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# Toward More Usable Electronic Voting: Testing the Usability of a Smartphone Voting System

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**Objective:** The goal of this research was to assess the usability of a voting system designed for smartphones.

**Background:** Smartphones offer remote participation in elections through the use of pervasive technology. Voting on these devices could, among other benefits, increase voter participation while allowing voters to use familiar technology. However, the usability of these systems has not been assessed.

**Method:** A mobile voting system optimized for use on a smartphone was designed and tested against traditional voting platforms for usability.

**Results:** There were no reliable differences between the smartphone-based system and other voting methods in efficiency and perceived usability. More important, though, smartphone owners committed fewer errors on the mobile voting system than on the traditional voting systems.

**Conclusion:** Even with the known limitations of small mobile platforms in both displays and controls, a carefully designed system can provide a usable voting method. Much of the concern about mobile voting is in the area of security; therefore, although these results are promising, security concerns and usability issues arising from mitigating them must be strongly considered.

**Application:** The results of this experiment may help to inform current and future election and public policy officials about the benefits of allowing voters to vote with familiar hardware.

**Keywords:** interface, usability, voting, mobile

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## INTRODUCTION

Newer electronic voting technologies have been developed and implemented in many jurisdictions across the United States, largely as a response to the challenges associated with older legacy voting systems. For example, punch card voting systems were responsible for widespread controversy following the results of the 2000 U.S. presidential election. Although several usability problems associated with legacy voting systems have been eliminated by newer direct recording electronic voting systems (DREs), these technologies have brought with them their own usability challenges. A poorly designed electronic voting system can introduce new problems that are detrimental to accurate voting counts, the overall voting experience, and even election participation (Conrad et al., 2009).

Designing systems for voting is inherently challenging for several reasons. Voting systems must accommodate an extremely wide array of users. A critical requirement for any voting system developed in the United States is to allow all eligible voters to effectively express their preferences for the candidates and propositions they intend to elect. In addition, this task occurs infrequently, and it is likely that most voters do not actively practice voting in elections. Thus, a majority of voters could be considered novices voting on unfamiliar technology. Finally, accuracy is a critical concern. As demonstrated by the uproar following in the 2000 U.S. presidential election (e.g., Wand et al., 2001), election administrators have the added pressure of developing or purchasing effective voting systems to avoid undermining the democratic process.

Implemented correctly, allowing people to vote in remote locations with their own equipment could yield several benefits, including enhanced usability, increased voter participation, and reduced election administration costs (Brucher & Baumberger, 2003). Although security concerns are generally seen as the highest barrier to preventing Internet voting from being widely deployed, smartphones and other technologies could provide familiar access to those with limited access or disability. Indeed, iPads are already being used to help disabled persons to vote in some U.S. counties (Seelye, 2011). We therefore assessed the usability of voting on a web-based system optimized for use on a smartphone.

## BACKGROUND

Usability should be a primary concern in the design of any voting technology. Clearly, the integrity of elections depends on the voting technologies to effectively display ballot information, allow voters to select options according to their intent, and accurately record votes. Following the infamous Palm Beach County U.S. presidential election debacle in 2000, the U.S. Congress passed the Help America Vote Act (HAVA), with the goal of replacing legacy voting systems with newer voting technologies. As a result, DRE voting systems were the second most common voting system in the United States in 2008, with 32% of voters using them to cast their ballots (Brace, 2008).

The underlying problem with the 2000 Palm Beach County presidential election, however, was not that the voting technology was too antiquated. Rather, the ballot's format (the "butterfly ballot") led to a substantial decrease in usability for many voters. In the United States, states have individual authority over the design an implementation of the ballots used within their boundaries. In particular, the butterfly ballot made it very difficult for voters (especially the visually impaired) to confirm the selections they had made. Although Palm Beach County is the most well-known U.S. example, there are many documented cases in U.S. elections where usability issues are likely to have determined the outcome of the election (see, e.g., Norden, Kimball, Quesenbery, & Chen, 2008).

Prior to HAVA and the upswing in adoption of electronic voting systems, little usability research existed on efficacy of these systems or how they compared to legacy voting systems (Byrne, Greene, & Everett, 2007). Since then, a few studies have demonstrated the importance of usability in voting along with the unique challenges associated with this research.

Everett et al. (2008, Experiment 1) found no overall differences between their electronic voting system and paper ballots in regard to effectiveness (i.e., number of errors committed) or efficiency (i.e., ballot completion times). Although they did note a relatively large difference in ballot completion times between their DRE and lever voting machines (DREs were more efficient), as of 2010 New York state became the last U.S. state to abandon lever voting machines, making lever machines defunct. In their second experiment, Everett et al. (2008) corroborate Jastrzembski and Charness's (2007) findings that direct navigation models in the voting context, though more efficient, are likely to produce a decrease in voting system effectiveness and that the disparity has the potential to be much greater for older adults.

Furthermore, examining the designs of several commercial DRE user interfaces using a sample of older adults and computer novices, Conrad et al. (2009) found that both effectiveness and efficiency (measured as both "ease" and "comfort") were tightly coupled with voter satisfaction such that satisfaction dropped significantly when effectiveness or efficiency was low. The authors discovered that many of the electronic voting systems they tested yielded an alarmingly high number of errors during the course of testing—up to 9% in some cases.

