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Disenfranchised by design: voting systems and the election process

Susan King Roth

This article was published in 1998, and is now being re-issued by the editors and publishers of the Information Design Journal for free distribution on the Internet, in the wake of concerns about the impact of information design on the November 2000 U.S. Presidential elections. The author is Chairperson and Associate Professor of the Department of Industrial, Interior, and Visual Communication Design at The Ohio State University.

Recent research on voting systems demonstrates the need to improve usability and ensure equal access to the election process for all voters. Information design and human factors could offer help in meeting this need.

The ballot is the component of a voting system that displays information supporting decision-making for a large and diverse population. The size of this group in the United States is substantial – 121 million people were registered to vote as of 1990 and over sixty percent of the electorate voted in the 1996 national election. While the political and social consequences of voting are significant, there are very few studies on the effect of ballot interface and system design on the voting process.

Voting systems consist of hardware (e.g., voting machines, card holders), ballots or information displays, and devices for recording and compiling votes. Systems in current use include punch cards, mechanical lever machines, mark-sense ballots, and computer-based electronic voting machines. (Paper ballots are rarely used.) Voting systems are developed and marketed competitively to state and local election officials responsible for certifying and purchasing voting equipment.

The human use of voting equipment and voter's perceptions of the voting experience have largely been overlooked. Acknowledging this situation, a feasibility report issued by a panel of the National Clearinghouse of the Federal Election Commission identified the

> need to look at related human engineering standards; panelists stated that neither the manufacturer of voting systems nor most state and local election offices pay much attention to how the voter interacts with the various voting devices … Panelists stressed that standards should encompass such matters with an emphasis on ballot design and format (National Clearinghouse on Election Administration, 1984: 12).

However, subsequent federal guidelines produced for evaluating voting systems, while comprehensive in other areas, did not address the panel's concerns.

The widespread distribution of voting systems, the size and diversity of the user group, and the hypothesis that more effective information design could improve the usability of voting systems prompted a preliminary study on the effect of ballot interface design on voting behavior (Roth, 1994) and a subsequent evaluation of provisional voting processes (Roth, 1996).

The preliminary study

The preliminary study was conducted in Franklin County, Ohio, in 1993 comparing the mechanical lever machine and the direct record electronic voting machine in use. The study was conducted with a select sample of the voting population under conditions simulating those found in the polling

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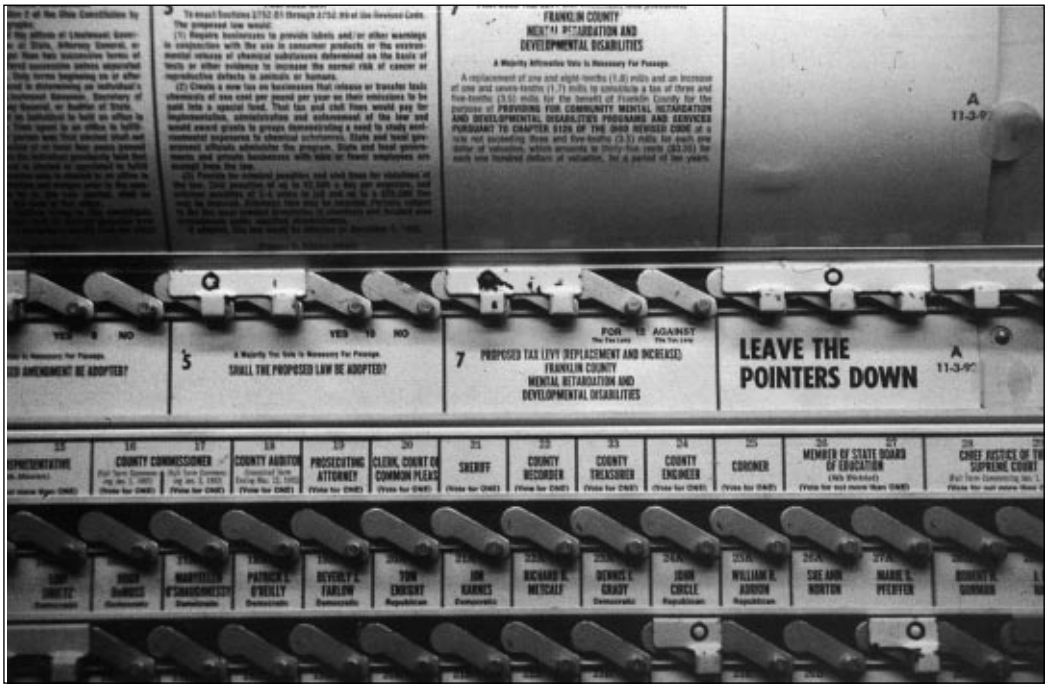

Figure 1:
The mechanical lever machine and ballot display.

place. Nineteen subjects from 18 to over 75 years of age were videotaped while voting on one of two machines using a ballot from the 1992 presidential election.

