Election 2000:

A Case Study in Human Factors and Design

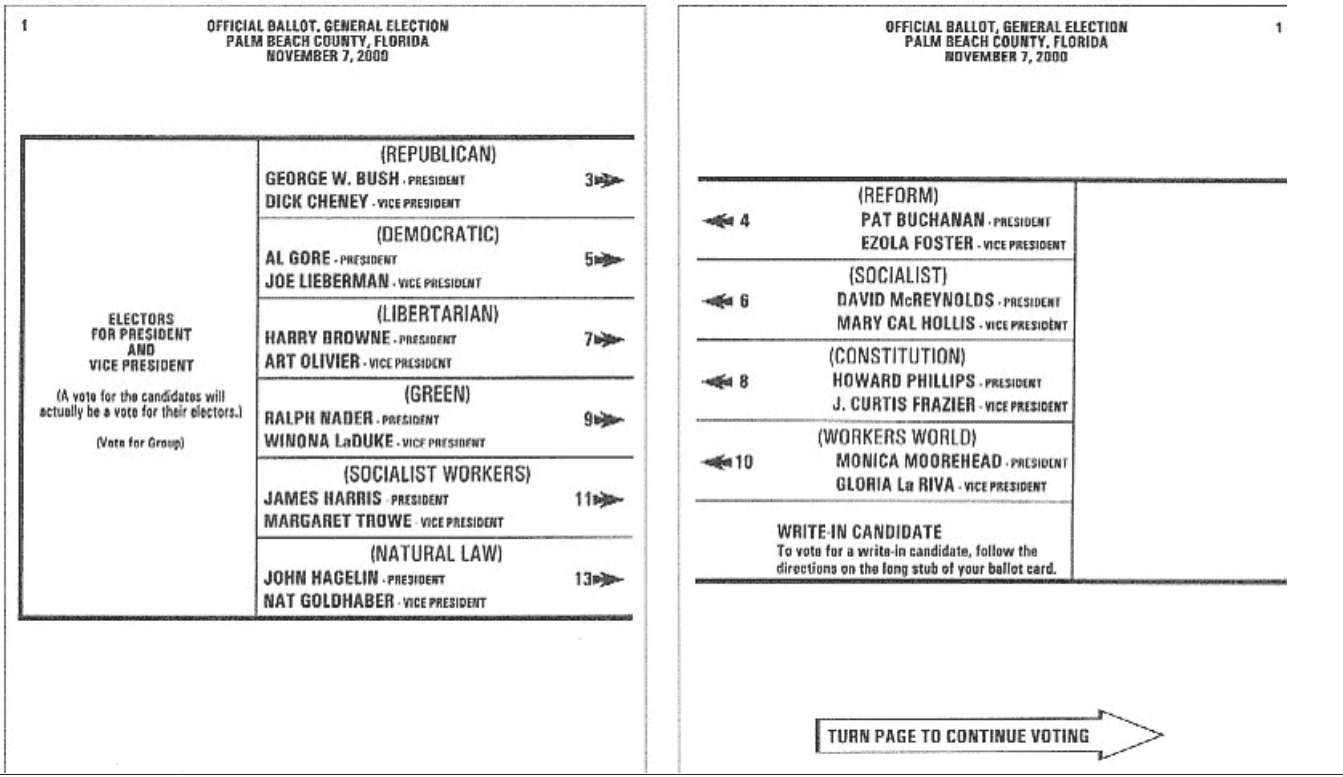
by
Ann M. Bisantz
Department of Industrial Engineering
University at Buffalo

Part I – Ballot Design

The Event

On November 8, 2000, people around the U.S. awoke to the news that there was no clear outcome of the previous day's Presidential election—the vote counts were simply too close to call. After more than a month of recounts, lawsuits, and court decisions, the U.S. Supreme Court rendered a decision on December 12 that ended the process of vote recounting and brought the election to a close. Throughout this period, and subsequent to the January inauguration of George W. Bush as President, many concerns were raised about factors that impacted the election results. In particular, a great deal of attention was paid to the voting methods used in Florida (where issues of vote recounts were focused) and the extent to which ballot design and voting methods may have resulted in errors by which voters inadvertently cast votes for the wrong, or more than one, candidate.

