



RICE

# How to Build an Undervoting Machine: Lessons from an Alternative Ballot Design

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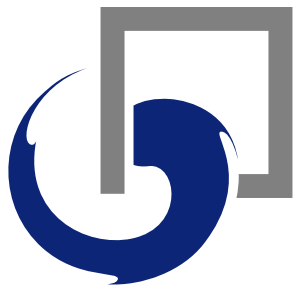
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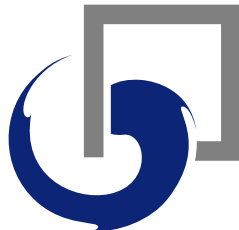
THE COMPUTER-HUMAN  
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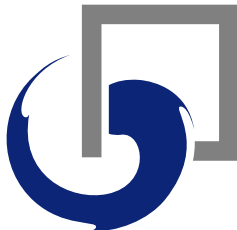
# Acknowledgements

- National Science Foundation
  - ACCURATE center
- Local election officials
  - Brazoria County, TX
  - Victoria County, TX



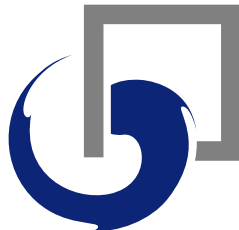
# Overview

- Research Aims
- Prior Research
- Method
- Results
- Discussion



# Why Electronic Voting Machines?

- Despite security concerns, there are several compelling reasons why DREs (direct recording electronic voting machines) remain an important research area
  - Potential for accessibility accommodations that traditional paper-based systems cannot offer
  - Opportunity to present ballots to voters in novel ways
    - + This space has not been systematically explored
    - + Need baseline data against which to evaluate emerging and future voting methods



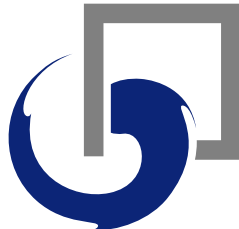
# Research Aims

- Widen the space of DRE design inquiry
  - How does changing the ballot navigation model impact usability?
- Explore the relationship between residual votes and true error rates through experimental work
  - Prior work (Campbell & Byrne, 2009a) found that while the overall average residual vote and true error rates may be similar, the variability in one is not mirrored by the other



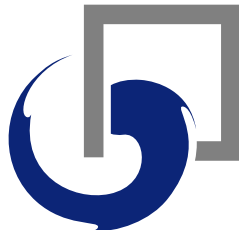
# Prior Research

- Our previous work is the only work we know of that directly assessed usability of older voting systems
- Key results from prior research:
  - Methods comparable in terms of efficiency
  - “Bubble” style paper ballots superior subjective usability relative to lever machines and punch cards
  - Error rates ranging from 1.5% to 5% per race
- Need research that directly compares typical DREs and older methods
  - Furthermore, how do novel design features (like navigation) of DREs affect performance—or do they?



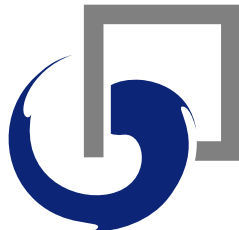
# Current Research

- Compared four voting systems:
  - DREs: sequential vs. direct access navigation
  - Paper ballots
  - Punch cards
  - Lever machines
- Used metrics from International Organization for Standardization (ISO):
  - Efficiency (time to cast ballot)
  - Effectiveness (errors)
  - Satisfaction (SUS, a subjective usability questionnaire)



# Method

- Participants
  - 64 paid volunteers (30 male, 34 female) from Houston area
  - Ages 18-77 years, mean age of 50.3 (SD = 14.8)
  - Diverse in terms of education, ethnicity, and income
- Primary independent variable: **DRE navigation style**
  - Half of participants voted with *direct access* DRE
  - Half of participants voted with *sequential* DRE
  - Each participant voted twice on assigned DRE





## Main Page: Make Your Choices

STEP 1  
Read Instructions

This is called the 'Main Page' screen. Below are all the races on the ballot. Click on the race you want to vote in. You will see a new page where you will make a choice. Then you will return to this page, where you will see the choices you have made.

If you would like to make changes, click on the race you would like to change. If you do not want to make changes, click the 'Next Page' button to go to Step 3.

