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An Investigation of Ways to Support Older Adults when Using Mobile Interfaces

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Abstract
In this paper, we describe a study designed to examine the effects of modality, target size and other design features on task performance. The study has specifically focused on older adults when accessing a mobile interface. Twelve participants (aged 55-89) conducted a set of pointing and steering tasks. Targets 32px in size were found to be most effective to support pointing performance, while targets 64px in size assisted older adults when performing steering tasks. Shorter lasting steering tasks (6 seconds) were performed with lower levels of error compared with 12 second tasks. Guidance from the study offers a reference point for mobile developers interested in designing touch screen interfaces to cater to the needs of older adults.

Keywords: Auditory interfaces, mobile devices, multimodal interfaces, speech interfaces, touch screens
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1 Introduction

Mobile touch screen devices offer considerable promise to older adults. These technologies can be used to access and share information, and maintain contact with others while on-the-go. However, mobile applications developed to meet the specific needs of older adults, who may experience a decline in physical function, are limited in number. This is somewhat ironic as direct interaction with a mobile device using the finger offers a superior alternative to using a desktop device, if the user faces difficulties guiding a mouse or aligning the cursor with an on-screen target. To support the decline in sensory function associated with the aging process, design guidance suggests that larger targets can be implemented to improve cursor positioning accuracy among older adults (Caprani et al., 2012). The process of targeting objects may be challenging if interface objects are densely packed together, or in scenarios when layout is not optimized (Ziefle, 2010).

Researchers have found that auditory feedback can be used to assist older adults to identify when targets on an interface have been missed (Moffatt and McGrenere, 2007), or when erroneous data has been entered on an interface (Komninos et al., 2015). Auditory feedback presented alone or in concert with other modalities has been found to lead to improved performance on tasks which many users take for granted (e.g. drag and drop tasks (Emery et al., 2003)). These types of task are particularly challenging for older adults, due to the need to apply pressure to select buttons on the mouse, while moving the device at the same time. Research indicates that older adults tend to be more easily distracted, so auditory feedback may refocus them on the task at hand (Emery et al., 2003). Jacko et al. (2003) suggest that as auditory feedback can support users with computer-based tasks, and is relatively inexpensive to use, this provides a strong cost/benefit argument for integrating some form of auditory feedback into applications. However, further research is needed to understand the ways in which audio (both speech and non-speech auditory feedback) can be designed to support older adults when interacting with mobile touch screen devices, along with identifying the ways in which interface objects can be presented to improve the targeting process.

In this paper, we describe a study examining older adults' interaction with a mobile touch screen interface. While researchers have traditionally focused on manipulating target sizes and distance between targets to improve interaction, the novelty of our work focuses on the examination of using speech and non-speech auditory cues to support targeting by older adults on mobile touch screen interfaces (specifically tablet interfaces). The longer-term aim is to identify ways in which touch screen interfaces can be designed to better support the needs of older adults.

2 Related Work

2.1 Target selection using pen-based input

In terms of research involving pen-based interaction, Moffatt and McGrenere (2007) analyzed the difficulties encountered by participants of varying ages (18-54 year olds, 55-69 year olds, and 70-85 year olds) when performing tapping and menu selection tasks. The width of the target circle, the distance to the target, and the angle of motion were varied across trials. Findings from the tapping task suggested that speed and accuracy decreased with age. Older adult users were found to experience greater difficulty with slipping from smaller targets compared with larger ones, whereas slipping was infrequent for younger users across all widths. With the menu selection task, the researchers found that older adults “drifted” more than younger adults, where the pen accidentally hovered over another menu near the targeted menu, impeding task performance. Hourcade and Berkel (2006; 2008) explored the accuracy of three age groups (18-22 year olds, 50-64 year olds, and 65-84 year olds) when performing tapping, touching, straight-steering, and circular-steering tasks using a pen and a handheld computer. The researchers found that accuracy levels of 65-84 year olds were similar to the other two age groups when performing tapping tasks with 24 and 32 px targets. However, lower levels of accuracy were experienced when performing tapping tasks with 16 px targets. Touching was found to result in better accuracy than tapping, most significantly for 65-84 year olds. No significant differences could be identified in steering performance among the age groups. However, steering tasks appeared to demand a greater amount of attention from participants, and yielded lower accuracy rates.

