

# What Older Adults Can Teach Us About Designing Better Ballots

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A gerontechnological approach to the human factors of voting machines and ballot design can minimize error and increase efficiency for older adults.

**T**HE 2000 U.S. PRESIDENTIAL ELECTION raised many questions about the accuracy of casting and counting votes and the integrity of the democratic process as a whole. Related issues arose in the 2004 presidential election, when doubt was raised about whether every eligible citizen had an equal opportunity to make his or her vote count. Although close elections are nothing new in the United States, the fact that the contested seat was for president made people realize that sound planning is crucial to voting technology and ballot design and that dire consequences can result if poor designs are implemented.

In this article, we describe a gerontological approach to the study of the human factors of voting designs and argue that close inspection of the performance of older users can elucidate potential problems that may otherwise go undetected in human factors tests of other age groups. By taking human abilities across the life span into account, designers can determine the most usable system for older users and thereby improve performance for all.

## Background

A great deal of effort has gone into improving the U.S. voting system since the 2000 election, but much work still remains, as evidenced by the 2006 midterm elections. Scattered nationwide glitches with electronic voting machines forced delays in the opening of polling places and/or caused them to remain open later, resulting in longer lines, longer wait times, and a greater chance that voters would leave in frustration before casting their ballots (CNN, 2006). To prevent situations like this, human factors/ergonomics professionals should perform tests to examine the ability of voters not only to cast a vote accurately but also to cast a vote in a timely and efficient manner. The United States is not the only country with such problems (Fryklund, 2004).



In the research reported in this article, we took a gerontechnological approach (Bouma, 1992) to the study of the human factors of voting designs. This approach implies that designs that accommodate the capabilities and limitations of older adults – a group that is more variable than any other age group with regard to both interindividual (e.g., Morse, 1993) and intraindividual differences (e.g., Krampe, Engbert, & Kliegl, 2001) and more sensitive to slight design and interface distinctions because of physical, perceptual, and cognitive changes associated with age – should make systems more user-friendly for all (also see Kroemer, 2006).

This approach of attending particularly to the needs of older users is logical because people are living longer thanks

**FEATURE AT A GLANCE:** In this article, we examine the interplay between electronic voting technology machine types (touchscreen vs. touchscreen + keypad) and ballot designs (full ballot vs. one office per page) that together comprise the interface to which voters are exposed. Using a gerontological approach, we show that determining the most usable system for voters with the most limited capabilities (in this study, older participants) also corresponded to higher performance across groups (younger participants). Because older adults are more sensitive to slight differences in human-computer interaction designs, examining their performance may help shed light on potential problems that could otherwise go undetected.

**KEYWORDS:** usability, human factors, aging, technology, design

to dramatic increases in life expectancy (Rowe & Kahn, 1998), and the baby boom generation is entering older adulthood (U.S. Census Bureau, 2004a). More important, elections bring out a larger proportion of older adults than of any other age group in America, so ensuring the usability of voting technologies for older adults should be of paramount importance. In the 2004 presidential election, for example, 69% of eligible voters aged 65 and older turned out to vote, compared with only 42% of eligible voters aged 18 to 24 (U.S. Census Bureau, 2004b).

## Does Every Vote Count?

The 2000 presidential election made clear that the outcome of a race could depend, at least partly, on a lack of human-centered design. Human perception is clearly affected by design layout; designs that employ patterns with familiar shapes and locations can be read quickly and easily by users, whereas designs of inferior quality lead to patterns that are easily mistaken and take longer to decipher.

This issue of so-called format literacy grabbed the nation's attention when Palm Beach County, Florida, voters expressed frustration about the ballot. They were confused by the layout of the ballot (punch card, butterfly design) and may have mistakenly voted for Reform Party candidate Pat Buchanan rather than Democratic Party candidate Al Gore. This confusion resulted in more than 29,000 spoiled ballots, 19,000 of which were double-punched. This produced an overall error rate of about 6.1% (Caltech-MIT Voting Technology Project, 2001) and an error rate of 4.1% for double-punched ballots alone. These rates are about five times higher than for presidential ballots cast in other states (Fessenden, 2000). By comparison, only 3,700 senatorial ballots were double-punched or spoiled in the same county because of the layout of the butterfly ballot.

