PREFERENCES FOR INTERFACE DESIGN FOR A NAVIGATION ASSISTANT ON A WHEELED WALKER

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INTRODUCTION

Since cognitive decline, physical impairment, and sensory degradation may reduce older adults' ability to walk steadily and find their way in familiar and unfamiliar environments, we are developing a navigation assistant, or *i*Walker, described in detail elsewhere [1], a modular, rollator-mounted, wayfinding system. As part of the iterative design process, we have engaged selected stakeholders, namely staff working with frail older adults and older adults themselves, in a series of focus groups. Here we describe the methods and findings from our investigation of stakeholders' views about who might benefit from such robotic assistive technology and their preferences for selected interface designs.

BACKGROUND

As people age, they experience changes in cognitive processes that affect their ability to acquire and use information about the spatial structure of their environment [2]. Compared with younger counterparts, older adults are poorer judges of their wayfinding abilities and their perceptions of distance [3]. Such deficits contribute to reduced mobility and affect autonomy and self-esteem [4]. Older adults with visuospatial disorientation and wayfinding difficulty must rely on others for guidance wherever they go. Further, their caregivers have little more than random observations to help estimate the amount of physical activity these individuals engage in, the speed at which they move along frequently-traveled routes, and whether they make mistakes during navigation.

Though not a normal consequence of aging, wayfinding difficulty may result from progressive neurodegeneration caused by a variety of dementing disorders including Alzheimer's disease (AD) [5], Parkinson's disease, and multiple sclerosis [6]. Among individuals with the most common of these disorders, dementia of the Alzheimer type, memory impairment is a cardinal, early-stage sign, as are disorientation and wayfinding difficulty. Performance of tasks that require spatial planning, spatial memory, decision making, and mental representation is impaired [7]. Thus, the return trip from a destination poses as much of a challenge as finding it in the first place [4]. Wayfinding difficulties typically first become evident in journeys to unfamiliar locations far from home. They worsen as intellectual abilities decline, with navigation problems surfacing first at the neighborhood level and then closer to home. In the late stage of AD, moving about independently in the most familiar surroundings is not possible [8].

Several navigational mobility aids based on walkers are currently in development, including the Personal Aid for Mobility and Monitoring (PAMM) [9], the Personal Adaptive Mobility Aid (PAMAID) [10], an intelligent system based on the Care-O-bot [11], and the Intelligent Mobility Platform (IMP) [12,13]. The *i*Walker we are developing differs from these in that it offers navigational guidance using a less expensive, smart-world perspective gleaned from sensor-embedded mats located in the environment. Since we are targeting users with adequate vision, our navigation assistant is not equipped to avoid obstacles. It will, however, capture data regarding walking speed, route, and distance, enabling users and caregivers to monitor ambulation behavior over time, based on illustrated feedback that may serve as an incentive for increased physical activity.

METHODS

To optimize the usability of the wayfinding system we are developing, we invited staff and clients from Community LIFE, Inc., a senior services agency in southwestern Pennsylvania that provides on-site and in-home supportive services to frail older adults in the community, to take part in a series of focus groups conducted during the first eight months of the project. The first focus group was conducted with staff within 10 weeks of initiation of the project. The second and third focus groups involved staff and clients, respectively, and occurred approximately six months later, after the first iteration of the *i*Walker had been built. Staff who took part in Focus Group I were permitted to take part in Focus Group II.

Focus group activities

Written informed consent and sociodemographic information were obtained from participants prior to initiation of focus group activities that took place in a conference room at the Homestead site of Community LIFE, Inc. With participants' permission, all discussion during each two-hour session was audiotaped.

Focus Group I: Staff. Using a PowerPoint® presentation for illustration, a member of our team (JTM) provided a brief overview of current walker designs and asked seven participants to imagine a device called a navigation assistant that could be attached to a wheeled walker, or rollator, and be capable of guiding people from one place to another while keeping track of the path they take. Participants were asked to identify conditions affecting clients who might benefit from such a modified walker.

Four scenarios were presented depicting elderly individuals whose ability to navigate independently was impaired due to specific medical conditions (e.g., Alzheimer's disease, stroke, traumatic brain injury, skeletal deformity due to osteoporosis) and complicated by varying life circumstances (e.g., living alone but requiring a companion when venturing out, recently moving to a retirement community with a complex indoor and outdoor layout, needing constant vigilance from a family caregiver due to impulsive behavior and disorientation). These scenarios provided a springboard for discussion about who might benefit from such technology and what interface designs for offering guidance cues might be helpful.

