Voting on a Smartphone: Evaluating the Usability of an Optimized Voting System for Handheld Mobile Devices

Bryan A. Campbell, Chad C. Tossell, Michael D. Byrne, Philip Kortum
Rice University, Houston, TX
{bryan.campbell; chad.tossell; byrne; pkortum}@rice.edu

The goal of this research was to assess the usability of a voting system designed for current-generation smartphones. Smartphones offer remote participation in elections through the use of pervasive technology and voting on these devices could, among other benefits, increase voter participation while allowing voters to use familiar technology. We developed a mobile voting system for the iPhone and compared its usability with traditional voting platforms. Results showed that the mobile voting system was not as efficient as the other voting methods in total interaction time. However, smartphone owners committed fewer errors on the mobile voting system than on the traditional voting systems. These results, along with others, are discussed along with several important design considerations for voting technology.

INTRODUCTION

Using technology to vote in a national or local election is an important task that offers unique challenges in human factors. Systems designed for this task must account for an extremely wide array of users. Accuracy is also a critical concern, as can be attested by the uproar caused in the 2000 presidential election (Wand, Shotts, Sekhon, Mebane, Herron & Brady, 2001). Additionally, voters have to travel to local polling places and interact with unfamiliar technology to accomplish this low-frequency activity.

Using smartphones as voting platforms could address some of these concerns. If implemented correctly, distributed voting on mobile devices could increase voter participation, reduce election administration costs, and allow voters to interact with familiar technology.

For all of these benefits, however, there are still questions that remain unanswered. For instance, how do the limiting factors of a smaller screen and awkward data entry influence the usability of voting on a smartphone? While previous research has assessed the usability of other technological platforms, smartphones offer unique challenges and potential benefits. There is simply too little known about the specific human factors and security requirements needed to support such a large transformation in the way this nation votes.

Nevertheless, there is some evidence that a trend toward mobile voting is already underway both in this country and abroad. In the U.S., the Federal Voting Assistance Program, under the direction of the Overseas Citizens Absentee Voting Act of 1986 and the Military and Overseas Voter Empowerment Act of 2009, has called for the immediate development of Internet voting standards and pilot projects. Abroad, the Republic of Estonia is attempting to capitalize on these benefits in 2011 by being the first democracy to allow mobile voting in an election.

It follows then that smartphones and other Internet-capable mobile technologies, due to their rapidly increasing ubiquity, will likely play a key role in remote voting. While security concerns will certainly be a central challenge to enable mobile voting, usability concerns associated with using smartphones as voting platforms represent significant challenges as well.

The present experiment assessed the usability of a Web-based voting system optimized for iPhones. First, we review the importance of usability in voting systems and challenges associated with designing for smartphones. We then introduce a mobile voting system designed to leverage affordances of current smartphone technology to enhance voting effectiveness and report a usability evaluation comparing this system with traditional voting methods. Finally, we discuss the implications of our experiment to the design of voting technology.

Voting Usability

The fallout of the infamous Palm Beach County (PBC), FL, U.S. presidential election debacle in 2000 caused the United States Congress to pass the Help America Vote Act (HAVA) in 2002 with the goal of replacing legacy voting systems with newer voting technologies. As a result, direct recording electronic (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 PBC presidential election, however, was not that the voting technology was too antiquated. Rather, the ballot's format (a.k.a. the "butterfly ballot") led to a substantial decrease in usability for many voters. In particular, the butterfly ballot made it very difficult for voters (especially the visually impaired) to confirm the selections they had made. While the PBC election is the most well known example, there are many cases where usability issues are likely to have determined the outcome of elections (e.g., see Norden Kimball, Quesenbery & Chen, 2008). Prior to 2002's 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). As a result, many electronic voting systems may actually serve to hinder the voting process rather than improve it.

Designing a Voting UI for Smartphones

Usability challenges with other technologies have demonstrated the need to evaluate new paradigms to enhance the effectiveness of voting. In Europe, for example, research has shown the potential benefits of using mobile technology to this end. Coleman (2002) found that voting on mobile phones could increase voter turnout with minimal cost. Weinstein (2004) showed that 49% would rather vote on their mobile phone than a paper ballot sheet. Brucher and Baumberger (2003) asserted that mobile voting on phones could increase voter trust.

