Early Appraisals of Electronic Voting

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Abstract

With the recent troubles in U.S. elections, there has been a nationwide push to update voting

systems. Municipalities are investing heavily in electronic voting systems, many of which use a

touch screen. These systems offer the promise of faster and more accurate voting, but the current

reality is that they have some shortcomings in terms of voter usability. This study examines issues

related to the usability of electronic voting systems and reports on a series of usability studies that

involved expert review, close observation, a field test, and an exit poll to learn voters' responses

to a new voting system. Our analysis shows these systems work well, but they have some

shortcomings including some that have raised concerns among a minority of voters.

A major lesson derived from the 2000 presidential election is that the manner in which voters cast their ballots is important. Voting technology and ballot design can influence election outcomes, affect how voters feel about their ability to exercise their right to vote, and influence voters' willingness to accept the results of an election as legitimate. The 2000 election also revealed that most polling places employed outdated technology, including unreliable punch-card ballots and mechanical lever machines. Only one-third of the electorate used modern computerized technology, such as optical scanning systems or direct recording electronic (DRE) systems with ATM-style touch-screens (Election Data Services, 1998; Federal Election Commission, 2000).

States have responded to the problems associated with the 2000 elections by commissioning studies, revamping election administration, redesigning ballots, and, in some cases, by investing heavily in new electronic voting equipment in response to the Help America Vote Act passed by Congress in 2002. Electronic voting systems have been a popular response to the problems associated with the 2000 election because they are able to record and tabulate votes quickly and accurately. They also can change font size and language on demand, making ballots easier to read.

However, there is little solid information about the interface between voters and various voting systems and ballots on which to base or evaluate their success or justify the expenditures that are planned for the future. In this paper, we present the issues involved in evaluating electronic voting systems. We report on a study we performed on the Diebold AccuVote-TS voting system, and make suggestions for improvements.

The Impact of Procedural Reforms

There is a long history of research in political science on the impact of procedural reform on elections. Early twentieth century research examined length and lack of uniformity of ballots and found evidence of their effect on roll-off and split-ticket voting (Allen, 1906; Beard, 1909).[1] More recent studies generally conclude that office-bloc ballots result in greater roll-off than party-column or party-row ballots (Key, 1956, p. 212; Walker, 1966).[2] The provision of straight-party circles or levers also reduces roll-off, at least in partisan contests (Robinson & Standing, 1960; Walker,1966; Nichols,

1998, pp. 109-110; Kimball, Owens, & McAndrew, 1996). Moreover, party-column ballots encourage straight-ticket voting in comparison to office-bloc ballots (Bain & Hecock, 1957; Campbell et al., 1960; Rusk, 1970).

Studies of ballot order effects often report that candidates listed first or at the top of the ballot perform better in elections than do those listed at the bottom, at least in nonpartisan and non-salient elections (Mueller, 1970; Taebel, 1975; Darcy & McAllister, 1990; Darcy, 1986; Miller & Krosnick, 1998; Krosnick, Miller, & Tichy, 2003). One study showed that placing a salient race at the bottom of the ballot caused some voters not to cast a ballot (Darcy & Schneider, 1989; though see Bullock & Dunn, 1996). Ballot propositions also were less favored the further down they appeared on the ballot (Bowler & Happ, 1992). Electronic voting, however, is promising in this regard. Studies have shown that electronic voting machines result in less roll-off, presumably because they alert voters to whether they have completed the ballot (Nichols & Strizek, 1995; Nichols, 1998).

In the aftermath of the 2000 election, a number of studies evaluated various aspects of the Florida vote. Analyses showed, for example, that there were many more "overvotes" in Palm Beach County, which used the "butterfly ballot" design (Wand et al., 2001).[3] The U.S. Commission on Civil Rights (2001) concluded that poorer and minority communities more often utilized less modern equipment that is prone to overvotes and other kinds of errors. A major study of voting technology reported that "residual votes"[4] were typically greater in jurisdictions using DRE systems than other kinds of machines (with the exception of punch cards), even when controlling for confounding factors (Caltech/MIT Voting Technology Project, 2001). DRE machines produced a slightly higher residual vote than optical scan ballots (Kimball, Owens, & McAndrew, 2002).