**\*\*Your vote will not be recorded unless you finish Step 3.\*\***

You are now on  
STEP 2  
Make your choices

<b>President :</b>	GordonBearce	<b>Court of Criminal Appeals :</b>	None
<b>Vice President :</b>	NathanMaclean		
<b>United States Senator :</b>	FernBrzezinski	<b>District Attorney :</b>	None
<b>US House of Representative :</b>	RobertMettler	<b>County Treasurer :</b>	None
<b>Govenor of Texas :</b>	None	<b>Sheriff of Harris County :</b>	JasonValle
<b>Lt. Govenor of Texas :</b>	None	<b>County Tax Assessor :</b>	None
<b>Attorney General of Texas :</b>	Tim Speight	<b>Justice of the Peace :</b>	DeborahKamps
<b>Public Accountants:</b>	None	<b>County Judge :</b>	None
<b>General Land Office :</b>	Sam Saddler	<b>Proposition 1:</b>	No
<b>Comm.of Agriculture :</b>	None	<b>Proposition 2:</b>	Yes
<b>Railroad Commisioner:</b>	ZacharyMinick	<b>Proposition 3:</b>	None
<b>State Senator of Texas :</b>	WesleySteven Millette	<b>Proposition 4:</b>	Yes
<b>State Rep. of Texas :</b>	None	<b>Proposition 5:</b>	None
<b>State Board of Education :</b>	PeterVarga	<b>Proposition 6:</b>	No
<b>Texas Supreme Court :</b>	Tim Grasty		

STEP 3  
Record your vote

[Click to go back to instructions](#)

[Click to go to Step 3: Record your vote](#)

[← Previous Page](#)

[Next Page →](#)

STEP 1  
Read Instructions

You are now on  
STEP 2  
Make your choices

STEP 3  
Record your vote

## President and Vice President of the United States

To make your choice, click on the candidate's name or on the box next to his/her name. A green checkmark will appear next to your choice. If you want to change your choice, just click on a different candidate or box. When you are done, click the 'Return' button.

President and Vice President of the United States	
<i>(You may vote for one)</i>	
<input type="checkbox"/> Gordon Bearce Nathan Maclean	REP
<input type="checkbox"/> Vernon Stanley Albury Richard Rigby	DEM
<input checked="" type="checkbox"/> Janette Froman Chris Aponte	LIB

[Click to go back to 'Main Page'](#)

Return

## Record Vote

STEP 1  
Read Instructions

You can not make any changes once you click the 'Record Vote' button. When you click the button, your vote will be officially recorded.

If you want to make changes, click the 'Previous Page' button to go back to the Main Page.

STEP 2  
Make your choices

STEP 3  
Record your vote

Click to go back to Main Page.

[← Previous Page](#)

Click to record your vote

[Record Vote](#)

## President and Vice President of the United States

STEP 1  
Read Instructions

To make your choice, click on the candidate's name or on the box next to his/her name. A green checkmark will appear next to your choice. If you want to change your choice, just click on a different candidate or box.

You are now on  
STEP 2  
Make your choices

President and Vice President of the United States	
<i>(You may vote for one)</i>	
<input checked="" type="checkbox"/> Gordon Bearce Nathan Maclean	REP
<input type="checkbox"/> Vernon Stanley Albury Richard Rigby	DEM
<input type="checkbox"/> Janette Froman Chris Aponte	LIB

STEP 3  
Review your choices

STEP 4  
Record your vote

[Click to go back to instructions](#)

[Click to go foward to next race](#)

[← Previous Page](#)

[Next Page →](#)

