

## **Human Factors Research on Voting Machines and Ballot Designs: An Exploratory Study**

### Section 2: Human Interfaces with Election Technology

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According to the Government Accounting Office, there are 51 different election systems – one for each of the 50 states and the District of Columbia. “Because each of the major stages of an election depends on the effective interaction of people (election officials and voters), processes (internal controls), and technology, each stage poses a major challenge for election officials.”<sup>i</sup>

The lack of standardization and quality control in the election process has created a system greatly in need of reform. Several high-level commission reports and task force findings have been issued since November 2000, and legislative proposals to improve the situation through funding and policy changes are currently progressing through Congress. Suggestions include restructuring the Federal Election Commission, revising and updating *Voting System Standards*<sup>ii</sup> to include human factors criteria, and increasing the role of the federal government in equipment certification, ballot guidelines, and collecting system performance data from states and local officials.

As a result of its analysis of voluntary federal voting system standards, the GAO has determined that more information is needed in a key area: the interaction between voters and voting technology. Voting systems subjected to technical tests prior to the publication of *Voting Systems Standards* (punch card, Marksense or optical scan, and direct recording electronic systems) were not evaluated on criteria related to human factors and usability – in the unique context of use during an election situation. They were not evaluated on the ability to accurately record voters’ intentions, minimize voter error (such as overvoting), or accurately tally results. This will become even more important as the number of new touch screen direct recording electronic (DRE) systems increases, and funding through grants or loans becomes available to promote voting technology replacement. Although new, smaller DREs seem to offer advantages in such areas as access for the disabled and the ability to accommodate multiple-language ballots, they also present new challenges. There is a need for further research on factors such as the willingness of voters to navigate through multiple ballot screens before casting a vote, delays caused by use of the “review” feature when coupled with extended ballots, the use of unfamiliar onscreen or hybrid

controls, durability of touch screen technology (reliability and accuracy in the event of degradation), etc.

While technology may change over time, human behavior remains constant. There is currently no federal agency empowered to conduct research related to voting systems and human factors. Due to the complex nature of the election situation, a comprehensive evaluation of voting systems should include expertise in human factors and behavior (engineering; cognitive psychology), the voting process (political science and election administration), ballot design (information design and technical writing) and interactive systems (computer science). Because the ballot *is* the interface between the voter and the system, information display (including type size, visual organization of information, ballot language, directions for use, etc.) can either increase or reduce the potential for voter error. Many problems attributed to “voter error” or “voter stupidity” in the last presidential election may in fact be attributed to poor design of voting systems and ballots, as well as disregard for the way people process information and interact with equipment in the context of an election situation. Catastrophic problems with some voting systems in November 2000 resulted in lost votes and skewed election outcomes. An indirect casualty was faith in the election process.

Had there been greater emphasis on usability, access and accuracy in the FEC’s *Voting System Standards* published in 1990 it is conceivable that there would have been more emphasis on these criteria during the design, certification and purchase of voting technologies. Ease of use and accessibility are essential to the administration of fair and accurate elections. “Ease of use (i.e., the equipment’s user friendliness) is important not only because it influences the accessibility of the equipment to voters but because it also affects the other two performance measures discussed here – accuracy (i.e., whether the voter’s intent is captured) and the efficiency of the voting process.”<sup>iii</sup>

#### Voting Systems in Use

Voting systems used in the November 2000 election were based on five different methods. These systems, and the percentage of registered voters using each, were: DRE (12%); mechanical lever machines (17%); punch card (31%); optical scan (31%); paper ballots (1%); and mixed systems (8%)<sup>iv</sup>

