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Navigation for People with Mild Dementia

Marike HETTINGA[a,b,1], Johannes DE BOER[b], Eli GOLDBERG[c], Ferial MOELAERT[b]
[a] *ICT-Innovations in Healthcare, Windesheim University of Applied Sciences, Zwolle, The Netherlands*
[b] *Novay, Enschede, The Netherlands*
[c] *Department of Human Centered Design & Engineering, University of Washington, Seattle, USA*

Abstract. Community dwelling is a problem for people with dementia. Can GPS route navigation support on a mobile device provide a solution? In a small scale exploratory research with this target group we studied the effects of two different types of audio instructions and assessed the pedestrian safety while operating the device. Methodological issues that limited the size and scope of data collection notwithstanding, evidence of unsafe behaviour was not found. Navigation instructions spoken by a familiar voice seemed to have a positive impact on the effectiveness of the navigation system, while the use of warning sounds seemed to have the opposite effect.

Keywords. navigation, GPS, dementia, safety, user interface, community dwelling

1. Introduction

Mrs. de Vries, an active 72 year old lady, suffers from mild dementia. Although living with her husband, she still likes to go out by herself for a walk to the park. Recently she lost the way for the first time: she was not able to find her house when returning from the park. Could navigation support be a solution for people like Mrs. de Vries?

This case was the starting point for a small pre-test: two people with mild dementia walked a predefined route with help of visual and auditory navigation instructions from a PDA. These instructions were given via the Wizard of Oz method: the navigation system was not working, but simulated. From this pre-test we learned that navigation support seemed indeed of value for this target group. The pre-test also raised a concern: is it safe to let people with mild dementia walk independently with navigation support? This concern was based on the observation that one of the participants crossed the street without paying attention to the traffic: he was looking at the mobile device.

We set up a small scale exploratory experiment in which four participants walked in total 14 routes with navigation support (TomTom). We studied the safety of the participants and the effects of two types of audio instructions: with unfamiliar (default) voice, familiar voice, warning sounds before an instruction and no warning sounds.

This experiment was a preparation for a large scale field test of the COGKNOW project: a European project which aims at developing a user-validated cognitive

[1] Corresponding Author: Marike Hettinga, PO Box 10090, 8000 GB Zwolle, The Netherlands; E-mail: m.hettinga@windesheim.nl.

prosthetic device (stationary and mobile) with a broad range of services to support people with mild dementia (www.cogknow.eu).

2. Relevant Literature

Dementia is a progressive disease affecting cognitive functions. The most commonly known symptom is the loss of memory. In an early stage of dementia people also lose spatial and topographic orientation [1, 2]. This results in problems finding their way home and because of their topographical disorientation, interpreting a map is not feasible. Hence, the informal carer often accompanies the person with dementia. A suitable navigation system could partly relieve informal carers. Additionally such a navigation system could motivate persons with dementia to go out for a walk which may have a positive effect on cognitive functions [3].

Perhaps due to the newness of portable navigation devices, scientific studies surrounding safety issues in their use by individuals with dementia could not be found. Thus, we focused the safety question on cognitive performance: what cognitive impact may occur when an elderly individual's attention is divided between navigation and the operation of a portable navigation device? An abundance of research suggests that senior citizens – and especially senior citizens with cognitive impairments – suffer especially diminished task performance in divided attention/dual-task scenarios [4–8]. This research encompasses dual-task scenarios involving second tasks that are purely cognitive, as well as the hybrid cognitive-motor second task of walking. Thus, we may expect participants to experience "cognitive overload" symptoms while simultaneously operating the navigation device and performing ambulatory tasks more complex than simple, linear walking.

We learned that for navigation instructions an audio prompting-system would be of best benefit to persons with cognitive impairments [9]. Studies on which type of audio prompts are most effective, were not found. Studies on the recognition and the memory storing of familiar voices [10, 11] made us want to explore the use of familiar voices in audio prompts for navigation. Furthermore, we learned that the use of sounds – earcons, or warning sounds – can help communicate more effectively with interfaces of mobile devices [12]. This finding led us to question whether these warning sounds could also be of benefit in navigation support.

3. Methodology

Four participants each walked four pre-defined pedestrian routes of approximately 20 minutes each, varying from .89 km to 1.16 km. Every route contained the same number of decision points and the same difficulties in decision points. Participants were randomly assigned to a certain order of routes and audio conditions. To prevent learning effects participants walked the routes on two days with a multi-day gap in between.