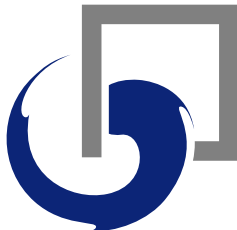
# Method

- **Non-DRE voting method**

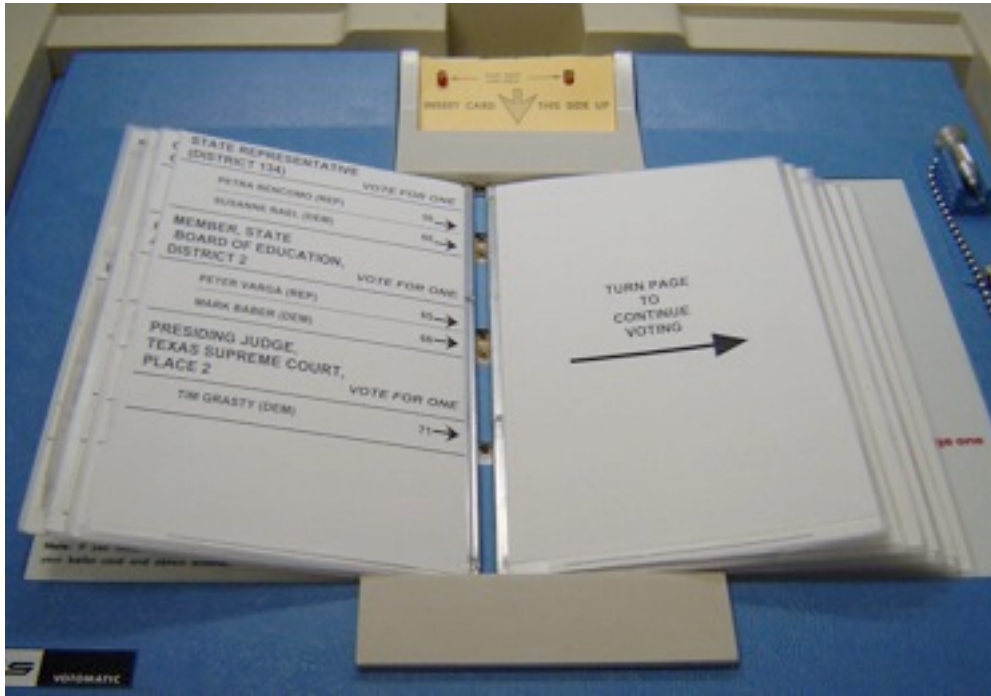
- In addition to voting twice on a DRE, each subject voted on one of three other non-DRE methods: *paper ballots*, *punch cards*, or *lever machines*

- **Information condition**

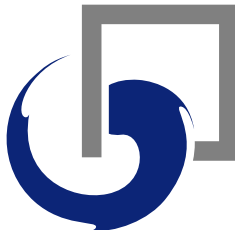
- *Undirected*: users given a “guide” and allowed to vote as they pleased
- *Directed*: users given a sheet, told who to vote for
  - + Directed with no roll-off, directed with moderate roll-off, directed with additional roll-off



# Non-DRE Voting Methods

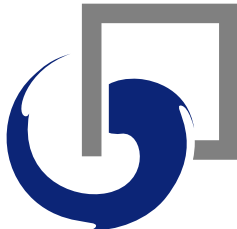


PRESIDENT AND VICE PRESIDENT		
PRESIDENT AND VICE PRESIDENT (Vote for One)		
<input type="radio"/>	Gordon Bearce Nathan Maclean	REP
<input type="radio"/>	Vernon Stanley Albury Richard Rigby	DEM
<input type="radio"/>	Janette Froman Chris Aponte	LIB



# Ballots

- Same ballot on all voting methods
- Entirely fictional candidates
- 21 offices
  - Choose one candidate per office
- 6 propositions
- See <http://chil.rice.edu/research/jets13/> for complete materials



# Error Measures

## ● **Extra vote error**

- A voter makes a selection for a race s/he had originally intended to skip

## ● **Omission (undervote) error**

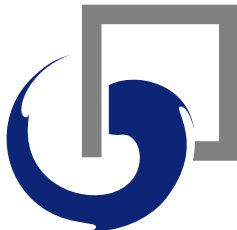
- A voter fails to choose a candidate for a race in which s/he had intended to vote

## ● **Wrong choice error**

- A voter makes a selection other than the one intended

## ● **Overvote error**

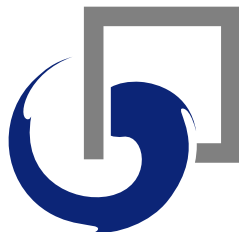
- A voter makes more than the allowed number of choices (paper or punchcard only)