However, over the past 15 or so years, there has been a substantial amount of human factors research on the challenges associated with designing for mobile phones. Much of this research has shown the difficulties involved with interaction on previous-generation smartphones and mobile phones. Specifically, these devices have noted usability problems with small-screen displays (e.g., Duchnicky & Kolers, 1983), data entry (Smordal & Gregory, 2005), slower network speeds (Kukulska-Hulme, 2007), and a lack of optimized mobile content. Other problems associated with the user experience include low battery life and wireless network reliability. Mobile usability has been described as an oxymoron because of these problems (Nielsen, 2009).

Current smartphones, led by the iPhone, have made human-computer interaction much easier. These devices offer advanced functionality for improved efficiency and have opened up new ways for users to retrieve and use information (Matthews, Pierce & Tang, 2009). Mobile content, optimized for small screen viewing and data entry, is now more commonplace on the Web. While still not as efficient as the PC, this content has significantly enhanced usability for a number of tasks (Tossell, Kortum, Shepard, Rahmati & Zhong, 2010). For instance, Web navigation on optimized content yielded significantly reduced network wait-time and increased efficiency compared to non-mobile sites.

METHOD

Participants

Fifty-five subjects (31 female) were recruited from the greater Houston, TX area via local print and online advertising. All subjects were paid a $25 stipend for their time regardless of their voting performance. Previous research has been unable to conclude that monetary incentive influenced subjects' voting performance (Goggin, 2008).

Subjects were required to be (1) 18 years of age or older and (2) native English speakers. The subjects ranged in age from 18 to 68 years old with an average age of 37.7 (SD = 13.3).

We observed a diverse range of voting histories. Five subjects had voted in 10 or more national elections and nine had voted in 10 or more non-national (i.e., state & local) elections. The vast majority of subjects, however, had voted in fewer than 6 national (89%) and non-national elections (82%).

In order to obtain a more representative sample of the general voting population, subjects were not recruited on the basis of smartphone ownership. Nevertheless, twenty-four subjects (44%) reported owning a smartphone of some kind. Seven participants reported owning an iPhone and 17 reported owning another type of smartphone. Of the seven iPhone owners, six reported having owned their iPhones less then six months. Of the 17 non-iPhone smartphone owners, eight reported having owned their smartphones less than six months.

Design

The usability metrics of interest were (1) efficiency, measured as the time it took a subject to complete a ballot, (2) effectiveness, measured as how many errors a subject made when completing a ballot, and (3) satisfaction, operationalized as subjects' subjective usability score, measured by the System Usability Scale (SUS; Brooke, 1996), for each voting system.

The experimental design was mixed using the within- and between-subjects independent variables listed below.

Voting System: within-subjects, 2 levels. Subjects voted on two voting systems including the mobile voting system and one other non-mobile voting system. Voting system order was counterbalanced across subjects.

Non-mobile Voting System: between-subjects, 2 levels. The non-mobile voting system was either the Flash VoteBox DRE voting system or the bubble-style paper ballot. Subjects were randomly assigned to a non-mobile voting system.

Information Condition: *between-subjects, 2 levels.* Subjects were either given a slate (i.e., list) of candidates to vote for—the directed information condition—or were given a voter guide and allowed to vote for whomever they wished—the undirected information condition. Subjects were randomly assigned to an information condition.

The demographic variables age, smartphone ownership, and education were also included as independent variables.

Materials

The mobile voting system was a custom-built mobile Web application. The UI (Figures 1 & 2) was designed to provide voters the capability to effectively and efficiently vote in a national election. The system required voters to view every race sequentially. Subjects could vote by selecting anywhere within the white box that contained the candidates name. They navigated to the next page by selecting the right arrow. In addition, the user could go back, ask for help, and change selections as needed. After participants saw every race, a review screen was presented with their choices on each race as well as orange highlighting on any race that was skipped. The review screen allowed participants to go directly to the skipped race to make a vote by touching anywhere in the orange section. On the review screen, subjects had to scroll down to the bottom to submit their votes.

