Usability of Electronic Voting and Public Opinion about the New Technology

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Washington Statistical Society
10.24.08

Electronic Voting

- Florida electoral debacle in 2000 led to Help America Vote Act (HAVA)
  - Congress allocated funds to the states to buy new voting equipment
- Most states and DC now use some form of electronic voting
  - Primarily touch screen and optical scan, paper ballot
- Hanging chads are no longer possible but serious concerns have emerged
  - Security: Fraud, Hacking
  - Usability: Can voters vote as they intend?

Our Focus

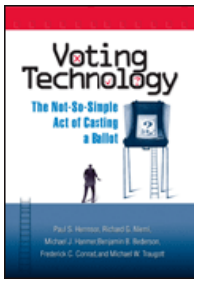
- Empirical Measurement of Usability
  - Laboratory (Conrad et al., in press)
    - users' ability to vote their intentions and satisfaction with the experience
  - Natural Experiment (Hanmer et al., in press)
    - comparison of "spoiled ballots" in two states before and after widespread introduction of e-voting
- Public Opinion about E-Voting (Traugott et al., AAPOR 2008, in preparation)
  - Vignette experiment embedded in 2 telephone surveys
  - varied description of technology

Acknowledgment

- The usability studies were part of a larger study funded by NSF
  - Grant # IIS-0306698
    - Herrnson, Traugott, Conrad, Niemi, Bederson & Hanmer
- The public opinion studies were made possible by support from
  - Time Sharing in the Social Sciences (TESS)
  - University of Michigan, Program in Survey Methodology practicum
  - Howard R. Marsh Center, UM Department of Communication Studies

Multifaceted Project on Usability of E-Voting

- Field Study:
  - ~1500 participants
- → Laboratory study
  - 42 participants + video
- Expert Review
- → Natural Experiment



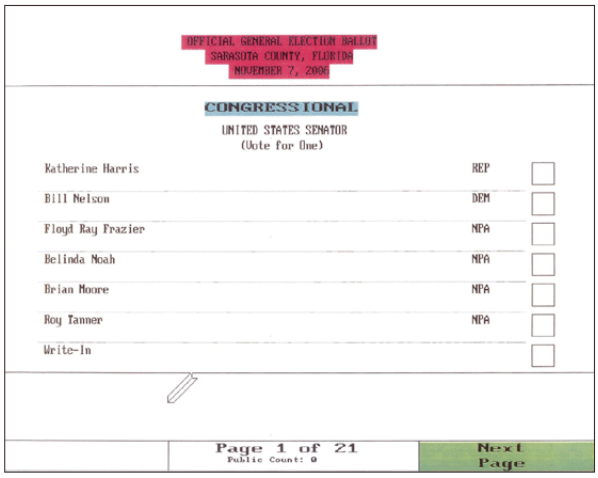
Usability Has Real Consequences: *Satisfaction*

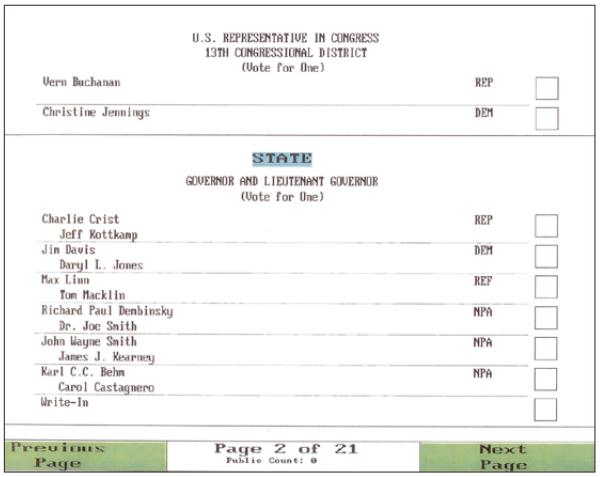
CLEVELAND --- A 61-year-old man was arrested after an alleged poll rage incident, NewsChannel5 reported.