These examples demonstrate why voting system usability should be of great concern for voting system design and serve to highlight the need for a greater understanding of how the technology itself can support voters in casting an accurate ballot. Usability concerns, however, are only one piece of the puzzle. Voting over the Internet, whether on smartphones or other computers, has not been implemented in U.S. national elections because of security concerns.

### Security Concerns

Some researchers believe that voting via the Internet is an insurmountable challenge (Wolchok, Wustrow, Isabel, & Haldreman, 2012, p. 6). For example, Jefferson, Rubin, Simons, and Wagner (2004) assessed the security of voting in a U.S. Department of Defense (DoD) trial of Internet-based voting systems. This trial allowed individuals in 21 states and 11 countries to use their technology of choice to cast ballots in several jurisdictions over the Internet (DoD, 2003). They concluded that this particular initiative, and Internet voting in general, “cannot be made secure for use in real elections for the foreseeable future” because election officials are not in control of the voting hardware (Jefferson et al., 2004, p. 64).

Despite these security concerns, using the Internet for voting is not a novel idea; it is already occurring. Indeed, there is already a trend toward Internet voting both in this country and abroad. In the United States, the Federal Voting Assistance Program has called for the immediate development of Internet voting standards and pilot projects, and iPad technology is being leveraged to enhance the voting experience for disabled persons (Seelye, 2011). Abroad, the Republic of Estonia was the first country to fully embrace Internet voting by recently holding the first digital election where anyone in the country could vote for public officials and policies via the Internet. In 2011, 15% of the population of Estonia used the Internet to vote, which led to a 2.6% increase in voter turnout.

### Mobile Voting

Despite the trend toward Internet voting, there has been little research that specifically assesses the usability of Internet voting on mobile platforms. Intuitively, however, voting with mobile technology has several potential advantages. For example, Coleman (2002) found that voting on mobile phones could increase voter turnout with minimal cost. Weinstein (2004) showed that 49% of their subjects would rather vote on their mobile phone than a paper ballot sheet. Brucher and Baumberger (2003) asserted that mobile voting on phones could enhance the voting experience by giving users access to ballots via well-known tools in private surroundings instead of forcing individuals to vote on unfamiliar technologies in public places. Finally, access to mobile platforms is very high (and rising), with 91% of the U.S. population owning a mobile phone and more than half of those being smartphones (Pew Research Center, 2013).

Despite these potential advantages, there are significant usability challenges associated with mobile computing. Namara et al. (2011) report survey results in which middle age and older adults overwhelmingly responded believing that paper-based voting systems were easier to use than newer electronic voting systems. These results may indicate that a majority of voters would likely prefer a more traditional method of voting, though it is unclear how a mobile voting system may or may not alter these results given its potential benefits. The high turnover rate of mobile technologies, however, could also prevent users from gaining familiarity with their devices or mobile voting procedures. Handheld mobile devices also have noted usability problems with small-screen displays, awkward text entry, and slow network speeds (Tossell, Kortum, Shepard, Rahmati, & Zhong, 2010). Thus, even if security concerns were resolved, the usability of mobile voting platforms would remain an important challenge to effective voting in a real election.

Therefore, in this paper, we assessed the usability of a web-based voting system designed for use on a smartphone. We compare the effectiveness, efficiency, and satisfaction of this system with those of other voting methods using a sample of voters from our local area.

## METHOD

### Subjects

A total of 84 subjects (46 female) were recruited from the greater Houston, Texas, area via local print and online advertising. All subjects were paid a $25 stipend for their time regardless of their voting performance and were required to be 18 years of age or older and native English speakers to participate. The subjects we recruited ranged in age from 18 to 68 years old, with a mean age of 35.7 ($SD$ = 13).

Our subjects also had a fairly diverse range of voting histories and educational backgrounds. Seven subjects had voted in 10 or more national elections and 10 had voted in 10 or more nonnational (i.e., state and local) elections. The vast majority of subjects, however, had voted in fewer than 6 national (92%) and nonnational (88%) elections. Subjects’ education levels were

**TABLE 1:** Distribution of Subjects' Level of Education by Smartphone Ownership

| | High School or Less | Associate's Degree | Bachelor's Degree | Graduate Degree | Total |
|---|---|---|---|---|---|
| Smartphone nonowners | 5 | 15 | 12 | 4 | 36 |
| Smartphone owners | 5 | 20 | 16 | 7 | 48 |
| Total | 10 | 35 | 28 | 11 | 84 |

also well distributed, with a majority of subjects (75%) having obtained either an associate's or a bachelor's degree.

To obtain a more representative sample of the general voting population, subjects were not recruited on the basis of smartphone ownership. Nevertheless, as shown in Table 1, 48 subjects reported owning a smartphone at the time of experimentation, and there was insufficient evidence to conclude that smartphone ownership was a function of education, $\chi^2(3, N = 84) = 0.40, p = .94$.

## Materials

Three voting methods were assessed in this study. The smartphone-based method was designed specifically for this experiment, whereas the Flash VoteBox and paper ballot methods have been used in previous experiments. The primary design goal for our mobile voting system (MVS) was to maximize accuracy (effectiveness), with efficiency as a secondary goal. Efficiency was given secondary weight as the pressure to vote in a timely manner is potentially eliminated by the mobility of the voting device. Designed in late 2011 for the iPhone 3GS, the MVS presents each ballot sequentially and requires users to select a "Next" button to navigate across races. Because smartphones have small screens, we avoided multiple contests on each screen to help prevent errors of omission. Screenshots of the MVS can be seen in Figure 1.