2.2 Target selection using finger-based input

In more recent years, finger-based input has become more commonplace when interacting with touch screens. Findlater et al. (2013) compared the performance of older adults (61-86 year olds) and younger users (19-51 year olds). A set of mouse and touch screen tasks were presented where participants were required to perform the following activities: pointing, dragging, crossing, and steering. The researchers presented targets varying in width (48, 64, 96, and 128 px). In the pointing task, participants were asked to tap a target circle and in the steering task, participants were asked to start at an initial circle and steer through a rectangle. Similar to the findings of Moffatt and McGrenere (2007), older adults were slower than younger adults in performing these tasks. However, across dragging, pointing, steering and crossing, older adults’ movement times decreased by 35% when moving from the desktop to the touch screen; younger adults only saw a 16% reduction. The researchers concluded that the touch screen was able to reduce the performance gap between older and younger adults, compared to a traditional desktop set-up.

Kobayashi et al. (2011) conducted a similar study where participants (in their 60-70s) performed tapping, dragging, and pinching tasks, as well as other realistic tasks on small and large touch screen devices. For the tapping portion of the study, participants were asked to tap a rounded-square that appeared at random locations on the screen. Targets varied in size (e.g. 30, 50, or 70 px). The researchers found that 30 pixel targets frequently caused errors and increased the task completion times, while fewer errors were made when accessing larger targets. In terms of subjective preference, participants found the dragging and pinching tasks to be easier than the tapping task. Jin et al. (2007) conducted experiments to learn about the optimal button size and spacing for touch screens for older adults (53-84 year olds). Although older adults did not perform tasks with significantly greater accuracy when button size increased, the majority expressed a preference for larger size buttons, In terms of spacing, the researchers discovered that participants performed better when the buttons were located closer together – likely because more space led to more searching and travel time.

2.3 Target selection using auditory and multimodal feedback

Non-visual feedback has been used to replace or to supplement existing graphical feedback to support the targeting process. In a study described by Hwangbo et al. (2013), the researchers examined the impact of auditory, tactile and audio-tactile feedback when areas outside of the target area on an interface were selected. The greatest task completion time was found when tactile feedback was presented (33.26s), while the audiotactile feedback condition was performed in the shortest task completion time (24.0s). The fewest number of errors were made when performing conditions where audio-tactile feedback was presented (9.61). Interestingly, participants reported the highest levels of satisfaction when auditory feedback was presented via the interface (4.64), although the researchers conclude the multisensory feedback is a more effective solution than unisensory feedback for older adults.

Lee et al. (2009) compared unimodal, bimodal, and trimodal feedback with a numeric keypad tapping task with older adults (69-75 year olds). Findings revealed that both objective and subjective measures of older users' performance were enhanced by the presentation of bi- and trimodal (as opposed to unimodal) feedback including auditory stimulation. Vitense et al. (2002) examined how multimodal feedback could affect the performance of individuals with low vision when dragging and dropping using a mouse. Performance was measured in two ways: mental workload and performance time. Further, mental workload was measured in two ways: subjectively through a ranking of mental demand and physiologically through pupil diameter. In terms of objective mental demand, the trimodal feedback condition (audio, haptic and visual feedback) led to significantly smaller pupil diameter, indicating a lower level of expenditure of cognitive workload. However, in terms of subjective mental demand, the unimodal conditions as well as the bimodal haptic/visual condition were perceived to require low levels of mental demand. Results from the studies reviewed suggest that participants' satisfaction and comfort with the feedback should be taken into account in the design process, even if this may not be the fastest or most accurate method of selecting targets.

2.4 Characteristics of older adults

Mobile touch screen interface design should ideally account for the impacts of aging, particularly as sensory and psychomotor capabilities undergo decline. For example, to support deficiencies in levels of auditory acuity, Fisk et al. (2009) suggest that sounds above 4000 vibrations per second may be inaudible. Lower frequency tones (in the 500-1000 Hz range) according to IJsselsteijn et al. (2007) should be used, as these are easier for older adults to hear compared with higher pitched sounds. In terms of graphical feedback, the researchers advise against using small interface objects and font sizes as these may be difficult to detect. Fisk et al. (2009) suggest that declines in motor control may make it challenging for older adults to select moving targets. The researchers suggest that to estimate movement times, on average, older adults will be approximately 1.5-2 times slower compared to younger users. Their movements may be less precise and more variable, so design should ideally account for their abilities.

