

Beyond the Hanging Chad: The Promise and Performance of Electronic Voting

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Overview

- Importance of Voting System and Ballot Design
- Voting Systems
- Ballots
- Study Design
- Findings
- Implications

Importance of Voting Systems and Ballot Designs

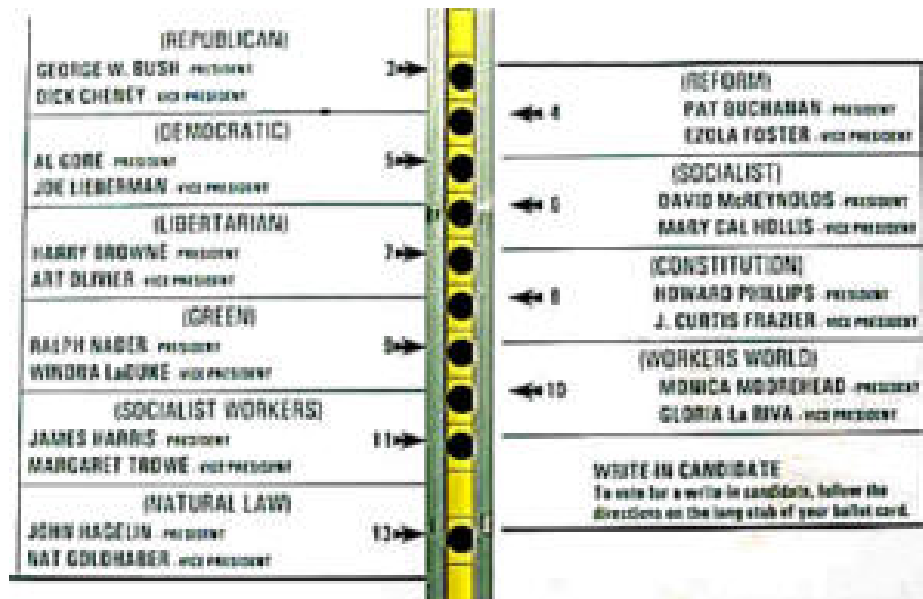
- Individuals' abilities to vote accurately
- Candidates selected
- Completion of the ballot
- Outcomes of some close elections
- Trust, confidence, and satisfaction with elections
- Opinions about the legitimacy of government

Voting Systems: Minimal Requirements

- **Enable voters to accurately register their voting intentions**
- **Accurately record votes**
- Accurately count votes
- Prevent coercion or vote tampering

Ballot Design Matters

The “Butterfly Ballot” used in Palm Beach County, Florida



Voting Technology Matters

- Votomatic Vote III
 - Used in Palm Beach County, Florida in 2000
- Punch card systems used by 28% of voters in 2000



Poor Design Can Lead to Big Problems

- Is this chad...
Pregnant?
Dimpled?
Hanging?
- For whom did this person mean to vote?
Actually vote?



Florida canvassing board member Judge Robert Rosenberg.
Source: Alan Diaz – Associated Press

Overall Study Objectives

- Test the usability and accuracy of existing voting technology and ballots
- Create and test the usability and accuracy of new voting technologies
- Assess the responses of different population groups
- Develop recommendations

Selected Collaborations

- **Governmental**
 - Federal Election Commission
 - Board of Elections, State of Maryland
 - Board of Elections, Prince Georges County, Maryland
 - National Institute of Standards and Technology
- **Voting System Manufacturers**
 - Avante
 - Diebold
 - ES&S
 - Hart InterCivic
 - Nedap

This is NOT a Consumer Report

- Not all voting systems were tested
- Not all features were assessed
- Not evaluate:
 - Security
 - Affordability
 - Durability
 - Transportability
 - Disabled voters