Subjects voted by selecting anywhere within the white box that contained the candidate's name. Subjects navigated forward to each race by selecting the right arrow and could also go backward through the ballots to change selections using the left arrow. We used common iOS layouts and placement of buttons, icons, text, and other formatting.

After subjects saw every race, a review screen was presented with their choices for each race as well as orange highlighting on any race that was skipped. The review screen allowed subjects to go directly to a skipped race to make a vote by touching anywhere in the race area. Finally, subjects had to scroll down to the bottom of the review screen to submit their votes. This forcing function was deliberately enabled to help prevent errors of omission.

Of the other, nonmobile, voting systems, Flash VoteBox was used as the DRE voting interface in this experiment. Flash VoteBox (Figure 2) is a Flash implementation of the VoteBox DRE platform (Sandler, Derr, & Wallach, 2008) capable of logging and time stamping all user actions. The paper ballots used in this experiment (Figure 3) were custom designed to mimic traditional bubble-style columnar paper ballots.

All three voting systems in this experiment employed the same basic ballot format used in previous mock election research (Byrne et al., 2007; Campbell & Byrne, 2009; Everett, Byrne, & Greene, 2006; Everett et al., 2008; Greene, Byrne, & Everett, 2006). This ballot format featured 27 contests in total. The first 21 contests were single-selection partisan races, whereas the remaining 6 contests were fictional yes–no propositions representative of local ballot referenda. Candidate names were also fictional, but party affiliations were real (e.g., the Democratic and Republican Parties were used).

## Procedure

After obtaining Institutional Review Board–approved informed consent, those in the directed information condition (where voters were told who to vote for) were given one of two randomly generated slates. One slate was primarily Democratic (85%) and the other was primarily