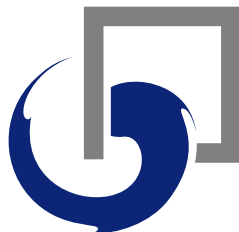
# Error Rates

	<b>Extra vote</b>	<b>Omission</b>	<b>Wrong choice</b>	<b>Total error</b>
<b>Sequential DRE</b>	0%	.2%	1.2%	1.3%
<b>Direct DRE</b>	.2%	13.1%	1.2%	14.5%
<b>Bubble ballot</b>	0%	.2%	.2%	.4%
<b>Lever machine</b>	0%	.6%	1.1%	1.7%
<b>Punch card</b>	0%	0%	.2%	.2%



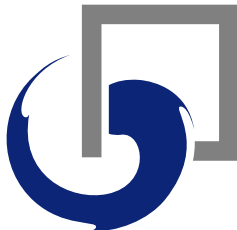
# Omission Errors

- Direct access DRE omission error rate significantly greater than sequential DRE
  - 8 of 32 people (25%) cast vote prematurely with direct access DRE
  - 0 of 32 did so with sequential DRE
- Postcompletion errors: “Fleeing voter” problem
  - 4 of 32 people (12.5%) failed to cast vote with direct access DRE
  - 2 of 32 people (6.3%) did so with sequential DRE



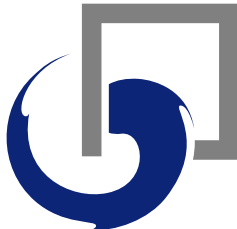
# Intentional Abstentions

- Undirected information condition only
- People using the direct access DRE voted in far fewer races
  - With direct access DRE, voters *abstained from nearly half of all races*: intentional abstention rate of 45.4%
  - With sequential DRE, voters *almost never abstained* from a race: intentional abstention rate of .7%
  - Those using the direct access DRE were therefore significantly faster
    - + Difference in overall ballot completion time only; per-race voting times similar between navigation types



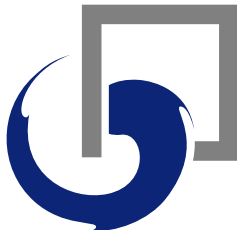
# The Residual Vote in Political Science

- The residual vote rate reflects the total number of votes for any given race that cannot be counted
- Historically used in Political Science field studies as an *indirect measure* of accuracy
- Comprised of overvote errors, omission errors, and intentional abstentions
- No information on wrong choice errors
- No differentiation between omission errors and intentional abstentions
- Requirements to report number of unrecorded votes vary by state