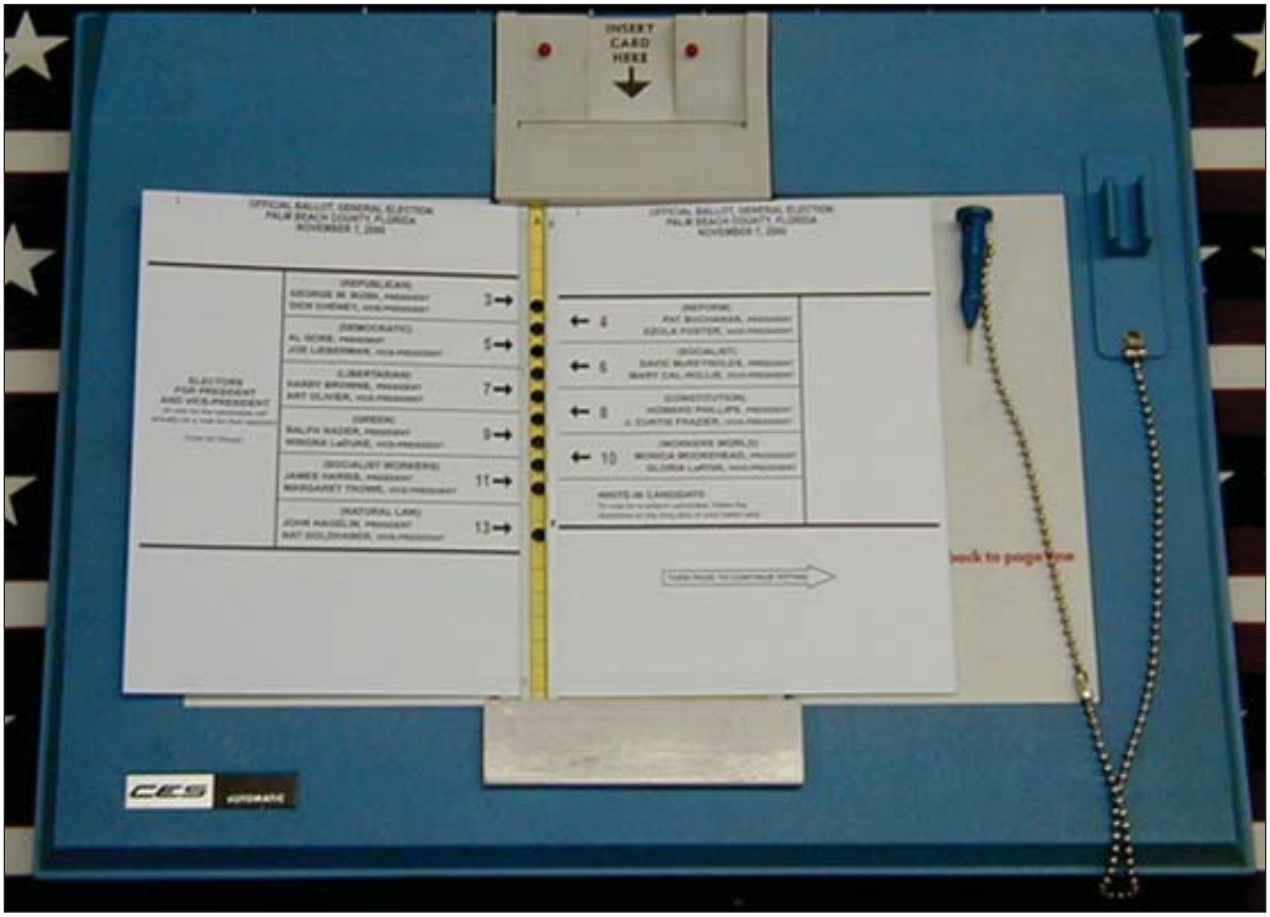
Figure 1. Sample ballot. *Source:* http://www.usccr.gov/pubs/vote2000/report/appendix/app4.htm