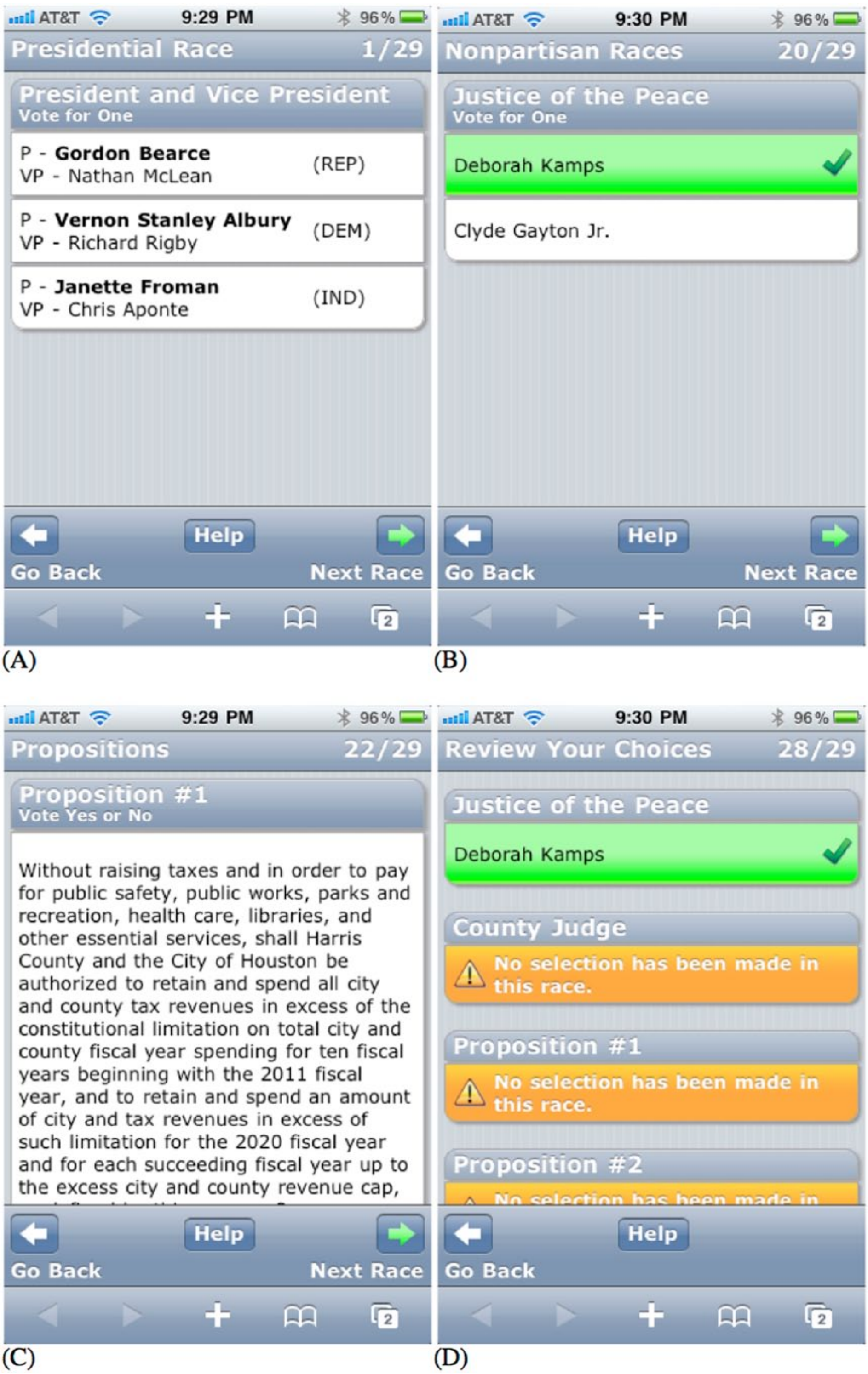



*Figure 1.* Screen shots of the mobile voting system. Panel A shows the presidential race with no candidate selected. Panel B shows the 19th race with a single candidate selected. Panel C shows the first two thirds of the first proposition. Panel D shows a portion of the middle of the review screen.

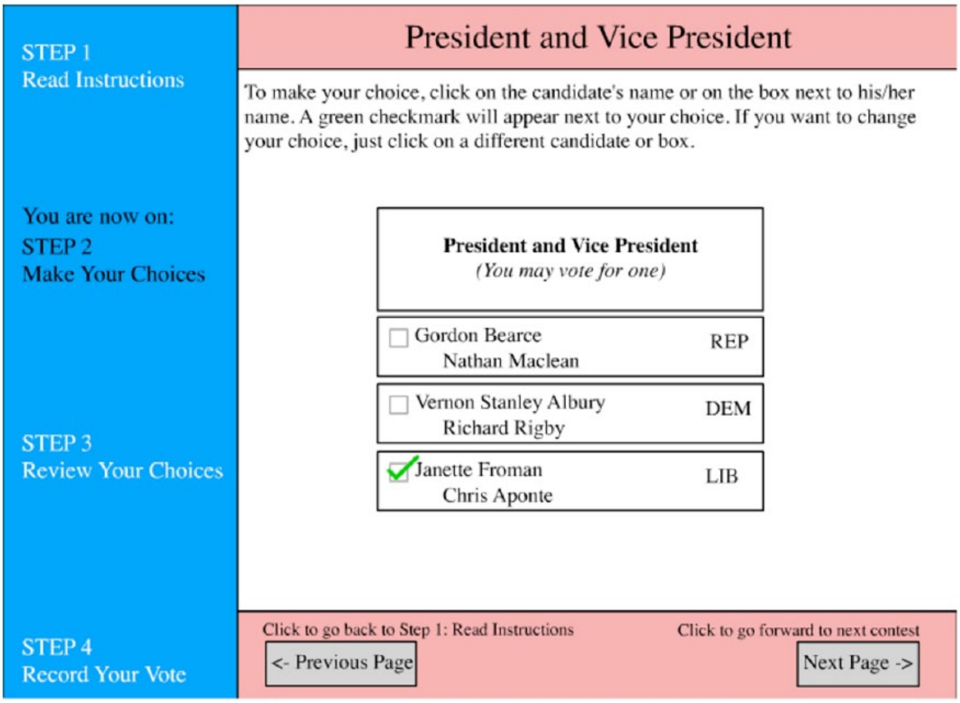
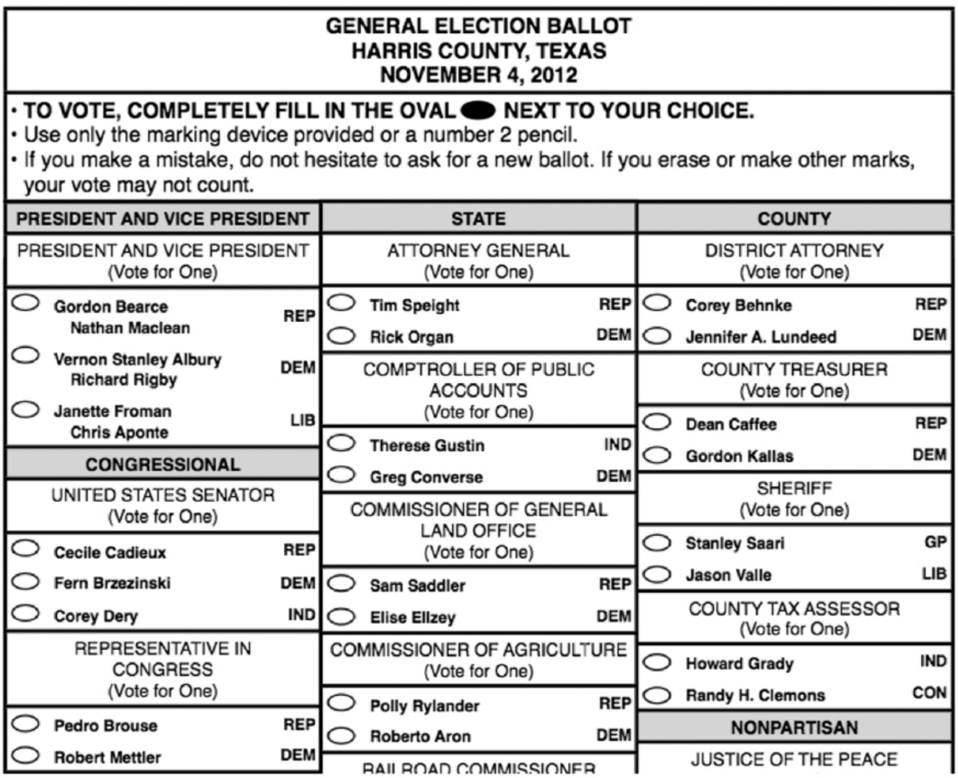



*Figure 2.* Screen shot of the Flash VoteBox DRE showing the presidential race with a candidate selected.


