Clemson University RAAV Final Report

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II. EXECUTIVE SUMMARY

The research conducted by the Prime III research team under the U.S. EAC Accessible Voting Technology Initiative has changed voting in the U.S.A. Voting machine manufacturers are creating universally designed voting machines, which were unheard of 10 years ago when Prime III was created. Prime III was the first universally designed voting machine intended for use by all voters. The results reported below include the Prime III interface design, implementation and evaluation. Also included in these results were multiple pilot and demonstration elections. You will also find the team was active in disseminating information about the research to elections officials and members of the general voting population. The Clemson University team moved to the University of Florida in 2014 where the voting research activities have continued under Dr. Gilbert's supervision.

A. Interface Design, Implementation & Evaluation

The Prime III interface is a multimodal user interface, meaning voters use it in multiple modalities, i.e. speech and touch. With the Prime III interface, voters that can't see, hear, and those without arms can all privately and independently vote on the same machine as anyone else. This design is a universal design that accommodates more voters on a single machine. Here's a summary of the major accomplishments conducted by the Prime III team.

Our early efforts on this grant began with incorporating the latest research and technological innovations to enhancing the interface design and system functionalities of the Prime III system. The team updated the Prime III interface to run within the web browser environment to improve portability and broaden access. This allowed Prime III to become a more commercial off-the-shelf (COTS) friendly system. In addition the Low Error Voting Interface (LEVI) designed by Dr. Ted Selker was integrated into Prime III, see figure 1. Prime III uses optical character recognition (OCR), to tally ballots. However, we have found that OCR software is about 90% accurate. As a result of these findings, we made a modification to the OCR software that will tally the results by reading each ballot and tallying the selection similar to how humans tally ballots. We call this process Informed OCR, or iOCR. We also conducted a sound detection study to evaluate the system's speech recognition at various levels of background noise. The goal of the study was to establish a threshold for when distortion occurs and speech recognition accuracy declines to establish a threshold for ambient noise to determine when speech recognition degrades. A setup using speakers inside a sound booth was used to imitate a voter marking their ballot using Prime III in a voting precinct.

In further exploring the imminent needs of the voting community, the Prime III team decided to expand its research efforts beyond the core Prime III system, by designing and developing solutions that address other gaps in the process that disenfranchises voters. For example, the Prime III Team created Televoting, designed to enable UOCAVA voters to return their ballots in a timelier manner versus mailing them back to the U.S.A. Per the request of the company Clear Ballot, the Prime III team produced a marked optical scan ballot as an option for the printout from Prime III. In response to the long lines of the 2012 Presidential Election, the Prime III Team developed VoterPass, a voter-line management tool designed to make voting more efficient. The Prime III team designed an Auto-Paper Handling concept for voting to make paper ballots accessible. Additionally, Balloting is a concept created by the Prime III team that involves the use of QR Codes for voting in an effort to make voting more efficient and accurate with respect to capturing the voter's intent. Voters mark a ballot online or using their phone. The resulting ballot is a QR Code that is scanned on Election Day at a Prime III voting machine. As a proof of concept, the Prime III team conducted a study using the 2012 Presidential optical scan ballot from Broward County, Florida. The results heavily favored the Balloting concept.

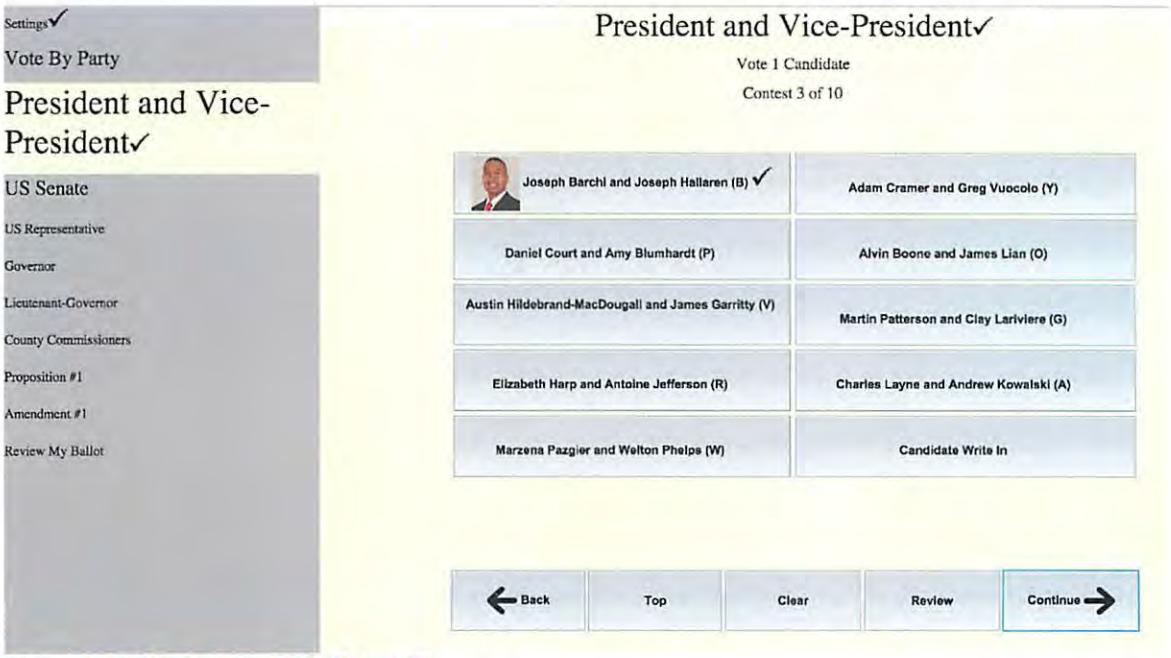

Figure 1: LEVI integrated into Prime III

B. Pilot and Demonstration Elections

To truly make a societal impact the Prime III team went beyond design and development in a laboratory space and took on partnerships and opportunities to put these efforts, theories and ideas to use in the public domain. There were more than 9 elections, or pilots, that used Prime III during the past 3 years. These elections range from student and national disability organizations to State elections. Prime III was used by National Society of Black Engineers (NSBE), National Council on Independent Living (NCIL) and Self Advocates Becoming Empowered (SABE) for their national elections over the life of the grant. In May of 2012, the State of Oregon used Prime III in the Presidential Primary in 5 counties. Dr. Gilbert also served as a participant on a roundtable discussion with the Presidential Commission on Election Administration (PCEA) in Cincinnati, OH where Prime III and Balloting were demonstrated to the commission. The Town of Newton and Town of Kossuth in Wisconsin used Prime III on April 1, 2014 in a statewide election. The election was a success, but there were many lessoned learned from this pilot. The State of New Hampshire used Prime III in a primary election in September 2014 in 2 precincts. The team also gave demonstrations to the League of Women Voters in South Carolina, election officials at Election Center meetings, and the team also consulted with the Los Angeles County Voting System Assessment Project (VSAP). Also, the Prime III team conducted the usability and accessibility evaluation of the ES&S ExpressVote machine. The resulting report was used in the certification of the ExpressVote machine.

C. Information Dissemination & Presentations

Much of the research and innovations the Prime III team implemented, were birthed from what was learned in the opportunities of information dissemination and presentations. In these opportunities the Prime III team interfaced with election officials and advocates that are on the ground. The team heard their needs and issues facing them in elections. In 2012, Dr. Gilbert gave presentations at the U.S. Access Board and he served as a panelist on the U.S. EAC Roundtable on Best Practices for Veterans Voting. He also gave a TEDx presentation and demo of Prime III in Greenville, South Carolina. The Clemson University Team gave presentations at the NIST Future of Voting Symposium on Prime III and

TeleVoting. Prime III team gave a demonstration of Televoting and Prime III on Capitol Hill in Washington, DC sponsored by Congressman James Clyburn of South Carolina. Prime III was demonstrated to several election officials in Savannah, GA at the Election Center Annual National Convention. As a result of this demonstration, the State of Wisconsin decided to pilot test Prime III in April 2014. In 2014, the team gave multiple presentations to the National Federation for the Blind, an accessible voting webinar sponsored by NIST, South Carolina: Laurens and Pickens County Election officials, Election Center Seminars (San Francisco, St Louis) and Richland County Columbia, SC election officials.

The future of voting has been positively impacted by the research we have conducted with Prime III. We have demonstrated concepts that were once thought impossible. For example, secure, accessible and usable voting. Prime III is the only voting technology, to our knowledge, that addresses all 3 of these requirements simultaneously for all voters on the same machine. We provided VoterPass and Balloting as methods to make voting more accurate, efficient and shorten lines. We provided a hands-free design to making paper universally accessible. We also created Televoting for overseas and military voters.

III. PERSONNEL

Juan E. Gilbert Ph.D. is the RAAV project primary investigator (PI). Dr. Gilbert has a B.S. degree in Systems Analysis from Miami University in Ohio and he received his M.S. and Ph.D. degrees in Computer Science from the University of Cincinnati. He is currently the Andrew Banks Family Preeminence Endowed Chair and Associate Chair of the Research Computer & Information Science & Engineering Department at the University of Florida. Dr. Gilbert has more than 20 years of research experience in usability, accessibility and advanced database systems. He has been designing and testing accessible voting systems for more than 10 years. Over the past 10 years, Dr. Gilbert has been a PI or Co-PI on more than 35 grants and contracts for more than $20 million dollars. Dr. Gilbert is a senior researcher who has worked with multiple organizations and researchers from coast-to-coast. He has also managed large-scale multi-year, multi-investigator, multi-institution research projects. Dr. Gilbert has published more than 100 articles, given more than 170 invited or keynote talks and he has received numerous awards for his research, leadership and innovative thinking. Dr. Gilbert has testified and served as an expert for the EAC, NIST, U.S. Senate and various other companies and organizations. He is a Fellow of the American Association for the Advancement Science (AAAS), an ACM Distinguished Scientist and one of the 50 most important African-Americans in Technology by eAccess Corp. He was also named a Speech Technology Luminary by Speech Technology Magazine and a national role model by Minority Access Inc. Dr. Gilbert is also a National Associate of the National Research Council of the National Academies, an ACM Distinguished Speaker and a Senior Member of the IEEE Computer Society. He was named a Master of Innovation by Black Enterprise Magazine, a Modern-Day Technology Leader by the Black Engineer of the Year Award Conference, the Pioneer of the Year by the National Society of Black Engineers, and he received the Black Data Processing Association (BDPA) Epsilon Award for Outstanding Technical Contribution. In 2002, Dr. Gilbert was named one of the nation's top African-American Scholars by Diverse Issues in Higher Education. Dr. Gilbert's research lab consists of 2 postdoctoral researchers and 16 graduate research assistants. He has directed more than 50 graduate degrees, including 13 Ph.Ds. In 2003, Dr. Gilbert's research team created Prime III, an accessible proof of concept voting system. His Prime III research team was awarded the Best Usability Metrics and Best Human Factors awards in the 2007 VoComp,

http://www.vocomp.org, competition in Portland, Oregon over other university teams that developed voting technologies.

James (Jim) Charles Dickson, who has more than 24 years of experience with non-partisan voter registration and education issues and served on the Board of Advisors to the U.S. Election Assistance Commission. Jim Dickson has 30 years experience with nonpartisan voter engagement issues. He is the former Vice President for Organizing and Civic Engagement for The American Association of People with Disabilities (AAPD). He led AAPD's nonpartisan Disability Vote Project, a broad coalition of 36 national disability-related organizations whose mission is to close the political participation gap for people with disabilities. The project focuses on voter registration and education, Get-Out-The-Vote drives, election reform and polling place access. Mr. Dickson played a central role with the Leadership Conference on Civil and Human Rights (LCCRH) effort to pass the Help America Vote Act (HAVA). He was part of the leadership team which passed The National Voter Registration Act. Mr. Dickson organized the campaign to place a statue of President Roosevelt in his wheelchair at the Franklin Delano Roosevelt Memorial on the National Mall in Washington, D.C. Mr. Dickson has organized grassroots, multi-issue organizations in Rhode Island, Connecticut and California. With the support of the Sierra Club, he organized the first grassroots congressional mobilization for the environmental movement, which resulted in the passage of the first Clean Air Act. In 1987, Mr. Dickson became the first blind person to sail a boat alone from Rhode Island to Bermuda. His objectives were to have a good time and to stimulate public discussion on the abilities of people with disabilities. Mr. Dickson is a graduate of Brown University.

Wanda Eugene is postdoctoral researcher in the Computer & Information Science & Engineering Department at the University of Florida, who specializes in the design of human centered computational artifacts, user interfaces. She is interested in how cultural, social, and personal surroundings affect the appropriation and can influence the design of new technologies. Dr. Eugene completed her doctoral studies in Computer Science and Software Engineering Department at Auburn University. She earned a bachelor's in Electrical Engineering a master's in Industrial Engineering from the Florida Agricultural and Mechanical University Florida State University College of Engineering, and a master's in Interdisciplinary Studies specializing in Instructional Technology and African American Studies from George Mason University. Prior to her current appointment she was a postdoctoral researcher at Clemson University in the Human Centered Computing Division where she served as the project coordinator on the Prime III team facilitating research studies.

IV. RESEARCH RESULTS

The Clemson University team was led by Dr. Juan Gilbert. The major results and accomplishments of this team will be described in the sections that follow. These results include Prime III interface design, implementation and evaluation. Also included in these results were multiple pilot and demonstration elections. You will also find the team was active in disseminating information about the research to elections officials and members of the general voting population. The Clemson University team moved to the University of Florida in 2014 where the voting research activities have continued under Dr. Gilbert's supervision.

When the U.S EAC awarded the Accessible Voting Technologies (AVT) grant to Clemson University under Dr. Gilbert's leadership, Dr. Gilbert had already been actively conducting research on how to make voting more accessible, usable and secure. This effort was manifested in voting system called Prime III. The Prime III system is a software tool that allows people to vote using touch and/or their voice. The system consists of a headset with a microphone, a touch screen, a 2-button switch and a printer. To make selections, voters can touch the screen, touch the switch and listen to the audio prompts, they can respond to the audio prompts with their voice and they can do all of these interchangeably. In other words, the voters do not have to specify how they will interact with the system; they simply use it. The Prime III interface is a multimodal user interface, meaning voters use it in multiple modalities, i.e. speech and touch. With the Prime III interface, voters that can't see, hear, and those without arms can all privately vote on the same machine as anyone else. This design is a **universal design**. Universal design refers to the fact that we design it once and multiple groups can use it.

A. Informed Optical Character Recognition (iOCR)

When the voters are done marking their ballot, the ballot is printed on an adjacent printer with only the contests and the selections the voter made. The printed ballot is the official ballot of record. This ballot is placed into a ballot box. Later, the ballot is scanned using an off the shelf scanner. The scanner takes a picture of the ballot and stores it on a computer attached to the scanner. The scanned images are then read by another piece of software called OCR (optical character recognition). OCR software is commonly used on most computers; however, it's not used in voting because it the accuracy rate isn't high enough for voting systems. We have found that OCR software is about 90% accurate. As a result of these findings, we made a modification to the OCR software. The modification is called Informed OCR, or iOCR. Given the fact that we have knowledge of the candidates and the contests that will appear on the ballot, we can use that information to correct mistakes made with the OCR. For example, a ballot may have the following selection for President.

1. President & Vice-President ==> Barack Obama & Joe Biden

When the OCR reads this line, it may produce something like

2. President Vice-President ==> Baran Odamu Joe Bibon

When we as humans see this, we know it's supposed to be the text from line 1. Therefore, using the information about the actual ballot options, we know that

President Vice-President ==> Baran Odamu Joe Bibon
are not options on the ballot, but

President & Vice-President ==> Barack Obama & Joe Biden

are options that are very similar to the OCR text that was produced. Therefore, the iOCR software will correct the OCR text to the correct ballot text. After iOCR has corrected the text, the software will tally the results by reading each ballot and tallying the selections. This approach was designed to model how humans tally ballots. We read them and score the results.

As such, we believe this will eliminate discrepancies between the machines' tally and any human tallies.

B. Prime III User Interface

In the beginning of the grant, the research team began making modifications to the Prime III interface. The original version of Prime III was developed in the Java programming language. Although Java runs on multiple devices, it's not very portable to modern mobile devices. Therefore, the team updated the Prime III interface to run within the web browser environment. This modification made the Prime III software immediately more accessible to more devices and ultimately more voters. We also implemented the Low Error Voting Interface (LEVI) designed by Dr. Ted Selker into Prime III. With these upgrades of the Prime III software, we were ready to do pilot elections, usability studies, and demonstrations.

C. Elections and Demonstrations

In 2012, the National Society of Black Engineers (NSBE) used Prime III in their national election. NSBE is the world's largest student run organization. They rented touchscreen computers and printers to conduct the election with Prime III. We had more than 200 voters use the software. We also tallied the results using the iOCR software. The election was a success and we have been doing the NSBE national election since 2012.

The National Council on Independent Living (NCIL) also used Prime III for their national election in 2012. NCIL is an organization of people with varying levels of ability or disability. In this election, the team didn't use the iOCR. Instead the team used barcodes on the ballots and a barcode scanner. This approach worked, but voters expressed concerns about what was actually in the barcode; therefore, we dropped the barcode implementation for tallies. The election had less than 100 voters, but the voters used the speech interface and other features of Prime III successfully.

In May of 2012, the State of Oregon used Prime III in the Presidential Primary in 5 counties. Prime III was setup on tablet devices with printers at rehabilitation and independent living centers. Voters used Prime III to print a ballot and the ballot was mailed in for tallying. The election was a success in that we had a significant number of voters use Prime III and there were no major issues with software.

Self Advocates Becoming Empowered (SABE) used Prime III for their national election in St Paul/Minneapolis, MN - Sept 1, 2012. SABE is an organization that represents people with cognitive disabilities. The SABE election was important for the development of our research because we put pictures on the ballots. We were aware that some of their voters would have reading literacy limitations. Therefore, we put pictures of the candidates on the ballots to see if the pictures would help the voters that may have low reading literacy. As a result, we never identified a single voter that could not use Prime III. Although we were fully aware that some of the voters had reading limitation, they could all vote using the pictures. This was a major development in our research because it suggested the pictures enabled people with reading limitations the ability to vote without assistance. Because we didn't setup the election as a formal study to definitively determine the effect the pictures were having on those with reading

limitations, we conducted a mock election at Clemson Elementary School. The mock President Election used pictures of the Presidential candidates and the voters were the students in grade PK5 through 5th grade; therefore, we knew there were voters that could not read. Just like the SABE election, all the students voted successfully using the touchscreens irrespective of their reading literacy levels. It was apparent that some of the students clearly voted using the pictures and they could tell you whom they voted for. Again, the major result here was the impact pictures could have for voters at various levels of reading literacy.

These elections provided input into the new interface for Prime III. We had people with and without disabilities use the same system in different elections. We learned that the barcodes would not work in a real election because of voter confidence issues. We also learned that iOCR was a much more effective way to process paper ballots.

In 2012, Dr. Gilbert gave a TEDx presentation and demo of Prime III in Greenville, South Carolina. TEDx presentations are viewed by thousands of people locally and worldwide. This presentation was a great way to disseminate what the team had done and the impact Prime III could have on voting nationally. The team also held a RAAV meeting at the Grand Hyatt in Atlanta where the new Prime III interface was demonstrated. The Clemson team worked with members of NIST to develop a survey for data collection purposes in future experiments and they also met with the Tennessee Disability Coalition to discuss poll worker training in Nashville, TN.

In 2012, the Prime III team decided to take on internet voting. Specifically, voting for military and overseas voters. We started a project called Televoting. Televoting was designed to enable UOCAVA voters to return their ballots in a timelier manner versus mailing them back to the U.S.A. Here's an overview of how Televoting works.

D. Televoting

Telemedicine is the use of telecommunication and information technologies in order to provide clinical health care at a distance (Wikipedia). Televoting is an approach that uses telecommunication and information technologies to provide our uniformed and overseas citizens the ability to vote from a distance, similarly to all voters. The conceptual model below, will describe the concept of Televoting.

Conceptual Model

Figure 2 illustrates the Televoting polling place. Notice the camera in the upper left-hand corner. This is a webcam that allows anyone and nearly everyone to be a poll watcher.

Figure 2: Polling place

Figure 3 is also an illustration of the polling place that captures the remote election officials. Notice that the remote election officials are seated with a monitor equipped with a webcam, a printer and a ballot box. We have made a recent recommendation to place the remote election officials against the walls if possible or maybe facing each other. Figure 3 does not include those recommendations. The remote election officials will service the overseas voters.

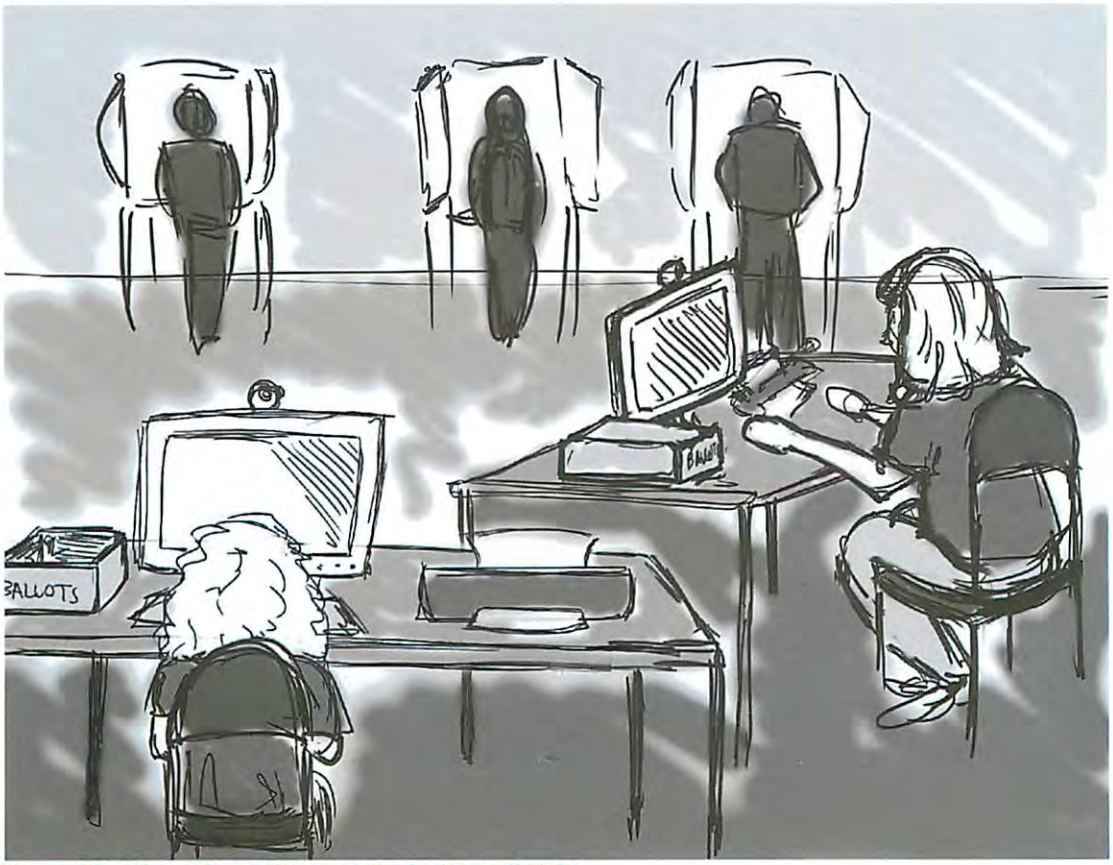

Figure 3: Polling place with remote election officials

Next, we have a soldier overseas that goes online and fills out his ballot. When the soldier is ready to cast his ballot, s/he will press a submit button and s/he will be placed into the queue for remote election officials. When the soldier's turn arrives, s/he will enter a live videoconference session with the remote election official, see Figure 4. The remote election official will verify the soldier's identity before printing the soldier's ballot. We are also adding a telephone line to the remote election official's desk so that s/he can actually use the phone line to also verify the soldier's identity and vice versa. Also, keep in mind that the remote election officials are located in the polling place; therefore, their identity is known by anyone that wants to poll watch.

Figure 4: Soldier interacting with a remote election official to cast his ballot

After the soldier's identity has been accepted, the remote election official will press a button on the screen and the soldier's ballot will print on a printer in the precinct. The soldier can actually hear and see his/her ballot being printed in real time using another camera that is positioned on the printer.

After the ballot prints, the remote election official will ask the soldier to confirm that his/her ballot printed correctly. If the soldier confirms that the ballot is correct, the ballot will go into the ballot box.

We have implemented a version of Televoting ready for pilot testing. We have Okaloosa County, Florida on board to pilot test Televoting as soon as we work out the details. Verizon Wireless has

come on board as a partner for the Televoting project as well. Verizon wireless has agreed to work with the Prime III team to provide the necessary network security for Televoting in a pilot.

In 2012, the Prime III team also met with Mr. Larry Moore, CEO of Clear Ballot. Mr. Moore's company has a technology that is used in optical scan voting. His technology uses images to better determine voters' marks on ballots. Mr. Moore asked the Prime III team to produce a marked optical scan ballot as the printout from Prime III. Therefore, our team took sample optical scan ballots, scanned them and developed a process to use Prime III to print a marked optical scan ballot on a blank piece of paper. Note that Prime III is not marking an existing optical scan ballot. Instead, we are printing a marked optical scan ballot on a blank piece of paper. This has significant benefits because there's no need to pre-print ballots, which saves money and paper. You only use blank paper with Prime III. This new extension to the Prime III system would be very useful in future elections. However, we personally prefer the iOCR ballots because humans more easily count them, but this approach works too.

In 2012, Dr. Gilbert also gave presentations at the U.S. Access Board and he served as a panelist on the U.S. EAC Roundtable on Best Practices for Veterans Voting.

Also in 2013, Clemson University Team gave presentations at the NIST Future of Voting Symposium on Prime III and TeleVoting. There were voting systems experts, election officials, researchers and others present.

On June 18, 2013, the Prime III team gave a demonstration of Televoting and Prime III on Capitol Hill in Washington, DC sponsored by Congressman James Clyburn of SC, see figure 5. The demonstrations included the acting Director of the National Science Foundation and other representatives from the NSF. The graduate students conducted demos of the technologies for all that attended.

Figure 5: Dr. Gilbert demonstrates Prime III to South Carolina Congressman James Clyburn

Furthermore, in 2013, Prime III was demonstrated to several election officials in Savannah, GA at the Election Center Annual National Convention. As a result of this demonstration, the State of Wisconsin decides to pilot test Prime III in April 2014.

In 2014, the Town of Newton and Town of Kossuth used Prime III on April 1, 2014 in a statewide election. The election was a success, but there were many lessoned learned from this pilot. First, this pilot election was critical in that it revealed some interesting findings about using commercially off the shelf (COTS) components in elections. Here's a breakdown of the findings:

1. If COTS components are used in elections, the local elections authority must have a strong technical staff. In the event, anything goes wrong, it is important that the staff have the necessary technical backgrounds to address any issues.

2. Extensive pre-election testing with the actual COTS components is required to validate all the components are working together.

The Wisconsin election resulted in a report that describes some of the issues experienced with the iOCR. The election found a flaw in the iOCR logic. This did not change the outcome of the election because the election staff did a manual recount, so no harm was done to the election. This bug was difficult to find, but it has been found and fixed.

Dr. Gilbert also served as a participant on a roundtable discussion with the Presidential Commission on Election Administration (PCEA) in Cincinnati, OH. The team also gave demonstrations to the League of Women Voters in South Carolina, election officials at Election Center meetings, and the team also consulted with the Los Angeles County VSAP. LA County has decided to build their own voting system and they consulted with the Prime III team on specific aspects of their designs.

The State of New Hampshire used Prime III in a primary election in September 2014 in 2 precincts. This election used Prime III to produce an optical scan ballot that was manually counted. The NH election officials have agreed to use Prime III in the November elections and they are making plans to go statewide in 2016 with Prime III.

In 2014, the team gave multiple presentations to the National Federation for the Blind, an accessible voting webinar sponsored by NIST, South Carolina: Laurens and Pickens County Election officials, Election Center Seminars (San Francisco, St Louis) and Richland County Columbia, SC election officials.

E. Elections and Demonstrations Summary

In summary of the year 2012, we had multiple demonstrations and presentations. One of the most frequent recommendations was for larger screen size. Given Prime III had moved to the web browser, this was not an issue because the system could operate on any device, so larger devices would work just as well as smaller devices. If the device had zoom capabilities, the device could enlarge the screen as well. It is important to remember that almost all of the participants were able to become independent users after a short demonstration and training of about 5 minutes. In addition a good number of individuals were able to use the standard features of the voting system to complete the sample ballot independently. This indicates that the current equipment does provide a solid array of access features and has some good universal design features built into the voting interface that enable voters with different needs to vote independently provided they have the opportunity to interact with a system before sitting down to cast their ballot at their polling place.

F. VoterPass

In 2013, the Prime III team also developed VoterPass in response to the long lines in the 2012 Presidential Election. VoterPass is a voter-line management tool designed to make voting more efficient. Voters will access VoterPass through multiple interfaces, including, but not limited to, Internet web browsers, mobile phone applications, interactive voice response over a phone line, etc.

Upon identifying the registered voter, the voter will select their assigned precinct and VoterPass will provide him or her with timeslots available for voting. VoterPass can provide the voter with a reminder email, phone call, or another form of communication to confirm the chosen time slot.

On Election Day, the voter will arrive at the voting precinct where he or she will bypass the regular voting line and enter the VoterPass line. When the voter reaches the front of the VoterPass line, his or her identity will be verified for voting as well as for the VoterPass time slot.

VoterPass was implemented, but we haven't had a chance to do a pilot study of the technology.

G. Balloting

Balloting is a concept created by the Prime III team in an effort to make voting more efficient and accurate. The concept involves the use of QR Codes for voting. Before an election, voters can go online or use their mobile phone to mark a ballot. When they are done, the system generates a QR Code representing their ballot. You can scan the QR Code and it will reveal the ballot to you. On Election Day, the voters can approach a Prime III voting machine, scan the QR Code and the machine will bring the voter's selection up on the screen in review mode. Therefore, the voters can change their selections if they chose to do so. After the voter accepts the ballot as is or the voter modifies the ballot, the system will print the ballot. The printed ballot is then ready to be cast. This changes the voting paradigm from read, mark and print my ballot to review and print. We conducted a study using the 2012 Presidential optical scan ballot from Broward County, Florida. We had voters mark the ballot using Prime III, mark an optical scan paper ballot and then some used Balloting. The results were clear. On average, it took voters 4.5 minutes to complete the paper ballot, 3.8 minutes to complete the ballot using the touchscreen on Prime III and 48 seconds to complete the ballot using the QR Code and Balloting. These findings reveal that the use of QR Codes to represent ballots before the election can significantly decrease voting times.

ES&S is the nation's largest voting machine manufacturer. In 2013, ES&S developed a new voting machine called the ExpressVote. This new machine implemented the Balloting concept created by our team. Also, this new machine was ready for certification and ES&S asked the Prime III team to conduct the usability and accessibility evaluation of the ExpressVote. The Prime III team successfully evaluated the ES&S ExpressVote and the machine successfully passed certification. Additionally, the ExpressVote is an universally designed voting machine like Prime III.

H. Refreshable Braille

In 2014, the Prime III team also explored avenues for integrating refreshable Braille with Prime III. At this time, the grant was coming to an end, so we didn't complete the implementation, but we have designs on how to make this work.

I. Auto-Paper Handling Concept

In 2014, the Prime III Team designed an Auto-Paper Handling concept for voting. It has been discussed at nearly all accessible voting technology meetings the fact that paper is inaccessible. The Prime III team developed a concept to make paper accessible and published a YouTube video sharing this discovery with the hopes that a manufacturer will implement the designs.

V. CONCLUSIONS

The research conducted by the Prime III research team under the U.S. EAC Accessible Voting Technology Initiative has changed voting in the U.S.A. Voting machine manufacturers are creating universally designed voting machines. Prime III was the first universally designed voting machine intended for use by all voters. The future of voting has been positively impacted by the research we have conducted with the funding from this grant. On November 4, 2014, the State of New Hampshire used Prime III in 2 precincts for voting. This is a great example of the impact of our work. In the September 9, 2014 primaries in New Hampshire where they used Prime III as well, our team was there to support and run the Prime III machines. We had 1 postdoc and 2 PhD students on site. On November 4th, no one from our team was present. The New Hampshire staff purchased off the shelf Dell Tablets that ran Windows and they setup Prime III per our instructions and ran the election without our help. Figure 6 contains an illustration of the Prime III setup in New Hampshire on November 4th. Notice they have the Dell Tablet running the Prime III software with a printer and attached headset. They also used a 2-button switch to run Prime III as well. Voters could touch the screen or use the switch to interact with Prime III as they listened to the audio in the headset or simply read the screen.

Figure 6: Prime III setup in the New Hampshire, November 4, 2014 election

According to Thomas F. Manning, the Assistant Secretary of State in New Hampshire

> *"We had a very successful trial of the Prime III voting system at Ward 4 in Concord yesterday. Extremely positive reports from the elections staff, voters and the head of our Disabilities Rights Center. Actually, the results were more positive than we had expected from the roll out of a new technology."*

In an interview with the New Hampshire Concord Monitor, Mr. Manning said,

> *"While Manning and others with the Secretary of State's office stressed that no firm plans are in place to expand the system statewide, Manning said it's his "personal goal" to implement this software-driven system by the next presidential primary in 2016."*

Now that we have New Hampshire on board, we are working towards pilots in Ohio and Florida. Mr. Manning's response is not unique from our experiences. When we have tested Prime III, we have consistently received reports about how it empowers and enables voters that couldn't vote privately and independently before.

We have also demonstrated concepts that were once thought impossible. For example, secure overseas voting via the Internet, which is Televoting. We provided VoterPass and Balloting as methods to make voting more accurate, efficient and shorten lines.

The funding from the Accessible Voting Technology Initiative also paved the way for the Research Alliance for Accessible Voting (RAAV). The RAAV consisted of 3 teams, Accessibility and Assistive Technology (AAT), Applied Research (AR) and the Election Administration (EA) Team. Our teams worked collaboratively to conduct research, pilots and more. The Applied Research team's research was informed by the research on accessibility from the Accessibility and Assistive Technology team. The Election Administration team made it possible for all teams to engage with election officials for pilots, presentations and demonstrations. Each team made contributions to the projects on the other teams. This was a collaborative effort that has resulted in findings that continue to positively impact elections in the U.S.A.

As the PI of this initiative, my outlook of the future of voting is positive. The EAC Accessible Voting Technology Initiative will be seen as the catalyst for making voting work in the U.S.A. after many years of challenges in security, accessibility and usability.

VI. YOUTUBE VIDEOS

Accessible Paper for Voting, http://youtu.be/YPorhOMzaKk

Prime III & Balloting Demo, http://youtu.be/bM5DKP4c4aw

Nancy Ward Post SABE Election Interview, http://youtu.be/G9NYbntJflw

Televoting Demo, http://youtu.be/plxh-O-fcVQ

Disability, Voter Turnout, and Voting Difficulties in the 2012 Elections

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July 18, 2013

This research project is part of an inter-university consortium, the Research Alliance for Accessible Voting (http://www.accessiblevoting.org/). Funding was provided by the U.S. Election Assistance Commission. Valuable comments have been made by participants in workshops with the National Institute of Standards and Technology, Election Assistance Commission, National Association of Election Officials, and Society for Disability Studies.

Executive summary

Ensuring that citizens can vote with little or no difficulty is fundamental to a democracy, and an important topic in public debates and policy initiatives. We report results on disability and voting from analysis of two surveys: the Census Bureau's voting supplement for November 2012, and a separate nationally representative survey of 3,022 citizens following the 2012 elections that includes new measures of voting difficulties and experiences. The second survey was conducted by a professional survey firm, and was stratified to oversample citizens with disabilities to obtain a clearer portrait of their experiences and challenges.

The key results on disability and voter turnout include:

- 15.6 million people with disabilities reported voting in the November 2012 elections.
- The voter turnout rate of people with disabilities was 5.7 percentage points lower than that of people without disabilities. There would be 3 million more voters with disabilities if they voted at the same rate as people without disabilities who are otherwise similar in age and other demographic characteristics.
- Employed people with disabilities were just as likely as employed people without disabilities to vote, suggesting that employment helps bring people with disabilities into mainstream political life.
- The voter registration rate of people with disabilities was 2.3 percentage points lower than that of people without disabilities. The lower voter turnout is due in part to a lower registration rate among people with disabilities but more to lower turnout among those who are registered.

The key results on voting difficulties and experiences include:

- Almost one-third (30.1%) of voters with disabilities reported difficulty in voting at a polling place in 2012, compared to 8.4% of voters without disabilities
- The most common problems reported were difficulty in reading or seeing the ballot, or understanding how to vote or use voting equipment.
- People with disabilities were just as likely as those without disabilities to say they were treated respectfully by election officials
- Almost one-third of the voters with disabilities required assistance in voting, most commonly given by election officials or family members
- Among voters with disabilities, 6.5% used extra features or devices in voting such as large displays, magnifiers, lowered machines, and accessible voting machines

- While three-fourths of voters with disabilities said it was very easy to vote at a polling place, this is lower than for voters without disabilities, and 5.8% of voters with disabilities said it was somewhat or very difficult to vote

- Over one-fourth of voters with disabilities voted by mail in 2012, compared to one-sixth of people without disabilities. Among people with disabilities who voted by mail, about one-tenth reported difficulties and the need for assistance in filling out or sending the ballot.

- Asked about alternative voting methods for the next election, majorities of people both with and without disabilities say they would prefer voting in person in a polling place. Among other potential options, people with disabilities are relatively more likely to say they would prefer voting by mail, while people without disabilities are more likely to say they would prefer voting by Internet.

The findings point to the difficulties faced by many people with disabilities in exercising the right to vote, and establish a baseline that may be used to judge future progress in improving the voting experience for people both with and without disabilities.

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I. Introduction

There are at least 35 million voting-age people with disabilities in the United States, representing 1 out of 7 voting-age people, and the number is likely to grow with the aging of the population.[1] While people with disabilities have made tremendous political gains over the past few decades, most notably with the passage of the Americans with Disabilities Act (ADA) in 1990, evidence indicates that their levels of voter turnout and other forms of political participation are lower than that of people without disabilities. Ten surveys over the 1992 to 2004 period found disability voting gaps ranging from 3% to 21%, while analysis of large surveys based on Census Bureau data found disability gaps of 12% in both 2008 and 2010 after adjusting for differences in age and other demographic characteristics (Schur and Adya, 2012).[2] These gaps remain after controlling for standard predictors of voter turnout (resources, mobilization, and feelings of efficacy)(Schur et al., 2002). While it is difficult to make comparisons across time due to differences in samples and disability definitions, results from the Harris (2010) surveys suggest that the gap narrowed from 1996 to 2008.[3]

Polling place accessibility is an important factor that can affect political participation of people with disabilities. The Government Accountability Office (GAO 2009) found that only 27% of polling places in 2008 had no potential impediments to access by people with disabilities.[4] Inaccessibility may reduce voter turnout not only by making it more difficult to vote, but also by sending the message that people with disabilities are not fully welcome in the political sphere.

This study reports on voter turnout and voting difficulties in the 2012 elections. We use two sources of data: a) the Census Bureau's Voting Research Supplement in November 2012 that contains survey data on disability and voter turnout for 94,321 citizens, and b) a separate national household survey of 3,022 citizens with and without disabilities following the 2012 elections focusing on polling place accessibility and voting experiences. While the 2009 GAO report provided valuable information, it only addressed physical impediments to voting, and did not measure other potential problems that people with disabilities may face, such as reading or seeing the ballot, understanding how to vote or use the voting equipment, or standing in long lines. The second survey allows us to investigate the full range of difficulties that people may face for those who voted in 2012 or the prior 10 years, and any expected difficulties in voting among

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[1] Based on data from the Census Bureau's American Community Survey in StatsRRTC (2011). A larger estimate of 46 million people with disabilities age 21 or older is based on a more expansive disability definition using the 2005 Survey of Income and Program Participation in Brault (2008).

[2] Among the 10 surveys, 7 are based on broad samples of people with disabilities (Harris 2004, 2010; Schur et al. 2002; Schur et al. 2005), while two are based on non-employed respondents who answered an employment question by saying they have a disability (Shields, Schriner, and Schriner 1998a; LoBianca 1998); and one is based on New Jersey residents with spinal cord injuries (Schur and Kruse 2000). See review in Schur and Adya (2012) and Schur, Kruse, and Blanck (2013).

[3] The Harris surveys show a disability turnout gap of 17 percentage points in 1996 decreasing to zero in 2008, although the much larger sample from the Census Bureau data indicates a continuing significant disability turnout gap in 2008.

[4] Also see the recent 2-13 GAO statement at http://www.gao.gov/assets/660/654099.pdf.

those who have not voted at a polling place in the past 10 years.

Following a brief description of the data sources in section II, we present results on 2012 voter turnout by disability status in section III, polling place difficulties in section IV, the need for assistance and the use of extra devices or features in section V, perceived treatment by election officials in section VI, and preferences over voting methods in the next election in section VII. The conclusion is in section VIII.

II. Data Sources

The first data source is the Census Bureau's Voting Research Supplement, conducted as a supplement to the monthly Current Population Survey (CPS) following national elections in November of even-numbered years. The CPS is a monthly representative survey of the U.S. population designed primarily to obtain employment information. The Bureau of Labor Statistics added six questions to identify disability status starting in June 2008.[5] The sample sizes for the supplement were 92,360 in 2008, 94,208 in 2010, and 94,311 in 2012. The data and further description are available at http://www.census.gov/hhes/www/socdemo/voting/.

The second data source comes from a survey of 3,022 voting-eligible citizens following the November 2012 elections. Voter turnout questions were used from the U.S. Census Bureau's Voting Research Supplement, and the demographic questions and six of the disability questions came from the Current Population Survey and American Community Survey (see http://www.bls.gov/cps/cpsdisability.htm/). In order to catch impairments or conditions that may not have been covered in these six questions, a seventh question asked about any conditions that limit one's major life activities (to address potential limitations of the Census measure identified by Burkhauser et al., forthcoming). This seventh question was taken from 1998 and 2000 national surveys on disability and voter turnout (Schur et al., 2002). The seven disability questions are in Appendix 1. Since there are very few extant questions about voting experiences inside the polling place, we developed and tested new questions with other members of the Research Alliance for Accessible Voting. The questions about voter turnout, difficulties in voting, and polling place experiences are contained in Appendix 2. Questions about actual polling place difficulties were asked only of those who had voted in a polling place since 2002, and the remainder were asked parallel questions about what types of difficulties the respondent would expect to encounter if he or she wanted to vote in a polling place.

The survey was conducted by a professional survey firm (Survey Research and Technology), overseen by researchers at Rutgers and Syracuse Universities. It was a representative random-digit telephone survey, including both landlines and cell phones in the 48 contiguous states, of 3,022 U.S. citizens who were eligible to vote in the 2012 elections. Each

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[5] The questions are presented by the Bureau of Labor Statistics at http://www.bls.gov/cps/cpsdisability_faq.htm#Identified.

person contacted was first asked a series of questions to establish the number of people in the household who were eligible to vote in 2012, and was then asked seven questions to establish the number of people with a disability. The households were divided into disability and non-disability households, and in the disability households the interviewer asked to speak with the person with a disability (or if there was more than one, the person with the most recent birthday to ensure random selection). People with disabilities were oversampled for the remainder of the questions so that they represent 2000 of the final respondents, while people without disabilities represent the remaining 1022 respondents. The oversampling helped ensure both that the disability sample is large enough to reach solid conclusions about their experiences and to do analysis of subgroups within the disability sample.

We use the large sample from the Census Bureau dataset to analyze voter turnout in section III, and then use the additional questions asked in the second survey to analyze voting difficulties and other issues in sections IV to VII.

III. Voter turnout

A. Voter turnout in 2008-2012

People with disabilities were less likely to report voting in 2012 relative to people without disabilities, consistent with surveys for prior elections. As shown in Table 1, 56.8% reported voting, compared to 62.5% of eligible citizens without disabilities.[6] This difference is strong enough to reject sampling error as an explanation.

An estimated total of 15.6 million people with disabilities voted in 2012. This is comparable to the number of African-Americans who voted (17.8 million) and the number of Hispanics who voted (11.2 million)(File, 2013).

When broken down by type of disability, the turnout gap for people with hearing impairments is very small and we cannot reject sampling error as an explanation, but the other disability gaps are large and strong enough to reject sampling error. The lowest rate was among

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[6] The overall rate of turnout is higher than the rate calculated on actual votes cast, which was 57.5%, http://bipartisanpolicy.org/news/press-releases/2012/11/2012-election-turnout-dips-below-2008-and-2004-levels-number-eligible-vo This likely reflects the well-known problem of overreporting that affects nearly all voting surveys, as people overreport socially desirable activities like voting (Clausen, 1968; Holbrook, & Krosnick, 2010; Traugott & Katosh, 1979). See further discussion of upward and downward biases in File (2013). Examining the disability turnout gap remains valid, however, because it does not appear that people with disabilities are more or less likely to overreport voting, which means there is no obvious bias in the estimated turnout gap between people with and without disabilities. While studies have not specifically analyzed the relation of disability to overrreporting, it does not appear to be linked to age or other variables associated with disability, as discussed in Schur et al. (2002).

those with a cognitive impairment (29.6%).

The disability turnout gaps were 7.2% in 2008 and 3.1% in 2010 compared to 5.7% in 2012. The smaller gap in 2010 reflects especially low turnout in midterm elections by younger voters, who are less likely in general to have disabilities. When age and other demographic characteristics (gender, race/ethnicity, and marital status) are held constant, the adjusted disability gap is close to 12 points in each year, and when education is also held constant, the adjusted disability gap is close to 8 points in each year. This means that people with disabilities were 8 percentage points less likely to vote than people without disabilities who are otherwise similar in demographic characteristics and educational status.

Given the size of the voting-eligible disability population, these numbers imply that there would be 3.0 million more voters with disabilities if they voted at the same rate as people without disabilities with similar age, gender, race/ethnicity, and marital status. About one-fourth of this gap, or 0.8 million people, is accounted for by educational levels, indicating that improvement in the educational levels of people with disabilities could help reduce but not close the disability gap in voter turnout.

One important factor in the lower turnout is economic and social resources. This is shown by the finding in Table 2 that there was no gap in voter turnout between employed people with and without disabilities, indicating that employment helps provide resources and social contact that encourage voting.[7] The disability voting gap was concentrated among the non-employed. Table 2 also provides a breakdown of disability and voter turnout by gender, age, and region, showing that the disability turnout gap was:

- larger among women (8.3%) than among men (2.9%), reflecting especially high voter turnout among women without disabilities;
- larger among those age 35-49 (18.1%) than among other age groups; and
- larger in the Northeast (8.8%) than in the Midwest (5.7%), West (5.1%), and South (4.9%).

A state-level breakdown of disability and voter turnout is presented in Table 3. While the possibility of sampling error is higher due to the smaller sample sizes at the state level, the disability gap is large enough to reject sampling error in 21 of the states and in the District of Columbia.

B. Voting early and by mail

People with disabilities may especially benefit from more flexible opportunities to vote, including the chance to vote before election day at a more convenient time (e.g., when accessible transportation is more easily available) or to vote by mail, which may be of special value for those

[7] This is consistent with other research on the role of employment summarized in Lisa Schur, Todd Shields, and Kay Schriner, "Voting," in Gary Albrecht, ed., Encyclopedia of Disability (Thousand Oaks, CA: Sage Publications, 2005)

with mobility impairments who have difficulty getting to a polling place. Table 4 shows that voters with disabilities in 2012 were no more likely to vote early in a polling place or election office (14.8% did so compared to 14.2% of voters without disabilities), and this varied only slightly by type of disability. Voting by mail was, however, substantially higher among those with disabilities: over one-fourth (28.4%) of voters with disabilities did so, compared to one-sixth (17.3%) of voters without disabilities. Voting by mail was high among people with each of the impairments, and was especially high among those with difficulty dressing or bathing (39.6%), or difficulty going outside alone (36.0%).

A separate analysis of the 2008 and 2010 Census Bureau data also revealed that voters with disabilities were more likely than those without disabilities to vote by mail (Schur and Kruse, 2012). A striking finding was that relative voter turnout was especially high among people with disabilities in jurisdictions that a) had everyone vote by mail (in Washington and Oregon states), or b) made "no-excuse" mail ballots available, so that citizens would not have to report having a disability in order to be given a mail ballot.

IV. Difficulties in voting

We now turn from the Census Bureau survey to the second data source: a national household survey with 3,022 respondents that asked a number of additional questions about voting difficulties and experiences.

A. Difficulties at polling place in 2012

People with disabilities who voted in a polling place in 2012 were more likely than those without disabilities to report some type of difficulty in voting. As shown in column 1 of Table 8, over one-tenth (11.7%) reported difficulty in reading or seeing the ballot, while just slightly fewer (10.3%) reported difficulty understanding how to vote or operate the voting equipment. These difficulties were much less common among voters without disabilities (0.9% and 1.3% respectively, in column 2) and the differences are strong enough to reject sampling error. The next most common difficulties among voters with disabilities were waiting in line (8.3%), finding or getting to the polling place (5.9%), writing on the ballot (4.5%), and getting inside the polling place (3.6%).