Developed more than 100 years ago, the mechanical lever machine is operated by turning down metal levers located beneath candidate names and issues. Ballot text is printed on strips of card stock inserted between metal frames. Mechanical lever machines are common in metropolitan districts with large populations, and although they are no longer manufactured they remain in widespread use (see figure 1).

The electronic voting machine is a recently developed system that 'records votes by means of a ballot display provided with mechanical or electro-optical devices that can be actuated by the voter, that processes the data by means of a computer program, and that records voting data and ballot images in internal memory devices' (Federal Election Commission, 1990: 24). Selections are made by pressing touch-sensitive switches arrayed in 504 possible voting positions under the ballot, and votes are recorded on internal computer cartridges. Unlike mechanical machines, electronic machines display a large single-sheet paper ballot that is generated by computer software and printed on a plotter (see figure 2).

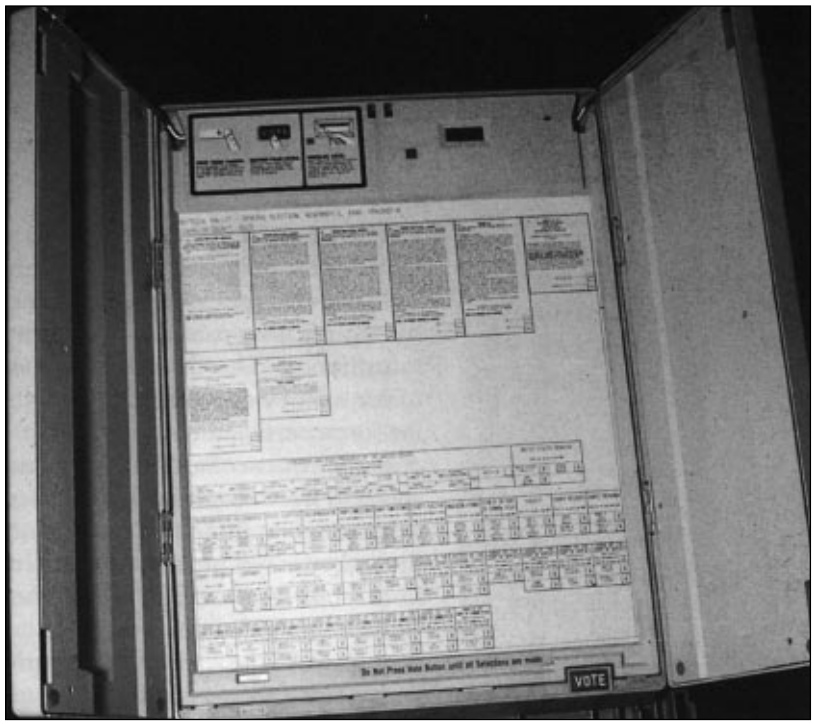

Figure 2: The electronic voting machine and ballot display.

Subjects

Because legibility and readability of information displayed on the ballot were factors thought to be particularly relevant for older voters, nine of nineteen subjects selected were over age 65. Older participants were volunteers from an urban senior center; seventeen of the nineteen subjects were female.

Testing procedure

A time limit of five minutes per subject was established due to the state regulation restricting voting to five minutes when lines are long at the polling place. The voting procedure was recorded by a video camcorder positioned behind the subjects and directed at the ballot. (Subjects were assured that political preferences would not be divulged nor were they relevant to the study, and instructed to vote as they would normally.)

Written questionnaires were administered directly afterwards and respondents identified by age, sex, and previous experience with voting systems. Subjects were queried on the content of Questions and Issues text as a gauge of comprehension and also asked to evaluate the experience of voting. A lively and informal group discussion took place at the end of the testing session and comments were recorded via notes and audio tape.