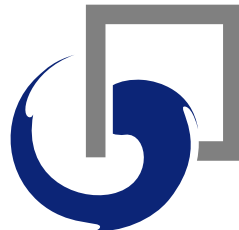
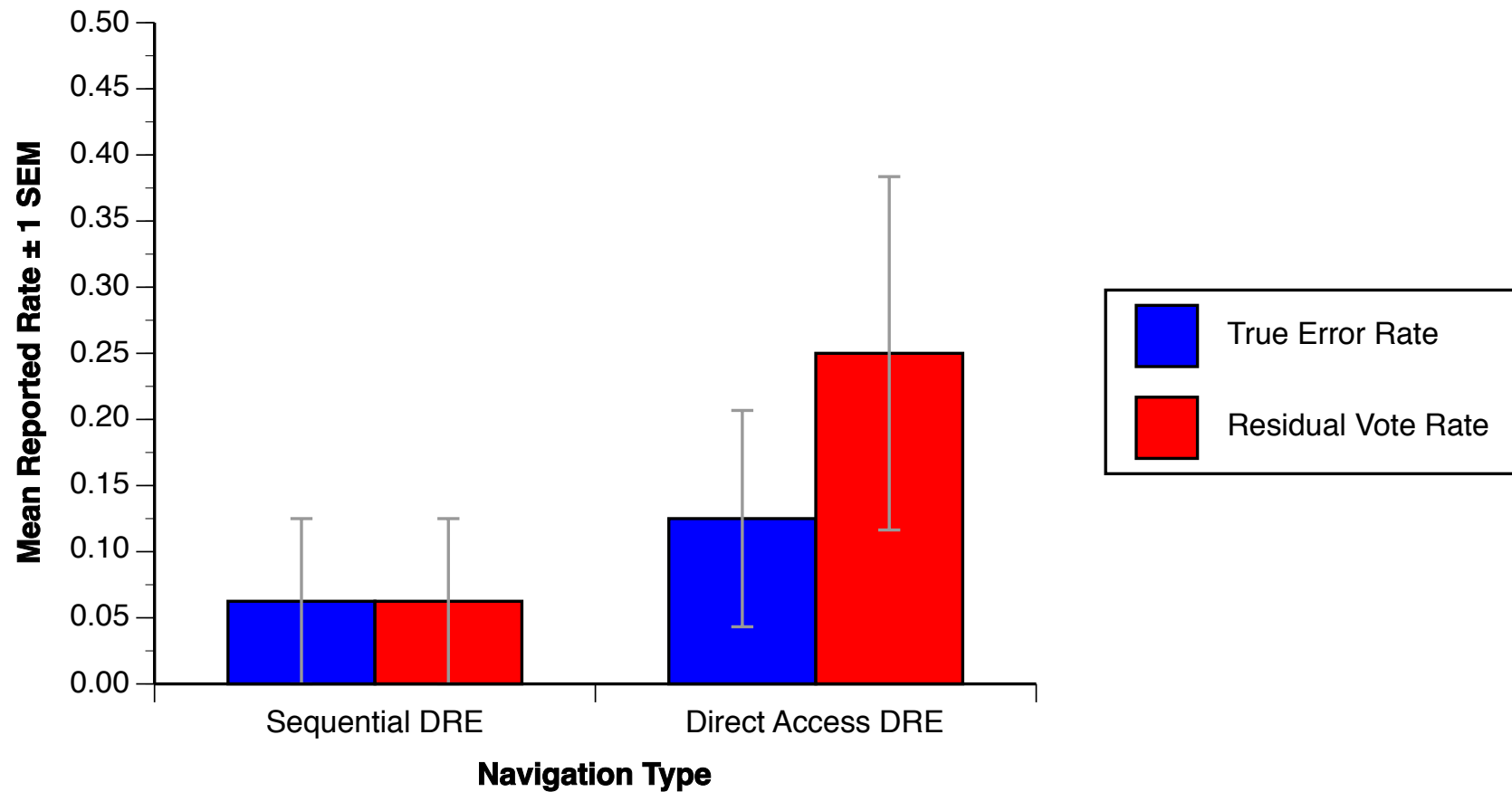