Voter smashes touch-screen machine in Allentown, PA

Usability Has Real Consequences: *Election Outcomes*

- Sarasota County, FL, 13th CD, 2006
  - 18,000 (13%) “undervotes” for Congressional race in precincts that otherwise voted Democratic
  - So, likely more of the undervotes would have gone to Jennings (Dem) than Buchanan (Rep)
  - Jennings led in rest of district
  - Yet, Buchanan won by 369 votes
- Poor ballot design
  - Voters may not have noticed House race above Gubernatorial race
  - Usability explanations:
    - inconsistencies between 1st and 2nd page
    - “banner blindness”





U.S. REPRESENTATIVE IN CONGRESS
13TH CONGRESSIONAL DISTRICT
(Vote for One)

Vern Buchanan	REP	☐
Christine Jennings	DEM	☐

STATE

GOVERNOR AND LIEUTENANT GOVERNOR
(Vote for One)

Charlie Crist Jeff Kottkamp	REP	☐
Jim Davis Daryl L. Jones	DEM	☐
Max Linn Tom Macklin	REF	☐
Richard Paul Denbinsky Dr. Joe Smith	NPA	☐
John Wayne Smith James J. Kearney	NPA	☐
Karl C.C. Behm Carol Castagnero	NPA	☐
Write-In		☐

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Public Count: 0

Lab Study

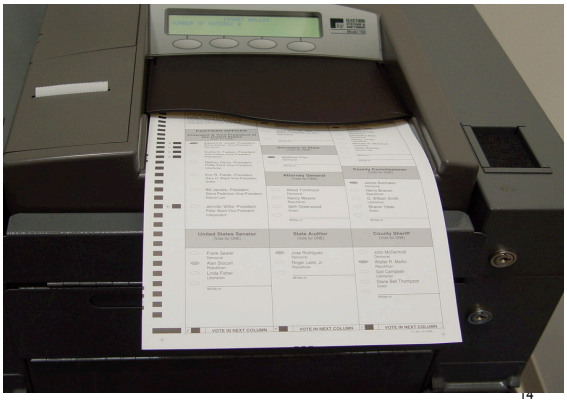
Participants

- 42 participants visited lab in Ann Arbor, MI in Summer, 2004
  - 31 with limited computer experience
    - "less than two times a week" or less
  - 29 older than 50 years of age
  - Each paid $50 for up to 2 hours

Procedure

1. Voters (users) indicate intentions by circling choices in booklet, simulating a voter pamphlet in a real election
   a. In a few cases, voters instructed how to vote
2. Voters vote for their choices on each of 6 systems
   a. Interactions video-recorded
   b. After using each system complete satisfaction questionnaire
3. Voters complete questionnaire about overall experience, opinions, demographics

Optical Scan, Paper Ballot:
ES&S Model 100



Manual-Advance TS:
Diebold AccuVote-TS

Auto-Advance TS with VVPAT:

Avante Vote Trakker

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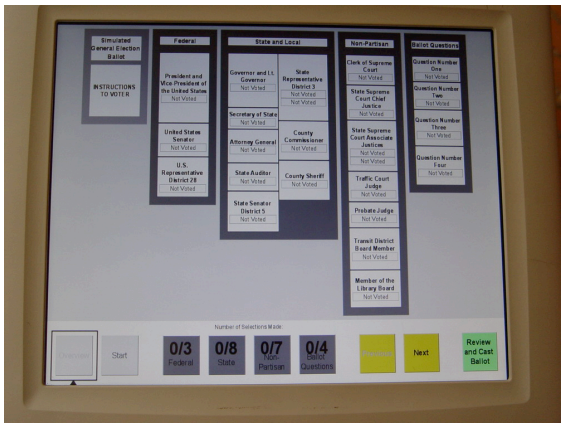
Zoomable Prototype:

Developed at U. of MD



External Dials and Buttons:

Hart InterCivic eSlate

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Full Face, Membrane Buttons:

Nedap LibertyVote

Hypotheses

1. The more effort required to vote, the less satisfied voters will be
2. As voters become “lost” they are more likely to vote inaccurately
4. Voters will be sensitive to their inaccuracy, indicated by lower satisfaction when inaccurate than accurate

Results: Satisfaction and Effort

- Satisfaction (“easy to use” and “comfort”) depends on the user interface
  - Manual advance TS (Diebold) rated highest
  - External Dials and Buttons (Hart) lowest
- Effort (number of actions and duration) depends on user interface
  - Manual advance TS (Diebold) requires fewest actions and the least time
  - External Dials and Buttons (Hart) lowest requires most actions and most time