These error rates are in complete opposition to error rates found in the Caltech-MIT Voting Technology Project, in which data were gathered from the 1988, 1992, 1996, and 2000 presidential elections and which revealed that the error rate for presidential races was 2.5% compared with an error rate of 4.7% for Senate races. This clearly illustrates that the ballot design implemented in Palm Beach County was misleading and probably led to a distortion of the actual number of votes cast for each presidential candidate.

One key factor that contributed to the confusion was the voting device. Punchcard ballots lead to major problems with reliability, because card readers may scan the same ballot and come back with different results if there are incom-

plete punches ("hanging chads") or multiple punches. As far back as 1988, the National Bureau of Standards, now the National Institute of Standards and Technology (NIST), strongly recommended that counties eliminate punchcard systems completely (Saltman, 1988), yet there was no authority to enforce its recommendation. Only when the situation became so dire that the 2000 presidency hinged on a recall of ballots from Palm Beach County did counties nationwide seriously consider upgrading dated voting technologies.

A second key factor was the design of the ballot. In Palm Beach County, a butterfly ballot design was used in which a column of radio buttons down the center of the ballot failed to align with a corresponding list of candidates' names (see Figure 1). Voters who believed the second circle represented the second candidate would have mistakenly cast their votes for an unintended candidate.

*Human factors/ergonomics professionals should perform tests to examine the ability of voters not only to cast a vote accurately but also to cast a vote in a timely and efficient manner.*

This problem could have been avoided if voters had been given the ability to easily *verify* their choice before casting the ballot. Many county officials believe that electronic voting machines may provide the easiest, most reliable way to provide this verification. For example, these machines could provide a review page showing voters' choices so that a voter can confirm the ballot or go back and make revisions.

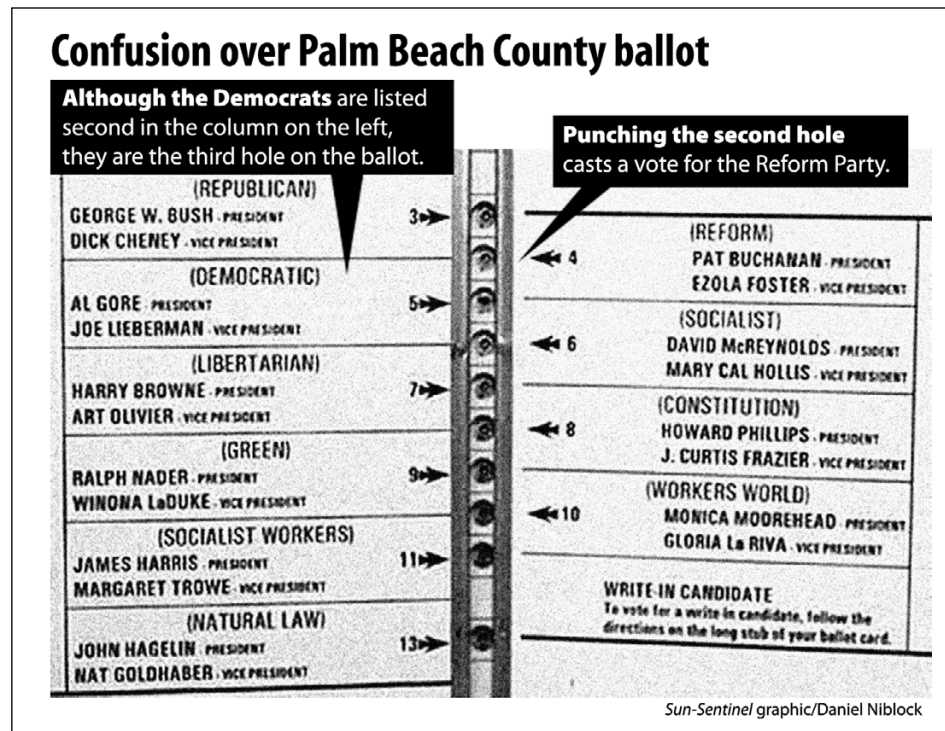


Figure 1. Butterfly ballot, punch card used in Palm Beach County, Florida, 2004.

## Will Voting Be Time-Costly?

In the 2004 election, the presidency again hinged on one state's electoral votes, this time in Ohio. In this case, Franklin County voters reported waiting in lines in the rain for three hours or more to cast a vote, and polls were forced to remain open well past intended closing times to accommodate resolute voters. It is unclear how many voters were deterred by the long lines, but as one Ohioan stated after an eight-hour workday, "I was all for voting, but the lines were too long. I wasn't going to mess with it" (Siegel, 2004).

