Accessible Polling Places for the Visually Impaired: A Compilation of Survey Results

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Abstract

The Help America Vote Act mandated that all polling places have an accessible method of voting that provides privacy and independence. Direct Recording Electronic voting machines (DREs) have been assumed to be the solution to providing accessible voting, but there is reason to believe extant systems do not adequately serve this goal (Runyan, 2007). This survey builds upon previous work with the visually disabled population and provides the opinions and recommendations of 202 legally blind voters. Topics addressed include obstacles at the polling place, multiple modality systems, voting confidence, and input devices. Data-based recommendations for auditory modes of voting systems include adjustable speed and volume, using male text-to-speech synthesized voices, and allowing for flexible navigation and the ability to skip through sections of text.

1. Introduction

The process of voting is a complex task that includes the logistics of getting to and from a polling place, queuing and signing in to vote, social interactions with poll workers, reading and comprehending instructions on how to use a machine or ballot, completing a ballot to correctly reflect voter intention, reviewing the ballot for any errors, and casting the vote in a way to ensure that it is counted. This can prove challenging for any member of the population, but for some individuals having a disability can serve to complicate the process. This is especially true when election administrators and voting equipment designers do not have a complete understanding of the processes someone with this disability must go through in order to vote. The purpose of this study is to detail the responses gathered by a comprehensive survey given to visually impaired voters, and further examine issues brought up by Piner and Byrne (in press).

A substantial portion of the voting population is visually impaired. According to the U.S. Census Bureau Americans with Disabilities report (2005), 19% of the US population lives with one or more disabilities. 1.3 million persons (0.5%) reported legal blindness. A fifth of Americans with disabilities (more than eight million people) have been unable to vote in presidential or congressional elections due to barriers at or getting to the polls (National Organization on Disability, 2004). The Help America Vote Act (HAVA) of 2002 was the federal government's response to this situation, and mandated that all polling places have an accessible method of voting available for those wishing to vote in federal elections privately and independently. For legally blind voters, a DRE (direct recording electronic) voting machine that utilizes an audio interface has a lot of potential that needs to be explored. Previous work by Piner and Byrne (2010) addressed problems voters faced during the process of casting a ballot. The mock election showed that visually impaired voters took significantly longer than sighted voters (31 minutes compared to 5 minutes) to complete an identical ballot. Both groups had similar error rates (roughly 2%) and similar high ratings of satisfaction with the voting method used.

This paper is a follow-up to the survey completed by Piner and Byrne (in press) and provides additional analyses that address what people say they dislike about current voting technology as well as what obstacles affect their voting experience.
An audio interface allows the highest level of accessibility across individuals with some form of

visual impairment. An audio-only interface certainly disenfranchises voters with co-occurring visual and hearing impairments. But unlike instructions and interactions relayed in Braille, audio requires no specialized skills. This survey focused primarily on an audio-based system of interaction. As well as interacting with an audio DRE, voters receive instructions and assistance from poll workers. Poll workers go through little, if any, training and their experience tends to be with the many administrative tasks surrounding an election rather than the ever changing and sometimes technically challenging interfaces of the voting systems themselves. This necessitates an interface that is essentially "walk up and use" by the voter.

Understanding the voting process and how to better advocate for equal rights for the visually impaired is a topic that has received a lot of attention from the NFB (National Federation of the Blind), the country's largest membership organization of blind people (NFB, n.d.). Elections give people opportunities to voice their opinions about elected officials and legislation relating to disability benefits, employment equality, health benefits for visually impaired individuals, and many more highly relevant issues for visually impaired citizens. Research performed by the NFB's Jernigan Institute used a phone-based survey of blind voters and asked about their experiences in the 2008 presidential election (Hollander Cohen & McBride Marketing Research, 2008). Many of the specific questions asked to the voters in the NFB study complement the more general preferences and opinions that are detailed by Piner and Byrne (in press). Additionally, comparisons between the general and sighted populations' use of voting technologies are considered.

Results from this survey will inform upcoming research and directly impact how the input devices and user response or interactions are designed in a future accessible DRE. Using the mock election results from Vote-PAD, a non-computerized technology, as a baseline, a direct comparison between the usability of different accessible technologies can be obtained (Piner & Byrne, 2010). There will be an emphasis in future studies on utilizing the survey responses in order to make informed decisions during the design process, ultimately with the goal of devising a multi-modality accessible interface that out-performs currently available systems.

2. Method

2.1. Subjects

Subjects were recruited and interviewed both in person and online. Twenty-two individuals were recruited in person at the National Federation of the Blind's Texas state convention, and were compensated with $15 for their participation. One hundred and eighty people were recruited online through Internet correspondence sent to email lists, blogs, and message boards that serve the visually impaired community, in order to reach a larger portion of this population. Subjects completing the survey online were given a chance to express their thoughts and opinions, but were not compensated monetarily for their time.

The total two hundred and two subjects (112 female, 76 male) ranged in age from 19-86, with a mean age of 50.42 (SD=13.5). Table 1 shows the frequency of the subjects' education levels; nine subjects did not report their level of education. Table 2 shows the frequency of the subjects' ethnicity; 11 subjects did not report their ethnicity.