GENERAL ELECTION BALLOT
HARRIS COUNTY, TEXAS
NOVEMBER 4, 2012

- TO VOTE, COMPLETELY FILL IN THE OVAL NEXT TO YOUR CHOICE.
- Use only the marking device provided or a number 2 pencil.
- If you make a mistake, do not hesitate to ask for a new ballot. If you erase or make other marks, your vote may not count.

PRESIDENT AND VICE PRESIDENT

PRESIDENT AND VICE PRESIDENT (Vote for One)
Gordon Bearce / Nathan Maclean REP
Vernon Stanley Albury / Richard Rigby DEM
Janette Froman / Chris Aponte LIB

CONGRESSIONAL

UNITED STATES SENATOR (Vote for One)
Cecile Cadieux REP
Fern Brzezinski DEM
Corey Dery IND

REPRESENTATIVE IN CONGRESS (Vote for One)
Pedro Brouse REP
Robert Mettler DEM

STATE

ATTORNEY GENERAL (Vote for One)
Tim Speight REP
Rick Organ DEM

COMPTROLLER OF PUBLIC ACCOUNTS (Vote for One)
Therese Gustin IND
Greg Converse DEM

COMMISSIONER OF GENERAL LAND OFFICE (Vote for One)
Sam Saddler REP
Elise Ellzey DEM

COMMISSIONER OF AGRICULTURE (Vote for One)
Polly Rylander REP
Roberto Aron DEM

RAILROAD COMMISSIONER

COUNTY

DISTRICT ATTORNEY (Vote for One)
Corey Behnke REP
Jennifer A. Lundeed DEM

COUNTY TREASURER (Vote for One)
Dean Caffee REP
Gordon Kallas DEM

SHERIFF (Vote for One)
Stanley Saari GP
Jason Valle LIB

COUNTY TAX ASSESSOR (Vote for One)
Howard Grady IND
Randy H. Clemons CON

NONPARTISAN

JUSTICE OF THE PEACE

*Figure 3.* Paper ballot showing the top two thirds of the front side of the ballot.

Republican (85%). The voter guide given to subjects in the undirected information condition (where voters freely selected their own candidates) was inspired by the League of Women Voters publication describing each candidate and their position on a few key issues.

After reviewing either the slate or voter guide, subjects commenced voting without practice in two separate voting sessions using two different voting technologies. At the conclusion of each of their first and second voting sessions, subjects were given the System Usability Scale (SUS; Brooke, 1996) to capture their immediate perceptions of each system. After both voting sessions had concluded, subjects were given an exit interview and were paid for their participation.

Consistent with previous research (Campbell & Byrne, 2009; Everett et al., 2008; Greene, 2008), in the directed information condition, a voting error was defined as any deviation from the slate provided. In the undirected information condition, a "majority rules" method of error attribution was used as subjects provided three sources of intent: (a) their ballot from the first voting session, (b) their ballot from the second voting session, and (c) their exit interview.

All subjects given a voter guide were explicitly asked, during their exit interview, which candidates they intended to vote for in each race. Thus, in the undirected information condition, any vote that did not match the other two sources of intent was considered a voting error.

## DESIGN

### Experimentally Manipulated Variables

*Mobile versus nonmobile voting system (within subjects; two levels)*. Subjects voted on only two of the three possible voting systems, one of which was always the MVS. The alternative voting system was one of the nonmobile voting technologies; however, voting system order was counterbalanced across subjects.

*DRE or paper nonmobile voting system (between subjects; two levels)*. As noted previously, in addition to the MVS, subjects also voted on one of two possible nonmobile voting systems to which they were randomly assigned. The first possibility was the Flash VoteBox DRE voting system, whereas the second possibility was the bubble-style paper ballot. Subjects were not assigned to vote on all three voting systems for two reasons. First, limiting voting sessions to a maximum of two was done to help alleviate subject fatigue, as the entire experiment was rather lengthy. Second, and related to the first point, limiting voting sessions to a maximum of two reduced the time need to complete an entire experimental session.

*Information condition (between subjects; two levels)*. Subjects were given either a slate (i.e., list) of candidates to vote for—the directed information condition—or a voter guide and were allowed to vote for whomever they wished—the undirected information condition. Subjects were randomly assigned to an information condition.

### Other Independent Variables and Covariates

*Smartphone ownership (between subjects; two levels)*. Smartphone ownership was included in the design to assess the potential impact that familiarity with the technology may have on the usability of the MVS.

*Education (between subjects; four levels)*. Similar to smartphone ownership, education was included in the design to assess what, if any, impact education had on the usability of the voting systems used in the experiment.

*Subjects' age (covariate)*. Subjects' self-reported age was used as a covariate in this experiment.

### Dependent Variables

The dependent usability metrics of interest were (a) *efficiency*, measured as the time it took a subject to complete a ballot, (b) *effectiveness*, measured as how many errors a subject made when completing a ballot, and (c) *subjective usability*, operationalized as usability ratings given by subjects on the widely used SUS (Brooke, 1996).