The Design

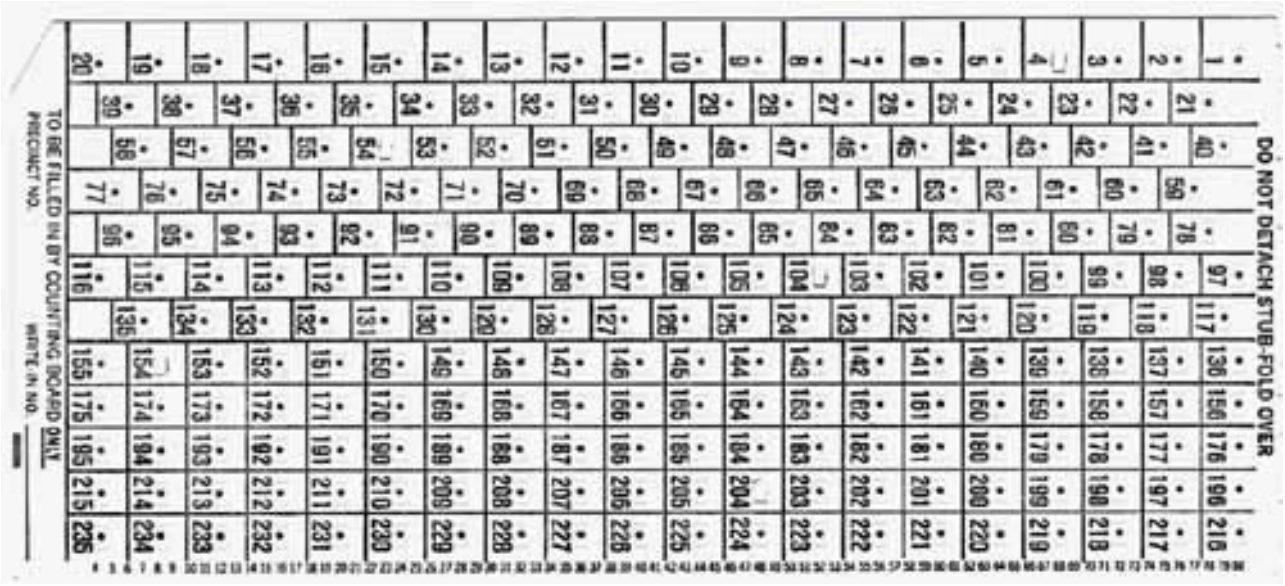
A primary focus of media and political attention in the immediate aftermath of the election was the design of the ballot book in Palm Beach County. Election officials in the county had designed a twopage "butterfly" ballot. According to news accounts, the reason for this design was to accommodate a larger font size in order to make it easier for elderly residents in the county to read the names of the presidential candidates Pacenti, 2000; Van Natta Jr. and Canedy, 2000). A sample ballot book available to voters prior to voting is depicted in Figure 1, and the official version voters saw on election day is represented in Figure 2.

Figure 2. Official version. *Source:* Votomatic Punchcard Vote Recorder and replica of the Palm Beach County "Butterfly" Ballot provided courtesy of the Psephos Corporation, used with permission.



In order to understand the potential problems with this design, it is necessary to understand the process of voting using such a ballot (a 2.3MB video clip providing an overview of the process can be viewed **here**). To vote, voters pick up a punch card ballot (see Figure 3) and proceed to a voting booth. On a stand in the booth is a ballot book. Voters slide the punch card into a slot, which secures it underneath the pages of the ballot book. Each page of the ballot book lists candidates for a particular office. As voters turn the pages in the ballot book, holes in the "spine" of the book are revealed. These holes line up with locations on the punch card (which has been slipped underneath the book). To vote for a candidate, voters push a punch (a small knob with a pointed stylus) into the corresponding hole, which punches out a small perforated rectangle (a "chad") at the correct location on the punch card. Once voting is completed, a voter removes the perforated punch card from the slot and drops it in a sealed ballot box. There is no indication to voters on the punch card itself as to which perforation corresponds to which office or candidate. Also, because the punch card is

Figure 3—Punch card ballot (without ballot stub) used in a Votomatic machine. *Source:* "A Brief Illustrated History of Voting" (http://www.cs.uiowa.edu/~jones/voting/pictures/), used with permission of Douglas W. Jones.



slipped underneath the ballot book, voters cannot see that the punch has punched out the appropriate chad. Therefore, voters receive no information as to which candidates they voted for.