The used hardware consisted of PDA's from HTC, type P3300. To hide all hardware buttons a metallic case was put around the PDA. Participants could choose between hanging the device around their neck with a cord, or just hold it in their hands. As navigation software we used the TomTom 6 SDK engine and adapted it for maximum simplicity for the target group: showing no menus, functions, and status bars, except the remaining distance to the next decision point. Furthermore, we put the TomTom interface on arrow navigation.

All participants were 55 years of age or greater, and were required to score between 17–25 on the Mini Mental State Evaluation (MMSE) test of cognitive impairment [13, 14], signifying mild dementia. All participants were able to walk at a "normal" speed; all but one participant used a walker. One of the four participants declined to further participate after the multi-day break.

Data collection during the experiments was done by two researchers who walked along. The first observer trailed each participant while taking observation notes. He also conducted a mid-route interview on task load and an interview afterwards on user preferences. The second observer was responsible both for data collection on participant safety, and for raising an alarm in the event of imminent traffic safety risks to the participant. Data collection on participant safety raised complications: in-situ coding was abandoned after a pilot test revealed that the observer was unable to concurrently remain alert to participant safety risks. Several video cameras were tried. Ultimately, a total of 2 hours and 36 minutes of video were collected with a second regular video camera, encompassing 4 of the 14 participant sessions.

Data analysis on unsafe walking behaviour consisted of coding the videos on 5 variables (see Table 1). Data analysis on audio conditions focused on Effectiveness (see Table 2 for variables), User satisfaction, and Load on working memory. User satisfaction was measured with 5 questions (5-point scale) on user preferences per audio condition. Load on working memory was measured by an adapted version of the NASA Task Load Index (TLX) [15].

4. Results

For all results mentioned below we point out that the number of participants was small and hence quantitative results are not generalisable. In compliance with the exploratory nature of the studies, the quantitative results are indicative.

It is noteworthy, in the observer's dual-role as a safety monitor for the participant, that at no point during the coded studies did the observer feel it necessary to warn the participant of any lurking dangers unseen by the participant.

Table 1. Results on unsafe walking behaviour

Behaviour	Observation results (4 routes by 3 different participants)
Stopping in device use	17% (21/123) of the voice prompts was followed by participant stopping.
Difficulties in walking	Only a single instance of walking-related difficulties was observed, which occurred while walking through a shopping centre sidewalk. The participant was neither using the device, nor had she recently done so.
Looking at the navigation device	Participants did not look at the device constantly, they glanced occasionally: on average 9.5 times per route.
Navigation instruction while crossing	In the coded sessions this occurred three times. The first two times the participants did not slow or otherwise respond to prompt. The third time the participant looked at the device afterwards while in the intersection, but appeared to do so without any pause in walking.
Street crossing behaviour	In 84% (41/49) of the intersection crossings participants explicitly looked before crossing.

The results in Table 1 indicate that no evidence was found of unsafe walking behaviour with navigation support. The 84% (41/49) of participants looking before

Table 2. Average results on effectiveness calculated per audio condition per route

variable			results per audio condition per route (14 routes by 4 participants)			
			unfamiliar voice	**familiar voice**	**without warning sound**	**with warning sound**
Effectiveness	***Task duration***	*walking time [min:sec]*	16:53	16:27	15:53	16:58
	Errors	*number of route deviations*	1.00	0.67	0.43	1.29
		number of repeated instructions	1.50	1.00	1.00	1.57
	Requested assistance	*number of asked questions*	1.67	1.33	2.14	1.00
Load on working memory		*TLX score [5–25 points]*	13.58	13.09	13.74	13.70
User satisfaction		*average preferences [1–5 points: from very negative to very positive]*	3.67	3.67	3.51	3.74

street crossing was compared with a later conducted control study where participants walked without a navigation device. In this study in 79% (15/19) of the street crossings participants explicitly looked before crossing. Although statistical tests were not employed, this percentage is in the ballpark range of device users, and suggests that the presence of the navigation device may not bring a substantial change in street crossing behaviour.

Looking at the results on audio conditions in Table 2 we see that participants overall scored better in the familiar voice conditions than in the unfamiliar voice conditions. Therefore we expect that there is a small positive benefit in using familiar voices in navigation systems for people with mild dementia. We also see that participants experience a lower workload on working memory in familiar voice conditions. Participants do not have a preference for instructions by a familiar or unfamiliar voice.

Remarkable in the results is that the use of warning sounds almost always results in worse achievements of the participants than when no warning sounds are used. Although the differences are small, warning sounds seem to have a negative effect on the quality of way finding for people with mild dementia. The load on working memory is equal for both audio conditions, but the preference of the users is for instructions with a warning sound.