Table 1: Level of Education

High school or less	25 (13%)
Some college	46 (23.8%)
Bachelor's degree or higher	122 (63.2%)

Table 2: Ethnicity

African American	6 (3.1%)
American Indian	2 (1%)
Asian American	1 (0.5%)
Caucasian	176 (92.1%)
Mexican American or Chicano	3 (1.5%)
Multiracial	1 (0.5%)
Other	2 (1%)

The subjects' previous voting experience and number of elections voted is shown in Table 3. Only 5 subjects had never voted in any type of election.

Table 3: Election Participation (number of subjects)

	0	1-8	9-15	15+
National-Level Elections	6	52	39	64
Governmental Elections	15	61	36	56
Local/Other Elections	36	63	39	33

All subjects reported being legally blind. "Legally blind" is defined as having "central visual acuity of 20/200 or less in the better eye with the use of a correcting lens" and/or having "the widest diameter of the visual field subtend an angle no greater than 20 degrees" (National Federation of the Blind, 1986). This is a fairly broad definition that encompasses many levels of impairment. The *low vision* respondents are individuals who retain residual vision that allows them to read larger point text or regular text with the assistance of a magnifying glass. The *light perception* respondents are individuals who are able to tell light from dark and the general direction of the light source. And the *no vision* respondents are individuals with no vision or light perception. Table 4 displays the breakdown of respondents by magnitude of vision loss.

Table 4: Magnitude of Vision Loss among Respondents

Low Vision	48 (26.7%)
Light Perception	24 (13.3%)
No Vision	108 (60%)

2.2. Procedure

All materials were read to the subjects who were interviewed in person. The respondent was seated across from the experimenter, with a microphone in the middle to record their answers. Subjects were first given a consent form and agreed that they were both over the age of 18 and considered legally blind. Following that, they received 50 questions including demographic questions, questions related to their previous voting experiences and questions about desired changes and future directions for the voting industry (see Appendix for the complete survey). Question formats included multiple choice, open-ended, and 5 or 10-point Likert scale questions. Subjects were given as much time as desired to respond. After completing the survey, they were debriefed regarding the nature of the experiment and given contact information if they desired to follow up on anything with the experimenters.

Subjects who completed the survey online read the materials themselves by any method they chose, such as increasing the font size, a screen reader, having a friend read it to them, etc. Those who received the survey online were given a link to SurveyGizmo, a survey tool that collected and reported their answers. Whenever applicable, an "other" option along with the direction to "please specify" and a text box were provided in an attempt to account for a wide range of experiences and preferences.

3. Results

The results of some of the general response questions are summarized in Table 5.

Table 5: Respondent Characteristics
(Piner and Byrne, in press)

- 16.4% of respondents would choose to use a visual display in addition to an audio interface while voting, if provided.
- Eleven percent of respondents report never having used Braille and 40% report being completely proficient Braille readers. If a Braille interface were offered, only 34.4% would choose to use Braille over an audio interface.
- When reporting computer skill (on a 10-point Likert scale with 1 being a novice and 10 being an expert) no one reported being lower than a 3 (2.2%) and 7.8% reported to be experts. The majority of respondents were experienced computer users, ranging between 7-9 (55%). 78.9% of respondents use a computer more than 20 hours a week. Older respondents tended to be less skilled and use computer less frequently than younger respondents. There were significant negative correlations between age and both computer skill (r (158) = -.20, p = .01) and usage (r (156) = -.20, p = .02).

- When asked about using an automated teller machine (ATM) to get money or complete a transaction, 23.9% of respondents never use one, 28.0% use one occasionally (several times a year), and 39.4% use one often (at least once a month).

Several of the survey questions used were taken from previous voting research done with a sighted population. This allows for a direct comparison between the populations to see if what ways, if any, they differ (Everett, et al., 2008). The similarities between the study populations of both blind and sighted individuals can be seen in Table 6. The only significant difference between the two groups is the level of self-reported computer expertise, with visually impaired subjects rating themselves as more competent than did the sighted subjects (χ^2 (9, N = 308) = 41.08, $p < .001$, Cramer's V = .37).

Table 6: Study population of sighted and blind individuals.

	Sighted	**Blind**
Mean Age	46.8 (SD=17.6)	51.8 (SD=12.8)
Gender - % Female	52.8%	59.6%
Computer Expertise	6.08 (SD=2.6)	7.24 (SD=1.7)
Typically vote absentee	14.50%	12.30%
Worried about figuring out technology	37.30%	31.20%
Time pressure cause to rush	18.30%	22.60%
Typically cast a vote for every office	65.10%	72.30%

3.1. Accuracy and Election Confidence

During an election, 31.2% of respondents reported they worried about figuring out how to use the technology to cast their vote and 22.6% felt that time pressure caused them to rush or make a mistake. Only 16.3% of respondents reported they never review their completed ballot before casting it and 38.8% always review their ballot. Over half of the respondents (58%) indicated that having a way of directly verifying that their ballot accurately represented how they intended to vote was an essential part of any voting system. Only one respondent felt that the ability to review the ballot was unimportant,

3.2 Audio Interface

There was a slight preference overall among respondents for a voting machine's audio to use a recorded human voice rather than a synthesized text-to-speech program (Piner & Byrne, in press). There was a significant difference in preference between levels of vision (χ^2 (2, N = 152) = 7.05, p = .03), see Figure 1. The effect size, as measured by Cramer's V, was .215. A follow-up test between the no vision and light perception groups found no significant preference for either type of audio (χ^2 (1, N = 108) = 1.26, p = .26). Among low vision respondents, there was a significant preference for recorded human voices (χ2 (1, N = 44) = 7.36, p = .01).