Results: Satisfaction and Effort

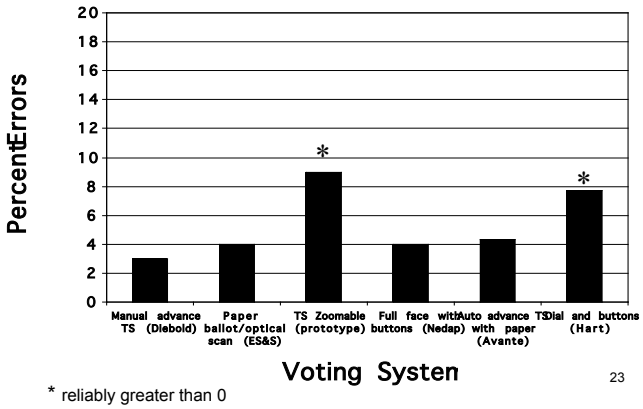
- The more effort required to vote, the less satisfied voters are with the experience
  - Effort: Number of Actions, Duration
  - Satisfaction: "easy to vote" and "comfortable voting"*

	Satisfaction	
Effort	Ease	Comfort
Duration	-0.40	-0.37
Number of Actions	-0.33	-0.33

$p < .001$ for all correlations

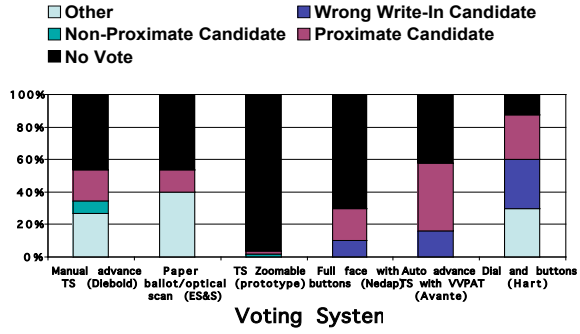
*Agreement scale (1 = strongly disagree, 7 = strongly agree)

Errors (Inaccuracy)



* reliably greater than 0

What kind of errors did voters make?

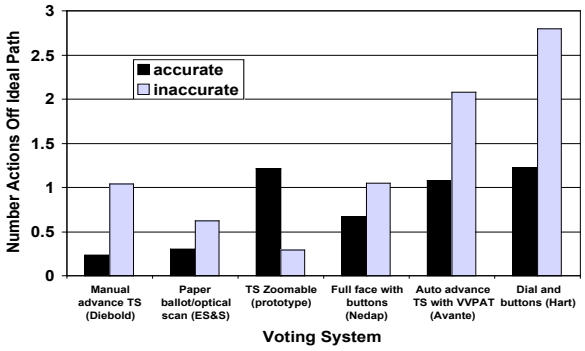


Note: In field study, proximity errors were most frequent

Results: Errors and Satisfaction

- As voters make more errors they are less satisfied
  - Easy to use (ρ = -0.23, p < .001)
  - Comfortable using (ρ = -0.18, p < .005)
- Suggests that errors are associated with frustration, not simple inaccuracy

When voters get lost*, they are less accurate



*The more actions off the critical path, the more lost a voter is.

Note: Effect is stronger for voters with low computer experience

Video Examples:

- Some tasks lead to low levels of performance no matter how implemented in different interfaces
  - Changing a vote
  - Writing-in a vote
- What happens if voters do not take advantage of features that might help?
  - Reviewing ballot
- Verifying paper audit trail

vote change video

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Write-in video

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Review Screen Video

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Paper Trail

- "Voter verified paper audit trail" makes recounts possible despite temporary character of touch screen voting choices
- But critical that voters verify
- Usability of Avante Vote Trakker printed receipt interferes with voter verification
  - System times out, automatically depositing (unverified receipt) for 38% (16/42) of voters
  - 24% (10/42) of voters deposited (verified) receipt without looking at it
  - Only 26% (11/42) follow ideal sequence of looking at receipt then depositing

Voter Verified Paper Audit Trail Video

Conclusions

- Although error rates were relatively low, we observed serious usability problems and, for some systems, errors were disturbingly frequent
  - Particularly for complex voting tasks
  - For different reasons for different interfaces
- When people have trouble they have serious trouble
  - Long inefficient sequences of actions
  - Lower levels of satisfaction
- An unsatisfying experience could well translate to lower turnout and lower confidence in electoral process
- Many design problems can be identified with usability engineering techniques
  - But industry and election officials need to make a priority

Natural Experiment

Purpose of the Study

Significant change in voting technology since 2000 raises two important research questions

- Were problems with residual votes (undervotes, overvotes, and uncounted ballots) reduced or eliminated?
- Did the shift in technology have any "unintended consequences" for voting behavior?