5. Conclusion and Discussion

Navigation support on a mobile device can be used by people with dementia. In our small scale exploratory research we found no evidence of unsafe walking behaviour of people with mild dementia receiving navigation support. Using familiar voices for the navigation instructions may have a positive impact on the effectiveness and on experienced work load. The use of warning sounds, although appreciated by the users, seems to have a negative impact on the effectiveness of way finding.

These conclusions must be put in the perspective of the exploratory nature of this study. Only a small number of people with mild dementia participated in the studies.

The results may give an indication, but for generalisation purposes need to be repeated in a large scale research.

Our study essentially relied upon discovering participant risks through firsthand observation: we placed participants in an ecological setting, prepared to intervene should any actual participant safety danger transpire. However, no such dangers occurred during our three hours of study. Therefore, for future safety studies we must determine how pedestrian behaviour may be studied in a higher-traffic or automobile-centric neighbourhood without actually placing participants at risk.

Future studies should also look into navigation systems that may prevent unsafe situations. For example by means of technologies such as an active attention management system which prevents the GPS device from creating participant interruptions during the higher-risk activity of crossing a street.

Our follow-up research will focus on the use of 'social navigation': people with dementia press an emergency button when they get lost and the informal carer sees the location of the person on a map and through a phone connection can guide the person home. The safety benefit of this application is that the informal carer can instruct and warn the person with dementia for any unsafe traffic behaviour.

References

[1] Cherrier, M.M., Mendez, M., Perryman, K. (2001) Route learning performance in Alzheimer disease patients. *Neuropsychiatry, Neuropsychology and Behavioral Neurology* 14(3):159–168.

[2] Alzheimer's Disease International. (2007) *Early Symptoms of Dementia – Alzheimer's Disease International* (n.d.), http://www.alz.co.uk/alzheimers/symptoms.html.

[3] Uffelen, J.G.Z. (2007) *Prevention of Cognitive Decline, Effectiveness of Physical Exercise and Vitamin B Supplementation*. PhD Thesis, Vrije Universiteit Amsterdam, the Netherlands.

[4] Baddeley, A.D., Baddeley, H.A., Bucks, R.S., Wilcock, G.K. (2001) Attentional control in Alzheimer's disease. *Brain* 124:1492–1508.

[5] Camicioli, R., Howieson, D., Lehman, S., Kaye, J. (1997) Talking while walking: The effect of a dual task in aging and Alzheimer's disease. *Neurology* 48(4):955–958.

[6] Oxley, J., Charlton, J., Fildes, B. (2005) The effect of cognitive impairment on older pedestrian behaviour and crash risk. http://www.campusglobal.org/muarc/reports/muarc244.pdf.

[7] Sheridan, P.L., Solomont, J., Kowall, N., Hausdorff, J.M. (2003) Influence of executive function on locomotor function: Divided attention increases gait variability in Alzheimer's disease. *Journal of the American Geriatrics Society* 51(11):1633–1637.

[8] Verghese, J., Buschke, H., Viola, L. et al. (2002) Validity of divided attention tasks in predicting falls in older individuals: A preliminary study. *Journal of the American Geriatrics Society* 50:1572–1576.

[9] Fickas, S., Yao, X., Sohlberg, M., Hung, P.F. (2007) Route-finding assistances for community travelers with cognitive impairments: A comparison of four prompt modes. Unpublished manuscript (Available from Mobile HCI 2007, In-situ 2007: Accepted papers, http://insitu2007.freeband.nl/docs/papers/Fickas_InSitu2007.pdf).

[10] Nakamura, K., Kawashima, R., Sugiura, M., Kato, T., Nakamura, A., Hatano, K., Ito, K. et al. (2001) Neural substrates for recognition of familiar voices: a PET study. *Neuropsychologia* 39(10):1047–1054.

[11] Winkler, I., Cowan, N. (2005). From sensory to long-term memory – Evidence from auditory memory reactivation studies. *Experimental Psychology* 52(1):3–20.

[12] Brewster, S.A., Wright, P.C., Edwards, A.D.N. (1993) An evaluation of earcons for use in auditory human-computer interfaces. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 222–227.

[13] Folstein, M.F., Folstein, S.E., McHugh, P.R. (1975) Mini-mental state: a practical method for grading the cognitive state of patients for the clinician. *Journal of Psychiatric Research* 12(3):189–198.

[14] Molloy, D.W., Alemayehu, E., Roberts, R. (1991) A standardized mini-mental state examination (SMMSE): Its reliability compared to the traditional mini-mental state examination (MMSE). *American Journal of Psychiatry* 148:102–105.

[15] Hart, S.G., Staveland, L.E. (1988) Development of NASA-TLX (Task Load Index): Results of empirical and theoretical research. *Human Mental Workload* 1:139–183.