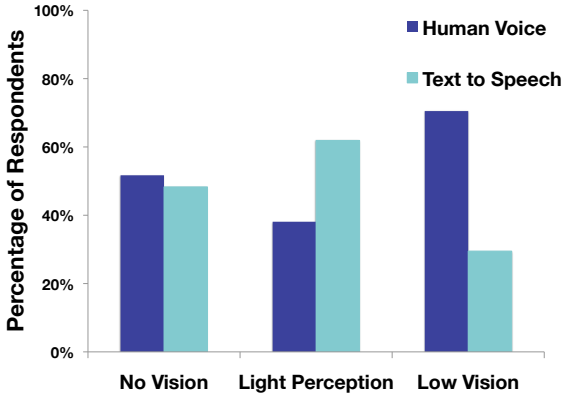

Figure 1. Percentage of respondents in category of visual ability and their preference for type of DRE audio.

Piner and Byrne (in press) found that most respondents were familiar and comfortable with using and understanding synthesized voices. Most had no preference regarding the gender of the audio voice, but among those with a preference male voices were significantly more preferable (χ^2 (1, N = 63) = 26.68, $p < .001$). There was no significant difference in desired audio gender based on the respondent's own gender, χ^2 (1, N = 58) = 1.73, p = .19. Comfort varied significantly across level of vision (χ^2 (16, N = 158) = 31.96, p = .01, Cramer's V = .32), with no vision users being more comfortable than low vision users (χ^2 (8, N = 137) = 24.28, p = .002, Cramer's V = .42).

The ability for the user to be able to change audio volume and speed were both highly desired aspects of a computerized audio interface, followed by the ability to change pitch and language to a less extent (Figure 2).

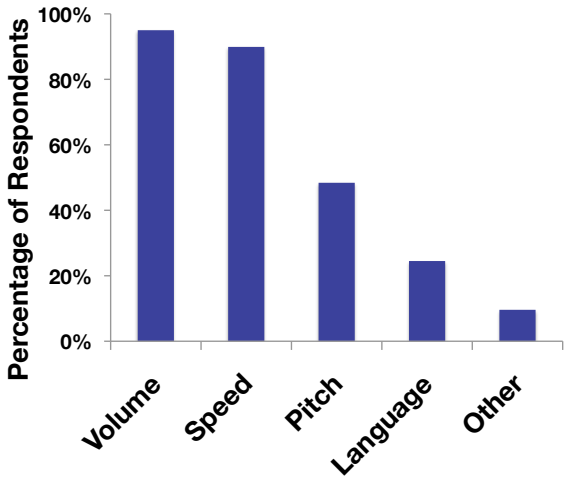

Figure 2. Percentage of visually impaired voters who would like to be able to adjust the given setting on an audio interface.

3.3 Multiple Modalities

Some voting machines offer multiple modalities to help accommodate the large diversity present in the voting public. If provided, 16.4% of respondents would like to use a visual and audio mode simultaneously.

If it were available, 34.4% of respondents would prefer to use a Braille interface instead of an audio interface. A significant relationship between a respondent's Braille ability and their desire to use the Braille interface was found (and as expected, better Braille readers responded that they would prefer a Braille interface more often), r (151) = .55, $p < .001$. There is also an influence of individual preference beyond just the ability to read Braille. Out of the 64 total respondents who reported completely proficiency with reading Braille (a 10 on a 10-point Likert scale), over a third (37.5%) still would prefer to use an audio interface. There was no significant preference between a Braille interface and an audio interface, $\chi 2$ (1, N = 63) = 3.57, p = .59 among Braille readers.

3.4 Input Devices

Respondents were asked to think about how comfortable they would be with using different methods to control their interactions with a voting machine. Piner and Byrne (in press) found that a large majority of respondents would feel comfortable using directional arrows or a telephone keypad to interact with a voting machine. Table 7 shows the types of input devices used by respondents to interact with their computers on a daily basis.

Table 7: Input Devices Used

Keyboard	163	99.4%
Mouse	35	21.3%
Microphone/Speech Recognition	13	7.9%
Touch screen	9	5.5%
Joystick	1	0.6%

Subjects surveyed in person were asked two questions concerning a proposed input device, the button box, which they had the opportunity to feel and explore tactilely (see Figure 3). 85% of respondents (17 out of the 20) said that they felt the six different buttons on the button box were easy to discriminate and tell which one performed which function. 1 respondent felt this task was difficult, and the final 2 respondents rated the level of difficulty as average. A large majority of respondents (75%, or 15 out of 20) felt the button size was fine. 4 respondents would have preferred to have smaller buttons, and 1 respondent would have preferred to have larger buttons.