For several of these difficulties, respondents were asked to describe the difficulty, and the answers were recorded verbatim. Typical answers regarding the difficulty in finding or getting to the polling place were:

- problems in transportation (e.g., "needed a ride," "waiting for a ride")
- problems in basic mobility (e.g., "barely able to walk")
- problems finding the polling place (e.g., "just didn't know where to go," "they had relocated to another building and had not put up signs," "major lack of communication as to where the polling place was")

Among those reporting difficulty getting inside the polling place, typical descriptions were:

- steps or stairs (e.g., "there was no ramp so I had to go up steps," "there were about 20 steps")
- walking distances (e.g., "parking was too far from the building," "there was an incline in the parking lot which I had to climb").

There was a wide range of problems reported in understanding how to vote or use the voting equipment, mostly concerning the technology (e.g., "unfamiliar with computers," "didn't know how to use the machine") but some expressing more general difficulties (e.g., "understanding the process," "too much information that I couldn't handle," "the place was unorganized and confusing"). Problems in actually recording the vote included:

- being able to reach the machine (e.g., "the machine was up too high." "voting machine not made for handicapped people—it's about 6 feet high")
- machine malfunctions (e.g., "screen started rolling," "the machine did not work," "it would take multiple tries for the touchscreen")
- difficulty operating the machine (e.g., "trouble pulling final large handle of voting machine," "getting the knob to put the indicator in the right box")

In total, almost one-third (30.1%) of voters with disabilities reported one or more difficulties in voting, compared to about one-twelfth (8.4%) of voters without disabilities. This difference is large enough to strongly reject sampling error as an explanation (at the 99.9999% level). Applied to the population of voters with disabilities, this indicates that about 3.4 million voters with disabilities experienced some type of difficulty in voting in a polling place.

Do these difficulties vary by type or severity of disability? As shown in Table 8, each of the major impairments (vision, hearing, cognitive, and mobility) was linked to greater difficulties in reading or seeing the ballot, and all except hearing impairments were significantly linked to difficulty in understanding how to vote or use the voting equipment. Not surprisingly, people with mobility impairments were the most likely to report difficulty getting inside the polling place, or difficulty waiting in line. The last row shows that the likelihood of reporting any difficulty was higher for people with each type of impairment relative to people without disabilities.

One measure of disability severity is the need for assistance in activities of daily living. Those who reported the need for such assistance were about twice as likely as those not needing assistance to have some type of voting difficulty (39.7% compared to 21.1%), but both numbers were significantly above the figure for people without disabilities (8.4%).

Different voting technologies may present different challenges. Voters were asked how they recorded their vote, and if they encountered any difficulty in doing that. As shown in Table 9, close to half of voters marked their choices on a paper ballot (48.9% of voters with disabilities and 52.4% of voters without disabilities), while about one-eighth punched buttons on a machine (12.2% and 13.1% respectively), about one-third touched a computer screen (36.9% and 31.8% respectively), and about 2% flipped switches on a machine or used some other method. Table 9

also shows that for each of the three common voting methods, people with disabilities were more likely than those without disabilities to report difficulty reading or seeing the ballot, and difficulty understanding how to vote or use the voting equipment. Comparing among those who used the different technologies, the reported difficulties are slightly higher among those who wrote on a ballot, but the differences from those using other methods were not strong enough to reject sampling error as an explanation. There appear to be no noteworthy differences in reported voting difficulties among those using the different voting technologies.

For a summary measure of their voting experiences, respondents were asked "Overall, how easy or difficult was your experience in voting at the polling place?" As shown in Table 10, among those who voted at a polling place in 2012, close to three-fourths (76.0%) of voters with disabilities said it was very easy, which is lower than among voters without disabilities (86.4%). The difference is mostly accounted for by a higher likelihood that voters with disabilities said the experience was "somewhat easy" (17.6% compared to 11.2%), but they were also more likely than those without disabilities to say it was somewhat or very difficult (5.8% compared to 1.7%). While the 5.8% and 1.7% figures may seem small, given the size of the populations, these represent about 1.5 million people with disabilities and 1.5 million people without disabilities, or 3 million people total, which is enough to swing an election if these people decide not to vote.

The reports that voting was very easy were lower among people who had visual or cognitive impairments, and among those who need help with daily activities (all close to 70%), and these groups were the most likely to say that voting was somewhat or very difficult (6.7%, 9.7%, and 9.8% respectively).

What types of problems were experienced by voters with disabilities who found the overall voting process difficult? It is worth focusing on this group since they are likely to be the most discouraged from voting in the future. Table 11 shows that the most common problems in this group were difficulty in understanding how to vote or use the voting equipment (68.1%) and difficulty reading or seeing the ballot (58.6%), while nearly half cited difficulty writing on the ballot (49.7%), difficulty finding or getting to the polling place (47.6%) or another type of difficulty in voting (49.7%).

B. Difficulties at polling place in past 10 years

How do these reported difficulties compare between those who voted at a polling place in 2012 and those who did so only in prior years? These are reported in columns 3 and 4 of Table 12. A noteworthy finding is that the pattern of difficulties in both the disability and non-disability samples is very similar to the pattern in 2012. In addition, the overall percentages who reported any type of difficulty is similar between this group (28.6% of voters with disabilities and 10.2% of voters without disabilities) and those who voted in 2012 (30.1% and 8.4% respectively). On the face of it, this indicates little change in the likelihood of voting difficulties over the past 10 years, although it must be cautioned that the two groups may be different in other ways that affect the reporting of voting difficulties.

C. Expected difficulties if have not voted at polling place in past 10 years

If respondents had not voted in a polling place in the past 10 years, either because they voted by mail or did not vote, they were asked a hypothetical question about any difficulties they would expect if they wanted to vote inside a polling place. As shown in Table 13, two-fifths (40.1%) of people with disabilities in this group said they would expect some type of difficulty, compared to 1.2% of people without disabilities. This figure is high among people with all the major impairments. The most commonly expected problems are: getting to the polling place for people with hearing problems (28.8%), reading or seeing the ballot for people with vision impairments (22.0%), understanding how to vote or use the voting equipment for people with cognitive impairments (15.1%), and getting to the polling place for people with mobility problems is (16.6%). Not surprisingly, the figure for any expected difficulty is smaller among people who do not need help with daily activities (19.0%) compared to people who do need help (56.3%).

It is clearly possible that these reports are upwardly biased—that people who have not voted at a polling place are more likely to cite polling place difficulties as a way to justify their decision. This is not, however, likely to impart a strong bias. Based on actual reported difficulties from otherwise-similar people who voted, almost one-third (31.6%) of the non-voters answering the hypothetical question would be predicted to experience voting difficulties if they tried to vote, which is very close to the overall figure among people who voted in a polling place.[8] Therefore while the high rate of hypothetical difficulties (40.1%) may represent some upward bias, the majority of these reports appear to reflect realistic expectations of polling place difficulties, and the overall level of voting difficulties would be at least as high if these citizens were to decide to vote in polling places.

D. Difficulties in voting by mail

Voters with disabilities were more likely than those without disabilities to vote by mail in the 2012 elections, as noted earlier. Table 14 shows that among people who voted by mail, about one-eighth of those with disabilities (13.3%) reported some difficulty in doing so, compared to only 2.2% of mail voters without disabilities. Similarly, mail voters with disabilities were more likely to report needing assistance in filling out or sending their mail ballots (11.3% compared to 0.4%).[9]

Most of the reported problems with mail ballots concerned the ability to read them. Some examples of these problems were "can't read small print because of vision problems," and "had to use a magnifier." A number of respondents also reported difficulty in understanding the written material, such as "I could not understand some of the propositions" and "too

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[8] This estimate was based on a probit regression in the sample that had voted at a polling place in the past 10 years. The regression predicted any voting difficulty with disability types, severity, and demographic characteristics, and the coefficients were used to impute the likelihood of voting difficulty for those who answered the hypothetical question.

[9] See Tokaji and Colker (2007) for a discussion of problems faced by people with disabilities in voting by mail.

complicated." Several respondents also noted physical difficulties such as "checking off the squares on the ballot" and "I have a hand tremor from a previous surgery and it was difficult to mark the ballot easily."

V. Need for Assistance and Use of Extra Devices or Features

Among those who voted in a polling place in 2012, Table 15 shows that almost one-third of people with disabilities (29.9%) reported needing some type of assistance, compared to one-tenth (10.7%) of people without disabilities. For people with disabilities, the needed assistance was equally likely to be provided by family members or election officials (42.2% for each), while only a small percentage used friends, home care aides, or others. For people without disabilities, the needed assistance was most commonly provided by election officials (71.6%), followed by family members (18.8%). Among both groups, just over two percent said that they needed assistance but none was provided. The verbatim descriptions of the provided assistance ranged widely, from help getting into the polling place (e.g., "access in getting there") to help with understanding the process (e.g., "they just explained how to use the machine and how the process worked") and operating the equipment (e.g., "physical assistance in pulling the large mechanical handle," "needed help pushing the buttons").

A variety of features and devices are available to help people with disabilities vote, and the Help America Vote Act (HAVA) requires each polling place to have at least one fully accessible voting machine that enables confidential voting by people of all abilities. In the disability sample, Table 15 shows that 6.5% reported using one or more of these extra features or devices. Among those who used these, the most commonly used features were large displays (58.1%) and magnifiers (32.7%), followed by earphones (10.1%) and adjustment of the seating or lowering of the machine for people in wheelchairs (2.2%). These features or devices can create extra delays if they are not set up in advance or the election officials do not know how to use them. Among voters using these features or devices, three-fourths (75.4%) said that they were set up and ready to use, and almost all (96.9%) said that the election officials knew how to set up and use the features and there were no problems.

VI. Treatment by Election Officials

Apart from issues of physical access and understanding and using the voting equipment, the voting experience can be affected by how voters feel they are treated. Table 16 shows that among people who voted at a polling place in 2012, the large majority said they were treated very respectfully, and the percentages were very similar between people with and without disabilities (86.8% and 84.7% respectively). Only a small minority said they were treated somewhat or very disrespectfully, and this was also similar between people with and without disabilities (1.7% and 3.2%). The pattern of reported treatment did not vary substantially by type of impairment or need for help with daily activities (columns 3 to 8).

To complement the question on need for assistance reported in Table 15, voters were asked a more general question about the helpfulness of the election officials. As shown in Table 16, most people said they did not need any help, particularly among people without disabilities (79.8% compared to 59.8% among people with disabilities). Among those who needed help, close to nine-tenths of people reported that the election officials were very helpful, and this was similar between people with and without disabilities (92.6% and 87.4% respectively) and across the disability categories. Only 1.7% of people with disabilities who needed help said the officials were not helpful at all, compared to 8.0% of people without disabilities. The rates of dissatisfaction was highest among people who need help with daily activities (2.4%) and lowest among people with hearing and cognitive impairments (0.5% and 0.8% respectively).

VII. Preferences for How to Vote

There has been increasing public debate over how voter turnout may be affected by increased availability of alternative methods such as voting by mail or on the Internet. To assess preferences over voting methods, all respondents—whether they voted or not in 2012—were asked ""If you wanted to vote in the next election, how would you *prefer* to cast your vote?"

The majority of people both with and without disabilities said they would prefer to vote in person in a polling place, as shown in Table 17. This figure is somewhat lower among people with disabilities (58.0% compared to 67.7% among people with disabilities). One-fourth (25.0%) of people with disabilities said they would prefer to vote by mail, compared to about half that number (13.6%) among people without disabilities. People with disabilities were also relatively more likely to prefer voting by telephone (5.0% compared to 1.5%), and less likely to prefer voting on the Internet (9.6% compared to 16.1%). This latter result probably reflects the lower rates of computer use and Internet access among people with disabilities: a 2011 U.S. Department of Commerce report found that more than half (54%) of households headed by someone with a disability had no Internet access from home, compared with 25% of households headed by someone without a disability (U.S. Department of Commerce 2011: 16).

The preferences over voting method vary by impairment and severity. People with hearing or vision impairments, and those who do not need help with daily activities, were about as likely as people without disabilities to say they prefer voting in a polling place (66.1%, 67.9%, and 65.5% respectively), while people with cognitive or mobility impairments, or who need help with daily activities are the least likely to prefer this (57.7%, 55.0%, and 51.5%). The relatively high likelihood of preferring to vote by mail, however, exists across all of the impairments and levels of severity, with especially high likelihoods among those with mobility impairments (29.0%) and those who need help with daily activities (28.1%). Similarly, the relatively low likelihood of preferring to vote by Internet exists across all of the impairments and levels of severity.

VIII. Conclusion

In conclusion, we have found that there is a significant gap in voter turnout between people with and without disabilities, and that people with disabilities experience greater problems with accessibility when it comes to voting. Prior studies have consistently found such a gap as well, suggesting more needs to be done to encourage voting by people with disabilities. While our findings suggest that the help provided at polling places is viewed favorably, many people with disabilities prefer alternative forms of voting because of perceived challenges that they may face at polling sites. These perceptions are not unwarranted as they are consistent with the problems reported by those who actually voted at polling sites. To ensure that every citizen has an unrestricted right to vote, it is important to eliminate these challenges or barriers and make it clear to people that they will not experience them. Fortunately, the problems that were reported are not difficult to remediate, mostly requiring simple changes such as making ballots easier to read, simplifying instructions, communicating clearly the location of polling sites, providing accessible parking close to polling sites, ensuring the polling site is accessible without navigating stairs, providing seats for those who have difficulty standing in line, and making any machinery easier to operate. For those who find it easier to vote by mail, the adoption of no-excuse systems for requesting mail ballots appears to increase their likelihood of voting.

Simple solutions like these can help eliminate barriers that keep many people with disabilities from voting. They can combine with stronger get-out-the-vote campaigns by disability organizations plus other efforts that increase turnout through enhancing the economic and social inclusion of people with disabilities. Closing the disability turnout gap would add 3.0 million more voters, which could increase the voice of people with disabilities and make the political system more representative of American citizens.

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Appendix 1: Survey questions to identify disability status

If not all household residents are citizens: "For our study we're focusing on citizens, so for the following questions I'd like to know just about those who are citizens."

1. "(Of those 18 or older,) (are you/is anyone) deaf or (do you/does anyone) have serious difficulty hearing?"

2. "(Of those 18 or older,)(are you/is anyone) blind or (do you/does anyone) have serious difficulty seeing even when wearing glasses?"

3. "Because of a physical, mental, or emotional condition, (do you/does anyone age 18 or older) have serious difficulty concentrating, remembering, or making decisions?"

4. "(Do you/Does anyone age 18 or older) have serious difficulty walking or climbing stairs?"

5. "(Do you/Does anyone age 18 or older) have difficulty dressing or bathing?"

6. "Because of a physical, mental, or emotional condition, (do you/does anyone age 18 or older) have difficulty doing errands alone such as visiting a doctor's office or shopping?"

7. "(Do you/Does anyone age 18 or older) have a long-term health problem or impairment that limits the kind or amount of work, housework, or other activities he or she can do?"

"For the following questions, I'd like to (talk to the/talk to just one) person with the impairments or conditions I've mentioned – (the person with the most recent birthday). "

Appendix 2: Survey questions on voting

[Note: --all questions were put into CATI (Computer-Aided Telephone Interviewing) software using the indicated skip logic.]

Now, I'd like to ask you some questions about elections.

C-1. In any election, some people are not able to vote because they are sick or busy or have some other reason, and others do not want to vote. Did you vote in the election held on Tuesday, November 6, 2012?

1. Yes **Skip to question C-3.**
2. No
8. Don't know
9. Refused

C-2. Were you registered to vote in the November 6, 2012 election?

1. Yes
2. No **Skip to question C-5.**
8. Don't know **Skip to question C-5.**
9. Refused **Skip to question C-5.**

C-2a. Did you try to vote in the November 6, 2012 election but were unable to?

1. Yes **Skip to question C-4a.**
2. No **Skip to question C-5.**
8. Don't know **Skip to question C-5.**
9. Refused **Skip to question C-5.**

C-3. Did you vote in person or did you vote by mail?

1. In person **Skip to question C-4.**
2. By mail **Ask question C-3a.**
8. Don't know **Skip to question C-4.**
9. Refused **Skip to question C-4.**

C-3a. Did you have any type of difficulty in reading or filling out the mail-in ballot?

1. Yes **Ask question C-3b.**
2. No **Skip to question C-4.**
8. Don't know **Skip to question C-4.**
9. Refused **Skip to question C-4.**

C-3b. What type of difficulty did you have? (coded verbatim)

C-3c. Did you receive any assistance in completing your mail-in ballot?

1. Yes
2. No
8. Don't know
9. Refused

C-4. Was that on election day or before election day?

1. On election day **If C3=1 then ask C-4a, else ask C5.**
2. Before election day **If C3=1 then ask C-4a, else ask C5.**
8. Don't know **If C3=1 then ask C-4a, else ask C5.**
9. Refused **If C3=1 then ask C-4a, else ask C5.**

C-4a. Was there any problem with your voter registration when you tried to vote?

1. Yes **Ask C-4b.**
2. No **If C3=1 then skip to C-6, else skip to question C-5.**
8. Don't know **If C3=1 then skip to C-6, else skip to question C-5.**
9. Refused **If C3=1 then skip to C-6, else skip to question C-5.**

C-4b. What type of problem did you have? (coded verbatim)

If C1 = "Yes" then ask
C4c1. Did you vote by regular or provisional ballot?

1. Yes
2. No
8. Don't know
9. Refused

If C1 = "No" then ask (READ LIST)
C4c2. Were you offered a provisional ballot?

1. Yes, but I chose not to vote using it
2. No, I was not allowed to vote
3. Other (code verbatim)
8. Don't know
9. Refused

C-5. Have you voted inside a polling place in any previous national election?

1. Yes
2. No **Skip to question C-13.**

8. Don't know **Skip to question C-13.**
9. Refused **Skip to question C-13.**

C5a. What year was the last election in which you voted inside a polling place?

/____/____/____/____/
IF LATER THAN 2002- Ask question C-6
IF 2002 OR EARLIER - Skip to question C-13
IF DON'T KNOW OR REFUSED - Skip to question C-13

C-6. When you voted in the polling place did you have any:

a. Difficulty in finding or getting to the polling place (yes/no/don't know/refused)
   IF yes: What type of difficulty did you have (coded verbatim)
b. Difficulty in getting inside the polling place (for example, steps)(yes/no/don't know/refused)
   IF yes: What type of difficulty did you have (coded verbatim)
c. Difficulty waiting in line (yes/no/don't know/refused)
d. Difficulty reading or seeing the ballot (yes/no/don't know/refused)
e. Difficulty understanding how to vote or use the voting equipment (yes/no/don't know/refused)
   IF yes: What type of difficulty did you have (coded verbatim)
f. Difficulty in communicating with poll workers or other officials at the polling place

C-7. How did you record your vote? Did you:
1. Write on a ballot Ask C-7a
2. Punch buttons on a machine Ask C-7b
3. Flip switches on a machine Ask C-7b
4. Touch a computer screen Ask C-7b
5. Use some other method [coded verbatim]_____ Ask C-7b
8. Don't know ASK C-7b
9. Refused ASK C-7b

C-7a, Did you have any difficulty writing on the ballot? GO TO C-7c
1. Yes
2. No
8. Don't know
9. Refused

C-7b. Did you have any difficulty using the voting machine?
1. Yes
2. No
8. Don't know
9. Refused

IF yes: What type of difficulty did you have (coded verbatim)

C-7c. Did you have any other type of difficulty in voting?

1. Yes
2. No
8. Don't know
9. Refused

IF yes: What type of difficulty did you have (coded verbatim)

C-8. How easy or difficult was it to record your vote?

1. Very easy
2. Somewhat easy
3. Not easy or difficult
4. Somewhat difficult
5. Very difficult
8. Don't know
9. Refused

C-9. If you needed any assistance in voting, who provided the assistance?

1. Did not need any assistance **If in disability sample ask C-9c, else skip to C-10.**
2. An election official
3. A family member
4. A friend
5. A home care aide or health aide
6. Someone else
7. Needed assistance but no one provided Go To C9c

C-9b. What type of assistance did you receive? [coded verbatim]

If in disability sample ask C-9c, else skip to C-10.

C-9c. In addition to standard voting equipment, were there any extra features or devices that helped you vote, such as a magnifier, large visual display, special keypad, or earphones?

1. Yes
2. No **Skip to question C-10.**
8. Don't know **Skip to question C-10.**
9. Refused **Skip to question C-10.**

C-9d. What type of extra features or devices did you use? (coded verbatim)

C-9e. Were those extra features or devices set up and ready to use when you arrived?

1. Yes
2. No

C9f. Did the election officials know how to set up and use the extra features or devices?

1. Yes, there were no problems
2. Yes, but there was some delay or problems
3. No, they did not know how to set up and use the features or devices

C-10. How helpful were the election officials?

1. I did not need any help
2. I needed help, but they were not helpful at all
3. I needed for help, and they were somewhat helpful
4. I needed for help, and they were very helpful

C-11. In your opinion, how respectful were the election officials to you? Were they ...?

1. Very disrespectful
2. Somewhat disrespectful
3. Neither respectful nor disrespectful
4. Somewhat respectful
5. Very respectful

C-12. Overall, how easy or difficult was your experience in voting at the polling place?

1. Very easy **skip to C-14.**
2. Somewhat easy **skip to C-14.**
3. Not easy or difficult **skip to C-14.**
4. Somewhat difficult **skip to C-14.**
5. Very difficult **skip to C-14.**

[For those who haven't voted at polling place in past 10 years]

C-13. If you wanted to vote in person inside the polling place, do you think you would experience any difficulty in getting to the polling place or in using the ballot or voting machine?

1. Yes **Ask question C-13a**
2. No **skip to C-14.**
8. Don't know **skip to C-14.**
9. Refused **Skip to C-14.**

C-13a. What type of difficulty do you think you would experience?
[interviewer coding—do not read options]
[more than one answer may be coded]

1. Finding polling place
2. Getting to polling place
3. Getting inside polling place (stairs/steps)
4. Long lines
5. Difficulty seeing or reading ballot
6. Difficulty understanding how to vote or use voting machine
7. Other difficulty using ballot or voting machine: [coded verbatim]:_____
8. Other problem: **[coded verbatim]**_____

C-14. How likely are you to vote in the next Presidential election four years from now?

1. Will definitely vote
2. Very likely
3. Somewhat likely
4. Not very likely
5. Not at all likely
8. Don't know or depends (DNR)
9. Refused

C-15. If you wanted to vote in the next election, how would you *prefer* to cast your vote?

1. In person inside the polling place
2. Mail-in ballot
3. On the Internet
4. By telephone
8. Don't know
9. Refused

Table 1: Voting by disability status, 2008-2012

	Voter turnout			Disability gap	Number of voters (millions)
	2008	2010	2012	2012	2012
No disability	64.5%	45.9%	62.5%		117.3
Any disability	57.3%	42.8%	56.8%		15.6
Disability gap	-7.2% **	-3.1% **	-5.7% **	-5.7% **	
Type of disability:					
Hearing impairment	63.1%	50.0%	63.2%	0.7%	5.0
Visual impairment	56.8% **	39.5% **	57.3% **	-5.2% **	2.4
Cognitive impairment	46.1% **	29.6% **	44.8% **	-17.7% **	3.7
Mobility impairment	56.8% **	43.5% **	56.3% **	-6.2% **	9.3
Difficulty dressing or bathing	46.4% **	32.4% **	46.7% **	-15.8% **	2.2
Difficulty going outside alone	45.7% **	32.9% **	47.3% **	-15.2% **	4.6

* Difference from non-disability sample is significant at 95% level ** 99% level

Table 2: Voter Turnout by Employment Status and Demographics

Voter turnout in 2012

	Disability	No Disability	Disability Gap	
Overall	56.8%	62.5%	-5.7%	**
Employed	64.6%	64.2%	0.4%	
Not employed	55.0%	59.2%	-4.2%	**
Women	56.5%	64.8%	-8.3%	**
Men	57.2%	60.1%	-2.9%	**
Age 18-34	32.6%	48.8%	-16.2%	**
Age 35-49	45.4%	63.5%	-18.1%	**
Age 50-64	58.1%	71.0%	-12.9%	**
Age 65+	64.4%	75.4%	-11.0%	**
Northeast	54.5%	63.3%	-8.8%	**
Midwest	60.1%	65.8%	-5.7%	**
South	56.4%	61.3%	-4.9%	**
West	55.6%	60.7%	-5.1%	**

* Difference from non-disability sample is significant at 95% level ** 99% level

Table 3: Voter Turnout by State

	No disability	Disability	Disability Gap			No disability	Disability	Disability Gap	
Alabama	62.7%	57.8%	-4.9%		Montana	65.8%	64.9%	-0.9%	
Alaska	58.3%	59.1%	0.9%		Nebraska	61.5%	62.2%	0.7%	
Arizona	56.9%	48.1%	-8.9%		Nevada	57.9%	58.5%	0.7%	
Arkansas	54.7%	46.2%	-8.4%	*	New Hampshire	70.8%	59.0%	-11.9%	**
California	58.4%	50.4%	-8.0%	**	New Jersey	62.5%	56.8%	-5.7%	
Colorado	71.1%	65.6%	-5.5%		New Mexico	62.1%	57.7%	-4.5%	
Connectic	63.8%	52.7%	-11.1%	**	New York	59.7%	50.2%	-9.5%	**
Delaware	66.8%	71.1%	4.3%		North Carolina	69.8%	62.5%	-7.3%	*
Florida	60.7%	62.0%	1.3%		North Dakota	64.7%	57.2%	-7.6%	
Georgia	62.9%	54.9%	-8.0%	*	Ohio	63.9%	58.3%	-5.6%	*
Hawaii	51.7%	51.4%	-0.2%		Oklahoma	53.0%	49.4%	-3.6%	
Idaho	64.9%	56.6%	-8.3%		Oregon	67.8%	66.6%	-1.1%	
Illinois	61.6%	60.4%	-1.2%		Pennsylvania	62.6%	54.9%	-7.7%	**
Indiana	59.9%	54.8%	-5.2%		Rhode Island	62.7%	61.0%	-1.7%	
Iowa	70.2%	63.9%	-6.3%		South Carolina	65.5%	59.8%	-5.7%	
Kansas	63.3%	63.0%	-0.3%		South Dakota	60.4%	64.7%	4.2%	
Kentucky	61.4%	48.5%	-12.9%	**	Tennessee	57.4%	47.9%	-9.5%	**
Louisiana	67.6%	58.7%	-8.9%	*	Texas	53.5%	55.8%	2.3%	
Maine	71.0%	55.9%	-15.1%	**	Utah	56.7%	59.8%	3.1%	
Maryland	66.0%	58.3%	-7.7%	*	Vermont	63.4%	62.1%	-1.3%	
Massachu.	72.3%	59.7%	-12.6%	**	Virginia	68.2%	57.1%	-11.1%	**
Michigan	68.0%	60.7%	-7.3%	**	Washington	66.0%	63.6%	-2.4%	
Minnesot:	74.2%	65.7%	-8.4%	**	Washington, D.C.	77.6%	63.8%	-13.8%	**
Mississipp	75.9%	67.9%	-8.0%	*	West Virginia	48.8%	42.9%	-5.8%	
Missouri	65.8%	53.5%	-12.2%	**	Wisconsin	74.7%	66.5%	-8.2%	**
					Wyoming	58.7%	59.7%	1.0%	

* Difference from non-disability sample is significant at 95% level ** 99% level

Table 4: Voted Early or by Mail

Among those who reported voting in 2012

	Voted early in polling place or election office	Voted by mail	
No disability	14.2%	17.3%	
Any disability	14.8%	28.1%	
Disability gap	0.6%	10.8%	**
By type of disability:			
Hearing impairment	15.4%	28.4%	**
Visual impairment	15.2%	26.5%	**
Cognitive impairment	12.9%	30.1%	**
Mobility impairment	14.6%	31.0%	**
Difficulty dressing or bathing	12.3%	39.6%	**
Difficulty going outside alone	12.8%	36.0%	**

* Difference from non-disability sample is significant at 95% level ** 99% level

Table 5: Voter Registration

	Disability	No Disability	Disability Gap	
Registered to vote	69.2%	71.5%	-2.3%	**
Voted if registered	82.1%	87.5%	-5.4%	**
How registered to vote:				
Went to a town hall or county/ government registration office	31.5%	22.4%	9.1%	**
At a department of motor vehicles	21.9%	30.9%	-9.0%	**
At a public assistance agency	2.7%	1.3%	1.4%	**
Registered by mail	15.8%	16.3%	-0.5%	
Registered at polling place	8.8%	7.7%	1.1%	**
Filled out form at a registration drive	7.2%	6.1%	1.1%	**
At a school, hospital, or on campus	4.9%	7.1%	-2.2%	**
Registered using the Internet or online	1.3%	3.9%	-2.6%	**
Other	6.0%	4.3%	1.7%	**

* Difference from non-disability sample is significant at 95% level ** 99% level

Table 6: Why Not Registered to Vote

If not registered to vote, why not:	Disability	No Disability	Disability Gap	
Not interested in the election or not involved in politics	32.1%	45.2%	-13.1%	**
Permanent illness or disability	24.5%	1.2%	23.3%	**
Did not meet registration deadlines	9.0%	15.6%	-6.6%	**
Not eligible to vote	6.0%	7.5%	-1.6%	**
My vote would not make a difference	4.3%	4.8%	-0.5%	
Did not know where or how to register	4.1%	4.8%	-0.8%	
Did not meet residency requirements/did not live here long enough	1.2%	3.5%	-2.3%	**
Difficulty with English	1.5%	1.6%	-0.1%	
Other reason	17.4%	15.8%	1.6%	

* Difference from non-disability sample is significant at 95% level ** 99% level

Table 7: Why People Did Not Vote if Registered

Why didn't vote	Disability	No Disability	Disability Gap
Illness or disability (own or family's)	43.6%	8.2%	35.4% **
Not interested, felt my vote wouldn't make a difference	12.3%	17.0%	-4.7% **
Didn't like candidates or campaign issues	9.7%	13.8%	-4.1% **
Too busy, conflicting work or school schedule	5.9%	22.4%	-16.5% **
Forgot to vote (or send in absentee ballot)	2.8%	4.3%	-1.5% **
Transportation problems	6.1%	2.8%	3.3% **
Out of town or away from home	3.1%	10.1%	-7.0% **
Registration problems (i.e. didn't receive absentee ballot, not registered in current location)	4.0%	6.0%	-2.0% **
Inconvenient hours, polling place or hours or lines too long	2.0%	2.9%	-1.0%
Bad weather conditions	0.6%	0.9%	-0.2%
Other	10.0%	11.8%	-1.8%

* Difference from non-disability sample is significant at 95% level ** 99% level

Table 8: Polling Place Difficulties in 2012

			Type of Impairment				Disability Severity	
	Any Disability (1)	No disability (2)	Hearing (3)	Visual (4)	Cognitive (5)	Mobility (6)	No need for help in daily activities (7)	Need help in daily activities (8)
When you voted in the polling place, did you have any:								
1 Difficulty in finding or getting to the polling place	5.9%	1.6%	1.6%	11.2%	11.6%	3.8%	1.6%	10.5%
2 Difficulty in getting inside the polling place (for example, steps)	3.6% **	0.2%	6.4%	3.2% *	4.1%	4.4% **	2.0% **	5.4% **
3 Difficulty waiting in line	8.3% *	3.5%	8.9%	4.6%	7.7%	9.4% *	10.6% *	5.8%
4 Difficulty reading or seeing the ballot	11.7% **	0.9%	12.6% **	21.5% **	20.0% **	8.2% **	6.5% *	17.2% **
5 Difficulty understanding how to vote or use the voting equipment	10.3% **	1.3%	6.4%	14.6% *	20.1% **	9.7% **	3.7% *	17.3% **
6 Difficulty communicating with poll workers or other officials at the polling place	1.6%	1.2%	2.0%	2.1%	1.0%	1.6%	1.6%	1.6%
7 Difficulty writing on the ballot	4.5%	0.3%	0.7%	2.9% *	7.8%	1.0%	2.0%	7.2%
8 Difficulty operating the voting machine	1.3%	0.9%	2.6%	1.8%	1.4%	1.8%	0.5%	2.2%
9 Other type of difficulty in voting	3.8%	0.6%	0.9%	1.2%	7.2%	1.6%	1.5%	6.3%
"Yes" to any of above	30.1% **	8.4%	26.9% **	44.3% **	43.2% **	31.2% **	21.1% **	39.7% **
Sample size	1040	710	264	197	344	651	562	478

* Difference from non-disability sample is significant at 95% level ** 99% level

Table 9: Voting Methods and Difficulties

	Any Disability (1)	No disability (2)
How did you record your vote? Did you:		
Write on a ballot	48.9%	52.4%
Punch buttons on a machine	12.2%	13.1%
Flip switches on a machine	1.4%	1.8%
Touch a computer screen	36.9%	31.8%
Use some other method	0.6%	0.8%
If wrote on ballot:		
Difficulty reading or seeing the ballot	13.8% **	0.8%
Difficulty understanding how to vote or use the voting equipment	12.8% *	1.3%
Difficulty writing on ballot	9.6%	0.5%
If punched buttons on machine:		
Difficulty reading or seeing the ballot	10.8% **	0.0%
Difficulty understanding how to vote or use the voting equipment	8.0% **	0.0%
Difficulty using voting machine	4.1% *	0.3%
If touched a computer screen:		
Difficulty reading or seeing the ballot	9.9% *	1.5%
Difficulty understanding how to vote or use the voting equipment	8.3%	2.0%
Difficulty using voting machine	2.1%	2.9%

* Difference from non-disability sample is significant at 95% level ** 99% leve

Table 10: Overall Ease or Difficulty of Voting

			Type of Impairment				Disability Severity	
	Any Disability	No disability	Hearing	Visual	Cognitive	Mobility	No need for help in daily activities	Need help in daily activities
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Overall ease or difficulty of voting								
Very easy	76.0% **	86.4%	79.8%	71.8% *	69.4% *	76.4% *	81.8%	70.0% **
Somewhat easy	17.6%	11.2%	14.8%	20.7%	20.7%	17.8%	15.5%	19.7%
Neither easy nor difficult	0.6%	0.7%	0.5%	0.8%	0.2%	1.1%	0.8%	0.4%
Somewhat difficult	2.7% *	0.8%	4.5%	5.8%	3.3%	4.0% *	1.6%	3.8% *
Very difficult	3.1%	0.9%	0.4%	0.9%	6.4%	0.7%	0.4%	6.0%
Somewhat or very difficult	5.8%	1.7%	4.9%	6.7%	9.7%	4.7%	2.0%	9.8%
Sample size	1037	709	263	195	343	650	559	478

* Difference from non-disability sample is significant at 95% level ** 99% level

Table 11: Specific Difficulties for Those Who Found Overall Process Difficult

All figures refer to voters with disabilities in 2012

	Overall voting process was:		
	Somewhat or very difficult (1)	Somewhat easy (2)	Very easy (3)
When you voted in the polling place, did you have any:			
1 Difficulty in finding or getting to the polling place	47.6%	7.9%	2.3%
2 Difficulty in getting inside the polling place (for example, steps)	12.9%	6.1%	2.3%
3 Difficulty waiting in line	22.8%	15.4%	5.5%
4 Difficulty reading or seeing the ballot	58.6%	11.6%	8.1%
5 Difficulty understanding how to vote or use the voting equipment	68.1%	7.6%	6.4%
6 Difficulty communicating with poll workers or other officials at the polling place	8.1%	2.5%	0.7%
7 Difficulty writing on the ballot	49.7%	5.0%	1.2%
8 Difficulty operating the voting machine	3.2%	3.7%	0.4%
9 Other type of difficulty in voting	47.7%	1.8%	1.0%
"Yes" to any of above	93.7%	46.8%	21.1%
Sample size	56	149	817

Table 12: Polling Place Difficulties in Past 10 Years

	If voted at polling place in 2012		If voted at polling place in last 10 years but not in 2012	
	Disability (1)	No disability (2)	Disability (3)	No disability (4)
When you voted in the polling place, did you have any:				
1 Difficulty in finding or getting to the polling place	5.9%	1.6%	3.3%	1.5%
2 Difficulty in getting inside the polling place (for example, steps)	3.6% **	0.2%	5.4% **	0.0%
3 Difficulty waiting in line	8.3% *	3.5%	9.4%	2.8%
4 Difficulty reading or seeing the ballot	11.7% **	0.9%	14.9% **	1.8%
5 Difficulty understanding how to vote or use the voting equipment	10.3% **	1.3%	10.5% **	2.7%
6 Difficulty communicating with poll workers or other officials at the polling place	1.6%	1.2%	5.0%	1.4%
7 Difficulty writing on the ballot	4.5%	0.3%	1.3% *	0.0%
8 Difficulty operating the voting machine	1.3%	0.9%	5.0% *	0.0%
9 Other type of difficulty in voting	3.8%	0.6%	2.5% *	0.0%
"Yes" to any of above	30.1% **	8.4%	28.6% **	10.2%
Sample size	1040	710	403	116

* Difference from non-disability sample is significant at 95% level ** 99% level

Table 13: Expected Polling Place Difficulties if Have Not Voted at Polling Place in 10 Years

			Type of Impairment				Disability Severity	
	Any Disability (1)	No disability (2)	Hearing (3)	Visual (4)	Cognitive (5)	Mobility (6)	No need for help in daily activities (7)	Need help in daily activities (8)
Any expected difficulty if wanted to vote at polling place	40.1% **	1.2%	55.9% **	44.1% **	40.7% **	48.8% **	19.0% **	56.3% **
Expected difficulty in:								
Finding polling place	2.3% *	0.0%	0.0%	2.7%	2.7%	2.8%	0.9%	3.5%
Getting to the polling place	12.8% **	0.2%	28.8% *	11.2% **	11.4% **	16.6% **	5.0% **	18.8% **
Getting inside the polling place	7.4% **	0.0%	21.3%	5.4% **	3.7% **	11.4% **	2.1% *	11.5% **
Waiting in line	3.4% **	0.0%	5.6% *	4.0% *	3.9% **	5.0% **	2.3% *	4.2% **
Reading or seeing the ballot	6.4% **	0.6%	12.7% **	22.0% **	8.4% **	7.3% **	3.4%	8.8% **
Understanding how to vote or use the voting equipment	10.3% **	0.0%	12.8% **	5.9%	15.1% **	8.2% **	7.4%	12.5% **
Other difficulty recording vote	4.3% **	0.5%	4.4%	4.0%	4.6% **	7.6% **	0.0%	7.6% **
Any other problem	9.8% **	0.0%	5.7% *	6.9% *	10.4% **	13.7% **	4.3% **	14.0% **
Sample size	556	196	124	122	236	392	229	327

* Difference from non-disability sample is significant at 95% level ** 99% level

Table 14: Problems in mail voting		
	Any Disability	No disability
	(1)	(2)
Voted by mail in 2012	23.8%	16.4%
If voted by mail:		
Any difficulty in reading or filling out mail-in ballot	13.4%	2.2%
Need for assistance in completing mail-in ballot	11.3%	0.4%
* Difference from non-disability sample is significant at 95% level ** 99% level		

Table 15: Need for Assistance and Use of Special Features

Among those who voted at polling place in 2012

	Disability (1)		No disability (2)
Needed assistance in voting	29.5%	**	10.7%
If yes, who provided assistance			
Election official	42.2%	**	71.6%
Family member	42.2%	**	18.8%
Friend	9.0%	**	2.1%
Home care aide	0.5%		0.0%
Other	3.6%	*	5.2%
Needed but none provided	2.5%		2.3%
Used extra features or devices to help vote	6.5%		
If yes, what features or devices			
Large display	58.1%		
Magnifier or visual aid	32.7%		
Earphones	10.1%		
Seating/lowered machine	2.2%		
Other	1.0%		
Features or devices were set up and ready to use	75.4%		
Election officials knew how to set up and use features			
Yes, no problems	96.9%		
Yes, but some delay or problem	1.7%		
No	1.4%		
Sample sizes			
Total	1034		708
If needed assistance in voting	431		69
If used extra features or devices	54		

* Difference from non-disability sample is significant at 95% level ** 99% level

Table 16: Treatment by Election Officials

Among those who voted at polling place in 2012

			Type of Impairment				Disability Severity	
	Any Disability	No disability	Hearing	Visual	Cognitive	Mobility	No need for help in daily activities	Need help in daily activities
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
How respectful were election officials								
Very respectful	86.8%	84.7%	86.4%	84.2%	88.5%	82.2%	85.3%	88.3%
Somewhat respectful	8.2%	6.8%	10.2%	12.2%	8.5%	11.2%	8.5%	7.9%
Neither respectful nor disrespectful	3.2%	5.3%	2.0% *	1.4% *	1.5% *	4.5%	4.4%	2.0% *
Somewhat or very disrespectful	1.7%	3.2%	1.5%	2.2%	1.5%	2.1%	1.7%	1.8%
How helpful were election officials								
Did not need help	59.8% **	79.8%	59.7% **	45.5% **	48.6% **	60.5% **	65.0% **	54.2% **
If needed help:								
Very helpful	92.6%	87.4%	94.5%	92.5%	94.1%	91.1%	92.6%	92.5%
Somewhat helpful	5.7%	4.6%	5.0%	6.1%	5.1%	7.0%	6.5%	5.0%
Not helpful at all	1.7%	8.0%	0.5% *	1.5%	0.8% *	1.8%	0.9% *	2.4%
Sample size	1037	709	263	195	343	650	559	478

* Difference from non-disability sample is significant at 95% level ** 99% level

Table 17: Preference for How to Vote

"If you wanted to vote in the next election, how would you *prefer* to cast your vote?"
All respondents (whether or not voted in 2012)

			Type of Impairment				Disability Severity	
	Any Disability	No disability	Hearing	Visual	Cognitive	Mobility	No need for help in daily activities	Need help in daily activities
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
In person in polling place	58.0% **	67.7%	66.1%	67.9%	57.7% *	55.0% **	65.5%	51.5% **
By mail	25.0% **	13.6%	22.6% *	21.0% *	23.7% **	29.0% **	21.4% **	28.1% **
On the Internet	9.6% **	16.1%	4.1% **	4.1% **	10.7%	7.7% **	9.3% **	9.9% *
By telephone	5.0% **	1.5%	5.4%	3.5%	4.5% **	6.1% *	1.6%	7.9% **
Don't know	2.4% *	1.0%	1.8%	3.4%	3.5% **	2.2%	2.2%	2.6% *
Sample size	2000	1022	496	401	731	1331	929	1051

* Difference from non-disability sample is significant at 95% level ** 99% level

Research in Accessible Voting Report[1]

Final report for subcontract of Research Alliance for Accessible Voting:
Creating audio, graphical, and physical technology, to address voting process and product.

Ted Selker with Dan Gillette, Linda Avendano, Shama Hoque, Kate Liu, Minh Pham, and Mike Vroomen

July, 2014

FIGURE 1 DAN GILLETTE, SHAMA HOQUE AND TED SELKER IN A PROTOTYPE REVIEW

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[1] This material is based upon work supported by the U.S. Election Assistance Commission (EAC) as part of the Research Alliance for Accessible Voting. Opinions or points of views expressed in this document are those of the authors and do not necessarily reflect the official position of, or a position that is endorsed by, the EAC or the Federal government.

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1. Executive Summary

This report describes results of the Research in Accessible Voting (RAV) subcontract of the Research Alliance for Accessible Voting (RAAV) grant from the Election Assistance Commission. The Research in Accessible Voting (RAV) work was performed at CMU-Silicon Valley and at the Data Democracy Initiative at CITRIS at the University of California Berkeley. New techniques were developed and tested to improve physical, cognitive, and perceptual accessibility of voting.

RAV research addresses technological opportunities for improving voting for individuals with disabilities throughout the current voting process in the United States. The projects range from solutions that can be implemented with no change to equipment or process, to those that provide direction for next-generation voting systems, with a focus on audio voting, electronic voting interfaces, visual aids for paper ballots, and polling place operations. The direction of the projects was motivated by experiences with existing voting equipment and prototypes, poll watching, and interviews with election officials. All RAV software prototypes will be released into the public domain, allowing other researchers to build on the work.

1.1. Projects:

Below is a brief overview of RAV activities conducted as part of RAAV. A section below provides details for each project.

FIGURE 2 AD HOC LIGHTING IN A DARK POLLING PLACE

1. Freestanding Ballot Magnifiers: Created the Magnifying Illuminated -Support (MI-S, pronounced "my eyes"), a freestanding magnifier for improving focus on and legibility of paper ballots. These are currently being tested by election officials.

2. Write-in Techniques for Audio-Only Ballots: Developed a technique for improving the entry of write-in candidates for voting systems that do not possess an alphabetic keyboard. Prototypes were developed to explore a variety of new methods for alphabet browsing, instructing voters, and mapping of buttons/controls. The technique allows for quickly browsing the alphabet in a structured manner that improves usability in noisy environments, such as polling places [Gillette].

3. List Browsing in Audio-Only Ballots: Prototypes were developed to explore a variety of existing and new list browsing techniques for audio interfaces, such as audio-only ballots. This published work showed that lag in feedback greatly affects the efficiency of audio ballots. Additionally, we showed that gaps between list items can be condensed without a loss in usability.

4. Low Error Voting Interface (LEVI): Significant enhancements were made to improve feedback overview and redundancy in ballot design. The techniques are designed to reduce cognitive and perceptual problems with ballot overview, focus, and redundant feedback. We built prototypes for and collaborated with projects at Clemson University (PRIME III) and Maryland (online ballot marking wizard) to embed LEVI features into their systems. Additionally, a new web version of LEVI was created which allowed for the exploration of new techniques for tracking one's selections during the voting process, and a new software architecture based on web2.0 technologies. The web services version allows for easier distribution for testing (the new system runs in a browser) and for including LEVI in others' research. The system is available for use at

http://researchinaccessiblevoting.bitbucket.org/levi2. A video demonstration of the voter interface is available at https://www.dropbox.com/s/pux38k5nojv0891/LEVIhtml5.mp4.

5. Polling Place Support Tool: A web-based interactive polling place design and management system was developed. The system supports the design, analysis, and preparation of polling place layouts prior to an election. It can provide procedural support for opening and closing the polls. It can document problems during Election Day for election auditing and learning. A video overview of the system is available at https://www.dropbox.com/s/s3l0kfmexkiq2wv/pollingplacesimulator_x264.mp4, online demonstration of the system is available at http://pollingplace.nettempo.com:3000/#!/ .

6. Scrim: Scrim is a web-based, semi-transparent overlay with focus apertures that can be added to voter registration and education websites to improve flow and focus, especially for individuals with reading and memory disabilities, without webpage redesign. This Scrim Chrome extension is available for download at http://researchinaccessiblevoting.bitbucket.org/Scrim%20v1.2.zip A video demonstration of Scrim guiding a user through a webpage is available at https://www.dropbox.com/s/efyrm8g3eswtp6m/Scrim%20demo.mov .

7. Website Accessibility Analysis Tool: The website Analysis Tool provides visualization and data to understand accessibility problems. It presents webpage color and brightness issues graphically. It presents font usage, font size and alternative accessible text statistics graphically. The Chrome extension is available for download at http://researchinaccessiblevoting.bitbucket.org/Scrim%20v1.2.zip . A video demonstration of web Disability Analysis is available at https://www.dropbox.com/s/6emue4akikn1o11/website%20Analyzer%20Quick%20Demo.m4v .

8. DRE Instruction Set Analysis: Instruction set scripts were collected from a variety of Direct Record Electronic voting machines (DREs) audio-only ballots and analyzed for consistency, coherence, and efficiency.

9. Accessible Voting Technology Course: A course was taught at CMU-SV that yielded 5 projects, viewable at http://cmu96772.wordpress.com/. Projects included our first web accessibility tool, Polling Place Support Tool, a Wii controller-driven voting scenario, and a polling place locator.

10. Annotated Bibliography: As part of getting started, the project created an annotated bibliography. It can be accessed at https://www.dropbox.com/s/xd10idzbs945lij/RAV%20Bibliography%20final.pdf?dl=0 .

1.2. Report structure

The final report is organized as follows. It includes an Executive Summary in section 1, sections describing each project, a Conclusion, a list of References, and Appendices. Sections 2 and 3 describe simple approaches to help with perceptual interfaces in voting. Section 2 describes MI-S, illuminators, and magnifiers for paper ballot support; this is followed by Section 3 showing audio voting improvements for write-ins, the most difficult audio-voting task. The report moves on from there to more universally accessible opportunities. Section 4 shows progress on Low Error Voting Interface which could greatly reduce problems in making voting selections for people with cognitive disabilities, slight visual disabilities, for sample ballots, and for overseas voters. In accordance with universal design, LEVI style ballots can also reduce lost votes for all voters [Goler]. Section 5 shows tools RAV built to help web masters notice and reduce webpage visual and alternate screen-reader text problems, improve online access to voter information and registration, and make sample ballot marking more successful. Section 6 presents a new tool that could solve polling place training, operations and auditing problems. It describes two iterations of web-based polling place support suites. As polling place problems often disenfranchise individuals with disabilities, the tools help training, polling place planning, setup, problem resolution, and closing. Section 7 is even more exploratory. It describes a Nintendo Wiimote gesture-based voting platform that might address a variety of physical disabilities. Section 8 describes a number of smaller RAV projects that motivated the major projects or have valuable implications for policy creation regarding voting with disabilities. The report concludes with section 9, asserting that technological solutions must continually be explored as part of policy creation. We promote continued technology research funding support. Funded research is necessary to create and understand policy options and opportunities to increase available solutions for allowing individuals with disabilities to successfully vote privately and independently.

