Audio Voting for the Visually Impaired: Virtual Keyboard Navigation

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ABSTRACT
Since the United States federal law Help America Vote Act was passed in 2002, it is widely recognized that all Americans should have equal access to vote with privacy and security, but current electric voting technologies have failed to provide a barrier free access system for visually disabled and impaired population to write and check their desired candidates? names without assistance. Attempts have been made to create audio voting systems that read letters to visually impaired voters for picking, but with lack of checking and correcting features for users? typing. This paper will describe a new technology that allows users to navigate a virtual keyboard to type, check and modify their desired candidates? names using mouse movement and clicking. This new voting system was recently tested at Clemson University, South Carolina on 16 subjects who were blindfolded to simulate the experience of visually impaired voters. The result shows that blindfolded users have difficulty to find keys they want on a virtual keyboard using mouse, no matter how the keys are sorted. This research is expected to reveal the difference between human muscle memory and spatial memory, and to provide a new reference for human-computer interaction research in the future.

INTRODUCTION
In 2002 the Help America Vote Act was passed. The act said that all American's had the right to vote with privacy. Voting systems present a unique challenge to interface designers because voting systems must be usable by every citizen at least 18 years old; this includes the elderly, disabled, uneducated, and poor users [2]. The purpose of this project was to try and create a program that visually impaired users can use without assistance while allowing the voter to submit a write-in candidate with full confidence and accuracy.

There are multiple electronic,touch screen, voting systems available, the Diebold AccuVote-TS and Hart InterCivic eSlate to name a few. None of these systems have audio capabilities and thus cannot be used by visually impaired voters [2]. The most accessible voting system is currently the Prime III voting system created by Dr. Juan Gilbert; and this system also lacks an audio write-in component[1]. Even with the most accessible system available voters who are blind or visually impaired have to rely on another person to type in a candidate. Carnegie Mellon University has created write-in system that works as a Google Chrome extension. This system, which is described in more detail below, uses the keyboard, which makes it incompatible with the electronic touch screen systems.

We created an audio program that would allow voters to type in their votes without assistance. Our system, detailed below, currently uses a mouse to interact with the interface. We did this because we did not have access to a touch screen and coded it in such way that the interface could be shifted from using a mouse to a touch screen.

METHOD

Figure 1. Qwerty Keyboard Set Up

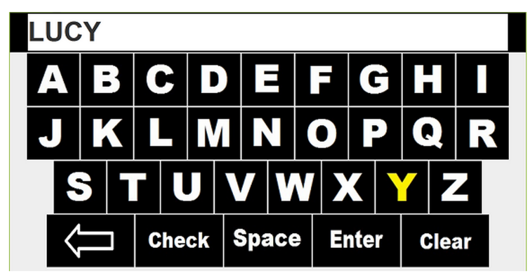

Figure 2. Sequential Keyboard Set Up

We created an interface that follows the track of the mouse. We found thirty-nine sound files and associated each sound file to either a location or to an action. Each image had a sound file associated with it so, when the mouse moved over the image then the participant would here the name of the key. When they typed a letter they would hear "typing..." and the letter they typed. When the participant deleted the letter they would hear "deleting..." and the letter they deleted. When the check button was selected they would hear every letter in

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DOI string from ACM form confirmation

There was also a bicycle bell when they moved beyond the keyboard.

There were two versions of the program created for the study. The first keyboard was set up as a regular Qwerty keyboard (see Figure 1) and the second keyboard was arranged in sequential order (see Figure 2). There were three parts to the study, an audio gram, one version of the program we created and the interface created by Carnegie Mellon University and then a survey.

Apparatus

The audio gram was run on a website on Google Chrome. The Carnegie Mellon University interface was run as an extension on Google Chrome. The participant used the arrow keys and shift keys on the keyboard to navigate and select respectively. Using the left and right arrow keys to move back and forth over the letters and then uses the shift key to select the correct letter. The interface we created was run on Eclipse. The participant used a mouse to interact with the interface, scrolling over the keys to here the sound and clicking in order to select the letter or key.

The participant was working on an iMac inside of a sound proof booth.

Participants

There was a total of sixteen participants. In order to gather participants flyers were displayed around the town. All interested participants were then scheduled for a convenient time. Half of the participants were male and the other half was female. Five participants were between the age of eighteen and twenty-two. Five participants were between twenty-three and twenty-seven. The rest of the participants were above the age of thirty. All participants were healthy users who said they had average to excellent typing skills.