# How Accurate is the Residual Vote as a Measure of Voter Error?

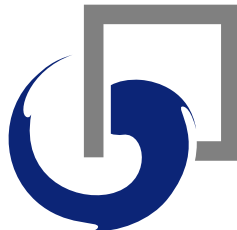
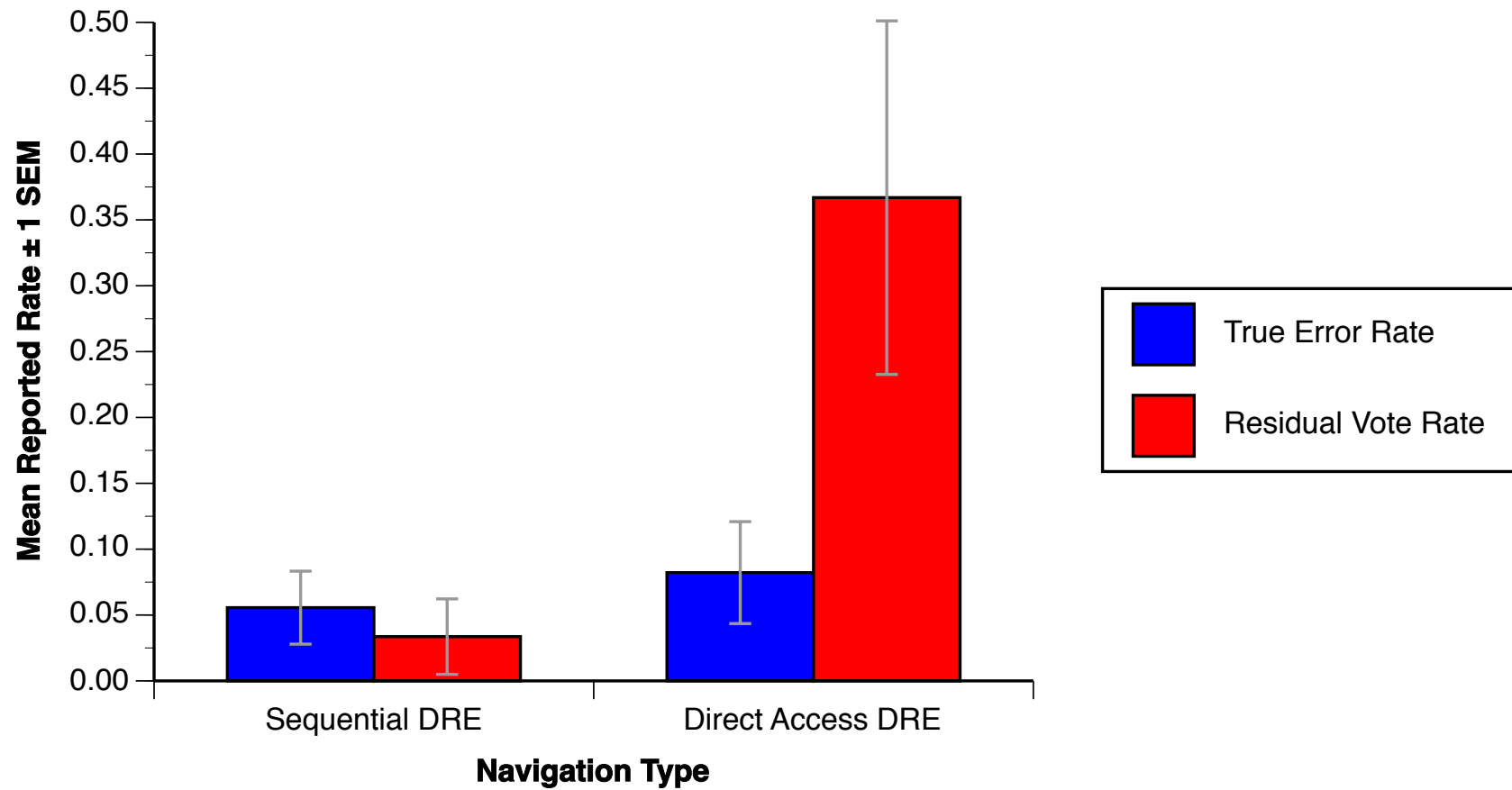
- Must know voter intent to answer this question
- Design of our experiment explicitly tracked this, providing a *direct measure* of accuracy
- How well does the true error rate correlate with what would have been reported as the residual vote?



# Top-Ballot (Presidential) Residual Votes vs. True Error Rates

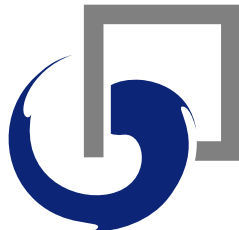


# Down-Ballot Residual Votes vs. True Error Rates



# Top-Ballot (Presidential) Residual Votes vs. True Error Rates

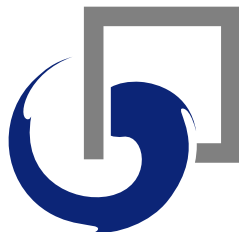
- Sequential navigation:
  - correlation between residual vote and true error rate was not significant,  $r(6) = -.14$ ,  $p = .74$ ,
  - nor was the difference in means,  $t(7) = 0.00$ ,  $p = 1.00$
- Direct access navigation:
  - correlation between residual vote and true error rate was not significant,  $r(6) = .41$ ,  $p = .32$ ,
  - nor was the difference in means,  $t(7) = 1.00$ ,  $p = .35$