Legibility, readability, and older voters

Issues of legibility and readability of ballot papers were examined. Reynolds considers legibility to 'encompass all those factors in typography and layout which may influence the ease, speed and accuracy with which information can be read' (Reynolds, 1984: 187). Readability is defined as 'recognition of the information content of material' (McCormick and Sanders, 1982: 98). Legibility and readability are influenced by such factors as linespacing, letterspacing, width of margins, type size, viewing distance, lighting, and the ability to comprehend meaning. Because the successful communication of information depends on perceptual abilities of the reader, visual acuity is also a factor. Tests of visual acuity include measurements of the smallest feature that the eye can detect, and visual acuity declines naturally with age. 'Aging affects many aspects of visual function but the changes are primarily physiological and anatomical … in any of these changes there is a loss of sensory function that results in a decrement in performance as a person ages' (Pitts, 1982: 131). With older voters, the need for greater illumination and larger type is increased. The American Association of Retired Persons notes in *Truth about aging* that 'by age 65, virtually every person will suffer some loss of ability to focus, to resolve images, to discern colors and to adapt to light. Over 60% of those considered visually impaired are older persons.' (American Association of Retired Persons, 1986: 25.) It should be noted that as a subset of the electorate, the elderly represents one of the most active segments of the voting population in the U.S.

Type size for candidate names listed on the ballot in Ohio is mandated at 12 points, but type size in other areas, including the Issues section which displays the greatest amount of text, is not mandated and in practice may be reduced or condensed to fit space available. In the preliminary study, one subject over 65 years of age stated that the ballot text was 'too small and some people may have difficulty reading it.' Other subjects mentioned the small size of type and their need to get 'really close' to read it. Thirteen out of nineteen subjects wore glasses and eight of those needed glasses for 'close' vision, according to responses on the questionnaire.

Organization of information

In viewing video tapes it was noted that the visual organization of information on the ballot appeared to influence voting order – the sequence in which selections were made. Voting on the electronic ballot followed the traditional Western reading order from left to right and top to bottom compared to a random pattern on the mechanical level ballot. There was greater overall response in all areas with minimal voting 'fall-off' on the electronic ballot. (Fall-off refers to the tendency to vote the beginning of the ballot but gradually fall off in voting activity before the end.) The electronic voting machine displayed flashing red lights located at each voting position which stopped flashing when activity at that position had been completed. One subject mentioned that the flashing lights prompted her to continue voting and kept her from 'getting lost'.

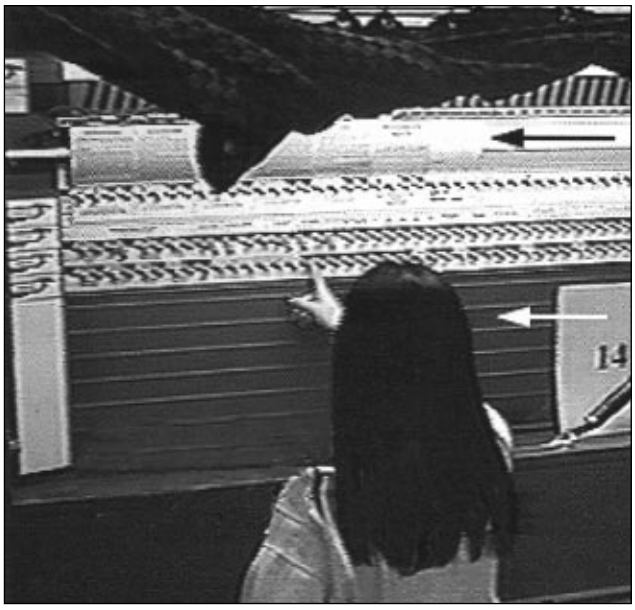

Figure 3: A subject who commented 'I did not see any issues' standing before the mechanical voting machine ballot. The black arrow indicates the display height of issues text and the white arrow indicates eye level. (Captured from videotape.)

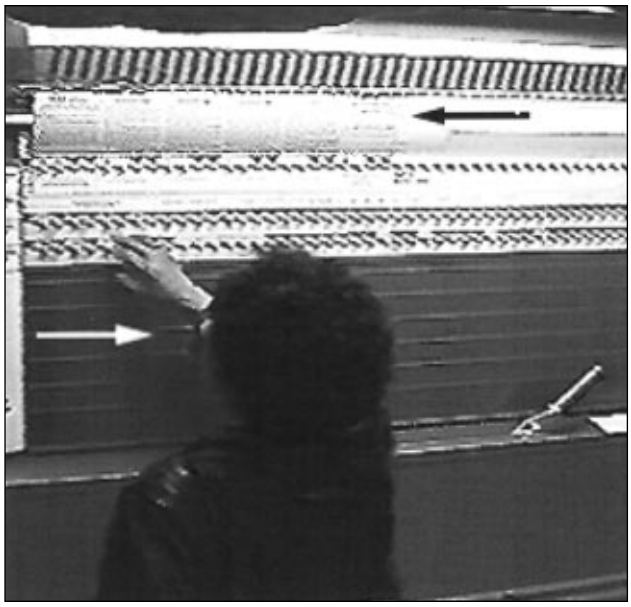

Figure 4: A subject voting on the mechanical lever ballot with Issues text (black arrow) and eye level (white arrow) marked. (Captured from videotape.)

