ACT-R as a Usability Tool for Ballot Design

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Acknowledgments

- National Science Foundation
- ACCURATE Center
Overview

- Problem Basics
- Simple Model
- The Sarasota Problem
- Modeling Sarasota
- A Tool for Ballot Design
Depending on how you count, ACT-R is somewhere between 19 and 21 years old.

That means the 2012 Presidential election will be the first one in which ACT-R would be eligible to vote.

- Except in Chicago, where it’s been voting under the name ACT* for years.
The Backstory: Florida 2000
The Problem: Florida 2000

Confusion at Palm Beach County polls
Some Al Gore supporters may have mistakenly voted for Pat Buchanan because of the ballot’s design.

Although the Democrats are listed second in the column on the left, they are the third hole on the ballot.

Punching the second hole casts a vote for the Reform party.

Sun-Sentinel graphic
Maybe Voters Are the Problem?

Florida is ready for 2004

Fisher-Price Voting Device

If you can't vote with this you can't think enough to choose.

Choose Your Shape
Oh, those voters...
### Proposed 2004 Election Ballot For Palm Beach County, Florida

**Parties that had no trouble with the 2000 election ballot:**

<table>
<thead>
<tr>
<th>Party</th>
<th>Presidential Candidate</th>
<th>Vice-Presidential Candidate</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Republican</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(presidential candidate)</td>
<td>&gt;</td>
<td>O</td>
</tr>
<tr>
<td>(vice-presidential candidate)</td>
<td>&lt;</td>
<td></td>
</tr>
<tr>
<td><strong>Libertarian</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(presidential candidate)</td>
<td>&gt;</td>
<td>O</td>
</tr>
<tr>
<td>(vice-presidential candidate)</td>
<td>&lt;</td>
<td></td>
</tr>
<tr>
<td><strong>Green</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(presidential candidate)</td>
<td>&gt;</td>
<td>O</td>
</tr>
<tr>
<td>(vice-presidential candidate)</td>
<td>&lt;</td>
<td></td>
</tr>
<tr>
<td>** Socialist Worker**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(presidential candidate)</td>
<td>&gt;</td>
<td>O</td>
</tr>
<tr>
<td>(vice-presidential candidate)</td>
<td>&lt;</td>
<td></td>
</tr>
<tr>
<td><strong>Socialist</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(presidential candidate)</td>
<td>&gt;</td>
<td>O</td>
</tr>
<tr>
<td>(vice-presidential candidate)</td>
<td>&lt;</td>
<td></td>
</tr>
<tr>
<td><strong>Constitution</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(presidential candidate)</td>
<td>&gt;</td>
<td>O</td>
</tr>
<tr>
<td>(vice-presidential candidate)</td>
<td>&lt;</td>
<td></td>
</tr>
<tr>
<td><strong>Natural Law</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(presidential candidate)</td>
<td>&gt;</td>
<td>O</td>
</tr>
<tr>
<td>(vice-presidential candidate)</td>
<td>&lt;</td>
<td></td>
</tr>
<tr>
<td><strong>Workers World</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(presidential candidate)</td>
<td>&gt;</td>
<td>O</td>
</tr>
<tr>
<td>(vice-presidential candidate)</td>
<td>&lt;</td>
<td></td>
</tr>
<tr>
<td><strong>Write-in Candidate</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Follow directions on your ballot stub</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Parties that DID have trouble with the 2000 election ballot:**

<table>
<thead>
<tr>
<th>Party</th>
<th>Presidential Candidate</th>
<th>Vice-Presidential Candidate</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Democratic</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(presidential candidate)</td>
<td>&gt;</td>
<td>O</td>
</tr>
</tbody>
</table>

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ganns.com
DEMOCRATIC RECOMMENDATION FOR FLORIDA BALLOTS FOR THE ELDERLY:

AL GORE: ⭕

GEORGE W. BUSH: •
RALPH NADER: •
PAT BUCHANAN: •
HARRY BROWNE: •
Still More “Solutions”

Revised Florida Presidential Ballot

Directions: Using the provided crayon, please circle the picture of the person you want to vote for.

Please circle only one person.

A circle looks like 0

Al Gore

George Bush
Or Maybe Not?

Official Florida Presidential Ballot

Follow the arrow and punch the appropriate dot.

Bush

Buchanan

Gore

Nader
Punch Card UI in Real Life
Despite demonstrable security vulnerabilities

- There is no evidence that the outcome of any election has ever been decided by computer hackers
- Not that there would be

However, there is clear evidence that elections have been decided by usability failures

- Florida 2000 is only one of many examples
- Multiple “epic failures” have been documented
- Personal favorite: Sarasota in 2006, which we’ll get back to
Modeling Voting

Not worried about the decision about who to vote for
- That’s a Political Science problem

A simpler problem:
- How do people fill out the ballot?

Turns out even for this simple problem, the strategy space is substantial:
- Recall candidate name and search for that
- Read list of candidates and rely on recognition
- Use of parties

It’s almost certain that individual voters vary their strategies within a single ballot
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.