These five systems require the voter to interact in a variety of ways: pushing buttons, turning knobs, touching computer screens (DREs), turning metal levers (Mechanical Lever), punching cards with a stylus (Punch Card); using a pencil to mark forms (Optical Scan; Paper Ballots). Newer DREs also provide one or more of the following mechanisms for use by the disabled: sip and puff plug-ins, joystick, headphones with audio, Braille keypad, or voice command, making it possible for all but the most disabled voters to participate. (The polling place must also be accessible to entry, or reasonable accommodations made to bring voting technology to the disabled.) Mechanical lever, punch card, paper ballots and optical scan systems all present

difficulties for at least some portion of the disabled population while DREs are most promising with regard to providing equal access. A report issued by The National Commission on Federal Election Reform<sup>v</sup> recommended “New voting equipment systems certified either by the federal government or by any state should provide a practical and effective means for voters with physical disabilities to cast a secret ballot.” Following its investigation on the accessibility of voting equipment, the GAO reports “most voting equipment presents some challenges to voters with disabilities...election officials and representatives of disability organizations told us that DREs can be most easily adapted (with audio and other aids) to accommodate the widest range of disabilities.”<sup>vi</sup>

#### Human interaction with voting systems

A lack of familiarity with voting technologies and ballots may increase voter error. Voting systems are infrequently used and are not standardized across the U.S. Ballot formats vary from election to election, and systems are not always transparent in terms of use. New voters – those who have reached 18 years of age as well as those who have never voted in an election – continually join the voting population. An article on OrlandoSentinal.com<sup>vii</sup> notes that an election task force assembled to provide recommendations to Florida’s legislature identified lack of familiarity as one factor in voter error. “New machinery might produce elevated levels of voter confusion, simply because people make mistakes more with unfamiliar tasks.”

It is undeniable that voter error is a significant problem whether associated with new or existing systems. Another article from the Sentinel noted that Orange County, Florida collected 10,547 “spoiled” ballots during the November 7, 2000 presidential election while using a precinct-count optical scan voting system.<sup>viii</sup> All but 661 ballots with overvotes in the presidential contest were corrected and lost votes recaptured because errors were caught at the precinct and voters were permitted to cast corrected ballots. (A central-count system - ballots tabulated in a central location away from the polling place - would have discarded over 10,000 votes.) Reportedly voters were confused by the large number of candidates running for president, expecting only Bush and Gore to appear on the ballot. An Orange County poll clerk stated “Many voters believed the 10 candidates were running for different offices and cast votes for several of them.”

Voting technologies may have no reference to familiar systems. Obsolete but still widely used mechanical lever machines are a case in point, based on an antique system of levers and counters and ballot strips that impede the reading of Ballot Issues text. Punch card systems are particularly vulnerable to voter error. Problems with incorrect insertion of cards in holders (reported in the media after the last presidential election) can result in misalignment that makes punching holes difficult or recording selections as intended impossible. Some hybrid punch card systems and absentee ballots require voters to read small numbers on the card presenting difficulties for older voters and the visually impaired. Finally, voters may

inadvertently punch the hole above the number rather than the one below it, as required, due to ambiguity in the design of the punch card ballot interface.<sup>ix</sup>

#### Instructions for use

Optically scanned ballots - though similar to forms used for educational testing or applications - have nonetheless produced undesirable levels of voter error in past. Ballots have been marked with the wrong instrument (for example, a colored pen brought into the booth by the voter) or completed on one side only even though the ballot is printed on both sides. An election official in Virginia described a case in which a voter instructed to “complete the arrow” on an optical scan ballot added an arrowhead to the end of one line segment rather than fill in the space between segments as intended by the form’s designer.<sup>x</sup> Because it is difficult to anticipate voter errors, research methods that include usability testing and the collection of “stories” from officials with experience in election administration can help to identify the source of errors identified only as lost or residual votes by a statistical analysis of election results.

Information printed on the ballot or displayed on computer screen should meet minimum legibility criteria including conspicuity, readability, and comprehensibility. An examination of sample ballots from across the U.S. reveals a lack of clarity in instructional language or the display of instructional text in a way that fails to attract attention. For example, an official election ballot from Rhode Island dated November 7, 2000 displays instructions to “Vote both front and back of ballot” in small regular (not bold) type at the bottom of the front page where it could easily be missed by the voter. In another case, “Instructions to Voter” on the general election ballot of Clearfield County, Pennsylvania are written in language so confusing they almost defy interpretation. They state: “3. To vote for an individual candidate of another party, after blackening an oval in the Straight Party Column, blacken the oval to the left of the candidate’s name. For an office where more than one candidate is to be voted for, the voter, after blackening an oval in the Straight party Column, may divide his vote by blackening the oval to the left of each candidate for whom he or she desires to vote. For that office, votes shall not be counted for candidates not individually marked.” Voting under the pressure of time and confronted with an unfamiliar system and ballot display, it is not difficult to imagine that a voter could be confused by these instructions. The correct use of voting technology is based on effective information design.