Figure 3. Large, tactile button box proposed as a possible DRE input method in future mock election studies.

3.5 Voting Experiences

Straight-party voting is the practice of voting for candidates of the same political party for multiple offices. In some states, there is a single option on the ballot that allows a voter to cast a vote for a selected political party for every partisan race. A total of 16 states presently offer some form of straight-party voting on the ballot. Table 8 shows a breakdown of survey respondents who have previously voted in one or more states that offer straight-party voting. Only 9.3% of respondents always chose to vote a straight-party ticket. 23% usually voted straight-party, 37.9% sometimes voted straight-party, and 29.8% never voted straight-party. Out of respondents who have voted in 1 or more states where a straight-party voting ballot option was available, 60.4% did so by voting in each race individually and 39.6% used the single straight-party option on the ballot.

Table 8: Respondent Access to Early Voting and Straight-Party Voting

	Voted in a Straight-Party Voting State	Voted in an Early Voting State
Yes	71 (56.2%)	106 (65.4%)
No	91 (43.8%)	56 (34.6%)

When asked about their participation in early voting, 48.4% of respondents never early vote, 25.8% sometimes early vote, 14.5% usually early vote, and 11.3% never early vote. These results are similar to those from the NFB survey, which found that early voting was used of by 16.2% of respondents in the 2008 election. This is a fairly substantial proportion, considering only 32 states (plus the District of Columbia) offer in-person early voting as an option (National Conference of State Legislatures, 2010). The distribution of respondents who have voted in one or more of these states can be found in Table 6.

When querying respondents who have voted in 1 or more states where early voting was available, over a third of respondents (37.4%) usually take advantage of early voting opportunities, 28.3% sometimes do, and only 34.3% never do. Table 9 compares survey respondents to the general population of the 2008 Election (U.S. Election Assistance Commission, 2008) and the NFB survey of blind voters in the 2008 Election (Hollander Cohen & McBride Marketing Research, 2008).

Table 9: Voting Method

	2008 Election, General Population	**2008 Election, Blind Voters (NFB)**	**Blind Voters (Piner and Byrne)**
In person, on Election Day	60.2%	45.9%	
Absentee Ballot	17.3%	38%	12.3 % [1]
Early Voting	13% [2]	16.2% [3]	51.6% [4]
Provisional Ballot	1.4%		

1 Typically cast their vote by absentee ballot
2 This increases to 25.7% when only considering states that allow early voting.
3 26% of blind voters who voted at the polls (rather than by absentee ballot) used early voting
4 Sometimes (25.8%), Usually (14.5%), or Always (11.3%) used early voting. This increases to 65.7% when only considering respondents who have voted in 1 or more states where early voting was available

Most respondents (85.2%) reported that they never cast a write-in vote. 14.2% sometimes cast a write-in vote and 0.6% (1 respondent) always chose to cast a write-in vote. Most respondents (72.3%) also cast a vote for every office on the ballot.

3.6 Poll Worker Relations

Piner and Byrne (in press) found that most respondents have received assistance with voting at some point.

Table 10: Percentage of respondents who have received assistance during the process of voting by the following people.

Assistance	
Family Member	65.1%
Poll Worker	58.4%
Friend	41.0%
Other	9.6%
Never received assistance/ No assistance required	7.8%

While Piner and Byrne (in press) found that a large majority of voters trusted the poll workers to provide them with accurate information, nearly a quarter of respondents said that poll worker attitude was an obstacle that they felt make it difficult for them to vote. This was exacerbated when the respondent had previously been assisted by a poll worker and these individuals were significantly more likely to mention that poll worker attitude was a problem, χ^2 (1, N = 166) = 5.04, p = .03, Cramer's V = .17.

3.7 Obstacles

Multiple obstacles at or getting to the polls exist for blind voters beyond the attitude of poll workers, although that was the most mentioned barrier. Table 11 categorizes the most frequent responses. Over two-thirds of respondents (67.3%) reported they faced one or more obstacle.

Table 11: Reported Obstacles at the Polls

Obstacle	Respondents affected
Attitude of poll workers	44 (24.4%)
Location of polling station	38 (21.1%)
Length of time it takes to vote	35 (19.4%)
Physical layout of polling station	30 (16.7%)
Long lines	19 (10.6%)
No friend/family member available to help	19 (10.6%)
Hours the polls are open	11 (6.1%)

4. Discussion

One focus of this study is to observe how blind voters differ, if at all, from the sighted population. This comparison could potentially guide the direction of changes that need to be made when implementing truly accessible voting systems for the entire population. As can be seen in Table 6, the age range and gender division of the two subjects pools is very similar. Blind users did self rate themselves higher in computer expertise. This is in part due to the majority of the survey responses from blind voters being collected on the computer using an online polling site. To be able to respond to the survey in the first place required a large amount of computer knowledge and comfort with using accessible technologies (like a screen reader). Beyond this limited context, visually impaired individuals also need to use computer systems in many daily tasks in order to interact with the visual world. Both these factors explain why computer expertise is the only significant difference between the sighted and blind subjects. In the mock election, only voting time differed between blind and sighted voters, with error rates and satisfaction scores remaining consistent (Piner & Byrne, 2010). In the survey, both groups of users were equally as likely to be confronted and unsure about certain obstacles in the polling place (Piner & Byrne, in press).