As research examining ways to present information via touch screen devices to older adults is limited in nature, we aim to identify ways in which interfaces can be developed to support the needs of this population, some of whom may experience a decline in sensory, motor and cognitive function. More specifically, we have designed an empirical study to identify the ways in which modality and presentation of targets affect performance when interacting directly with a mobile touch screen interface. The study examines both pointing and steering behavior among older adults. The long term goal would be to use findings from our studies to support the development of mobile interfaces for older adults.

3 Method

3.1 Objectives

This study was designed to explore the ways in which mobile touch screen interfaces could be developed to support older adults, through a set of pointing and steering tasks. We aimed to understand the impact of modality (visual, speech and non-speech auditory feedback), target size and other presentation features, with a view to optimizing interfaces to maximize interaction potential.

3.2 Participants

Twelve adults aged between 55 and 89 were recruited from a local residential community for older adults. When asked about difficulties with hearing, vision, and dexterity, abilities were found to vary. For the majority of participants, vision was corrected using glasses. Even when wearing glasses, participants suggested that magnification tools were used to read fine print (e.g. labels on bottles or other products). Examples of physical challenges faced by the participants included tremors, but the most prevalent issue reported by them was arthritis. Participants highlighted difficulties performing certain household tasks which younger adults may take for granted (e.g. opening door knobs, reaching for items etc.), and tasks where fine motor control was needed (e.g. sewing, buttoning clothes etc.). Only two of the twelve participants owned touch screen devices; technologies given to them by family and friends, which enabled them to stay in contact with their loved ones.

3.3 Apparatus and materials

A mobile application was designed for the Apple iPad[1]. The iPad 2 device was chosen for presentation as it offered a large display area which users could interact with through touch-based input (display: 9.7 inches (250 mm), resolution: 1024 × 768 px). The device was placed horizontally on a desk, directly in front of where the participant was seated. The height of the desk was adjusted to be at the participant's elbow when the arm was orthogonal to the ground. The device rested on a 20 degree incline from the table, as per the recommendation of Wacharamanotham et al. (2011). The application described in this study was developed using PhoneGap[2], and the cocos2d-iphone library[3] for the iOS platform[4]. Participants were encouraged to use their dominant hand to interact with the application. Spatialized headphones were used to perceive the auditory feedback presented by the application. The mobile application was designed to enable users to conduct both pointing and steering tasks. Feedback designed for the pointing and steering tasks are described in Tables 1 and 2. The application is described in further detail in 3.4.

3.4 Study design

A 3x2x3 repeated measures design was used for the pointing task. To access the application, a single button presented on the center of the screen would be selected. This would start the timer for the pointing task. Two further buttons (termed in this papers as "targets") would appear, arranged at the top and bottom of the interface. One button would be green in color, denoting that the user should select it. The other button would be colored gray. Each virtual button would alternate in color once successfully selected by the user, signaling that the other target should be tapped. Targets would vary in size (8, 16, and 32 px), and in distance from one another (128, and 256 px). Different forms of feedback (termed "modality") (visual feedback, combined visual and speech audio feedback, and combined visual and non-speech audio feedback) were also presented (Table 1).

The combined visual and speech audio condition used speech design guidance from a study by Kuber et al. (2011), where cues were presented at 60dB. For example, when the button towards the top of the interface was the intended target, it would turn green in color and the word "up" was presented. This would cue the user to select the target. Conversely, the word "down" was presented to indicate that the button at the lower side of the interface should be selected (Figure 1). For the combined visual and non-speech audio condition, the starting target (at the upper side of the interface) would turn green in color, and a high pitched sine tone would be presented. A lower pitch sine tone would cue the user to select the target towards the lower side of the interface. The audio cue (earcon) lasted for 300 milliseconds. In total, 18 conditions were presented. Each was performed ten times by participants. The 18 conditions were presented in randomized order. Task time was recorded from selection of the first target to when the final target was touched.

Modalities	Design of feedback
Visual	Square (8, 16 or 32 px wide) turns green in color to indicate that it should be selected.
Speech audio	Terms "up" or "down" voiced by system to indicate position of target on interface (60dB).
Non-speech audio	Sine tone presented to indicate position of target on interface (60dB, 300ms duration). Higher pitch represents upper target, while lower pitch represents lower target.