Many features were intentionally designed for more systematic and accurate voting. For instance, requiring the user to scroll through the entire review screen was to allow any missed votes to be recognized and addressed. The serial navigation model was implemented based on previous literature (Greene, 2008) and design testing that showed a reduced number of errors compared to other options that could have been implemented (e.g., a direct navigation approach). We also disabled gesture-based swiping to the next screen. While we expected these features to decrease efficiency, we focused on reducing errors as our primary goal in design. This metric (reduction of errors) is generally considered the most important human factors consideration in voting and was the primary driver of the current implementation.

Figure 1. The mobile voting UI showing and unselected race (left) and a selected race (right).

Figure 2. The mobile voting UI displaying a proposition screen (left) and the review screen (right).

Flash VoteBox was used as the electronic voting interface in this experiment. Flash VoteBox is a Flash implementation of the VoteBox DRE platform capable of logging and time-stamping all user actions (Sandler et al., 2008).

The paper ballots used in this experiment were custom designed to mimic traditional bubble-style columnar paper ballots. These ballots are usually tabulated with optical scanning equipment in real elections but were counted by hand in this experiment.

All three voting systems in this experiment employed the same basic ballot format used in previous mock election research (Byrne et al., 2007; Everett et al., 2008; and Greene et al., 2006). This ballot format featured 27 contests in total. The first twenty-one contests were single-selection partisan races whereas the remaining six contests were fictional yes-no propositions representative of local ballot referenda. Candidate names were also fictional (as this has been shown not to influence voting performance in Everett et al., 2006 and Greene et al., 2006) but party affiliations were real (e.g., Democratic and Republican parties).

Subjects in the direct information condition were given one of the two randomly generated slates used in this experiment. One slate was primarily Democratic (85%) and the other was primarily Republican (85%).

The voter guide given to subjects in the undirected information condition was a document inspired by the League of Women Voters publication describing each candidate and their position on a few key issues.

Procedure

Subjects gave informed consent before receiving instructions on the experimental procedure. After reviewing a slate or voter guide, subjects commenced voting, without practice, in two separate voting sessions using two different voting technologies. At the conclusion of both their first and second voting sessions, subjects were given the SUS in order to capture immediate impressions. After both voting sessions, subjects were given an exit interview and were paid for their time.

Consistent with previous research (Campbell & Byrne, 2009; Everett et al., 2008; and 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: (1) their ballot from the first voting session, (2) their ballot from the second voting session, and (3) their exit interview. Every subject given a voter guide was 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.

RESULTS

A 2 (voting system) X 2 (non-mobile voting system) X 2 (information condition) X 2 (age-median split) X 2 (smartphone ownership) X 4 (education) mixed-design ANOVA was used to analyze subjects' ballot completion times and SUS ratings. Analysis of error rates was identical except for the addition of a 4-level within-subjects variable, *error type* (described below). Age and education, while involved in several effects, are not discussed below due to space limitations. Where applicable, custom post-hoc interaction contrasts were used to interpret interactions.

Efficiency

Three subjects were removed from this analysis due to ballot completion times exceeding 3 interquartile ranges (IQRs) above the upper hinge. Subjects took, on average, 89 seconds longer to vote on the mobile voting system (M = 376.9s, SD = 193.8s) than when they voted on one of the non-mobile voting systems (M = 288s, SD = 158.4s), $F(1, 15) = 5.81$, $p = .03$.

Effectiveness

One subject was removed from this analysis due to technical difficulties and two more were removed for having error rates exceeding 15% on *both* their mobile and non-mobile voting system ballots—indicating a lack understanding of, or unwillingness to conform to, the experimental task.

Subjects were able to make one of four types of voting errors. The first, *overvote errors*, occur when a voter makes more than the allowed number of selections in any given contest. This type of error was not possible on either the mobile or DRE voting systems—an advantage of electronic voting systems. The second, *omission errors* (a.k.a. undervote errors), occur when a voter does not make a voting selection when their intent was to do so. The third, *wrong choice errors*, occur when a voter makes a voting selection other than the intended one. Finally, the fourth voting error, *extra vote errors,* occur when a voter intends to abstain from voting in a contest but inevitably does so anyway.