Display height of text

The display height of ballot text on the mechanical lever machine emerged as an unexpected but significant problem affecting access to information – the Questions and Issues section of the ballot was positioned well above eye level for some participants.

In the course of analyzing videotapes some subjects were observed to stand several inches below the text on the Issues section. The top of the Issues insert measured 67 inches from the floor. Anthropometric data on human dimensions is organized into 5th, 50th, and 95th percentiles, and the majority of the population falls within the 50th percentile. Average male eye height in the 50th percentile was found to be 64.7 inches and female eye height 60.3 inches (Woodson, Tillman, and Tillman, 1992: 556). The eye height of adult males in the lowest 5th percentile is 60.8 inches while the corresponding female population registers 57.3 inches. Eye height is even lower for females over 70 years of age – 50.8 inches, significantly less than the display height of Issues text on the mechanical lever ballot.

In the study one subject, observed on videotape to be at the low end of the range for height, was asked to describe the first four ballot issues in her own words on the questionnaire. She responded: 'I did not notice any "questions and issues" … I only voted for candidates.' Figure 3 is an image taken from videotape of the subject which demonstrates the distance between eye level and the display height of Issues text (see arrows). Figure 4 provides another example of this occurrence with another subject. Four of nine subjects failed to vote on the Issues section of the mechanical lever ballot and all were at the low end of the range for height, while only one of ten participants using the electronic voting machine failed to vote on this section which was displayed at a lower height.

Ambiguity and ballot format

The 'Presidential/Vice Presidential Candidate' section of the electronic ballot was organized in a manner that caused confusion as to which button was associated with the corresponding candidate's name. Three subjects mentioned this on the written questionnaire. Referring to presidential candidates Bill Clinton and George Bush, one responded: 'The square next to (candidate) Clinton's name was for the other candidate to the left. The square for Clinton was to the right.' Another wrote: 'It seemed

that the buttons were closer to the adjoining candidate. I tend to vote by president's name but the correct button was closer to the vice president's name.' Consequences of ambiguity in this section could include lost votes and skewing of election results. Fortunately ballot rotation, the sequential rotation of candidate names as required by Ohio law, probably prevented any single candidate from enjoying an advantage in the previous election.

Comprehension and 'plain English'

Ballot language was a concern for some subjects who reported that Issues text was hard to understand or confusing. One expressed uncertainty about whether she was voting for or against an issue stating that the 'wording has a lot of negatives'. Broadbent states that informational materials are most effectively posed in the active, affirmative mode while the passive, negative mode should be avoided for this reason (cited in McCormick and Sanders, 1982: 98).

The importance of using 'plain English' in governmental documents has been acknowledged in the past. In 1978 President Carter signed an executive order requiring that any contract generated by executive agencies must be 'as simple and clear as possible, written in plain English, and understandable to those who must comply with it' (Bowen, Duffy, and Steinberg, 1986). The use of plain language on the ballot is especially important for voters with lower literacy levels or citizens for whom English is a second language.

Summary of the preliminary study

The study comparing mechanical and electronic voting machines in use explored issues related to information design and the effective communication of information. Problems related to text display height, type size, and the organization of information on the ballot were identified. Videotape analysis indicated that the display height of 'Questions and Issues' text on the mechanical lever machine appeared to be too high for some subject to read easily (or at all). Several subjects who were observed to stand well below the top of the ballot interface did not vote at all on this section. One subject stated that she did not see any issues on the ballot. In another finding, the electronic ballot format displayed the presidential candidates in an ambiguous manner that caused some confusion. Beyond the normal scope of information design, the problems identified in this study included the failure to consider human factors and human scale in the design of the machine displaying the ballot. Results of the study were supplied to election officials with the suggestion that further studies be conducted on other systems. Soon afterwards electronic machines were purchased for use in the county, replacing mechanical lever machines.