There were two reasons for these inordinate wait times. First, the number of voters on registration rolls in that county had increased 25% since the 2000 election, yet the number of voting machines remained the same. Election officials should have anticipated this problem long before the polls opened. Second, it was reported that the ballot design was complicated, and therefore time-consuming, because of poor layout and design, so it took longer to complete ballots than in past elections (Knapp, 2004). In today's convenience-based society, it is reasonable to assume that people will not be willing to invest more time on any task, so accounting for the amount of time it takes to get to the polling location and complete a ballot is not trivial.

### LEGISLATIVE ELECTION BALLOT ANYTOWN, USA

GOVERNOR	LIEUTENANT GOVERNOR	SECRETARY OF STATE
1. John Thune 2. Kurt Evans 3. Tim Johnson 4. William Smith <input type="text" value="Enter Choice #"/>	1. Terry Banks 2. Linda Anderson 3. Mike Rounds 4. Dennis Duggard <input type="text" value="Enter Choice #"/>	1. Nathan Barton 2. Jennifer Ramsey 3. Ian McArthur 4. Roger Brooks <input type="text" value="Enter Choice #"/>
ATTORNEY GENERAL	STATE AUDITOR	STATE TREASURER
1. Bob Sahr 2. Bob Newland 3. Alex Martin 4. Kate Nelson <input type="text" value="Enter Choice #"/>	1. Chris Marley 2. Lynne McDougall 3. Jean Harrison 4. Robert Warner <input type="text" value="Enter Choice #"/>	1. Pat Crist 2. Bill Nelson 3. Charles Sheridan 4. Robert Charles <input type="text" value="Enter Choice #"/>
COUNTY AUDITOR	REGISTER OF DEEDS	COUNTY COMMISSIONER
1. John Fitzgerald 2. Ralph Goode 3. Thomas Everly 4. Howard Dickens <input type="text" value="Enter Choice #"/>	1. Emily Robson 2. Kevin O'Rourke 3. Scott Peterson 4. William Banning <input type="text" value="Enter Choice #"/>	1. Tony Ricks 2. Susan Hanson 3. Marjorie Brown 4. Robert Boris <input type="text" value="Enter Choice #"/>
MAYOR	COUNCIL SEAT 4	COUNCIL SEAT 7
1. Alice Scheffers 2. Lou Davis 3. Mary Carriere 4. Susan Lowe <input type="text" value="Enter Choice #"/>	1. Mitch Sheedy 2. Norman Letterman 3. Alan Jones 4. Peter Main <input type="text" value="Enter Choice #"/>	1. Neil Sommers 2. Stan Harris 3. Bill Sinclair 4. Abe Peters <input type="text" value="Enter Choice #"/>

ACCEPT VOTE

Figure 3. Full ballot for touchscreen + keypad condition.

### LEGISLATIVE ELECTION BALLOT ANYTOWN, USA

GOVERNOR	LIEUTENANT GOVERNOR	SECRETARY OF STATE
<input type="radio"/> John Thune <input type="radio"/> Kurt Evans <input type="radio"/> Tim Johnson <input type="radio"/> William Smith	<input type="radio"/> Terry Banks <input type="radio"/> Linda Anderson <input type="radio"/> Mike Rounds <input type="radio"/> Dennis Duggard	<input type="radio"/> Nathan Barton <input type="radio"/> Jennifer Ramsey <input type="radio"/> Ian McArthur <input type="radio"/> Roger Brooks
ATTORNEY GENERAL	STATE AUDITOR	STATE TREASURER
<input type="radio"/> Bob Sahr <input type="radio"/> Bob Newland <input type="radio"/> Alex Martin <input type="radio"/> Kate Nelson	<input type="radio"/> Chris Marley <input type="radio"/> Lynne McDougall <input type="radio"/> Jean Harrison <input type="radio"/> Robert Warner	<input type="radio"/> Pat Crist <input type="radio"/> Bill Nelson <input type="radio"/> Charles Sheridan <input type="radio"/> Robert Charles
COUNTY AUDITOR	REGISTER OF DEEDS	COUNTY COMMISSIONER
<input type="radio"/> John Fitzgerald <input type="radio"/> Ralph Goode <input type="radio"/> Thomas Everly <input type="radio"/> Howard Dickens	<input type="radio"/> Emily Robson <input type="radio"/> Kevin O'Rourke <input type="radio"/> Scott Peterson <input type="radio"/> William Banning	<input type="radio"/> Tony Ricks <input type="radio"/> Susan Hanson <input type="radio"/> Marjorie Brown <input type="radio"/> Robert Boris
MAYOR	COUNCIL SEAT 4	COUNCIL SEAT 7
<input type="radio"/> Alice Scheffers <input type="radio"/> Lou Davis <input type="radio"/> Mary Carriere <input type="radio"/> Susan Lowe	<input type="radio"/> Mitch Sheedy <input type="radio"/> Norman Letterman <input type="radio"/> Alan Jones <input type="radio"/> Peter Main	<input type="radio"/> Neil Sommers <input type="radio"/> Stan Harris <input type="radio"/> Bill Sinclair <input type="radio"/> Abe Peters

