewees is needed in future investigations.

To accommodate participants' special needs, interviews were conducted by dementia-educated interviewers, who strengthened the participants' self-confidence. The interview was adopted to the degree of participants' cognitive abilities. Showing participants options of a future device helped their understanding of the concept of a navigational assistance technology as well.

Social desirability bias can be increased through direct contact with researchers and the resulting temporary lack of anonymity. The interviewers tried to create a rapport during the interviews to ensure that participants feel comfortable answering honestly.

Triangulation by involving caregivers and other experts would be useful for further investigation and is already in progress. Also, an affinity for technology for people with dementia is poorly researched and should also be focused on in future investigations.

Implications

On mobility behaviour

Despite participants' cognitive impairment, valuable results were obtained on mobility behaviour, on participants' experience with technology, and on their ideas regarding the equipment characteristics of a navigational assistive technology for external mobility in dementia. The interviewees named independent mobility as a basic need and felt that it was restricted by the disease.

On navigational assistive technology

Recommendations for navigational assistive technology for people with dementia, according to our participants:

Functional recommendations

- Built-in security features (e.g., emergency button or localization tools)
- Easy-to-read touch screen (large letters or symbols as well as sufficient brightness and antireflection coating)
- Individual programming of functions and displays (e.g., an app for public transport only for people who use bus/train/tram)

Design recommendations

- Inconspicuousness of the devices' design which is similar to mainstream devices (e.g., smartphone, a watch, or a necklace)
- Clearly structured display formats (e.g., clear symbols or easily structured menus)

Recommendations for training und technological support

- Intensive and regular examination of technological equipment (e.g., provide a permanent technological contact)
- Regular training with the integration of self-chosen compensation strategies
- Integration of the relatives in training and compensation strategies.

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Research ethics and patient consent

- For this qualitative study, a positive ethics vote of the University Medical Centre Rostock (Nr.: A 2013-0072) had been obtained.

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