Focus Group II: Staff. After our first navigation assistant was constructed, members of our research team met with eight staff, including five individuals who had taken part in Focus Group 1. One of our team members (EFL) provided a brief explanation of the *i*Walker components (i.e., encoder, digital compass, radio-frequency [RFID] reader and antenna, touch-sensitive PDA screen) mounted on a commercially-available rollator, and he demonstrated its use in the hallways adjacent to the conference room where the focus group was held.

Participants were shown a series of interface options for guidance cues in sets of two to four, first projected individually as images in PowerPoint® and then depicted together on single pages of hard copy survey forms. They were asked to draw a vertical line through a visual analog scale (VAS)—a 100 mm. horizontal line anchored by *Not at all helpful* on one end and *Extremely helpful* on the other—to indicate how helpful they thought each option would be in offering guidance. The VAS value was measured as the distance between the left end of the horizontal line and the point where a participant's mark intersected the horizontal line. Participants were then asked to rank the interface options in each set from *Most preferred* to *Least preferred.*

Interface options included visual display of text or graphics on the touch-sensitive screen (e.g., text instructions, stationary vs. moving arrows, photos of landmarks along the route, colored shapes such as circles or icons for matching similar markers posted along the route, and maps) as shown in Figure 1 and Figure 2, issuance of human and non-human sounds

Figure 1. Sample visual display images

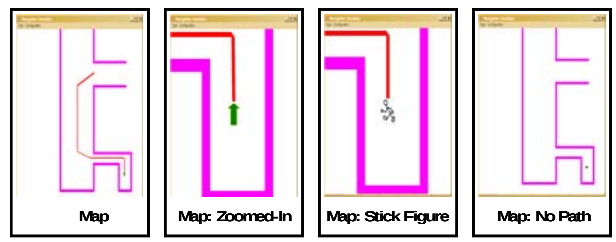

Figure 2. Sample map images

(e.g., voice, tonal alert prior to issuance of a cue) as listed in Table 1, and physical indicators (e.g., handle vibration, flashing turn signals, compass), either alone or in combination.

Table 1: Types of Audio Cues

Audio Cue	***Example***
Recorded voice	*"Turn right."*
Computer-generated voice	*"Turn right."*
Tone + voice	*<Ding> "Turn right."*
Voice with name	*"Helen, turn right."*
Voice with *Please*	*"Please turn right."*
Changing message	*"Helen, turn right… Please go straight… Now, turn left."*

Focus Group III: Clients. Five clients participated in this session, which began with the same explanation of components of the *i*Walker and demonstration of its navigational guidance capabilities. As with Focus Group II, these participants were shown each interface option and asked to mark a VAS, indicating their assessment of how helpful it would be in guiding someone from one place to another. Likewise, they were asked to rank order their preferences among options within each set, indicating their responses on hard copy survey forms. Due to the slower pace at which these participants completed each task within the time allotted for the session, only selected interface options for guidance cues involving visual display, sound, and physical indicators, either alone or in combination, were considered.

Data collection and analysis

Sociodemographic data were self-reported and gathered using a codesheet developed by the Center for Research in Chronic Disorders at the University of Pittsburgh. Participants in Focus Group III who had difficulty completing their own codesheets were interviewed by a member of our research team (NRN) to ascertain the data. Audiotaped discussion from each focus group session was transcribed verbatim and subjected to content analysis to identify recurring themes.

FINDINGS

Ten staff, five of whom took part in both sessions, enrolled in Focus Group 1 and Focus Group II, including nursing, physical therapy, occupational therapy, and program support personnel. One participant in Focus Group I was called back to work before the first scenario was discussed, thus we excluded this participant's data from the group demographic profile (see Table 2). Both groups were predominantly female, white, married, and middle-aged, with greater than a high school education. Clients (n=5) who took part in Focus Group III were day program participants and were older, less educated, and more likely to be widowed and poor. Though fewer in number, they were proportionately more racially diverse than the staff.

Table 2: Demographic Profile of Participants, by Group

Characteristic	***Focus Group I: Staff (n=6)***	***Focus Group II: Staff (n=8)***	***Focus Group III: Clients (n=5)***
Age (yrs): *M/SD*	45.00/4.20	44/7.17	73.60/4.98
% Female	100	75	80
% White	67	75	40
% Married	83	75	40
Education (yrs): *M/SD*	14.00/2.28	15.30/2.95	11.25/0.97

Content analysis of transcripts revealed that staff in Focus Group 1 endorsed our concept of a navigation assistant as potentially helpful to persons with stroke, traumatic brain injury, early- to mid-stage Alzheimer's disease, macular degeneration, cataracts, and other causes of visual impairment. This endorsement was confirmed by participants in Focus Group II after demonstration of the *i*Walker. Among the recurring themes were suggestions for walkers that could not only guide people but also prompt their safe use, inform them of hazards in their paths, and help pace their physical activity.