ACCEPT VOTE

Figure 2. Full ballot design for touchscreen.

## Electronic Voting Machines and User Testing

It seems clear that better planning and better selection of voting technologies could have eliminated many of the observed problems. Electronic systems, known as direct recording electronics (DREs), are more advanced and are considered the wave of the future in voting design. They are compact and cost-effective and require no mass of paper ballots, and they could be highly accurate and efficient if usable ballot interfaces were implemented.

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Despite the perceived benefits of DREs, they must first withstand the scrutiny of quality empirical testing and assessment that takes into account known human capabilities and limitations. With proper application of human factors knowledge and research strategies in the domain of voting, the number of miscast ballots and miscounted votes can be reduced substantially, future problems with misleading or confusing interfaces can be avoided, and confidence in new systems can be gained.

In our study, we examined several conditions that pertain to successfully casting an intended vote. First, we compared two common DRE machine types and then compared two common ballot designs that a DRE may implement. A task analysis is a useful tool for measuring the likelihood that each specified voting technology will produce a spoiled ballot. This involves taking a representative sample of the

voting population and determining the probability of an error being made during each step of the process. It is then possible to design and test systems that will help to reduce both human and machine error.

It is particularly important to review the data on older adults, given that the chance of making an error may be higher for this group if time pressure plays a role (Salthouse, 1996). If manufacturers would design systems that support the capabilities of older adults, who typically encounter the most problems with human-computer interaction, the rest of the population would almost certainly benefit because the system would be inherently simpler to use. This is the premise that underlies the field of gerontechnology and that motivates this study.

To provide an initial assessment of how design can constrain speed and accuracy in voting technology, we recruited 30 participants between the ages of 18 and 26 ( $M = 20.5$ ) and 30 participants between the ages of 64 and 77 ( $M = 68.3$ ) from the community. Participants were asked to cast a hypothetical vote using systems and interfaces similar to existing DRE technologies. We gave them a printed list of candidates for whom to cast votes and informed them they could refer back to this list as often as necessary to cast the correct vote. This scenario may closely resemble Election Day for some voters; many jurisdictions and newspapers provide test ballots to allow people to familiarize themselves with the format and content before going to the polls, and some voters bring those ballots with them as a guide.

We tested each individual across four experimental conditions, including a touchscreen system that presented a full ballot on one screen (see Figure 2), a mixed system (touchscreen + keypad) that presented a full ballot on one screen (Figure 3), a touchscreen system that presented one office per page (Figure 4), and a mixed system that presented one office per page (Figure 5). We hypothesized that accuracy would be highest when the voter was presented with one office per page, because verification could be provided for each office individually rather than verification being provided only once for the entire range of offices presented with the full ballot design. However, we hypothesized that the increased accuracy would come at the expense of total time to complete the ballot.

For the touchscreen systems, we gave participants a light pen (direct positioning device) and asked them simply to point to the screen to highlight the candidate of choice. Once selected, that candidate's name was highlighted and the vote was cast only when the voter touched "Accept Vote" at the bottom of the screen. Past research indicates that the use of a direct positioning device minimizes differences across age with regard to pure pointing tasks, which in turn reduces time and increases accuracy for attaining a target item (Charness, Holley, Feddon, & Jastrzembski, 2004). As such, we hypothesized that age differences would be minimized using the pure touchscreen system.