#### Navigation

Touch screen DREs have a ballot interface or screen display that is smaller than early generation full-page DREs. This requires creating several “pages” in sequence and providing navigation to ensure continuation through the entire ballot, and possibly supplying an incentive to do so. Will the necessity to read and respond through multiple iterations lead to ballot roll-off due to voter fatigue? This phenomenon is the tendency of voters to vote at the top or beginning of the ballot (highest offices) while voting for fewer positions at the bottom of the ballot. With older DREs there is some

indication that flashing red lights on the ballot interface encouraged voters to complete the ballot when compared to voting on mechanical lever machines.<sup>xi</sup> Can attributes of new touch screen systems such as highlighted or colored text, motion graphics or audio capabilities prompt voters to continue voting and reduce fall-off? (This question is based on the assumption that voters should be prompted to continue voting. Do voters avoid the end of the ballot because of “fatigue” or because they know or care less about positions and candidates in these races?)

Testing newer systems in a simulated election situation or during actual elections will provide concrete information on the human use of voting technology and identify problem areas to address in new systems. Pre-certification testing of DRE touch screen systems in Virginia indicated that “voters misread the instructions and bypassed the screen for choosing among the candidates for governor and attorney general races...The biggest display on the screens was a ‘button’ for the instruction ‘next,’ and some voters pressed that before voting for governor.”<sup>xii</sup> This finding could begin to explain why the CalTech/MIT study found a high incidence of residual votes in DRE systems even though they prevent overvoting, a common error.<sup>xiii</sup>

Future human factors research on voting systems should include the following variables:

- 1) ease of use
- 2) accessibility
- 3) effective communication of information on the ballot
- 4) ability of the system to reduce voter error
- 5) potential to reduce voting fall-off (undervoting)
- 6) time to vote

#### Ease of use

Voting systems should be easy to use considering the diverse characteristics and capabilities of the voting age population. Voters vary according to education and literacy levels, prior experience with the voting process, physical and cognitive abilities, size and age. Equipment design (hardware/software) should support use by voters of all sizes, capabilities and education levels. Older voters have decreased levels of visual acuity and may require more time to vote, as evidenced by earlier studies. Controls (touch screen, electronic or manual) must clearly communicate their correct operation and function to all voters.

#### 2) Accessibility

Voting systems should accommodate the majority of physically disabled voters allowing them to vote in secret and unassisted and review selections before casting a vote, whether by adding capabilities to existing systems or setting aside at least one machine per precinct to accommodate those who need it. Ideally accommodations should be integrated seamlessly into the general voting process at the polling place.

### 3) Effective communication of information on the ballot

Ballot design or format can be defined as the organization of information on the ballot, including text, symbols, indicators or mechanisms for selecting and casting votes, and instructions. Factors related to readability and clear communication include text size, font or typestyle, line spacing and line length, proximity between candidate positions and selection controls, and wording and placement of instructions.

Interactive touch screen ballots can incorporate color, motion and sound to ballot design adding to the number of variables that should be tested for effectiveness.

### 4) Ability of the system to reduce voter error

Two common categories of error made by voters are overvoting and undervoting. DREs prevent overvoting while optical scan systems do not. However, optical scan ballots that are read at the precinct level permit voters to correct errors and submit new ballots. Neither system prevents undervoting, but the review feature on DREs and precinct reading of optical scan ballots can each alert the voter who may choose to complete the ballot, or not. With absentee ballots that are tabulated at a central location instructions for use should be explicit to reduce error.

### 5) Potential to reduce roll-off

A more complex issue is ballot roll-off or failure to complete the ballot. This may be intentional, in which case improving the voting system will not result in change.

Should it be unintentional, systems need to provide feedback or enhance motivation (for example, by prompting with visual cues) thus encouraging the voter to continue to the end of the ballot. In order to examine this area, qualitative methods (such as interviewing voters and distributing questionnaires after voting) are needed to supplement statistical studies of election results.