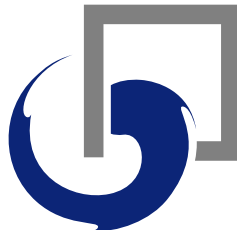
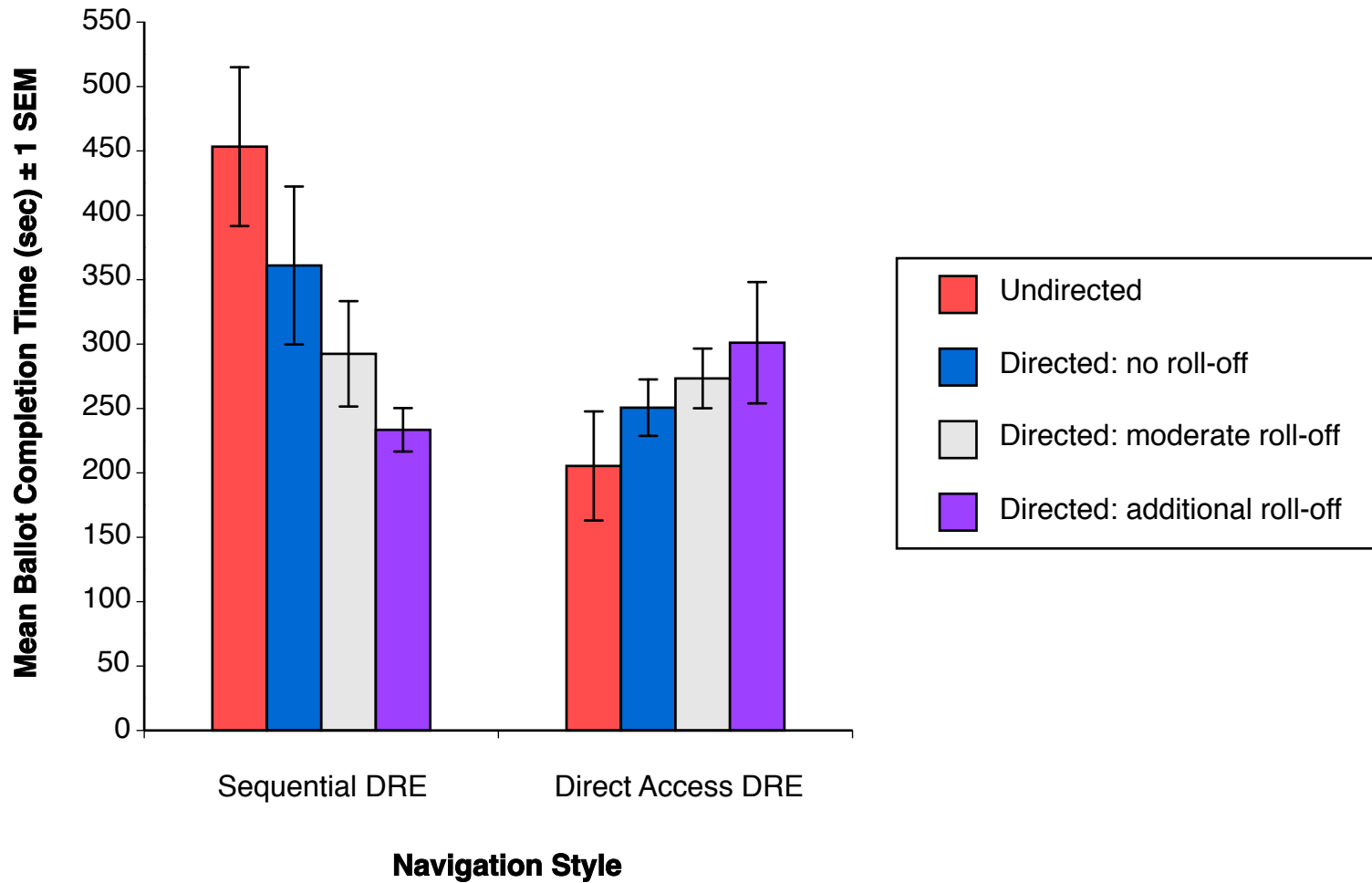