When subjects used the mobile voting system they tended to commit more voting errors (M = 1.5%, SD = 6.5%) than when they used one of the non-mobile voting systems (M = 1.1%, SD = 4.3%) however, the difference in means was not statistically significant at the conventional alpha level $F(1, 16) = 3.81$, p = .07.

Shown in Figure 3, smartphone ownership had an important influence on voting system error rates. When voting on the mobile voting system, smartphone owners made fewer voting errors (M = .2%, SD = .8%), on average, than non-smartphone owners (M = 2.4%, SD = 8.4%). The two-way interaction between smartphone ownership and voting system was statistically reliable, $F(1, 16) = 88.6$, $p < .01$ and a post-hoc interaction contrast confirmed that the difference in means between smartphone and non-smartphone owners between voting systems was statistically significant, $F(1, 16) = 66.4$, $p < .01$.

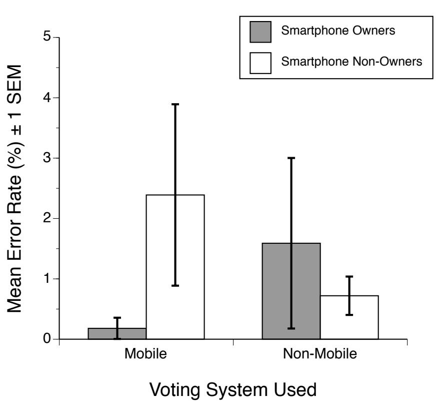

Figure 3. Mean voting system error rates as a function of smartphone ownership.

As shown in Figure 4a, when voting on the mobile voting system, non-smartphone owners committed, on average, many more wrong choice voting errors (M = 2%, SD = 8.3%) than smartphone owning subjects (M = .2%, SD = .8%). As shown in Figure 4b, when voting on the non-mobile voting system, non-smartphone owning subjects committed, on average, many fewer wrong choice voting errors (M = .2%, SD = .9%) than smartphone owning subjects (M = 1.6%, SD = 6.5%). The three-way interaction between voting system, error type, and smartphone ownership was statistically reliable ($F(3, 48) = 69.38$, $p < .01$) and a post-hoc interaction contrast confirmed that the difference in means between smartphone and non-smartphone owners for wrong choice errors between voting system was statistically significant. ($F(1, 16) = 11.02$, p = .004).

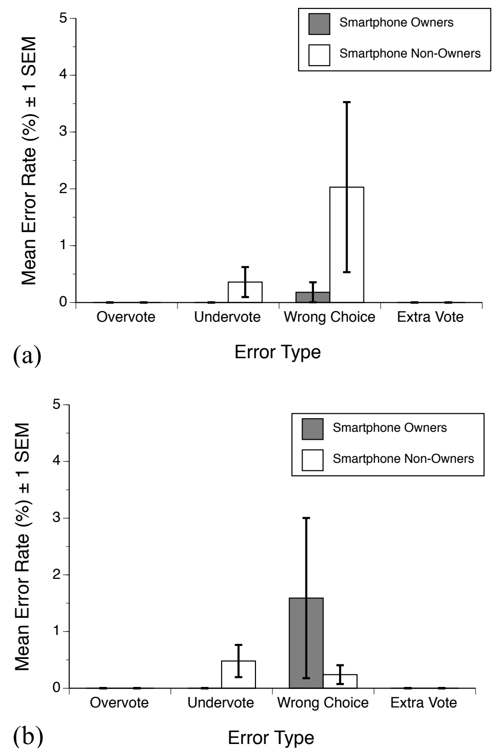

Figure 4. Mean voting error rate for each voting error type as a function of smartphone ownership for (a) the mobile voting system and (b) non-mobile voting system.

Satisfaction

Three subjects were removed form this analysis due to SUS ratings exceeding 3 IQRs below the lower hinge. While subjects rated the mobile voting system 5.8 points lower on the SUS (M = 83.8, SD = 17.4), on average, than the non-mobile voting systems (M = 89.6, SD = 10.6) this difference was not statistically reliable, $F(1, 18) = 0.70$, $p = .40$. Nevertheless, both the mobile and non-mobile voting systems scored rather favorably as far as SUS scoring is concerned (Bangor et al., 2008).