Only rarely have researchers considered whether or how ballot features might confuse voters. They have demonstrated that the labeling of rows on lever machines results in considerably different ballot order effects (Bain & Hecock, 1957). Particular demographic groups, including the elderly, poor, and uneducated are more likely to cast incomplete ballots, which suggests the possibility of confusion, though indifference and lack of knowledge about the candidates also might explain these

results (Walker, 1966; Darcy & Schneider, 1989; Nichols & Strizek, 1995; Nichols, 1998; Wand et al., 2001). Experimental studies of the voting process, while limited in scope, also revealed some confusion on the part of voters (Roth, 1998; Sinclair et al., 2000).

The events surrounding the 2000 presidential election also highlighted an aspect of voting that has not been dealt with since the introduction of the Australian (secret) ballot at the end of the 19th century—namely, that voting technology and ballot design affect how voters feel about their ability to exercise their right to vote and influence voters' willingness to accept the legitimacy of the election results. Thus, despite high quality research on turnout, roll-off, split-ticket voting, and order effects, there is little information about how to reform voting technology and ballot design in ways that will develop, encourage, and support perceptions of the voting process as an accurate and fair reflection of voters' intentions.

Specialized Voting Concerns

Voting systems present a unique challenge to interface designers because of the nature of the social contract our society has for voting. Unlike just about every other system in our society, voting systems must be usable by every citizen at least 18 years old. This includes elderly and disabled users, as well as those with little formal education. It also includes individuals who, for whatever reason, have opted out of using electronic machinery, such as those who go into a bank and see a teller rather than use an ATM, those who do not scan their own groceries, and those who purchase gasoline with cash. The requirements of voting systems bring some concerns related to citizens' support, access, and trust of voting machines. In addition, there are issues related to the possibility that ballot formats might favor some candidates over others, and voting machine designs could jeopardize the anonymity of voters. Some questions even exist about the validity of the recorded vote. We now examine the importance of each of these issues, with special attention to electronic voting systems.

Accessibility

One of the largest issues related to DRE voting systems is accessibility. For designers of computer programs, accessibility is the easiest design factor to ignore. Although the federal Voting

Accessibility for the Elderly and Handicapped Act (VAEHA), passed in 1984, mandates that polling places be usable by the elderly and handicapped, in both 1998 and 2000, 47 percent of polling places had some type of accessibility problem (National Voter Independence Project 2001), with additional problems related to equal treatment within the voting area.

Age and Technical Experience

Older adults consistently perform worse than do younger adults on computer-based tasks, both with respect to the amount of time required to perform the task and the number of errors made (Kulbeck, Delp, Haslett, & McDaniel, 1996). Age is positively correlated with difficulty in performing tasks with a computer, including using a mouse (Riviere & Thakor, 1996). Older adults typically have greater difficulty viewing a computer screen. They also struggle more with conceptualizing the relationship between screen or button manipulation and computer program activity.

Additionally, challenges extend to those of all ages who are uncomfortable with new technology. The first time many voters touch a voting system is when they cast their initial ballot. Once they start voting, there is tremendous social pressure to cast a ballot without asking for help. Voters may be unwilling to ask for assistance for various reasons: they may be too embarrassed to ask for help or they may feel pressured by others who are waiting on line. Moreover, some voters may be unwilling to ask for assistance because they do not want to compromise the secrecy of their ballot. Educational programs can help alleviate this situation, but voter guides, television commercials, and other materials that election officials, the media, political parties, and other groups distribute are no substitute for hands-on experience.

Bias

The potential for bias presents both logistical and legal challenges in ballot design. Candidates believe that their location on the ballot is important. Indeed, those listed first are generally favored (Darcy & McAllister, 1999; Krosnick, Miller, & Tichy, 2003). Potential biases have led most jurisdictions to designate the balloting order by law. Candidates are often listed by office sought or by party in a specified configuration. Their ordering is often determined by lottery or alphabetically.

Computers, of course, can randomize the presentation of names, but this creates difficulties for users who have pre-planned their voting. Randomized names also complicate the efforts of groups that seek to educate voters by distributing sample ballots.