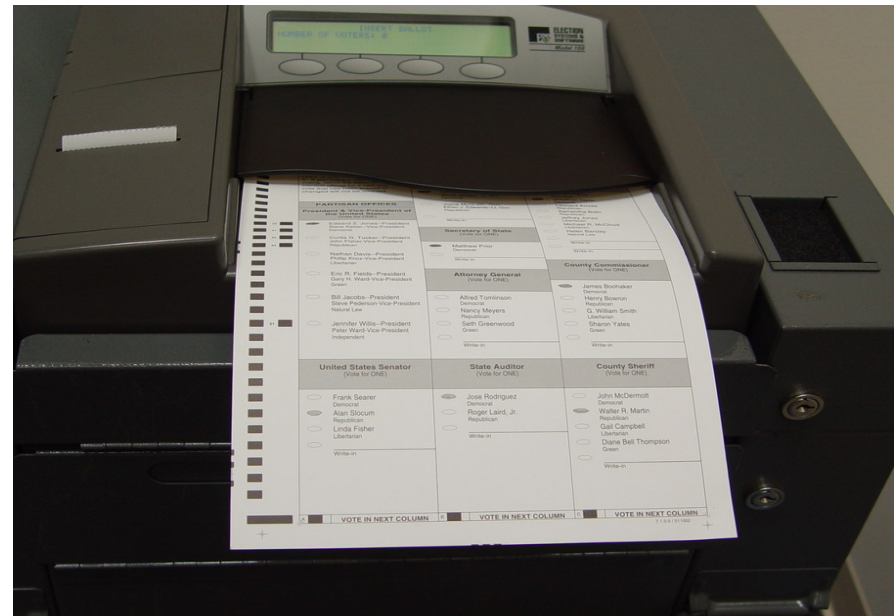
Voting Systems

- **Selected to illustrate specific design principles**

ES&S Model 100

System Type:

- Paper ballot/optical scan
- Intake similar to a fax machine
- Warnings for overvotes
- No warning for undervotes
- Can cast a flawed ballot



Diebold AccuVote-TS

System Type:

- Touch screen
- Smart card activation
- Manual navigation
- Ballot review
- Impossible to overvote
- Highlights undervotes



Avante Vote Trakker

System Type:

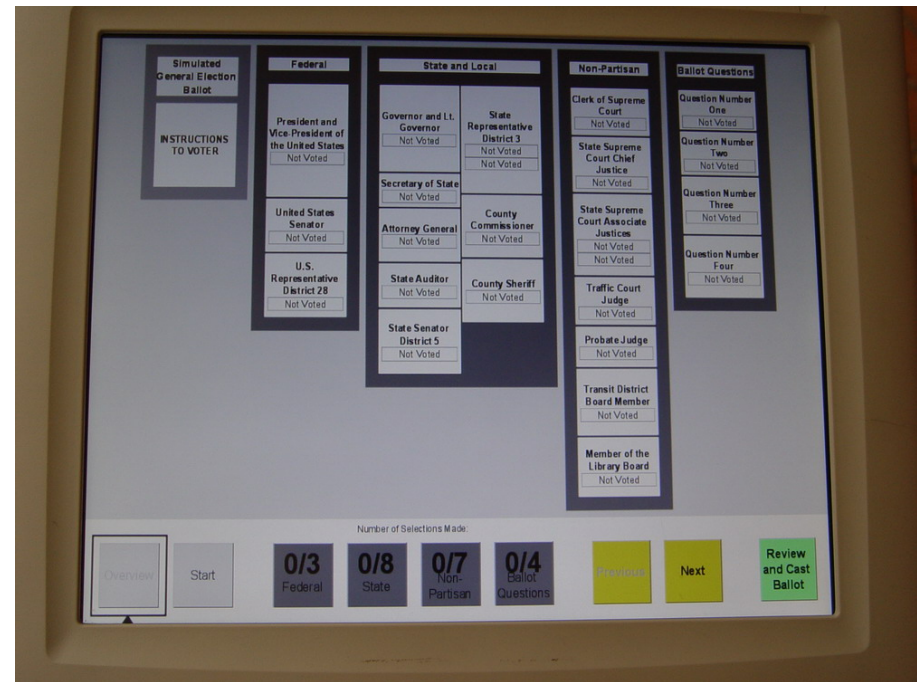
- Touch screen
- Automatic advance navigation
- Paper printout for verification
- Impossible to overvote
- Highlights undervotes