## RESULTS

A 2 (voting system: MVS or non-MVS) × 2 (nonmobile voting system: DRE or paper) × 2 (information condition: directed or undirected) × 2 (smartphone ownership: owners or nonowners) × 4 (education: high school, associate's, bachelor's, or graduate) mixed-design ANCOVA

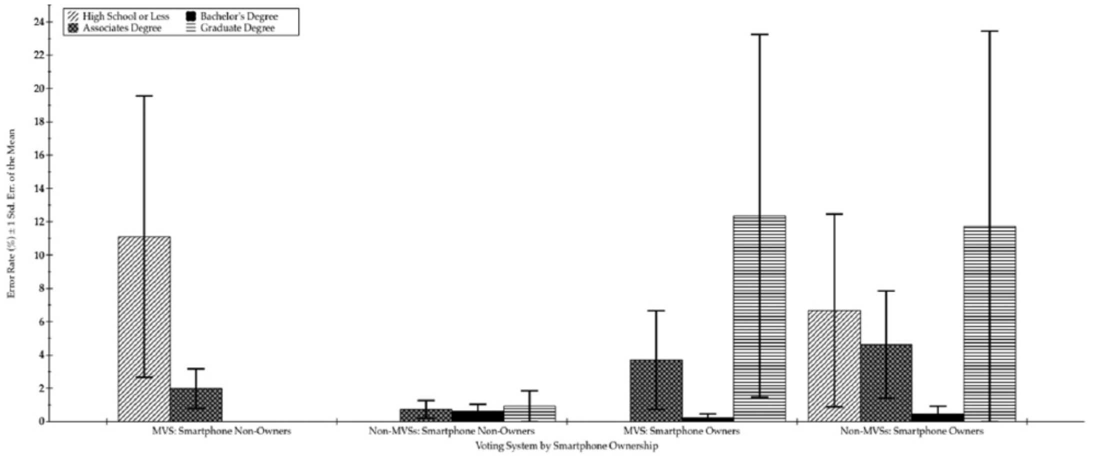



*Figure 4.* Mean overall error rate (%), as a function of subjects' self-reported level of education and smartphone ownership when voting on the MVS and the nonmobile voting systems. Error bars represent standard errors of the mean. Means represent the untransformed data.

was used to analyze ballot completion times and SUS ratings. Analysis of error rates was identical except for the addition of a two-level within-subjects variable, error type (described later). Although not explicitly reported later, all two-way and higher order interactions were included in the ANOVA model.

One subject, however, was removed from all following analyses due to noncompliance with the experimental task. Furthermore, the covariate, subjects' age, was not a statistically significant predictor of voting performance, ballot completion time, or SUS ratings, nor were there any interpretable main effects or interactions involving information condition, and thus these factors are not discussed further.

## Effectiveness

It was possible for subjects to make one of four, mutually exclusive, types of voting errors: overvote (too many), omission (too few), wrong choice (mistake or miss-click), and extra vote errors (voting by accident). Since no participant made any overvote (because the electronic systems prevent such occurrences) or extra vote errors on any voting system, these error types were excluded from the analysis of error rates. Furthermore, since we discovered insufficient evidence to conclude that error type was a significant factor, the reported error rates are averages of both wrong choice and omission errors.

Finally, all per-technology error rates were transformed, prior to analysis, using an arcsine-root transformation. This was done to reduce the impact of a few subjects' comparatively high per-technology error rates (i.e., at or near 100%). These subjects were unwilling to vote for the candidates provided to them via the slate in the directed information condition, thereby artificially inflating their overall error rates.

As indicated by the overall three-way interaction among voting system, smartphone ownership, and education (Figure 4), when voting on the MVS, lower educated smartphone nonowners were much more likely to make a voting error than lower educated voters using one of the nonmobile voting systems, $F(3, 54) = 2.81$, $p = .048$, $MSE = .006$, $\eta^2_p = .14$. The primary driver of this interaction appears to be disproportionately high error rate for MVS voters who have the lowest education (high school) and do not own smartphones. This was corroborated by a custom post hoc interaction contrast suggested that unfamiliarity with the technology might disproportionately affect lower educated voters. In other words, the difference in error rates between the highest and lowest levels of education was greatest when smartphone nonowners were using the MVS, $F(1, 54) = 9.30$, $p = .004$, $MSE = .006$, $\eta^2_p = .15$.