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In the mixed-system design, the voter typed in the number of the candidate in a box on the ballot and then touched "Accept Vote" at the bottom of the ballot with the light pen to verify and cast the vote. Past research has revealed that older adults have more difficulty with interleaving devices (the light pen and the keypad, similar to the technology of an automated teller machine; see Jastrzembski, Charness, Holley, & Feddon, 2005). Therefore, we hypothesized that older adults would be at a particular disadvantage compared with younger adults when performing with mixed systems in this applied setting.

## Results Confirm the Need to Design for the Aging Voter

To assess the efficacy of each machine type/ballot design combination, we recorded the accuracy of casting the hypothetical vote across all experimental conditions and the time required to complete each ballot on each voting machine type (very useful information, given long lines at polls).

We found very low error rates across both younger and older adult age groups (0.2%–1.9%; see Figure 6), but it is

**LEGISLATIVE ELECTION BALLOT  
ANYTOWN, USA**

**DISTRICT 9**

STATE SENATOR, District 9

- Thomas A. Dempster
- Ryan D. Kannas
- Carl Twedt
- Cindy Blake

ACCEPT VOTE AND CONTINUE TO NEXT PAGE

Figure 4. Ballot design for touchscreen, one-office-per-page interface.

**LEGISLATIVE ELECTION BALLOT  
ANYTOWN, USA**

**DISTRICT 9**

STATE SENATOR, District 9

- 1. Thomas A. Dempster
- 2. Ryan D. Kannas
- 3. Carl Twedt
- 4. Cindy Blake

Enter  
Choice #

ACCEPT VOTE AND CONTINUE TO NEXT PAGE

Figure 5. Ballot design for touchscreen + keypad system, one-office-per-page interface.

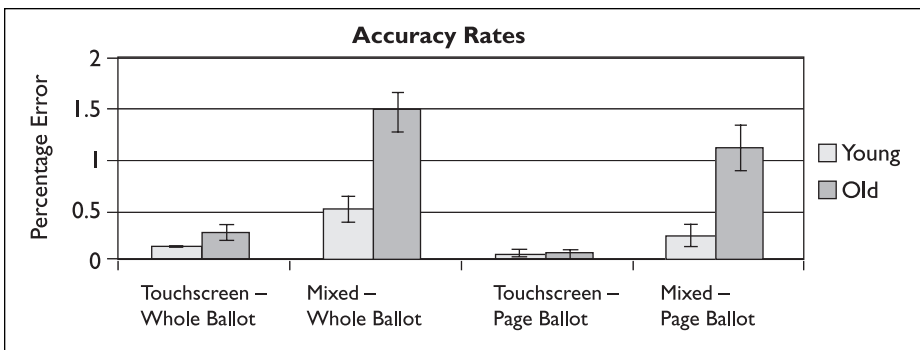


Figure 6. Error rates for condition and age with standard error bars.

important to keep in mind that even seemingly low error rates can translate into significant numbers of spoiled ballots in a national election. For instance, in the 2004 presidential election, these rates would have resulted in 25,000–2,400,000 spoiled ballots.

We found that pure touchscreen systems proved to be more accurate than mixed touchscreen + keypad systems for both older and younger participants,  $F(1, 58) = 70.63$ ,  $MSe = 3156.84$ ,  $p < 0.01$ . In fact, error rates were consistently lower across age groups in the design displaying one office per page for both touchscreen and mixed systems. In addition, error rates were lowest overall and error rates were minimized across age in the touchscreen design with ballots displaying one office per page, and error rates were highest across age in the mixed system with the entire ballot displayed at once.

Older adults made nearly three times as many errors as their younger counterparts in the worst scenario, which suggests that older voters would be far more likely to cast a vote that did not reflect their intention based solely on characteristics of the system and display. This result alone provides a strong rationale for designing with the older voter in mind.

Analyses of ballot completion times, however, revealed a different story. Touchscreen designs still produced faster completion times than did mixed designs, and displaying the whole ballot at once was more time-efficient than displaying one office per screen. Mixed designs proved to be the most time-consuming for older adults, requiring more than twice the time compared with younger adults' completion times (see Figure 7).