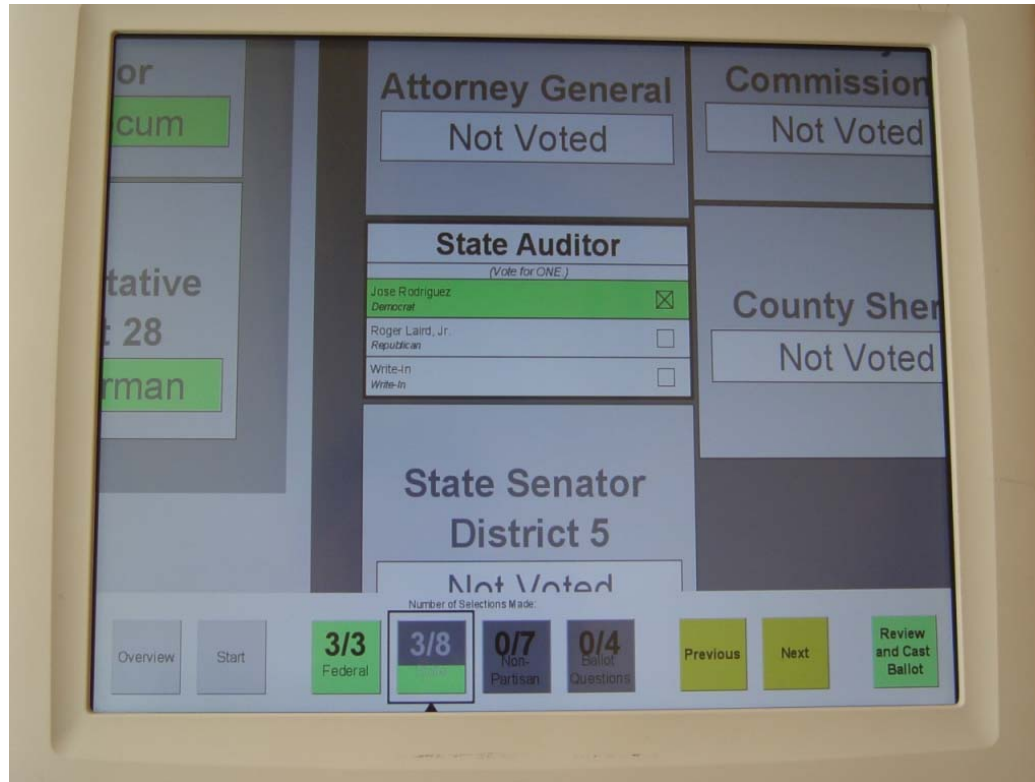
Zoomable Prototype

System Type:

- Zooming navigation
- Overview of full ballot
- Voting decisions replace names of offices
- Impossible to overvote
- Highlights undervotes
- Developed at the University of Maryland



Zooming in on One Election



Hart InterCivic eSlate

System Type:

- Mechanical buttons and dial for navigation and candidate selection
- Impossible to overvote
- Highlights undervotes



Nedap LibertyVote

System Type:

- Full-face voting system
- Membrane buttons to select candidates
- Blue lights indicate selections
- Impossible to overvote
- Warning for undervotes