Machine Purchase, Evaluation, and Maintenance

How officials purchase and evaluate voting machines also can be problematic. State or county purchasers are usually more concerned about cost than usability, which is understandable because usability was not an issue prior to 2000. Despite some outreach attempts, few voters are able to use the machines for evaluation. Election workers who design ballots tend not to have experience in usability and screen design.

Hardware maintenance is another issue that is especially important with touch screen voting systems. With repeated use, touch screens can wear out. In particular, problems can develop with localized sensitivity. This means that without proper maintenance, it could physically become more difficult to vote for a popular candidate than for unpopular ones. Should voters touch the screen for a particular candidate and not realize the machine did not register their vote, this could affect official vote totals and influence the outcome of a close election.

Accountability and Verifiability

Traditionally, voters cast their ballots on paper, and election officials counted the results by hand. Voters were confident that the marks they made on ballots reflected their intended vote (even though off-centered X's and stray marks sometimes invalidated ballots.) Voting machines with levers and punch card systems also provided voters with a high degree of confidence that they cast their votes as intended. Until the 2000 elections voters also routinely assumed that election officials counted their votes properly. Because they are paperless, DRE systems raise the question: how can voters know the candidates they have chosen were accurately recorded? One solution to this problem is to allow the voter to view a printed record of the ballot that was electronically recorded. The printed records could be manually counted in the event of a challenge or sampled to verify the computerized tabulation. This procedure, some argue, would foil any attempt at falsifying votes internally to the

voting system. However, this approach has the potential to create a nightmare scenario for election officials. The very existence of a discrepancy between electronic and paper ballots would leave election officials with a potentially explosive conundrum when determining which is valid.

The Research Project

It is not always easy to identify the strengths and weaknesses of each DRE system. Election officials need to become accustomed to thinking in terms of usability, and especially with regard to less technologically sophisticated or practiced users. We evaluated the Diebold AccuVote-TS, which is in use in California, Georgia, Kansas, Maryland, North Carolina, and Washington (see Figure 1).[5] It has a touch screen with a card reader that the voter receives after being authenticated by polling officials.

[Insert Figure 1 here]

We used four methods, each a study in itself: expert review, close observation, a field test, and an exit poll. Each of these techniques enabled us to identify some of this system's shortcomings and indicated features to be tested on other voting systems. Unfortunately, we did not have the ability to design the ballot or change the interface. The expert review, close observation, and field test used a somewhat unrealistic ballot, which consisted of five races and one ballot question. The ballot was presented on two screens.

Method 1: Expert Review

Expert review consists of having several individuals with significant experience in user interface design examine the system in detail, perform representative tasks, and record weaknesses (Nielsen, 1993). Five faculty and staff at a university human-computer interaction lab performed this task. Each researcher spent approximately one hour evaluating the system and independently reported his or her concerns and suggested solutions. The standard visual and audio-only systems were evaluated independently. The following shortcomings were identified.

Visual System

1. *Inconsistent terminology/labeling (5 reviewers)*. Several words were confusing, inconsistent, or

did not match the instructions.

2. *Color usage (4 reviewers).* Dark background colors resulted in poor contrast with the black text.

3. *Inserting/removing card (4 reviewers).* It was difficult to locate where to insert the card and to actually insert it. The short delay that occurs before the machine reacts compounded the problem.

4. *Help/instructions (4 reviewers).* The instructions are long and unclear, and no help button is visible during voting.

5. *Layout (4 reviewers).* It was unclear how the ballot would look if the list of candidates fills more than one column or when names are exceptionally long. The review screen may cause confusion because it is organized differently than the voting screens.

6. *System information (4 reviewers).* The startup screen showed information irrelevant to voters.

7. *Screen glare (3 reviewers).* Screen glare may cause problems in some polling places.

8. *Change feedback (2 reviewers).* Voters must unselect an existing candidate prior to selecting another. The machine provides no warning for overvoting.

9. *Graphics/design quality (2 reviewers).* The images are low resolution, the colors are strong, and there are too many font styles.

10. *Privacy (1 reviewer).* Others might be able to see one's vote as it is being cast.

Audio-only System

1. *Keypad mapping (5 reviewers).* The keypad mapping is inconsistent and unusual, making it hard to remember which number is assigned to which function.

2. *Audio quality (5 reviewers).* Static, clicks, and delays make the audio difficult to understand.