Much of the code can be found at http://researchinaccessiblevoting.bitbucket.org. The voting course work should be viewable at https://cmu96772.wordpress.com/ . Links to videos and other materials are included throughout this document.

1.3. Staffing

Below is a list of the principle contributors to the work and writing in this report:

- Ted Selker: Director
- Dan Gillette: Research Scientist
- Shama Hoque: Research Assistant, software developer: all projects
- Ashwin Arun: Research Assistant, LEVI, magnifier, audio ballots and instruction sets
- Aja Hartman: Research Assistant, MI-S magnifier
- Linda Avendano: Student in CMU-SV Accessible Elections class: Polling Place Support Tool
- Kate Liu: Student in CMU-SV Accessible Elections class: Wiimote voting
- Minh Pham: Student in CMU-SV Accessible Elections class: Wiimote voting
- Mike Vroomen: Student in CMU-SV Accessible Elections class: webpage assessment
- Rahul Rajan: Research Assistant, software developer: Audio Voting
- Cliff Chen: Research Assistant, software developer: Audio Voting
- Joey Hsiao: Research Assistant: Audio Voting
- NetTempo Inc.: Technical assistance and project management: web-based LEVI system
- Pepper Consulting: Technical assistance: web-based LEVI system

1.4. Acknowledgements

This work is a direct result of the insight and foresight of the EAC to focus on technology for voting with disabilities. The work would not have been possible without Jim Dickson's constant caring and thoughtful encouragement. We also enjoyed the collaborations with and appreciate all the support from our larger Research Alliance for Accessible Voting project. We appreciate the input and support from EAC, NIST, and the Caltech/MIT Voting Technology project. We appreciate the collaboration with and potent feedback from Linda Lamone and her team in Maryland. The feedback from Conny McCormack and Wendy Noren has been a constant source of deep wisdom. We appreciate access to the deep experience and thoughts of Dean Logan, Tim MacNamara, and others in the Los Angeles Registrar's office. We appreciate our access to the fine people at Disabilities Advocates, the election officials in San Francisco, and the many vendors and election officials who took time to interact about our work. Finally, we are appreciative of Mary Knoll for her administrative support, and Ellen Shay, Bob Parks, and Kathy Silke Prewitt for their patient support in writing and editing this paper.

2. Optical Magnifiers and Illuminators for Paper Voting Materials

2.1 Magnifier – Summary

RAV recognizes that paper ballots have increasingly been the preferred way of conducting elections. The illuminated magnifier is intended to ameliorate issues voters with moderate visual impairment may encounter when using paper ballots. Most people over 50 need magnification to read a ballot. Tremor is the most common movement disorder [Smaga] and negatively impacts any hand-held magnifier. Reading disabilities also affect approximately 45 million Americans [Shaywitz]. Finally, approximately 5 million Americans live with Alzheimer's memory loss [Alz], for which physically-organizing actions can be of assistance. A device that structures movement through a ballot, illuminates it, and magnifies it could improve voting for these populations. RAV worked through dozens of designs to create the Magnifying Illuminated Support (MI-S), a freestanding magnifier for improving legibility of paper ballots and improving voter focus while using it [Figure 11]. This is currently being tested by election officials.

2.2 Magnifier – Introduction

FIGURE 3 ASHWIN ARUN REVIEWING A BALLOT IN THE LAB

A growing portion of US voters experience difficulty reading paper ballots due to evolving trends in ballot design and national demographic trends among voters. Voters may be challenged by the size of ballot text and reading conditions inside the polling booth, such as a lack of lighting and glare.

The potential for reading difficulties and errors on ballots is heightened in the United States. [Figure 2], for example, shows a polling place with ad hoc poor quality lighting added after the polls opened. Counties have increased the use of paper-based systems over electronic systems in recent years. Font sizes on paper ballots are limited, as ballots often have more than ten races and sometimes as many as 100. These factors can especially create difficulties for voters with diagnosed and undiagnosed reading problems.

The potential for residual votes, a race that was over-voted or under-voted and will not be counted in the election [Alvarez], is also greatly impacted by trends in ballot layout. Interviews with election officials suggest that those who manage elections are reluctant to carry a single race over two printed pages because, in the past, many voters have not noticed the second page of candidates, which generated uncountable "residual" votes. As a result, there is a trend to condense the typeface used on ballots to fit each race on one page. Also, the number of local propositions has increased across the US, with an additional onus placed on the voter to read multiple paragraphs of text, sometimes in a small typeface which adds to difficulties for tens of millions of people with moderate visual impairment. There is evidence that when a race on a ballot with only a few selections is just above or just below a race with many, voters skip the race with few selections. In Sarasota, Florida, for example, a poorly designed ballot for a highly politicized race had over 13% falloff for a [2]famous and highly contested second race on the ballot. A nearby jurisdiction with the same ballot problem had 21% falloff on a less known race [Sarasota].

The number of older Americans with often improperly diagnosed reading difficulties is increasing. Most people over 50 need glasses. The national prevalence of age-related macular degeneration alone is calculated to be around 1.5 million people, but the number is likely to double by 2020 (Eye Diseases Prevalence Research Group, National Institutes of Health). Overall, the population of the US is aging, with the number of Americans over 65 currently at 14 percent of the population, and is projected by the Census Bureau to increase to 20 percent by 2030.

[2] The race was to replace Katherine Harris's congressional seat(who is known for stopping the Florida recount in 2000)

As people age, many acquire strategies to overcome moderately impaired vision in their daily lives without formal intervention. They may not seek intervention such as glasses or renewed prescriptions, and so they may not be prepared to read material with typefaces as small as those found on ballots. Voters with severe vision impairment or blindness are likely to possess their own assistive technology or employ other assistive strategies that would allow them to vote, either on paper or with an accessible voting machine. However, a much larger set of individuals with moderate vision impairment or reading disabilities often have difficulty getting through a ballot as well. For instance, one's reading prescription may be adequate for pleasure or computer reading, but may not be strong enough to read small ballot print, due to size and/or poor lighting conditions. In many cases, the needs of individuals with moderate vision impairment have been too diverse for generalized solutions to be provided in the polling place. While magnifiers are available at most polling places, poll workers often forget to offer them to voters, and they tend to be inadequate for the task.

2.2.1 Magnifiers - problems with traditionally available approaches:

- Inexpensive hand-held magnifiers are the common solution. Unfortunately, these must be held with one hand, stopping a voter from holding a sample ballot worksheet or stabilizing their ballot as they mark it.
- Any problem with physical coordination such as tremor compromises the use of hand-held magnifiers.
- Frequently picking up and putting down the magnifier is likely to cause additional disruptions to attention. Common magnifiers are typically manufactured with a width narrower than a typical ballot page, causing users to move the device from left to right in steps, often momentarily losing their place in the text.
- Polling stations rarely have a place for holding another piece of paper. Therefore, referring to notes or a sample ballot must be accomplished using only one hand. This can compromise the error-reducing practice of referring to a sample ballot.
- Many jurisdictions use hand-held Fresnel lenses, which are able to magnify a large area with limited distortion. Unfortunately, their flat design makes them prone to being overlooked by voters and scratched as they are laying around. When they bend, Fresnel lenses also distort the image they are magnifying. Additionally, the focal length is often too short to allow writing underneath, forcing one to give up magnification during the marking step of the voting process, which has the likelihood of significantly increasing errors.
- Magnifiers may also be difficult to hold steady for many users, especially for populations with tremors. Indeed, dexterity and grip strength have been found to correlate directly with reading rate when using a handheld magnifier [Dickinson].
- Voters also show an inclination to bend over a ballot to look through a traditional magnifier, creating an unnatural posture [Figure 3].
- Lighting also greatly affects the use of the sheet magnifiers commonly found in polling places. The optical properties of the lens attenuate light under the device, further degrading reading conditions for a population that many require optimal lighting. Meanwhile, strong lighting above the device may create glare on the magnifier's reflective top surface, obscuring the field of view beneath.
- A 2002 voting study found that test subjects who used a ruler to keep their place as they read down the page made fewer errors in [Goler].
- A final problem to highlight is that a lack of training in magnifier use has been shown to negatively impact reading rate [Cheong 2005). As users train with magnifiers, they become accustomed to the magnification level inside the viewing field. Cheong showed that short-term practice with a magnifier in an optometrist's office was effective in increasing reading rate in patients, to a degree that matched their rate with large-print media. Trained users also tend to move the page under the magnifier for greater success, instead of moving the magnifier across the page [Dickinson]. However, voters with moderate low-vision and/or reading difficulties are typically not identified before entering the polling booth and many do not identify themselves. Short-term practice could be then used to improve the value of any magnifying prosthetic that a voter uses.

To address these issues, RAV iterated through a series of magnifier designs specifically intended for use in the polling place, arriving at the improved MI-S voting magnifier. Additionally, feedback from prospective users with moderate vision impairment (the target demographic) and from election officials was incorporated into our design process.

2.3 MI-S Magnifier - Design and Testing

The MI-S magnifier hardware design has been created in an effort to remedy the reading, writing, and ergonomic challenges which have been exacerbated by the typical magnifier designs for voting while also remaining affordable. The device went through seven prototype stages.

Ted Selker first began exploring polling place magnifiers in the Caltech/MIT Voting Technology Project. The first design was a barrel magnifier with fuzzy feet to slide easily on a page [Figure 4]. To help focus voters on an individual race, the magnifier only magnified in one dimension. The idea was to simplify keeping checkboxes and association aligned. The barrel magnifier was fashioned from a half-round 1 inch diameter rod. Enough of these were made to give one to each Secretary of State, to publicize problems and possible solutions for voting this way. Because it physically covered what it magnified, it needed to be moved away to allow marking the ballot.

FIGURE 4 HALF-ROUND BARREL MAGNIFIER

The image shows a half-round rod that lies directly on the ballot magnifying through the rod in the vertical dimension.

Several goals became part of the device design focus. We needed a device that would:

- Stay where positioned for one-handed use to make it appropriate for individuals with dexterity and upper-limb disabilities
- Frame single sections of the ballot at a time to address cognitive disabilities
- Not in the way during ballot marking
- Available in the voting booth to allow people to decide to use it when needed

These considerations resulted in the voting magnifier currently available from Inclusion Solutions. This magnifier is an injection molded, free-standing barrel magnifier that stays stable magnifying what is being marked as selections are made. It has a magnification greater than 2, and stands on its own [Figure 5]. This version has an etched, horizontal line slightly above its center spot, to guide the eye across a line of text. A tether is included for attachment to the leg of the polling booth; an instructional diagram is also attached to the tether. The transparent nature of the magnifier allows maximum

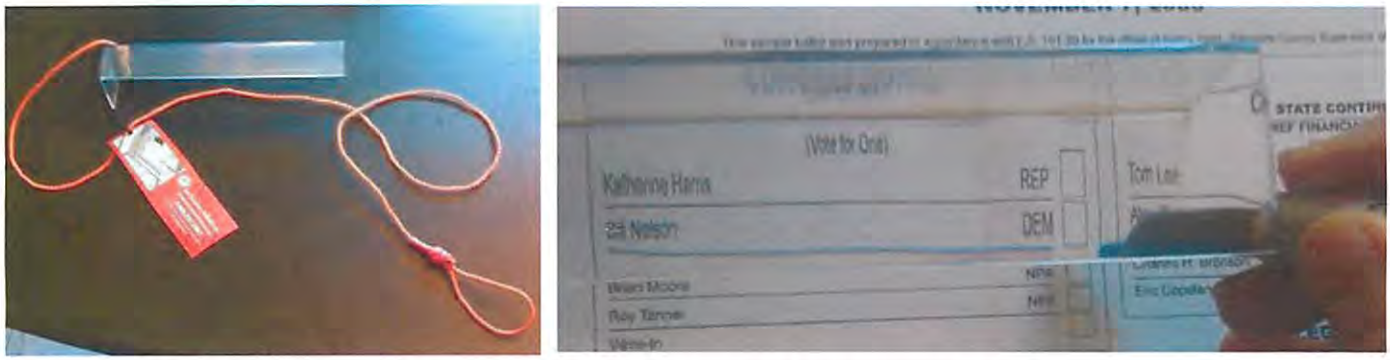


FIGURE 5 SELKER'S MOLDED BARREL MAGNIFIER USED IN MANY JURISDICTIONS

THE LEFT IMAGE SHOWS A 2 INCH HIGH 1 3/8 X 8 INCH CLEAR PLASTIC MAGNIFIER. IT SHOWS A CORD TO ATTACH THE MAGNIFIER TO A POLLING BOOTH. THE CORD HAS A CARD WITH A CARTOON SHOWING HOW TO INSTALL, HOLD, AND USE THE MAGNIFIER TO MARK SELECTIONS UNDERNEATH IT. THE RIGHT IMAGE SHOWS A PERSON MARKING A VOTING SELECTION UNDER THE MAGNIFIER.

illumination of the ballot from ambient light. As one votes, the magnifier can be moved down the page using just one hand, helping voters keep track of where they are in the voting process without having to let go of the marking pen. By being freestanding and smaller than the entire ballot, the magnifier also assists in holding a user's place in the ballot, which is especially important for individuals with reading disabilities, attentional difficulties, and short-term memory problems.

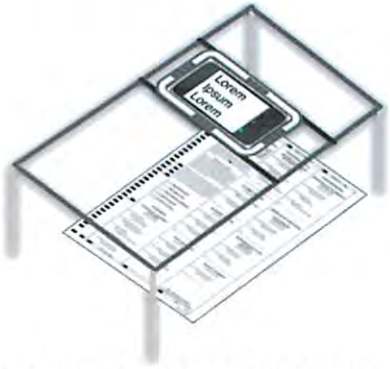


FIGURE 6 ARTIST'S SKETCH SHOWING A PHONE AS PART OF A MAGNIFYING SYSTEM

Thousands of these magnifiers were acquired by municipalities [Inclusion]. While a clear improvement over handheld sheet magnifiers, there was a clear need for further refinement. Concerns developed around the need to stand directly over the magnifier to view the ballot correctly. The viewing area was problematic when reading the multi-line text of initiatives; there was no built-in illumination and the quality of the lenses was variable. Indeed, the biggest problem came from the fact that molding the lens and base together caused difficulty in creating quality optics. The MI-S RAV magnifier work below is motivated by several difficulties marking under this low device: its field of view, reflection caused by lighting from above, its illumination distortion, and magnification problems.

As a result, we began to explore how to resolve these issues with new designs. An electronic magnifier could illuminate the ballot and its display, digitally enhance the image, and otherwise help a voter keep track of their progress. An adjustable stand to hold a voter's mobile phone for use as a digital magnifier was developed [Figure 6]. Unfortunately, many mobile phones have an offset lens so that the users' hands and pens would not appear where expected. It would also be expensive to deploy such a device. Additionally, many jurisdictions are outlawing the use of mobile phones in

FIGURE 7 COMMERCIALLY AVAILABLE STANDOFF MAGNIFIER: UNSTABLE, HIGH GLARE, UNEVEN ILLUMINATION.

The image shows a commercial fold-up standing magnifier with a flat Fresnel lens on top that straddles a ballot. It has illuminators that create uneven artifacts on the ballot. Its batteries don't last long enough to use for voting.

the polling place. We reverted to improving the molded magnifier.

The use of a barrel lens in the first molded version reduced the viewable area and didn't actually appear to significantly improve voters' ability to keep track of their position, so it was abandoned for the use of flat Fresnel lenses. By moving to a Fresnel lens, we were able to achieve magnification both horizontally and vertically, allowing for more text to be read before moving the magnifier. We built standoff magnifiers and adapted commercially available illuminating magnifiers. The vertical magnifiers [Figure 7] would not easily allow viewing from in front of the polling booth. Inexpensive solutions did not evenly illuminate and created glare. We designed cantilevered stands with illumination made from plastic bins and acrylic. They had many advantages. To best understand where to position the lens, we built a platform for experimenting with the height and size of the lens [Figure 9].

FIGURE 8 STUDY OF FRESNEL WITH CANTILEVERED LEGS

We experimented with device's lens choice, width, viewing angle, and height off the page. Tilting the lens ~12 degrees is a trade-off between ergonomics and optics (if a lens of the desired size of four inches deep is tilted past 15 degrees, the text at the top and bottom of the lens would be distorted by the change in focal length). To allow for greater ease while marking the ballot, the position of the lens was raised. This also helped to achieve a slightly higher-level magnification. We eliminated the left leg of the original design to better accommodate ambidextrous marking. The field of view was vertically increased to aid interactions around longer races and paragraphs describing initiatives. Finally, we found that adding a built-in light could greatly improve readability and reduce glare reflected off the surface of the lens [Figure 10, 11]. We tried making angled larger standoff magnifiers in various ways. Achievements for the device include allowing hands-free use with a viewing angle pitched slightly toward the user. The new devices have slightly higher magnification. They sit higher off the page, allowing the user to write beneath it with either hand. The lens itself would allow higher light transmission and exhibit low reflectivity from above to prevent glare. A downward-facing electric light originating below the magnifier raises the illumination levels. Additional goals were to allow easy setup, left hand/right hand independence, portability, a wider base to allow stacking, and the ability to fit into existing polling-booth geometry. For instance, the device would have a tether to keep it attached to the booth and word-free instructions on the tether to instruct poll workers and voters. Unfortunately, the acrylic voting stand blocked writing easily underneath and was delicate. For flexibility of experimentation, we found a wire frame holding a magnifier to be an excellent choice [Figure 10, 11]. This wire frame design turned out easy to manufacture as well and is the

FIGURE 9 A SPECIAL POLLING STATION STAND FOR TESTING MAGNIFYING ANGLE AND POSITION

current MI-S testing platform with 100 devices available for election officials and others to try.

The purpose of this design is to improve voting for individuals who cannot read small text, individuals with tremors who have difficulty holding a magnifier steady, individuals with attentional difficulties, individuals with reading disabilities who may benefit from a mechanism that helps structure progression through the ballot, and anyone else who may need help keeping track of multiple tasks during a challenging, unpracticed activity.

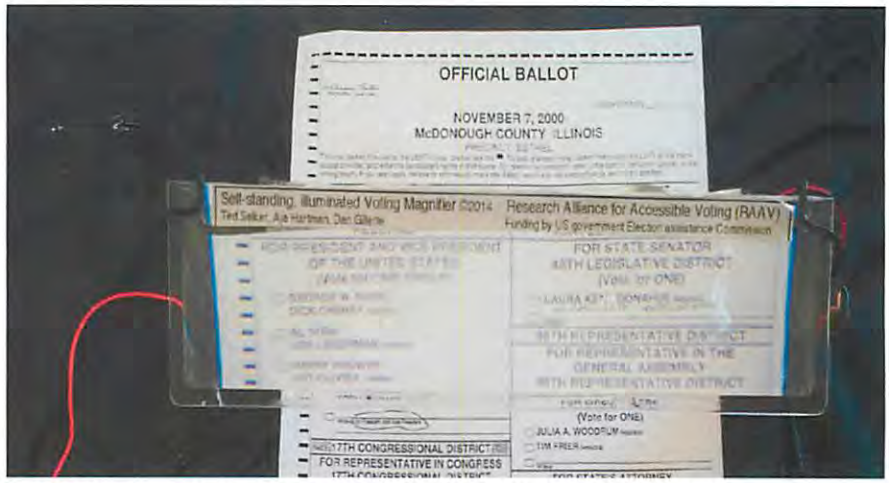


FIGURE 10 EARLY SMALL VERSION OF WIRE FRAME MI-S SELF-STANDING BATTERY POWERED MAGNIFIER

The image shows an 11 inch wide magnifier on a wire stand magnifying the ballot. A battery is visible on the right that powers this magnifier for 12 hours.

2.4 Magnifier – Experience

As tested, MI-S measures 12 inches wide at its base, with a lens of 11 inches wide. The depth of the lens is 4.75 inches, and the device stands 4.5 inches high to accommodate the use of writing instruments underneath. In addition, the device uses an LED light powered by a 9-volt battery, which was suggested by some election officials over the use of plug-in illumination [Figure 10,11].

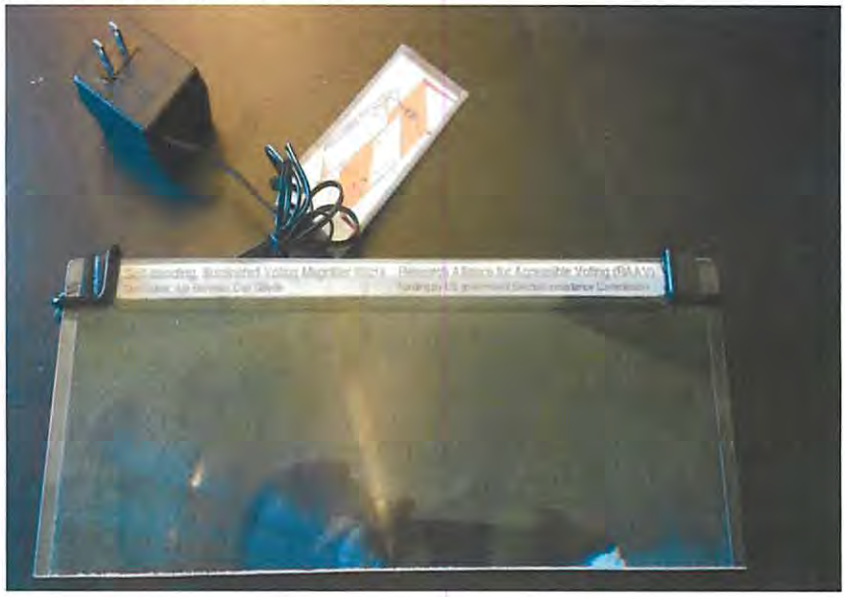


FIGURE 11 FULL SIZED PLUG IN VERSION OF MI-S

The image shows a 4 .75 inch by 11 inch magnifier held 4.5 inches over a ballot area with a wire stand. It also shows an illuminator power supply with a card on its cord. The language-free, cartoon on the card shows how to install and use the magnifier

During development, several researchers and students experimented to determine an appropriate magnification level. The optical magnification level of the test device was deemed most effective at a 2.5 times normal, similar to typical handheld magnifiers. Too much magnification appeared to be disorienting to users; the 2.5 magnification rendered a text size comparable to a large-print book, but preserved the context of the other items around the highlighted text. With the lower magnification and a total lens depth of 4.75 inches, the device's field of view displayed several lines of text at a time, providing good contextualization and ease of reading multi-line text.

When magnifiers with a narrow depth were tested, the need to move the device up and down to read a paragraph tended to cause a loss of one's place in the reading. The final design reflects weighing the benefit of a shallower field of view for structuring the reading activity, versus a wider one for giving a contextual overview. The horizontal aspect of the design itself helps users structure the activity, while the larger aperture aids in orienting users to a larger context. Several prototypes were built to establish an effective tilt angle, placing the lens in a custom jig made by cutting slits in cardboard. The tilt was around 15%, which allowed a user of average height to stand normally in front of a poll booth. The final

version is a Fresnel magnifier with a stand constructed of stiff bent wire that holds the magnifier 4 or more inches off the paper.

2.5 Magnifier - Discussion

To many, a magnifier appears to be a simple intervention for voters with reading difficulties. However, in addition to magnification, our experiences showed that illumination, height from ballot, and size of the reading area matter. The area shown through MI-S mimics the scrolling of electronic interfaces, in terms of their potential to direct and serialize voter attention. A freestanding magnifier (in contrast to a manually-held device which must maintain focal length) does several things. It places relevant content in front of the voter's eyes, in a stable state, at a comfortable viewing angle. It can ameliorate problems for voters with hand tremors. It can ameliorate low vision. It can also help a voter keep their place while referring to notes or election materials; voters can look away from the ballot then look back to find their place, aiding attention. In addition, the view through the magnifier's lens extends across the page, highlighting a limited number of text lines, in the same way that an effective electronic voting machine interface can focus on race while maintaining the larger context. This work suggests that such a magnifier may also help voters with normal vision who have cognitive impairments such as attention deficit, offering a tool for completing a paper ballot that they can certainly read, but may have trouble following in its compressed format.

Even without a significant improvement in reading speed, magnifiers with interventions to direct reading (such as a guide line) elicit a positive response from users with reading difficulties [Cheong 2005]. Cheong has also shown that such devices can give users confidence, which in itself may reduce errors. Conditions at many polling places are such that voters feel pressure to finish marking a ballot and relinquish the polling booth to others in line; poll watching experience finds voters with and without reading difficulties frequently making hasty selections, because they simply want to finish a cumbersome and protracted process.

Many voters may put themselves outside the category of users needing interventions. Challenges to adoption of such a magnifier include hesitancy from users without severe vision or cognitive impairments or from users who may have undiagnosed impairments. The value of a tether to maintain a magnifier in the polling booth is particularly important to allow voters to casually use the prosthetic, without having to leave the booth and ask for help.

The optimal deployment of magnifiers would be to have them tethered to each polling station before the polls open. Alternatively, some polling sites provide reading glasses to voters. This could be an extremely positive remediation, however, such an accommodation does not structure the ballot-marking activity and could pose a health hazard as glasses are shared between voters. Additionally, election workers have found that glasses create a management problem in the polling site because of the need to loan and accept returns of the appliances.

The decision to make a battery-powered, as well as a plug-in illumination version, came as a result of the wishes of election officials.

Finally, we designed MI-S to give some of the ballot-structuring advantages that DREs offer. 2004 data showed that no state depending on paper ballots had less than 0.9 % residual errors (of a voter not successfully making a selection for the race at the top of the ballot) while all four states that used DREs had 0.4% or less [Stewart]. We believe the DRE advantage came from many user interface advantages: focusing on a race, structuring the activity, and feedback. Our goal was to take Low Error Voting Interface features and make them available for paper, in an attempt to reduce the difference in residual votes in paper ballots.

3. Audio-Only Voting Interfaces for Improving Write-In Candidate Text Entry

3.1 Write-in – Summary

Few blind individuals are proficient in Braille. Audio voting has become an important way to allow voters who cannot read well (including individuals with reading disabilities) to vote independently and privately. Unfortunately, the process can take many times longer than that for a graphical ballot, due to the way text is presented, confusing feedback, and poor navigational schemes. To resolve these issues, RAV has explored how to improve audio-only voting.

Ted Selker's previous work in the Caltech/MIT Voting technology project is a backdrop for the RAV audio ballot prototype. A first student project by Reesa Phillips explored using 3D to improve orientation and reduce time for voting. While promising, the ability to use 3D to orient a voter is brittle. Such an advanced use of audio will require much more development. Another effort of ours used "abbrievicons" - speaking a reduced version of often spoken control words. Mathew Hockenberry worked with Ted to show that the approach can significantly reduce speaking time in audio ballots [Hockenberry]. Vendors have been encouraged to consider using the abbrievicon idea in their audio interface systems. The RAV audio work focused on input for selecting items in a long list, like an alphabet, for the purpose of writing a word that must be done for write-in candidates. RAV created and published work suggesting that audio lag, and requiring the user to listen to entire selections before moving on (as in many of today's voting systems), are both impediments to usability. The project's prototype audio-only write-in process was improved with simplified button controls. The work also indicates increased usability with structured audio presentation, when background noise or distractions are present.

3.2 Write-in - Introduction

Many constraints impact an accessible voting experience for voters who cannot read a graphical ballot. While a tactile Braille interface is often suggested by those new to the problem, in the United States only 10 percent of blind individuals are proficient at using Braille [Jernigan], and not all voters are familiar with typical text-input and assistive technologies, such as standard keyboard layouts or screen readers [Granata]. As a result, the 2005 Voluntary Voting System Guidelines

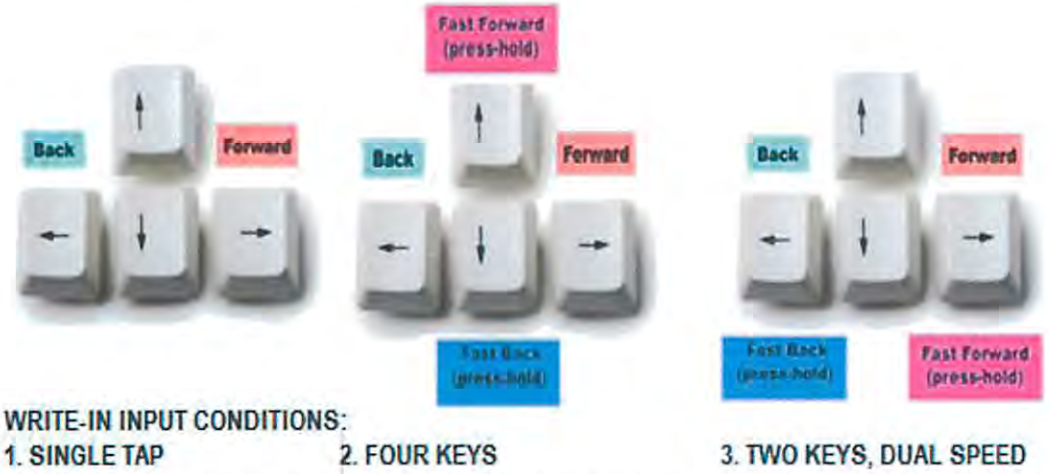


FIGURE 12 KEY INPUT CONDITIONS FOR AUDIO WRITE-IN EXPERIMENTS

(VVSG) specifies that the inclusion of audio-based voting be provided [United States Voluntary], while allowing for voting privately, independently, and verifiably (the ability to confirm one's choices before casting a ballot). Because of the lack of voter training opportunities, user interfaces should be usable without prior training. Direct Record Electronic voting machines (DREs) have therefore been developed with a simplified button-input array that controls an audio-only user interface. With DREs, screens are typically blank during audio voting to preserve the privacy of the vote. Such audio DREs might seem simple for some voting tasks. However, the multiple processes of inputting the name of a write-in

candidate, selecting characters, checking accuracy, making edits, and submitting one's choice can be especially frustrating and time consuming. Many voters who use the audio write-in feature need extra time and commonly fail to enter a name at all. In practice, such interfaces have presented voters with their most difficult task of the election experience [Herrnson], contributing to a higher ratio of unrecorded votes [Niemi]. For this reason, RAV has focused on how to improve the write-in experience by exploring how to better use controls, provide instruction, and improve input-editing strategies.

Speech recognition and auto-completion of text might seem appropriate for writing in a candidate's name. Unfortunately, these technologies would spoil privacy and could even be inappropriately coercive for voting. Using speech recognition for direct text entry in the polling place, where others can listen in, would jeopardize one's right to vote privately. In the case of auto-completion, there are also many issues that cannot be resolved. To begin with, auto-completion requires that words be previously known by the system, but many states do not require write-in candidates to pre-register [Helm]. Additionally, in the context of voting, auto-completion can potentially introduce coercion, by priming the voter think of one candidate over another through the ordering of suggestions. For these reasons, we focused on creating new text entry methods for audio-based write-in that does not rely on alphabetic keyboards, speech recognition, or auto-completion of text.

This section covers the development and testing of three novel audio interfaces that enable navigation and selection of characters through simple techniques that allow users to linearly access an alphabet for the purpose of typing a specific name, discussing the strengths and weaknesses of each in relation to existing methods.

3.3 Write-in - Discussion

Voting machines can be designed according to several sets of guidelines, most notably the Federal 2005 VVSG, which designates that every polling place should have at least one accessible voting station. Such devices are intended to allow people to use a range of adaptive input devices such as an Audio-Tactile Interface (ATI), intended to provide voters with earphones and a set of buttons, or a sip and puff device for non-manual use (with graphical or audio interfaces). The VVSG includes guidelines for volume, frequency, and speed of audio between 75 and 200 percent of normal rate of speech. The VVSG does not specifically address how write-in candidates should be entered by voters who do not use graphical interfaces. We followed guidelines on how operational instructions are to be given by audio at initial activation, and repeated as desired during the voting session. Our prototypes also fell within the VVSG guidelines for audio speed, after iterative testing and refinement.

Several researchers and students helped to determine reasonable rates for presenting audio. Participants found that audio with the standard speech rate equivalent of 200 words per minute (WPM) seemed slow, while an equivalent rate of 700 WPM and higher was incomprehensible. Though audio at a rate of 500 to 600 WPM could be understood, users found it too fast for maintaining comfortable and accurate navigational control. As a result, audio generated at 400 WPM was considered appropriate (in line with the VVSG's upper limit of 200 percent above normal). This also fits with the findings of Asakawa, et al, on general comprehension of listeners of sped-up synthesized speech, which saw an upper limit for comprehension at around 300 to 500 WPM (278) [Asakawa]. The prototype platform strayed from the VVSG in regard to providing multiple modes for navigation keys, depending on whether the key is tapped quickly or held down.

The VVSG suggests that press-hold commands (for instance, repeating the entry of a letter if a key is held down) be avoided as an attempt to limit unintended letter entry, but we introduced such a capability into two of our three prototypes to see if the command's utility might outweigh the concerns posed in the VVSG. The potential to positively impact future criteria is a goal of our work, adding to the motivation to reevaluate existing guidelines.

The goals in developing the three prototypes were to test how to best orient the user during the text-entry task, shorten the amount of time required to enter a candidate's name, and improve accuracy. The prototypes were created in a Google Chrome browser extension, built with HTML and JavaScript. The extension utilized Chrome's text-to-speech capabilities to generate audio feedback, and also HTML5 to manipulate audio files. These were generated using text-to-speech

features in the MAC OS X command line interface. While the system works with Windows machines as well, the testing was conducted on a 2012 MacBook Pro.

A version of the prototype was created for each condition listed below:

- Condition 1, Single Tap with Two Navigation Keys: Participants moved through the alphabet one letter a time by tapping the left or right arrow keys to navigate; selections were made by pressing 'Enter'.
- Condition 2, Four Navigation Keys: Participants used the Up and Down arrow keys to navigate through the alphabet at 400 words per minute (WPM), pausing to distinguish marker letters (A, G, M, T, Z), and the Left and Right arrow keys, to navigate one letter at a time.
- Condition 3, Two Navigation Keys Utilizing Two Speeds: In contrast to the single tap, with these two-key conditions participants used only the Left and Right arrow keys for navigation. By holding down the keys, users moved through the alphabet at 400 WPM, pausing to distinguish marker letters (A, G, M, T, Z), and then navigating one letter at a time with single taps.

The rationale behind the development of marker letters was to provide a fast way to navigate closer to an intended target letter by browsing through groupings, to select the target letter with only a few key presses. The initial exploration divided the alphabet evenly, but informal testing indicated that most people do not have an adequately stable model for where lesser-used letters fall in the alphabet. Most people, however, could easily establish a letter's location in the alphabet by recalling its proximity to commonly used anchor letters. Through trial and error we found A, G, M, T, and Z to work best as markers (or waypoints) to segment the alphabet.

Experimental instructions for write-in experiments:
"To write in a candidate's name, follow these instructions:

1. [Condition 1] "Single-tap the Left or Right arrow key to move through each letter. Press Enter to select a letter."
2. [Condition 2] "Press and hold the Up or Down arrow key to find the general area for the letter you are looking for. Single tap the left or right arrow key to narrow in on the letter. Press Enter to select the letter"
3. [Condition 3] "Press and hold the Left or Right arrow key to find the general area for the letter you are looking for. Single-tap the Left or Right arrow key to narrow in on the letter. Press Enter to select the letter."
4. "To move through the alphabet quickly, like this [play audio sample], press and hold the Left or Right arrow key. Try it [allow user to try]."
5. "To move one letter at a time, like this, press the Left or Right arrow key. Try it [allow user to try]."
6. "To select a letter, press Enter. Find and select the letter S [allow user to try]."
7. "To review what you have already typed, press the Up arrow key [allow user to try]."
8. "To remove the last letter typed, press Delete [allow user to try]."

"To listen to the instructions again, press the Down arrow key. To begin, press an arrow key."

To test our prototypes, thirty computer science graduate students participated. All possessed average vision, none were regular users of text-to-speech technology, and only one was a native English speaker. For each condition, participants were asked to enter two different names. The order of conditions was randomized. The time taken to input eight letters using each approach was compared. Each test condition had a sample size of ten participants.

The data shows a statistically significant improvement between Condition 2 and Condition 3 with a 25 percent reduction in task time when using a two-key interface over a four-key interface (with a t-test p value of 7.1E-06). In contrast, there is no statistically significant performance difference between condition 1and 2 (t-test p value of approximately 0.88). A critical finding was that all conditions improved audio-enabled write-in speeds over existing and prototype DRE systems with a similar functionality. The majority of our testers completed audio write-in entry in less than one minute in every

trial. DRE voting equipment with audio write-in capability tends to utilize a condition similar to Condition 1, yet in the field, this method is very difficult. In field tests and observations of various deployed and emerging voting devices, selecting eight letters for a name can rarely be done in one minute. As a gauge, we looked at efforts using machines going through or carrying VVSG certification. For instance, on a Sequoia AVC Edge machine manufactured by Dominion and tested in January 2014, a user entered only four letters in 56 seconds with great effort. In addition, when the tester entered a letter erroneously on the AVC Edge, he was unable to correct it.

There are a number of reasons for slower write-in speeds on current equipment. Many DRE voting machines in current service present a lag in response—a detectable or sometimes uncomfortably long period of time between when the user presses a button and when the device responds. DRE machines with older hardware and software may suffer delays because software has not been optimized or hardware is underpowered to keep up with the voice interface. (The prototype did not present noticeable lag.) As well as lag, some systems do not register button input while audio is playing, meaning the voter cannot skip past or truncate (cut short) any information, which can impede alphabet browsing. Another factor may be key design.

DRE machines may not match the effectiveness of the prototypes using a computer keyboard because of the actual design of the DREs' specialized buttons, which are typically large and made from plastic, soft rubber, or silicone, and behave quite differently from the type of computer controls most people encounter in their daily lives. Although standard computer keyboard keys are pressed with 182 to 193 grams of pressure anywhere on their surface [Rempel], many accessible ATI buttons on voting systems vary in actuation pressure across the key, requiring pressures that are multiple times the minimum pressure needed near the hinge. Recently, our researcher team had access to a newer DRE that responded with no perceivable lag, but used the standard Accessible Technology Interface (ATI) button design. While not available for our study, in a limited hands-on test the new machine yielded vote times closer to those experienced in our test conditions, but still not as fast. It is likely that differences in key feel contributed to this difference.

Faster overall entry speeds in the experimental conditions may have also resulted from the ways the conditions attempted to orient users on how to go forward and backward, and to navigate the interface itself. This data shows that using fewer keys increased performance in both of the experimental conditions. The four-key interface was more difficult for participants to learn, remember, and use efficiently. Surprisingly, the data did not show a significant improvement for the novel press-hold feature of Condition 2 and Condition 3, over the simple tapping of Condition 1. Simply tapping through each letter one at a time enabled users to enter letters faster than they could with Condition 2 and at similar speeds as Condition 3. In interviews, however, the majority of participants reported a preference for the sped-up letter browsing of Condition 3. In spite of not being native English speakers, participants also reported that utilizing A, G, M, T, and Z marker letters to chunk the alphabet into four sections improved their sense of location in the alphabet. Although these preferences did not significantly increase text-entry speeds, participant feedback speaks to an increased comfort level with having an overview of the alphabet and a greater context for navigating it. These marker letters, however, did affect use under stress as described below.

The testing also revealed the importance of suggesting an efficient strategy to voters, rather than simply listing features in the instruction set. Without any instruction on strategy (when we described what each feature was, but not the purpose), only some participants developed efficient methods for text entry while others struggled, either sticking to using single tap or sped-up letter browsing, or frequently changing strategy. Testers who developed an efficient strategy did so by taking a moment to experiment with the controls before commencing to spell the name, but such experimentation is not easily available while voting, given the pressure of time and the fear of making an error that would affect a live ballot. When we changed the instructions to clarify various strategies (for instance, initiating a press-to-hold on an arrow key to quickly move to a letter region, or tapping the arrow keys to browse one letter one at a time), almost all used an efficient strategy from the start. The testers' response prompts the question of whether polling guidelines should encourage a period of practice, sample vote completion, or simple drills before commencing to enter write-in candidate names. Unfortunately, voters are currently unlikely to have consistent training before voting.

While not part of our formal prototype testing, an important benefit of using sped-up reading of the alphabet with marker letters became apparent when using the prototypes in noisy surroundings, such as found in typical voting sites. Many

users stated that when the volume of the prototype could not fully compete with ambient noise, it was still easy to hear the pattern of the marker letters as the alphabet sped by. This pattern made it possible to easily get within range of the target letter, and the cognitive model it developed provided secondary context to discern partially heard letters when zeroing-in on the target one letter at a time. This suggests that while there were not significant improvements in speed between Condition 1 and Condition 3, in the noisy environment of the polling place Condition 3 should present a valuable benefit in real world voting.

3.4 Audio – Conclusions

This work demonstrates techniques for write-in design that could be introduced in future voting machines and highlights underlying questions related to the ongoing design strategies of electronic voting equipment. The previous discussion concerning ATI button design and our experience with these specialized buttons cautions us that the presence of such unusual, specialized input hardware (presumably to show extra care and attention to voters with disabilities) may actually introduce difficulties for many users. Experiments indicate that a typical consumer-grade keyboard is much easier to operate than available adaptive input devices and would speed input. As well, the arrow configurations on such keyboards (sometimes a cross style or inverted T with Up-and-Down arrows sandwiched between Left and Right arrows as in Figure 12) are typical to most people's communication use in daily life. While early VVSG may have been made when fewer people used computers, it has become difficult to live in society today without using a keyboard for communication and other activity. While the goal may be a variety of input methods to suit the user's tastes (common QWERTY keyboard, Braille keyboard, or audio-tactile interface) in line with the findings of [Oliveira] in "Blind People and Mobile Touch-based Text-Entry: Acknowledging the Need for Different Flavors," a functional interface that follows the most successful conditions in our testing would form an appropriate path for simplified entry of write-in candidates. Eliminating keyboard-to-audio lag, allowing key press to interrupt audio at any time, and varying audio speed each improved audio-based character input. In addition, structuring the alphabet with fixed marker letters did not slow input, and indeed, should make performance more reliable in the context of the perceptual and cognitive challenges of real-world voting input. The results of this work should also be useful for entry of passwords or proper names in any computer interface not relying on speech recognition or keyboard input.

4. Low-Error Voting Interface Development

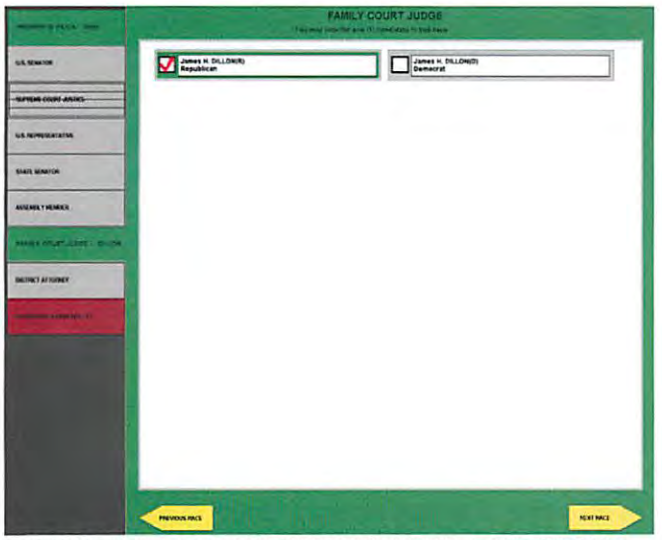


FIGURE 13 EARLY LEVI SHOWING A SELECTED CANDIDATE

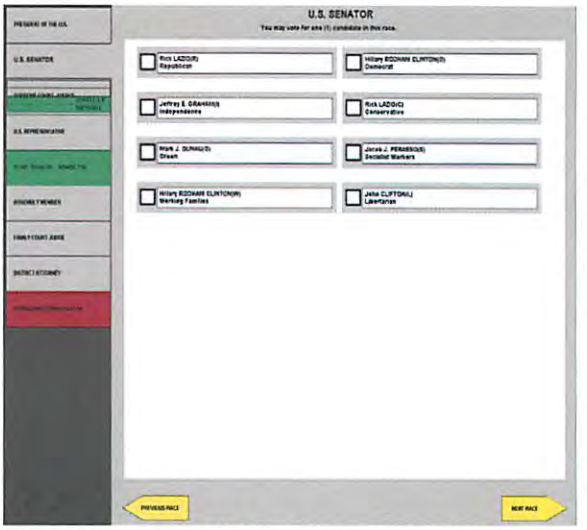
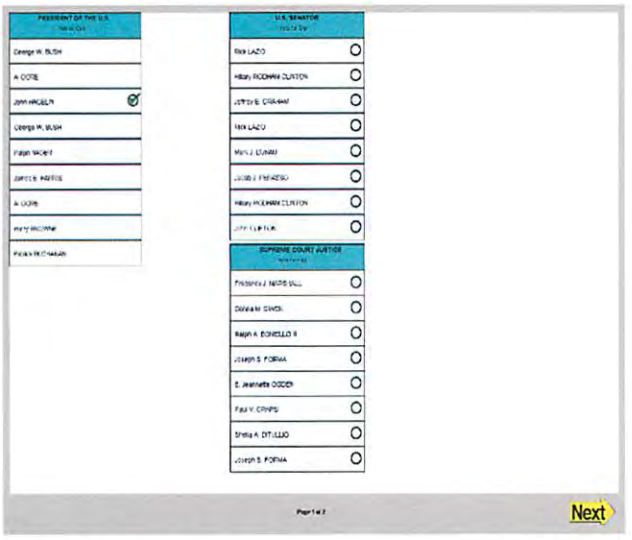


FIGURE 14 UNVOTED AND PARTIALLY-VOTED RACES



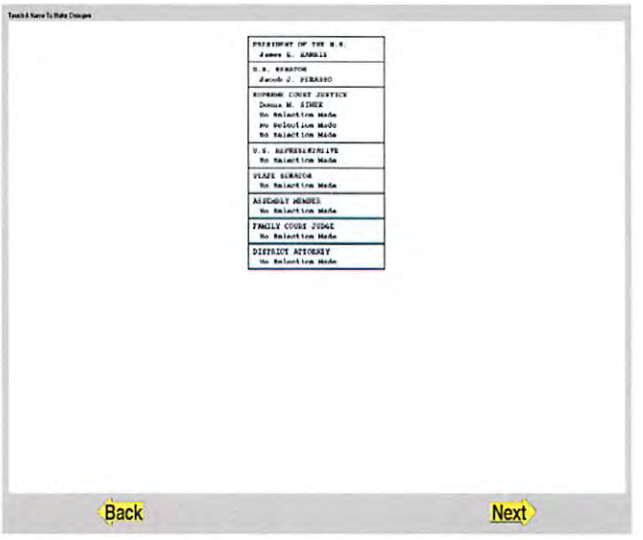


FIGURE 15 LEVI SIMULATOR PRESENTING TYPICAL VENDOR BALLOT AND REVIEW PANES

4.1 LEVI - Introduction

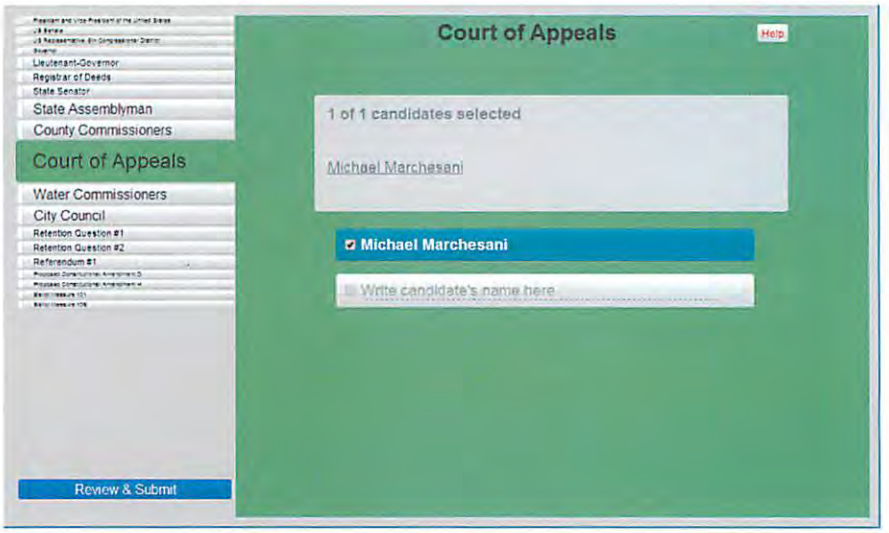


FIGURE 16 LEVI CONSTANTLY REVIEWS SELECTIONS FOR ALL RACES

The Low Error Voting Interface started as an effort to reevaluate electronic voting ballots in 2001. Graphical ballot design has not typically used state-of-the-art user experience and graphic design techniques. Ballot designs usually use a simple, narrow, dark line between areas on a screen. They often forego using shading, color, or texture for distinguishing a selectable item or space to separate them. They often do not vary layout spacing for different kinds of things, or in reaction to selections. Modern cognitive science and user interface research show much better alternatives. Shaded outlines are more noticeable. Border lines that mimic three dimensions with contour and shadows recruit precognitive perceptual capabilities [Ennes]. Using such cognitive science-inspired techniques should greatly improve speed and accuracy of distinctions. Texture and color can also make differences more apparent. Organizing races so that they aren't visually lost on the ballot is important. In Sarasota County in 2006, for example, 13% of voters didn't see the second race on the ballot due to a graphic design glitch [Sarasota, Selker LEVI]. My VTP LEVI work explored changing the look of a ballot so that a voter could always see the status of all races. We added a zooming feature called fisheye views, which has been shown to help people orient and focus. We made feedback for what the voter had selected redundant and obvious. Finally, we realized huge reductions in errors when we compared these to simulations of Sequoia and ESS ballots [Goler].