Ballots

- **Selected to illustrate specific design principles**

Office Bloc Ballot

<p>INSTRUCTIONS TO VOTER</p> <p>1. To vote, completely blacken the CIRCLE (?) to the LEFT of the candidate. Do not vote for more than the authorized number of candidates.</p> <p>2. Use only the #2 pencil provided.</p> <p>3. To vote for a person whose name is not on the ballot, write in the candidate's name on the Write-In line AND completely blacken the CIRCLE (?) to the LEFT of your choice.</p> <p>4. If you make a mistake while voting, return the ballot to the election official for a new one. A vote that has been erased or changed will not be counted.</p>	<p>United States Senator (Vote for ONE.)</p> <p><input type="radio"/> Frank Searer Democrat</p> <p><input type="radio"/> Alan Slocum Republican</p> <p><input type="radio"/> Linda Fisher Libertarian</p> <p><input type="radio"/> _____ Write-In</p>	<p>State Auditor (Vote for ONE.)</p> <p><input type="radio"/> Jose Rodriguez Democrat</p> <p><input type="radio"/> Roger Laird, Jr. Republican</p> <p><input type="radio"/> _____ Write-In</p>	
	<p>U. S. Representative District 28 (Vote for ONE.)</p> <p><input type="radio"/> Larry Herman Democrat</p> <p><input type="radio"/> Rebecca Rehberg Republican</p> <p><input type="radio"/> William Petelos Natural Law</p> <p><input type="radio"/> _____ Write-In</p>	<p>State Senator District 5 (Vote for ONE.)</p> <p><input type="radio"/> Bill Forbes Democrat</p> <p><input type="radio"/> Victoria Snyder Republican</p> <p><input type="radio"/> Joseph A. Jackson Libertarian</p> <p><input type="radio"/> _____ Write-In</p>	
	<p>Governor & Lt. Governor (Vote for ONE.)</p> <p><input type="radio"/> Conrad Schweitzer--Gov. James Milligan--Lt. Gov. Democrat</p> <p><input type="radio"/> Joyce McGrath--Gov. Ethan J. Edwards--Lt. Gov. Republican</p> <p><input type="radio"/> _____ Write-In</p>	<p>State Representative District 3 (Vote for no more than TWO.)</p> <p><input type="radio"/> Cheryl Adams Democrat</p> <p><input type="radio"/> Jonathan Davic Democrat</p> <p><input type="radio"/> Leonard Arnold Republican</p> <p><input type="radio"/> Samantha Bolin Republican</p>	
	<p>Secretary of State (Vote for ONE.)</p> <p><input type="radio"/> Matthew Prior Democrat</p> <p><input type="radio"/> _____ Write-In</p>	<p><input type="radio"/> Jeffrey Jones Libertarian</p> <p><input type="radio"/> Michael R. McCloud Libertarian</p> <p><input type="radio"/> Helen Barclay Natural Law</p> <p><input type="radio"/> _____ Write-In</p>	
	<p>Attorney General</p> <p><input type="radio"/> _____ Write-In</p>	<p><input type="radio"/> _____ Write-In</p>	
	<p>PARTISAN OFFICES</p>		
	<p>President & Vice-President of the United States (Vote for ONE.)</p> <p><input type="radio"/> Edward Z. Jones--President Steve Kaiser--Vice-President Democrat</p> <p><input type="radio"/> Curtis G. Tucker--President John Fisher--Vice-President Republican</p> <p><input type="radio"/> Nathan Davis--President Phillip Knox--Vice-President Libertarian</p>		

Office Bloc Ballot with Straight-Party Voting Device

Straight-party device →

<p>INSTRUCTIONS TO VOTER</p> <p>1. To vote, completely blacken the CIRCLE (●) to the LEFT of the candidate. Do not vote for more than the authorized number of candidates.</p> <p>2. Use only the #2 pencil provided.</p> <p>3. To vote for a person whose name is not on the ballot, write in the candidate's name on the Write-In line AND completely blacken the CIRCLE (●) to the LEFT of your choice.</p> <p>4. If you make a mistake while voting, return the ballot to the election official for a new one. A vote that has been erased or changed will not be counted.</p> <p>5. To vote for every candidate of one party, blacken the CIRCLE (●) to the LEFT of the name of the party for which you wish to vote. To vote for non-partisan offices, blacken the CIRCLE (●) to the LEFT of the candidate for whom you wish to vote.</p>	<p>United States Senator (Vote for ONE.)</p> <p><input type="radio"/> Frank Searer Democrat</p> <p><input type="radio"/> Alan Slocum Republican</p> <p><input type="radio"/> Linda Fisher Libertarian</p> <p><input type="radio"/> _____ Write-In</p>	<p>State Auditor (Vote for ONE.)</p> <p><input type="radio"/> Jose Rodriguez Democrat</p> <p><input type="radio"/> Roger Laird, Jr. Republican</p> <p><input type="radio"/> _____ Write-In</p>	
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	<p>STRAIGHT PARTY VOTING</p> <p><input type="radio"/> Democratic Party</p> <p><input type="radio"/> Republican Party</p> <p><input type="radio"/> Libertarian Party</p> <p><input type="radio"/> Green Party</p> <p><input type="radio"/> Natural Law Party</p>	<p>Governor & Lt. Governor (Vote for ONE.)</p> <p><input type="radio"/> Conrad Schweitzer--Gov. James Milligan--Lt. Gov. Democrat</p> <p><input type="radio"/> Joyce McGrath--Gov. Ethan J. Edwards--Lt. Gov. Republican</p> <p><input type="radio"/> _____ Write-In</p>	<p>State Representative District 3 (Vote for no more than TWO.)</p> <p><input type="radio"/> Cheryl Adams Democrat</p> <p><input type="radio"/> Jonathan Davic Democrat</p> <p><input type="radio"/> Leonard Arnold Republican</p> <p><input type="radio"/> Samantha Bolin Republican</p> <p><input type="radio"/> Jeffrey Jones Libertarian</p> <p><input type="radio"/> Michael R. McCloud Libertarian</p>
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Party Column Ballot