3. *Ballot review (3 reviewers).* There is no review of the ballot before casting it.

4. *Feedback (2 reviewers).* The buttons do not have any audio feedback when pressed. No warning is given for overvoting.

5. *Cast ballot (2 reviewers).* Voters have no option but to listen to the entire ballot.

6. *Volume Control (1 reviewer).* The volume control does not indicate which way is loud or soft.

Method 2: Close Observation

We observed and videotaped non-experts responding to all aspects of the voting process, including inserting the ballot card, selecting candidates, and casting their ballots. We employed the "think aloud" method in which voters describe what they are doing and any issues they encounter while using a piece of equipment (Ericsson & Simon 1993). Voters used a questionnaire to provide their reactions to the voting system. We measured how long it took each individuals to vote from the time they walked up to the machine until the time they left it. We also counted the number of errors they made.

For this study, we observed 47 university students, faculty, and staff. The test ballot (designed by Diebold) included five races and one question that was split between two screens. The average time to complete the ballot was 2 minutes and 10 seconds. All participants except one, who was unable to determine how to write in a candidate, cast their votes successfully.

The participants generally liked the DREs, rating their overall comfort 7.7 on a 9-point scale where 9 represented highest level of comfort. They found the screen layouts and color slightly less satisfactory (6.9 out of 9). The primary issues we observed from the videotapes were:

1. System failure. One of the two machines malfunctioned (it would not return the voter card) and was rendered unusable at the start of the test.

2. Card insertion. Many participants had difficulty inserting the card, which begins the voting process. They expected the machine to accept the card as ATMs do. They put the card in the slot gently and waited for the machine to pull it in. However, the system requires the card to be inserted hard until it "clicks." The card is ejected when the ballot is cast.

3. System startup. There were two language options: English and Spanish. English is the default. Because the button layout was unclear most of the subjects touched "English" and waited for the next screen. It often took several seconds for voters to recognize they also had to press the "Start" button.

4. Undervoting. The system provides a summary page once the voter has sequenced through the entire ballot. This page highlights via a distinct color the races in which a candidate was not selected.

However, if a full complement of candidates was not selected in multi-candidate contests (i.e., it was undervoted) that race was not highlighted.

Method 3: Field Study

The field study involved a larger, more representative group of individuals in a more natural setting. We administered a questionnaire to record the respondents' assessments of the system. We were unable to record information about their interactions with the voting system because we had to rely on individuals untrained in usability research to implement this portion of the study. Another shortcoming of this part of the research is that the participants comprised an economic and social elite, mainly suburbanites who had high levels of educational attainment, computer usage, and Internet usage.[6] Thus we have responses from a narrow slice of the population and the results probably give an overly favorable assessment of how voters can be expected to respond to the voting system. The same caveats about the simplicity of the ballot discussed above apply here.

The questions in the field study used a scale of 1 to 9, where 1 represented the most negative and 9 represented the most positive evaluations. The respondents' overall reactions to the system were generally positive: 81 percent reported that the system was easy to use (rated an 8 or 9); 11 percent reported the machines were moderately easy to use (rated 7); and the remaining 9 percent indicated it was anywhere from difficult to somewhat challenging to use (rated from 1 to 6; see Table 1).

[Insert Table 1 here]

Although 9 percent seems a small portion, it is important to recall that this is an elite group, and 9 percent of the United States' voting age population equals roughly 9.5 million voters.[7] Despite the homogeneity of the sample, there was some variation of opinion among the respondents. Individuals who own a personal computer, use computers frequently, or live in a city or suburban area had more favorable overall impressions of the new voting system than did others. Women had more favorable impressions than did men. (Note: all of the comparisons reported here and below are statistically significant at p<.05 or better.)

The respondents' evaluations were largely positive for the other criteria. More than eight of ten evaluated the system positively in terms of their comfort in using it, the readability of the characters on the screen, the clarity of the terminology on the screen, the ease of correcting mistakes, and their trust that the machine recorded their vote accurately. Nevertheless, the negative evaluations often approached the seven to eight percent level for four of the remaining five criteria. Only the readability of characters on the screen had fewer than five percent report a negative rating.