4.1 Accuracy

To review a ballot a sighted voter only needs to look at the paper or computer screen and verify that how they intended to vote is the same as the answer that is marked on their ballot. Visually impaired voters must often take someone's or something's word that their ballot represents their intentions, as there are very few ways for them to directly verify what is on the paper. Paper-based non-computerized systems like VotePAD utilize a tactile feedback mechanism in the form of the light-sensing wand to allow voters to verify their marks (Piner & Byrne, 2010). All but one survey respondent felt that some method of ballot review was an important aspect to include in a voting system. However, only a little over a third (38.8%) of blind voters reported that they always review their ballot.

Ballot review needs to be an available option, for times when a voter is uncertain or needs to double check a race. In other situations, a long and tedious review process can actually become a hindrance. A new DRE design should aim to strike a balance between the two, with a review process available when needed but not a prerequisite for casting the ballot.

4.2 Interface Options

The use of an audio interface either by itself or conjunction with another modality (such as a visual or refreshable Braille display) is fundamental to providing an accessible DRE interface. Allowing multiple options to be tailored by voters to suit their own needs is critical. Most of the survey respondents have experience with screen readers (pieces of software that

are used to convert computer and web content into audio navigation). Experienced users set the speech rate upwards of 300 words per minute, a speed far faster than an inexperienced listener could comprehend (WebAIM, n.d.). DRE interfaces should allow voters to capitalize on this expertise, as it is not unusual for auditory interfaces to have extremely steep time costs relative to visual interfaces (e.g., Piner & Byrne, 2010).

Braille interfaces have been discussed as a viable alternative for blind voters. Braille provides visually impaired individuals with a special system designed exclusively to allow them to read and interact with the world. But when designing a voting system, the number of Braille readers (approximately 10% of legally blind adults) makes this impractical. Braille is usually only learned by those who are visually impaired from a young age and attend a school that offers a Braille literacy program. Hollander Cohen & McBride Marketing Research (2008) found that on average study respondents learned to read Braille at age 19, with 50% of Braille readers learning it before age 10. A Braille-based voting system would fail to take into account the large portion of our population that has vision problems due to aging, such as age-related macular degeneration (the leading cause of blindness in the United States as reported by the World Health Organization) (Resnikoff S, Pascolini D, Etya'ale D, et al., 2004). Out of the 64 Braille readers among Piner and Byrne's (in press) survey respondents, over a third would still prefer to use an audio interface rather than a Braille interface. The question of the "best" modality is not just a matter of ability, but also of preference. This underlines the need to offer options so that people can tailor the voting experience to their unique needs. Designers should not make assumptions about what works best for an entire group of diverse individuals. One possible solution would be to combine elements of Braille into an existing interface, such as Braille button labels. These would appeal to and enhance the experience of even novice Braille readers, while not distracting from the overall interface or being a necessary part of being able to vote.

4.3 Levels of Vision

The magnitude of someone's vision loss directly impacts the type of technology they come into contact with on a daily basis. Low vision users may be adept at utilizing their own magnifying tools to make regular print, computer screens, and publicly accessible terminals (like ATMs or airport check-in kiosks) accessible to them. Users with no vision may be comfortable with listening to text-to-speech computerized voices like those that are used in screen readers and be able to listen to them at a rapid pace that would be unintelligible to those with no experience with speeded up audio.

Furthermore, respondents with no vision rated themselves as significantly more comfortable with listening to and understanding synthesized audio. Out of 112 no vision or light perception respondents, only 4 people (3.6%) rated themselves at a 5 or less on a 10 point scale, indicating relatively little exposure and comfort with using this type of audio. On the other hand, 8 out of 46 low vision respondents (17.4%) rated themselves a 5 or less. This division between technologies can also be seen in the preferences for type of DRE audio, with low vision users preferring a human voice, and no vision users showing no preference between human or synthesized voices.

4.4 Poll Workers

With almost two-thirds of the blind population choosing to vote in person, it is essential that accessible voting machines that allow people to cast a secret ballot be provided. This is one of many obstacles to overcome at the polls. The most evident in the open-ended survey results was the interaction between the voters and the poll workers (Piner & Byrne, in press). The expressed problems included a desire for more training of the poll workers on how to use the technology, how to assist people with disabilities, and a general acceptance of accessible technology.

Accessible voting options (like large print, audio, or even Braille interfaces) need to be integrated with all voting machines so the process is no different from a poll worker's perspective. Alternatively, machine manufacturers should endeavor to provide a simple setup that poll workers with limited technological experience can successfully complete.