Procedure

The participants were blindfolded in order to simulate a being visually impaired and then asked to do five sets of five tasks. The first set of tasks asked the participants to type a single letter, i.e. B, and hit enter. The second set of tasks asked the participants to type a single name, i.e. Mark, and hit enter. The third set of tasks asked the participants to type a full name, i.e. Tom Baker. The fourth set of tasks asked the participants to type a name, i.e. Barbara, and then use the check button to check their typing before hitting enter. The fifth set of tasks asked the participants to type a name then delete part of the name and retype it, i.e. John Smith changed to John Locke, and then enter the new name.

Given the limits f the Carnegie Mellon University interface, lack of delete, check, and enter button, participants received altered instructions. They were told to select a hyphen instead of hitting the enter key to denotate that the task ended. They were told to ignore the checking part of the task; they were asked to just type the name. When completing the final set of tasks they were asked to type the name as they first hear it and then type the new part of the name only.

I then stayed with the subject to through the very first task to ensure the subject fully understood. I then left them to finish the rest of the first set and the rest of the sets of tasks alone in the sound proof booth.

Study Design

The study took place in three separate parts. The very first part of the study was an audio gram that tested the participants hearing. We chose three rows of sound files and asked participants to face the door and raise their hand when they heard the sound. If the participants failed the audio gram, which was a score over 30 on two or more rows, then they were paid $5.

Then the participants were asked to use either the Qwerty or the alphabetical version of our interface (see Figures 1 2) and then Carnegie Mellon University interface to complete all of the tasks. The study was run with a balanced condition. When the participants finished the study they received $10 for the hour with an additional $5 every half hour rounded to the nearest 15 minutes.

The independent variables are the tasks. The dependent variables in this study are time and accuracy. Time was measured by timing how long it took to complete a task and accuracy was measured by measuring how often the completed task was correct.

After the tasks were complete we asked them to fill in a survey.

RESULTS AND DISCUSSION

The results were split into two classifications, accuracy and time, and then separated by task. We compared all of the systems to get the p value for each task, if the p was greater that .05 then the difference was significant. Then we compared two systems for a c value; the c value was a range of numbers, if zero was included in the range then there was a significant difference between the two systems. I will display below the graphs for the third task. The third task was the one that asked participants to type a full name and is the most similar to real life application should the interface be adopted into an existing voting system.

Time

Time was measured by taking the time it took to complete each task. The time reading may be a little skewed because the Carnegie Mellon University did not have a check or delete button. So the time readings for tasks four and five may be shorter because of that.

Time per task

The three systems were then compared to each other as shown in figure 3. The p values for all of the time per task were under .05, meaning that when the average time for all tasks were significant. Task one's c values showed that the Carnegie Mellon interface had a significant difference to both of our interfaces while there was no big difference for the Qwerty and the Alphabetical interfaces. This pattern is repeated in tasks three and four. The c values of task two and five showed that there was a signifiant difference between all of the different interface, including the two versions we created.