As was the case with the respondents' overall reactions, these results indicated that women, individuals who own personal computers, use computers frequently, or live in a city or suburban area were the most comfortable using the system. In addition, older individuals and those with higher levels of education had more difficulty reading the characters on the screen, reflecting what is generally known about the poorer eyesight of these groups. Individuals who use personal computers less frequently were most likely to find the terminology more ambiguous.

Individuals who use computers frequently found it easier to correct mistakes than did others. Ironically, these individuals reported having *less* trust in the voting system than did others. This result probably stems from their greater understanding of the limitations of computer technology, exposure to computer "crashes," familiarity with viruses, and awareness of other challenges facing the computer industry. Whatever the explanation, this somewhat counter-intuitive result suggests that the kinds of individuals most likely to vote (well-educated citizens) may have the greatest doubts about DRE systems.

Method 4: Exit Poll

We conducted an exit poll on Election Day in 2002 to evaluate the performance of the voting machines under the most realistic of circumstances—an actual election. We used a multi-stage cluster sampling design to collect the data (Babbie, 1990, pp. 90-91). We conducted the poll in twenty-three precincts located in two fairly diverse counties in a very heterogeneous state. We selected the precincts to ensure that a variety of population groups were represented, and administered the survey at

predetermined intervals to ensure further that we collected data from a diverse sample of voters. A total of 1,266 voters participated in the study.

We designed the exit poll to obtain five types of information: 1) voters' assessments of the systems; 2) the problems they encountered when using the system; 3) their computer usage levels; 4) their demographic characteristics; and 5) their party affiliation and gubernatorial vote. Although we did not attempt to assess the impact of the education campaigns that the state and local boards of elections, the local media, political parties, and other groups sponsored, the efforts of these organizations constituted an important intervention that occurred between the other portions of our study and the exit poll.

It should be recalled that voters residing in the two counties comprise an elite population.[8] Nevertheless, the sample has substantial variance on several key demographic variables, such as age, race, and gender. Seventeen percent of the respondents were between 18 and 34 years of age, 59 percent were between 35 and 64, and 24 percent were over 65. African Americans accounted for 33 percent of the respondents; whites accounted for 57 percent; and Hispanics, Asians, and others accounted for the remaining 10 percent. Female respondents outnumbered men by 54 to 46 percent. Despite the diversity of the sample, the exit poll results are probably similar to the field tests in that they provide an overly favorable assessment of how voters respond to the new voting system.

The questions in the exit poll used a scale of 1 to 7, where 1 represented the most negative and 7 represented the most positive evaluations. The respondents' overall reactions were again very positive (see Table 2). Ninety-one percent reported that the system was easy to use (rated 6 or 7), 4 percent reported it was moderately easy to use (rated 4 or 5), and the remaining 5 percent indicated it was anywhere from difficult to somewhat challenging to use (rated from 1 to 3). Of course, this 5 percent would translate into 5.3 million of the nation's voters, and a more representative sample of voters may have provided a less favorable assessment.[9]

[Insert Table 2 here]

The respondents provided similar evaluations concerning their comfort using the system, the readability of the characters on the screen, the clarity of the terminology, the ease in correcting mistakes, their belief that the machine recorded their votes accurately, their trust in the system, and the helpfulness of election judges. The voters' overall trust in the system received the least favorable evaluations. Eighty percent rated their trust in the system six or higher, while the remaining 20 percent rated their trust level five or lower. These levels of trust may reflect voters' unfamiliarity with the system and may improve as voters become more accustomed to the machines. But they also may reflect unease with the notion of relying on computers for this most important democratic function.

There was not much variation of opinion among exit poll participants. Voters who used computers frequently had more favorable overall impressions of the new voting system than did others; senior citizens found it slightly easier to correct mistakes than did others; female voters reported having more confidence in the voting system than did male voters; women and older voters were significantly more trusting of the system than were men and youths.

Three percent of all voters encountered one of the following difficulties: difficulty navigating between screens or using write-in options, a lack of privacy, screen glare, or technical problems, such as a power failure or some other shortcoming intrinsic to the voting machine itself. The most common difficulty was related to the insertion of the ballot card, which 40 percent of the voters who reported a difficulty in voting reported as problematic. Twenty percent reported difficulty navigating between screens. Limited screen visibility (including glare), a lack of clear screen labels, and the write-in option each constituted 8 percent of the problems cited by voters. Power failure and problems using the language selection options each comprised 4 percent of the voters' complaints.