Table 1. Design of feedback for conditions presented in the pointing task. Speech audio feedback and non-speech audio were presented alongside visual feedback.

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[1] www.apple.com
[2] www.phonegap.com/developer/
[3] www.cocos2d-swift.org/
[4] www.apple.com/ios/

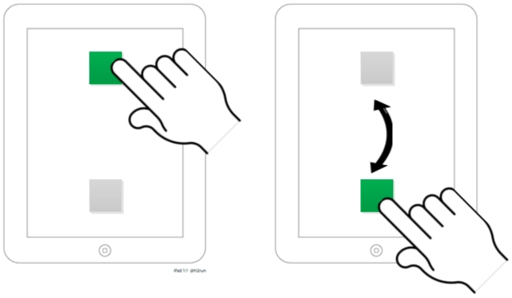

Figure 1. Diagram illustrating the pointing task
(Not to scale)

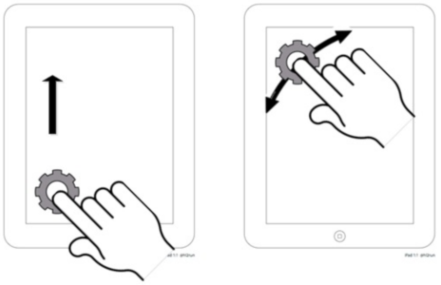

Figure 2. Diagram illustrating the steering task
(Not to scale)

A 2x2x3 repeated measures design was used for the steering task. An image of a cogwheel was presented at the center of the screen. Once tapped, the graphic would begin to rotate in a clockwise fashion. The cogwheel would then begin moving around the screen, either along a straight path, or in a curve around the corners of the interface. Participants were instructed to select the center of the cogwheel with their finger, and follow the graphic as it moved across the interface, maintaining contact with the screen for a set period of time. The diameter of the cogwheel would vary (32 and 64 px), along with the duration spent selecting the cogwheel (6 or 12 seconds), and the modalities presented (visual, combined visual and speech audio, and combined visual and non-speech auditory feedback) (Table 2). The task is illustrated in Figure 2.

Modalities	Design of feedback
Visual	Cogwheel image (32, 64 px diameter) rotates when selected.
Speech audio	Terms “up”, “down”, “left” and “right” presented to indicate direction of movement of target on interface (60dB).
Non-speech audio	Sine tone presented to indicate position of target on interface (60dB, 300ms duration). Higher and lower pitch indicates target moving upwards or downwards, while tone panned to left or right cues user that target is moving left or right.

Table 2. Design of feedback for conditions presented in the steering task. Speech audio feedback and non-speech audio were presented alongside visual feedback.

Participants were required to perform all 12 conditions, which were presented in randomized order. As in the pointing task, the combined visual and speech audio condition used speech sounds from a study by Kuber et al. (2011). For example, as the cogwheel moved towards the right of the screen, the word “right” was voiced by the system. The combined visual and non-speech audio condition used auditory cues similar to those from the pointing task. The position of the cogwheel was conveyed to the user, by manipulating the pitch and spatial position of a pure sine tone. For example, as the cogwheel moved towards the right of the screen, a right panning sine tone was played for 300ms. Accuracy was determined by identifying the location selected on the screen in relation to the center of the target. Errors were recorded when the user would lose contact with the moving target, and reposition their finger on the touch screen.

3.5 Hypotheses

Non-speech auditory feedback can offer considerable promise when integrated with a graphical interface. However, designers often favor speech output, with the aim that these cues can be recognized more effectively, in a faster time to their non-speech equivalents. We aimed to design non-speech cues to be more effective compared with speech effects. As a result, we hypothesized the following:

- H1: When conducting pointing tasks, participants would select targets in less time when a combination of visual feedback and non-speech audio was presented, compared to other modal conditions.
- H2: When conducting pointing tasks, participants would spend less time selecting larger sized targets (e.g. 32px) and selecting targets in close proximity to one another (128px), compared with other conditions. It was anticipated that larger size objects would be easier for participants to locate, while smaller distances between targets would require less time and effort to traverse the interface.
- H3: Participants would perform steering tasks with greater levels of accuracy (i.e. fewer attempts to reposition the finger over the target) and lower levels of deviation error (i.e. less drifting from the center of the target) when presented with a combination of visual feedback and non-speech audio, compared with the other multimodal condition.
- H4: Participants would perform steering tasks with greater levels of accuracy and lower levels of deviation error when interacting with larger sized targets (e.g. 64px) and when the duration of the task was shorter (e.g. 6 seconds, instead of 12 seconds).