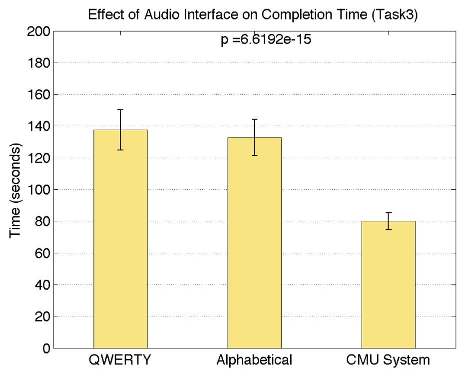

Figure 3. Task 3 Time Comparison

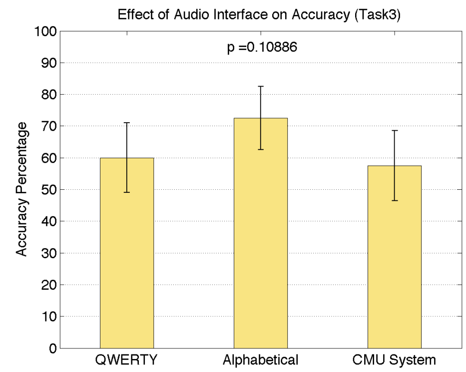

Figure 5. Task 3 Accuracy Comparison

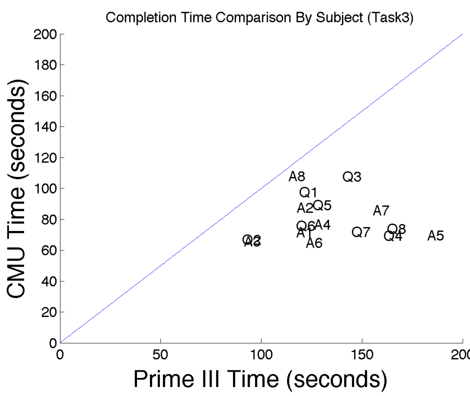

Figure 4. Task 3 Time Scatter Plot

Time per subject
The scatter plots were separated by subject. The thin blue line means that the person scored the same average time between our system and the Carnegie Mellon interface. If a person fell underneath the line then it took more time to complete the tasks using our interface and above means they took more time with the Carnegie Mellon Interface. The Q or A in each point means they used either the Qwerty interface or the Alphabetical interface. Please refer to Figure 4. As you can see in Figure 4 it took the majority to all of the participants more time to complete it in our interface. This pattern remains true for all of the tasks.

Accuracy
Accuracy was measured by looking at the completed tasks and adding one to the accuracy score if it was correct and zero if it was submitted incorrectly.

Accuracy per task
The p values for the accuracy comparisons showed that there was a significant difference between all of the interfaces for participants completing tasks one, two and four. The p value also showed that there was no significant difference for the third and fifth tasks in terms of accuracy. The first task's c values showed that there was a significant difference between the Alphabetical interface and the other two but no difference between the Qwerty interface and the Carnegie Mellon interface. The second tasks interface showed that there was only a significant difference between the Alphabetical and the Carnegie Mellon Interface. The fifth task's c values showed that there was no difference between the Qwerty and the Alphabetical interface and a significant difference between the other combinations.

Accuracy per subject

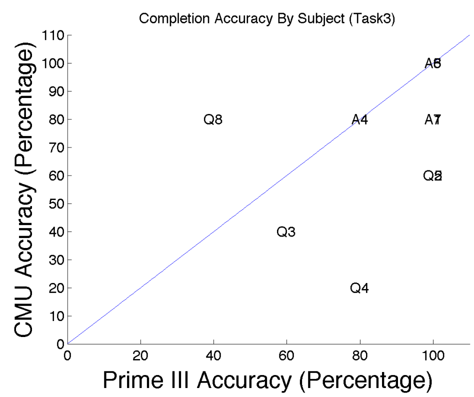

Figure 6. Task 3 Accuracy Scatter Plot

The scatter plots were separated by subject. The thin blue line means that the person scored the same accuracy between our system and the Carnegie Mellon interface. If a person fell underneath the line then more accurate when completing the tasks using our interface and above means they were more accurate with the Carnegie Mellon Interface. The Q or A in each point means they used either the Qwerty interface or the Alphabetical interface. Please refer to Figure 6. As you can see in Figure 6 the majority of participants were either just as accurate or more accurate when using our system. This is true for all of the tasks.

Survey
The survey asked the participants a variety of questions. When asked their typing proficiency all participants said they had average or better typings skills. But when they were asked if they needed to learn more skills to use the interface the over 2/3 of the participants replied negatively. Over 80% of participants thought the system was easy to use but about 80% of participants also thought the system would be difficult to use over a long period of time. However as you can

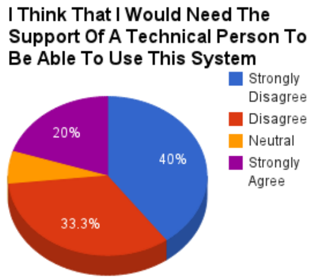

Figure 7. I would need the help of technical person to use this interface

see in Figure 7 80% of participants felt like you could use this system without assistance.

CONCLUSION

We created two versions of an audio interface that we one day hope will be integrated into an electronic voting system so that voters who are visually impaired can vote without assistance. The interface currently uses a mouse that you scroll over the keys in order to hear the letter as well as a deleting and a checking function. We have found that there is no significant difference between the Qwerty and the Alphabetical systems the majority of the time. That it took less time with the Carnegie Mellon interface then the interface we created. However, participants were just as or more accurate using our system over Carnegie Mellon's. The participants felt that the system was easy to use but could not be used frequently or over long periods of time. However they could use it privately which was one of our goals for the program. For future projects the plan is to put the system on a touch screen interface and find a way to make it less cumbersome to use.

ACKNOWLEDGEMENTS

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