As a result of shortcomings in the voting experience, 9 percent of all voters asked for the help of an election official. An additional 8 percent who did not ask for help received some form of assistance. The attentiveness of election officials undoubtedly made the voting process smoother for many individuals. Casual observation suggests that once on-site poll workers recognized that some voters were having problems inserting their ballot cards, the workers voluntarily performed this function.

The time that voters spend at the polls is also of concern to citizens and election officials. Long lines can lead to voter frustration and dampen turnout. The voting machines could have performed better in this regard. Two-thirds of all voters reported spending 5 minutes or less casting their ballots, 27 percent between 5 and 15 minutes casting their votes, and 7 percent spent more than 16 minutes in the polling booth. However, the amount of time voters spend using the new voting machines may be a function of their lack of familiarity with them. Once voters become accustomed to the machines, and their novelty wears off, we anticipate a reduction in the time that it takes many to cast a vote.

A major concern of virtually all candidates for public office is the potential for partisan bias in the election process. As the 2000 presidential elections demonstrated, voting technology and ballot design can influence an election in ways that favor one candidate or party over another. To determine whether Democratic, Republican, and independent voters had different points of view regarding the voting machines, we collected information about the respondents' party identification and voting behavior in the 2002 elections. The analysis demonstrated that Democratic and Republican voters and supporters of each major party's candidates provided similar appraisals of the new voting machines. There were no significant differences among Democratic, Republican, or independent voters.

Conclusion

The 2000 presidential election demonstrated that how people cast their ballots is important and can determine the outcome of an election. Our efforts to understand electronic voting systems in general, and the Diebold AccuVote-TS in particular, provide reasons for optimism and some cause for concern. On the positive side, the voting machine performed quite well, and alert election officials took the initiative to overcome some of its shortcomings. Moreover, the education campaigns conducted by the state and local boards of elections, local media outlets, political parties, candidates, and others appeared to familiarize many voters with the new machines prior to their having an opportunity to vote on them. This may account for the fact that participants in the exit poll responded to the machines more favorably than did the participants in other parts of the study.

In addition, participants in the field study and exit poll were asked to perform a more complicated task than may be asked of other voters. Voters were exposed to both a new voting machine and a new ballot design in 2002. Prior to that election, the counties used a ballot design that did not match that which appeared on the new machines. More specifically, voters previously voted on mechanical lever machines that used a single-face party-row ballot. In 2002 they used the Diebold system and a multiple-page office-bloc ballot. Hence, their responses reflected their simultaneous exposure to both a new voting machine and a new type of ballot. Other states and localities may introduce new machines but maintain the same basic ballot design that they had used previously. As such, their voters will be put to a less challenging test.

However, the study demonstrated there is room for improvement, particularly with respect to voters' trust in the system. Trust in the system is paramount to a healthy democracy, and one of the goals of introducing new voting technology is to restore it. There also is time to improve the machines. Further usability studies can be performed, software packages updated, and the systems improved. We recommend that election officials commission studies before they purchase new election machines, when they design new ballots, and after they have conducted an election using a new voter interface.

The interactions between voting technology and ballot design, which together comprise the interface to which voters are exposed, also are an important subject for further study. The same is true of the impact of changing from one voting interface to another. Other subjects worthy of further research involve the impact of specific voting interfaces and the effect of the transition from one voting interface to another on voter roll-off, split-ticket voting, and other voting decisions of importance to candidates, political parties, and other groups.

Thus, our research leaves us with several unanswered questions, including: Do some combinations of voting machines and ballots perform better than others? Do voters who have previously used one type of voting machine, ballot, or combination thereof more readily adapt to some specific new voting interfaces than others? Does changing voting interfaces work to the advantage of one party, both major parties, or no parties? The search for answers to these and related questions

comprise a rich and important research agenda for the future. We plan to address some of these

questions and to develop a protocol to help election officials, voting machine manufacturers, ballot

designers, and others involved in or affected by the election process to understand better the impact of

new voting machines and ballots.