Based on responses to the 100 mm. VAS, staff judged as most helpful: arrow + text, stationary arrow, tonal alert prior to issuance of a verbal cue, and sound + text + graphics. Clients preferred icons, zoomed-in maps, photo images, color-coded graphics [circles, triangles] matched to environmental landmarks, and cues delivered using a tape-recorded human voice (see Table 3). Staff considered having the capability to

Table 3: Preferences and Rank Ordering of Sets of Interface Options, by Group

	Focus Group II: Staff (n=6*)		***Focus Group III: Clients (n=5)***	
Interface	*M/SD*	#1	*M/SD*	#1
Arrow	74.7/20.9	0%	57.9/30.6	20%
Text	31.7/25.0	0%	71.8/21.9	20%
Arrow/text	83.6/11.9	100%	70.9/22.3	60%
Rotating arrow	54.2/29.7	50%	57.3/27.7	60%
Flashing arrow	60.1/22.0	50%	62.1/28.8	40%
Photo	41.5/10.6	33%	76.3/6.0	0%
Text + circle	42.0/26.7	17%	75.4/14.6	40%
Icons	66.5/23.5	50%	82.0/11.6	60%
Map	73.2/8.0	17%	73.2/8.1	**
Map: Zoomed-in	57.7/25.9	83%	78.0/10.3	**
Map: Stick figure	29.9/23.4	0%	66.4/25.5	**
Map: No path	16.22/9.9	0%	56.3/39.2	**
Voice: Recorded	56.1/25.05	17%	73.9/19.0	**
Voice: Computer	63.5/19.26	17%	67.1/13.5	**
Tone + voice	72.6/19.4	67%	57.7/20.6	**
Voice w/name	67.7/33.0	100%	60.2/30.4	**
Voice w/please	52.4/24.4	0%	46.1/30.4	**
Changing message	40.5/29.5	0%	54.1/27.7	**
Sound + graphic	69.1/22.2	17%	**	**
Sound + text	49.3/30.6	0%	**	**
Sound + text + graphic	69.6/30.6	83%	**	**

*Data excluded for two staff unable to stay for entire session
**Data not ascertained due to time limitations

adjust settings for contrast, brightness, and volume as more helpful (*M/SD*=84.1/10.6; 50% ranked as *Most preferred*) than mounting a compass on the walker (*M/SD*=39.6/26.0) or adding turn signals (*M/SD*=58.5/ 24.6) or vibrating handles (*M/SD*=51.6/35.4). Clients, in contrast, rated turn signals as most helpful (*M/SD*=82.1/14.3) among physical indicators.

DISCUSSION

Preferences for interface options designed to provide navigational guidance to individuals with wayfinding difficulty varied considerably between staff who work with frail older adults and older adults themselves. It should be noted, however, that both groups frequently qualified their written responses with verbal anecdotes about how persons with certain conditions or functional characteristics (e.g., low vision, hearing impairment, easy distractibility, impulsiveness) might benefit—or not—from a particular interface.

We recognize that participants in Focus Group 2 and Focus Group 3 were asked to evaluate the potential helpfulness of each interface option separately and that they were asked to indicate their preferences for small, thematically-grouped sets of interface options rather than for each option in relation to all others. We took the former approach because we thought that the latter would be difficult, if not impossible, for staff to perform, and we anticipated that it would be even more difficult, if not impossible, for older adults.

Though we knew neither the health history of any of our participants nor any clinical information regarding their cognitive and physical functional status, our casual observation of the verbal and non-verbal reactions of participants in Focus Group 3, in particular, led us to surmise that deficits in attention and memory, reading ability, and hearing and vision were present among several in this small group. In our judgment, it is likely that these deficits contributed to diminished ability among some of the clients to address the task at hand in a nuanced fashion.

Further, we recognize that since the number of participants in our focus groups was small, our quantitative findings may be unstable and should be interpreted with caution. Nevertheless, our findings suggest that the ideal navigation assistant should offer an array of interface options that include simple text and arrows or other graphics, tonal alerts prior to cues, and voice prompts to help older adults compensate for wayfinding difficulty associated with brain disorders and sensory deficits more frequently experienced in old age.

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