Punch cards: game of chance

After converting to electronic voting machines, the Franklin County Board of Elections commissioned a study in 1996 on provisional voting processes.

The provisional voting process is used by voters who have moved from one location to another but not yet changed their voting district. They can vote in the previous district, but not directly on systems that automatically record selections because their eligibility must be verified. Because they could not vote on the electronic machines, provisional voters had been voting on punch cards while seated at a table using a printed ballot book. The goal was to integrate these voters into the normal process by having them read the electronic ballot while voting on punch cards, eliminating the need for a separate printed ballot and voting station. The study evaluated and compared the existing process with variations of the proposed process.

The punch card is the most widely-used voting system in the U.S. A component of early IBM computer systems, they were originally designed for machine reading. They have been adapted for use as vote-recording devices which can be batch-fed into card readers for computation of election results. Punch cards used in the study contained a matrix of pre-scored holes and printed numbers corresponding to candidates and issues found on a separate ballot. The small copy area on the punch card, only 7½ inches by 3¼ inches, contained 228 numbers and pre-scored holes. (Other types of punch cards exist but were not used in this study.) The cards were inserted in a hand-held holder with a clear plastic cover containing drilled holes, and an attached stylus for punching holes through (see figure 5).

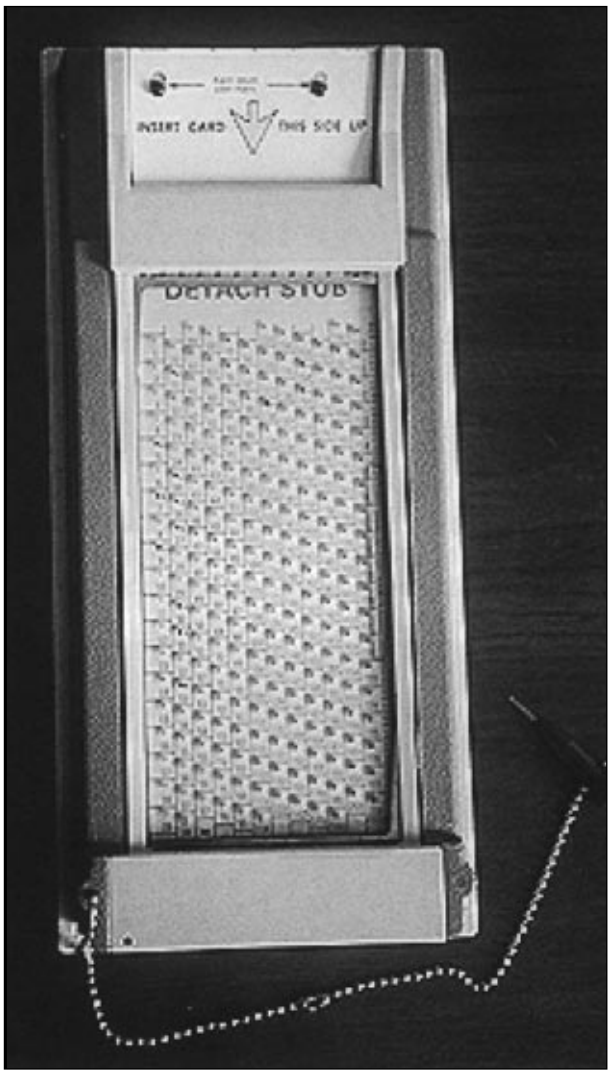

Figure 5: Punch card ballot inserted into a hand-held holder with plastic cover; the stylus used for punching holes in the card is attached by a chain.

Two different ballot displays and three situations of use were compared in this study. In process 'A' subjects were standing in front of the electronic voting machine ballot, in process 'B' subjects were seated at a table using a printed ballot booklet, and in process 'C' subjects were seated in front of the electronic ballot. In all cases subjects used punch cards to record selections. The three processes and situations of use are illustrated in figures 6, 7, and 8 on the next page.

A representative group of 32 subjects ranging in age from 18 to 65 years was selected. Seventeen were female and fifteen were male. Testing conditions were similar to those in the preliminary study.

Findings of the second study

Four factors were examined in the second study: usability, speed, accuracy, and acceptability of the processes reviewed. Usability was defined as the ease with which the process could be used by a cross-section of voters; speed was defined as the time required to vote for each process; accuracy as error rate; and acceptability measured voters' perceptions of the process as well as suggestions for improvement.