Notes

1. Roll-off is the failure to cast votes for some offices on the ballot—usually offices below those at the top of the ballot—or for ballot propositions. Split-ticket voting is casting votes for more than one political party.

2. An office-bloc ballot lists candidates for each contest (e.g., governor) in a bloc. It is in contrast to the party-column (or party row) ballot, which lists all candidates for a given party listed under a single, party heading. Often, but not always, party-column ballots have a circle or other device that allows a voter, with one mark, to vote a straight ticket (i.e., for all members of the party).

3. Overvotes occur when individuals cast votes for more candidates than are to be elected for a given office (typically one).

4. Residual votes were defined as ballots on which no presidential vote was counted—because no vote was cast or because of human or machine error.

5. For a more complete discussion of the range of voting systems on the market, see Herrnson et al. 2003.

6. The tests were conducted in four libraries, a shopping mall, the lobby of a county administration building, and a relatively affluent retirement community. Virtually absent were individuals in rural or farming communities, individuals 34 years of age or younger (more than 60 percent of the participants were over 65 years of age), individuals who have not earned a high school diploma (over half had a degree from a four-year college and 32 percent had done some post-graduate work), members of most minority populations (Latinos, Asian Americans, Native Americans, and multiracial citizens each comprised less than 3 percent of the participants and African Americans accounted for only 8 percent), and individuals born outside the United States or whose native language is not English.

7. Some 105,586,274 people voted in the 2000 election (see http://www.fec.gov/pages/ 2000turnout/ reg&to00.htm). Nine percent of those who voted equals 9.5 million.

8. Eighty-nine percent of the respondents received at least some college education and 41 percent attended graduate school.

9. See Note 7. Five percent of those who voted equals 5.3 million.

References

Allen, P. L. (1906). Ballot laws and their workings. Political Science Quarterly, 21, 38-58.

Babbie, E. (1990). Survey research methods. Belmont, CA: Wadsworth.

Bain, H. M., & Hecock, D. S. (1957). Ballot position and voters choice. Detroit: Wayne State University Press.

Beard, C. A. (1909). The ballot's burden. Political Science Quarterly, 24, 589-614.

Bederson, B. B., Lee, B. S., Sherman, R., Herrnson, P. S., & Niemi, R. G. (2003). Electronic Voting System Usability Issues, ACM Conference on Human Factors in Computing Systems, CHI Letters.

Bowler, S., Donovan, T., & Happ, T. (1992). Ballot propositions and information costs: Direct democracy and the fatigued voter. Western Political Quarterly, 45, 559-568.

Bullock, C. S. III., & Dunn, R. E. (1996). Election roll-off: A test of three explanations. Urban Affairs Review, 32, 71-86.

Caltech/MIT Voting Technology Project. (2001). Residual votes attributable to technology: An assessment of the reliability of existing voting equipment. Available: http://www.vote.caltech.edu/Reports.

Campbell, A., Converse, P. E., Miller, W. E., & Stokes, D. E. (1960). The American voter. New York: Wiley.

Darcy, R. (1986). Position effects with party column ballots. Western Political Quarterly, 39, 648-662.

Darcy, R., & McAllister, I. (1990). Ballot position effects. Electoral Studies, 9, 5-17.

Darcy, R., & Schneider, A. (1989). Confusing ballots, roll-off, and the black vote. Western Political Quarterly, 42, 347-364.

Election Data Services Inc. (1998). 1998 voting equipment report. Available: http://electiondataservices.com/content/vote_equip.htm.

Election Data Services Inc. (2002). 2002 voting equipment report. Available: http://www.electiondataservices.com/2002Voting%20Equipment%20Reports.pdf.

Ericsson, A., & Simon, H. (1993). Protocol analysis: Verbal reports as data (2nd edition). Cambridge, MA: MIT Press.

Federal Election Commission. (2000). The administrative structure of state election offices: Voting systems. Available: http://www.fec.gov/elections.html.

Herrnson, P. S., Niemi, R. G., Horowitz, J. M., Richman, S., Bederson, B. B., Conrad, F., & Traugott. M. (2003). Characteristics of contemporary voting machines. Available: http://www.capc.umd.edu/rpts/md_evote_ContempVotingMach.pdf

Key, V. O. Jr. (1956). American state politics. New York: Knopf.