LEVI is designed to ameliorate several accessibility problems, while reducing error rate for all voters. It is designed with several concepts to orient and organize voting. It gives visual feedback of voter progress at all times. Texture and color are used as secondary cues to clarify whether or not more action is possible for a contest and what type of information is being displayed. Has the person completely voted for a contest? Is there is the option to vote for more contests? Controls are mode-less between voting and review, allowing ballot review during the entire process. Neither linear nor non-linear navigation loses track of progress.

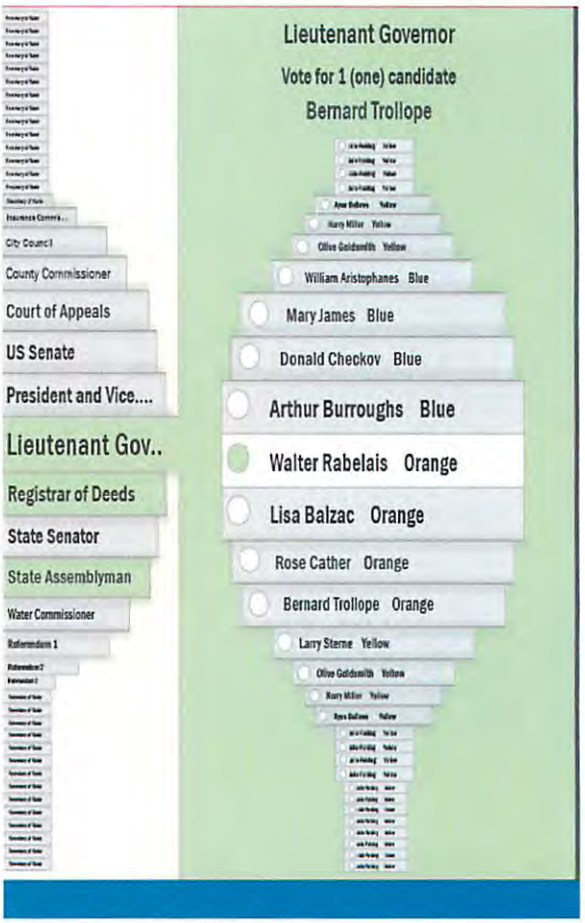


FIGURE 17 FISHEYE STUDY FOR FOCUSING WHILE VOTING

4.2 LEVI – RAV web Services System

The project created an HTML5 and JavaScript Low Error Voting Interface experimental platform. The system uses a

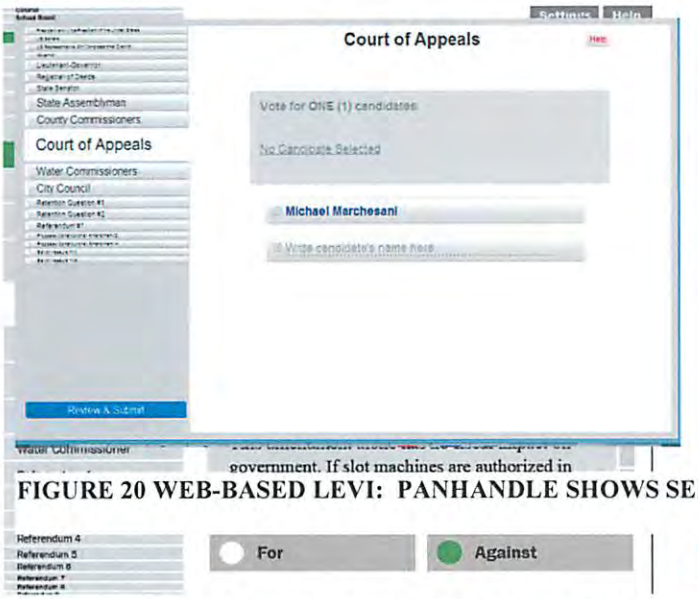


FIGURE 18 LEVI MOCKUP EXPLORING SCROLLING INSTEAD OF FISHEYE FOR INITIATIVES

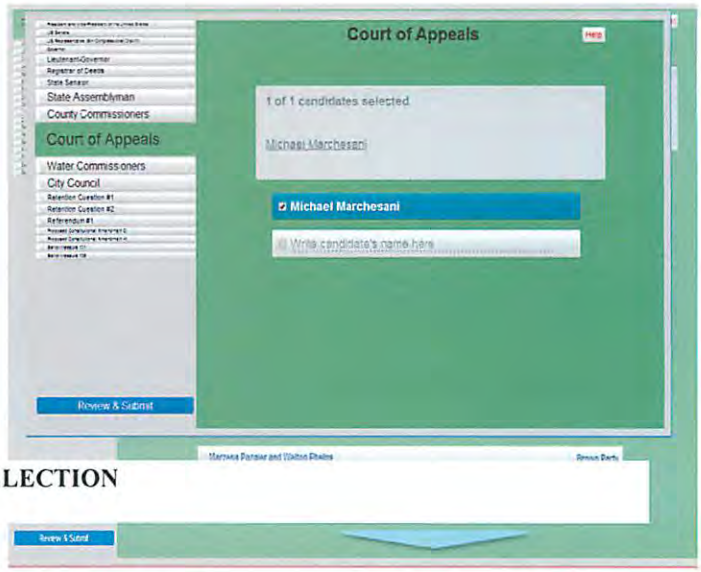


FIGURE 19 A SELECTED RACE WITH MANY CANDIDATES

FIGURE 20 WEB-BASED LEVI: PANHANDLE SHOWS SELECTION

JSON file to define ballot goals. Live demos are available at http://researchinaccessiblevoting.bitbucket.org/levi2-old and http://researchinaccessiblevoting.bitbucket.org/levi2-old/src/index.html .

A persistent menu shows all the races and provides a method for nonlinear navigation through the ballot. It is located on the left as a sidebar. The Main Trunk features include Tabs and fisheye text. Text is full size for the selected tab; text and tabs get smaller for the other tabs as they move away from the selected tab. Color, texture, size, and border are used to increase orientation.

When a trunk tab is selected, its contents are displayed in the main content area. The background between the tab and the main content area is the same, creating a left-hand tab "panhandle" that shows the connection between the tab and its content and shows which race is active. It is magnified and opens up to the race to associate with it in the main viewing area.

Implementation of the RAV web version explored many uses of fisheye, scrolling buttons, etc. Some of these are evident in the exploration slides included. The work inspired projects by various vendors, states, and others. A working version of the system can be found at http://researchinaccessiblevoting.bitbucket.org/levi2 .

5. Polling Place Support Tool

5.1 Polling Place Support Tool – Summary

FIGURE 21 DIFFICULT TO FIND "ACCESSIBLE" VOTING PLACE ENTRANCE DUE TO POLLING PLACE SETUP PROBLEMS

Polling places are intimidating, especially for people with disabilities. Since polling is episodic, polling physical settings are often different, making physical accessibility a recurring design challenge. Due to training and communication problems accessible voting machines are often not operational or not used during elections. Even simple lighting challenges are common in polling places. Logistical problems can multiply for people with disabilities as well.

This section describes interaction in student and final browser-based prototypes that provide assistance to election officers in several ways. The scenario supports polling place design, training, operations, problem solving, and auditing. It presents a spatial/graphical user interface for interacting with representations of voting space, furniture, and equipment layout, to assist election officers in better fulfilling polling place administrative activities before, during, and after the election.

The application, Polling Place Support Tool, is designed to improve on the current paper-based checklists an election officer uses to remember the different activities he or she has to do before, during, and after the election. The tool will be customized to include local voting materials for testing in a jurisdiction.

The RAV Polling Place Support Tool is a simulation that allows poll workers and officials to explore the possibilities for optimizing the design of an accessible and compliant polling place.

The system's layout capability is envisioned as a way to plan paths, ingress and egress, equipment, and furniture placement. It could train and test poll workers before the day of election.

- It could help associate check lists with particular equipment and positions in the polling place for opening and closing a polling place.
- It could allow poll workers to record situations associated with the polling place. It could let central election officials communicate about specific problems and make a lasting audit trail of problems in the polling place.

FIGURE 22 NEW ORLEANS 2006, THE POLLING PLACE SETUP DIDN'T ALLOW FOR PUBLIC NOTICE PLACARDS OR SAMPLE BALLOTS TO BE ACCESSIBLY PLACED WHERE VOTERS COULD READ THEM.

- The software then could be used to help plan everything, from the arrangement of pencils and materials, to the layout and booth arrangement and power connections in a polling place.
- It makes available a list of all pertinent factors poll workers and officials should think about while handling each aspect of the undertaking.

The goal of the application is to provide an active teaching experience for those learning about polling-place setup and the issues involved with it. The intention is for the application to provide a learning option that is better than sitting passively in a classroom or studying a leaflet. The current prototype is available at http://researchinaccessiblevoting.bitbucket.org .

5.2 Polling Place Support Tool – Introduction

Polling places are notoriously difficult for individuals with disabilities to navigate and often accessible voting devices are improperly setup. In the aftermath of the 2000 presidential election, research and statistics showed that polling place operations were responsible for losing over a million votes [Alvarez]. They rank as one of the top three aspects of the voting process that hinder and disenfranchise voters. Setting up the polling place during an election is a process that requires following strict guidelines and rules, as well as understanding how to efficiently control voter flow. Indeed, in 2013 President Obama convened a task force to look at the problems, such as long lines in polling places [Presidential].

Several mechanisms have been employed to teach people how to design and plan polling places. One is the lecture hall approach, where those learning how to operate a polling place face an instructor at the front, who discusses various parts of the undertaking. At another extreme, some poll workers might only get a color-coded leaflet that helps people to understand some parts of it.

Live presentations and leaflets might not have been the most effective approaches to teaching or motivating election workers to create seamless, functioning spaces to hold elections, especially as polling place design relates to accessibility to all voters. In recent history, significant problems have arisen during the actual operation of polling places on election days.

5.2.1 Polling Place - Examples

The following are examples of some of the problems that have occurred:

- In Boston in 2006, Ted watched a dark polling place with many people having trouble reading their ballots. Additional lights were installed so people could vote without flashlights in a dimly-lit auditorium polling place at 9:30 AM, 1.5 hours after the polling place opened [Figure 2].
- Polling places have literally moved from one location to another on the day of an election. In 2002, Ted Selker witnessed one being moved from the gymnasium to the library of a building at 7 AM. A change such as this, of course, alters the way in which a polling place is set up. A poll booth collapsed to the floor as we arrived. In a hastily designed polling place, people's ballot privacy can be easily compromised by being readable by people in line to vote.
- In 2004, a voting information placard was posted on an accessible door where reading it would make the door hit the reader in the face [Figure 23].

FIGURE 23 AN "ACCESSIBLE" DOOR THAT AUTOMATICALLY SMACKS INTO A VOTER WHEN APPROACHING THE POSTED VOTING INFORMATION

- At a polling place in Nevada in 2004, Ted watched as all twenty voting machines at the site were plugged into one outlet. Power was lost for that outlet; when all of the batteries died 2 hours later, the polling place ceased operation. An ad hoc decision was then made: all of the machines were plugged into a different (single) outlet. That outlet, it turned out, had a microwave oven plugged into it. When a pollworker was asked, "Shouldn't the microwave be unplugged?" another pollworker replied, "No, it's okay." Soon after, the polling place went down again [Figure 24] [Selker].

- To allow very local decisions, some "split ballot" precincts give different ballots to people in the same precinct. In Chicago in 2002, at a split-ballot polling place voters were given Ballot A or Ballot B. After voting on the correct ballot, they needed to scan them at the correct scanner. Poll workers in other such polling places had taken it on themselves to think this through and create a sign at the last minute with a felt marker and tape it to the scanners so that voters would know where to correctly scan their ballot. Sadly, at this polling place Ted witnessed as the ballots were randomly assigned to one of two scanning machines. Half of the ballots were, therefore, read by the wrong machine. Accidentally going to the wrong scanner would compromise a voter's selection for a race.

FIGURE 24 PEOPLE NOT ABLE TO VOTE ON LOCAL ELECTIONS DUE TO POLLING PLACE PROBLEM

- In 2004, Ted visited a polling place in Boston which had four voting areas inside of a building. One of the entrances at the back of the building behind a fence was wheelchair-accessible. The door to this entrance bore a sign identifying this as a polling place, but since the door was open, the sign remained invisible [Figure 21]. Other problems, such as the absence of the check-in portion of the voting procedure and the lack of signs to identify the four voting areas, led arriving voters to line up along steep, wheelchair-inaccessible stairs

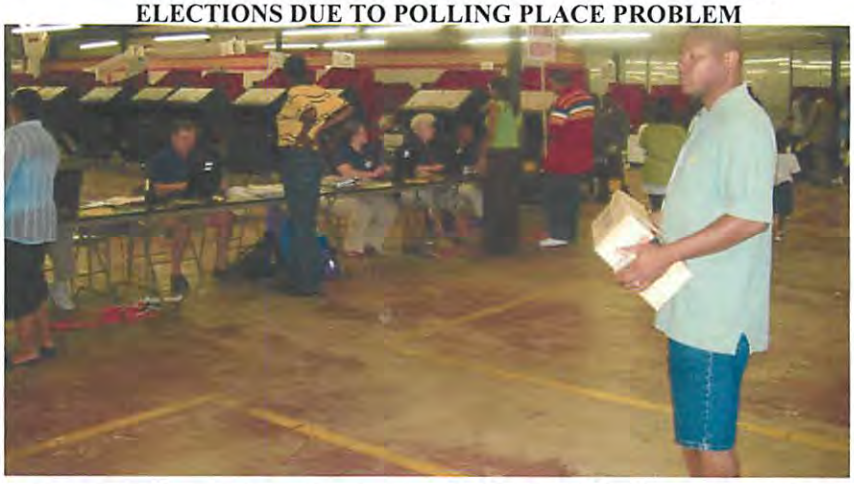


FIGURE 25 NEW ORLEANS 2006. 50 PRECINCTS VOTED IN THIS ACCESSIBLE WAREHOUSE. POLLING PLACE WORKERS WITH POLLBOOKS USED REGISTRATION LISTS TO DIRECT PEOPLE EFFICIENTLY. THERE WERE NO LINES.

to one of the voting areas. The line became very long and the voters didn't realize until they got inside that they could have walked into any one of the voting areas and finished voting much sooner.

- At help stations in some polling places, important information is posted below the edge of the desk, hanging well below eye level, requiring voters to lean far over, squat, or put both knees on the floor to read the material [Figure 22]. The elderly voters in the figure demonstrate how people with disabilities would miss most of this information.
- Sometimes, normal care and attention of poll workers can overcome inherent problems with polling place design and planning. Post-Katrina in New Orleans, Ted watched an election day in which dedicated helpers from the Secretary of State's office came from Baton Rouge to help people identify their voting place, reach it, and even get their cars parked. The largest polling place that day had 50,000 people assigned with no lines! This was the famous Ward 9 that had flooded during Katrina. For that reason only 5,000 – 5 times the number of people that typically vote in a polling place – not 50,000 showed up to vote. But, 5,000 people going to one polling place would be a debacle in most polling places. It was accessible and easy to navigate, because it was spacious, organized and there were people telling voters which of the 50 different precinct polling places inside that warehouse they should go to, or if they had to go to another site [Figure 25].

FIGURE 26 POLLING PLACE OPERATIONS CAUSED VOTERS TO BE GIVEN WRONG INSTRUCTIONS FOR USING TOUCH SCREEN, BALLOT PRIVACY WAS ALSO COMPROMISED

5.2.2 Polling Place - Training

Poll worker training varies from election to election and jurisdiction to jurisdiction. It is common to visit polling places with poll workers that were enlisted the morning of the election. It is also not uncommon for poll workers to have spent hours or days in classroom settings learning about voting. It is less common for them to role-play or simulate accessible processes. We see the training practices in polling places lean on support of more experienced poll workers, a telephone helpline, or a poll worker pamphlet on the day of election when the process is happening[3].

When a problem arises in the polling place, poll workers have to make decisions in the moment without supervision, and possibly without proper analysis of the problems. Figure 26 shows a poll booth that was setup incorrectly, putting ballots in plain view of onlookers. As well, by giving the voter a pencil to poke the touch screen, the pollworker inadvertently made the touch screen very difficult to use. As we began thinking about these situations, we realized that many of the problems that polling places face could be avoided just by conceptually walking through the experience ahead of time and role playing the experience for the voter and poll worker.

5.2.3 Poll worker Training –Alternative

"Polling places should be organized so that all voters can be processed efficiently and voters with disabilities can navigate the voting area and participate in the electoral process without assistance"[US VVSG]. As easy as the task might sound, it can take 178 pages to explain which guidelines and rules to follow and which activities to do before, during, and after the election to create a well-organized polling place layout.

[3]We pollwatched in CA, IL, LA, MA, NV, NY, and talked to pollworkers from many other states.

Even though technology has been used in assisting voters to make their voting experience easier, there are no tools to help the election officer to ease his or her task. There are several reasons for this. First, each jurisdiction potentially has its own guidelines and procedures to set up a polling place. Another reason is that in some states the elections office will do a "site survey" [Rick Urps, personal communication] to identify the features of the facility where the polling place will be set up, and create the layout for the polling place. The layout should not be changed once it is set by the office, so poll workers only reproduce the diagram. Third, so far people have not used tablets to assist in polling place setup. As an attempt to make some tasks easier for the elections officer, we have designed and created a prototype for a web application that will help officers and workers in setting up the polling place more quickly, and also in completing a long list of "to-dos" to comply with the laws regarding elections and regarding Americans with Disabilities Act (ADA) [US Department of Justice ADA].

The RAV Polling Place Support Tool provides an alternative to teaching with a slide-based presentation or paper-based instruction, with the goal of encouraging election officials to plan the polling location beforehand, test it, and document how to do it.

The student prototype, created as part of the CMU accessible voting technology class, included two main functions: creating a diagram on how to set up the polling place, and checking the tasks that need to be done before, during, and after the election. The final app includes documentation and communication to potentially reduce difficulties for poll workers to get help during an election. The application provides a reflection tool for the poll worker to be able to easily figure out the proper layout to make the voting area accessible with good traffic control. It should also provide enough information for the poll worker to quickly perform the tasks associated with the voting process.

FIGURE 27 STUDENT POLLING PLACE SUPPORT TOOL START PAGE

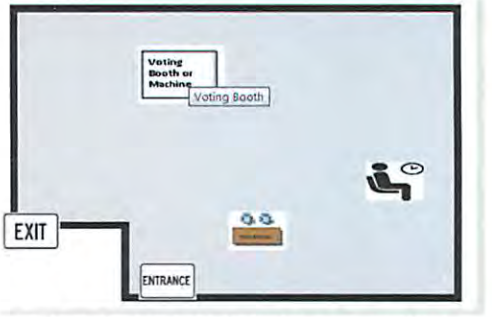


FIGURE 28 BEGINNING A LAYOUT WITH SOME ELEMENTS IN PLACE

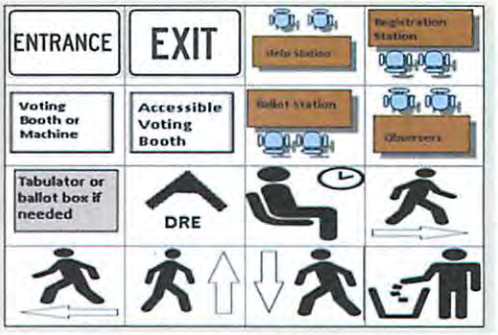


FIGURE 29 TOOLBOX OF FURNITURE TO BE PLACED IN VOTING AREA

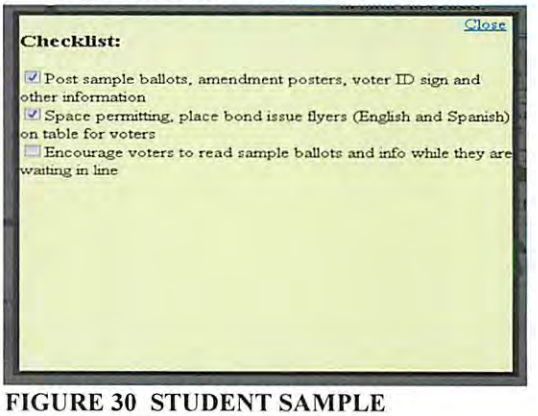


FIGURE 30 STUDENT SAMPLE CHECKLIST

5.3 Polling Place Support Tool – Student Version

The student version was based on HTML 5, CSS3, JavaScript. The final version described in the next section was written to be scalable. It is written in JavaScript using MEAN Stack, MongoDB, Node.js and Express.js for the web server, and Angular.js for the client-side software.

The student version of the Polling Place Support Tool started using the guidelines for setting up a polling place for Fairfax County, VA [Virginia]. It provides visual representations of entrance, exit, voting booths, accessible voting booths, tabulation boxes, help station, registration station, waiting areas, and walking directions which allow the user to plan and reflect on a polling place layout.

It contained a list of "to-do" tasks that can be marked as completed within the tool. In this way the officer might be more aware of the tasks he or she needs to do, and also be certain about which tasks have already been completed. This live application can be accessed at http://linda.nul-unu.com.s3-website-us-east-1.amazonaws.com/ .
The final version is also there; it has a backend that can support many polling places and is designed for secure login as well. It can be accessed at http://pollingplace.nettempo.com:3000/#!/ .

List of features of the Polling Place Support Tool:

- Room layout: The first page allowed the user to select a room layout that best fits with the actual dimensions of the voting area [Figure 27]. While the first version gave a user the task of choosing a room layout shape, the second version simply allows a user to block out parts of a square grid with architectural features or furniture that can't be moved.

- The toolbox contained the basic elements that a polling place should have. Examples of these elements are: exit, entrance, help station, registration station, ballot station, ballot box, observers' station, accessible voting booth, and so forth. The elements in the toolbox can be dragged and dropped into the room layout to start designing the voting area layout [Figure 29]. The second version puts such polling place tools in tabs of a toolbar that can be selected more simply [Figure 33].

- Furniture manipulation: The elements on the toolbox could be dragged and dropped into the room layout. The item could be put in different position on the layout. Once an item is added to the layout, the user can "hover" over the item to see a bigger representation of it. Features on the second version allow deeper engagement with a gear toolbox, and handles allow sizing and rotation.

- The user could click on the image to show the different activities the poll worker needs to do to set up that particular furniture. The items associated with each station could be checked too. In the second version, clicking on an item's gear icon produced a popup menu checkbox, tags, duplicate, or delete [Figure 34].

- The application could save and download a current layout as an HTML file. It also had a "reset" button to erase the current diagram and start all over again. The second version has a more sophisticated login and database load approach to working on specific polling places.

- Beside the activities that the poll worker needs to do for the polling place station, the tool provided information on the activities that he or she needs to do before the election, when opening the polls, during the Election Day, and when closing the polls. The second version includes versions of such lists in a database that can be edited.

Polling place activities were organized to aid poll workers understand the sequence of the tasks they need to do.

Rick Urps, Deputy Director of Maryland State Board of Elections, provided feedback on the prototype. He wasn't sure that the Board would use the layouts previous to the election during a 'site survey', but he saw a lot of potential for associating checklists positions within the polling place. He said "Combining the site survey map with checklists is where

we see potential for an app such as this. In Maryland, we envision that the app is used to initially map out the polling place during the site survey, or the existing polling place map is entered into the app. On Election Day, the map and checklists are there for the chief judges to reference."

Poll workers are often undertrained or new to the activity. We held a workshop for ten persons with little or no experience in the polling place to try using the student application. They worked in pairs using the application and reading the guidelines. They found it easy to start creating a layout but found the manipulation impoverished, so the final version below includes simple handles for sizing and rotating items. Some of them used the app first; some of them used the paper guidelines first. It took them several minutes to read the documentation to start using the application, so the final version below simplified learning and using though a simpler user interface. They wanted better information on the use of the checklist and other elements of the system; the final version below makes it easier to add modify and delete items. People wanted more status feedback; the second version below treats the poll designer and poll worker differently.

5.4 Polling Place Support Tool – Final Version

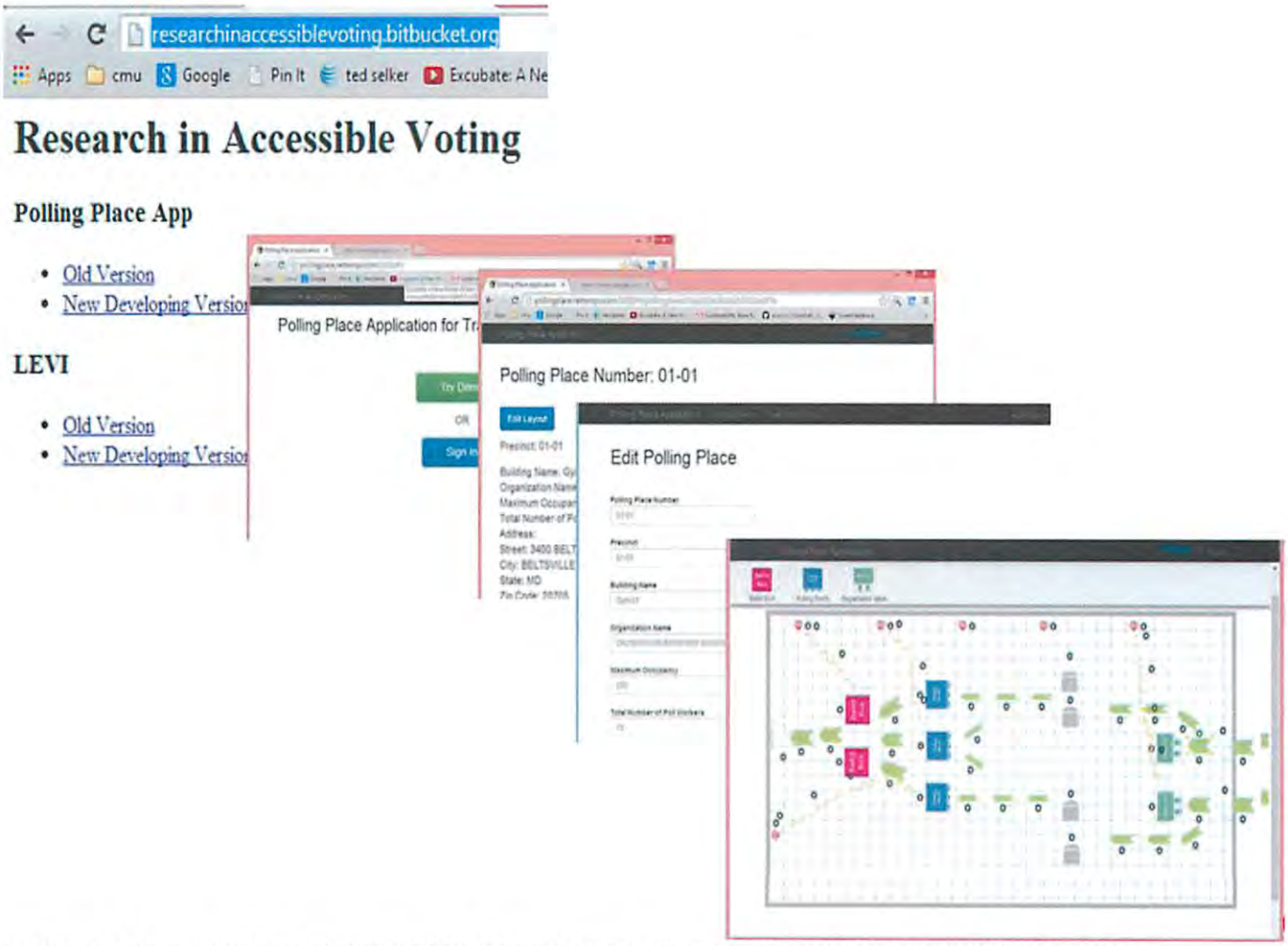


FIGURE 31 SCREEN SHOWING THE STEPS TO USING THE FINAL POLLING PLACE SUPPORT TOOL

The image is a cascading set of screen grabs showing what must be selected to set up a polling place with Polling Place Support Tool. The first screen shows choosing the application. The second screen shows choosing a demo. The third screen shows choosing a polling place. The fourth screen shows a polling place with objects and paths as movable graphical objects.

Final Version Highlights

The final Polling Place Support Tool is written in JavaScript using MEAN Stack, MongoDB, Node.js, and Express.js for the web server, and Angular.js for the client side software. A live demo can be found at http://pollingplace.nettempo.com:3000/#!/ . It solves problems found in the user exploration with the first prototype. It also adds capability to make the simulator testable for even more purposes.

For physical accessibility, the final Polling Place Support Tool focuses on making physical obstructions and paths through the polling place a priority. Notably, it dispenses with a separate user interface for creating the room and simply allows a user to put blocks on a grid to define it. The new user experience focuses most of the screen real estate on the room itself instead of tools. It also adds important items such as electrical outlets, existing furniture, wires, illumination, and notes. Figures 31 through 34 shows screenshots showing these features.

Figure 31 shows the sequence of getting into and using the application. Going to Researchinaccessiblevoting.bitbucket.org takes you to a screen where you can choose the new polling place application. From there, a screen allows you to try a demo or log in. If you try the system by default, you are shown polling place number 01-01, which you select to edit layout. This takes you to the architectural layout that you can experiment with.

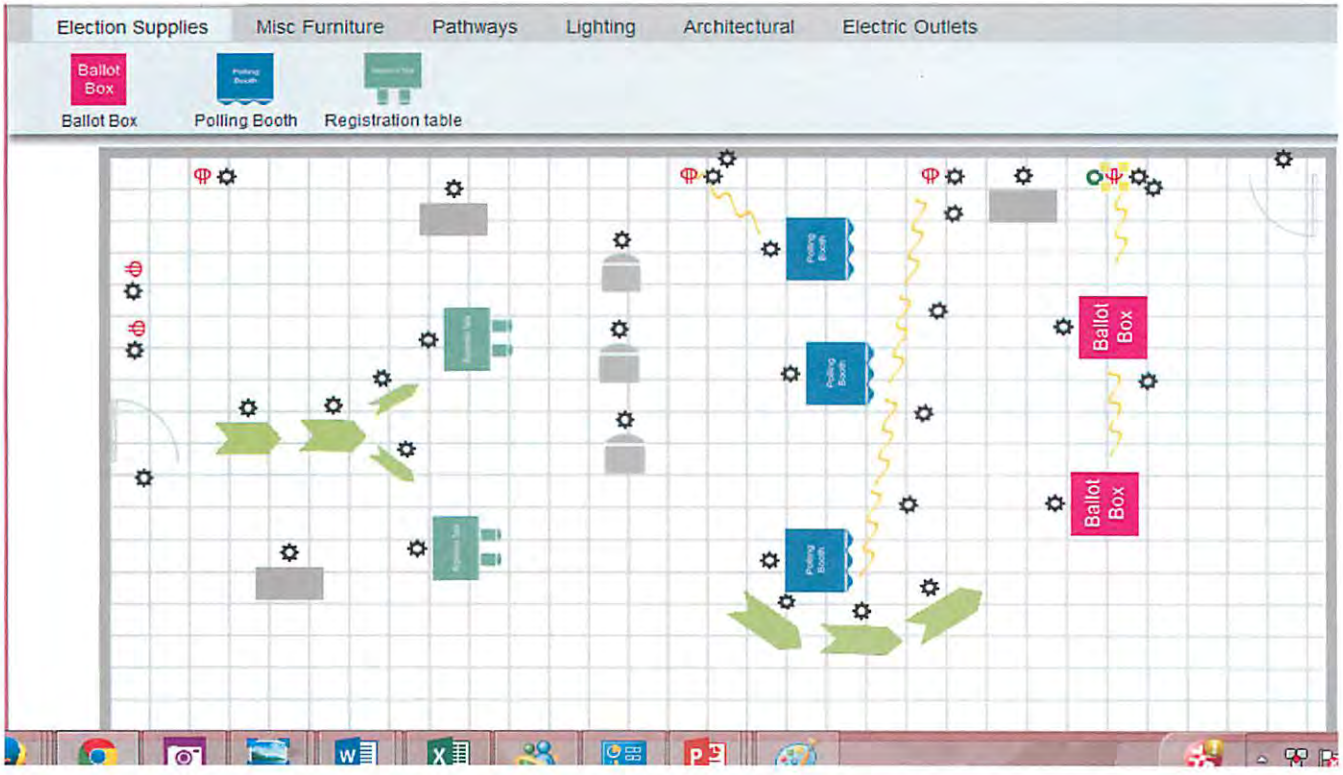


FIGURE 32 EXAMPLE OF PATHS, OUTLETS, CORDS, EQUIPMENT AND EXISTING FURNITURE IN FINAL POLLING PLACE SUPPORT TOOL

The image shows a polling place layout on a computer screen. A grid on it aids knowing how much space is around things. The image has outlets, wires, walking paths, doors, registration desk, ballot box, chairs, and immovable objects in the space.

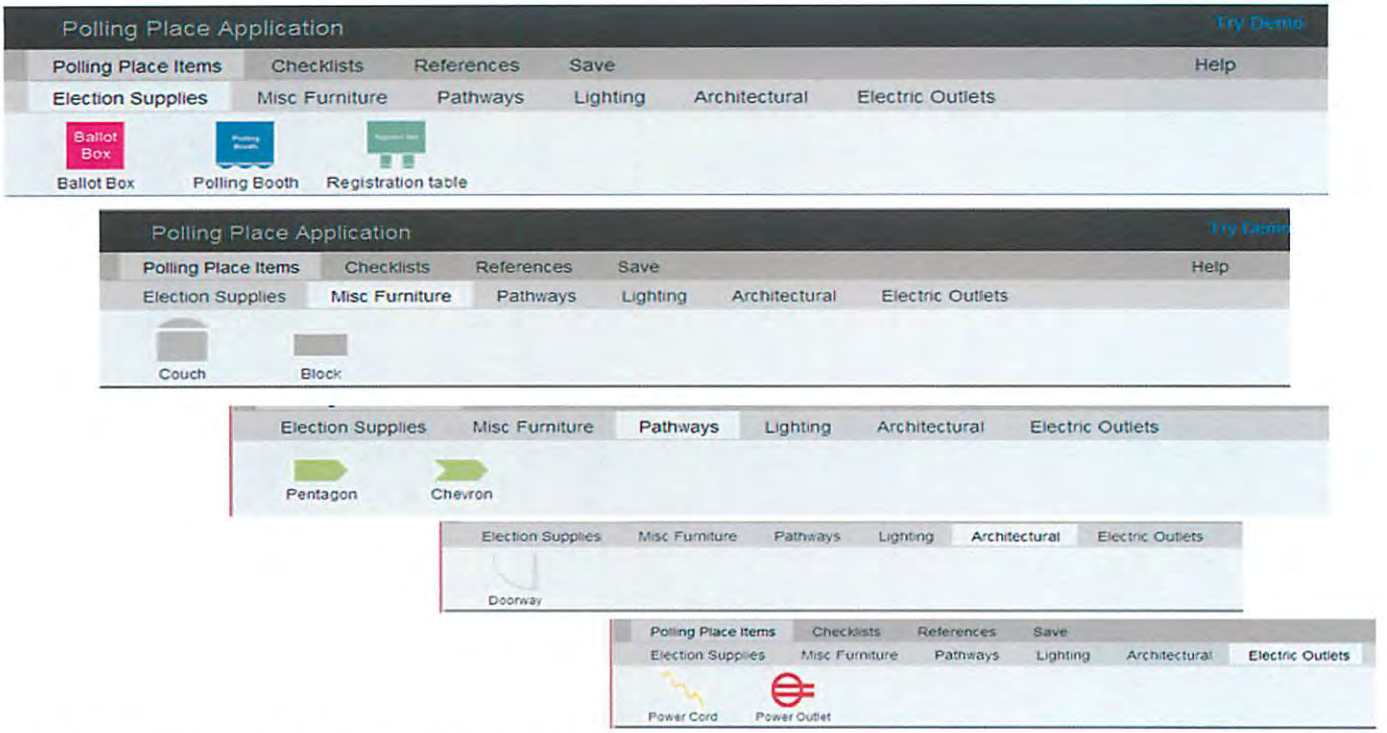


FIGURE 33 TOOLBARS AVAILABLE FOR ADDING ELEMENTS IN THE FINAL POLLING PLACE SUPPORT TOOL

The image shows the menu tabs for putting things in a polling place simulation. These menus shown include tab bars for Election Supplies, Furniture, Pathways, Architectural Elements, Electrical Wiring.

The application's polling place screen presents a polling place floor plan grid and tabs for things to place in it, as in Figure 32. A grid of 1-foot by 1-foot flooring tiles indicates specifically where various elements of the polling place can be placed. The elements, such as an entrance in an architectural diagram, can be dragged from the "toolbox" on the right to spots on the grid.

Polling place designers can place a polling place element in a spot on the grid, then click on it to see relevant information. The toolkits in the new

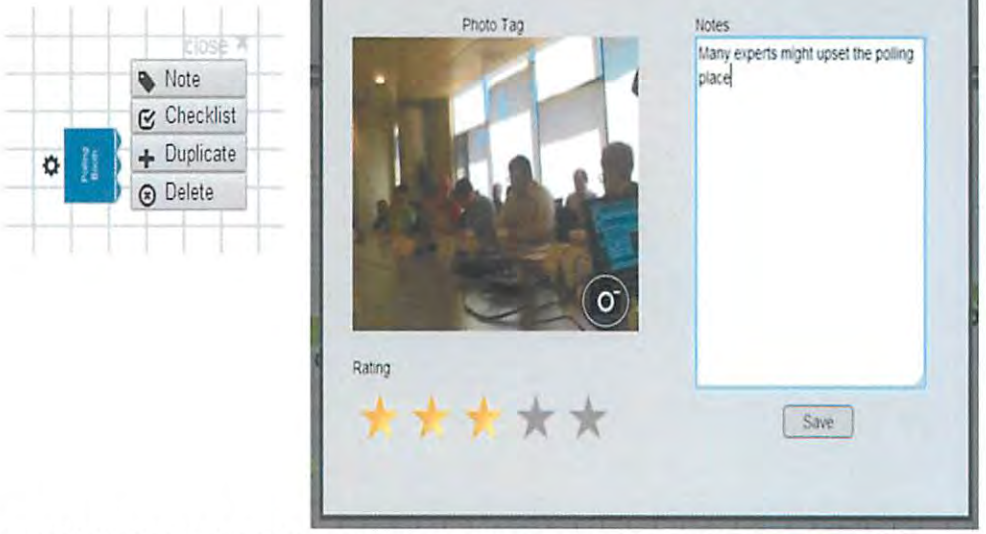


FIGURE 34 USING A PHOTO WITH THE FINAL POLLING PLACE SUPPORT TOOL TO MAKE A TAG RECORD FOR AN INCIDENT

The image shows the Note selection made on a polling place object selected. The interface includes a picture taken from the laptop's camera (several people at a conference table), a notepad pane with text about the incident being noted ("many experts might upset the polling place"), a set of stars (three selected), and a Save button at the bottom.

application are in tool bars shown in Figure 33. The objects include election supplies, furniture, pathways, lighting, architectural elements, and electrical outlets. Selecting one of these tabs shows a set of items that can be dragged onto the polling place grid, such as the ballot box, polling booth, and registration table icons, in the election supplies tab in Figure 33. Each placeable item has 'handles' to place, rotate, or stretch it. Selecting the gear icon next to the item brings up a popup menu including note, checklist, duplicate, and delete, as shown in Figure 34. Building and exploring polling places with the system is meant to have a spatial game-like experience to inspire new poll workers to learn about and succeed in setting up a polling place. The simulator becomes an interactive experience that is likely to be memorable to them.

For each of the elements on the grid, there is the option to use a device called a "tag," which also can be clicked upon to leave a note and record the position and time shown in Figure 34. If someone is using this application on an election day, as an aid for setting up a polling place, or as an educational tool, the tag option allows this person to rate a problem, or add text and/or a photo that will appear with the element on the polling place grid. A photo of a help station in an actual polling place can be added and might be useful to whomever looks at the tag. The tag photo could show how the setup election device should look on Election Day. The photographs could also be used by an online help desk to diagnose problems remotely, such as a poorly positioned sign hanging below the desk. An employee at a town or city's election office could view various polling places prior to the election with the application and, upon noticing an ineffective aspect, attach text to the help desk to indicate the need to post important material in a more accessible spot.

5.5 Polling Place Support Tool - Conclusion and Future Work

Two iterations of a Polling Place Support Tool were made. The final one is created as a professional web services app that should be deployable for testing in jurisdictions.

This platform demonstrates a range of support that can make polling places more functional, reliable, and accessible. The web-based interactive polling place design and management system can be used on most any web-enabled desktop or mobile device. Poll workers access to the app, their checklist activity, and tags can play a role in auditing. The system can be used for polling place site analysis and preparation of layouts prior to an election. It can be used for procedural support for opening polls, for closing the polls, for facilitating communication about problems and solutions during Election Day. Such visual and text records of polling places created with the software can be used as a reference to analyze things that happened and to consider and improve operations for the future. The next step in exploring this approach would be to deliver it for a pilot trial in a jurisdiction.

FIGURE 35 ARTISTS CONCEPTION OF AN ELECTION CONTROL ROOM USER EXPERIENCE TO ACCESS POLLING PLACES, ESPECIALLY WHEN THEY HAVE RED, IMPORTANT TAGGED PROBLEMS

The image shows a map with pushpin icons identifying polling places. One is green, one is red, and the rest are purple. These pushpins can be selected to bring up a Polling Place Support Tool view to help understand the problem at a site.

Figure 35 shows a rendition of a future use. It includes a control panel that could allow an election headquarters to keep track of and communicate with polling places through this application. Without phones, the central support people could then be made aware of and address problems throughout the jurisdiction. "Pins" on a map could indicate pending requests for communication. The official could view the polling place, its checklists, and its notes to be oriented as they work with a pollworker who is grappling with a problem. As well, VTP personnel at MIT have shown interest in working with the system to add a simulation mode, allowing users to see how various changes to the polling place affect throughput and other aspects of efficiency.

6. Tools for Improving Existing Voter Education and Registration websites

6.1 Adding Translucent Overlays to webpages

6.1.1 Translucent Overlays Overview- Summary

RAV created a method for adding translucent overlays to voter registration and voter education websites to help improve focus on one task at a time, which could be especially helpful for individuals with several kinds of cognitive and perceptual disabilities, as well as for individuals with low vision. While the gold standard is to design such websites based on the best accessibility guidelines, many counties do not have the resources to do this. The Scrim app provides a mechanism for adding accessibility features without redesigning an existing website.

Scrim is currently implemented as a Chrome browser plug-in and acts as a method for graying out parts of a webpage, drawing users' attention to areas of the page, with the overall goal of improving the browsing and data entry functions of these websites. The tool is designed to allow a "trainer" to select a sequence of "apertures" in a WYSIWYG manner on any webpage. It also includes an approach for reading the positions of the objects as an alternative authoring approach. The user sequences through these apertures, viewing the material while still able to select items anywhere on the webpage. The apertures help serialize a user's path, guiding the user through reading and procedures one step at a time.

6.1.2 Overlays – Introduction

Leading up to creating the Help America Vote Act (HAVA), registration problems were identified as the number one obstacle for citizens, accounting for over 2 million lost votes in 2000. Registering to vote online is now the preferred mechanism for voters, state governments, and the federal government as a way of facilitating registration while obtaining a driver's license. Since Arizona first put its voter registration online in 2002, followed by Washington State in 2008, online voter registration has expanded rapidly with the number of states online at 19 in 2014, providing access to 47 percent of all eligible voters. According to a 2014 Pew study, 11 of the 13 states surveyed reported greater voter satisfaction, with 65 percent of registered voters in support of online systems. Factors that influenced satisfaction included the voters' ability to instantly confirm registration through the Internet and to update personal information at any time. Online at-home registration removes barriers to participation for those with limited mobility. States have moved online because it reduces fraud and saves money, among other benefits. By using an online system, Arizona was able to reduce the cost of registration from 83 cents to 3 cents per voter. The Presidential Commission on Election Administration called for further broadening online registration to the remaining states in the January 2014 report and recommendations. By making the registration process available from any computer in a person's home, school, or library, the new approach expands beyond even the improved voting access of the Motor Voter Act, which makes registration open to anyone by simply checking a box as they renew a driver's License.

Online registration is arguably most important for people with physical, perceptual, and cognitive barriers to registering on paper at an election office. Concerns of security are simpler for registration than some online transactions as they are typically checked against several records, and in many cases require demonstration of response to mail to be validated. A drawback to the rapid deployment of online registration sites and other government sites, however, is lack of accessible user interfaces and difficulties with demonstrating their accessibility. Such sites have not been validated for ease of use, lack long-term user feedback regarding interface problems, and likely are deficient in the benefits of formal critiques from those familiar with designing online interfaces for accessibility. Any complicated online interface can disorient and disorganize a user. Government or voter registration sites are especially challenging in that they are fraught with the stress of creating important credentials and are used only once. Problematic issues include the number of steps involved in the process, and the difficulty of accessing pages and fields where the voter needs to enter essential information. Some voters with cognitive impairments may face additional challenges when trying to navigate the steps in the specified sequence required by the form.

A prominent factor in the high number of unregistered voters in the US (more than 51 million citizens or 24 percent of the eligible population) remains the persistent impediments to registering, especially for those with cognitive disabilities or low vision. The portion of such users among the unregistered group is likely significant, given the number of such users in the general US adult population. US citizens with mild short-term memory loss (excluding dementia) number between 3 to 4 percent and the prevalence of US adults with attention deficit hyperactivity disorder is over 4 percent. Adults with dyslexia number at least 10 percent, and those with low vision (excluding blind adults) make up 2 percent. The increase in the incidence of diabetes in the population can be associated with vision problems as well. Considering learning disabilities in general, one could extrapolate the adult population with learning disabilities from that of American public school students, which is approximately 5 percent of the total public school enrollment. Another important user group coming to registration sites includes the undetermined number of citizens who have difficulty focusing, but who have not recognized it, disclosed it, or sought professional help to diagnose it, in addition to those who have a modest degree of distraction that cannot be categorized as a cognitive disability or impairment.

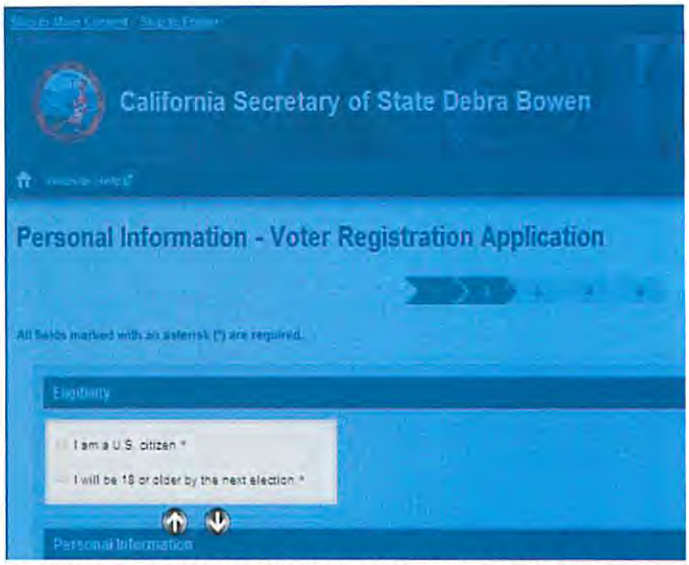


FIGURE 36 SCRIM INTERFACE HIGHLIGHTING CITIZENSHIP DECLARATION SELECTION

The image shows the California Secretary of State webpage covered with a blue scrim tint everywhere except for a box surrounding the selection "I am a US citizen, I will be over 18 by the next election". Below this white box are two round buttons: one for down, one for up. These buttons take the viewer to the next crucial thing to select in the web experience. All selectable objects on the webpage continue to be selectable through the blue tint scrim.

RAV has created Scrim, a Chrome browser plug-in that acts as a method for drawing voters' attention to specific areas on the page by hiding most of the page with a semitransparent "scrim" and showing the area to focus on via a transparent section called an "aperture". The extension is available for download at http://researchinaccessiblevoting.bitbucket.org/Scrim%20v1.2.zip . Research shows that people can select through scrims without cost to time, but can find material in apertures as fast as if it is the only material on the screen [Klein]. The software does not impede the legibility of the screened parts of the pages, as it focuses attention on the apertures. It allows election administrators, with minimal training, to create a pattern ahead of time for where aperture openings in the scrim appear and their sequence for the user to fill out information on the page. The result draws the user's attention to a specific area on the computer screen. As they select or fill in material in the aperture, a new aperture guides them to the next required action. They are drawn by their successes through the steps of filling out a registration form or other web interface.