### 6) Time to vote

Time to vote can reveal differences in voting time based on age and experience with voting systems as well as relative differences between systems. It may also indicate whether new, unfamiliar systems slow the voting process but this requires collection of data over time. Systems that allow voters to complete the process more quickly reduce wait time at the polling place and can serve more voters with fewer machines.

Measuring time to vote on comparative systems could be accomplished at the polling place or in a simulated election situation. Poll workers at each precinct could record the time a voter enters the booth and the time they exit using simple timekeeping devices. DRE systems can automatically record such information. In a simulated election, a video camcorder that records voter activities also can display a counter indicating time elapsed from start to finish.

### Research methods

In evaluating all of these factors related to human interaction with voting systems qualitative testing methods conducted on a sample of the voting population could provide valuable information to supplement quantitative analyses of voting results.

Methods include videotaping simulated elections, administering questionnaires and conducting interviews immediate after the voting activity, or in actual elections soliciting comments or responses from voters who agree to participate immediately after voting. Voted ballots from simulated elections can be analyzed to identify individual errors and patterns of error.

Election administrators at the state and local level can be interviewed and categories of error identified by compiling results of multiple interviews. Finally, participant observation can be conducted by researchers who volunteer to work the polls on election day, speak to election officials and poll workers, and go through training to understand the operation of voting systems in context. By combining information from these methods with technical information on computer-based systems and statistical analyses of results, a holistic view of human interaction with voting technology can be produced.

Findings should prompt developers of new computer-based systems to incorporate improvements and provide election administrators with guidelines for ensuring that systems meet the highest standards of usability, accuracy and access for the next generation of voters.

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<sup>i</sup> *Elections: Perspectives on Activities and Challenges Across the Nation*. 2001. GAO-02-3. Washington, D.C. U.S. General Accounting Office, <http://www.gao.gov/cgi-bin/getrpt?gao-02-3>, p.7.

<sup>ii</sup> *Voting System Standards. Performance and test standards for punch card, Marksense and direct recording electronic voting*. 1990. Washington, D.C. Federal Election Commission.

<sup>iii</sup> *To Assure Pride and Confidence in the Electoral Process*. August 2001, The National Commission on Federal Election Reform, p.57.

<sup>4</sup> *Elections: Perspectives on Activities and Challenges Across the Nation*. 2001. GAO-02-3, Washington, D.C. U.S. General Accounting Office, p. 261 (see also forthcoming GAO publication: *Voters with Disabilities: Access to Polling Places and Alternative Voting Methods*).

<sup>v</sup> *To Assure Pride and Confidence in the Electoral Process*. August 2001, The National Commission on Federal Election Reform, p.57.

<sup>vi</sup> *Elections: Perspectives on Activities and Challenges Across the Nation*. 2001. GAO-02-3, Washington, D.C. U.S. General Accounting Office, p. 261 (see also forthcoming GAO publication: *Voters with Disabilities: Access to Polling Places and Alternative Voting Methods*).

<sup>vii</sup> Jon Steinman. <http://www.orlandosentinal.com/news/nationworld/orl-asec-votingmachines-020401.story>

<sup>viii</sup> R.Roy, MGriffin. <http://www.orlandosentinal.com/news/nationworld/orl-nws-votepad04020401.story>

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<sup>ix</sup> Susan King Roth, “Disenfranchised by design: voting systems and the election process.” November 2000. <http://www.informationdesign.org/pubs/roth1988.html> (Originally published in *Information Design Journal*, U.K., 1998).

<sup>x</sup> Conversation with Cameron Quinn, Secretary, Virginia State Board of Elections, March 3, 2002.

<sup>xi</sup> Susan King Roth, “Disenfranchised by design: voting systems and the election process.”

<sup>xii</sup> T. Whitley. “Researchers study voting machines.” *Richmond Times-Dispatch*, November 4, 2001.

<sup>xiii</sup> CalTech/MIT, 2001. *Voting: What Is, What Can Be*. CalTech/MIT Voting Technology Project. <http://www.vote.caltech.edu>.