3.6 Procedure

The study was designed to fit into one 45-60 minute session to limit fatigue on the participants. Regular breaks were also provided during this time. A short questionnaire was presented covering health conditions and participants' use of technology and mobile touch screen devices. Findings have been highlighted in 3.2. Participants were given an overview and demonstration of the software developed for the study. For purposes of training, they were encouraged to practice pointing and steering tasks for a period of ten minutes. After completion of the main task, subjective comments relating to the interface were solicited from participants.

4 Results and Discussion

4.1 Pointing task

Participants were able to complete the task, and spent on average 1.49s (SD: 1.64s) selecting both the upper and lower targets in sequence. Time taken by condition is shown in Table 3. A repeated measures ANOVA was conducted to test the effects of target size, distance between targets and modality on time taken for the selection process. A significant main effect could only be identified for target size (F(2, 2346) = 20.932, p = 0.000). Post-hoc analysis (Bonferroni corrected) confirmed that as target size increased, the amount of time taken to perform the pointing task reduced (p = 0.000 for all conditions).

Condition	Time Taken (s)
Size: 8px	1.79
Size: 16px	1.37
Size: 32px	1.30
Distance between targets: 128px	1.47
Distance between targets: 256px	1.50
Modality: Visual	1.50
Modality: Visual and speech audio	1.47
Modality: Visual and non-speech audio	1.50

Table 3. Time taken by condition for pointing task.

Condition	Time taken for Feedback Type		
	Visual	Visual and speech	Visual and non-speech
Size:8px, Distance:128px	1.89	1.78	1.95
Size:8px, Distance:256px	1.72	1.59	1.82
Size:16px, Distance:128px	1.32	1.30	1.36
Size:16px, Distance:256px	1.43	1.53	1.29
Size:32px, Distance:128px	1.19	1.33	1.16
Size:32px, Distance:256px	1.46	1.27	1.40

Table 4. Time taken by condition for pointing task.

When targets were larger in size, results suggested that when the spacing between these targets was increased from 128px to 256px, the time taken to perform tasks would also increase (6.82% increase in time taken for 16px targets; 12.3% increase in time taken for 32px targets). In terms of modality, increasing target size from 16px to 32px appeared to impact performance most in the visual and speech condition (8.82%) compared to the visual (3.93%), and combined visual and non-speech conditions (3.32%). A more detailed view of results are shown in Table 4.

4.2 Steering task

Table 5 shows the number of attempts made to reposition participants' fingers over targets. Findings suggested that participants made 2.3 attempts on average to perform each steering task. Fewer attempts were made when tasks were shorter in duration (6 second steering task - 1.9) compared with those longer in duration (12 second steering task – 2.7). Fewer attempts were also made to reposition the finger when presenting targets via the visual (1.8) and combined visual and non-speech modalities (1.9), compared to the combined visual and speech conditions (3.1). Interestingly, the level of accuracy (measured through identifying deviation of the finger from the center of the stimulus) was lower in conditions where speech was presented in conjunction with visual feedback (26.5px), compared with the visual only condition (24.7px).

The results suggest that there was more scope for error when focusing on the target for longer periods of time (i.e. 12s compared to 6s durations) as there was a greater chance of losing contact with the moving stimulus, and when selecting targets encoded with speech audio as difficulties would be faced staying positioned on the center of the target.

Condition	Attempts	Deviation from Center (px)
Steering task duration: 6s	1.9	23.8
Steering task duration: 12s	2.7	27.1
Modality for both 6 and 12s tasks: Visual	1.8	24.7
Modality for both 6 and 12s tasks: Visual and speech audio	3.1	26.5
Modality for both 6 and 12s tasks: Visual and non-speech audio	1.9	25.1

Table 5. Attempts and deviation from center of target for steering task.