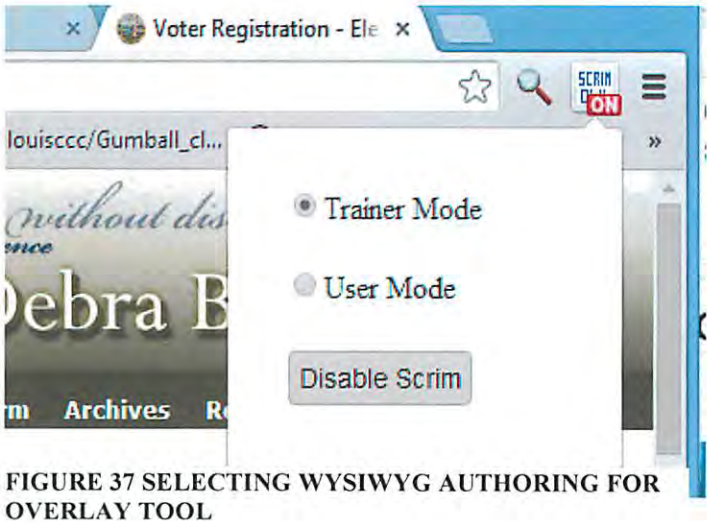


FIGURE 37 SELECTING WYSIWYG AUTHORING FOR OVERLAY TOOL

The image shows that selecting the Scrim Chrome extension icon opens a window. The window shows a button for selecting, one for selecting user mode, and a large "disable scrim button".

6.1.3 Translucent Overlays Related Work

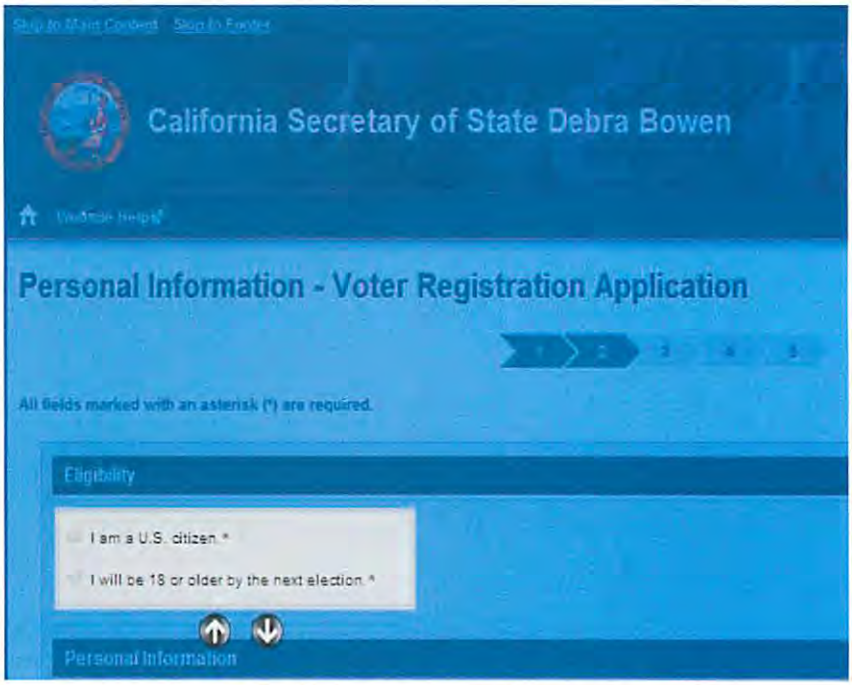


FIGURE 38 SCRIM IN USE HIGHLIGHTING THE ELIGIBILITY CHOICE. THE ARROWS BELOW IT ADVANCE THE OVERLAY TO THE NEXT SUGGESTED ITEM. THE WHOLE PAGE IS ACTIVE EVEN WHERE NOT IN APERTURE.

Highlighting content using color, clear windows, blurry/sharp windows, lines, and other focus-and-context techniques helps the user visually focus on a selection of the content within a larger document [Kelin]. A mask that reduces contrast is more effective, and can be created with as little as 12 percent of pixels screened out to produce a strong effect. Such scrimming of the less relevant part of a webpage provides attention cues to relevant information, and yet allows any other information on the page to be accessed at any time. Other methods, such as using thin lines onscreen connecting content, have been effective in expediting search tasks on a page for users [Steinberger]. However, the examples used in this study could be categorized as complex data visualizations, and a technical user was assumed. A blend of all techniques is employed on commercial webpages, sometimes in combination with grayed-out areas, as well as hand-drawn lines directing attention within the masked area. Various online shopping pages have marked current steps on a check-out form in bold or a bright color, conducting users through the page.

Analog methods for focusing attention have been created in the past that contribute to the ease of reading. One example is our magnifier described above that can be slid down the ballot to the election contest a voter is considering. The means of directing a user's attention in voting has also been explored without a mediating layer, namely by manipulating the location, size, and grouping of candidate names and selection points in the Low Error Voter Interface described above.

6.1.4 Translucent Overlay – Prototype

Scrim is a tool with which annotations can be added to website pages or forms using the Chrome browser. Administrators designated to improve websites can train themselves to use it with a provided instructional video in a few minutes.

Scrim was designed as a simple quick way of stepping a user through a set of steps on a webpage. It follows the process first introduced in the IBM OS/2 SmartGuides interface. The goal of improving the accessibility of a registration site is achieved. The primary objective of Scrim's design is that it preserves the generality of the page, allowing users to orient themselves without changing the layout, color scheme, or content of the page. As such, it is a technique applicable to any webpage.

The Scrim software is an extension for the Chrome browser, programmed in Java for the purposes of prototyping. The software implements a layer over the page through Cascading Style Sheets (CSS) [CSS] called a canvas. The

experimental prototype works in Chrome and saves the scrim as a browser cookie. This approach could be extended to work for other major web browsers such as Firefox, Internet Explorer, or Safari.

An automated scrim was also made that parses and adapts a scrim to a sample ballot in a web browser. It highlights individual races, not individual candidates, to avoid supporting bias for the first candidate in a race.

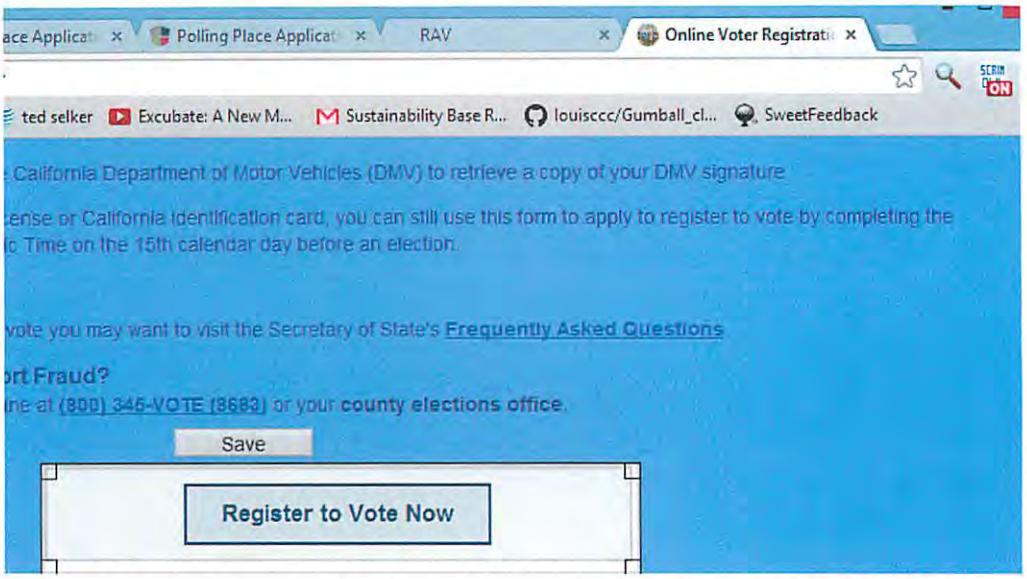


FIGURE 39 SCRIM OVL "ON" IN CHROME TOOLBAR. THE APERTURE BOX IS HIGHLIGHTING THE REGISTER TO VOTE NOW BUTTON ON THE WEBPAGE. THE HANDLES ON THE CORNERS ALLOW RESHAPING THE APERTURE. THE SAVE BUTTON IS SELECTED TO MOVE TO THE NEXT BUTTON TO HIGHLIGHT.

An unusual quality of such a software tool is its ability to improve website interaction after the site is already launched and its potential value in helping users navigate existing online content. We expect that this kind of annotation could be useful for consumer and/or broader technical applications, where a low-cost, low-training software add-on would allow vendors to create a template for users. For instance, Scrim can work as a tutor conducting listeners through a complicated training document to help direct listener focus.

6.1.5 Translucent Overlays - Interactive Pages

With the registration scrim example, the web document is active and changes as the user inputs relevant information. This creates an additional need for adapting to the document as it changes. For instance, dialog boxes on a webpage link to other pages that can also be given Scrim translucent overlays.

6.1.6 Translucent Overlay – Summary

The Scrim Chrome extension enables translucent-overlay stepping support for any webpage. Scrim was made as a system that allows a trainer to graphically select and highlight sequentially important places on a webpage. Scrim then helps a user step through a process while not stopping them from selecting any part of a page at will. Scrim can be used to help focus attention for people with cognitive disabilities. It is a way of testing and improving webpage usability without reprograming it. A version of it automates the training phase for ballot-like pages if needed. We hope this app is used to validate and improve accessibility improvements for registration, polling-place location finding, and will be used to highlight progress in marking sample ballots. Security issues are important and the authenticity of the scrim must be established to assure that a rogue scrim isn't influencing a voter in some way.

6.2 Automated website Analysis for Visual Design
(First Prototype—Mike Vrooman; Current System—Shama Hoque)

6.2.1 Website Analyzer – Summary

Many aspects of website design can impact readability and comprehension of tasks. Some of these aspects include color choices, font choices, font style and size, and alternate text for image and input elements. This section discusses an automated tool that shows user accessibility problems that may be encountered on their webpages. This Chrome plugin puts up a separate window that shows font number, size statistics, color contrast choices, and alternative metadata that might easily be changed to improve webpage accessibility. This system is based on a student project conducted by Mike Vrooman during an accessible voting class taught by Ted Selker and Dan Gillette at CMU-SV. A video of the website Analysis is available for viewing at

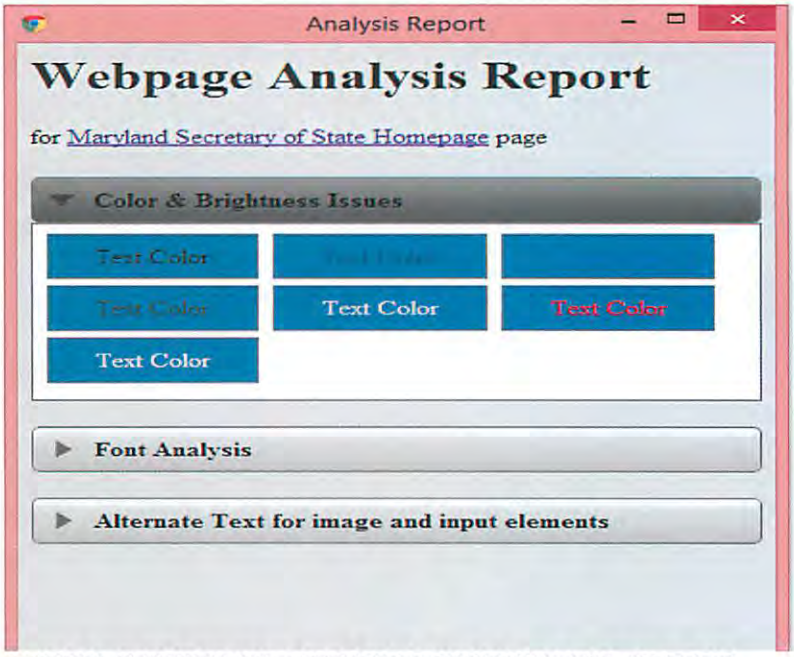


FIGURE 40 WEBPAGE ANALYZER SHOWING COLOR TEXT CONTRAST USES ON PAGE: BLUE ON BLUE IN THIS CASE IS TOUGH TO READ.

[4]https://www.dropbox.com/s/6emue4akikn1o11/Website%20Analyzer%20Quick%20Demo.m4v .

6.2.2 Website Analysis - Introduction

The primary objective of this project is to provide a way to analyze voting information websites in order to find ways in which they can be improved to be accessible to as many people as possible. Many systems have been made to analyze webpages. These systems, unfortunately, are hard to interpret or present problems that are difficult to address (see http://www.w3.org/WAI/ER/tools/complete for a list of these tools). The RAV Website Analysis System checks for color scheme contrast issues, brightness issues, and will also analyze text formatting in regard to font type, style, and size. While issues identified by the tool should not solely be used in order to initiate changes to a website's design, it can provide a great starting point for discussion and the review of a website's design.

6.2.3 Color and Brightness

When a webpage is being analyzed, the CSS for each element is inspected and passed through an algorithm to calculate the difference in color and the difference in brightness. This is done through a formula provided by the W3C for suggested techniques for analyzing webpages.

[4]Mike Vrooman's early version and documentation available at https://cmu96772.wordpress.com/studentwork/mike-vrooman/

Brightness is evaluated as:
((Red * 299) + (Green * 587) + (Blue * 114)) / 1000

Color difference is calculated as:

(max (Red1, Red2) - min (Red 1, Red2)) + (max (Green1, Green2)- min (Green1, Green2)) + (max (Blue1, Blue2) - min (Blue1, Blue2))

When brightness values are below 125, the W3C indicates there is a potential problem with the color choices. Similarly, color differences of less than 500 indicate a potential problem in the color choices. While these numbers give a scientific way to analyze viewability, people don't find the actual numbers to be meaningful in deciding whether or not a color choice was poor. The tool uses these numbers on the backend in order to determine which color combinations will be displayed to the user, but the numbers won't actually be shown.

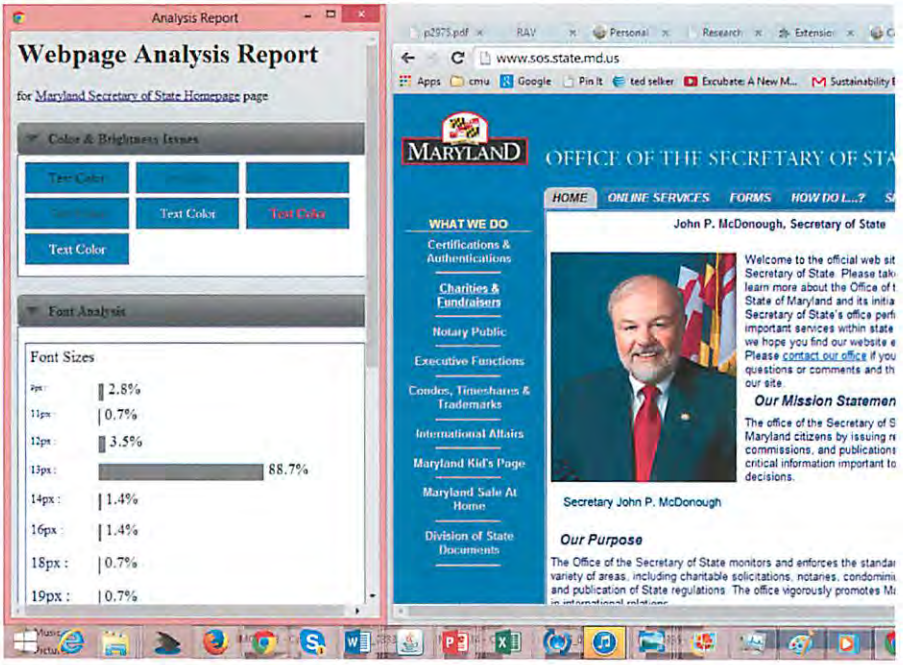


FIGURE 41 WEBPAGE ANALYZER SHOWING FONTS USED ON PAGE: WELL OVER 90% ARE SMALLER THAN READABLE.

6.2.4 Font Type

The question of whether to use a sans-serif font or a serif font for websites will elicit arguments for both sides. Some of the common arguments revolve around serif fonts allowing letters to be visually combined to form a word and allow better distinction between characters. However, on low resolution screens with a low pixels-per-inch (PPI) count, serif fonts may not render smoothly. Modern monitors support much higher PPI now and can render serif fonts without noticeable pixilation, even with small fonts. However, there are still low-quality monitors in use by people today and these users should also be taken into consideration. While not making a recommendation for serif vs. sans-serif, it is just as important to pick a font style and be consistent. Switching between many font styles will make a page harder to read.

6.2.5 Font Style

The style of text on a website can be set to normal, italics, and oblique. Text written in italics will use a completely different glyph to represent a letter. This can make it harder to recognize the letters when reading text. Because of this, italic font usage should be minimally used. Oblique text will use the same glyphs as normal text, except the characters will be slanted. This text can also be difficult to read if it is overused.

6.2.6 Font Size

The distribution of font sizes can also be reviewed in order to identify the overuse of small text. The W3C accessibility guidelines recommend using an 18 point or 14 point bold font. This can also be represented as a 1.5cm or 1.2cm bold font.

While not measured by this tool, the guideline also states that text should be able to zoom to 200%, the default size without causing display issues or requiring the user to scroll off the screen in order to read the text. As tablets are being used more frequently, meeting this scaling recommendation will be an important feature of websites.

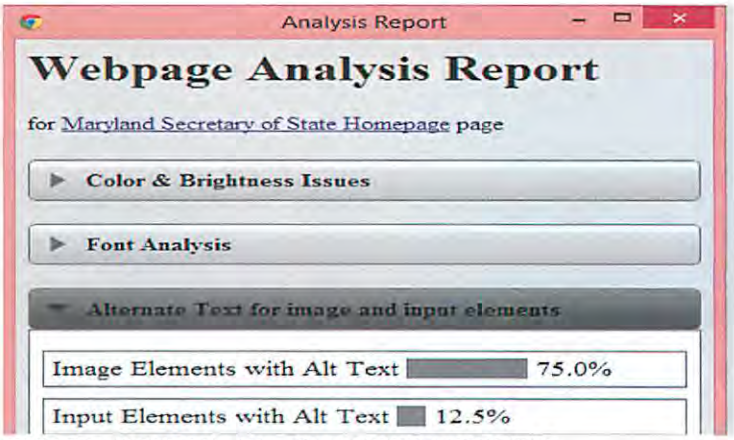


FIGURE 42 WEBPAGE ANALYZER SHOWING "ALTERNATIVE TEXT AND IMAGE" EVALUATION

The image shows the webpage analyzer window with banner buttons: Color & Brightness, Font Analysis, and Alternate Text for Image and Input elements. The "Alternative text for image and input elements" is selected revealing that image elements with alternate text at 75% and input elements with alternate text at 12.5 %.

6.2.7 Technology Used

RAV's first automation tool was built using C# in a Microsoft Windows environment. A third party plugin written by Juicy Studio called 'Color Contrast Analyzer,' was used to calculate color and brightness levels. The open source framework 'White' was used to control the plugin. The open source framework 'Selenium' was used to control the browser and analyze the final HTML created by the plugin-based system; it directly interacts with a web browser and can be interactive. It can process an entire page in less than a second. As a limitation, it is restricted to the browser it was made for (prototype was for Firefox, final version is for Chrome). The Selenium framework's advantage is that it will work with all of the popular browsers available today. It is a widely used framework and isn't limited to any particular operating system or programming language. The current code could easily be migrated from C# to Java, Ruby, or Python, with just syntax changes. Selenium does not have direct access to the document object model created by the web browser and uses JavaScript to access the page. This results in page analysis taking up to several minutes to process. When testing a page in Firefox with 500+ unique web elements it took 115 seconds to process, while Chrome was able to process the page in 45 seconds. Updating the code to a multithreaded approach resulted in only a 10% performance gain. Chrome processed the page in 41 seconds and Firefox was taking about 99 seconds to process the page.

A second version was built in JavaScript and JSON for Chrome to better integrate a user interface and eliminate performance problems. The current extension is written in JavaScript and can be downloaded at http://researchinaccessiblevoting.bitbucket.org/website_analyzer.zip .

6.2.8 Web Analyzer Going Forward

Currently the tool will display results in real time. Adding the feature of storing the results would allow conclusions to be made about a large sample of websites. For example, as bad color combinations are identified, checks could be done against all analyzed websites in order to see how frequently similar combinations are being used. Other areas of interest could be analyzed, such as checking for alternate text for image links. Different areas of keyboard accessibility could be automated. As the user tabs through the controls, a comparison of an image of the webpage before and after tabbing should show a visible change in selection. As the selection changes, the program can look for expected transitions, such as left-to-right, or right-to-left and down, but from right-to-left and up as unexpected and unacceptable, unless it is restarting to the beginning of the page. This area would require research to find the right patterns to look out for as indicators of a poorly designed page. Also, we would love to integrate usage evaluation tools. Tools that allow users to show how complex mouse paths are through a webpage, for example, would help developers reevaluate where to put buttons and fill-in windows.

We can imagine integrating Scrim with this tool to make a suite of solutions for analyzing and reducing impediments for individuals with disabilities. The approach presented here is a post hoc solution. We would be even more enthusiastic if typical program development suites used for web design and web design tools can be enhanced to encourage designers to

test using accessible techniques. web designers could permanently embed code in the website, instead of using a temporary plug-in or add-on to the browser. The software could be turned on or off by the user as needed.

7. Wii-based Voting

7.1 Wii Voting – Summary

Ying-Chuan Liu and Minh Pham created a voting system that utilizes the Wiimote, a remote game controller for the Nintendo Wii game console system, in an accessible voting class taught by Ted Selker and Dan Gillette at CMU-SV[5]. The system is a platform to explore novel gestural and button selection options for voting with disabilities. Several users felt comfortable and would recommend using a Wiimote as a voting device. However, more exploration is needed to explore its general usability for backgrounds and the disabilities it might address.

7.2 Wii Voting – Introduction

Researchers have proposed using visual and audio assistances to help the disabled cast their ballots.
However, there are no specific solutions that are broad enough to cover the entire disability population. This project explored a portable controller with multiple input and feedback alternatives. The Wiimote is a flexible movement-capturing interface that utilizes the 3D motion-capturing controller in the Wiimote to provide a rich voting experience.

A Wiimote provides multiple interfaces for interacting with users, including buttons, gestures, and vibrations [Wiimote]. With their growing popularity, Wiimotes are inexpensive and available and widely used in various applications. One important feature of the Wiimote is its motion-sensing capability. Specifically, in the gesture recognition area researchers tried to utilized this capability of the Wiimote to evaluate human activities. For example, Kiefer used the Wiimote as a musical controller [Kiefer] and assessed its usability.

These interfaces could provide a voting system to serve people with sight and/or hearing impairment because they could provide prosthetics for either visual or hearing abilities.

7.3 E-Voting System Using Wiimotes

Commands	Gestures	Buttons
Next Stage	Button B	Button B
Previous Candidate	Swipe Left	Button Left
Next Candidate	Swipe Right	Button Right
Select Candidate	Swipe Down	Button Down
Deselect Candidate	Swipe Down	Button Down
Confirm	Swipe Down	Button Down

FIGURE 43 A DEMONSTRATION MAPPING BETWEEN COMMANDS AND INPUT MESSAGES

The Wii voting system divides a voting process into five stages: Welcome, Introduction, Vote, Review, and Confirm [Figure 45]. The Welcome stage gives the user a general idea of what the election is all about, and instructions are given in the Introduction. In the Vote stage, the user is able to browse all the candidates with their basic information, and then make a vote. During the Review stage, the user is able to view his or her voting result before sending out the ballot. Once the user Confirms the voting decision, the process completes and the user is not able to go back and change the result. To travel among the five stages mentioned above, the following command set is used:

1. Go to the next stage
2. View the previous candidate
3. View the next candidate
4. Select the candidate
5. Deselect the candidate
6. Confirm the decision

[5] https://cmu96772.wordpress.com/studentwork/kate-liu/

7. Wii Voting system Input Interface

A Wiimote provides a variety of methods for interaction. The voting prototype focused on buttons and gestures. To reduce the learning curve, gestures were limited to just four: left, right, down and the B button. In this scheme, left represents back while right represents next.

Pressing the left button or a left swipe gesture is used to navigate to the previous page, while button right and swiping right is used to switch to the next page. Additionally, pressing the down button or a down gesture selects or deselects an item. Figure 43, we define the gestures and buttons that individually map to the commands mentioned in the previous section.

To indicate what the user can do to make selections and what selections they have done, output shows the user on the screen, in sound or through vibration. Individuals with visual impairment are able to receive auditory feedback, while individuals with hearing impairment can receive feedback through vibrations. Figure 44 shows audio instructions that individually map to the commands.

Feedback	Audio
Next Stage	Next Page
Previous Candidate	Back
Next Candidate	Next
Select Candidate	Vote
Deselect Candidate	Cancel
Confirm	Send

FIGURE 44 A DEMONSTRATION MAPPING BETWEEN COMMANDS AND OUTPUT FEEDBACK

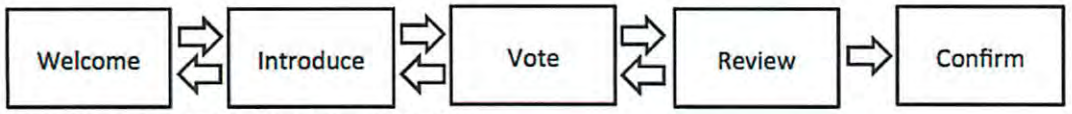


FIGURE 45 THE WII VOTING PROCESS

FIGURE 46 THE ENTRY PAGE FOR WII VOTING

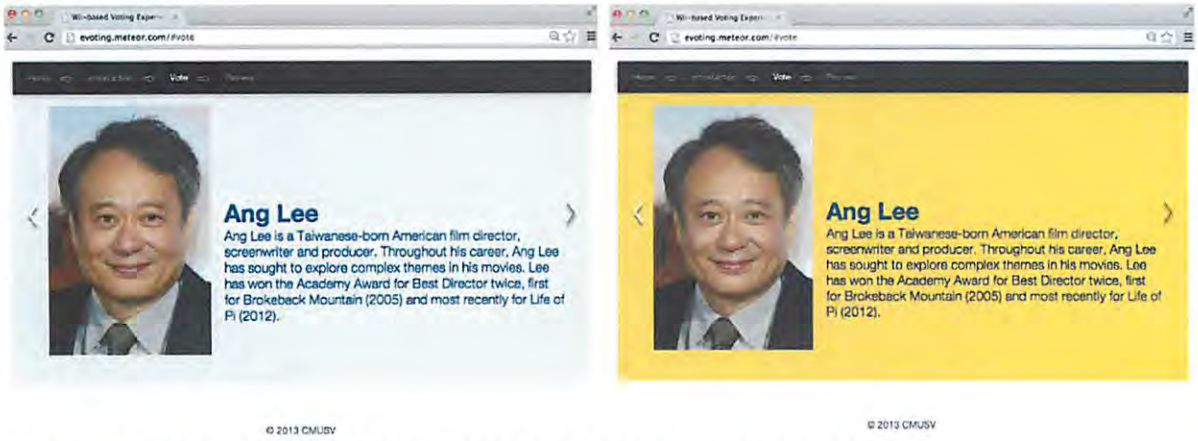


FIGURE 47 COLOR CHANGE INDICATES USER SELECTION IN WII VOTING

The implementation of the voting system is divided into two parts: website and Wiimote connection. The website uses HTML, JavaScript and CSS to implement the UI mockup illustrated in the previous section. The website is deployed to the Meteor environment. On the Vote page, the user is able to browse all candidates and related information. When the user casts a vote, the background color will change to notify the user [Figure 47]. The Wiimote to-laptop-communication is managed by BlueCove 2.1 [Bluecove] to set up connection between the computer and the Wii. WiiuseJ [WiiuseJ] and JavaFx [JavaFx] are used to program the Wiimote to trigger its buttons, gesture detection, and vibrations. A video of how it works can be found at https://www.youtube.com/watch?v=O0D2ZzOhWFY&feature=youtube_gdata_player .

The voting system proposed in this section is aimed at people with physical limitations, sight, and/or hearing impairment. We invited four participants who have slight visual impairment to test our system. The participants are all far-sighted people over 50. The pilot users were more concerned with font size than other graphic features such as colors, and layout.

The pilot users were satisfied with the sensitivity of gesture recognition, and they felt that the feedback could prevent errors, such as voting for the wrong candidates. Among the three types of feedback, initial users preferred visual and auditory aides to haptic feedback. Pilot users were divided as to recommending the Wiimote; a formal experiment could follow with people with particular disabilities to further validate the approach.

7.4 Wii Voting - Conclusion and Future Work

Wiimote voting is a demonstration of how today's Commercial, Off The Shelf Technology (COTS) could offer new affordances that offer a range of opportunities for voting with physical and perceptual disabilities. The system worked well in demonstrations and was tried by 4 users. The interesting demonstrations for this work would come with experimenting with individuals with tremor, Parkinson's, multiple sclerosis, etc. Refining the platform with such experiences could improve and simplify the interface. Currently, the demonstration interface provided by the platform provides buttons and gestures as the input interfaces, and applies sounds and vibrations to be the feedback. A next version of the Wii-based voting system may merely focus on one input interface and one feedback source.

8. Other RAV Work

As well as the research and teaching work described above, RAV also participated in nationwide voting technology discussions, created policy proposals, participated in nationwide forums on voting with disabilities run by NIST, the Election Center, and others. We began work on 3D audio selection. We performed small exploratory projects including considerate response, more efficient list browsing, Earcon design, and more efficient ballot reviews for individuals with disabilities. RAV also explored systematizing audio commands to simplify the wording. An analysis for instruction syntax

and word choice was made for several vendors' voting machines. Continued work in this area could greatly simplify audio voting. [Figure 48, 49]

RAV drafted a proposed list of simple improvements that could be implemented in the run-up to the 2012 election shown in the appendix. Such lists that we made and distributed from the Voting Technology Project helped in past elections. In the end, RAAV was not convinced the list shown in the appendix shortly before the election would help.

RAV substantiated the value of running project-based graduate-level classes to explore technology for voting with disabilities. The Wiimote, the first prototype of the RAV Webpage Analyzer, and a first prototype of the Voting Place Simulator were made with students in a RAV-driven CMU graduate program class called Extreme Interfaces: Voting with Disabilities. This class was partially motivated by the success that came from a Voting Technology class Ted ran earlier at MIT. In that case, Mathew Hockenberry worked with us to invent Abrievicons, which shorten audio voting [Hockenberry]. He also demonstrated that mouse buttons were an improvement over standard specially-designed accessibility paddle buttons for speed and accuracy of accessible voting. RAV is convinced that such mouse buttons are an excellent alternative voting-input approach. We conclude that exploratory projects in graduate courses on technology for voting can be extremely productive.

FIGURE 48 THIS DIAGRAM SHOWS THE DIVERSITY OF TERMS USED FOR COMMANDS IN DIFFERENT COMMERICAL AUDIO

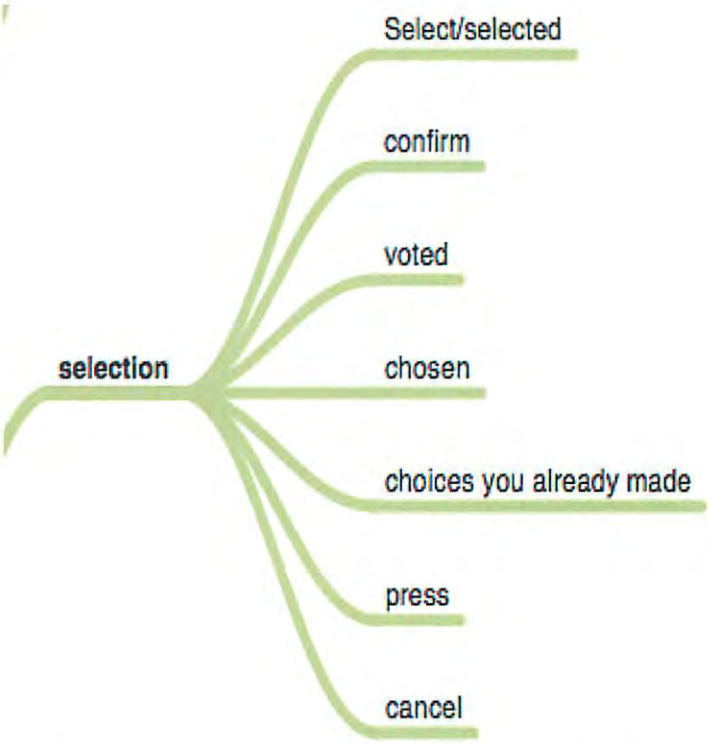


FIGURE 49 THIS DIAGRAM REPRESENTS AN ANALYSIS OF THE VARIOUS WORDS USED IN DIFFERENT AUDIO VOTING SYSTEMS FOR A SELECTION ACTIVITY. THIS IS AN EXPANSION OF THE 6TH TERM EXPANSION OF FIGURE 48.

9. RAV Final Report Conclusion

The work of the RAV offers a roadmap of technical solutions that can improve voting for individuals with disabilities. To ensure that people are voting privately, they must vote in public. To vote, we must register, in many cases online. RAV has made tools [Scrim, Web Analyzer, LEVI] to help web designers be aware of and solve many problems individuals with disabilities face online. To vote independently in public, polling place operations have to work. Voting independently at public polling places is rarely easily successful for our population. RAV hopes to make real and lasting improvements to voting for individuals with disabilities. We have made the Polling Place Support Tool to solve many polling place problems not adequately addressed today. Many disabilities create difficulties for paper. We have created physical structuring, illumination, and magnifying prosthetics to explore and ameliorate many problems individuals with disabilities have working directly with paper. People make mistakes marking selections, whether marking up a sample ballot or marking a ballot to print out; RAV introduces graphical, audio, and physical interface voting alternatives. With more development and testing, RAV solutions can tremendously increase individuals with disabilities' success in voting. RAV explorations could convincingly eliminate millions of errors made in voting throughout the country. We expect they could also reduce recordable residual votes significantly.

The number of individuals with disabilities that could be disenfranchised in voting is not an insignificant portion of our population. We are the disabled and the not currently disabled. As well as addressing disability access, the technology we create can help voters universally. RAV has worked to make real and lasting improvements to voting for individuals with disabilities. The RAV graphical interface solutions are being used by researchers and are in plan for Maryland's overseas voting approach. RAV paper ballot Magnifier Illuminator Support (MI-S) is being tested. RAV audio interface improvement work has been published, and is available. RAV webpage access tools are available and being considered by various voting jurisdictions. The RAV Polling Place Support Tool is in consideration by large voting jurisdictions as well. With continued support, this work could help cement the impact of these solutions academically and practically.

RAV has shown improvements for universal access across a range of today's voting scenarios. They range from solutions that can be implemented immediately, to ones that provide direction for next-generation voting systems. Additionally, all software prototypes will be released into the public domain, allowing other researchers to build on the work.

The Research in Accessible Voting project focused on creating technology to address a variety of disabilities issues in voting. In a technological age, technology creation can make profound improvements on policy creation. Some years ago the person responsible for deciding what technology to use for voting in China contacted Ted Selker. He wrote a very long paper including the work we had done and asked for comments and interaction. After about a year, he decided to create a new kind of optical scan system for China: one that would rely only on the text shown on the ballot that their voter viewed. Instead of using an internal ballot module, it scanned the physical ballot to establish what races and decisions the person viewed for their selections. Interestingly, by consulting with the Voting Technology Project, they established this improved practice many years before anyone in the USA had such a secure and accurate way to vote with a paper ballot.

Policy creation should not be limited to Common Off The Shelf technology. Unlike 2000 when the country began focusing on voting technology problems, today almost everyone owns a cellphone with a camera and a GPS in it. Unlike 2000, mobile tablets and laptops are available for most data-oriented jobs. The implications of pervasive computing must be considered in approaches for all citizen activities. Now researchers are defining and describing a future in which sensors, analytics, and effectors make up the Internet Of Things (IOT). This IOT too, is transforming how people and technology work together. How will cameras and people sensors everywhere impact voting? The need to continuously fund technology research in service of policy decisions is critical today. The RAV work promotes the value of continued, non-vendor research in technology that can improve access, integrity, and accuracy. Specifically, the value of creating technology for voting with disabilities is urgent. Early attempts to incorporate new web technologies for election services may have been hastily planned and executed. The return to paper ballots in many jurisdictions have, in many cases, left individuals with disabilities without working systems that allow them to succeed in voting on their own.

The Research in Accessible Voting (RAV) project has endeavored to provide innovations that can offer new solutions for policy that can improve voting for individuals with disabilities. Historically, policy decisions have been focused on available resources, problems, and technical systems. Such analysis of the 2000 election showed that problems with registration, polling place operations, and ballot design were the main causes of lost votes [Alvarez]. The following few years, however, showed technologists dominating the conversation by pointing to their predictions that *potential problems* in computer security could be even more dangerous than the *known* problems. The NSF and others responded by funding the concerned technologists. We are now in a place where technological progress is as important as cultural readiness for change. Our research has tried to strike a balance, creating technology that could solve measured and prospective problems for individuals with disabilities. We hope that this report helps show how investment in technological solutions can help improve policy options for the US.

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11. Appendicies

11.1 Write-in Experiment Materials

Participant	Order	Condition 1: Single Tap			Condition 2: Four Keys			Condition 3: Two Keys		
		1st Trial	2nd Trial	Average	1st Trial	2nd Trial	Average	1st Trial	2nd Trial	Average
1	1, 2, 3	34	36	35	34	40	37	45	42	43.5
2	1, 2, 3	37	38	37.5	43	36	39.5	30	40	35
3	1, 2, 3	46	49	47.5	40	43	41.5	41	39	40
4	1, 2, 3	40	38	39	47	49	48	36	40	38
5	1, 2, 3	37	41	39	56	58	57	39	--	39
6	1, 2, 3	51	41	46	--	--	--	--	--	--
7	1, 2, 3	52	49	50.5	--	--	--	--	--	--
8	1, 2, 3	55	53	54	--	--	--	--	--	--
9	1, 2, 3	55	41	48	--	--	--	--	--	--
10	1, 2, 3	38	42	40	--	--	--	--	--	--
11	2, 3, 1	31	35	33	--	51	51	48	37	42.5
12	2, 3, 1	27	40	33.5	50	60	55	38	32	35
13	2, 3, 1	39	36	37.5	63	65	64	35	43	39
14	2, 3, 1	42	40	41	63	58	55.5	46	50	48

15	2, 3, 1	32	32	32	--	53	53	40	39	39.5
16	2, 3, 1	44	53	48.5	66	61	63.5	42	55	48.5
17	2, 3, 1	41	36	38.5	69	68	68.5	39	48	43.5
18	2, 3, 1	36	36	36	62	48	55	25	39	32
19	2, 3, 1	--	--	--	64	65	64.5	--	--	--
20	2, 3, 1	--	--	--	64	50	57	--	--	--
21	3, 2, 1	--	--	--	--	--	--	49	44	46.5
22	3, 2, 1	--	--	--	--	--	--	48	32	40
23	3, 2, 1	--	--	--	--	--	--	50	45	47.5
24	3, 2, 1	--	--	--	--	--	--	39	37	38
25	3, 2, 1	--	--	--	--	--	--	44	40	42
26	3, 2, 1	49	36	42.5	65	55	60	45	50	47.5
27	3, 2, 1	34	33	33.5	41	42	41.5	40	45	42.5
28	3, 2, 1	53	52	52.5	45	46	45.5	38	49	43.5
29	3, 2, 1	40	--	40	53	58	55.5	49	48	48.5
30	3, 2, 1	--	--	--	--	--	--	48	40	44

FIGURE 50 DATA SHOWING THAT THE SIMPLER TWO-KEY INTERFACE ALLOWED PARTICIPANTS TO COMPLETE TASKS FASTER THAN WITH FOUR KEYS, BUT NOT NECESSARILY FASTER THAN TYPING ON A KEYBOARD.

11.2 Magnifier Experimental Materials

11.3.1 IRB Protocol

Study Title
Usability Testing of New Election Technologies
Complete each section. When a question is not applicable, enter "N/A". Do not leave any sections blank.
1. Purpose
Provide a brief explanation of the proposed research, including specific study hypothesis, objectives, and rationale.
This research is intended to explore the utility of new ways to focus the visual attention of voters when voting on paper, marking ballots online and registering to vote. The prototypes to be tested include a physical reading magnifier for paper ballots and a website scrim (a semi-transparent filter with a dynamic rectangle cutout that exposes only certain sections of a website at a time) for online materials. The hypothesis is that these aids will make it easier for individuals with less than average vision and/or learning disabilities to focus on tasks, perceive content and work accurately, leading to faster task completion times. The rationale for this hypothesis is that the existing voting materials (such as election ballots and online registration sites) provide information a manner that is too free-form and crowded with content; our prototypes are intended to simplify the browsing of such materials. The overall objective is to garner objective and qualitative data that will inform the next iteration of our designs.
2. Background
Give relevant background (e.g., summarize previous/current related studies) on condition, procedure, product, etc. under investigation, including citations if applicable (attach bibliography in Attachments section).
Voting can be confusing and election materials difficult to work with (Alvarez, R., Ansolabehere, S., Antonsson,E., Bruck, J., Graves, S., Siegel, J., Palfrey, T., Rivest, R., Selker, T., Slocum, A., & Stewart III, C. (2001) Voting: What is, what could be. Caltech - MIT Voting Project.)(Selker, T. (2004) Processes can improve electronic voting: a case study of an election. Caltech/MIT Voting Technology Project.). This can be especially true for individuals with reading disabilities and poor eyesight. Previous research has shown that focusing voter attention and providing larger text can be helpful (Selker, T., Goler, J., Wilde, F. (2005) Who does better with a big interface? Improving Voting Performance of Reading Disabled Voters. Caltech - MIT Voting Project.). This study is intended to test an improvement on voting magnifiers with a freestanding prototype specifically intended for use with paper ballots. The study will also test a new web-based tool to focus voter attention when registering to vote online by creating an interactive overlay system that exposes a web-form's content sequentially to the user without modifying the underlying webpage.
3. Collaborative Research
a) If any non-UCB institutions or individuals are engaged in the research, explain here.
None are currently engaged.
b) If any non-UCB institutions or individuals are collaborating in the research, complete the table below and attach any relevant IRB approvals in the Attachments section.
Non-UCB institutions
Previous Next
4. Qualifications of Study Personnel
a) Explain expertise of Principal Investigator, Student/Postdoc Investigator, Faculty Sponsor (if applicable), any Co-Investigators or other key personnel listed in the application, and how it relates to their specific roles in the study team.

Eric Paulos is the Director of the Living Environments Lab, Co-Director of the CITRIS Invention Lab, and an Assistant Professor in Electrical Engineering Computer Science Department at UC Berkeley where he is faculty within the Berkeley Center for New Media (BCNM). His areas of expertise span a deep body of research territory in urban computing, sustainability, green design, environmental awareness, social telepresence, robotics, physical computing, interaction design, persuasive technologies, and intimate

media. Eric received his PhD in Electrical Engineering and Computer Science from UC Berkeley where he helped launch a new robotic industry by developing some of the first internet tele-operated robots including Space Browsing helium filled blimps and Personal Roving Presence devices (PRoPs). As PI of this study, his experience creating and testing novel interfaces will allow him to provide valuable insight into the design of the prototypes and meaning of collected data.

Ted Selker is a visiting scholar in the data and Democracy Initiative at CITRIS, UCB. Ted spent 5 years as director of Considerate Systems research at Carnegie Mellon University Silicon Valley. He was also responsible for developing the campus's research mission, teaching HCI, Android product design, and research in voting with disabilities. Ted spent ten years as an associate Professor at the MIT Media Laboratory where he created the Context Aware Computing group, co-directed the Caltech/MIT Voting Technology Project, and directed the CIDI Kitchen of the future/ product design of the future project. His work in voting technology, as a designer and researcher, provides critical grounding for this project.

Dan Gillette is a visiting scholar in the Data and Democracy Initiative at CITRIS, UCB. He also is a member of the CITRIS Social Apps Lab, where he leads a product team creating PIC Your Future, a college readiness app funded by UCOP. Previously, Dan held research and teaching positions at Carnegie Mellon University, Stanford University, Mills College, and CSU Monterey Bay. Additionally, Dan was a cofounder and design principal at In World Solutions, a startup that provides virtual reality tools for the behavioral healthcare market. From 2002-2008, Dan was chair of the Innovative Technology for Autism Initiative. Dan holds a B.A. in human development from the Lesley College Graduate School, and an Ed.M. from the Harvard Graduate School of Education, with a concentration in cognitive science, psychology, and instructional design. Dan brings to this project two decades of experience designing and testing accessibility products.

11.3.2 Specific Protocol

Subject Population
a) Describe proposed subject population, stating age range, gender, race, ethnicity, language and literacy.
The proposed population for this study will be students and staff of UC Berkeley who have a moderate vision impairment that affects reading, but is correctable with glasses and individuals with dyslexia and/or attention deficit disorder. The age range is 18 years and older. Gender, race and ethnicity will be representative of the available recruitment pool. Participants must be fluent in written English and able to follow spoken English instructions.
b) State total (maximum) number of subjects planned for the study and how many must be recruited to obtain this sample size. Explain how number of subjects needed to answer the research question was determined.
The number of participants sought is 10-16, which will provide a sample pool of 5-8 individuals that meet each the two main population groups for the study -- moderate vision impairment and learning disabilities -- and still provide some room for administration error. It is standard practice to conduct exploratory usability studies with 4-6 individuals, such as this one. The plan is to conduct rolling recruitment until we have successfully completed the study, meaning that we will not recruit a pool of alternate participants.
c) If any proposed subjects are children/minors, prisoners, pregnant women, those with physical or cognitive impairments, or others who are considered vulnerable to coercion or undue influence, state rationale for their involvement.
We will be recruiting individuals with mild-to-moderate learning disabilities, as this is one of the target populations for the study.

6. Recruitment
a) Explain how, where, when, and by whom prospective subjects will be identified/selected and

approached for study participation. If researcher is subject's instructor, physician, or job supervisor, or if vulnerable subject groups will be recruited, explain what precautions will be taken to minimize potential coercion or undue influence to participate. See CPHS Guidelines on Recruitment for more information.
Recruitment will be handled by the distribution of flyers. Recruitment will begin in proximity to our office in SDH and extend to the distribution of flyers in other parts of campus if needed. Subordinates or current students of the research team will not be actively recruited. When a potential participant contacts the recruiter, a private discussion will take place in person, by phone or by email to determine if s/he is eligible for the study.
b) Describe any recruitment materials (e.g., letters, flyers, advertisements [note type of media/where posted], scripts for verbal recruitment, etc.) and letter of permission/cooperation from institutions, agencies or organizations where off-site subject recruitment will take place (e.g., another UC campus, clinic, school district). Attach these documents in Attachments section.
When meeting a potential participant, the following script will be used:
"Hi, I'm [recruiter's name]. I'm part of a team working on technology to make voting tasks easier for individuals with minor vision problems or learning disabilities. Would you be interested in participating in our usability study to assess these tools? It should take no more than 50 minutes and you will receive a $25 gift card as a thank you for your participation."
If the answer is that would like to participate, the recruiter will provide a flyer. If the answer is no, the recruiter will thank the individual and say goodbye.
Another recruitment tactic will be email, sent to those known by the project with the intent of the message being forwarded. The following text will be used in the email.
"Ted Selker and Dan Gillette, visiting scholars in the Data and Democracy Initiative at CITRIS, are currently conducting a study to assess prototypes they have built to help individuals with minor vision difficulties or learning disabilities complete voting-related tasks, such as voter registration and voting with paper ballots. If you know anyone who might be interested in participating in this study, please forward this email and the attached flyer."
c) Will anyone who will be recruiting or enrolling human subjects for this research receive compensation for each subject enrolled into this protocol? If yes, please identify the individual(s) and the amount of payment (per subject and total).
No one conducting enrollment will have compensation tied to successful recruitment.

7. Screening
a) Provide criteria for subject inclusion and exclusion. If any inclusion/exclusion criteria are based on gender, race, or ethnicity, explain rationale for restrictions.
Since we are developing aides for individuals with minor vision difficulties that affect reading, as well as dyslexia or ADD, participants will need to have one of these conditions. Additionally, since this study focuses on reading tasks, all participants will be required to be fluent in written English and able to follow verbal instructions in English. Participants must be at least 18 years old, since that is the minimum age for voting in the United States and we are testing aides for voters. Self-report will be the means for verifying the participant meets the inclusion criteria.
b) If prospective subjects will be screened via tests, interviews, etc., prior to entry into the "main" study, explain how, where, when, and by whom screening will be done. NOTE: Consent must be obtained for screening procedures as well as "main" study procedures. As appropriate, either: 1) create a separate "Screening Consent Form;" or 2) include screening information within the consent form for the main study.
NA

8. Compensation and Costs
a) Describe plan for compensation of subjects. If no compensation will be provided, this should be stated. If subjects will be compensated for their participation, explain in detail about the amount and methods/ terms of payment.