Kimball, D. C., Owens, C., & McAndrew, K. (2002). Unrecorded votes in the 2000 presidential election (Unpublished manuscript). University of Missouri-St. Louis.

Krosnick, J. A., Miller, J. M., & Tichy, M. P. (2003). An unrecognized need for ballot reform: The effects of candidate name order on election outcomes. In Crigler, A. N., Just, M. R., & McCaffery, E. J. (Eds.), Rethinking the vote: The politics and prospects of American election reform. New York: Oxford University Press.

Miller, J. M., & Krosnick, J. A.. (1998). The impact of candidate name order on election outcomes. Public Opinion Quarterly, 62, 291-330.

Mueller, J. E. (1970). Choosing among 133 candidates. Public Opinion Quarterly, 34, 395-402.

National Voter Independence Project. (2001). Voting reform. Available: http://www.halftheplanet.com/departments/vote/intro.html.

Nichols, S. M. (1998). State referendum voting, ballot roll-off and the new electoral technology. State and Local Government Review, 30, 106-117.

Nichols, S. M., & Strizek, G. A. (1995). Electronic voting machines and ballot roll-off. American Politics Quarterly, 23, 300-318.

Nielsen, J. (1993). Usability engineering. San Diego: Academic Press.

Riviere, C. N., & Thakor, N. V. (1996). Effects of age and disability on tracking tasks with a computer mouse: Accuracy and linearity. Journal of Rehabilitation Research and Development, 33, 6-16.

Robinson, J. A., & Standing, W. H. (1960). Some correlates of participation: The case of Indiana. Journal of Politics, 22, 96-111.

Roth, S. K. (1998). Disenfranchised by design: Voting systems and the election process. Information Design Journal, 9, 1-8.

Rusk, J. G. (1970). The effect of the Australian ballot reform on split ticket voting. American Political Science Review, 64, 1220-1238.

Sinclair, R. C., Mark, M. M., Moore, S. E., Lavis, C. A., & Soldat, A. S. (2000). An electoral butterfly effect. Nature, 408, 665-666.

Taebel, D. A. (1975). The effect of ballot position on electoral success. American Journal of Political Science, 19, 519-526.

U.S. Commission on Civil Rights. (2001). Voting irregularities in Florida during the 2000 presidential election. Available: http://www.usccr.gov.

Walker, J. L. (1966). Ballot forms and voter fatigue: An analysis of the office block and party column ballots. Midwest Journal of Political Science, 10, 448-463.

Wand, J. N., Shotts, K. W., Sekhon, J. S., Mebane, W. R., Herron, M. C, & Brady, H. E. (2001). The butterfly did it: The aberrant vote for Buchanan in Palm Beach County, Florida. American Political Science Review, 95, 793-810.

Table 1. Field Study Results for Citizens' Assessments of the DRE Voting System

Rating	Overall reactions	Comfort using system	Readability of characters	Terminology on screen	Ease correcting mistakes	Trust that vote was recorded
Positive	81%	85%	88%	83%	81%	85%
Moderate	11	7	8	10	11	7
Negative	9	8	4	7	8	8
(N)	(364)	(363)	(362)	(358)	(331)	(359)

Note: The questions in the field study used a scale of 1 to 9, where "positive" is defined as evaluations that were an "8" or "9"; "moderate" as a "7"; and "negative" as "6" or less. We regard 1-6 as negative because of the high standards to which voting systems must be held.

Table 2. Exit Poll Results for Citizens' Assessments of the DRE Voting System

Rating	Overall reactions	Comfort using system	Readability of characters	Terminology on screen	Ease correcting mistakes	Trust that vote was recorded	Trust in the system	Helpfulness of election judges
Positive	91%	91%	93%	89%	89%	86%	80%	84%
Moderate	4	3	2	6	6	8	16	11
Negative	5	6	5	5	5	6	4	5
(N)	(1,266)	(1,260)	(1,261)	(1,257)	(1,179)	(1,240)	(1,241)	(1,187)

Note: The questions in the exit poll used a scale of 1 to 7, where "positive" is defined as evaluations that were a "6" or higher; "moderate" as a "4" or "5"; and "negative" as "3" or less.

Figure 1: The Diebold AccuVote-TS system