INSTRUCTIONS TO VOTER

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Do not vote for more than the authorized number of candidates.
2. Use only the #2 pencil provided.
3. To vote for a person whose name is not on the ballot,
write in the candidate's name on the Write-In line
AND completely blacken the CIRCLE (●) to the LEFT of your choice.
4. If you make a mistake while voting, return the ballot
to the election official for a new one.
A vote that has been erased or changed will not be counted.

PARTISAN OFFICES

President & Vice-President of The United States (Vote for ONE.)

<input type="radio"/> Edward Z. Jones -- President Steve Kaiser -- Vice-President Democrat	<input type="radio"/> Curtis G. Tucker -- President John Fisher -- Vice-President Republican	<input type="radio"/> Nathan Davis -- President Phillip Knox -- Vice-President Libertarian
--	--	--

United States Senator (Vote for ONE.)

<input type="radio"/> Frank Searer Democrat	<input type="radio"/> Alan Slocum Republican	<input type="radio"/> Linda Fisher Libertarian
--	---	---

United States Representative District 28 (Vote for ONE.)

<input type="radio"/> Larry Herman Democrat	<input type="radio"/> Rebecca Rehberg Republican	
--	---	--

Research Approaches

- Review by human-computer interaction experts
- Laboratory tests @ 50 participants
- Natural experiments
- Field experiments @ 1,500 participants

Selected Voting Tasks

- Vote for candidates for 18 offices and 4 ballot questions
- Vote for more than two candidates in a multi-candidate election
- Change a vote

Experimental Procedures

- Complete cue sheet that lists votes they intend to cast
- Vote on system and fill out evaluation form for each system
- Complete questionnaire on demographics

Selected Dependent Variables

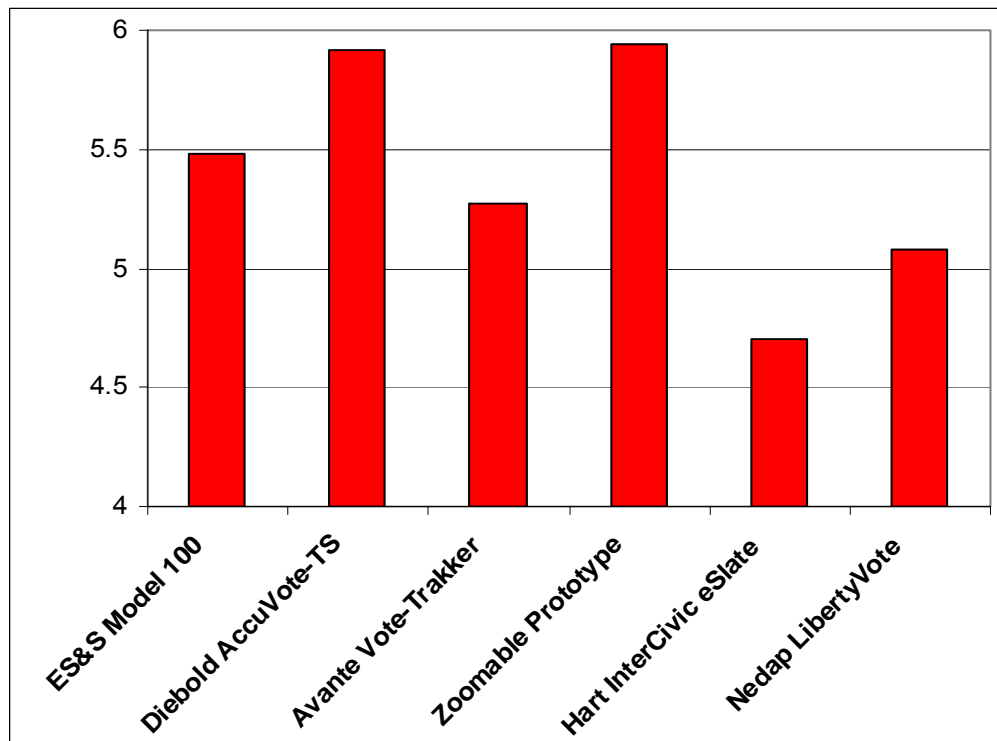
- Voter satisfaction
- Need for assistance
- Accuracy of votes cast