<table>
<thead>
<tr>
<th>President and Vice President of the United States (You may vote for one)</th>
</tr>
</thead>
<tbody>
<tr>
<td>□ Gordon Bearce</td>
</tr>
<tr>
<td>Nathan Maclean</td>
</tr>
<tr>
<td>□ Vernon Stanley Albury</td>
</tr>
<tr>
<td>Richard Rigby</td>
</tr>
<tr>
<td>□ Janette Froman</td>
</tr>
<tr>
<td>Chris Aponte</td>
</tr>
</tbody>
</table>

Click to go back to instructions  

[Previous Page]  

Click to go forward to next race  

[Next Page→]
Simple Model

This model

• Semi-random visual scan of candidates/parties
• Relies primarily on recognition of candidate names, but may also use parties

Demo time!

Interesting side note

• Model and voting UI implemented originally in MCL, but now running that code under ClozureCL/Cocoa
• Expect the release of a device for ClozureCL/Cocoa end of summer
  ❖ Including libraries to enable running old MCL code
Basic Voting Model

![Graph showing candidate selection time versus race number]

- **Race Number**
- **Candidate Selection Time (sec)**

Data points and model predictions are plotted, indicating a comparison between real data and the model's predictions.
The Sarasota Problem

- 2006 Congressional Election
- At the time, the most expensive non-presidential election ever
# CONGRESSIONAL

**UNITED STATES SENATOR**

*(Vote for One)*

<table>
<thead>
<tr>
<th>Candidate</th>
<th>Party</th>
</tr>
</thead>
<tbody>
<tr>
<td>Katherine Harris</td>
<td>REP</td>
</tr>
<tr>
<td>Bill Nelson</td>
<td>DEM</td>
</tr>
<tr>
<td>Floyd Ray Frazier</td>
<td>NPA</td>
</tr>
<tr>
<td>Belinda Noah</td>
<td>NPA</td>
</tr>
<tr>
<td>Brian Moore</td>
<td>NPA</td>
</tr>
<tr>
<td>Roy Tanner</td>
<td>NPA</td>
</tr>
<tr>
<td>Write-In</td>
<td></td>
</tr>
</tbody>
</table>

*Page 1 of 21  Public Count: 0*
**U.S. REPRESENTATIVE IN CONGRESS**  
**13TH CONGRESSIONAL DISTRICT**  
(Vote for One)

<table>
<thead>
<tr>
<th>Vern Buchanan</th>
<th>REP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Christine Jennings</td>
<td>DEM</td>
</tr>
</tbody>
</table>

**STATE**

**GOVERNOR AND LIEUTENANT GOVERNOR**  
(Vote for One)

<table>
<thead>
<tr>
<th>Charlie Crist</th>
<th>REP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jeff Kottkamp</td>
<td></td>
</tr>
<tr>
<td>Jim Davis</td>
<td>DEM</td>
</tr>
<tr>
<td>Daryl L. Jones</td>
<td></td>
</tr>
<tr>
<td>Max Linn</td>
<td>REF</td>
</tr>
<tr>
<td>Tom Macklin</td>
<td></td>
</tr>
<tr>
<td>Richard Paul Dembinsky</td>
<td>NPA</td>
</tr>
<tr>
<td>Dr. Joe Smith</td>
<td></td>
</tr>
<tr>
<td>John Wayne Smith</td>
<td>NPA</td>
</tr>
<tr>
<td>James J. Kearney</td>
<td></td>
</tr>
<tr>
<td>Karl C.C. Behm</td>
<td>NPA</td>
</tr>
<tr>
<td>Carol Castagnero</td>
<td></td>
</tr>
<tr>
<td>Write-In</td>
<td></td>
</tr>
</tbody>
</table>

Public Count: 0
Errors in Sarasota

- Not the most subtle problem ever, but missed by election officials

- So, how many votes in Sarasota were really lost?
  - “Residual vote” rate was approximately 14%
  - 18,413 votes lost. Margin of victory was 369 votes!

- What are residual votes?
  - Any difference between the number of voters who show up in the polls and the total votes cast in a race
  - Long-standing “coin of the realm” in Political Science

- Problematic measure, yes, but strong indicator of a problem
  - Rate for absentee ballots and in other counties in district was more like 2.5%
So What Happened?

The $64million question: Why did voters miss it?

Conducted an experiment that examined:

- Highlighting of race headers
  - No effect!
- Number of races on the first screen
  - Two races on first screen: 11% initial omission rate
  - Single race on first screen: 30% initial omission rate
- Note that most subjects self-corrected
  - In the actual election, most probably didn’t because of *intentional*
    ~200 ms lag in touchscreen response

But what’s the mechanism?
Modeling Sarasota

Model uses experience with initial screen to set expectations:

• When it’s time to go to the next screen
  ❖ That is, after making one selection

• Where to look for things
  ❖ Why start at the top if the top is just header stuff?

Demo #2 (if time)
This was a useful exercise; however

- We won’t significantly impact the problem with one-off post-hoc analyses
- Nor will 3,000 county clerks ever become HF experts

Need a tool that can automatically evaluate ballot layouts and identify potential problems

Sounds like a job for a model!

What would the model look like?
Ballot Layout Tool

- Need a way to make ballots visible to ACT-R
- Cover the strategy space
  - Cognitive strategies for candidate choice
  - Visual search strategies
  - Navigation strategies
- Cover the candidate choice space
  - Use polling to estimate proportions (don’t have to be perfect)
- Develop expectations based on experience with the ballot
- Need substantial Monte Carlo simulation across that space
- Challenging but would be a big win
  - Many potential applications outside of voting, too