DISCUSSION

The mobile voting system was slower than the non-mobile voting systems (DRE and bubble-style paper) by approximately 90 seconds on average. The causality of this time-cost is currently unknown, though, the proposition and review screens (Figure 2), which require the user to engage in a substantial amount of screen scrolling, appear to be likely culprits. Unfortunately, due to technical limitations, this claim cannot be substantiated with the current version of the mobile voting system. Nevertheless, the magnitude of the time-cost effect is such that it is likely to be inconsequential. A mobile voting system would come with at least two distinct timesaving advantages that could more than compensate for the time lost due to using the system. First, a mobile voting system would likely not require voters to spend time traveling to a polling location. A second related advantage is that a mobile voting system would not require voters to wait in lines to vote. 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).

While inefficient voting systems can indirectly affect election outcomes via longer lines at polling centers, thereby potentially disenfranchising some voters, ineffective voting systems can directly affect election outcomes by essentially altering voter intent. Thus, in this sense, the mobile voting system succeeded in providing enhanced effectiveness in voting for smartphone owners. Compared to the commonly used voting systems of today (DRE and paper-based systems), the mobile voting system resulted in a substantial increase in voting errors for non-smartphone owners and a significant decrease in voting errors for smartphone owners. These results highlight the importance of leveraging user experience with familiar technology for increased accuracy.

The current model of voting with any system requires voters to adapt to non-familiar systems in order to participate. From a human factors perspective, this could be problematic due to an increased reliance on knowledge-in-the-world. Interfaces in this model must support users with little to no familiarity with navigating the system. Developing content for smartphones, however, could provide tailored functionality that would prevent designer-user mental model mismatches associated with new interfaces. Capitalizing on user experience with their own smartphones could reduce costly mistakes such as wrong choice or omission voting errors. Clearly, it would also increase the accessibility and ease of voting for smartphone owners.

Future research needs to be conducted both inside and outside of the laboratory setting, as there are many questions that this research did not directly consider. 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? Additionally, interactions with smartphones are often interrupted by virtual or real-world events. It is also likely that providing subjects with practice sessions prior to voting would serve to reduce the disparity in error rates between smartphone and non-smartphone owners; though, it is not immediately clear if practice would serve to reduce omission errors, wrong choice errors, or both (see Figure 4). Finally, future mobile voting research should investigate the differences, if any, between native and web-based voting applications, navigation styles (i.e., sequential vs. direct), as well as the effect of extremely long ballots (e.g., ballots in which more than a screen full of candidates are running for a single race).

ACKNOWLEDGEMENTS

This material is based upon work supported by the National Science Foundation (NSF) under Grants CNS-0524211 (the ACCURATE center) and CNS-1049723. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation. The authors would also like to thank Adam Purtee and Esther Luk for their assistance with this research as well as 5 anonymous reviewers of a previous draft. The mobile voting system was built using portions of both the iScroll 4 (cubiq.org/iscroll-4) and iUI (code.google.com/p/iui/) projects.

REFERENCES

Bangor, A., Kortum, P. T., & Miller, J. T. (2008). An empirical evaluation of the System Usability Scale. *International Journal of Human-Computer Interaction*, *24*, 574–594.

Brace, K. W. (2008). *Nation sees drop in use of electronic voting equipment for 2008 election – A first*. Manassas, VA: Election Data Services Inc.

Brooke, J. (1996) SUS: A “quick and dirty” usability scale. In P. W. Jordan, B. Thomas, B. A. Weerdmeester, & A. L. McClelland (Eds.). In Usability evaluation in industry. London: Taylor and Francis.

Brucher, H., & Baumberger, P. (2003). Using Mobile Technology to Support eDemocracy. *In Proc. 36th International Conference on System Sciences.* Hawaii.

Byrne, M. D., Greene, K. K., & Everett, S. P. (2007). Usability of voting systems: Baseline data for paper, punch cards, and lever machines. *Human Factors in Computing Systems: Proceedings of CHI 2007*, (pp. 171–180). New York: ACM.