Can new methodological approaches be used successfully to address these questions in a reliable fashion that accounts for the nature of available data?

Hypotheses

1. Overall, the residual-vote rate will decline between 2000 and 2004 even where technology was unchanged; it will decline more in Florida than in Michigan.
2. Residual-vote rates will be lower for DREs than for OS systems.
3. The consistency in residual voting rates from 2000 to 2004 will be low, but it will be higher when an "older" voting system (e.g., lever system) was not changed than when a switch was made to "new" technology (e.g.,DRE or OS), and it will be higher in Michigan than in Florida.

Design of Natural Experiment Study

We wanted to look at “real world” results of switching to new voting equipment

1. Did voters do “better” in places where there was new technology compared to old in 2000 compared to 2004?
2. In the same places where there were changes to new technology from 2000 to 2004, were the results different in expected ways than in places that used the same technology?
3. Needed to select places that experienced change and had small unit data available for analysis

Data & Methods

- Natural experiments of shifting technology under Help America Vote Act (HAVA)
- Comparison of Florida and Michigan
  - Different types of data and jurisdictions
  - Florida is a “many to many” system
  - Michigan is a “many to few” system
- Employ descriptive statistics and ecological inference (Thomsen 1987)

Residual Votes Declined with the Implementation of “New” Technology

Table 1
Residual Votes in the 2000 and 2004 Elections in Florida and Michigan, by Type of Voting Equipment Used (Percent)

	President			U.S. Senate			Number of Cases	
Equipment	2000	2004	Change[a]	2000	2004	Change[a]	2000	2004
Florida								
Lever	0.3			16.7			39	
PC	6.3			7.2			1,508	
OS (precinct)	0.8	0.3	–0.5	2.2	1.6	–0.6	305	971
OS (central)	4.6			4.1			147	
DRE		0.6			4.1			1,588
Total[b]	5.2	0.5	–4.8	6.4	3.2	–3.3	1,999	2,559
Michigan								
Paper	2.2	1.6	–0.6	6.5	[c]		79	19
Lever	1.7	1.0	–0.6	6.0			210	116
PC	2.0	2.0	0.0	3.3			342	230
OS (precinct)	0.9	0.6	–0.3	2.3			671	961
OS (central)	1.7	0.6	–1.1	4.4			39	15
Total[b]	1.4	0.9	–0.5	3.5			1,341	1,341

Note: Selected precincts (Florida) or townships (Michigan). PC = punch card; OS = optical scan; DRE = direct recording electronic system.
a. Change calculated before rounding.
b. Weighted by the number of precincts or townships using each type of equipment.
c. There was no U.S. Senate election in Michigan in 2004.

Declines in Residual Votes Followed Shifts to "New" Technologies

Table 2
Change in Residual Votes in the 2000 and 2004 Elections in Florida and Michigan, by Type of Voting Equipment Change (Percent)

Equipment Change	*N*	President				U.S. Senate			
		2000	2004	Change[a]	*t*-score	2000	2004	Change[a]	*t*-score
Florida									
OS to OS	118	1.5	0.3	–1.2	–10.93	3.0	1.7	–1.3	–13.00
OS[c] to DRE	139	4.7	0.5	–4.1	–22.56	4.0	3.0	–1.0	–5.98
PC to OS	187	9.8	0.3	–9.4	–17.87	6.5	1.8	–4.7	–22.46
PC to DRE	1,029	5.7	0.6	–5.1	–34.50	7.5	4.2	–3.3	–16.46
Michigan									
Paper to paper	19	1.5	1.6	0.0	0.09				
Lever to lever	116	1.8	1.0	–0.8	–1.79				
OS to OS[d]	670	0.9	0.7	–0.2	–2.36				
PC to PC	229	2.2	1.8	–0.3	–5.00				
Paper to OS[d]	57	2.4	0.9	–1.5	–3.15				
Lever to OS	94	1.5	0.6	–0.8	–2.20				
PC to OS	113	1.6	0.4	–1.1	–14.13				