Include any provisions for partial payment if subject withdraws before study is complete.
When subjects are required to provide Social Security Number in order to be paid, this data must be collected separately from consent documentation. If applicable, describe security measures that will be used to protect subject confidentiality.
If non-monetary compensation (e.g., course credit, services) will be offered, explain how
Each participant will receive a $25 gift card to Target or Starbucks (participant choice). Participants will communicate their choice when scheduling their participation in the study and cards will be given to the participants at the end of testing.
b) Discuss reasoning behind amount/method/terms of compensation, including appropriateness of compensation for the study population and avoiding undue influence to participate.
In previous, recent research studies done by investigators involved with this study, the amount of the gift card, and the related-vendors was deemed as an appropriate thank you for participation and of interest to the majority of potential participants.
c) Costs to Subjects.
NA
9. Study Procedures
a) Describe in chronological order of events how the research will be conducted, providing information about all study procedures (e.g., all interventions/interactions with subjects, data collection procedures etc.), including follow-up procedures.
1. Greet participant
2. Introduction: "Thank you for agreeing to participate in this study. Today we are testing some ideas for changing the way people vote. During this study we will ask you to answer some questions and ask you to complete a reading level test before you try the technology. You will then try to use a few different systems. Finally we will discuss the systems. The time required for the testing portion of the test should take less than hour. Do you want to continue?" (2 minutes)
3. Consenting (if not completed prior to testing) (10 minutes)
4. Demographic Interview: Age, gender, education level, voting history (when was the last time the participant voted and with what technology) need for reading glasses and learning disabilities (5 minutes)
5. Administer the easy CBM Passage Reading Fluency measure, grade 8, form 8_2 (5 minutes)
6. Usability Test Administration: The order of the following conditions will be randomized and interwoven (ballot task/registration task/ballot task/registration task/ballot task).
A. Paper Ballot: The participant is asked to vote on three contests, two candidate and one proposition (the participant will be coached on which candidates to vote for and will be asked to vote his/her own opinion for the proposition) (5 minutes)
B. Paper Ballot with Magnifier: The participant is asked to vote on three contests, two candidates and one proposition using the prototype voting magnifier (the participant will be coached on which candidates to vote for and will be asked to vote his/her own opinion for the proposition) (5 minutes)
C. Online Ballot Marking with Scrim: The participant is asked to vote on three contests, two candidates and one proposition using an online ballot marker that resembles paper, but allows for the use of the scrim prototype (the participant will be coached on which candidates to vote for and will be asked to vote his/her own opinion for the proposition) (5 minutes)
D. Registration Site: The participant is asked to complete a subset of tasks on the Trust the Vote Project sample registration website (http://va-demo.voterportal.trustthevote.org) (5 minutes)
E. Registration Site with Scrim: The participant is asked to complete a subset of tasks on the Trust the Vote Project sample registration website (http://va-demo.voterportal.trustthevote.org) using the scrim prototype (5 minutes)
7. Post-testing debrief (10 minutes)
8. Thank participant and deliver gift card
b) Explain who will conduct the procedures, where and when they will take place. Indicate frequency and duration of visits/sessions, as well as total time commitment for the study.
The procedures will be conducted by Dan Gillette and Ted Selker in their office, room 462, Sutardja Dai Hall. Participants are only expected to complete one session, lasting 40-60 minutes. Testing will be scheduled

based on participant availability, with attempts to do back-to-back testing sessions whenever possible. Total time needed for administration of the procedures for all participants is estimated to be 16 hours.

c) Identify any research procedures that are experimental/investigational. Experimental or investigational procedures are treatments or interventions that do not conform to commonly accepted clinical or research practice as may occur in medical, psychological, or educational settings. Note: if the study only involves standard research or clinical procedures, enter "N/A" here.
N/A
d) If any type of deception or incomplete disclosure will be used, explain what it will entail, why it is justified, and what the plans are to debrief subjects. See CPHS Guidelines on Deception and Incomplete Disclosure for more information. Any debriefing materials should be included in the Attachments section.
N/A
e) State if audio or video taping will occur. Describe what will become of the tapes after the project (e.g., shown at scientific meetings, erased) and final disposition of the tapes.
Video recording will occur to record participant behavior during each experimental condition. The raw recordings will be copied to a hard-drive used to house experimental data at DDI and the original recordings will be deleted. The recordings will be kept in a locked cabinet in Dan Gillette's office and will be handed over to the director at DDI if he leaves UC Berkeley.
The recordings will be used by the researchers to review the test procedures and portions may be played at academic and governmental talks and conferences.

11. Alternatives to Participation

Describe appropriate alternative resources, procedures, courses of treatment, if any, that are available to prospective subjects. If there are no appropriate alternatives to study participation, this should be stated. If the study does not involve treatment/intervention, enter "N/A" here.

11.3 Wii Mote Experimental Materials

Demographic

Have you ever used any device that provides haptic, visual or sound feedback?	Yes or No
Have you ever used the Wiimote to use as a source of control?	Yes or No
What is your age range?	60-70, 71-80, 81-90, 91+
Have you ever used a computer based voting system?	Yes or No
Do you have any of the following impairment or uses any of these devices	Yes or No
Do you have any dexterity issues that may prevent you from using the Wiimote comfortably?	Yes or No
Graphic Does the layout remind you of any past voting system you used?	Yes or No
Where you able to read the text?	Yes or No
Did the color scheme and layout made it easier for you to navigate?	Yes or No
Did the picture of the candidates help when browsing for can date?	Yes or No

Given these new features that can be provided, which do you think would be more useful?
Ability to enlarge the text, change the layout, or change the color scheme

Feedback

Could you rank which feedback system was more important?	Haptic, visual, and sound
Was there any moment you wish the Wiimote gave a different feedback?	Yes or No
Do you feel that the gesture sensitivity needs to be more sensitive?	Yes or No
Did you feel the feedback system prevent any errors that may have occurred such as voting for the wrong candidates?	Yes or No
Do you know of any devices that provide feedback which you believe we should also look at?	Yes or No

General

Would you prefer the new Wiimote voting system over the current voting system?	Yes or No
Would you use the Wiimote system overall if it was available at the next election?	Yes or No
On a scale from 1-4, 4 being comfortable, did the Wiimote felt comfortable to hold and used as a voting device?	1-4
Would you recommend the Wiimote to anyone?	Yes or No

11.4 Making Voting Accessible for Election 2012

Twelve Quick Tips for Election Officials

Introduction

Voters with special needs are a large part of Presidential elections. The odds of a voter having a disability are about 1 in 5. About 1 in 7 voters will have a severe disability. These numbers indicate that approximately 20% of those participating in elections will have some form of special needs.

The most prevalent types of disabilities among all voters, (according to the US Census) are:

Difficulty standing	10.4%
Difficulty walking	9.8%
Cognitive difficulties	7.0%
Difficulty seeing	3.4%
Difficulty hearing	3.4%
Difficulty with speech	1.1%

Providing Accessible Information

- Prepare all voting instructions and all voting equipment to be used by all voters so that nothing else needs to be done for a voter with special needs. ***NOTE: The point here is to NOT wait until a special needs voter appears before preparing the voting equipment or the ballot and instead have it ready to go so that ANY voter can use the special needs provisions at any time. (can we provide a link to an exemplar?)***

- Work with state and local assistive technology groups to provide voting information, voting instructions, and equipment instructions in formats that can be easily used by individuals with disabilities. Look for alternative formats such as audio tools, video interpretations. ***NOTE: Voters with sight challenges cannot easily adapt PDF files for their use. (can we provide a link to a list of them ?)***

- For those with cognitive issues, provide simplifying graphics and easily understandable language. Meet with educators and/or disability advocacy organizations to assure that voting information and voting and equipment instructions can be clearly understood. ***NOTE: Because cognitive difficulties affect a significant portion of the population, developing instructions and information in easily understandable language at no higher than a sixth grade reading level is recommended. (can we provide a link to an exemplar?)***

Viewing the Polling Place from a Special Needs Approach

- Examine every polling place:
  - Can a voter in a wheel chair easily enter the polling place?
  - Is signage truly informative as to what is the most direct path for finding and entering the polling place?
  - Can entry doors be easily opened by any voter with limited strength?

- Use the tools developed to teach poll workers how to best approach and serve voters with special needs. (See Disability Etiquette from the Tennessee Disability Coalition).

- (See Election Center checklist on Accessibility). Also see www.ada.gov/votingchecklist.htm

- Casting A Ballot

- If permitted in your state, make sample ballots available to voters while they are waiting to vote. This tool can help them prepare for the actual voting process.

- Simplify ballot layout and language, while still complying with state election law. ***NOTE: Even though specific ballot language may be required by law, see if it can be simplified for comprehension. (can we provide a link to an exemplar?)***

- Be prepared for handling spoiled ballots or providing greater voting assistance. Be sensitive that some voters may not grasp what they need to do to vote successfully. ***NOTE: Audio ballots increase the demand for memory and that can be a problem for anyone with cognitive issues.***

- Integrate Not Isolate

- Set up all special needs equipment so that it is ready for use by ANY voter at any time. ***NOTE: The number one polling place complaint of voters with disabilities is that the accessible voting equipment is not ready to use and/or the poll workers don't know how to use it.***

- Train poll workers to greet all voters with a simple "Is there anything I can do to help you?"

- Ask area disability advocacy groups to provide greeters at polling places and/or provide additional trained assistance (if permitted by your state laws).

Finding Help from Government or Advocates

The U.S. Election Assistance Commission	www.eac.gov
The U.S. Access Board	www.access-board.gov/links/disability.htm
List of disability organizations	www.disaboom.com/organizations
Neighborhood Legal List of organizations	www.nls.org/dislinks.htm
Disability Resources	www.disabilityresources.org/DRMreg.html
Research Alliance for Accessible Voting	www.accessiblevoting.org
Civic Designing (Ballot Design Tips)	www.civicdesigning.org/fieldguides
Election Center – Accessibility Checklist	http://electioncenter.org/checklists.html
Tennessee Disability Coalition	www.tndisability.org
(and list all the other RAAV partners sites)	

Paraquad RAAV Summary

Overview of RAAV Poll Worker Training Project

From May 2011-May 2014, Paraquad and the MDVP set out to evaluate how Election Day workers are currently trained on issues of disability, access, and accommodations. We then developed and piloted suggested training materials to improve the interaction between poll workers and voters with disabilities and ensure that accommodations and accessible voting procedures are available and implemented effectively.

Overview of Background Research

Background research consisted of Election Day Experience Interviews with voters with disabilities and election administrators. During this research phase we administered a phone interview to 1,200 voters with disabilities in Missouri and Tennessee. We also interviewed 10 County Clerks from across Missouri.

During Voter Experience Phone Interviews, we learned that the major areas where voters with disabilities continue to have problems are the following:

- Inaccessible polling places
- Poll workers who are not knowledgeable about disability or accommodations
- Poll workers who are uncomfortable using the accessible voting equipment

During County Clerk interviews, we talked to a total of 10 County Clerks across Missouri and found the following:

- The most common poll worker training method is through PowerPoint Presentation and lecture with an average time of 1 ½ to 2 hours
- Checklists or visual aids on what accessible equipment and accommodations are available and how to use them would be helpful, especially aids that use real pictures
- Poll Workers understand information at training, but lose that information by Election Day and end up implementing procedures incorrectly or forgetting about accommodations available. There is a need to make information readily available and usable on Election Day for poll workers to review.
- Interactive and hands-on training modules are popular and well- received but are hard to implement in large group trainings

Poll Worker Training Material Development

During training material development, we were able to identify training focus areas and possible points of contact with poll workers based on Election Day Experience Research. We also integrated knowledge of best practices in teaching adults in order to develop evidence-based, effective training materials. The result was a well-rounded training packet which we offered to County Clerks to pilot in the August 2012 State Primary Election. The training packet consisted

of two main pieces of training material: 1) Pre-Election Poll Worker Training Curriculum Guide and 2) Election Day Picture Guide (job aid for poll workers).

State Primary Election Pilot and Findings

Training materials were piloted in four different Missouri counties, including Cape Girardeau County, Laclede County, Green County, and Christian County. Major findings included the following:

- Poll workers find that having a variety of training methodology is most helpful
- A majority of poll workers feel very confident and prepared to appropriately interact with voters and also carry out curbside voting accommodations
- There is a discrepancy between the percentage of poll workers who know how to set up an accessible voting machine and the percentage who know how to use accessible features on the voting machines
- The majority of poll workers who participated in the pilot found that having the Election Day Picture Guide available was helpful in carrying out Election Day procedures, especially regarding using accessible voting machines

Recommendations

Based on our work, Paraquad created a list of ten recommendations to make elections more accessible.

1. Work with community members with disabilities and disability advocacy groups year-round.
2. Consider basing poll worker training on teaching workers how to use job aids instead of information memorization.
3. Train poll workers on how to use accessible features of voting machines, in addition to training on voting equipment set-up.
4. Troubleshoot accessibility issues well before the Election.
5. Integrate information on accessibility, accommodations, and disability as much as possible into regular training materials.
6. Utilize well-designed and accessible signage at the polling place.
7. Keep yourself and your staff up to date on ADA and HAVA Guidelines.
8. Hire people with disabilities as poll workers and election staff.
9. Evaluate yourself, your staff, and poll workers!
10. Create and utilize networking and problem solving opportunities with other administrators and disability advocacy groups.

PARAQUAD

RAAV Research Alliance for Accessible Voting

RAAV Poll Worker Training Project

May 2011

through

May 2014

This material is based upon work supported by the U.S. Election Assistance Commission (EAC). Opinions or points of view expressed in this document are those of the authors and do not necessarily reflect the official position of, or a position that is endorsed by, EAC or the Federal government.

Training Poll Workers on Disability, Accessibility, and Accommodations

About Paraquad

Paraquad is a nonprofit organization whose mission is to empower people with disabilities to increase their independence through choice and opportunity. Founded in 1970 in St. Louis, Mo. by Max and Colleen Starkloff, we are one of the oldest non-residential Centers for Independent Living in the country.

Paraquad is a leader in advancing the independent living philosophy. We envision an integrated community in which people with disabilities are valued and participate in all aspects of society.

Values

- Respect, integration, equal access, opportunities, self-determination, informed choice and individual control for and by people with disabilities
- People with disabilities having control of their own lives and any necessary supports or assistance
- Full diversity within Paraquad, our programs and society at large, in terms of disability, race, ethnicity, age, gender, sexual orientation and religion
- Personal commitment and action to shape the future of Paraquad and the Independent Living Movement
- A work environment characterized by mutual respect, open communication, and team work
- People with disabilities taking a role in the policy and political decisions that impact their lives

About RAAV

The Research Alliance for Accessible Voting (RAAV) includes teams looking at all aspects of accessible voting. We will continue to work on technologies and approaches that address a variety of barriers to voting, including:

- Disabilities as defined by the Americans with Disabilities Act (ADA)
- Lack of educational opportunity
- Difficulties due to aging or other life circumstances
- Limited English proficiency

In addition, the project website www.accessiblevoting.org will be a national resource on the project and accessible voting in general. It is designed to be a model of accessible web design and web content.

EXECUTIVE SUMMARY

Overview of RAAV Poll Worker Training Project

Over the past ten years, Paraquad and the Missouri Disability Vote Project (MDVP) have found that access to the vote on Election Day is almost entirely reliant on the effectiveness of a dedicated team of poll workers who have an understanding of access and available accommodations. While election authorities have the ability to utilize accessible polling sites and purchase well-designed balloting equipment, poll workers are key in making sure that the sites and necessary equipment are set up properly on Election Day.

From May 2011-May 2013, Paraquad and the MDVP set out to evaluate how Election Day workers are currently trained on issues of disability, access, and accommodations. We then developed and piloted suggested training materials to improve the interaction between poll workers and voters with disabilities and ensure that accommodations and accessible voting procedures are available and implemented effectively.

Timeline for RAAV Poll Worker Training Project

- May 2011-April 2012 : Election Day Experience Research
- April 2012-July 2012: Material Development
- August 2012: Election Worker Training Pilot

Overview of Background Research

Background research consisted of Election Day Experience Interviews with voters with disabilities and election administrators. During this research phase we administered a phone interview to 1,200 voters with disabilities in Missouri and Tennessee. We also interviewed 10 County Clerks from across Missouri.

During Voter Experience Phone Interviews, we learned that the major areas where voters with disabilities continue to have problems are the following:

- Inaccessible polling places
- Poll workers who are not knowledgeable about disability or accommodations
- Poll workers who are uncomfortable using the accessible voting equipment

During County Clerk interviews, we talked to a total of 10 County Clerks across Missouri and found the following:

- The most common poll worker training method is through PowerPoint Presentation and lecture
- Average amount of time allowed for poll worker training session is 1 ½ to 2 hours
- Many County Clerks are opposed to collecting evaluations on poll worker trainings and election day experiences

- There is a need for more information on accessible signage and placement of signage
- Checklists or visual aids on what accessible equipment and accommodations are available and how to use them would be helpful, especially aids that use real pictures
- There is a huge need for *more* poll workers, especially younger, tech savvy workers. This would help with many Election Day issues
- Poll Workers understand information at training, but lose that information by Election Day and end up implementing procedures incorrectly or forgetting about accommodations available. There is a need to make information readily available and usable on Election Day for poll workers to review.
- Interactive and hands-on training modules are popular and well- received but are hard to implement in large group trainings
- Funding constraints prevent County Clerks from making some improvements

Poll Worker Training Material Development

During training material development, we were able to identify training focus areas and possible points of contact with poll workers based on Election Day Experience Research. We also integrated knowledge of best practices in teaching adults in order to develop evidence-based, effective training materials. The result was a well-rounded training packet which we offered to County Clerks to pilot in the August 2012 State Primary Election. The training packet consisted of two main pieces of training material: 1) Pre-Election Poll Worker Training Curriculum Guide and 2) Election Day Picture Guide (job aid for poll workers).

State Primary Election Pilot and Findings

Training materials were piloted in four different Missouri counties, including Cape Girardeau County, Laclede County, Green County, and Christian County. Major findings included the following:

- Poll workers find that having a variety of training methodology is most helpful
- While most poll workers are confident that their poll place is set up in an accessible manner, they still report witnessing voters having access issues
- A majority of poll workers feel very confident and prepared to appropriately interact with voters and also carry out curbside voting accommodations
- There is a discrepancy between the percentage of poll workers who know how to set up an accessible voting machine and the percentage who know how to use accessible features on the voting machines
- The majority of poll workers who participated in the pilot found that having the Election Day Picture Guide available was helpful in carrying out Election Day procedures, especially regarding using accessible voting machines

Challenges and Suggestions for Future Work

During the project, we identified several challenges. This included training time and financial constraints faced by Election administrators, diverse county specific processes in training and

elections, confusion among administrators and poll workers on ADA polling place guidelines, and the limited use of poll worker evaluations.

We also identified some suggestions for future work, including the following:

- Switch the focus of poll worker trainings to how to use job aids instead of information memorization
- Utilize roving deputies and pre-election polling place visits to minimize accessibility issues
- Create improved polling place signage
- Look into and evaluate more hands-on interactive training methodology
- Utilize networking and mutual problem solving opportunities between Election administrators and staff
- Require annual ADA poll place training for Election administrators and staff

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PROJECT OVERVIEW: RATIONALE

People with disabilities face many barriers to voting on Election Day. This makes it harder for many people with disabilities to exercise their fundamental right to vote and participate in our democracy. These barriers include everything from physical inaccessibility of polling locations and inaccessible voting equipment to misunderstandings about accommodations available to and proper etiquette for voters with disabilities.

The barriers to voting on Election Day have many different causes. The specific cause that Paraquad and the Missouri Disability Vote Project (MDVP) focused on for RAAV is that many Election Day workers still lack a basic knowledge of accessibility, disability etiquette, and accommodations available for voters with disabilities.

Over the past ten years, Paraquad and the MDVP have found that access to the vote on Election Day is almost entirely reliant on the effectiveness of a dedicated team of poll workers who have an understanding of access and available accommodations. While election authorities have the ability to utilize accessible polling sites and purchase well-designed balloting equipment, poll workers are key in making sure that the sites and necessary equipment are set up properly on Election Day.

In order to confront this barrier, Paraquad and the MDVP set out to evaluate how Election Day workers are currently trained on issues of disability, access, and accommodations. We then developed and piloted suggested training materials to improve the interaction between poll workers and voters with disabilities and ensure that accommodations and accessible voting procedures are available and implemented effectively.

PROJECT TIMELINE

The RAAV Poll Worker Training project was broken up into the following phases: 1) Election Day Experience Research, 2) Training Material Development, and 3) Training Pilot and Evaluation. Below is a brief overview of each phase. Specifics of each phase will be discussed in following sections.

Phase one was designed to collect basic data and lay a firm foundation for the remainder of the poll worker training project. Various methods were used to collect data on Election Day experiences of voters and training needs identified by administrators. The data collected in this phase informed the materials which were developed and piloted in subsequent phases of the project.

Phase two was the major material development phase. Information gathered during phase one research lead to the identification of training focus areas, major points of contact that can be used to influence poll workers, and best practices that already exist in adult learning. Using this framework, we developed materials to compliment this existing knowledge. Materials will be explained in detail in the following sections but include suggested Pre-Election Day Poll Worker Training Curriculum with lesson plans, PowerPoint, hands-on activities, handouts, checklists, and suggestions for dialogue; as well as an Election Day Picture Guide to be used as a polling place job aid.

Phase three was the pilot phase. All materials developed in phase two were disseminated to pilot counties and used at select polling sites within their jurisdiction. Poll workers and election administrators were given an evaluation of pilot materials to judge their effectiveness. Major findings from the pilot will be discussed in detail in following sections.

PHASE 1: ELECTION DAY EXPERIENCE RESEARCH

During Phase 1, Paraquad and the MDVP, in conjunction with the Tennessee Disability Coalition (TDC), conducted informal research in order to assess the current state of poll worker trainings regarding accessibility and disability, identify areas that need improvement, and secure pilot training sites to implement best practices and improved training materials. There were two main methods of collecting data during this phase: Voter Experience Surveys and County Clerk Interviews.

VOTER EXPERIENCE SURVEYS

The purpose of voter experience surveys was to get a sense of how people with disabilities were experiencing elections. The goal of the calls was to understand what people in the disability community still perceived as problems when it came to voting at their polling place on Election Day. Questions addressed the following areas: voting frequency and method (vote at home or in polling place); obstacles to getting to the polling place; polling place accessibility; poll worker knowledge about accessibility, available accommodations, and disability; poll worker knowledge about using accessible voting equipment; voter - poll worker interactions; and poll worker knowledge about disability etiquette.

Calls were targeted to areas where we knew there was a large disability population and a Center for Independent Living that was active and willing to partner on this project. Calls were also targeted in order to reach a diverse population with a mix of rural and urban voters with disabilities as well as voters from different geographic areas (counties in northern, southern, eastern, and western Missouri, as well as a few targeted counties in Tennessee). A total of 1,200 voters with disabilities completed a voter experience survey.

As a result of these calls we were able to identify the major issues that voters with disabilities face in their polling places. There were three major issues that stood out: 1) poll worker knowledge of how to use accessible voting machines, 2) poll worker knowledge of accommodations available to voters with disabilities, and 3) accessible set-up of polling places.

The first major area concerned poll worker knowledge about how to use accessible voting machines, specifically regarding accessibility features (large print, high contrast, audio, screen tilt, etc.). Only 48% of voters with disabilities from Saint Louis metropolitan area and 53% of voters from greater Missouri felt that their poll workers knew how to operate the accessible machines. No results were available for Tennessee voters.

The second major area dealt with poll worker knowledge about accommodations available to voters with disabilities, including curbside voting, alternative communication methods, offering extra chairs and tables, and moving to the front of the line when necessary. In the Saint Louis metropolitan area, only 44% of voters felt that poll workers were knowledgeable about available

accommodations for voters with disabilities, compared to 64% of voters from greater Missouri and 70% of voters from Tennessee.

The third major area regarded accessible set-up of polling places. This included available accessible parking, accessible entrances, doorways, and pathways, and accessible flow throughout the main voting room. Less than half (43%) of voters with disabilities from the Saint Louis metropolitan area said that their polling place was set up in an accessible manner, compared to 83% of voters from greater Missouri and 92% of voters from Tennessee.

The last major area which we addressed in Voter Experience Surveys was poll worker interaction and etiquette. Overwhelmingly, voters from every area agreed that poll workers were friendly, respectful, polite, and able to appropriately interact with voters with disabilities (98% in both Tennessee and greater Missouri).

COUNTY CLERK INTERVIEWS

The second method we used to gather information was through County Clerk interviews. This consisted of one-on-one, in-person interviews with County Clerks across Missouri. There were multiple goals for meeting with County Clerks. First, we wanted to gain an understanding of challenges that election administrators face regarding poll workers and voters with disabilities. We also wanted to learn about current poll worker training techniques and topics addressed regarding access and disability. Another goal was to get the election administrators' reaction to data we collected during voter experience surveys. Finally, we used County Clerk interviews to secure pilot sites for the 2012 August Primary Election.

County Clerk Interviews were initially targeted towards administrators from counties that participated in the voter experience surveys or clerks from areas where there is an active Center for Independent Living. We also sought interviews with well-respected administrators in Missouri known for using innovative training methods. A total of ten County Clerk interviews were completed. The following counties participated in an interview: Saint Louis City, Saint Louis County, Jefferson County, Saint Francois County, Cape Girardeau County, Boone County, Laclede County, Greene County, Christian County, and Taney County. We also completed an interview with a staff person from the Missouri Secretary of State's Office.

Interview questions fell into four different categories: training content, training logistics, major challenges and complaints, and innovative ideas and suggestions. Training content questions focused on what training methodology administrators used (PowerPoint, hands-on activities, handouts, training specialists, etc.), what content specific to disability and accommodations they trained on (etiquette and interaction, setting up accessible polling place, using accessible voting equipment features, accommodations available, etc.), and how administrators trained on each specific topic. Training logistics questions focused on what voting equipment was utilized in the county (Diebold, ES&S, touch screen, AccuVote, etc.), how long training sessions lasted, how many trainings were offered, and how many poll workers were in each session. Questions

addressing major challenges and innovative ideas and suggestions were broad and left open so as to solicit honest, thoughtful, and unique answers from administrators.

From the interviews, we learned that the most popular and, in many cases, the only training methodology used is lecture/PowerPoint presentation. Administrators that use this training method also usually include a poll worker training booklet of upwards of fifty pages of important information poll workers are supposed to read and know. Also, almost every administrator stated that they trained on disability etiquette, how to set up accessible voting machines, and how to administer curbside voting. However, few clerks trained on how to set up an accessible polling place, how to use accessibility features on a voting machine, and accommodations available to people with disabilities *outside of* curbside voting. The average length of time that administrators stated they spent on training was between 1 ½ to 2 hours. Nearly every administrator stated that lengthening training times was not an option. Finally, almost every administrator, for various reasons, had reservations about giving poll workers evaluations post-training and post-election.

Common needs expressed by County Clerks included the following:

- There is a need for more information on accessible signage and placement of signage
- Checklists or visual aids on what accessible equipment and accommodations are available and how to use them would be helpful, especially aids that use real pictures
- There is a huge need for *more* poll workers, especially younger, tech savvy workers. This would help with many Election Day issues
- Poll Workers understand information at training, but lose that information by Election Day and end up implementing procedures incorrectly or forgetting about accommodations available. There is a need to make information readily available and usable on Election Day for poll workers to review.
- Interactive and hands-on training modules are popular and well received but are hard to implement in large group trainings
- Funding constraints prevent County Clerks from making some improvements

PHASE 2: POLL WORKER TRAINING DEVELOPMENT

After completing Election Day Experience Surveys and County Clerk Interviews, we moved into Phase 2 – Training Development. During this phase, we used information collected during our research to develop poll worker training materials. After examining the information gathered during the research phase, we were able to point out major focus areas that both voters with disabilities and Election Administrators identified as being problematic or challenging, which will be explained below. Next, we brainstormed all of the points of contact that we possibly had to influence a poll worker. Finally, we gathered existing information on best practices in training adults in order to put together the most effective poll worker training plans. Training materials that were developed during this phase included a suggested Pre-Election Poll Worker Training Curriculum and an Election Day Picture Guide for poll workers to use as a job aid.

FOCUS AREAS

Interviews with voters and Election Administrators made it obvious to us that there were four main areas to focus on when developing training materials for poll workers. This included the following topics: poll worker knowledge of how to use accessible voting equipment, accessible set-up of polling places, accommodations available to voters with disabilities, and how to incorporate more checklists and job aids in poll worker trainings and on Election Day. All materials developed during this phase addressed each of these topics.

POINTS OF CONTACT

While brainstorming with fellow RAAV partners and Election Administrators, we were able to identify three different points of contact in which we could use materials and training to influence poll workers: Pre-Election Training with Administrators, Pre-Election Poll Worker Training Sessions, and Election Day job aids for poll worker use.

Pre-Election Administrator training was identified as being important because Election Administrators control the knowledge and materials available to poll workers. In many cases, administrators enjoy creative freedom to develop their own training plans based on suggested knowledge from the Secretary of State and the U.S. Election Assistance Commission. This creative freedom allows administrators to develop unique and exciting training materials that fit their own personality and training styles. However, because of this freedom, there is also the risk that some knowledge conveyed is less than complete or is inaccurate. If an administrator is not trained or up-to-date on accommodations or ADA polling place guidelines, then there is no way that their poll workers will be able to access the necessary knowledge or skills they need in order to run an accessible polling place. For these reasons, we included Pre-Election Administrator training as an important component in poll worker training materials.

Pre-Election Poll Worker training is perhaps the most popular and focused on the area of poll worker training. This is the day that every administrator and poll worker uses to guarantee that

poll workers have the information they need on Election Day. Pre-Election poll worker trainings are used to get a large volume of information out to the most poll workers in the least amount of time. For most poll workers, this is the only opportunity they have to learn the ins and outs of running a polling place, how to interact with various types of voters, and how to ensure that necessary Election laws are being respected and carried out. Pre-Election Day training is most commonly carried out by using a PowerPoint Presentation, disseminating hand-outs, and performing equipment demonstrations.

Election Day job aids were the final point of contact we identified as a way to influence poll workers. Job aids consist of anything available to poll workers at a polling place on Election Day to help them perform their jobs more effectively. These have a high capacity to help poll workers, but are surprisingly under-utilized according to our research. Job Aids are also the only way to deal with issues regarding poll worker retention of information. Election Administrators have to control over the poll workers ability to remember information or memorize processes; however, with the availability of job aids, administrators at least know that all of the information a poll worker needs is readily available for them to use on Election Day at their polling place.

BEST PRACTICES ON TRAINING ADULTS

While developing training materials, we also wanted to be sure that the materials we were developing were in line with existing knowledge on best practices for training adults. This is especially important because so many administrators expressed frustration at the challenges that come along with the prevalence of elderly poll workers, especially regarding highly technical information and retention of information. This section will explain some concepts we followed in creating poll worker training materials in order to ensure that materials developed would be successful and effective for adult learning.

The first best practice suggestion is the use of mixed methods when training adults. Adults learn in different ways and what is a learning strength for some is a weakness for others. Some people may need to read the information in front of them as they hear the trainer speaking it. Others might learn best by having the opportunity to get hands-on experience with the information. Still others are auditory learners and can simply listen to someone talk.. Therefore, presenting materials in different ways is necessary when training a group of adults. Further, by using different styles, adults will be more likely to remember and use what is being taught.

Finally, going along with the concept of mixed methods, the same method should not be used repeatedly for a long period of time. Adults get bored, overwhelmed, and tune out when the same method is used for too long. If someone is bored and tuning out, they most likely will not learn or remember the information that is being presented to them. Using mixed methods and switching up training techniques will encourage more participant engagement, information retention, and overall enjoyment for both poll workers and trainers.

The next concept to consider when training adults is that adults learn more by participating. As adults, we need to be involved and engaged in our own learning process. When someone is talking at us for a long period of time, it is easy to check out. This is especially true for topics that involve a lot of processes or complex information. Adults need to try on these tasks and information, make it familiar and relevant to us, practice it, and experience it. Participating in the learning will help adults better understand the concepts and retain the information. This type of participatory learning also encourages collaboration and knowledge transfer between poll workers who will most likely be working together on Election Day. Collaboration and knowledge transfer are two things that administrators should be encouraging in order to have an effective polling place, so it makes sense to start this process in training before Election Day gets here.

Another concept that is suggested for encouraging adult learning is using handouts. However, these handouts need to be thoughtful, well-designed, and paired with other methods of learning in order to be truly effective. Effective handouts will streamline large, complex bodies of knowledge into easy to understand, operational parts. Handouts or reference sheets should act as route maps, giving poll workers a step-by-step process of how to get from point A to point B while meeting the goals and objectives they are supposed to meet. Checklists and step-by-step guidelines following this concept can provide directions that will encourage and promote poll worker success on Election Day.

Next, when training adults, it is important to keep in mind that adults learn best when new information is reinforced and repeated. Adults need to hear things more than once. They need time to master new knowledge, skills, and attitudes. In order to encourage learning and retention, information needs to be reinforced at every opportunity.

Finally, when developing a training, trainers need to be cognizant of different learning exchanges that should be happening. Successful trainings will include all three of the following exchanges. The first exchange, and most common, is Facilitator to Participant. This consists of a facilitator presenting his or her expertise and information to the participant to learn and remember. The next exchange that should be used is Participant to Participant. This consists of poll workers learning from each other through small group work or partnering. This could also be accomplished through dialogue and group discussion. This type of exchange is especially important for poll workers because this is what they will be doing on Election Day - learning from and with each other. The final exchange is Participant to Facilitator, when a participant has the opportunity to use their knowledge and experience to better inform the facilitator. This comes from the idea that participants bring their own experiences with them and often times have experience that is different than that of the facilitator. Also, this type of learning can help the facilitator understand what participants already know and what information is still needed to ensure poll worker success. This is most likely accomplished in question and answer sessions, discussion and dialogue sessions if the facilitator sets up a really open, informal training environment, or through the use of training and Election Day evaluations.

The most important takeaway from this information is that the traditional style of poll worker training where poll workers sit for two hours and listen to a trainer talk about a PowerPoint presentation does not work. It does not follow best practices for training adults and it does not set poll workers up to be effective and successful. Unfortunately, many administrators who are up against severe time constraints and a small budget rely on this type of training. Traditional PowerPoint / lecture style training allows administrators the opportunity to get a large amount of information to a large group of people in a small amount of time with the least expenditure of resources. However, it is certainly not the most effective way to ensure that poll workers are trained and ready to administer one of the most important aspects of our democracy. All training materials that we developed and suggested for poll worker training use followed these best practices and encouraged administrators to follow them as well.

MATERIAL DEVELOPMENT

By utilizing information on important focus areas, points of contact with poll workers, and best practices in training adults, we were able to develop a package of in-depth and well-rounded training materials. For Election Administrator training, we relied on one-on-one conversations with Election Administrators to explain poll worker training materials and the rationale behind each training topic. Regarding Pre-Election poll worker training, we developed a suggested training curriculum which included a sample PowerPoint presentation, lesson plans, hands-on activities, handouts, checklists, and questions for dialogue. Finally, we developed an Election Day Picture Guide which could be used by poll workers at their polling place on Election Day to help them carry out important disability specific processes.

COUNTY CLERK / ELECTION ADMINISTRATOR TRAINING

As mentioned above, we used one-on-one meetings to brief Election Administrators on important topics and processes that we felt they should be training on. This allowed us the opportunity to speak in-depth about election laws and poll worker expectations. We also used the one-on-one meeting to gauge the administrator's understanding of laws, processes, and training materials. This interaction gave administrators the chance to ask detailed questions and make last minute changes to poll worker training curriculum and job aids.

PRE-ELECTION POLL WORKER TRAINING

Based on information regarding best practices in training adults, we developed an in-depth training curriculum for administrators to use during the Pre-Election poll worker training. We developed a lesson plan for each training focus area identified in the research phase of our project (using voting machines, setting up accessible polling place, and carrying out available accommodations). Each lesson plan included a purpose for the training module, supplies needed to carry it out, goals of the module, a sampling of activities to choose from, and questions for dialogue. Each lesson plan included a variety of activities to choose from including PowerPoint slides, hands-on simulations and activities, handouts, and questions for dialogue. By offering this

sampling, administrators could choose which activities worked best for their training style. Having mixed methods also follows suggested best practices in training adults.

The first lesson was on poll worker expectations and responsibilities. The purpose of this lesson was to help participants understand their expectations and responsibilities as judges and become familiar with tools that would be available at their polling place to help them carry out these responsibilities. Regarding disability and accessibility, this module introduced the tools and materials that would help them carry out required accommodations and communicate with certain voters with disabilities (pencil grips, magnifiers, rulers, pads of paper, extra chairs and tables, Braille and large print handouts). We felt that by telling workers about the available tools and showing them how and when to use those tools, poll workers would not be overwhelmed or confused when a voter with a disability came in and needed those tools or accommodations. Poll workers would not be forced to problem solve on the spot and guess the best way to handle that voter, this problem solving would have already happened in the poll worker training. Administrators could then choose to set these tools out on a table in the training room to allow poll workers to look at them and practice using them. However, because of the commonality and everyday use of these tools we did not feel that this hands-on practice was necessary.

The next lesson dealt with setting up an accessible polling place. The purpose of this lesson was to show poll workers how to effectively set up a polling place with attention to needs of all potential voters. Instead of bogging down poll workers with complex and detailed information on ADA guidelines, some of which poll workers have no control over, we focused on presenting easy actions that poll workers could do in order to ensure a more accessible voting experience. This lesson took poll workers through the entire voting process – parking, approaching the polling place, entering the polling place, finding the voting room, maneuvering around the voting room, and using the voting equipment. During each step of the process, poll workers were briefed on actions they could do in order to minimize common accessibility issues that voters face. Activities administrators could choose from included suggested PowerPoint slides with pictures of accessible voting places, a polling place simulation activity where the training room was set up like an actual accessible polling place, and a polling place set-up map that poll workers could look at as the facilitator was presenting and then take home with them. This showed a picture of an accessible polling place inside and outside, step-by-step instructions to set-up an accessible polling place, and a checklist to follow when setting up the polling place. The lesson ended with suggested questions for dialogue.

The third training topic focused on using accessible voting machines. The purpose of this lesson was to familiarize poll workers with voting equipment and show them how to use different features on the machine. The goals of this lesson were for participants to be able to confidently set up an accessible voting machine, run through a ballot in regular screen mode, run through a ballot in audio mode, learn how to change contrast and text size, and understand how to adjust the screen tilt. We developed a PowerPoint presentation for this lesson but strongly encouraged trainers to use hands-on, interactive activities for this section. Voting machines are complex and

complicated, especially for older poll workers, therefore hands-on, interactive methods were strongly encouraged for this part of the training. Hands-on activities included small group demonstrations, individual demonstrations, and voluntary practice days. We also included a voting machine features checklist so trainers and poll workers could be confident that they addressed all of the important features of the voting machine. The lesson ended with suggested questions for dialogue.

The fourth training topic addressed voter interaction and accommodations. The purpose of this training was to show poll workers how to interact with various voters with different needs. After this module, poll workers would be familiar with different needs voters might have, especially voters with disabilities. They would also be familiar with accommodations they can offer to address each of those needs. Activities included suggested PowerPoint slides, voter interaction demonstrations, voter interaction role plays and skits, and a handout on disability etiquette that poll workers could take home with them. Skits and demonstrations addressed the following situations: available accommodations and how to offer them, interacting with voters with visual disabilities, people-first language, interacting with a voter who is deaf or hard of hearing, and interacting with a voter with an intellectual or developmental disability. The lesson ended with suggested questions for dialogue.

The final training topic addressed the specific accommodation of Curbside Voting. The purpose of this lesson was to prepare poll workers to effectively implement curbside voting while respecting the rights and privacy of the voter. This lesson plan included a sample PowerPoint slide, curbside voting demonstration, and curbside voting small group role plays. The lesson ended with suggested questions for dialogue.

The cost to print one Election Worker Training Guide was $40 at FedEx Kinkos. This included plastic spiral binding, double-sided pages, color printing, dividing tabs, and a plastic cover and back binder.

ELECTION DAY JOB AID

The final training material we produced was an Election Day Picture Guide. This guide was available at select polling sites on Election Day for poll workers to use when they needed help remembering how to carry out a certain task. The guide was based on a similar guide that the Saint Louis City Election Administration created and currently use at its polling sites. Printed on 11"x17" paper, the guide features step-by-step picture guides on how to carry out important Election Day task. In Saint Louis City's guide, they featured such things as polling place opening instructions, touchscreen and optical scan opening and closing instructions, how to change paper in the machines, how to handle provisional ballots, and closing the polls. Because of the large size of the paper, Saint Louis City was able to use large pictures and large print for each process, which is necessary for some older poll workers, those with low vision or for people who are more visual learners.

In examining the guide, we really liked the use of pictures and the format of the step-by-step instructions. It is clearly in line with best practices in training adults, specifically regarding creating usable and successful handouts. However, Saint Louis City's guide did not feature any information on accessibility, disability, or accommodations. We decided to create our own guide, based off of Saint Louis City's original guide, specifically addressing information poll workers need to know on accessibility and accommodations.

The guide starts out with step-by-step picture instructions on how to set up an accessible polling place with words underneath describing each step in the process. It takes poll workers from the parking lot, to the entry way, down hallways and pathways, and inside and around the actual voting room. Poll workers are introduced to common but easily addressed accessibility issues in each area of the voting process and are given tips on how to minimize or eliminate such issues. On the back side, poll workers can see a checklist of steps to perform in order to set up an accessible polling place.

The next part of the guide addresses accessible voting machines. Since most Election Administrators already trained poll workers on setting up and starting the voting machines, we decided to focus on actually using the voting machine. It is important for poll workers to know how to use voting machines because oftentimes, if a voter has a question during the voting process, the poll worker is the person who is expected to answer it. Further, if a poll worker is confident and comfortable using the voting machine features, they will be more likely to feel comfortable and confident at their polling place when voters are using the machines. The guide featured step-by-step picture instructions on how to cast a regular ballot, change the screen from regular to large print, and change the contrast from low to high. It also featured a step-by-step guide on how to cast an audio ballot, which specific instructions on which buttons perform specific functions.

The guide concluded with step-by-step instructions on how to carry out curbside voting, with a specific section on the do's and don'ts of curbside voting.

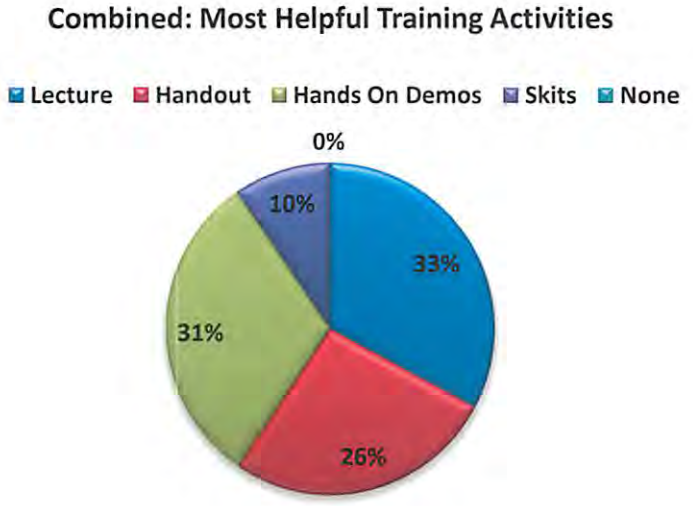
The cost to print one Election Day Picture Guide was $25 at FedEx Kinkos. This included legal size cardstock paper, plastic binding, double-sided pages, and color printing.

PHASE 3: PILOT AND FINDINGS

Materials which were developed in Phase 2 of our poll worker training project were piloted in the Missouri State Primary Election in August, 2012. Four different counties piloted training materials: Laclede, Cape Girardeau, Green, and Christian. Election Administrators and poll workers were given evaluations to give their feedback on the poll worker training and Election Day job aid. Results from the pilot will be described below.

MOST HELPFUL TRAINING ACTIVITIES

Poll workers reported that the most helpful training activities were a combination of lectures, handouts, and hands-on demonstrations. Only 10% of poll workers stated that skits were helpful. This is consistent with the best practice in training adults which states that mixed methods should be used when training adults. The graph below shows that 31% of poll workers preferred hands on demos, 33% preferred lectures, and 26% preferred handouts.



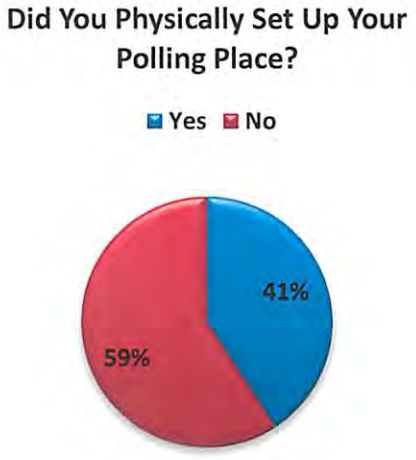
POLLING PLACE SET-UP

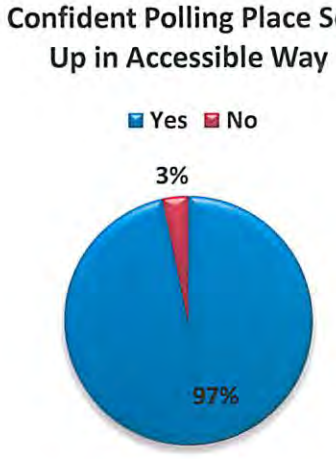
The next section of evaluation addressed polling place set-up training materials. The most common type of polling place set-up training was handouts, followed closely by lecture/PowerPoint. Surprisingly, overall, 9% of poll workers reported they received no training regarding properly setting up their polling place, with 18% of poll workers in one specific county reporting they received no training in this area.

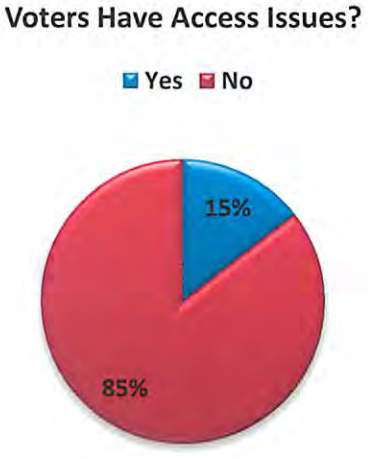
It is also interesting to note that in each county the majority of poll workers felt that their polling place was set up in an accessible way (between 95% and 100%). Yet, when asked if they witnessed a voter having accessibility issues in the polling place, a significant number of poll workers stated yes, there were voters who experienced problems with accessibility at their

polling place (between 10% and 26%). This suggests that there may still be a lack of understanding among poll workers about what it means for a polling place to be truly accessible.

The graphs below state the following information. About 30% of poll workers were given handouts on polling place set-up and 29% viewed a PowerPoint/lecture on this material. 23% had hands on training, 9% had skits, and 9% received no training on setting up an accessible polling place. Only 41% of poll workers physically set up their own polling place, with 59% reporting that someone else set the polling place up. 97% were confident their polling place was set up in an accessible manner, with 15% stating they witnessed a voter having an accessibility issue.





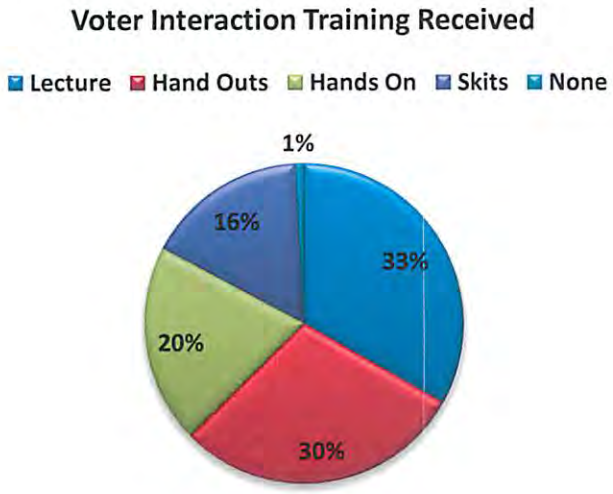


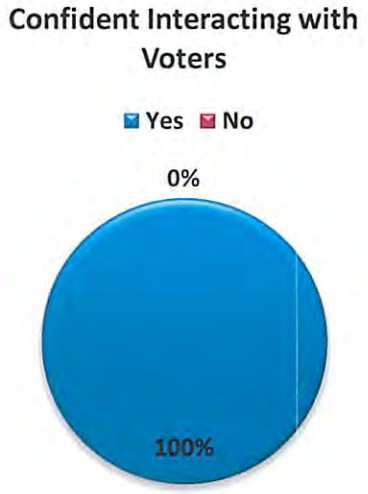
VOTER INTERACTION

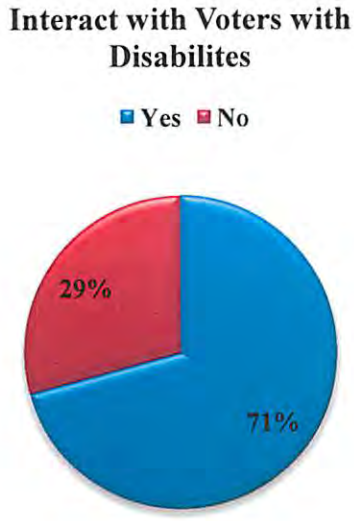
The next part of the evaluation addressed voter interaction. The most common type of training received regarding voter interaction was PowerPoint/lecture (33%) followed closely by handouts (30%). 20% of poll workers were trained with skits, 16% received other hands on training. Every

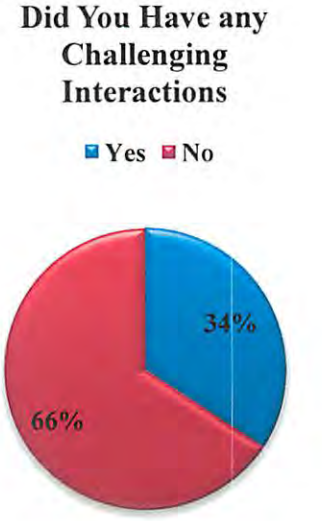
poll worker surveyed (100%) reported that they are comfortable interacting with voters on Election Day. Overall, 29% of poll workers indicated that they interacted with voters with disabilities. While 100% of poll workers reported confidence in interacting with voters, 34% reported having challenging interactions with voters.