Voter Satisfaction

- Rate six systems from 1 to 7 (negative to positive)
 - Confident vote recorded accurately
 - Ease of use
 - Comfort
 - Characters easy to read
 - Ballot easy to understand
 - Correcting mistakes easy
 - Changing vote easy
 - Casting write-in vote easy
- Satisfaction Index (1 to 7)

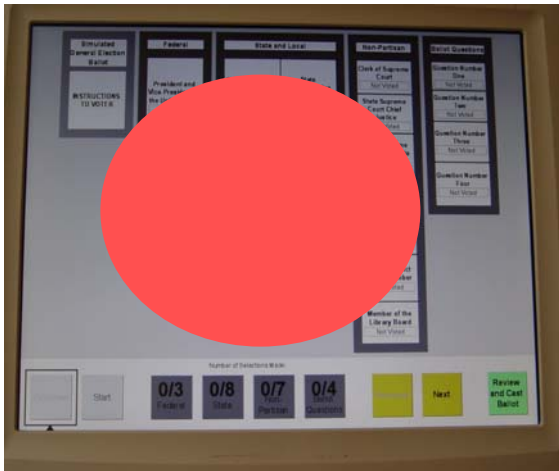
Findings for Voter Satisfaction

Average Satisfaction with each Voting System



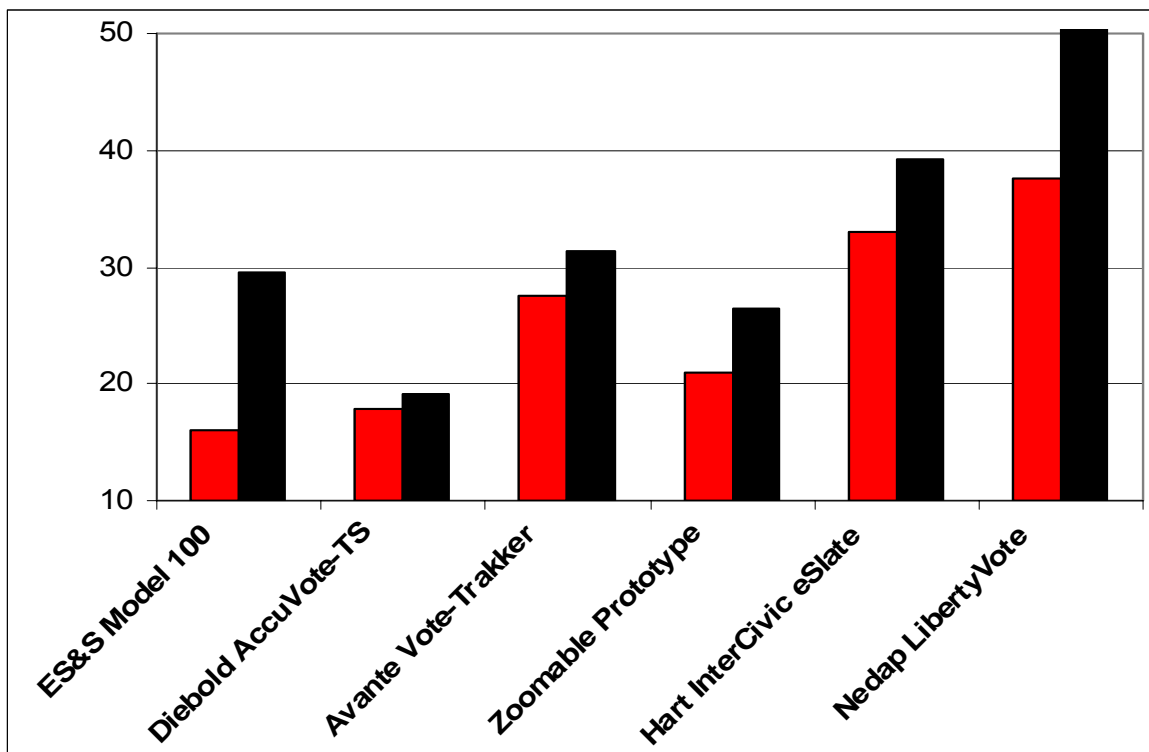
Notes: Based on a scale of 1 (least) to 7 (most) positive.