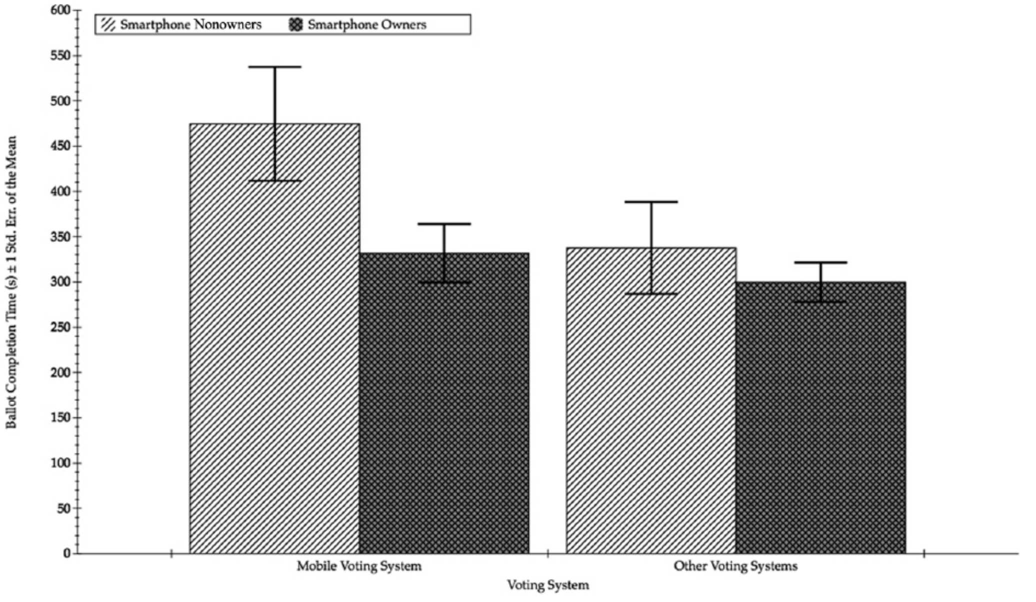



*Figure 5.* Mean ballot completion time, in seconds, as a function of voting system and smartphone ownership. Error bars represent standard errors of the mean. Means represent the untransformed data.

## Efficiency

A handful of subjects anomalously stopped voting to reread their voters' guide during their voting session. To reduce the impact of these comparatively long ballot completion times, all ballot completion times were transformed prior to analysis using a logarithmic transformation. As shown in the two-way interaction between voting system and smartphone ownership (Figure 5), $F(1, 54) = 6.67$, $p = .01$, $MSE = .03$, $\eta^2_p = .11$, when voting on the MVS, smartphone owners took an average of 140 seconds less time to complete their ballot than did smartphone nonowners, indicating that familiarity with the device allowed voters to save time during the voting process. A post hoc interaction contrast indicated that the disparity between smartphone owners and nonowners was greatest when subjects voted using the MVS, $F(1, 54) = 5.51$, $p = .02$, $MSE = .33$, $\eta^2_p = .09$.

Subjects' level of education was also a determinant of ballot completion times, as shown in the two-way interaction between voting system and education (Figure 6), $F(3, 54) = 4.1$, $p = .01$, $MSE = .03$, $\eta^2_p = .19$. Interaction contrasts were inconclusive; however, the interaction appears to be driven by those with a graduate degree. Although most subjects, regardless of education, took on average between 300 and 500 seconds to complete their ballot, when voting on the MVS those with a graduate degree took an average of 220 seconds longer to complete their ballot than similarly educated subjects voting on one of the nonmobile voting systems.

## Subjective Usability

We found no evidence that SUS scores depended on voting system, information condition, age, smartphone ownership, or level of education. Nevertheless, subjects rated the MVS ($M = 86.2$, $SD = 17.9$, out of 100 possible points) and the non-MVSs ($M = 88.4$, $SD = 13.4$) rather favorably as far as SUS scoring is concerned (Bangor, Kortum, & Miller, 2008), $F(1, 54) = 0.25$, $p = .62$, $\eta^2_p = .004$, indicating a high degree of perceived usability for all the voting systems used in this experiment.

# DISCUSSION

Although inefficient voting systems can indirectly affect election outcomes via longer lines at polling centers, thereby potentially disenfranchising some voters, ineffective voting systems can more directly affect election outcomes by essentially altering voters' ballots. Thus, in this

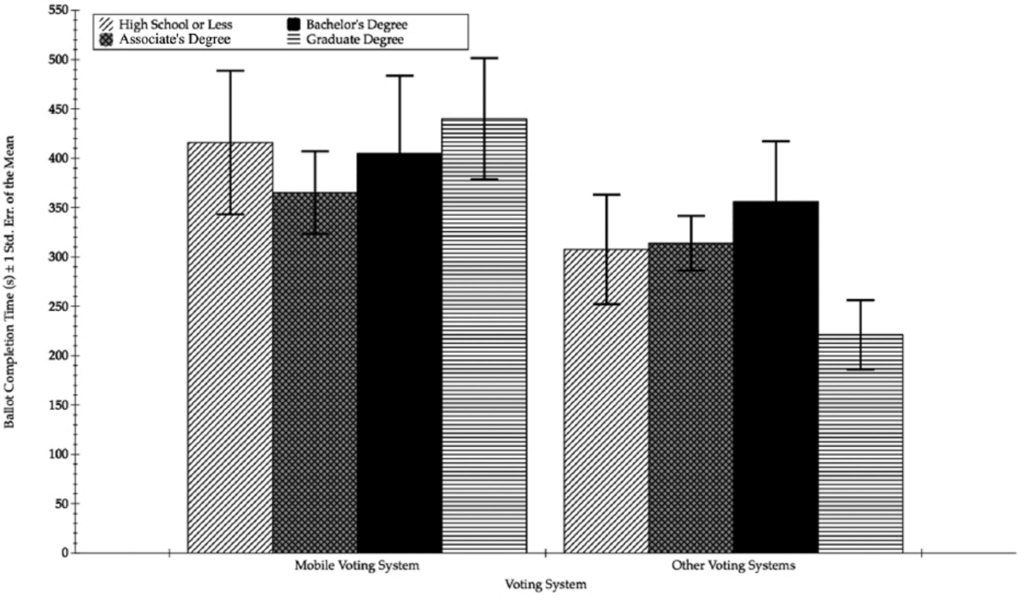



*Figure 6.* Mean ballot completion time, in seconds, as a function of voting system and self-reported level of education. Error bars represent standard errors of the mean. Means represent the untransformed data.