Almost No Carryover in Florida Residual Votes, 2000 to 2004

Table 3
Overvotes and Undervotes in the 2000 and 2004 Elections in Florida, by Machine Type (Percent)

County	2000					2004				
		Undervotes		Overvotes			Undervotes		Overvotes	
	Equipment	President	Senate	President	Senate	Equipment	President	Senate	President	Senate
Duval	PC	9.1	0.8	1.8	6.0	OS	0.0	0.0	0.3	1.6
Highlands	PC	1.8	0.0	1.6	2.2	OS	0.2	*	0.7	2.9
Marion	PC	1.0	0.7	2.0	2.6	OS	0.1	*	0.3	1.4
Miami-Dade	PC	3.0	1.5	1.6	7.6	DRE	0.0	0.0	0.7	4.8
Palm Beach	PC	4.9	1.8	2.0	7.4	DRE	0.0	0.0	0.5	3.6
	Average[b]	4.6	1.4	1.8	6.9	OS Average[b]	0.1	*	0.3	1.6
						DRE Average[b]	0.0	0.0	0.5	4.2

Note: The general analysis strategy was to use precinct-level data. For 2000, when precinct-level data were not available, individual ballot images were used to construct precinct totals. PC = punch card; OS = optical scan; DRE = direct recording electronic system.
a. Less than .05 percent.
b. Average calculated before rounding.

Previous residual voters less likely to cast invalid vote with new technology

Table 4
Rates of Casting a Residual Vote for President in 2004 among 2000 Residual Voters

Equipment Change	Repeat Residual-Voting Rate (%)
Florida	
Manatee (OS to OS)	0.3
Charlotte (OS[a] to DRE)	0.5
Lake (OS[a] to DRE)	0.5
Duval (PC to OS)	0.5
Highlands (PC to OS)	1.9
Miami-Dade (PC to DRE)	1.1
Palm Beach (PC to DRE)	1.0
Michigan	
Lever to Lever	1.9
Lever to OS	0.8
Paper to OS	3.1
OS to OS	1.7
PC to PC	8.6
PC to OS	0.9

Conclusions

- Is the new election administration system working?
  - Shifts in technology led to dramatic reductions in residual votes
  - No evidence of unintended consequences
  - The methodology works well in the context of machine changes, even in diverse areas
- What happens if (when?) the new technology presents usability issues for segments of the population? (The young? The elderly? Those with limited computer experience?)
- What happens if the push for new technology outstrips the ability of local officials to deal with it, i.e. if the administration of elections has to be outsourced to manufacturers and consultants?

Conclusions (2)

Researchers need additional data to pursue these questions, in order to understand how the new voting technology works and to help election administrators do their jobs

- Anonymized individual ballot images to understand roll-off, drop off, and spoiled ballots
- Disaggregation of "residual" votes into undervotes, overvotes, and spoiled ballots
- Small unit returns that correspond to other data sources about characteristics of those who vote there
- Information on other attributes of the election administration system, such as the allocation of machines by type, available before the election

Public Opinion about E-Voting

Post-Florida 2000

- After 2000 electoral debacle (e.g., hanging chads), many states replaced analog with digital voting equipment
  - Help America Vote Act (2002) provided Federal funds
    - most new systems touch-screen and optical scan
- New systems not the hoped-for panacea
  - scientific debate about security (e.g., Rubin, 2006) and usability (e.g., Herrnson, 2008) problems
  - media coverage mostly negative (Traugott, 2007)
- If public confidence in the new voting technology is harmed, electoral participation might also be harmed as well as willingness to support additional change

Where does public opinion about e-voting come from?

- media exposure
- personal experience
- scientific literacy, attitudes toward science and technology
- faith in government, partisanship, political efficacy
- demographics

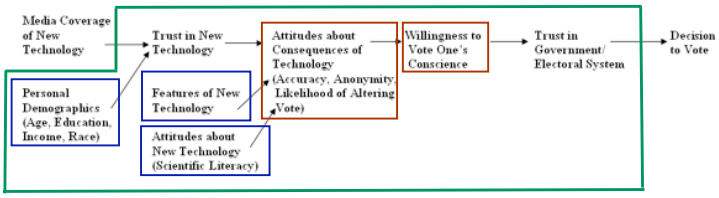
The Problem of Voter Confidence

- As a residual of the 2000 election, especially the long count in Florida, Americans are concerned about the accuracy of counts and potential manipulation of the vote count
  - Only 35% of a sample of likely voters had "a lot" of confidence that the votes would be counted properly, about the same as in 2006
  - 60% of respondents were "very" or "somewhat worried" that officials in other parts of the country would try to "manipulate vote counts to favor their candidate" and 25% expressed a similar concern "in their area"