When examining deviation from the center of the target, a significant effect was detected for target size (F(1,98) = 18.875, p = 0.000). Levels of deviation from the center of the target appeared to decrease, as target size increased from 32px to 64px (Absolute difference: 7.1 px) (Table 6). Similarly, the duration of the steering task impacted deviation from the center from the target. The distance from the center of the target increased as duration of the steering task increased from 6s to 12s (F(1,98) = 3.738, p<0.05). The greatest number of attempts to select targets were made when targets were smaller in size and speech was presented in conjunction with visual feedback (Table 7).

Condition	Deviation from Center for Feedback Type (px)		
	Visual	Visual and speech	Visual and non-speech
Duration: 6s, Size: 32px	27.8	28.0	25.4
Duration: 6s, Size: 64px	18.9	20.5	21.3
Duration: 12s, Size: 32px	28.0	31.7	30.6
Duration: 12s, Size: 64px	24.3	24.0	22.1

Table 6. Deviation from center of target for steering task (px).

Condition	Attempts to Select Target by Feedback Type		
	Visual	Visual and speech	Visual and non-speech
Duration: 6s, Size: 32px	2.1	4.0	1.1
Duration: 6s, Size: 64px	1.0	1.1	1.3
Duration: 12s, Size: 32px	1.6	5.3	2.5
Duration: 12s, Size: 64px	2.4	1.1	2.2

Table 7. Attempts to select target for steering task.

Participants were asked to discuss which conditions were the most effective for purposes of interaction. While visual feedback presented alone provided a discreet method of communicating the position of targets, audio played in conjunction with visual cues was generally favored as it would better alert users to the action which they should take (i.e. moving up or down). Participants suggested that sounds played at 60dB were audible, but could become overloading after a period of time. Graphics 16px and above were thought to be of a suitable size to be visible enough to support the targeting process. Suggestions for improvements to the interface included presenting audio when errors were made to indicate that the user had selected an incorrect part of the screen, developing auditory stimuli to better convey that the user should adopt a curved path in the steering task, and the ability to customize audio to use sounds familiar to the user.

4.3 Discussion

Findings from the pointing task showed that participants spent less time when selecting 32px targets (1.30s) compared with smaller target sizes (1.58s) (p=0.000). Although results suggested that shorter distances between targets (128 px) could be accessed in less time compared to targets spaced 256px from one another (absolute difference: 3 seconds), no significant effect could be identified. As a result, H2 could only be partially supported. Further work would need to be performed to identify whether increasing the distance between targets affects the time taken to target larger objects compared with smaller ones. There was no evidence to suggest that modality had an impact on time taken. Further work would need to be done to determine if H1 could be supported through statistical analysis.

Guidance to developers: *Designers should be aware of the difficulties which older adults may face when selecting targets on a mobile touch screen interface. The size of interface objects can impact the user's ability to target in a short period of time. Targets larger in size (e.g. 32 px) are recommended for pointing-style tasks, as these can be selected in less time compared to smaller targets. Factors such as spacing between targets and modality may not play a strong role in enabling users to save time when performing pointing tasks.*

When larger sized targets were presented in the steering task (64px), fewer attempts were made to remain positioned on the objects, compared to the number of attempts made to stay positioned on 32px targets (absolute difference: 4 attempts). Levels of deviation from the center of the target were also found to be lower when larger sized targets were presented (absolute difference: 7.1px). A greater number of attempts were also made to reposition the user's finger over moving targets, when steering tasks were longer in duration. Participants made on average 1.9 attempts to select targets (6 second steering tasks), while 2.7 attempts were made when duration of steering tasks was 12 seconds (absolute difference: 0.8 attempts) ($p<=0.05$). Findings enabled us to accept H4. In terms of modality, fewer attempts were made selecting the target when visual and non-speech auditory feedback were presented together (1.9), compared to conditions using speech-based presentation of cues (3.1). However, there was no evidence to suggest that deviation from the center of the target reduced when non-speech auditory feedback was presented, compared with other conditions. As a result, H3 could only be partially-supported.