sense, the MVS succeeded in providing enhanced effectiveness in voting for smartphone owners, particularly for those with the lowest levels of education. The MVS was designed to facilitate voting effectiveness. Even though we found some evidence of differences in the magnitude of efficiency, particularly for those with a graduate degree, compared to the commonly used voting systems of today (DRE and paper-based systems), the MVS resulted in a substantial increase in voting errors for smartphone nonowners and a notable decrease in voting errors for smartphone owners. These results highlight the importance of leveraging user experience with technology for increased effectiveness. The current model of voting in the United States, with any system, often requires voters to adapt to unfamiliar systems to participate. This study provides evidence suggesting individuals should vote on familiar systems for optimal usability.

In the near term, however, Internet-based voting should not be considered a viable option for real elections. Recent testing of Internet-based voting has shown substantial security vulnerabilities. In addition, the human factors community should work closely with the computer science community to develop authentication systems that do not overburden voters but at the same time allow them to securely and anonymously submit their ballots. There is simply too little known about the specific human factors and security requirements needed to support such a large transformation in the way the United States votes. However, an offline approach with familiar systems (e.g., Seelye, 2011) appears to be an appropriate first step in this direction. We expect that the inherent benefits of Internet-enabled voting may enhance current voting practices in the future.

If this is the case, our findings suggest that electronic voting via a smartphone could be implemented. Voting on a smartphone, even a prototype such as the one assessed in the current study, can provide an effective means to vote for users without any real decrement to user satisfaction or efficiency. Our study does not, however, suggest that smartphone voting systems are the answer to solving usability problems associated with voting. The ballot we used did not include common provisions such as a straight-party voting option, races with a large number of possible choices, or races in which more than one candidate can be selected per race. It is currently unclear how these ballot provisions interact with standard voting technologies, let alone a small-screen mobile device. Nevertheless, users' previous experiences with technology should be leveraged, and the voting system, at the broadest level, should provide users options to vote with methods that accommodate their unique demographics, experiences, contexts, and limitations. Smartphones can be an effective option to this end.

More specifically, exploiting users' experience with their own smartphones could reduce costly mistakes such as wrong choice or omission errors. Our findings call into question the current approach of "one-size-fits-all" technology requirements for voting. Indeed, current voting interfaces generally do little to support users with little to no familiarity with the system. Developing content for smartphones, however, could provide tailored functionality that would prevent designer–user mental model mismatches associated with new interfaces for the millions of smartphone users in the United States. It would likely also increase the accessibility of voting for smartphone owners by eliminating travel to polling stations and waiting in line at these locations. The time cost associated with voting has been posited as at least one reason why more votes are not cast on election day (Highton, 2006; Spencer & Markovitz, 2010).

## CONCLUSION

We tested one prototype of a smartphone voting system to understand important usability challenges associated with voting on a handheld mobile device. Several messages are clear from this research that are relevant for the design of such systems in the future. First, and most important, is that the MVS was far from perfect. Human factors research is needed to ensure that new (mobile) and existing (DREs, paper ballots, etc.) voting technologies support the diverse user population. Second, we made decisions early in our design to perhaps slow voting navigation by removing swipe gestures, adding functionalities and processes to verify voting actions, and requiring users to view every race on the ballot. We suspect these design features enhanced effectiveness for smartphone owners, perhaps at the cost of efficiency and perceived usability. Voting on smartphones, however, would remove the need to drive to a polling place and wait in line, thus decreasing the total time needed to vote in a given election and freeing up polling station capacity for non-MVS voters. Future research should assess other ways to vote (e.g., interactive voice response systems) across diverse groups for a better understanding of designing these systems.

Other research should also be conducted both inside and outside of the laboratory setting to address questions we did not directly consider in the current study. For instance, smartphones are operated in a variety of settings. How does the more dynamic nature of context (e.g., physical movement, time of day, location, etc.) influence the usability of this application? Furthermore, how do interruptions affect the voting process? Finally, future mobile voting research should investigate the differences, if any, between native and web-based voting applications and navigation styles, as well as the effect of longer ballots (e.g., ballots in which more than a screen full of candidates are running for a single race).

## ACKNOWLEDGMENTS

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## KEY POINTS

- The mobile voting system succeeded in providing enhanced effectiveness in voting for smartphone owners with lower levels of education.
- There is simply too little known about the specific human factors and security requirements needed to support such a large transformation in the way the United States votes.
- Even with the known limitations of small mobile platforms in both displays and controls, a carefully designed system can have excellent usability

characteristics even for an application as demanding as voting.

- Much of the concern about mobile voting is in the area of security, so although these results are promising, security concerns, and usability issues arising from mitigating them, must be strongly considered.
- The performance differences between owners and nonowners of smartphones highlight the need to allow users to select their own platforms for these kinds of infrequent but tremendously important tasks.

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