# Down-Ballot Residual Votes vs. True Error Rates

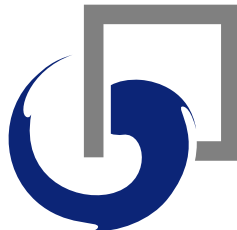
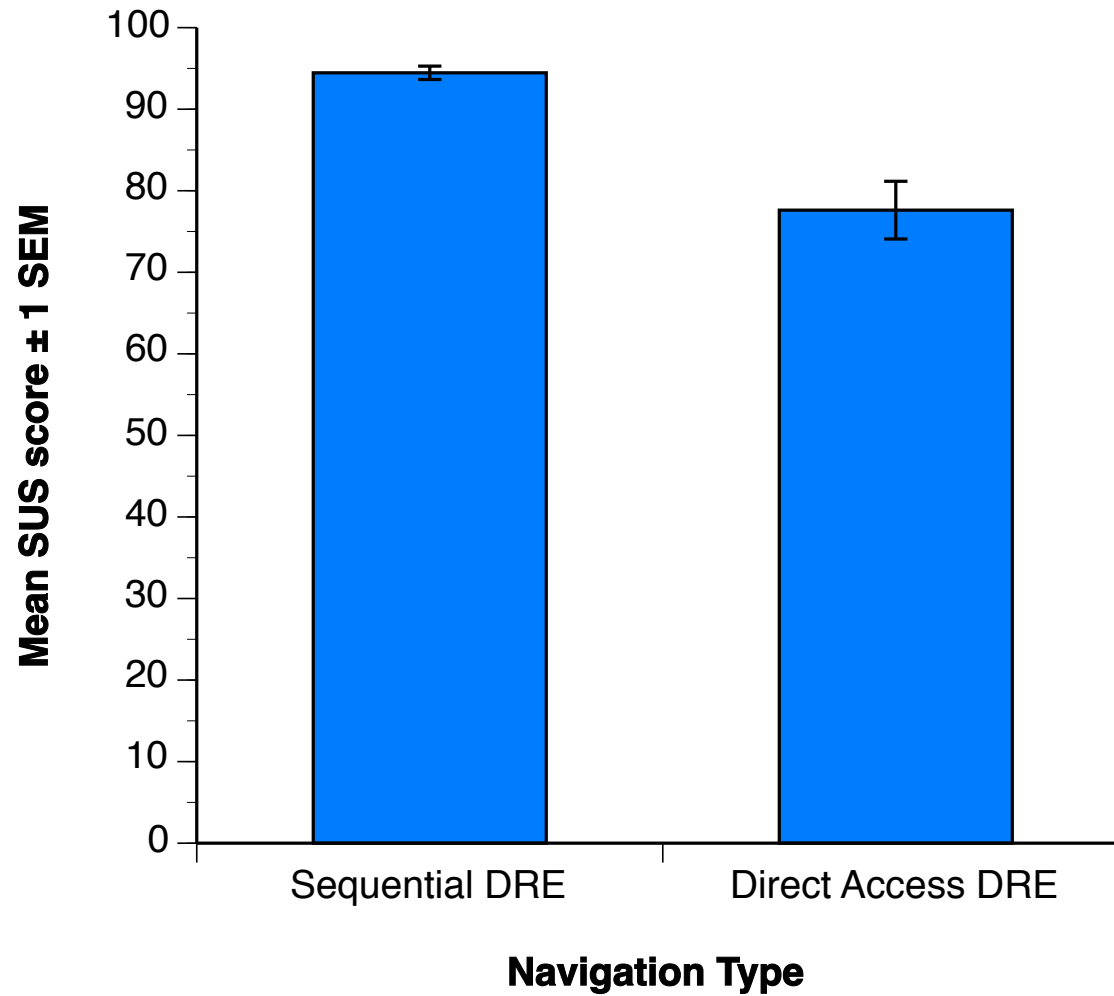
- Sequential navigation:
  - correlation between residual vote and true error rate was not significant,  $r(6) = .22, p = .60$
  - nor was the difference in means,  $t(7) = .43, p = .68$
- Direct access navigation:
  - correlation between residual vote and true error rate was not significant,  $r(6) = .16, p = .70$
  - nor was the difference in means,  $t(7) = 1.64, p = .15$
- Non-significant correlations suggest the residual vote may not be as tightly coupled to the true error rate as has often been assumed.



# Ballot Completion Times



# Satisfaction



# Discussion

- DREs were no better than traditional methods in terms of efficiency and effectiveness
- Manipulation of single design feature (navigation style) significantly impacted *both* subjective and objective usability
  - Best subjective usability ratings with sequential DRE
  - Direct access DRE faster and more error-prone than sequential DRE
  - Rate of intentional abstention much higher for direct DRE
  - New type of error seen with direct access DRE: voters cast ballot prematurely
  - Voters also failed to cast ballot entirely (“fleeing voter”)



# Discussion

- Consistent with (Campbell & Byrne, 2009a), our data indicate that residual vote rate may not be as tightly coupled to true error rate as has traditionally been assumed
- Mean error rate generated by both measures approximately the same
- As a tool to detect large-scale problems across many voters, residual vote rate is likely still a good tool
- Near-zero correlation at the ballot level warrants further research
  - Impossible to address during real elections, but feasible in laboratory environments



# Questions?