It would be interesting to see what kinds of interactions are considered challenging by poll workers. Also, further information is needed on how poll workers handled specific situations that required understanding of accessibility and accommodations. Poll worker confidence does not equal poll worker competence in areas of interacting with voters with accessibility needs. Further research should focus more on identifying what constitutes a 'challenging' interaction and methods used to address accessibility needs.



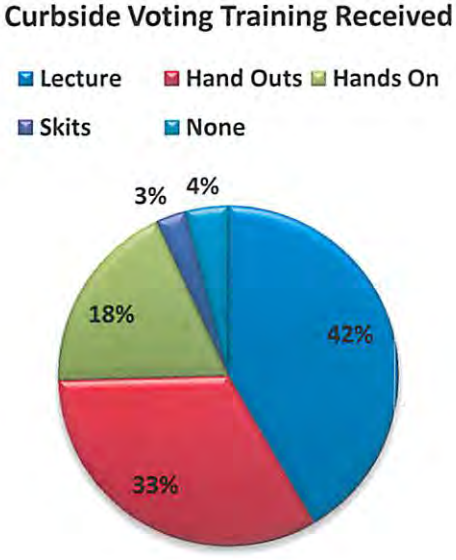


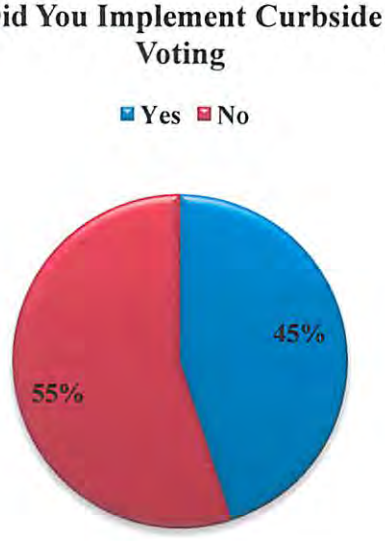




CURBSIDE VOTING

The next part of the evaluation addressed curbside voting. PowerPoint/lecture was the most common activity used to train poll workers on curbside voting (42%), followed closely by handouts (33%). 18% of poll workers were trained using hands-on techniques. Overall, almost half of poll workers stated that they, or someone at their polling place, implemented curbside voting (45%). Of those that implemented curbside voting, a very small percentage, 4% overall, indicated that they did not feel confident carrying out the tasks associated with curbside voting. The main issue with curbside voting seems to be a lack of signage letting voters know this is available for those who need it and an under-developed process for letting poll workers know that someone outside is waiting to curbside vote.





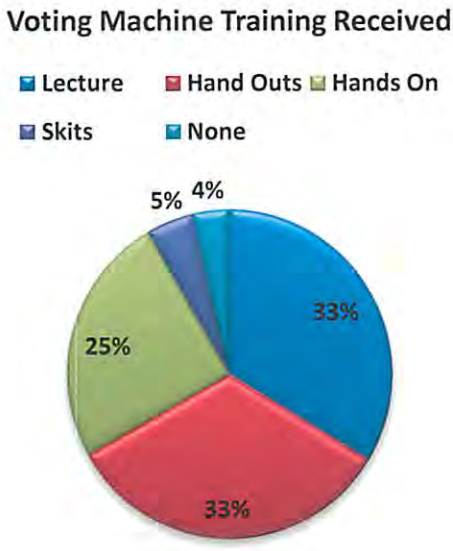
USING ACCESSIBLE VOTING EQUIPMENT

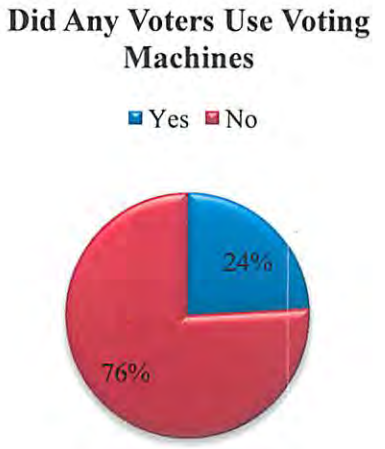
The next part of the evaluation addressed using accessible voting machines and touchscreens. The majority of training on using accessible voting machines consisted of lecture/PowerPoint (33%) and handouts (33%), despite an attempt to encourage more hands-on training with voting machines. Significantly more poll workers reported having some kind of hands-on training on voting machines than on other topics (25%).

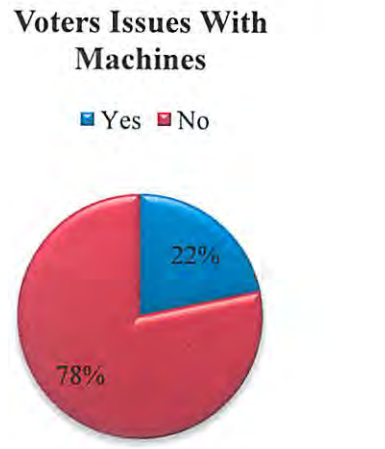
Overall, 24% of poll workers evaluated stated that the voting machine in their polling place was used by voters. Of those that reported machine use, 22% stated that a voter had issues or challenges using the voting machine.

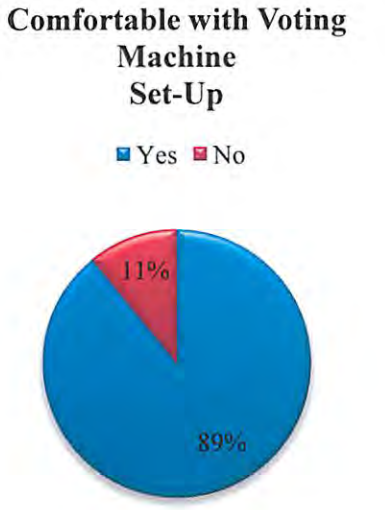
Interestingly, poll workers reported differences between confidence with setting up voting machines compared to confidence using accessible features on the machine. Overall, 11% of poll workers were not confident setting up their electronic voting machines. In comparison, 29% of poll workers were not comfortable using the accessible features on voting machines (over half, 52% of poll workers, in one county stated that were not comfortable using the accessibility features of the accessible voting machines).

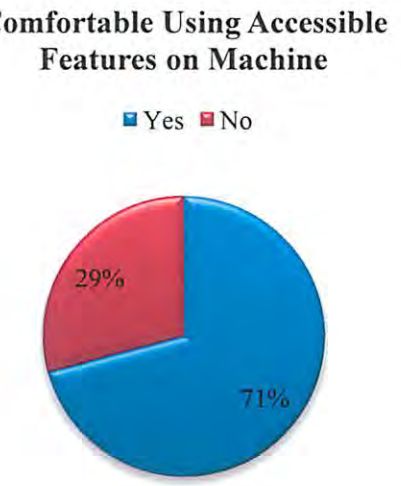
This indicates that there may be less emphasis in training on how to utilize features of the machine and that much of the focus is on setting up and closing down the machine properly. This could affect the probability of a poll worker encouraging people with accessibility needs to use the voting equipment and most likely affects the poll worker's ability to assist a voter with accessibility needs in using accessible features of the machine.









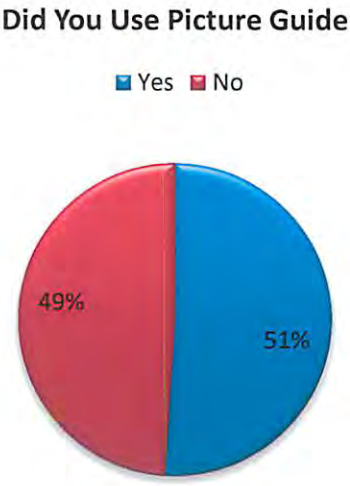


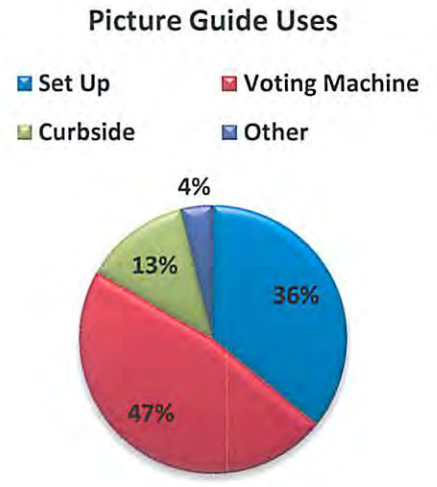
ELECTION DAY PICTURE GUIDES

Finally, poll workers were asked for feedback on the Election Day Picture Guide. Election Day Picture Guides were available in 93% of polling places evaluated. Just over half (51%) of poll workers exposed to the Election Day Picture Guide reported that they used it to help them during the Election Day (close to 70% of poll workers in one specific county reported using the guide). Of those poll workers who used the picture guide, a majority (90%) reported that they found the information in the picture guide to be helpful in carrying out their poll worker duties.

The most common use of the Election Day Picture Guide was for Electronic Voting Machine Assistance (47%). The second most common use was for polling place set-up, with 36% of poll workers overall stating that they used the picture guide to help them with this task. A very small percentage of workers used the picture guide to assist with curbside voting (13%).

It is interesting to note that the area where poll workers were the least confident (using accessible voting machines) is the same area where they sought the use of the Election Day Picture Guide the most. This suggests that the picture guide did fill a training gap for some poll workers. One County Clerk, in retrospect, suggested that the Picture Guides also would be a great option for those Election Administrators who had limited time and resources to train all of their poll workers on every piece of information they needed to know for the Election.





CHALLENGES

TRAINING TIME CONSTRAINTS

The main challenge we ran into with the curriculum development and implementation was with time constraints. Many County Clerks we spoke with only allowed between 1 ½ to 2 hours to train poll workers on everything they needed to know for Election Day, including logistics of the day, checking voters in, relevant regulations to follow, polling place set-up, using voting machines, interacting with voters, and specific accessibility and accommodation information. This is a huge amount of information to cover in a short amount of time. A few County Clerks gave feedback stating that even the PowerPoint/lecture portion of the curriculum developed was too lengthy to fit in the allotted time and keep poll workers' attention. This left very little room for hands-on training, interactive activities, or demonstrations.

FINANCIAL CONSTRAINTS

Another challenge we heard from County Clerks was that they actually would like to spend more time developing training materials and invest more time into adequately training their poll workers. However, they have experienced a shortage of resources (time and money) that would allow them to do such things. Poll workers already only get paid a very small amount of money to spend a few hours at training and a whole day working at an Election. This, plus the fact that Elections take place on a Tuesday in the middle of the work week, lead to a shortage of qualified poll workers.

In addition, to require more training time for poll workers would mean County Clerks would need more money to invest in paying poll workers for that extra time. Further, if County Clerks and Elections staff wanted to develop their own updated county specific picture guides and training materials, they would need more money for printing such materials and keeping them updated with ever changing guidelines and equipment. This makes updating and improving processes difficult, if not impossible, for many Election Administrators.

DIVERSE COUNTY SPECIFIC PROCESSES

Perhaps related to the problem of time constraints, we also found that there is extreme diversity between different counties and their voting machines and training processes. This leads to a great variety of training curriculum between counties. We found that some counties we talked with went above and beyond expectations, offering a multitude of hands-on opportunities to use voting machines and even separating poll workers into specialized roles in order to train people on more in-depth processes (especially regarding technology and voting equipment). One County Clerk stated that when he trained poll workers extensively on voting machines and encouraged them to offer this to all voters, they actually had record numbers of voters use the voting machine to cast their ballots.

While there were a few counties that went above expectations, there were also some that we found were not meeting the minimum training requirements that should be expected. For example, some counties did not even include accessibility and accommodation information in their standard Election Judge Training Manual, a paper handout with upwards of 50 pages of Election Day information for poll workers. If the information was not in this manual, we have reason to believe it was not being trained on in the actual poll worker training session as well. Other County Clerks expressed reservation about training in depth on the voting machines and curbside voting as they did not want to "encourage poll workers to encourage voters" to use such accommodations. There was a fear among some County Clerks that by advertising these accommodations and encouraging poll workers to use them, they would inadvertently encourage voters who do not have a need for that accommodation to take advantage of it.

Having such diversity in training curriculum, voting equipment, and poll worker expectations across the state made it very difficult to develop materials that would be helpful to different counties.

CONFUSION WITH ADA POLLING PLACE GUIDELINES

Another problem we ran into with curriculum development and implementation was that there seemed to be confusion among some Election staff on what they were required to do under the ADA polling place guidelines regarding accessibility. We received excessive feedback from one county in particular which expressed a lot of pushback against our polling place set-up training recommendations. All recommendations made in the curriculum were straight from the Department of Justice and the ADA Polling Place Guidelines. To receive such pushback from officials on these federally mandated guidelines suggests that there is still a lack of understanding among those in charge of county Election administration on their accessibility requirements. If County Clerks and training staff are confused and unaware of their requirements, then it is almost certain that they are not training poll workers and preparing them appropriately to run a truly accessible polling place.

LIMITED EVALUATION TECHNIQUES

A major limitation in Election Administration is a lack of poll worker evaluation techniques and an overwhelming opposition to evaluating poll worker trainings and Election Day happenings. Evaluation is crucial in order to assess if the poll worker training being administered is effective and gauge what information is still needed from workers. The only way processes and trainings can be improved is by utilizing an effective evaluation tool. Also, it is not enough to evaluate a poll worker at the poll worker training session. Such evaluations only tell you what the poll worker learned that day. They are not effective in evaluating if that training helped the poll worker successfully carry out necessary procedures on Election Day. An effective evaluation technique to assess poll worker knowledge on Election Day is also needed in order to improve poll worker training materials and processes. Most administrators are very opposed to this for

various reasons, from fear of receiving negative feedback to a feeling that evaluations will scare the already limited population of poll workers away.

Finally, regarding evaluation of our poll worker training curriculum and Election Day job aids, we were unable to create and use an in-depth open ended evaluation method. Per County Clerk request, we limited the number of questions we asked and only allowed yes/no or multiple choice answers. While this may have increased the number of poll workers who took the time to complete the evaluation, it also made it impossible to collect more specific and detailed information from poll workers. Many of the areas where the data is lacking is due to that inability to ask open ended questions. Further, some necessary data would best be collected by visual observation of poll places on Election Day by people trained and well versed in voting accessibility and accommodations. We were unable to contribute the people power or resources that would have been necessary to have these people watching every polling place which piloted training materials.

Also, we were unable to place evaluations or survey actual voters with disabilities at each pilot site. The data in this report is reflective only of the reactions and experiences of poll workers and County Clerks. To get a true picture of the effect of our developed training curriculum and job aids, we need to evaluate how it affects the experience of voters *and* poll workers.

SUGGESTIONS FOR FUTURE ACTIVITIES

Over the course of the poll worker training project, we were exposed to many different ideas and suggestions for poll worker trainings. Many of the ideas came too late to pilot and evaluate. However, they deserve a mention in this report as possible ways to improve our piloted materials specifically and poll worker trainings in general.

TRAIN BASED ON ELECTION DAY JOB AIDS

The first suggestion from a few well-known Election Administrators is to move away from a heavily information focused poll worker trainings and focus on training poll workers to effectively use job aids. Poll workers are increasingly expected to learn more and more complex information and processes. It is unlikely that a training can be developed that will effectively teach poll workers all of those processes and complex information while still respecting the funding and time constraints that County Clerks are facing. Therefore, it was suggested that Election Administrators focus on developing high-quality, process specific job aids for poll workers to use on Election Day and spend the majority of training sessions training poll workers on how to effectively use those job aids. This might solve the issues of too much information, lack of information retention, and limited training time and funding.

UTILIZE ROVING DEPUTIES FOR ELECTION DAY ACCESSIBILITY NEEDS

Another interesting idea that was suggested is to add one more point of contact with poll workers in our training curriculum. Roving Deputies play an increasingly important role in many voting jurisdictions. These deputies could also be trained on accessible polling place set-up and disability specific information. They could be given checklists regarding accessibility and accommodations which they would fill out when they visit each polling place. This could help insure that polling places are physically accessible on Election Day and help begin the troubleshooting process in order to make polling places more accessible in the future.

ASSESS POLLING PLACES IN PERSON BEFORE ELECTION DAY

Another suggestion along the same lines is to have each poll supervisor go with the County Clerk to each voting place in person before Election Day. This has been done in Jefferson County, Missouri, before and the County Clerk stated they saw great results. They were able to see accessibility issues before they happened and create plans to address those issues in advance, including improved signage, alternate pathways, and better voting room flow. Because of this pre-election planning, the supervisor was aware of potential unavoidable problems that might happen on Election Day and knew how to handle them when they came up.

CREATE IMPROVED ACCESSIBLE SIGNAGE

Something that County Clerks and administrators suggested more of, which we were unable to do during this project, is create and use more effective and accessible signage. Even voters in

post-election focus groups stated that polling place signage needs to be improved. Signage should clearly show voters what their voting options are, what accommodations are available, and what they can do in order to get assistance. Signage should also clearly point out accessible pathways and entrances.

EXPERIMENT WITH AND EVALUATE INNOVATIVE TRAINING METHODOLOGY

Regarding training methodology, there are two very unique and interactive training models being used in Missouri which are interesting and should be noted. We were unable to evaluate these training styles, but feel that it would be worthwhile to look into them and gauge their effectiveness. The first style is an interactive round-robin style training. This training is used in a largely rural county. The Election staff in this county stated that they decided to no longer use lecture and PowerPoint trainings because poll workers were not retaining information and there were too many errors. Instead, they used a round-robin style training. The training had twelve stations and poll workers were broken up into groups of six or seven. Each group visited a station for 15 minutes at a time to learn about different training topics and get hands on practice. They stated that poll workers loved this style of training and felt more prepared than they do following a PowerPoint based training. They also felt as if the monotony of regular trainings was broken.

However, there are a few setbacks to this style of training. First, it lasted four hours instead of the regular two. A larger training space was needed, it took a bigger time commitment from staff in order to successfully implement all processes, it cost more money overall, and was overall more wearing on the Elections staff. However, despite these setbacks, staff in the Elections office stated that the benefits of the training outweighed the extra costs.

The other interesting methodology is a mock election style of training. This training is used in a largely rural county with few voting places and few poll workers. The training room is set up exactly like a polling place should be. The County Clerk brings in two or three precincts at a time for training so that people are trained alongside the poll workers they will be working with on Election Day. Each group of workers goes through every process of Election Day together in a very interactive and hands-on training. Election staff pose as voters with various needs and poll workers are able to practice problem solving skills that they will need on Election Day in order to be successful. This type of training happens once every major election year. Again, we were unable to evaluate this method but feel that it would be useful for someone to evaluate its strengths and weaknesses in the future.

CREATE MORE NETWORKING AND PROBLEM SOLVING OPPORTUNITIES FOR ADMINISTRATORS

Another observation that came out of this project is that there is a lot of value in opportunities for Election administrators and training staff to come together and brainstorm solutions to challenges and ideas for improvement in elections. This goes beyond common election administrator trainings and information sessions and puts the election administrators and staff in the seat as

experts. Almost no challenge is a new challenge in elections; if one administrator is dealing with a new problem, it is likely that other administrators have dealt with it before and have come up with unique and innovative ways to deal with it. This idea sharing and networking could lead to more effective trainings and processes across the country. It would only be strengthened by then inviting actual voters who experience challenges or difficulties at the polls to share their insights and experiences and offer their own suggestions in an open and honest dialogue.

The following are two ideas that came out of this type of process this past year. First, many administrators experience challenges with voters who are unable to stand in lines for long periods of time. Legally, voters with disabilities who can't stand in line for long periods of time are allowed to cut to the front of the line as an accommodation. However, this can cause controversy with other voters who may not understand the reasoning behind the cutting and feel that it is unfair, as they have to wait the full time. Many voters with disabilities also do not feel comfortable cutting, as they do not want to be perceived negatively as rude or lazy. Finally, administrators are uncomfortable educating about this accommodation and enforcing it because they fear people will take advantage of it and use it when they do not really need it. One administrator has solved this issue in her area by instituting a "green card" system. If a voter cannot stand for long periods of time but does not want to cut the line, the poll worker simply gives a color coded card to the person directly behind that voter in line. The voter takes the same color of card, and sits in a chair, waiting for their turn to vote. Once the voter with the card gets to the front of the line, the poll worker at the check in table knows that another voter is comfortably waiting in a chair for their turn to vote. Of course, if the voter with the disability prefers to cut to the front of the line, this option is still available to them as well.

Another administrator wanted to figure out how to better evaluate her poll workers during their poll worker training. She wanted to be able to see what poll workers were learning as the training was happened so she would know what topics needed more time and which were nearly mastered. She instituted a "paddle game" where she would ask questions during the training to gauge what information had been learned. Once a question was asked, poll workers would hold up their paddles to indicate their answers. The trainer was able to see if a majority had gotten the information they needed to know or if she needed to reiterate the main points. This also showed her if there were particular poll workers who needed extra one-on-one attention regarding certain topics. This was a fun and non-threatening way that she was able to assess the effectiveness of her training with poll workers.

REQUIRE ANNUAL ACCESSIBILITY AND DISABILITY TRAINING FOR ADMINISTRATORS

Finally, as with any other profession, we feel it is necessary to continually offer trainings to election administrators and staff on issues of accessibility, accommodations, and disability. Even though the ADA was passed in 1990 and other pertinent election laws were passed well before then, it is obvious that there is still confusion and misunderstanding about what is necessary,

what is legally required, and how administrators can make sure legal election-related accessibility requirements are being successfully carried out. We strongly suggest that these types of trainings and information sessions still be offered to staff and administrators and that a system of accountability is set up in order to ensure that administrators across the country are trained and up-to-date on the important accessibility and disability specific information that is necessary in order to run a truly accessible, successful election.

CONCLUSION

Poll workers are expected to learn and memorize a growing body of information in order to implement Election Day processes. This information is increasing becoming technology based, especially with the use of accessible voting machines and iPads as part of an accessible voting place. While this technology can go a long way in improving voting options for voters with disabilities, it is up to the poll worker to ensure the technology is available for voters who need it. Further, election administrators are expected to train these workers on more information with limited time and resources available to dedicate to this task. This creates a complicating and seemingly impossible challenge for many election administrators.

In order to ensure that poll workers are prepared to implement these processes and make them available, election administrators need to be willing to think outside their normal training processes. It is evident that a traditional pre-election PowerPoint presentation is not enough to prepare poll workers to be successful, especially when it comes to accessible voting technology. It will be necessary for administrators to be creative and flexible in order to meet the training needs of their poll workers.

The step-by-step picture guide, which was piloted and evaluated in the 2012 State Primary Election in Missouri, has been shown to be popular with both administrators and poll workers alike. Election administrators should consider adapting this and using it to supplement their training process to meet their needs.

Several challenges still exist, which have been identified in this report, when it comes to ensuring accessible elections for everyone. However, a multitude of resources and suggestions exist and are just waiting for administrators to utilize them in their effort to improve elections. The Research Alliance for Accessible Voting (RAAV) is one such resource. Partners in RAAV can offer opportunities for networking and professional development, information on assistive technology and designing accessible voting machine interfaces, suggested practices for training poll workers and election administration in general, and up-to-date research on voting experiences and challenges for voters with disabilities, to name a few. Access these resources at www.accessiblevoting.org.

RAAV Research Alliance for Accessible Voting

Guide to Disabilities and Voting System Access Features

Abstract

This Guide is designed to assist anyone interested in or working in elections better understand the functional limitations of individuals with disabilities, how those limitations can impact voting, and what access features are available in accessible voting systems to help provide private and independent voting for individuals with disabilities.

This Guide was developed by the Association of Assistive Technology Act Programs as a partner on the RAAV Project.

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"The vote is the most powerful instrument ever devised by man for breaking down injustice and destroying the terrible walls which imprison men because they are different from other men."

~Lyndon Baines Johnson~

Introduction

The Help America Vote Act (HAVA), signed into law by President Bush on October 29, 2002, was designed to improve the overall voting system in America. Included in HAVA was the seminal requirement for each polling place to have at least one "accessible voting system" to support individuals with disabilities ability to vote privately and independently.

Post HAVA, voting jurisdictions worked diligently to implement the requirement for one accessible voting system per polling place by purchasing a variety of commercially available accessible voting systems with different sets of access features. Now that these systems have been deployed for a number of years, it appears clear that simply placing an accessible voting system in a polling place does not necessarily lead to widespread understanding or use of the system and its access features.

Purpose

This guide was developed to provide a concise overview of the functional limitations associated with various disabilities and the different access features (those typically found in existing accessible voting systems) that address those limitations. It is hoped this information will be valuable to election officials, voting system manufacturers, disability advocates, and others who want to support the use of accessible voting systems by individuals with disabilities enabling them to vote privately and independently.

Understanding Disabilities and Functional Limitations

It is always helpful to begin by reminding readers that a person with a disability is not defined by the type or number of functional limitations they may have – he or she is a person first and foremost. Based on census data, it is estimated that about 20% of the voting population has a disability or functional limitations due to age. Since many disabilities are not visible, simply looking at a voter is not an effective way of identifying any specialized needs a voter might have due to disability. Even when a disability is visually evident, that does not mean it is the only functional limitation the person has nor does it automatically translate into the need for some kind of "help". Individuals with disabilities are unique and will use different access features depending on their distinct needs.

By definition (Americans with Disabilities Act and Section 504 of the Rehabilitation Act), an individual with a disability has a physical or mental impairment that substantially limits one or more major life activities. These disabilities may fall into broader, more familiar areas such as vision, hearing, motor, or intellectual/information processing. For reference purposes, Appendix A provides a broader list of medical diagnosis of disabilities grouped under these broader areas.

A limitation is defined as a lack of capacity in an area that restricts functionality. For example someone with a mobility limitation might be able to walk, but only for a limited distance without the aid of assistive technology such as a cane, walker, etc.; or he or she might be unable to walk at all and require a wheelchair for mobility. To further understand functional limitations frequently experienced by individuals with disabilities, see Appendix B. This table provides descriptions of the activities associated with different functional areas.

Disability Etiquette

By nature, many of us want to help someone in need. We recognize someone with a flat tire, someone who has dropped their groceries or someone who is reaching for something high on a shelf as situations in which we should offer help. In these situations, it is appropriate to politely ask the person if they need assistance -- and only provide assistance if it is desired. The same is true for assisting individuals with disabilities.

The following are some basic disability etiquette guidelines:

- Speak directly to a person with a disability – not to a companion, personal assistant, interpreter or other support person.
- Be considerate of the extra time it may take for a person who is disabled or elderly to get things done, and give unhurried attention to a person who has difficulty speaking.
- Do not lean on or touch a person's wheelchair, service animal or other assistive device without permission.
- Do not assume someone with a disability needs or wants assistance in voting. Always ask before helping and respect a person's decision to decline.
- Do not stand by in case he or she needs help later. While the gesture seems supportive it can make both of you uncomfortable. If the person has declined assistance there is no need to "hover". In voting, this is particularly problematic since it can violate privacy.
- Even if the person appears that they need help, **DO NOT** impose your perception on the situation. You may be taking away his/her independence or you may even endanger the individual. The individual is the expert in knowing if they need assistance or not.

If someone does request assistance, make sure you are trained and able to provide the support needed. For voting, assistance could mean general support in registering or getting to the voting booth. It could also mean specific assistance needed to help an individual with a disability use a specific access feature. Hopefully someone at each polling place has the expertise needed to provide specific assistance when needed.

There are additional resources available from disability organizations (such as the United Spinal Association). They offer a free disability etiquette booklet that provides basic information as well as disability specific ways to help. (www.unitedspinal.org/disability-etiquette)

Functional Limitations and Access Features

Ensuring an accessible voting experience requires physical access to the polling place along with programmatic access of the voting experience, including checking in at the polling place, generating a marked ballot, verifying that marked ballot and finally casting the marked ballot. This guide does not attempt to address the issue of architectural access of polling places, however, it is obvious how critical this access is to voters with disabilities. The Department of Justice provides a checklist to use to evaluate the architectural accessibility of polling places, see http://www.ada.gov/votingchecklist.htm. Voting jurisdictions may also reach out to local community organizations to conduct access surveys of their polling places.

This guide focuses on making the voting experience of marking, verifying and casting a ballot accessible. This can be done by using the access features of an accessible voting system and/or using personal assistive technology that the voter brings with them to the polling place. Of course some individuals will choose to have human assistance to vote which certainly should be respected if that is their preference.

The legal definition of "assistive technology" is any item, piece of equipment, or product system, whether acquired commercially, modified or customized, that is used to increase, maintain, or improve the functional capabilities of individuals with disabilities. (Assistive Technology Act of 1998, as amended). Assistive technology can include mobility devices such as walkers and wheelchairs, hearing aids, glasses, electronic enlarging devices as well as hardware, software, and peripherals that assist people with disabilities in accessing computers or telephones. Those assistive technologies most comparable to the access features of a voting system are computer adaptations including screen enlargement software, text-to-speech (or screen reader) software, and alternative input devices (keypads, switches).

Table 1 provides a brief description of various functional limitations and identifies the types of access features that are frequently used to address those functional limitations. While each person with a disability is unique in their needs and requirements, this table is intended to provide a general framework for understanding the relationship between functional limitations and access features.

Vision Limitations - Blindness, Low Vision, Color Blindness

To be considered "legally blind" an individual has less than 20/200 vision in the better eye after correction, or less than a 20 degree field of view in the better eye after correction.

Individuals who are blind may rely on screen reading software, with speech or Braille output to use a computer. They may have speech on their smart phones to allow them to select appropriate keys and navigate phone based keypads. For movies and graphics, they may rely on added verbal description (narrated speech description) to access the information content.

Individuals who are blind may be unable to use a mouse and may require keys that can be "felt" to navigate through online or other electronic information.

There are many types of low vision, including poor acuity, "tunnel vision", clouded vision, "floaters" in the eye, peripheral vision only, etc.

People with low vision may need to enlarge fonts and images slightly or substantially using either electronic or manual magnifying. Electronic magnifying can be done via software on a computer or through stand-alone devices that take a picture or scan the text and then display it in an enlarged and/or enhanced version. Some individuals need to use specific combinations of text size and background colors, for example a 24-point yellow font on a black background, or to use specific fonts that are clearer for that individual to read.

Individuals with only central vision (tunnel vision) or only peripheral vision can actually be harmed by text that is too big because they are unable to "fit" the text into their visual window. For these individuals, lighting and positioning of text is critically important. Color blindness is a lack of perceptual sensitivity to certain colors. This may result in a difficulty distinguishing between red and green, or between yellow and blue. Sometimes it may mean an inability to perceive any color. Individuals with color blindness may be unable to perceive color that is used as a unique marker to emphasize text or be unable to perceive text that inadequately contrasts with background color.

Typical access features found in accessible voting systems that may be used by individuals who have vision limitations include the following -

- Contrast and color adjustments for screen display (different background and text colors and contrast levels)
- Screen enlargement with large text size (typically equal to about 18 point font)
- Synchronized speech output with visual display (can be enlarged text or regular size)
- Braille or other tactile marking on keys (please note only a very small number of individuals with vision loss read Braille)
- Color coded and different shaped keys to support easier visual recognition

Hearing Limitations - Deafness, Hard of Hearing, and Deaf/Blind

Deafness is typically considered to be a severe to profound loss of hearing which prohibits or significantly impacts use of hearing to receive and understand speech even when appropriately amplified. A person with a mild to moderate hearing impairment is usually considered hard of hearing. They typically can receive and understand some speech, especially with amplification, but still struggle with communication in noisy environments or when the listening situation is less than optimal.

Currently there is increased use of cochlear implants (a surgical treatment for hearing loss) along with more traditional hearing aids that are used to treat hearing losses of all kinds and degrees. Other assistive technology can also be used to ameliorate the impact of hearing loss such as assistive listening systems, telephone amplifiers, and visual alarms.

Captioning or transcription of audio information is another access feature that many individuals with hearing loss depend on to effectively watch television, participate in lectures, or follow other audio content.

Individuals who have both hearing and vision limitations frequently rely on amplified speech plus enlarged text. If their vision and hearing is severely limited, they may rely entirely on tactile communications, specifically hand-to-hand sign language for face-to-face situations and Braille for reading text.

Typical access features found in accessible voting systems that may be used by individuals who have a hearing or combination of hearing and vision limitations include the following –

- Visual cues for any auditory alert provided
- All of the access features identified for vision impairments
- Amplified audio output using the maximum volume control built into the voting system
- Amplified audio output using a neck loop or other personal amplification system coupled with the audio output of the voting system (headphone jack)

NOTES: Current voting systems do not have Braille output available as an access feature. Some jurisdictions have used hard copy Braille ballots with tactile marking guides to attempt to reach the deaf/blind population.

Motor and Dexterity Limitations

Paralysis involves partial or complete loss of muscular control and often sensation in part of the body. Paresis involves slight to extensive weakness in part of the body. Either condition may be accompanied by pain which can further impede movement. Individuals with paralysis or paresis may have difficulty with fine motor skills (limited hand and finger dexterity) and/or can have gross motor limitations (unable to stand, walk or control arm movements accurately). Individuals who have muscles that are tense and contracted or loose and flaccid can also have dexterity and gross motor limitations such as poor overall coordination or generalized involuntary movements. Any of these limitations can seriously impair a person's ability to accurately touch a small area on a voting system touch screen or accurately activate a key on a keypad. These limitations may also impact the pressure with which a person can touch or activate a control. These individuals may need keys to be activated with less pressure than most people or may be prone to using too much pressure that activates a repeat function on the key or selection spot. These individuals may frequently use adaptive keyboards with a layout of keys that matches their range of motion; they may use a head-mouse, mouth-stick or head-pointer, voice-recognition software, an eye-gaze system, or any one of a number of other assistive technologies to efficiently use a computer. They may need longer response times and adjustments in key repeat, requirements for simultaneous key use, etc. It is important to note that an individual's vocal chords can be affected by a motor disability resulting in difficult to understand speech. These individuals are not typically able to use even simple voice recognition systems, especially those based on a general "public" speech sample. These individuals will typically require an alternative to a voice-based user interface.	Typical access features found in accessible voting systems that may be used by individuals who have motor/dexterity limitations include the following – • Easy to activate keys, controls or other navigation features (These can be activated with a closed fist, an open hand, mouth-stick, hand gripped stylus, etc.) • Simple switch input devices (These devices are typically dual switch input that do not have auditory or visual scanning options – e.g. the voter may only be able to activate the A switch to go forward and the B switch to select which creates a very slow, laborious voting process) • Easily adjustable voting system position that provides control within reach and good visibility for voters who are seated while voting (e.g. a wheelchair user) • Voice recognition software is available on some prototype voting systems as an alternative input option

Intellectual and Neurological Limitations

Individuals with intellectual or neurological disabilities can have a wide variety of functional limitations that can impact voting. They may have difficulty processing written language when read visually, or processing spoken language when heard, or numbers when read visually or heard. There are some intellectual/neurological limitations that affect an individual's ability to focus or attend to a task. For some of these individuals, access to information in a redundant modality (audio in addition to visual, or text or visuals in addition to audio) can support comprehension. However, for those with focus or attending issues multimodal information can cause confusion and result in reduced comprehension. These individuals may have memory difficulties such as problems with short-term memory and/or long term memory and word finding challenges. In addition, these individuals may process information at significantly different rates that may vary depending on the information to be processed or the situation in which it is presented or other external influences. For some individuals, complex directions can derail them from undertaking a task that they are fully capable of completing. Using clear language that is not unnecessarily complex for the content, along with consistent instructions, is critically important to facilitate comprehension and support navigation through the voting process.	Typical access features found in accessible voting systems that may be used by individuals who have intellectual/neurological limitations include the following – • Contrast and color adjustments for screen display to improve discrimination • Screen enlargement to improve discrimination and comprehension • Synchronized speech output with visual display (should be voter adjustable to select visual only, audio only or both in synchrony to address unique individual needs) • Color coded and different shaped keys to support easier recognition • Easy to activate keys, controls or other navigation features (allows for intellectual focus on determining a selection not the motor task of activating) • Simple switch input devices (These devices could be extremely helpful in addressing intellectual/ neurological limitations with the addition of auditory or visual scanning options) • Easily movable system that provides the ability to adjust position and location to address individual needs • Voice recognition software is available on some prototype voting systems as an alternative input option

Access Features

Access features are those alternative input and output options provided as part of the accessible voting system. While each accessible voting system may have somewhat distinct access features, there is a common set of access features found in many if not most accessible voting systems. The information in Table 2 provides a basic description of these common access features. For specific information about the access features of a particular machine, the individual manufacturer user guide should be consulted.

It is important to remember that many access features are used by individuals with various types of disabilities and functional limitations. While no voter will use all of the access features of a voting system, a single voter may use a combination of access features to ensure they are able to vote privately and independently.

Examples of how the same access feature can be used by individuals with different needs include:

- Speech output (including synchronized speech and visual display) can provide access to ballot content for voters with visual disabilities along with voters with dyslexia and intellectual disabilities that include reading/decoding limitations.
- Tactile keypads (including those with keys of different color and size) can provide access to ballot navigation and marking for voters with visual disabilities; voters with motor and dexterity disabilities; and voters with intellectual disabilities that include visual discrimination limitations.
- Enhanced screen display can provide access to ballot content for voters with visual disabilities along with voters with dyslexia and intellectual disabilities who have visual tracking and discrimination limitations.

Access Features

Enhanced visual display output	The visual display output on most accessible voting systems provides an option for the voter to change the text size displayed on the screen. The voter does not typically have unlimited zoom or enlarging capacity. Instead there is a standard text size display option and a large text size display option. The large text size is similar to 18 point font size in hard copy print text. Another enhanced visual display access feature that is usually available on an accessible voting system is the contrast adjustment. Similar to enlarging, voting systems do not typically have unlimited contrast adjustments. This feature allows a voter to change the contrast on the screen from a traditional look with black text on a white background screen to a higher contrast option with white text on a black screen. If this feature is available on your accessible voting machine it will be activated either by a key on the touch screen or as part of the tactile input.
Speech output	When speech output is active, a voice will read all the words on the screen. In most voting systems, when this feature is active the voter can adjust the speech to: • Repeat the words on the screen • Change the tempo or speed of the speech • Change the volume to increase or decrease the loudness of the speech Some voting systems also have features that allow the voter to skip, pause and otherwise control the speech output function. In some voting systems the screen goes black when speech output is active. In other systems a voter can choose to have the screen active along with the speech (see synchronized speech and visual display below.) In most voting systems, the speech can only be heard via headset or comparable output using a standard headset jack. Voters may choose to bring their own headset, neckloop or similar audio output device if it is compatible with the audio output jack.
Synchronized speech and visual display output	As described in speech output, when synchronized speech and visual display output are engaged a voice reads each word as it is displayed on the screen. Additional adjustments can usually be made by the voter to change the volume and tempo of the speech along with having the system repeat words as needed.
Tactile keypad input	A tactile keypad or similar tactile input is an access feature provided to be an alternative to touch screen input. In some systems the touch-screen is inactivated when you activate the tactile keypad while in others both can be active at the same time. A tactile keypad provides keys/controls that can be felt in contrast to a touchscreen which provides no mechanism to "feel" the difference between selections.

Access Features (*Con't*)

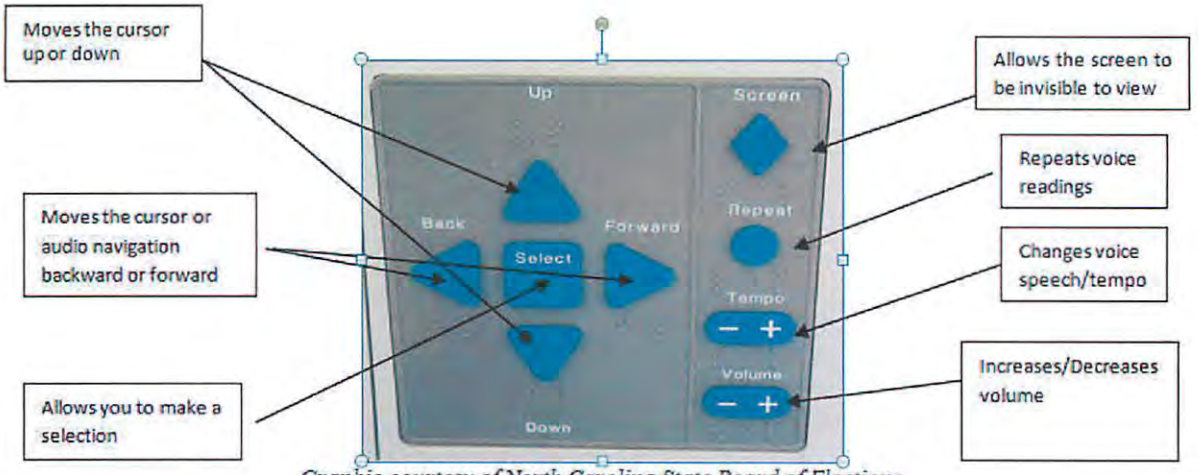
Switch input	Switch input as is currently available on some accessible voting systems consists of a dual switch (one that has two selection signals such as a sip and puff, two-sided plate switch, or rocker switch) and software that allows the switch to control navigation and marking of the ballot. Current voting systems do not include auditory or visual scanning software so the navigation is limited to a "forward/select" type of input option. As a result, the use of switch input is a rather time consuming way to interact with a ballot.
Touchscreen input	While technically not an access feature, a touchscreen is frequently the input mechanism used when a voter uses enhanced visual display or synchronized speech and visual display. The touchscreen on accessible voting systems typically responds to a light touch but does not necessarily have a large strike area. Some voters may be able to use this input with a stylus to assist in accurate "touch" selections.

Selected Access Features in Action

The following sections provide specific descriptions of access features of one voting system. While not all systems are the same, the features pictured below are representative of the access features on many accessible voting systems.

Speech output with tactile input

When speech output is active, a voice will read all the words on the screen. In general the voice is male and is the same one used in assistive technology (AT) products known as screen readers. Most accessible voting systems offer a method to repeat text, increase or decrease tempo, and adjust for volume. The picture below shows the tactile keypad used to navigate through and mark a ballot using speech output. Notice on this keypad there is Braille labeling. That may or may not be found on all systems. Also note that the keys on this machine are the same color. In some machines they will be a different color to support easier discrimination/identification. The keys on this system are different shapes, which is also done to support easier discrimination/identification. With many accessible voting systems, the tactile keypad input can be used as an alternative to the use of the touch screen (without using speech output).



Graphic courtesy of North Carolina State Board of Elections

The picture to the left shows a different tactile keypad layout on an accessible voting system. This keypad has only a forward/next key, a back key, and a select key (similar to a switch with three activations.) These buttons are different sizes and colors to support easy differentiation.

Yet another accessible voting system is pictured to the right and below with similar forward, back and select keys. The system to the right also has a "wheel" that moves the cursor through the ballot visually. This picture also shows two button switches and a "sip and puff" or pneumatic air switch that can be used to provide input.

Still another tactile keypad is pictured to the right with multiple keys of different shapes and colors.

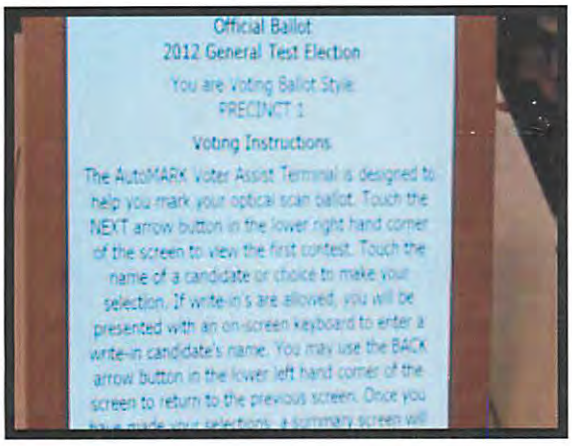
In summary, the tactile keypads of accessible voting systems may look a bit different, but they all provide a mechanism for a voter to navigate and mark a ballot through the use of keys that can be identified by feel and frequently also by color and shape.

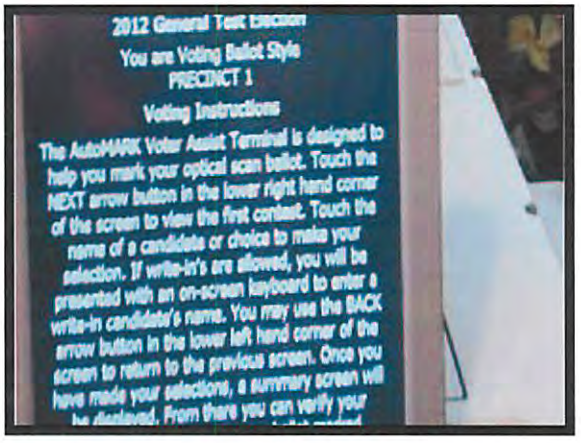
Enhanced visual display

Enhanced visual display typically allows the voter to do several things; increase the font size (Zoom In/Out in this sample) and adjust the contrast (change screen and text color in this sample). The voter can adjust these settings to best meet their needs through controls on the voting system. Those shown below are representative of how an enhancement feature is activated.

Graphic courtesy of North Carolina State Board of Elections

Below is a sample of enhanced visual display on an accessible voting system. Both pictures show the enlarged text option activated and the second picture shows the enhanced contrast activated (changing the display to white text on a black background).





Switch input

Some accessible voting systems are equipped to allow for switch input devices (have jacks that allow different switches to be attached) in addition to having a headset audio output jack. For a switch to work with the accessible voting system, it must have software designed to support the switch (usually a modification of the audio-tactile ballot software).

Accessible voting systems that do support switch input typically come with at least one dual switch. Almost all systems are set up to use a dual switch (A/B type input). Thus the types of switches that can be used include just about any dual switch such as:

Plate and rocker type switches

Pneumatic air ("sip and puff") and cheek switches

These are just a few of the examples of commonly used dual switches. Joysticks and many other devices commonly used by individuals with disabilities can be used as a dual switch so long as they can be attached to the accessible voting machine via the available jack.