Errors associated with the design of the Palm Beach County ballot were primarily due to poor ballot layout, resulting in problematic spatial mappings. The two-page format of the ballot violated the expectations of voters. People reading English text read from left to right and will read a left-hand page from top to bottom before reading a right-hand page. Thus, the natural behavior for voters was to start at the top of the left-hand page and read down. However, holes on the ballot book corresponded in alternating fashion to candidates on the left and right pages. Some voters claimed to be confused and said that they wanted to vote for the second candidate from the top left (Gore) but punched the second hole, which actually corresponded to Buchanan, who was listed on the right-hand page (Van Natta Jr. and Canedy, 2000).

Difficulties interpreting the design were compounded by the fact that more than one hole "lined up" with the block of text or the lines delineating each party's candidates. In addition, the mapping from ballot to holes was not indicated on the sample ballot made available to voters. Voters may have thought that all holes next to the block needed to be punched, or that two holes corresponded to the presidential and vice presidential candidates (thus, for instance, casting votes for Bush and Buchanan), resulting in multiple votes for a single office, or "overvoting." News reports (Van Natta Jr., 2000) indicated that out of more than 19,000 ballots invalidated due to overvoting in Palm Beach County, more than 9,000 of these had votes for Bush and an adjacent candidate, or Gore and an adjacent candidate.

While clearer design of this particular ballot might have solved some of the voting difficulties experienced by people in Palm Beach County, it would not have eliminated more general problems with the punch card voting system. Because votes are recorded with perforations on the punch card and the punch card is essentially concealed underneath the ballot book during the voting process, there is

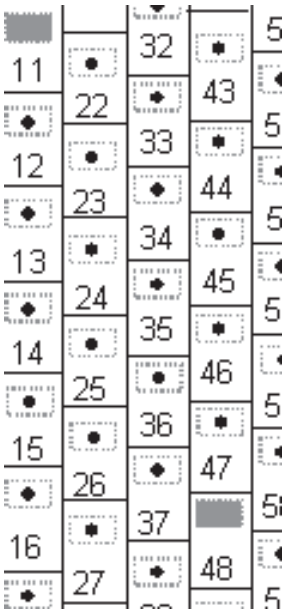


Figure 4—Illustration by author of a section of a punch card ballot. When a vote is recorded, the perforated rectangle (with a dot) is punched out of the card (as shown for areas # 11 and #48). There is no indication for voters on the ballot regarding which punched hole corresponds to which candidate.

no mechanism for voters to check to make sure that their vote is being recorded (that is, they cannot see if they have adequately "punched" out the chad). Additionally, because there are no clear markings on the punch card itself, once the card is removed there are no methods for voters to check to make sure that the correct perforation was removed (see Figure 4).

While the resulting "dimpled," "pregnant," and "hanging"chads (chads that were imperfectly punched and only partially removed from the card—see Figures 5–7), and the solutions proposed for interpreting them, resulted in many challenges for those performing vote recounts at the time (Cassidy, 2000), the problem is a standard one in human factors design: the punch card voting system does not provide voters with any feedback about the results of their actions. Voters cannot tell if their vote has been recorded (i.e., that they completely punched out the chad) as they are voting. Also, once they've taken their punch out of the hole in the ballot book, voters cannot tell which candidate they actually voted for. Such lack of feedback presents a significant "gulf of evaluation" (Norman, 1988) stemming from the voting system design. Errors in the system are also difficult to correct. Once a choice is made, voters cannot correct an error simply—they must follow procedures to invalidate their ballots and receive a new ballot (in cooperation with poll workers, who have different levels of skill and training). An error in selection for any candidate causes the voter to start the entire process over.

Another error that caused concern at the time was overvoting, or voting for more than one candidate for an office (due to the design of the butterfly ballot as described above, for example, or through errors in understanding the voting process, such as believing that it was legitimate to vote for the same candidate on more than one party line).

Figure 5. Dimpled chad.