Research methods

Research methods and testing procedures for the second study were similar to those used in the preliminary study and included videotaping voting activities, administering questionnaires (with the addition of rating scales) immediately after each process, and soliciting verbal feedback through interviews. All subjects were tested using all three processes, beginning on different systems to avoid the effect of practice achieved through repetition.

Evaluating accuracy

An additional factor was examined in this study – the correspondence of subjects' intentions and selections recorded on the punch cards. In order to generate data in this area, subjects were provided with instructions to vote for specific candidates and issues based on a voting guide posted next to the ballot display in each testing station. Errors were identified by comparing completed punch cards with the key of correct responses.

Error rate and the punch card format

The punch card was disliked by the majority of subjects who found it difficult to read due to the small size of numbers printed on the card. Number positioning also caused confusion – numbers were located between two scored holes, one above and one below, with a thin line separating voting positions. While verbal instructions were given to each subject before voting to punch the hole above the number, later analysis of punched cards indicated several cases where the hole below the correct number was punched. Subjects stated verbally and on questionnaires that they were unsure which holes corresponded to numbers desired, and had difficulty tracking progress on

Figure 6 (below): Process 'A' – subject standing before the electronic voting machine ballot while voting on the hand-held punch card.

Figure 7 (right): Process 'B' – subject seated at the table reading a printed ballot book while voting on the punch card.

Figure 8 (left): Process 'C' – subject seated in front of the electronic voting machine ballot while voting on the hand-held punch card.

the card because holes punched were not visible through the clear plastic cover (figure 5).

A large number of errors was generated by some subjects. The error rate (measured by the number of incorrect holes punched) was approximately 15 per cent for each process; however eight subjects were responsible for 93 per cent of all errors and thirteen subjects made no errors at all. Four of the eight subjects generating the most errors were elderly, although their error rate improved somewhat on the second or third process used. Elderly subjects overall required more time to complete voting activities than those in younger age groups.

An analysis of responses to questionnaires and interview notes on 'ballot readability', 'punch card readability', 'matching numbers on cards with information on the ballot' and 'use of the punch card holder' indicated that the preferred process was use of the punch card while seated before the electronic ballot.

Summary

Two studies of voting systems in use identified design problems related to the display height of text, organization of information on the ballot, legibility, and correspondence between voters' intentions and

recorded selections. It should be noted that design of the ballot interface (as with other fixed displays) must take into consideration the context of use – it presents information used in decision-making, under the pressure of time, in a controlled environment. The need to consider human factors and anthropometric data is as important in this case as more traditional design concerns such as specification of type size and format.

Problems identified can be traced to a sequence of interconnected factors: the failure to apply effective design principles at the system development stage; the lack of comprehensive federal guidelines related to system usability; and unfamiliarity with information design and usability issues at the local administrative level where systems are evaluated and purchase approved. In addition, market-driven competition between suppliers that might lead to an improved product is absent in the development of equipment sold through government contracts. There has been no mechanism to date for collecting feedback from users to inform the design or evaluation of voting systems, although subjects in these studies were willing and able to provide constructive criticism and valuable feedback from the user's perspective.

Additional studies should be conducted on other systems and results disseminated to election administrators. The mechanical lever machine should be replaced by newer systems where possible, and the punch card ballot redesigned with larger numbers and corresponding holes, or replaced entirely with a less problematic system.

In the future new systems should be developed based on computer technology and screen displays that permit enlarged text and multiple language ballots to adapt to users' needs, bringing the design of voting systems and situations into the twenty-first century. Similar systems have been proposed but not yet implemented and there is a general reluctance to institute any new system based on the cost of replacing existing systems with new ones. Always lurking behind any decision on voting system purchase is the need to justify increased expenses to the electorate and ensure that the new systems will not present technical problems which will become political ones. There are other questions as well: if systems are found to cause an unacceptable error rate resulting in rejected ballots, as evidenced by problems with punch cards in some districts in the U.S., does this imply that previous election results can be challenged by losing parties? Should there be national supervision and certification of voting systems rather than the local supervisory structures now in place, which means information may not be shared across state lines? Can public confidence in the voting process be maintained if problems with voting systems are published in the media? These are some of the pragmatic issues raised by these studies.

Regardless, results indicate that greater attention to the usability and accuracy of voting systems during the development and evaluation stage would raise awareness and prevent 'disenfranchisement by design'.

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Contact

Susan King Roth,
Dept. of Industrial, Interior & Visual Communication Design
The Ohio State University
152 Hopkins Hall,
128 N. Oval Mall,
Columbus, OH 432210, USA

email: roth.2@osu.edu