Appendices

Appendix A - Disability Areas and Medical Diagnosis

Developmental Disabilities	• ADD/ADHD • Asperger Syndrome • Autism • Down Syndrome • Dyslexia • Dyscalculia • Fragile X Syndrome • Metabolic Disorders Phenylketonuria Hypothyroidism • Sensory-related Disabilities Congenital Rubella Syndrome Williams Syndrome • Degenerative Disorders • Rett Syndrome
Mental Disabilities	A • Alzheimer's Disease • Anxiety Disorder • Bipolar Disorder • Depression • Dyscalculia • Learning Disabilities • Memory Loss • Obsessive Compulsive Disorder (OCD) • Phobia Acrophobia Agoraphobia More in List of Phobias • Schizophrenia • Age-related cognitive decline • Agoraphobia • Amnestic disorder • Amphetamine dependence • Amphetamine withdrawal psychosis • Anterograde amnesia • Anxiolytic-related disorders • Asperger syndrome • Autism • Autophagia B • Barbiturate dependence • Benzodiazepine dependence • Benzodiazepine misuse • Benzodiazepine withdrawal • Bereavement

Appendix A - Disability Areas and Medical Diagnosis (*Con't)*

Mental Disabilities *(Con't)*	• Bipolar disorder • Borderline intellectual functioning • Borderline personality disorder C • Catatonic disorder • Catatonic schizophrenia • Childhood antisocial behavior • Circadian rhythm sleep disorder • Cognitive disorder • Communication disorder • Conduct disorder • Cotard delusion • Cyclothymia D • Delirium tremens • Depersonalization disorder • Derealization disorder • Desynchronosis • Dissociative identity disorder (multiple personality disorder) • Dysthymia E • EDNOS • Encopresis • Erotomania • Ekbom's Syndrome (Delusional Parasitosis) • Enuresis (not due to a general medical condition) • Exhibitionism F • Factitious disorder • Fregoli delusion • Fugue State G • Ganser syndrome (due to a mental disorder) • Generalized anxiety disorder H • Hallucinogen-related disorder • Hallucinogen persisting perception disorder • Histrionic personality disorder • Huntington's disease

Appendix A - Disability Areas and Medical Diagnosis (*Con't)*

Mental Disabilities *(Con't)*	I • Intermittent explosive disorder K • Kleptomania • Korsakoff's syndrome L • Lacunar amnesia M • Malingering • Manic episode • Medication-related disorder • Melancholia • Mental retardation • Minor depressive disorder • Mood episode • Morbid jealousy • Munchausen's syndrome • Munchausen's syndrome by proxy • Multiple personality disorder (Dissociative identity disorder) N • Neuroleptic-related disorder O • Obsessive-compulsive disorder (OCD) • Obsessive-compulsive personality disorder (OCPD) • Oneirophrenia • Opioid dependence • Opioid-related disorder • Oppositional defiant disorder (ODD) P • Pain disorder • Panic disorder • Paranoid personality disorder • Parasomnia • Parkinson's Disease • Persecutory delusion • Phencyclidine (or phencyclidine-like)-related disorder • Phobic disorder • Phonological disorder • Physical abuse • Pica

Appendix A - Disability Areas and Medical Diagnosis (*Con't)*

Mental Disabilities *(Con't)*	• Polysubstance-related disorder • Post-traumatic embitterment disorder (PTED) • Posttraumatic stress disorder (PTSD) • Premature ejaculation • Primary hypersomnia • Primary insomnia • Psychogenic amnesia • Psychological factor affecting medical condition • Psychotic disorder • Pyromania R • Reactive attachment disorder of infancy or early childhood • Reading disorder • Recurrent brief depression • Relational disorder • Residual schizophrenia • Retrograde amnesia • Rett's disorder • Rumination syndrome S • Schizoaffective disorder • Schizoid personality disorder • Schizophrenia • Schizophreniform disorder • Schizotypal personality disorder • Seasonal affective disorder • Sedative-, hypnotic-, or anxiolytic-related disorder • Selective mutism • Separation anxiety disorder • Severe mental retardation • Shared psychotic disorder • Social phobia • Somatization disorder • Somatoform disorder • Specific phobia • Stendhal syndrome • Stereotypic movement disorder • Stuttering T • Tardive dyskinesia • Transient global amnesia

Appendix A - Disability Areas and Medical Diagnosis (*Con't)*

Visual Impairment	• Blindness • Blurred Vision • Cataract • Color Blindness • Low Vision
Hearing Impairment	• Hearing Loss • Meniere's Disease • Tinnitus (Ringing In the Ears) • Conductive hearing loss • Sensorineural hearing loss • Mixed hearing loss • Auditory neuropathy
Mobility Impairment / Dexterity Impairment (Arms/Hands/ Fingers)	• Arthritis • Rheumatoid Arthritis (RA) • Osteoarthritis • Cerebral Palsy • Multiple Sclerosis (MS) • Muscular Dystrophy (MD) • Paralysis • Parkinson's Disease • Stroke • Hand tremors • Reduced co-ordination • Reduced Strength Arm/Hand • Repetitive Strain Injury (RSI) • Paraplegia • Polio • Quadriplegia • Hemiplegia
Head Injury	• Traumatic Brain Injury
Chronic Illnesses	• Chronic Fatigue Syndrome • Diabetes • Hypoglycemia • Renal Failure • Tuberculosis (TB)

Appendix B - Functional Limitations

Mobility and Dexterity

- o Walking
- o Climbing
- o Balancing
- o Stooping
- o Kneeling
- o Crawling
- o Crouching
- o Running
- o Fingering
- o Range of motion in extremities (i.e. flexion, extension, rotation, abduction, supination, and pronation)
- o Motor coordination
- o Eye/hand/foot coordination
- o Wheelchair ambulation
- o Transfer capabilities
- o Grasping
- o Handling
- o Finger dexterity
- o Manual dexterity
- o Ability to operate hazardous equipment

Communication and Sensory

- o Speech
- o Hearing
- o Visual acuity
- o Visual fields (peripheral vision)
- o Visual figure ground
- o Visual motor integration
- o Language (phonology, semantics, symbols)
- o Tactile discrimination (i.e. surface textures and temperatures)
- o Visual discrimination
- o Auditory awareness
- o Auditory discrimination
- o Auditory figure ground
- o Auditory blending
- o Ability to use the telephone

Psychological Adjustment

- o Dependability
- o Conformance to rules
- o Decision making/judgment
- o Distractibility (tolerance to distractions)
- o Interpersonal social skills
- o Appropriate and meaningful leisure skills
- o Ability to adapt to frequent changes
- o Motivation/initiative
- o Ability to follow instructions
- o Self confidence/self image
- o Preoccupation to illness or limitations
- o Ability to obtain appropriate sleep
- o Poor eye contact
- o Dependency on others
- o Task attendance
- o Impulse control
- o Appropriate mood (affect)
- o Ability to assume responsibility
- o Ability to accept criticism
- o Concentration
- o Anxiety/tension control
- o Sobriety
- o Respect for people/property
- o Vulnerability
- o Tolerance to frustration

Activities of Daily Living

- o Eating/dressing
- o Hygiene/grooming
- o Control of bowel and bladder
- o Utilization of public transportation
- o Independence (relating to activities requiring assistance)
- o Cosmetic appearance (including dental conditions)
- o Food preparation
- o Driving a vehicle
- o Wheelchair transfers
- o Ability to handle finances
- o Utilization of community resources

Cognitive Functioning

- o General intellectual functioning
- o Abstract thinking
- o Reading
- o Writing
- o Form perception
- o Spatial perception
- o Reading comprehension
- o Spelling
- o Math
- o Auditory memory
- o Auditory sequential memory
- o Visual memory
- o Visual sequential memory
- o Problem solving
- o Short term memory
- o Long term memory
- o Ability to follow complex instructions
- o Orientation to reality
- o Judgment
- o Concentration (attention span)
- o Common logic
- o Ability to operate complex machinery
- o Calculations
- o Synthesis thinking
- o Associative thinking discrimination
- o Reading recognition

Strength and Tolerance

- o Lifting/carrying
- o Pushing/pulling/pressing
- o Physical stamina/endurance
- o Fatigue
- o Reaching
- o Sitting, standing, or stooping
- o Tolerance to frequent temperature changes
- o Tolerance to wet/humid conditions
- o Tolerance to dust/pollen/fumes
- o Tolerance to loud noises/vibrations

Adapted from Functional Limitation Guide from Missouri Department of Elementary & Secondary Education, http://dese.mo.gov/vr/CSG/FunctLimitGuide.pdf.

Appendix C – Disability Organizations

Election officials frequently need to reach out to individuals in the disability community for assistance with accessible voting system issues. The following is a brief list of major disability organizations that have a state and local level presence in most areas of the country. These state/local organizations can be an invaluable resource for election officials.

State Assistive Technology Programs

Each state and territory has a federally supported State Assistive Technology (AT) Program. These programs provide a set of services that support access to and acquisition of assistive technology (devices such as wheelchairs, hearing aids, electronic magnifiers, computer adaptations, etc.). Specific services can include financial loans for purchase of AT, AT reuse programs, short-term AT device loan programs, AT device demonstration programs, along with training and information and assistance. Many of these programs have been involved in accessible voting activities. The following link provides contact information for each State AT Program:
http://ataporg.org/states_listing.html

Deaf-Blind Equipment Distribution Programs

The National Deaf-Blind Equipment Distribution Program (NDBEDP) is a federally funded initiative designed to ensure that every person with combined hearing and vision loss has access to modern telecommunication tools and the training necessary to use them, granting every individual the opportunity to interact with the world as an involved, contributing member of society. The program provides outreach, assessments, telecommunications technology and training free of charge to those who meet federal eligibility guidelines. The following link provides contact information for each state organization/agency certified as a state deaf-blind equipment distribution program:
http://www.icanconnect.org/state-partners

Developmental Disabilities Councils

Each state and most territories have a federally funded Council on Developmental Disabilities (DD). These Councils are to engage in advocacy, capacity building, and systemic change activities and contribute to a coordinated, consumer and family-centered, system of services that enable individuals with developmental disabilities to exercise self-determination, be independent, be productive and be integrated and included in all facets of community life. Council members are appointed by governors to represent and advocate for people with developmental disabilities and more than 60% must be people with developmental disabilities or family members. The following link provides contact information for each DD Council:
http://www.nacdd.org/about-nacdd/councils-on-developmental-disabilities.aspx

Independent Living Organizations

Each state has a federally supported Statewide Independent Living Council (SILC). The SILC and the state entity responsible for vocational rehabilitation services are partners in the joint development of the State Plan for Independent Living, with input from the statewide network of Centers for Independent Living (CILs). Centers for Independent Living (CILs) are private, nonprofit corporations that provide services to maximize the independence of individuals with disabilities and the accessibility of the communities they live in. Centers can be funded with federal, state, local and private dollars or a combination of all of these funding types. Federally funded CILs provide, among other things, the

core services of advocacy, independent living skills training, information and referral, and peer counseling. Many states that fund CILs require the same core services be provided. CILs provide services for individuals of all ages with all types of disabilities. The SILC in your state is usually a good resource for identifying and locating all the CILs in your state or community. Most will have links to the CILs home page on the SILC web page. Another resource is this federally supported listing: **http://www.ilru.org/html/publications/directory/index.html**

Protection and Advocacy Agencies

Each state and territory has a federally funded protection and advocacy agency that protects the rights of individuals with various disabilities. The National Disability Rights Network (NDRN) is the nonprofit membership organization for the federally mandated Protection and Advocacy (P&A) Systems and Client Assistance Programs (CAP). Collectively, the P&A/CAP network is the largest provider of legally based advocacy services to people with disabilities in the United States. To find the protection and advocacy and client assistance agency or agencies in your state go to the following link: **http://www.ndrn.org/en/ndrn-member-agencies.html**

Vision Disability Organizations

There are two major national organizations for the blind that have chapters in most if not all states across the US. National Federation of the Blind (NFB) was founded in 1940 and advocates for the civil rights and equality of blind Americans, and develops innovative education, technology, and training programs to provide the blind and those who are losing vision with the tools they need to become independent and successful. The NFB has affiliates in all fifty states plus Washington, DC and Puerto Rico, and over seven hundred local chapters, see: **https://nfb.org/state-and-local-organizations**.

American Council of the Blind (ACB) was founded in 1961 but many of its state affiliates and local chapters have a history that can be traced back to the 1880s. Since its inception, ACB and its affiliates have been at the forefront of the creation of policies that have shaped the opportunities that are now available to people with disabilities in our country. ACB has also collaborated with Vision Rehabilitation Service providers to develop the principles and values that should be at the heart of providing adjustment and placement services to people who are blind: **http://www.acb.org/node/65**

American Foundation for the Blind (AFB) is a third major national organization that began in 1921. As a national nonprofit with offices in five US cities, the American Foundation for the Blind focuses on expanding possibilities for Americans living with any type or degree of vision loss through access and equality, and especially by promoting the use of new technologies: **http://www.afb.org/default.aspx**

Hearing Disability Organizations

The National Association of the Deaf (NAD) is a national civil rights organization of, by and for deaf and hard of hearing individuals in the United States. Established in 1880, the NAD was shaped by deaf leaders who believed in the right of the American deaf community to use sign language, to congregate on issues important to them, and to have its interests represented at the national level. These beliefs remain true to this day, with American Sign Language as a core value. Most states have a state organization that is an affiliated member of NAD, see:
http://www.nad.org/community/state-association-affiliates

The Association of Late Deafened Adults (ALDA) is an international organization with members throughout the United States, Canada, Europe, Asia and Australia. ALDA strives to provide education. role models and support for late-deafened adults. ALDA also advocates on behalf of late-deafened adults in promoting public and private programs that support their needs, and encourages research into the various aspects of late-deafness. ALDA was the pioneering force behind computer assisted real-time captioning that many individuals with hearing loss now use for communication access: **http://www.alda.org/about-alda/**

The Hearing Loss Association of America (HLAA) is the national organization representing people with hearing loss (used to be known as Self Help for Hard of Hearing). HLAA provides assistance and resources for people with hearing loss and their families to learn how to adjust to living with hearing loss. HLAA is located in the Washington D.C. area with 14 state organizations and many local and regional chapters across the country see: **http://www.hearingloss.org/support_resources/find-local-hlaa-chapter** .

Other Disability Specific Organizations

National Multiple Sclerosis Society
The National Multiple Sclerosis (MS) Society is an organization designed to help each person address the challenges of living with MS through a 50-state network of chapters. The Society helps people affected by MS by funding cutting-edge research, driving change through advocacy, facilitating professional education, and providing programs and services that help people with MS and their families move their lives forward. The following link provides access to the state/local chapters: **http://www.nationalmssociety.org/find-a-chapter/index.aspx**

ALS Association
The ALS Association was established in 1985 as a national non-profit organization fighting Lou Gehrig's Disease. The Association focuses on global research, providing assistance for people with ALS through a nationwide network of chapters, coordinating multidisciplinary care through certified clinical care centers, and fostering government partnerships. The following link provides access to the state/local chapters: **http://www.alsa.org/community/chapters/**

Brain Injury Association of America
The Brain Injury Association of America (BIAA) was founded by individuals who wanted to improve the quality of life for their family members and patients who had sustained brain injuries. BIAA focuses on advancing brain injury prevention, research, treatment and education and to improve the quality of life for all people affected by brain injury. BIAA has a network of state affiliates, local chapters and support groups, see: **http://www.biausa.org/state-affiliates.htm**

United Cerebral Palsy
United Cerebral Palsy (UCP) was founded in1949 when parents of children with cerebral palsy came together, looking for help, answers and information. Today UCP and its nearly 100 affiliates have a mission to advance the independence, productivity and full citizenship of people with a spectrum of disabilities. The following link provides access to the UCP affiliates: **http://www.ucp.org/findaffiliate**

Easter Seals

Easter Seals provides services, education, outreach, and advocacy so that people living with autism and other disabilities can live, learn, work and play in our communities. Easter Seals has been helping individuals with disabilities and special needs, and their families for nearly 90 years. From child development centers to physical rehabilitation and job training for people with disabilities, Easter Seals offers a variety of services to help people with disabilities address life's challenges and achieve personal goals. The following link provides a connection to local Easter Seals affiliates: **http://www.easterseals.com/connect-locally/**

The Arc

The Arc is a national community-based organization advocating for and serving people with intellectual and developmental disabilities and their families. The Arc encompass all ages and all spectrums from autism, Down syndrome, Fragile X and various other developmental disabilities. With more than 140,000 members and more than 700 state and local chapters nationwide, the Arc works to ensure that people with intellectual and developmental disabilities and their families have the support they need to be members of the community.The following link provides a connection to local Arc chapters: **http://www.thearc.org/find-a-chapter**

Paralyzed Veterans of America (PVA)

Paralyzed Veterans of America is a national organization that provides service officers who help veterans secure benefits that have been denied and Paralyzed Veterans' vocational rehabilitation counselors who help veterans get back to work. PVA currently has 69 National Service Offices nationwide and 34 chapters across the country, see the link below to identify these locations: **http://www.pva.org/site/c.ajIRK9NJLcJ2E/b.6452325/k.A0ED/Chapters_and_NSOs.htm**

National Spinal Cord Injury Association (NSCIA)

National Spinal Cord Injury Association was founded in 1948 to improve the lives of all paralyzed Americans. Their current mission is to improve the quality of life of all people living with spinal cord injuries and disorders. NSCIA provides peer support and advocacy that empowers individuals to achieve their highest potential in all facets of life focusing on civil rights; government policy and legislation; disability travel; accessible building and universal design; publications; research and education; and wheelchair and assistive technology. The following link can be used to identify local chapters across the country: **http://www.spinalcord.org/about/nscia-chapters/**

Learning Disabilities Association of America (LDA)

Learning Disabilities Association of America (LDA) was founded in 1963 and has grown to serve tens of thousands of members with learning disabilities, their families and the professionals who work with them. Today, LDA is the largest non-profit volunteer organization advocating for individuals with learning disabilities and has over 200 state and local affiliates in 42 states and Puerto Rico. The membership, composed of individuals with learning disabilities, family members and concerned professionals, advocates for the almost three million students of school age with learning disabilities and for adults affected with learning disabilities. The following link provides state and local affiliate information: **http://www.ldanatl.org/state_chapters/index.asp**

National Down Syndrome Society (NDSS)

The National Down Syndrome Society (NDSS) advocates for the value, acceptance and inclusion of people with Down Syndrome. NDSS envisions a world in which all people with Down syndrome have the opportunity to enhance their quality of life, realize their life aspirations and become valued members of welcoming communities. The following links provide information on local NDSS affiliates:
http://www.ndss.org/Resources/Local-Support/
http://www.ndss.org/PageFiles/3123/Affiliate%20Database.pdf

Tourette Syndrome Association (TSA)

Founded in 1972, the national Tourette Syndrome Association is a national non-profit membership organization whose mission is to identify the cause of, find the cure for and control the effects of Tourette Syndrome. TSA offer resources and referrals to help people and their families cope with the problems that occur with Tourette Syndrome. TSA membership includes individuals, families, relatives, and medical and allied professionals working in the field. The following link provides chapter information: **http://tsa-usa.org/aabout_tsa/ausachapters.html**

ACKNOWLEDGMENTS

This material is based upon work supported by the U.S. Election Assistance Commission (EAC). Opinions or points of views expressed in this document are those of the authors and do not necessarily reflect the official position of, or a position that is endorsed by the EAC or the Federal government.

Special thanks to the following individuals and organizations for their assistance in preparing, reviewing and making this guide available:

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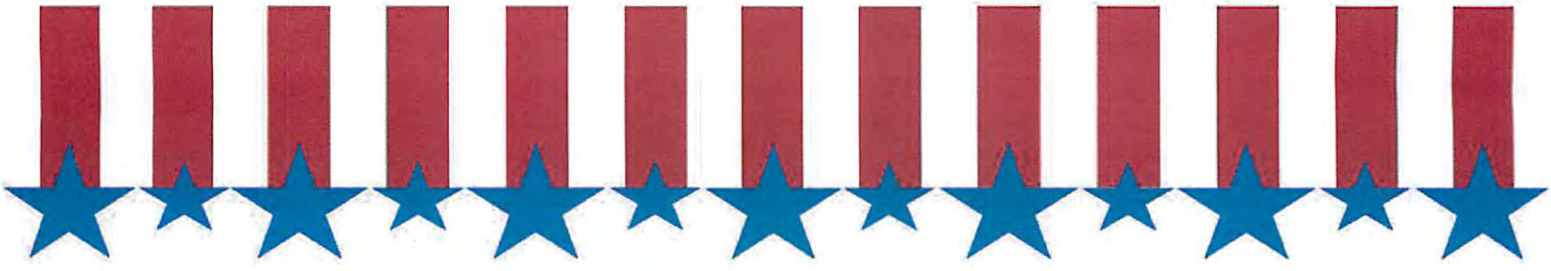
For more information about Research Alliance for Accessible Voting see
http://www.accessiblevoting.org/



TENNESSEE DISABILITY COALITION

Introduction

As part of the Accessibility and Assistive Technology team for the Research Alliance for Accessible Voting (RAAV) grant, the Tennessee Disability Coalition (TDC) was tasked to serve as an interface with the disability community to exercise their voting rights and to with volunteers to participate in RAAV pilots to break down barriers for voters with disabilities. TDC along with Paraquad worked extensively with local election administrations to train poll workers and voters with disabilities.

The Tennessee Disability Coalition (TDC) was founded in 1989 with the mission to promote full and equal participation of people with disabilities in all aspects of life. Today we are an alliance of over 47 member organizations who work together to accomplish this goal. Since the passage of HAVA in 2000, TDC has worked throughout Tennessee to break down barriers to voting for people with disabilities. By establishing local vote committees, people with disabilities in various parts of the state worked with county Election Administrators to train poll workers on accessibility and train community members on their voting rights. We have successfully seen the development of a formalized poll worker training by Disability Rights Tennessee who all 95 Tennessee counties use, and continue to advocate for voting machines to be the primary medium by which Tennesseans vote. Currently only 2 Tennessee counties use paper ballots. Our local vote committees also worked with local Election Administrators to conduct poll site accessibility surveys. In 2011 TDC continued its decade long work on increasing participation in voting by joining the RAAV team as a subgrantee.

Project Timeline

In November 2011 TDC hired a civic engagement specialist to work with the RAAV team. TDC began to develop relationships with county Election Administrators to identify problems and setbacks to determine our research and training models. To learn about the voter experience we conducted a phone survey in March 2012 following the Presidential Preference Primary. We were able to reach over 500 voters with disabilities in Tennessee to with responded positively to the voting experience. 84% of Tennesseans were highly satisfied or highly satisfied with their experience and 70% believed that poll workers were knowledgeable about accommodations available to individuals with disabilities.

Encouraged by these results we continued to test the voter experience in August 2012 and November 2012. In August we recruited exit pollers in three Tennessee counties (Davidson, Williamson, and Hamilton) to survey voters. We received over 500 responses. We received results that mirrored the phone survey – voters continued to be satisfied with their experience. We also observed a very low incidence of disability, which election administrators will echo, saying they believe most voters with disabilities vote during our early voting period or by absentee ballot.

In November 2012 TDC credentialed poll watchers to be inside the polling places. We wanted to make sure that voters were accurately conveying their voting experience and to be able to observe the poll workers inside the polling place. We worked with two counties for this project (Williamson and Hamilton). These poll watchers were given accessibility checklists and were each asked to write a report

reviewing what they had observed. Our volunteers found relatively typical Election Day problems particularly in a presidential election. Our most reported problem were long lines. Also minorly reported were some accessibility issues almost exclusively related to parking. Thousands of voters were observed, and there were no instances where a voter was not able to cast a ballot in our testing locations. Volunteers observed that there were few people with observable disabilities at the polling place on Election Day. Poll workers were generally friendly and helpful. Our research into the voter experience has been helpful in learning that generally, Tennessee voters feel satisfied with the way elections are run. They feel that poll workers are knowledgeable and helpful, and the statewide use of voting machines drastically cuts down on the learning curve for voters and poll workers alike. Election administrators believe their biggest problems are training time and poll worker retention.

From the three Tennessee election in which TDC observed the voter experience, we continually learned that voters were generally satisfied with their experience. Knowledgeable and helpful poll workers, coupled with low incidence and long standing relationships between advocacy groups and Election officials has proved to make voting a positive experience for voters with disabilities. While testing the voter experience was important, TDC continued to work with county Election Administrators to understand their best practices and learn where they needed additional training.

TDC staff met with over 40 county Election Administrators to learn how they trained poll workers around accessibility and accommodations for voters. From these meetings we learned that the most popular training medium was in person lecture style that typically lasted between 1-2 hours. Almost all Administrators felt they needed more training time but funding was an issue. The second biggest problem was Administrators has no way of knowing whether poll workers were retaining the information they were trained on. From meeting with RAAV partners across the county, a common theme amongst election officials was the more training materials the better. Job aids were a common tool to help poll workers remember what they learned in training. Tennessee Election Administrators did not have job aids relative to accommodating voters with disabilities. TDC, along with Paraquad began to develop picture guides that were step-by-step picture supported information of how to cast a regular and audio ballot on a voting machine. We developed these for all 5 voting machines currently being used in Tennessee and sent them to all county Election Administrators to use as job aids for the November 2012 Presidential election.

TDC performed its final pilot on March 5, 2013 during Chattanooga Tennessee's municipal elections. Understanding that poll worker retention is a forefront problem on Election Administrator's minds, we wanted to see if we could combat this through a partnership with advocates and election officials.

To research this, TDC worked with the Hamilton County Election Commission to create a pilot. We set up a test group of 2 polling places (8 poll workers) and a control group of 2 polling places (8 poll workers). Both groups received the tradition training from the Hamilton County Election Commission given every election cycle. The test group was given additional training from TDC. They received two in-person training on materials created and tested by the RAAV team. They spent an extra house in-person setting up and going through the access features of a voting machine. Then they received additional materials and job aids from TDC via mail and email.

TDC anecdotally gathered evidence from the poll workers post-election to see if their retention was higher. Because of a low turnout election and continued low incidence of people with disabilities using access features on the voting machines, much of what the poll workers learned was not able to be put to use. The test group of poll workers was able to recall information that the control group was not able to. We along with the poll workers believed the pilot to be a success. Poll workers were happy to receive additional job training and believe that take home, online, and day of materials all make them more successful and prepared for their job.

Year three of the RAAV project was spent sharing this information with election officials across the country at the Election Center's one day seminars on accessibility. TDC participated in 6 seminars with Paraquad on a panel to discuss our work on the RAAV grant. TDC continued to work with local election administrators to develop relationships and increase the usage of job aids for 2014 elections.

Also during year three, TDC began to work with other Tennessee stakeholders to disseminate our information and brainstorm ways to continue our this work. TDC, along with Disability Rights Tennessee and the Tennessee Secretary of State's office are committed to discovering ways to offer more information for poll workers and voters. Together we are developing a training video for voters with disabilities and poll workers to debut in the summer of 2015. This video will feature voter's rights and responsibilities, accessibility, disability etiquette, and assistive technology for voting machines. The video will be posted on YouTube and featured on all stakeholder's and the Secretary of State's website. We will also use it to train Election Administrator's to then train their poll workers.

Major Findings and Suggestions for Future

- Election Administrators in Tennessee believe that voters with disabilities are satisfied with their voting experience and they are providing a good service. All of TDC's voter experience surveys support this. **Recommendation:** Election officials should continue their work to make voting a positive and successful experience for all voters.

- Election Administrators believe they need more training time and they need to start looking at training poll workers on difference mediums. Planning the shortest possible training time to keep poll workers engaged and save funds can lead to disability/accessibility training being put on the backburner. Administrators spend their time focused on new voting laws and regulations and technical assistance. In order to poll workers to continue to serve voters to the best of their abilities, every training time needs to have a focus on accessibility. **Recommendation:** Administrators should continue partnering with disability advocacy organizations to troubleshoot budget friendly and time efficient ways to train poll workers. Advocacy organizations in Tennessee have developed an accessibility training manual used widely in election trainings.

- Poll workers feel confident and prepared to handle Election Day problems related to access.

- Poll workers and election administrators who used the Election Day picture guides believed it was a helpful job aid and yielded extremely high satisfaction. They are widely used throughout the state.

- As the population continues to age, more voters will require assistance than not. The three biggest barriers voters have to successful voting are standing, seeing the ballot, and marking the ballot.
  Recommendation: Barriers to the polling place are not always visible. Poll workers needs to offer assistance to every voter than enters a polling place to ensure each voter can privately and independently cast his ballot. As voters age the incidence of invisible disability will increase. significantly in the voting booth creating longer lines at the polling place. Accommodating seniors with invisible disabilities will speed up the voting process and will help eliminate lines. Election Administrators should consider hiring more poll workers with disabilities to help troubleshoot Election Day problems.

- Training on different mediums sets poll workers up for success. **Recommendation:** Take the focus off on memorizing and retention by giving poll workers access to different types of training materials. TDC will create a video in 2015 to give poll workers a different medium of training and train voters before election day.

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RAAV – EDS Project

What follows is Election Data Services, Inc.'s report on its activities in the Research Alliance for Accessible Voting (RAAV) project funded by the EAC.

Background

Election Data Services Inc. is a consulting firm that specializes in redistricting, election administration, and the analysis and presentation of census and political data. The firm was founded by Kimball Brace in 1977 and provides political information products and consulting services to businesses, associations, and governmental organizations, including state and local legislatures, and federal, state, and local election departments, boards, and commissions. Over the past 37 years, Election Data Services Inc. has monitored developments in election administration and conducted a wide variety of studies for federal and state governments. We have provided strategic assistance for voting equipment purchases, and conducted studies on voting equipment and voter registration systems. These have included feasibility studies, needs assessments, and systems requirements analysis for election organizations to develop or acquire new voting equipment or voter registration systems. During the 1990s, Election Data Services Inc studied various computer network options for statewide voter registration systems and models for integrating local voter registration systems into a statewide network. These studies were developed for both the federal government and several state governments. In 2004 and 2006 Election Data Services Inc tabulated and analyzed responses to three nationwide surveys distributed by the United States Election Assistance Commission (EAC) to Congress and state and local election jurisdictions under HAVA (Help American Vote Act). Election Data Services Inc. continued as a subcontractor to be involved in the 2008 and 2010 surveys and reports. Election Data Services Inc has also participated in EAC studies on poll workers and ballot counting and recounting procedures. Following heavy involvement in the 2010-12 round of redistricting around the nation, EDS's Brace returned to the election administration field within his own jurisdiction. First as a poll worker starting in 2008, Brace was appointed to a Task Force on Long Lines following the 2012 election and then served as Acting General Registrar for Prince William County, VA for five months in 2013 as they sought a full time Registrar.

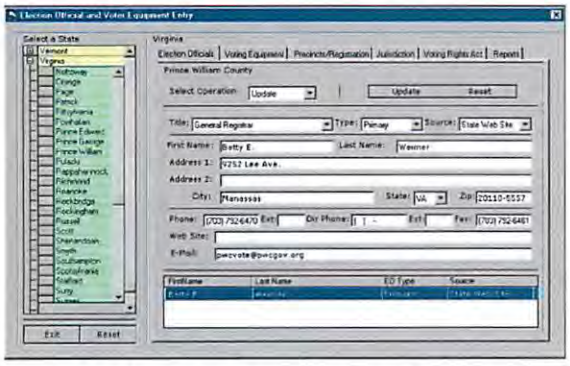
Since 1980, Election Data Services Inc. has maintained two nationwide election databases. An Election Administration Database provides contact information for state and local election officials and information on voting equipment used by over 10,000 election jurisdictions in the U.S. In addition to voting equipment types—electronic and optical scan systems, DataVote and Votomatic style punch cards, and hand-counted paper ballots—the database identifies voting equipment vendors and models for early, absentee, precinct (Election Day), and accessible voting. The system keeps track of when a jurisdiction has changed characteristics of their voting

process. The other database provides county-level election returns and voting statistics for federal and statewide offices, plus total and voting age population (VAP), voter registration, and voter turnout data.

The Project

Building on the long history of data collection and analysis, Election Data Services, Inc. involvement in the RAAV project was geared towards updating and making publically available information on voting equipment usage around the nation, particularly as it relates to machines and systems designed for disabled voters. The goal of this project is to expand and build a database of disabled voting equipment usage around the nation. Anticipating the need for public access to the database, Election Data Services Inc. undertook an initial effort to upgrade and expand both our computer server and software, along with upgrading the Sequel (SQL) database software that currently housed our election administration database. Because the prior system was over 15 years old there were a number of improvements in both software and database design that we were able to take advantage of by upgrading various aspects of the operation.

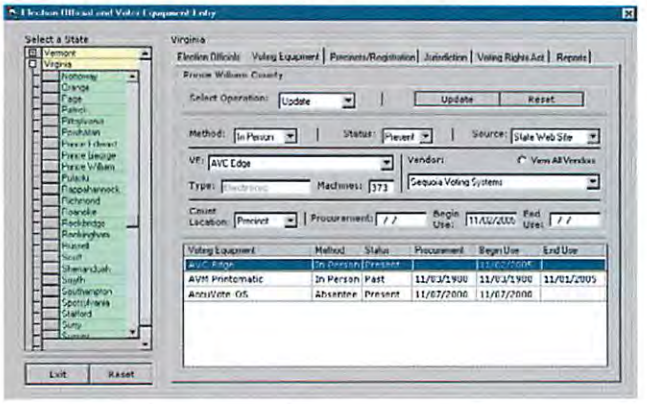
The heart of the election administration system is built upon the geography where voting decisions are made … the counties for most of the country and townships in New England states.



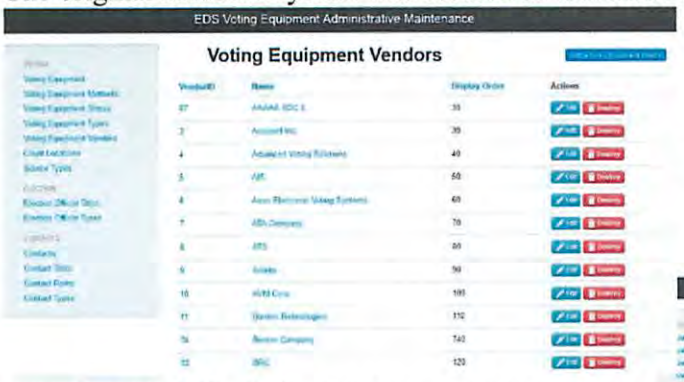
Internally the data is indexed with the Federal FIPS code, which allows other datasets (such as Census information) to be linked to the geography. This also includes the capability of joining the data to geographic mapping files that can be used in Geographic Information Systems (GIS) to create thematic maps of the information. For every jurisdiction we keep tract of contact information (see sample to left) for not only the main election administrator, but also the individuals in charge of registration and mapping operations. For the RAAV project we also added individuals that deal with the disabled community, if that exists in the jurisdiction.

The most extensive part of the election administration system is the collection of what kind of voting system is used in each jurisdiction. We started the database in 1980 as the result of a contract we had with the Federal Election Commissions' Office of Election Administration (FEC) in the later part of the 1970s. We helped manage a series of regional workshops that the FEC conducted around the nation. One of the sessions at each workshop dealt with the differences in voting equipment in use in that region. For that, we collected what voting equipment was being used in each county or jurisdiction in every state of the region and the information was provided to the participants as a handout.

Beginning in 1980 we updated and compiled all the information into a database, and then in advance of each subsequent general election we would recanvass every state to update the information. The structure of the database allows us to keep historical information in the system on when changes were made. For example, the picture to the right shows which election the equipment was changed within. With the data kept in this manner, it is possible to pull information for any given election and be able to match voting equipment to election returns, for example. During the 1990s we began noticing that absentee voting was gaining in the share of the balloting. Because many different voting equipment types are not conducive to the absentee process (for example, electronic machines, lever machines), we added an additional data item for each jurisdiction and began recording the type of equipment used for absentees. With the passage of the Help America Vote Act in 2002 and one of its focuses on disabled voters, we again expanded the database structure to keep track of the voting system being allocated for disabled voters. The focus of the RAAV-EDS project was to expand the information in the disabled category, both from collecting information from the jurisdictions as well as expanding the equipment being followed.



The original database system was created so that most fields were represented as being drop down menu options. This allowed for uniformity in data entry and avoided any misspellings. But the original system was set up by a programmer who has long ago left employment of Election Data Services Inc. and attempting to update the drop-down menu options proved more difficult for our current programmers and sub-contractors. As a result, they have built a process that allows staff to update the system so that additional data items can be added to the various data tables. Here are pictures of several of the update screens that have been developed and are in use by our staff to update the datafiles. We could then add to the overall types of voting equipment in use, as well the actual names of the equipment. There have been more names of different vendors in the marketplace over the past decade, and now this information was updated

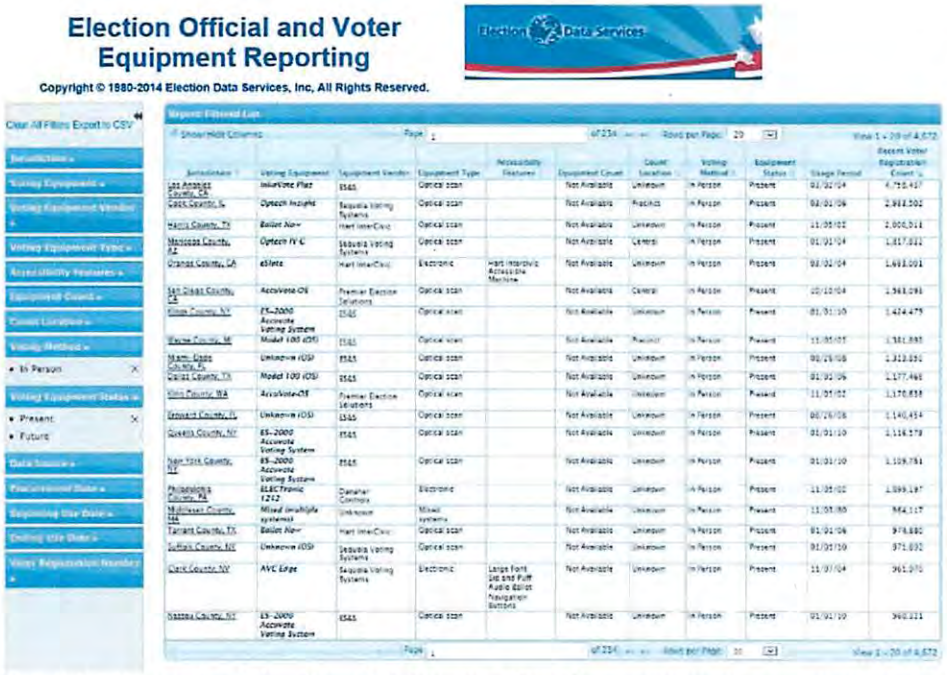


and tracked. In addition, the flexible nature of the new database allowed us to add an entirely new type of vendor, that of the company who provides maintenance of the equipment. Before it was assumed that the seller of the equipment would continue with the jurisdiction, but the more modern market place has allowed for smaller companies that are providing just maintenance services on the hardware.

These screens, and others, are being use by Election Data Services Inc staff to update information on equipment specially designed for disabled voters. This includes, for example, special add-on equipment (such as sniff-and-puff devises, headphones, tactile devises for directing screen movements, etc) that work with an already existing electronic voting machines (DRE), or full systems (like the Automark) that are used in a great number of jurisdictions as their "disabled" device. While we have long kept track of how many physical machines are owned by a jurisdiction, we have expanded that information to include how many disabled machines are in use by the jurisdiction.

In order to facilitate the database use on the web, Election Data Services Inc staff and subcontractors have also migrated the system to a newer version of SQL Server. Further development was done to update the look of the application for the user, as shown in this picture. This included adding pictures of the accessibility features that are utilized with each type of equipment. These features are tied to both the equipment name (so that they appear when the equipment is added to the jurisdiction), and can be over-ridden and adjusted within the individual jurisdiction.

The update to the newer version of SQL Server also meant there was a need to update to a newer version of the report generator software (Crystal Reports) and develop new report templates for the web. We actually implemented a revolutionary new design to the system so that the database



can be viewed, filtered and sorted in a spreadsheet report format by the user. By clicking on the "Report" tab in the main database screen, a user is then taken to the "spreadsheet report" screen, as shown in the picture to the left. All the data items (columns) in the report screen are listed down the first column on the left. By clicking on a data item, a pop-up screen appears that then allows the user to institute a filter for that data column(s). If a data item is not selected for a filter, then all records in the system are eligible to be shown. For example, a user can just look at the jurisdictions in a single state or a combination of states. Or a single or multiple types of equipment or equipment name(s), or vendor(s) can be selected. The "Voter Registration Number" can also be filtered so that the user will see jurisdictions that are within a user defined range or any jurisdictions above or below a certain number of voters. This then allows the user to query the database for any kind of information, or combination, which might be of use.

As a result of all this work, thirty-five years of voting equipment usage is now accessible to the general public, including updates on the use of accessible voting machines. The database can be viewed at: ea.electiondataservices.com. While the system is available in "view only" mode to the public, election administrators can update the information on their jurisdiction by sending an e-mail to login@electiondataservices.com. A User ID and password, specially designed for the individual jurisdiction, will be sent back within a day upon verification.

It must also be noted that Election Data Services, Inc. paid for staff time and subcontractor's time and expenses for the entire three year-long project even though the prime contractor and the EAC cut our budget by a third. As a result, Election Data Services lost over $150,000 on this project, money that had been promised at the beginning of the project.

The Future

If additional funding were to be provided, there are a number of efforts that could be performed to expand and enhance the voting equipment and election administration website.

Because a number of jurisdictions are anticipate to be in the market for new equipment in advance of the 2016 Presidential elections there should be a significant outreach effort to make the site known to all election administrators around the nation. An e-mail campaign to election offices can be conducted with explanations of how the site can be utilized and the type of queries that are possible.

Other possible enhancements include:

- More extensive information on different systems and features specifically of use by disabled voters would also be incorporated into the system.
- Investigate and incorporate changes in the system so that the table results are accessible to JAWS software used by the blind.
- Incorporation of data from the Election Administration Commission's 2014 Election Day survey, as well as expansion with previous year's survey results. In this manner users would be able to identify and track long term trends in the various data and results from the survey.
- Expansion of the website to include information on electronic poll books and their use around the nation.
- Additions to incorporate usage of iPads and other tablets to help poll workers provide information to voters as their wait in the voting line.
- Incorporate web tracking tools to assist in determining the type of users utilizing the site.
- Further research in different aspects of the voting process, including the effectiveness of accessible voting devises. For example, very little research has been done on the actual impact of the disabled machines and whether they are recording the proper votes being cast. On top of that, no research has been done on whether the machines lead to greater or lesser overvotes and undervotes. Part of the problem with this research is that many local jurisdictions simply submerge the disabled and absentee ballots into the normal precinct returns.
- On-going maintenance and improvements to the system.

Questions

Please direct any questions about this report to:

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For more information about the Research Alliance for Accessible Voting, see http://accessiblevoting.org

ACKNOWLEDGMENTS

This material is based upon work supported by the U.S. Election Assistance Commission (EAC). Opinions or points of views expressed in this document are those of the authors and do not necessarily reflect the official position of, or a position that is endorsed by the EAC or the Federal government.

ELECTION CENTER BACKGROUND

The Election Center's purpose is to promote, preserve and improve democracy. The Center is also known as the National Association of Election Officials.

The Center provides its members an alert service which informs and updates state, city and other elections and voter registration officials regarding legislation, regulations, court decisions and Justice Department rulings which affect the conduct of voter registration or elections administration. Additionally, the Center performs research for such governmental units concerning the similarities and differences in state or local laws, regulations or practices concerning voter registration and elections administration.

As the election profession's premier organization for training and certification of election and voter registration administrators, The Center also conducts annual events such as national conferences and several regional workshops and seminars throughout each year. These are designed specifically for government elections units. Each of these programs is designed to improve the methods of operation and efficiency of the affected offices. The result is improved service to voters, the public, taxpayers and to the government. The Center trains between 600 and 1,000 election and voter registration administrators every year.

Continuing professional education is the cornerstone of continuous improvement of democracy through The Election Center's Professional Education Program. A joint effort of The Center and Auburn University's public administration faculty, the Professional Education Program offers college level instruction for professional growth and development of government officials in the elections and voter registration process.

With more than 1,000 members nationwide, The Election Center has the largest number of state, local election, and voter registration administrators as members of any elections-related organization in America.

RESEARCH ALLIANCE FOR ACCESSIBLE VOTING (RAAV) FOCUS GROUP

The Election Center formed a focus group of state and local election officials to review and provide feedback to the other members of The Research Alliance for Accessible Voting. The focus group met seven times in cities across the nation.

RESEARCH ALLIANCE FOR ACCESSIBLE VOTING (RAAV) TRAINING SEMINARS

In addition, The Election Center conducted two sets of seminars to educate election officials. The first, a set of four, were a review of all current law and litigation impacting voter accessibility. The second, a set of six, were conducted to highlight the work of The Research Alliance for Accessible Voting.

The election officials who attended these training sessions completed an evaluation form that was used to improve subsequent trainings. The evaluations were extremely positive; each election official reported that their understanding of accessible voting, post seminar, grew significantly.

Noteworthy takeaways from these training sessions were: a revelation by the election officials that there are two kinds of disabilities, one type is the visual disability and the second is the invisible disability. Most election officials are aware of the disabilities that one can see such as a person in a wheelchair or a person who has vision issues and comes to the polling place with a guide dog or cane. However, not everyone was sensitive too or even thought about the invisible disabilities. Namely those with developmental disabilities such as cognitive disabilities, visual comprehension disabilities, Dyslexia or other reading disabilities, Attention Deficit Hyperactivity Disorder (ADHD), auditory processing disorders, to name a few. What we fail to realize is that the number of the invisible disabilities is greater than the number of visual disabilities.

Also a significant takeaway was the positive reaction from the disability groups regarding the imparting of the developmental disability component of the training. Some of the disability group members who were part of the RAAV team commented that the developmental disability portion of the training was the one of the best they had ever seen. As a result, some of these state disability organization members shared the information from the training with their colleagues at the federal level who in turn were so impressed by the content presented that they sent notice to their respective state agencies making sure they were aware of this training and that it had been offered to all local election officials at 6 training sessions offered throughout the United States.

Federal disability organizations in addition to the election officials being affected by the training sessions in a positive way was an unexpected takeaway.

RESEARCH ALLIANCE FOR ACCESSIBLE VOTING (RAAV) TRAINING TOOLS

Prior to this training session, election officials didn't have a training resource available that pointed out the visible versus invisible disabilities and also provided tools to understand all types of disabilities. These tools also got rave reviews from the disability groups from around the country. One of the 6 training sessions was also videotaped and all of the presentations

that were presented in the one day seminar are available on the Election Center Website as well as YouTube.

OTHER LESSONS LEARNED

Other lessons learned: the aging of the baby boom will result in nearly 40% of all voters having a disability, the need for more enhanced accessibility training of poll workers, particularly the need for poll workers to know how to use the magnification capacity of the accessible voting machines. Some election officials were not aware that there are approximately ten million voters who need to use magnification in order to vote accurately, efficiently, and with confidence.

RESEARCH ALLIANCE FOR ACCESSIBLE VOTING (RAAV) TRAINING ATTENDEES

The overwhelming majority of attendees came from jurisdictions with hundreds of thousands of voters. These large jurisdictions have staffs and budgets that allowed the attendees to travel to the training site and be out of the office for a day or two. Small jurisdictions, with fewer than a hundred thousand voters have very limited staffs and often have non-voting related responsibilities. It is common for these jurisdictions to have at best one full-time employee and many have only one or two part-time employees. Unfortunately, inquiries about accessibility to the Election Center and disability advocates from small jurisdictions often include a belief that their jurisdiction is exempt from laws requiring accessible voting. These jurisdictions often have no travel budgets.

ELECTION CENTER RECOMMENDATIONS

The Election Center recommends in order to provide training to these jurisdictions, funds will be needed so that trainers can attend state election official meetings. In some cases, there will be a need to provide funding so that small town and rural election officials can attend.

In order to improve the public's confidence in our nation's elections, there is a need for additional research and development. Some of this work will need to continue in order to improve accessibility but research and development is necessary to improve other parts of our complex voting processes. This work needs to involve election officials in order to prioritize the research and provide feedback so that the developments meet election officials' needs. Currently, voting system manufacturers develop software and hardware with the advice of some of their customers. Most of the time, this research involves adjustments to existing products. As a result of these grants several universities are continuing to design improvements to our voting systems and processes. This work will be most useful if election officials are able to work in tandem with designers helping to prioritize the research and development providing real world feedback to the researchers.

Center for Accessible Information
Research Alliance for Accessible Voting
Final Project Summary

April 30, 2014

Project Summary

Accessible websites and documents

We were responsible for developing and maintaining an accessible project website, including a document library. While accessible item descriptions were promised, we only made a best effort to make documents and other items accessible. We also created a YouTube video channel for video relating to RAAV goals.

Accessible instructions for accessible voting machines.

We created a two-sided instruction card for the Automark ballot marking device, one of the most widely used accessibility devices used in polling places. We tested the instruction card in 26 precincts that had been using the Automark for several years.

Accessible language for ballot measures and voter guides.

We sampled a number of ballots from different jurisdictions, and used the voter guide published on line by M-Live for Michigan after assuring ourselves that its contents were equivalent to voter guides in jurisdictions across the country. We wrote "clear and simple" versions of the selected text samples and then had them reviewed and revised by a consultant with intellectual disabilities.

Machine translation of "clear and simple" voting materials.

After creating "clear and simple" English translations of the ballot measures and voter guides in the preceding phase of the project, we ran the translations through Google Translate to obtain versions in Spanish and Korean. Bilingual reviewers then evaluated the quality of the resulting translations.

Key Findings

- It is extremely difficult to get people to create documents that are ready for conversion to accessibility as defined in Section 508, and even more difficult to gain attention to other accessibility features described in the WCAG guidelines and material concerning 'cognitive access".

- It is difficult to convert existing inaccessible documents to accessible pdf/word when the original document has complex tables and the associated text does not describe the table contents in reasonable detail. Even when converted, such documents present an extreme processing load to a reader using a screen reader or other audio access.

- There is a need for machine instructions, but it is too difficult to scan a densely printed instruction card to find needed information during the voting process. We replaced the card with a spiral-bound flip book, but this revision was not tested.

- There was no place to store the instruction card/book in the voting booth so that it was easily visible and manipulable.

- Many ballot and voter guide text samples scored above the college level for readability. We had little difficulty reducing the reading demand to the grade 8 level, but sometimes had difficulty getting to our target of grade 6.

- Machine translation of the readable materials failed in both languages. Spanish reviewers felt that many of the problems came from use of colloquialisms preferred by people with intellectual disabilities but challenging to the translation program. They felt that one could write a version that would translate adequately, but it might not be the one preferred by English-speaking people with disabilities. The Korean translation was a total failure. Most sentences were translated without any verbs, and the reviewers could not decipher the meanings of the text samples.

Recommendations and next steps

- There is a clear need for instructions for accessible voting machines located in the polling place. There needs to be a place to store the instructions in clear view. We believe that voting booths need redesign, both to allow for this and to allow voters to refer to completed sample ballots or other materials they bring with them to the polling place for reference during the voting process.

- Poll workers need more training in using the accessible technologies and in offering access to the technology to all voters.

- While federal agencies are already implementing accessibility guidelines (Section 508 compliance), there is a huge need for education of researchers, professionals, and the general public on the need for and creation of accessible documents, both print and digital.

We suggest that accessible products should be required of all contractors and grantees receiving federal support.

- It would be valuable to offer guidelines or tools to everyone creating materials to be read by voters to help make sure that what is written is readable and accessible to assistive technologies. The definition of readable needs clarification and general consensus. At present, too many people think it is simply a matter of print size.

- Low cost machine translation is not sufficient for translating voting materials into other languages. This technology is improving rapidly, and should be monitored for future use. In the meantime, though, it may be possible to create versions for translation into Spanish and other Indo-European languages. This possibility requires further research. It does not appear likely that the same can be done for non-Indo-European languages.

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