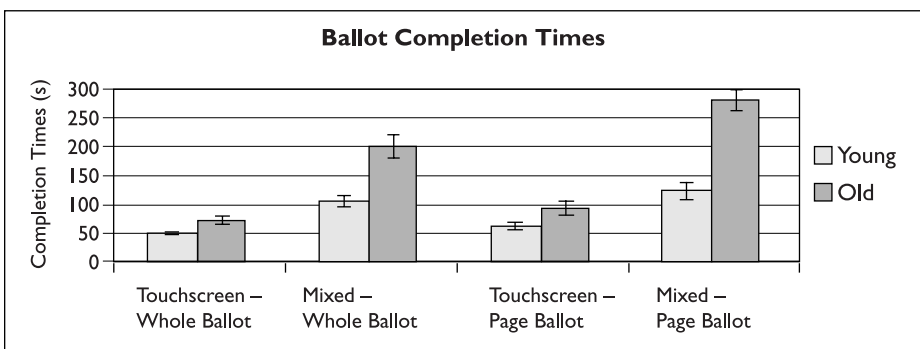


Figure 7. Completion times for machine type and ballot type by age.

To translate what these results might mean in a real election, we computed how many people of ages equally spread through the lifespan could be moved through a typical polling station in Leon County, Florida, given (a) the number of machines typically available on Election Day, (b) a steady flow of people waiting to vote, and (c) buffers of about one minute per person to get situated in the booth and then to collect materials to leave upon completion. To

demonstrate the trade-off in accuracy by machine type, in the table opposite, we report the number of spoiled ballots that would result if the nation were to use each of these respective systems, based on voter turnout numbers from the 2004 presidential election.

These analyses help to demonstrate the fact that even small discrepancies in the time it takes for an individual to complete a ballot can have a considerable impact on wait times over the course of an hour and, ultimately, over the course of a day. Seemingly small countywide design decisions pertaining to ballot layout or type of machine can lead to substantially longer wait times and raises the possibility that potential voters will be deterred from the polls.

Conversely, designs that result in shorter wait times may also increase the likelihood of a ballot being miscast. As is often the case with human performance in task completion, speed and accuracy seem to trade off and the costs (miscast ballots) must be weighed against the benefits (faster voter throughput). Nonetheless, it is clear from these analyses that mixed systems should be avoided.

## Recommendations

Little research that is publicly available exists, and high-quality empirical research in the field of voting design is needed to ensure the integrity of the electoral process. In the research described here, we studied the interplay between voting technology and ballot design, which together comprise the interface to which voters are exposed. A recent exit poll by Herrnson et al. (2005) highlighted voter comfort and satisfaction with regard to a particular electronic voting machine and ballot design (the Diebold AccurVote-TS with a multiple-page ballot format). The authors found that voters who had worked with full ballot formats in the past did not like the multiple-page ballot format.

In addition, multiple-page ballot designs were associated with greater accuracy but longer completion times (and potentially longer wait times at the polls). Thus, these findings and exit poll feedback indicate that users

## ESTIMATED U.S. FEDERAL ELECTION THROUGHPUT AND ERROR RATES BY DESIGN

Balloting System	Voters/Hour	Miscast Ballots
Touchscreen – Full	116	226,000
Touchscreen – By office	98	65,000
Mixed – Full	83	1,200,000
Mixed – By office	63	814,000

Note: Estimates are based on voting machine distribution at polling stations in Leon County, Florida, and assumed equal age group participation rates.

may feel that multiple-page formats are redundant because of verification requirements on each page and therefore are too time-consuming. We recommend that additional laboratory investigations of these interactions (including user satisfaction) be carried out to help evaluate systems more comprehensively and improve guidelines for future design.

Using a gerontechnological approach, we demonstrated that by taking into account human abilities across the life span to determine the most usable system for older users also corresponded with higher performance in younger users. Thus, examining the performance of older users can help shed light on potential problems that may otherwise go undetected in human factors tests of other age groups. And given that older adults are more likely to experience vision impairment and movement control difficulties, designers may gain insight into how some population groups with disabilities may perform under similar conditions. Therefore, we argue that it may make sense to recruit disproportionate numbers of older adults for subsequent usability studies of voting machines and ballot designs.

We hope that these analyses will be useful to county officials who seek to upgrade dated voting technologies and will promote the incorporation of user-friendly ballot design interfaces that allow for efficient and accurate use. Successful application of these findings could reduce wait times at the polls and reduce the number of spoiled ballots.

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This research was supported as a student pilot project by NIA 1 PO1 AG17211-05, Project CREATE. More detail about the study may be found in Jastrzembski, Holley, and Charness (2004). 