Accessibility for People with Visual Impairments

1. Identify who you are, where you are, and how you will be assisting the voter.
2. At the Qualifying Table:
    - Describe what you are doing as you do it;
    - Let the voter know when you need them to do something;
    - Provide a ruler to make signing on a line of the Signature Roster easier.
3. Escorting the voter through the polling place:
    - Talk the voter through the polling place;
    - Announce your destination and how far it is or how long it will take to get there;
    - Describe turns and obstacles;
    - Offer your arm; don't take the voter's arm;
    - Tell the voter when you are leaving them at the voting station;
    - Tell the voter who to ask for when they are ready to move again.
4. Don't distract a service animal from its job:
    - No petting or playing with the animal;
    - No treats;
    - No talking to the animal.

Figure 4: Excerpt from the State of Texas Online Poll Worker Training Program (The State of Texas, n.d.)

In general, the NFB Survey (Hollander Cohen & McBride Marketing Research, 2008) found that the instructions given to voters regarding the use of the voting machines were adequate, especially since most audio interfaces also have built-in systems of help and instructions. 84% of voters in the 2008 election said they were provided with clear instructions on how to use the voting machine or didn't need them at all. Out of those who did receive instructions, 92% felt these instructions were just right rather than too complicated or too simplistic. This corresponds to poll workers level of comfort. The Citizens Union Foundation reported that 77.3% of poll workers felt knowledgeable about demonstrating how to use a voting machine. This was also a task that most poll workers (70.6%) performed at some point on election day.

Poll workers volunteer for the position and are usually paid close to minimum wage. Training of poll workers varies between districts. Some poll workers receive comprehensive training courses whereas some poll workers receive no training at all. For example, the state of Texas offers an online training course (from http://www.texaspollworkertraining.com/) that can be distributed to poll workers. The course does provide guidelines for "Assisting Voters with Disabilities," including mobility, hearing, and visual disabilities. There is one page of guidelines for ensuring accessibility for people with visual impairment. The process of checking in, escorting the voter to and from their voting station, and the treatment of service animals are all covered, but the program completely fails to address any part of the actual means of casting a ballot (Figure 4).

A 2006 initiative by the Citizens Union Foundation in New York sought to address the shortage of poll workers and especially to recruit college-age poll worker applicants. A part of their project included sending a survey to all of the poll workers after the 2006 general election covering their experience at the polls, training sessions, and various tasks performed. Only 5.7% of the poll workers surveyed did not have any training before election day. About half (56.6%) of those who did attend training were introduced to an actual voting machine during that training and 45% recommended that they train on a voting machine during the class. When asked about their level of comfort performing certain tasks, only a third of poll workers (32.9%) said they would feel comfortable setting up a machine without assistance. The Citizens Union Foundation had several suggestions in line with the need for more practical training for the New York Board of Elections. These included encouraging "hands-on" demonstrations of the voting machines and mandatory training for all poll workers regardless of past experience.

Training issues are relevant because many DRE systems used today need to be rebooted and go through a set up process in order to put them into an accessible, audio mode. This level of technical familiarity would require a poll worker with the knowledge of how to set up a machine and could be gained through a training program on the actual election equipment. If an accessible machine was not available, respondents in the NFB's Survey (Hollander Cohen & McBride Marketing Research 2008) had to spend an average of 15 minutes waiting for poll workers to set up the machine. Perceived negative treatment by poll workers was partially dependent on whether or not a voter was provided with an accessible machine. Having the machines available and poll workers with the technical knowledge of how to set them up is essential to cutting down wait and voting times, and increasing voter satisfaction.

4.5 Voting Experience

As was demonstrated in Piner and Byrne (2010) there is a substantial time difference between sighted and visually impaired populations' voting times. This adds an extra incentive for blind voters to take advantage of both early voting and straight party voting. In early voting, individuals can arrive when it is convenient for them. This freedom of day and time may help alleviate their reliance on others, an obstacle mentioned by 10.6% of respondents.

Straight party voting provides a one-question solution to vote on the majority of the ballot (excluding non-partisan races and propositions). A time benefit for straight party voting was not seen among the general population but it might be relevant among a population that takes five times longer to vote (Campbell & Byrne, 2009). The improvement would also depend on how people choose to straight party vote; either by using the single ballot option (giving them a large time benefit if they were able to skip or skim through the already-voted races without reviewing them) or by voting in each race individually (which would most likely result in a similar voting time to voters who chose candidates of varying parties). A consistent order of parties on the ballot such as the Republican candidate always being listed first, Democratic candidate second, and Libertarian candidate third (as was the case with the ballot used by Piner & Byrne (2010)) may be highly beneficial to voters utilizing only the audio interface. These regular landmarks cold be used as an indicator of how far into a race one is, and used by voters to orient themselves on the ballot.

4.6 Input Devices

The relationship between a respondent's computer skills and their level of comfort with using directional arrow keys can be understood in terms of the keyboard, the preferred input device by a majority of users. Arrows keys are an integral part of navigation a webpage or document using a screen reader. This level of familiarity and comfort could be taken advantage of and designed into a voting machine's input device. Future research should include a comparison between a familiar input device (like a telephone keypad or computer keyboard) and one designed specifically for the needs of a voting system (such as the proposed button box mentioned in the survey).