Campbell, B. A., & Byrne, M. D. (2009). Now do voters notice review screen anomalies? A look at voting system usability. *Proceedings of the Electronic Voting Technology Workshop/Workshop on Trustworthy Elections (EVT/WOTE '09)*, Berkeley, CA: USENIX Association.

Coleman, S. (2002). Elections in the 21st century: from paper ballot to e-voting. *Report by the Independent Commission on alternative voting methods*, London, Electoral Reform Society.

Duchnicky, R. L., & Kolers, P.A. (1983). Readability of text scrolled on visual display terminals as a function of window size, *Human Factors, 25,* 683-692.

Everett, S. P., Byrne, M. D., & Greene, K. K. (2006). Measuring the usability of paper ballots: Efficiency, effectiveness, and satisfaction. *Proceedings of the Human Factors and Ergonomics Society 50th Annual Meeting*, (pp. 2547-2551). Santa Monica, CA: Human Factors and Ergonomics Society.

Everett, S. P., Greene, K. K., Byrne, M. D., Wallach, D. S., Derr, K., Sandler, D., & Torous, T. (2008). Electronic voting machines versus traditional methods: Improved preference, similar performance. *Human Factors in Computing Systems: Proceedings of CHI 2008* (pp. 883-892). New York: ACM.

Goggin, S. N. (2008). Usability of election technologies: Effects of political motivation and instruction use. *The Rice Cultivator: A Student Journal of Public Policy Research*, *1*, 30-45.

Greene, K. K. (2008). *Usability of New Electronic Voting Systems and Traditional Methods: Comparisons Between Sequential and Direct Access Electronic Voting Interfaces, Paper Ballots, Punch Cards, and Lever Machines* (Unpublished Master's thesis). Rice University, Houston, TX.

Greene, K. K., Byrne, M. D., & Everett, S. P. (2006). A comparison of usability between voting methods. *Proceedings of the 2006 USENIX/ACCURATE Electronic Voting Technology Workshop.*

Highton, B. (2006). Long Lines, Voting Machine Availability, and Turnout: The Case of Franklin County, Ohio in the 2004 Presidential Election. *PS: Political Science and Politics, 39*, 65-68.

Kukulska-Hulme, A. (2007). Mobile Usability in Educational Contexts: What have we learnt? *The International Review of Research in Open and Distance Learning, 8,* 356 – 362.

Matthews, T., Pierce, J., & Tang, J. (2009). *No Smart Phone is an Island: The Impact of Places, Situations, and Other Devices on Smart Phone Use.* IBM Research Report #RJ10452.

Nielsen, J. (2009). Mobile Usability. *Retrieved from* http://www.useit.com/alertbox

Norden, L., Kimball, D., Quesenbery, W., & Chen, M. (2008). Better ballots. New York, NY: Brennan Center for Justice at NYU School of Law.

Piner, G. E., & Byrne, M. D. (2010). Baseline usability data for a non-electronic approach to accessible voting. *Proceedings of the Electronic Voting Technology Workshop/Workshop on Trustworthy Elections (EVT/WOTE '10)*, Berkeley, CA: USENIX Association.

Sandler, D. R., Derr, K., & Wallach, D. S. (2008). VoteBox: A tamper-evident, verifiable electronic voting system. *Proceedings of the 17th USENIX Security Symposium.*

Smordal, O., & Gregory, J. (2005). KNOWMOBILE: Mobile opportunities for medical students. In A. Kukulska-Hulme & J. Traxler (Eds.) *Mobile Learning: A handbook for educators and trainers* (pp. 99 – 105). London: Routledge.

Spencer, D. M., & Markovitz, Z. S. (2010). Long Lines at Polling Stations? Observations from an Election Day Field Study. *Election Law Journal*, *9*, 3–17.

Tossell, C.C., Kortum, P., Shepard, C.W., Rahmati, A., & Zhong, L. (2010). Assessing the Performance of Common Tasks on Handheld Mobile Computers. *In Proc. Human Factors & Ergonomics Society (HFES).* San Francisco, CA.

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.

Weinstein, M. (2004). Political activity and youth in Britain. In Todd, M. J., & Taylor, G. (eds.). *Democracy and Participation. Popular Protest and New Social Movements*, London, S. 176-195.