Features Criticized



Need for Assistance

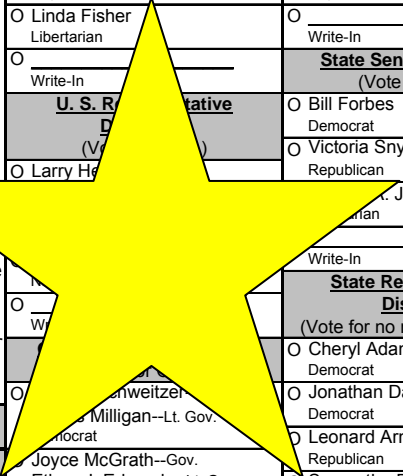
Did you feel the need to get help when using the machine?



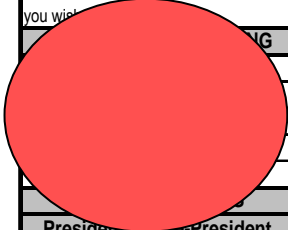
- Office bloc ballot
- Straight-party device (party column ballot for Nedap)

Note: Percent of voters report feeling the need for help.

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<input type="radio"/> Nathan Davis--President	<input type="radio"/> Phillip Knox--Vice-President	<input type="radio"/> Libertarian
Secretary of State (Vote for ONE.)		
<input type="radio"/> Matthew Prior	<input type="radio"/> Democrat	
<input type="radio"/> Write-In	<input type="radio"/> Write-In	
Attorney General		
<input type="radio"/> Write-In	<input type="radio"/> Write-In	



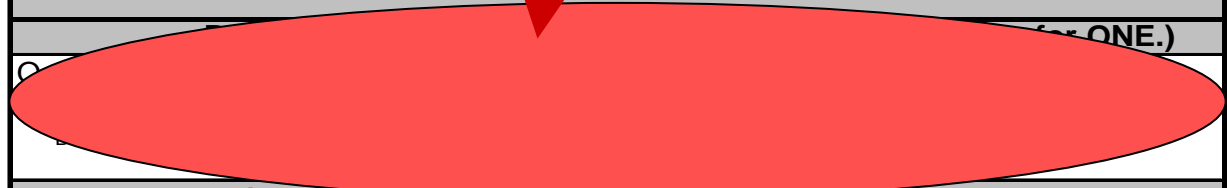
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<input type="radio"/> Rebecca Rehberg	<input type="radio"/> Republican	
<input type="radio"/> William Petelos	<input type="radio"/> Natural Law	
<input type="radio"/> Write-In	<input type="radio"/> Write-In	
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<input type="radio"/> Joyce McGrath--Gov.	<input type="radio"/> Republican	
<input type="radio"/> Ethan J. Edwards--Lt. Gov.	<input type="radio"/> Republican	
<input type="radio"/> Write-In	<input type="radio"/> Write-In	
Secretary of State (Vote for ONE.)		
<input type="radio"/> Matthew Prior	<input type="radio"/> Democrat	
<input type="radio"/> Write-In	<input type="radio"/> Write-In	
Attorney General		
<input type="radio"/> Write-In	<input type="radio"/> Write-In	