4.7 Solutions & Future Directions

In conclusion, our results suggest certain guidelines be followed based on the data collected in this survey and often supported by outside sources. Five proposed guidelines are listed here, based both on an analysis of response data as well as the ideas and thoughts presented by voters via the open-ended portions of the survey. These guidelines are designed to be flexible enough to be applied across devices, regardless of any specific details relating to input devices, screen size, audio equipment, etc.

First, an accessible DRE interface should include an audio mode that can be used in conjunction with the standard visual display. Currently, only a small number of respondents use both interfaces, but this would increase if users could change aspects of the display. This relates to the next guideline that a system should provide the ability to adjust audio speed and volume as well as text size and contrast. The third guidelines is in regards to audio and suggests that a male synthesized text-to-speech voice that can be sped up without distortion should be used. This was chosen over the slightly preferred human voice due to the high desired ability to speed up the audio (requested by more than 90% of respondents). Fourth, navigation should allow users to skip through sections of speech that are not important to them as well as allowing them to replay any parts they may have missed or not comprehended the first time. Finally, a way of reviewing the ballot must be included but should not be required to end the voting process.

By combining these unique perspectives with a solid understanding of human factors best practices, a voting system that is both accessible and useable can be designed. The integration of accessibility into mainstream technology often has benefits beyond allowing more of the population access to a system. As Vanderheiden (1990) points out, "When products, environments or systems are made more accessible to persons with limitations, they are usually easier for more able-bodied persons to use. Some of the potential benefits include lower fatigue, increased speed and lower error rates." Use of these guidelines to improve multi-modality audio and visual systems may improve the voting experience beyond visual impairments and impact individuals with other factors like aging, cognitive impairments or language-based disorders.

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Appendix

Survey Items

1.) What is your gender?
( ) Male
( ) Female

2.) How old are you?
_____

3.) While this research is currently focused on elections in the United States, we are interested in responses from those from other nations as well. If the voting experiences you are answering this survey about did NOT take place in the United States, please list what country or countries you are referring to
_____

4.) Are you a native English speaker? If no, what is your native language?
( ) Yes
( ) No

5.) Please indicate the highest level of education you have completed.
( ) Some high school
( ) High school or G.E.D.
( ) Some college or Associate's degree
( ) Bachelor's degree of higher

6.) What ethnicity do you consider yourself?
( ) African American
( ) American Indian
( ) Asian American
( ) Caucasian
( ) Mexican American or Chicano
( ) Other Hispanic or Latino
( ) Multiracial
( ) Other

7.) Are you left or right handed?
( ) Left-handed
( ) Right-handed
( ) Ambidexterous

8.) Do you have any residual vision? If yes, please describe.
_____

9.) Please rate your level of proficiency with reading Braille (With 1 meaning "I've never used it", and 10 meaning "I'm completely proficient"):
( ) 1
( ) 2
( ) 3
( ) 4
( ) 5
( ) 6
( ) 7
( ) 8
( ) 9
( ) 10

10.) How many hours per week do you use a computer?
( ) Less than 5 hours
( ) Between 5 and 20 hours
( ) Between 20 and 40 hours
( ) Over 40 hours

11.) Please rate your level of computer expertise (With 1 being a novice, and 10 being an expert)
( ) 1
( ) 2
( ) 3
( ) 4
( ) 5
( ) 6
( ) 7
( ) 8
( ) 9
( ) 10

12.) Which of the following input devices do you use to interact with your computer? (Please choose all that apply)
[ ] Keyboard
[ ] Mouse
[ ] Joystick
[ ] Touch screen
[ ] Microphone/Speech Recognition
[ ] Other (please specify)

13.) What is your preferred method of input when using a computer?
( ) Keyboard
( ) Mouse
( ) Joystick

( ) Touch screen
( ) Microphone/Speech Recognition
( ) Other

14.) How often do you use an ATM (Automated Teller Machine) to get money or complete other transactions at a bank, grocery store, or other location?
( ) never
( ) very infrequently
( ) occasionally (for example 1-4 times a year)
( ) often (for example once a month)
( ) frequently (for example once a week or more)

15.) How many national-level elections (that is, elections for President or Congress/Senate, typically held every two years; both 2004 and 2006 would count for this) have you voted in?
( ) None
( ) 1-8
( ) 9-15
( ) More than 15

16.) How many non-national, but governmental, elections have you voted in?
( ) None
( ) 1-8
( ) 9-15
( ) More than 15

17.) How many other elections of any type (such as local or school elections) have you voted in?
( ) None
( ) 1-8
( ) 9-15
( ) More than 15

18.) What states have you voted in?

_____

) If you have ever voted in a country other than the United States, please list the country or countries where you have voted.

_____

19.) If you have voted before, describe what types of voting machines or methods you have used, and what your experience was like using them.

_____

20.) Which of these voting methods did you like the best? Which of these voting methods did you like the least? Why?

_____

21.) Over the last 10 years, many jurisdictions have switched from an older voting technology to digital, computerized voting systems. Do you feel this change has been beneficial to you as a voter? Why or why not?