The Problem of Voter Confidence

- This is a mediated effect as most Americans have not had any direct experience with either counting problems or fraud
- Research shows that those who pay more attention to the media are more likely to be concerned about problems of new voting technology and about accuracy of tabulations
- Is it possible that well-conducted audits with widely disseminated results could reduce these concerns and anxiety about the electoral system?

Conceptual Model



•Current status: preliminary test of model in two national samples

- impact of
  - Personal Demographics
  - Features of New Voting Technology
  - Attitudes about Science and Technology, Scientific Literacy
- on
  - Attitudes about consequences of the technology
  - Willingness to vote one's conscience

Vignette Approach

- We cannot measure actual media exposure at the respondent level
- Voters are probably experienced with only one type of e-voting system -- if any -- and these vary depending on county and state
- But we would like to measure opinion about standardized notions of e-voting
- We described e-voting to members of the public in specific ways -- vignettes -- and then measured their opinion

Vignette Approach (cont'd)

- Vignettes varied in whether or not each of three e-voting features were described:
  1. Access card required to start the process
  2. Paper record of on-screen selections printed
  3. Votes transmitted over the Internet for tabulation
- chosen *a priori* because are plausible (if not actual) features of e-voting systems that could affect voters' attitudes

Factorial Design of Vignettes

- After short rationale for e-voting (presented to all Rs), vignette describes or does not describe each of the following features
  - Access Cards
  - Paper Record
  - Transmission via Internet for Tabulation
- 8 vignettes*:
  - 2(Access Cards) x 2(Paper Receipt) x 2(Transmission/Tabulation)
  - that mention 0, 1, 2 or 3 features

*in earlier study 16 vignettes because 4 transmission types

4 Attitudes

(dependent variables)

Now, after hearing this description of possible electronic voting machines, how confident would you be that your vote will be accurately recorded that is, just as you submitted it?

Very Confident, Somewhat Confident, Somewhat Unconfident, Very Unconfident

Still thinking about this description of electronic voting machines, if someone who was not an election official wanted to intercept the votes from your machine and change them, how likely is it that they could do this?

Very Likely, Somewhat Likely, Somewhat Unlikely,Very Unlikely

(Still considering this description of electronic voting machines,) If someone wanted to figure out how you voted, how likely is it that they could do this?

Very Likely, Somewhat Likely, Somewhat Unlikely,Very Unlikely

(Still considering this description of electronic voting machines,) how likely would you be to vote your conscience, without being concerned that someone else might find out how you voted?

Very Likely, Somewhat Likely, Somewhat Unlikely, Very Unlikely

Vignette Approach Evaluated in 2 National Samples

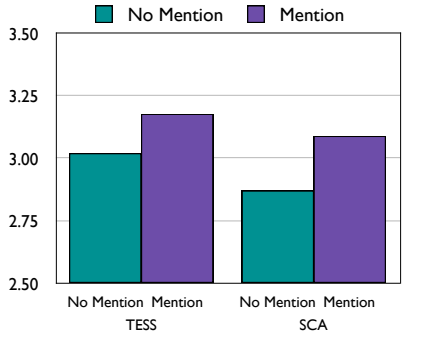
- Time-sharing Experiments in the Social Sciences (TESS)
  - 1214 US adults interviewed by telephone between October 2005 and February 2006
  - our experiment embedded among many others leading to wide variety of mostly political content
- Survey of Consumer Attitudes (SCA)
  - 477 US adults interviewed by telephone in June 2007*
  - our experiment embedded in production questionnaire about national and personal economic well-being

*congressional election of 2006 conducted between TESS and SCA data collection

How confident would you be that your vote will be accurately recorded that is, just as you submitted it?