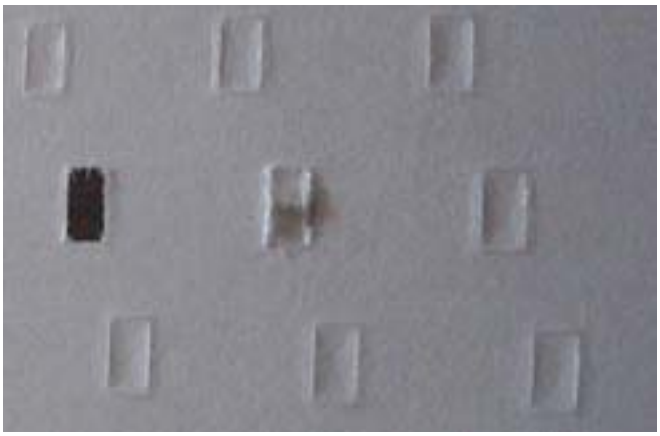


Figure 6. Pregnant chad.

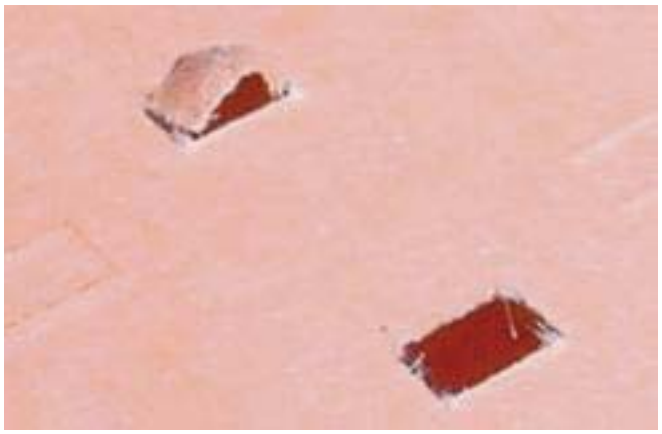
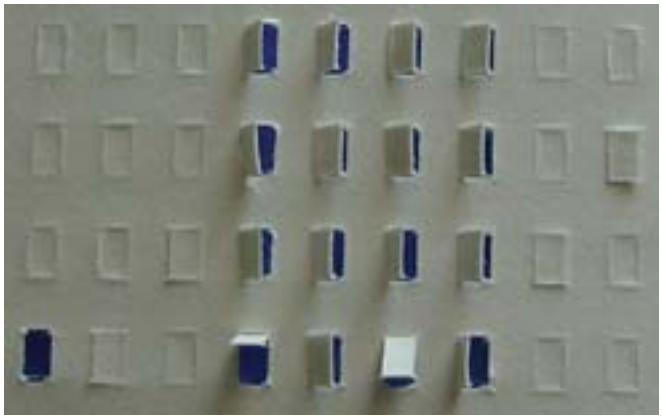


Figure 7. Hanging chads.



Source: Figures 5–7 originally appeared in "Chad—From Waste Product to Headline"(http://www.cs.uiowa.edu/~jones/cards/chad.html) and are used with the permission of Douglas W. Jones.

Overvoting may be a reason to invalidate votes for the office affected or perhaps the entire ballot (depending on voting procedures). However, there are no interlocks in the punch card system to prevent such errors. Overvoting errors are not restricted to the punch card voting system. A systematic study—the Florida Ballot Project—of uncertified ballots from the 2000 U.S. Presidential Election in Florida conducted by NORC (a non-profit research organization) with the sponsorship of national news organizations indicated that there were 84,822 ballots with overvotes from counties using the punch card (or Votamatic) system, compared to 28,998 ballots with overvotes from counties using either optical scan ballots or other technologies.

Examples of ballots that resulted in overvotes or undervotes are available at the web site for the project (see http://www.norc.uchicago.edu/fl/index.asp).

Discussion Exercise

Consider Norman's (1988) four recommendations for good system design: use good mappings, make things visible, provide good conceptual models, and provide immediate and informative feedback. List two or three examples of how these recommendations can be applied to the design of a voting system. List two or three gulfs of execution and gulfs of evaluation that should be avoided in a voting system.