_____

22.) If you had previously voted as a sighted person, have your voting habits changed? How?

_____

23.) How do you get to the polling station?

_____

24.) Have you ever received assistance during the actual process of voting and casting your ballot? If so, from whom? (Please choose all that apply)
[ ] Never Received Assistance
[ ] Family
[ ] Friends
[ ] Pollworker
[ ] Other (please specify)

25.) On average, how long does it take you from the time you enter the polling place until when you cast your ballot? (this includes waiting in line, the time to get the voting machine set up, etc)

_____

26.) On average, how long does it take you to fill out and cast your ballot? (this includes only the time spent listening to instructions and making selections on your ballot)

_____

27.) Are there any obstacles that you feel make it difficult for you to vote? (Please choose all that apply)
[ ] Location of the polling station
[ ] Physical layout of the polling station
[ ] Long Lines
[ ] Hours that the polls are open
[ ] No friend/family member available to help
[ ] Attitude of poll workers
[ ] Length of time it takes to vote
[ ] Other (please specify)

28.) Do you trust the poll workers to provide you with accurate information?
( ) Yes
( ) No

29.) Do you participate in early voting?
( ) Never
( ) Sometimes
( ) Usually
( ) Always

30.) How often do you review your completed ballot before casting it?
( ) Never
( ) Sometimes
( ) Usually
( ) Always

31.) How often do you cast a write-in vote?
( ) Never
( ) Sometimes
( ) Usually
( ) Always

32.) How often do you vote a straight-party ticket?
( ) Never
( ) Sometimes
( ) Usually
( ) Always

33.) If you vote straight-party, do you usually do it by:
( ) Using the single straight-party option on the ballot
( ) By voting in each race individually

34.) How do you learn about the candidates and issues?
_____

35.) Have you ever had difficulty obtaining campaign documents in accessible formats?
_____

36.) Have you ever felt worried about figuring out how to use the ballot or technology to cast your vote?
( ) Yes
( ) No

37.) Do you typically cast your vote on an absentee ballot?
( ) Yes
( ) No

38.) Have you ever felt that time pressure caused you to rush, make a mistake, or leave a choice blank when you would not otherwise have done so?
( ) Yes
( ) No

39.) Do you typically cast a vote for every office on the ballot?
( ) Yes
( ) No

40.) When you voted in an election, have you ever been unsure if your vote was cast correctly or would be counted? If yes, please describe the situation.
_____

41.) Some voting machines let you use both visual and audio modes while you vote. Would you prefer to use both modalities while you voted?
( ) Yes
( ) No

42.) Would the ability to change any of the following increase your likelihood of using the visual mode in addition to the audio? (You may choose more than one answer)
[ ] Increase Font Size
[ ] High contrast display
[ ] Other screen adjustment (please specify)

43.) If it were available, would you prefer to use a Braille interface instead of an audio interface?
( ) Yes
( ) No

44.) Please rate your level of proficiency on a scale of 1 to 10, with using a telephone keypad to enter numbers (With 1 meaning "I've never used it", and 10 meaning "I'm completely proficient")
( ) 1
( ) 2
( ) 3
( ) 4
( ) 5
( ) 6
( ) 7
( ) 8

( ) 9
( ) 10

45.) How comfortable would you be with using a telephone keypad to control your interactions with a voting machine?
( ) Very Comfortable
( ) Comfortable
( ) Neither Comfortable or Uncomfortable
( ) Uncomfortable
( ) Very Uncomfortable

46.) How comfortable would you be with using a direction keypad (four arrow keys, giving you the options of up, down, left, and right) to control your interactions with a voting machine?
( ) Very Comfortable
( ) Comfortable
( ) Neither Comfortable or Uncomfortable
( ) Uncomfortable
( ) Very Uncomfortable

47.) How important is it to you that you have a way of directly verifying that your ballot accurately represents how you intended to vote?
( ) Not important
( ) Somewhat important
( ) Very important
( ) Essential

48.) In general, would you prefer a voting machine's audio interface to use
( ) a recorded human voice
( ) a synthesized voice from text-to-speech software

49.) What gender voice would you prefer?
( ) Male
( ) Female
( ) No Preference

50.) Please rate your level of familiarity and comfort with using and understanding synthesized voices (With 1 meaning "I've never used it", and 10 meaning "I'm completely proficient"):
( ) 1
( ) 2
( ) 3
( ) 4
( ) 5
( ) 6
( ) 7
( ) 8
( ) 9
( ) 10

51.) Which of the following would you like to be able to adjust on an audio interface? (Please choose all that apply)
[ ] Speed
[ ] Volume
[ ] Pitch
[ ] Language
[ ] Other (please specify)

52.) Is there anything else you'd like to add? This could include any opinions your have on the existing voting systems, experiences you've had or heard about while voting, or suggestions for us on how to improve existing voting technology.
_____

Additional Questions Given in Person:

53.) Would you like the buttons to be
___Bigger
___Smaller
___This size is fine

54.) How easy would you say it is to discriminate between the buttons and tell which one is up, down, left, right, etc?
___Very Easy
___Easy
___Average
___Difficult
___Very Difficult