1 = Very Unconfident, 4 = Very Confident

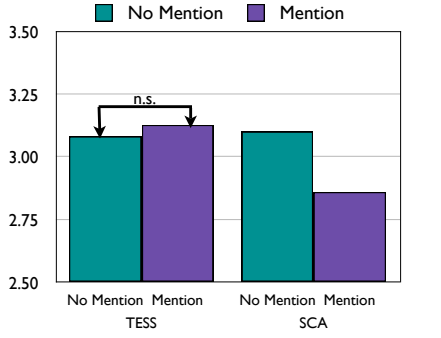
Technology Feature: Paper Record



How confident would you be that your vote will be accurately recorded that is, just as you submitted it?

1 = Very Unconfident, 4 = Very Confident

Technology Feature: Access Card



Joint Contributions of Personal Characteristics and E-voting Features

- Personal characteristics include Scientific Knowledge (Literacy) and Attitudes Toward Science and Technology
  - More Scientific Knowledge could increase enthusiasm for e-voting or could make vulnerabilities more salient
  - Attitudes toward e-voting special case of attitudes toward science and technology in which most coverage is negative
- Other characteristics include education, political efficacy, strength of partisanship, trust in government
- Fit separate models for Features (vignettes), Characteristics and both to the SCA data

Effects 1:

How confident are you that your vote will be accurately recorded...?

Technology Features	Peronsal Characteristics	Combined
Access Card (-)	Efficacy	Access Card (-)
Paper Record	Scientific Attitudes	Paper Record
	Scientific Literacy	Efficacy
		Scientific Literacy

Effects 2:

...if someone who was not an election official wanted to intercept the votes from your machine and change them, how likely is it that they could do this

Technology Features	Personal Characteristics	Combined
Internet transmission*	Efficacy (-)	Efficacy (-)
	Trust in Government (-)	Trust in Government (-)

*p = .06

Efffects 3:

If someone wanted to figure out how you voted, how likely is it that they could do this?

Technology Features	Peronsal Characteristics	Combined
Internet transmission*	Efficacy (-)	Efficacy (-)

*p = .06

Effects 4:

...how likely would you be to vote your conscience, without being concerned that someone else might find out how you voted?

Technology Features	Peronsal Characteristics	Combined
	Partisan Strength	Partisan Strength
	Education	Education
	Scientific Literacy	Scientific Literacy

What is an Audit?

Accuracy of the vote count is an important element but not the sole focus

An ***audit*** is a post-election process used to determine whether specified requirements for conducting elections have been fulfilled. This is distinct from a ***recount***, which is a post-election process to verify the accuracy of the tabulation of votes.

Issues of security, control of and accounting for ballots, and fully functioning voting devices are also important

Citizens want to know that if they are eligible to vote, they will get a ballot; all relevant procedures will be followed, and the vote count to determine the winner will be accurate

Expanding the Vignette Possibilities for the Fall Campaign

After the election, it is possible to conduct an independent check of election procedures to see whether they were followed correctly, whether there was no evidence of tampering, and whether the votes were counted accurately.

How confident would you be that the electoral system is working well? Would you say very confident, somewhat confident, not very confident, or not at all confident?

If a post-election check showed that all of the election procedures were followed correctly, there was no evidence of tampering, and the votes were counted accurately, how confident would you be that your vote would be accurately recorded just as you submitted it? (Etc., including confidence in the electoral system)

Conclusions

- Preliminary results consistent with conceptual model
  - Personal characteristics such as Scientific Literacy, Education, Efficacy, and Partisanship predict attitudes toward e-voting
  - The particular features of technology brought to mind by vignettes also affect attitudes toward e-voting
  - Relatively independent -- especially for confidence in accuracy
- Vignette approach is effective
  - Rs' attitudes affected by the particular technology features brought to mind by the description
  - Suggests that public opinion about voting technology is not yet stable

Conclusions (2)

- Longitudinal approach better suited to capturing evolution of opinion
  - media coverage may have reduced impact as the public becomes more personally experienced with the technology and their opinions more stable
  - or increased impact if high visibility incident with widespread negative coverage
- Election administrators may be able to improve opinion about the process -- and participation -- by implementing measures such as audit systems and announcing the results

Overall Conclusions

- E-voting eliminates some but introduces other usability problems
  - e.g., eliminates overvotes, some interfaces increase undervotes; counterintuitive interface actions like de-selection lead to error
- If these are systematic, can affect electoral outcomes
- The public has some concern about accuracy and security of e-voting but seem reassured by verification techniques like paper trail

Thank You