Guidance to developers: *When developing an interface which requires the user to perform steering-style tasks, interface designers should restrict the periods spent selecting moving targets to 6 seconds or less. Steering tasks long in duration may result in a greater number of attempts to reposition the finger over the target. Targets 64px in size offer potential to older adults, as there is greater likelihood that the user will remain focused on these, compared with smaller sized targets. While speech feedback may initially sound attractive to integrate with mobile touch screen interfaces, results from our study have highlighted that participants made more attempts to focus on the target when speech audio was presented. Non-speech audio combined with visual feedback can offer potential under these scenarios. However, further investigation is needed to better understand the ways in which non-speech cues can be designed to be more detectable.*

5 Contextualizing Research and Limitations of Our Study

Interface designers rarely prioritize the needs of older adults when developing mobile applications. However, research suggests that although older adults have historically been late adopters to the world of technology compared to their younger counterparts, their movement into digital life continues to deepen (Smith, 2014). Findings from our studies have provided insights into ways in which targets can be presented to support mobile touch screen interaction. While usability studies focusing on the needs of older adults have been valuable, these have been often restricted to smaller screen devices, such as smart phones (Leitao and Silva, 2012), which have their own unique requirements when compared to tablet-sized technologies.

In terms of pointing tasks, findings from our studies are consistent with Leitao and Silva (2012), who identified that task completion time was influenced by target size. In the researchers' study, task times were higher when targets were smaller than 14mm. Jin et al. (2007) found that older adults did not perform with greater levels of accuracy as button size increased. However, their participants were most accurate with buttons that were 19.05mm square. Hwangbo et al. (2013) also found that error frequency rate decreased as target size grew larger and target spacing became wider. Although significance could not be gained for target spacing in our studies, interesting effects were observed which could be worthy of further exploration. For example, the negative impact associated with increasing spacing from 128 to 256px for larger sized targets (e.g. 16px and 32px), described in 4.1. Jin et al. (2007) found that the impact of button spacing on time taken was significant, with more time spent when targets were spaced far apart from one another. The researchers recommend spacing buttons presented in a line with 3.17mm and 12.7mm. They suggest caution when buttons are not separated by space, as it may lead to slips, or difficulties identifying the target of interest. Hwangbo et al (2013) suggest that in large target layouts, target spacing does not affect pointing performance. However, in our study, pointing performance was slightly higher in narrow target spacing layouts rather than in wider spacing.

Presenting auditory feedback in conjunction with visual feedback is not uncommon in system design for older adults. Wickens (2002) suggests that time-sharing between two tasks is more efficient if the tasks utilize separate structures, rather than common ones. For example, in the Multiple Resources Theory, using vision and audio may lead to performance benefits in contrast to using two separate visual sources. Research suggests that speech audio from an interface can become overloading after a period of time, and can be difficult to perceive in the presence of ambient sounds (e.g. chatter from people surrounding mobile device user may negative impact interaction). Presenting non-speech feedback offers considerable potential under these surroundings, as studies have shown that users are able to process non-speech auditory cues under conditions where speech is present (Rouben and Terveen, 2007).

While the audio effects in our study were presented above the 60db threshold recommended for older adults (Fisk et al., 2009), hearing abilities among older users can vary considerably even when there are no self-reported hearing problems. Challenges may also be faced hearing pure tones due to erosion of the upper threshold (Fisk et al., 2009), so care should be taken in the auditory design process (Qian et al., 2011). Due to difficulties in with recruitment of participants, it has been acknowledged that findings may not be fully representative of the needs of older adults. Future work will ideally aim to extend our work to a wider population, including older adults with greater difficulties with manual dexterity, to reveal ways in which mobile touch screen technologies can be designed to support this population. By recruiting a more diverse set of older adults with varying levels of sensory, motor and cognitive abilities, links can be identified between age-related declines and performance.

6 Conclusion and Future Work

In this paper, we examined the effects of modality, target size and other design features when interacting with a mobile touch screen interface. Findings from the study have shown that in order to better meet the needs of older adults, 32px targets are recommended to support pointing performance, while 64px targets are suggested for steering tasks. Modifying the spacing between targets and modality may not offer much of a time saving when performing pointing tasks. More attempts may be made when steering tasks are longer in duration.

As the study described in this paper represented the first step in the research, the next logical step would be to examine the current data in greater detail to identify trends among different age groups (e.g. 55-64, 65-74, 75-84, 85+), and trends among those who experienced greater levels of visual decline or physical challenges compared to others. The aim would be to determine if the needs for an interface may differ, and if so how design can be used to address the difficulties faced with interaction. Mobile interfaces are known to be cluttered with graphical icons, so adding additional distracters would improve the realism of the task. We also aim to identify the ways in which tactile cues can be developed to support older adult users, particularly those who may experience challenges with interaction.

7 References

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