Part II – Calls for Improvements and Re-Design

Difficulties with the design of the "butterfly style" ballot and other aspects of the punch card system brought media and political attention to more general problems with all methods of voting (error rates of mechanical lever voting machines, optical scanning methods, etc.; Caltech/MIT Voting Technology Project, 2001a), the voting process more generally (registration process, verification of voters at the polls, training of poll workers, repair and maintenance of voting equipment), and various proposals for system redesign (Caltech/MIT Voting Technology Project, 2001b). For instance, standards being developed by organizations such as the Federal Election Commission and IEEE include recommendations regarding the design of the user interface to the voting system, including requirements for user testing, access for disabled voters, and the provision of feedback to voters regarding errors (Federal Election Commission, 2002; IEEE Standards Coordinating Committee 38, 2002). Similar considerations (access for the disabled, recognition and correction of voting errors) are included in a recently signed federal law ("Help America Vote Act," 2002). Other groups have documented difficulties that physically and perceptually challenged individuals have in reaching polling places and casting votes privately and independently (Seelye, 2001).

Any redesigned system would have to insure that votes can be cast privately, quickly (to prevent long lines), with a minimum of instruction and training for voters as well as most poll workers, and securely (so that votes are cast accurately and that vote counting can not be tampered with). Other issues of interest are requirements in some states for "full face" ballots (i.e., a ballot showing all offices and candidates simultaneously), laws in some states allowing (or disallowing) party-line votes (i.e., casting a single vote that registers votes for all candidates endorsed by a particular party), and the prevention of voting coercion or vote selling, which could occur if voters were able to produce a "receipt" proving who they had voted for (or may occur with paper absentee ballots or at home on-line voting).

One form of redesigned voting system is a direct-recording electronic device (DRE), implemented through a specialized kiosk system or on more off-the-shelf computer hardware (Mercuri, 2002; O'Hara, 2002). Significant challenges in the design of such systems include system security and verification that all votes are recorded and tallied correctly. The costs of implementation and providing enough systems to insure low waiting times at polling places are other problems. However, the design of a voting kiosk, where voters directly enter their selections into a computer system, offers opportunities to reduce voter errors and provide a more satisfactory voting experience.

Design Exercise

To design DRE voting systems successfully, aspects of the user interface and methods of interaction with the system must be carefully considered. In particular, the user population of voters is extremely diverse. In your groups, complete the following:

1. Describe the voting population in terms of the voter age, experience with voting (semantic experience), computer experience (syntactic experience), physical abilities, perceptual abilities, and primary language.

2. Identify key aspects of the voting kiosk and user interface (both styles of interaction, and methods of input/output) that would be needed to accommodate variations within these characteristics and present these aspects in terms of design recommendations.

3. Propose a method for evaluating your design. Consider methods of early (non-functional) and later (functional) prototyping. Who would your test participants be? What tasks would they perform? What information would you collect? How would you collect data?

References

Caltech/MIT Voting Technology Project. (2001a). Residual Votes Attributable to Technology: An Assessment of the reliability of existing voting equipment. Cambridge, MA: Caltech/MIT.

Caltech/MIT Voting Technology Project. (2001b). Voting: What is, what could be. Cambridge MA: Caltech/MIT.

Cassidy, T. (2000, 11/26). Election 2000/The Democrats; Data Collected on Faultiness of Mechanism. *Boston Globe*, pp. A31.

Federal Election Commission. (2002). FEC releases voting systems standards. *Information Management Journal*, 36(4), S4(1).

Help America Vote Act. (2002).

IEEE Standards Coordinating Committee 38. (2002). Draft Standard for the Evaluation of Voting Equipment (IEEE P1583/D2.5). New York, New York: Institute of Electrical and Electronics Engineers.

Mercuri, R. (2002). A Better Ballot Box? *IEEE Spectrum*, October, 46-50.

Norman, D. A. (1988). *The Psychology of Everyday Things*. New York: Basic Books.

O'Hara, J. (2002). Improving Voting Systems. *Human Factors and Ergonomics Society Bulletin*, 45(11), 1.

Pacenti, J. (2000, November 11). Legal challenges to ballot may hinge on what was feasible. *Palm Beach Post*, pp. 8A.

Seelye, K. Q. (2001). Disabled gaining on access to vote. *The New York Times.*

Van Natta Jr., D. (2000, November 21). Counting the vote: Palm Beach County. *New York Times*, pp. A22.

Van Natta Jr., D., & Canedy, D. (2000, 11/8/2000). The 2000 Elections: The Palm Beach Ballot. Florida Democrats Say Ballot's Design Hurt Gore. *The New York Times,* pp. A1.