Sources of confusion



PARTISAN OFFICES		
United States Senator (Vote for ONE.)		
<input type="radio"/> Frank Searer	<input type="radio"/> Alan Slocum	<input type="radio"/> Linda Fisher
<input type="radio"/> Democrat	<input type="radio"/> Republican	<input type="radio"/> Libertarian
United States Representative District 28 (Vote for ONE.)		
<input type="radio"/> Larry Herman	<input type="radio"/> Rebecca Rehberg	
<input type="radio"/> Democrat	<input type="radio"/> Republican	



Least problematic



Accuracy Measures

- Correct Vote
 - Selection matches candidate indicated in booklet
- Types of errors
 - Vote incorrectly cast for the candidate listed before or after candidate in booklet (slip)
 - Vote cast for some other candidate
 - No vote cast
 - Write-in incorrectly cast

The Impact of Voting Systems on the Accuracy of Voting

<u>Office</u>	ES&S Model 100	Diebold AccuVote TS	Avante Vote Trakker	Zoomable Prototype	Hart InterCivic eSlate	Nedap Liberty Vote
<i>US President</i>	95.7	96.6	96.6	97.4	96.2	96.2
Vote for Two						
<i>State Rep. (1)</i>	95.0	97.0	94.6	97.5	88.6	94.1
<i>State Rep. (2)</i>	94.0	95.3	93.7	95.2	88.3	92.9
Change Vote						
<i>Probate Judge</i>	84.2	85.0	79.6	84.8	86.3	85.1

Multivariate Hypotheses

- Digital divide
 - Computer use, education, age, English as primary language, sex, race/ethnicity
- Previous voting experience
 - Voted previously
 - System voted on (touch screens, wheels and buttons, paper trails, etc.)
- Partisanship
 - Democrat, Republican, Independent, other
 - Strength of Partisanship
- Ballot Design
 - Office bloc, straight-party device (party column for Nedap)

Overview of Multivariate Findings

- All systems performed well
- Paper vs. Touch Screens
 - Voters just as confident votes were recorded accurately on touch screen systems
 - Paper ballots and paper receipts did not inspire more confidence or result in greater accuracy
- Office bloc ballots performed better regardless of voting system
 - Voter satisfaction
 - Need for help
 - Accuracy of votes cast

Voter Satisfaction

- Few variables consistently influence voter satisfaction across systems
- Some evidence of the digital divide
 - Frequent computer users preferred touch screens
 - Elderly disliked mechanical and zoomable interfaces
- Partisanship had no impact

Request for Help

- Significant evidence of the digital divide
 - Computer usage
 - Education
 - Age
 - English as primary language
 - Sex
- Partisanship had no impact

Accuracy of Voting

- Significant evidence of the digital divide
 - Computer usage
 - Education
 - Age
 - English as primary language
 - Sex
 - Race/ethnicity
- Strength of partisanship
- Prior voting experience had no impact

Impact of Study

- Voting system manufacturers have changed some aspects of their systems
 - Auto-advance
 - “Standard” ballot layout
 - Notification of undervotes
- Election officials purchase systems, design ballots, and deploy resources
- Others replicate research (Utah, NIST)

Conclusions

- Voting technology and ballot styles influence
 - Voter trust, confidence, & satisfaction in general
 - Need for assistance when voting
 - Accuracy with which votes are cast
- The way people cast their votes is important
 - Can influence some close elections
 - Influences confidence and faith in the political system

Research Team

- **Paul Herrnson**, PI, Center for American Politics and Citizenship, University of Maryland
- **Benjamin Bederson**, Center for Human-Computer Interaction, University of Maryland
- **Richard Niemi**, Department of Political Science, University of Rochester
- **Michael Hanmer**, Department of Government, Georgetown University
- **Frederick Conrad**, Survey Research Center, University of Michigan
- **Michael Traugott**, Center for Political Studies, Institute for Social Research, University of Michigan

For More Information

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Thank you!