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Mapping U.S. Elections: An Empirical Analysis of Design Techniques

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Introduction: Few maps receive more attention than those created for political issues like nationwide elections (Vujaković 2014). Though methods of cartographic representation are well-studied for broad use cases, recent research proposes more specific approaches for particularly complex map themes (see Fish (2020) for an example of empirical research on another common theme: environment and science). In this study, I evaluate cartographic techniques employed by American and international news organizations for the 2020 United States presidential election. Specifically, I examine three design choices: 1. *thematic map type* (choropleth, proportional symbol, block cartogram, area cartogram), 2. *colour saturation* (saturated, desaturated), and 3. *visual accenting* of swing states (accenting, no accenting). Based on this empirical study, I suggest thematic map type has an influence on user accuracy, speed, and reaction to election maps, important to political information visualization in American and international settings.

Background: In this study, I test user accuracy, speed, and reaction to three factors: *thematic map type*, *colour saturation*, and *visual accenting*.

Thematic map type: Most American presidential election maps represent the winner of each state and the number of electoral votes per state. Electoral votes can be represented using common thematic map types, often visualized along two axes: abrupt to smooth and discrete to continuous (MacEachren and DiBiase 1991). Each thematic map type has the power to evoke a visual metaphor based on the characteristics of the represented phenomenon. In this study I test choropleth maps, associated with governmental activity, and proportional symbol maps, associated with economic production (Kraak et al. 2020). I also test two cartograms (Roth et al. 2010): area cartograms, an early proposed technique for American elections (Gastner et al. 2005), and block cartograms, an emerging technique in industry.

Colour saturation: Colour saturation, the intensity of a single hue based on amount of grey present, can be used to encode information. However, the range of saturation levels is limited, and is more appropriate to enhance a map's style (Brewer 1994). Bold colours activate audiences (Roth 2021), and saturated colour schemes used in election mapping may lead to increased perception of partisanship (Rutchick 2009). Therefore, I test one saturated and one desaturated colour scheme.

Visual accenting: Visual attention strategies, used to raise elements of interest in the visual hierarchy, are an emerging design consideration in cartography, driven by visual storytelling (Roth 2021). For American election maps, highlighting may be used to emphasize swing states, considered important to election outcomes. Additionally, accenting may reduce complexity for audiences unfamiliar with the United States. In this study, I test map sets with and without visual accenting.

Methods: I use a 4x2x2 factorial design to evaluate 1. thematic map type, 2. colour saturation, and 3. visual accenting. Factor 1 was tested within groups, while Factors 2 and 3 were tested between groups. I recruited 240 participants through Amazon Mechanical Turk to capture demographic diversity within the United States voting age population.

Participants first received a training block to increase familiarity with the survey interface and question style. Next, users completed the experimental block consisting of 48 multiple choice questions, 12 per thematic map type. Questions were divided between elementary (single object) and general (overall distribution) tasks, as well as identify and compare tasks (Bertin 1967/2010). One question was displayed at a time, each evaluated for accuracy and speed. Following the experimental block, users received reaction questions to capture opinion and preference in addition to quantitative data (Song et al. in press). Last, users answered demographic and background questions.

I analysed responses using factorial ANOVA to consider the influence of the three factors on accuracy, speed, and reaction, and interaction effects between factors. For Factor 1, this analysis was followed by a Tukey HSD Test to determine significance between thematic map types.

Results: The results of this study suggest thematic map type produces significantly different results for accuracy, speed, and reaction in American presidential election maps (**Table 1**). Overall, block cartogram and choropleth maps produced the highest accuracy, compared to proportional symbol and area cartogram maps. For comparison questions, choropleth maps produced more accurate results, possibly because identification of multiple states is easier on geographically

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familiar maps. For general tasks, block cartograms produced more accurate results, with choropleth maps ranking worst for both accuracy and speed metrics. All three other thematic map types visually encode numeric information, while this information must be written on choropleth maps, creating issues for general tasks. Choropleth maps consistently ranked the highest for reaction questions, likely due to user familiarity.

Factor / Interactions		Elem+Id			Elem+Comp			Gen+Id			Total		
Descriptive Statistics	n		Mean	SD		Mean	SD		Mean	SD		Mean	SD
Total	960		81.7%	21.1%		84.1%	22.4%		81.3%	19.8%		82.4%	15.0%
Choropleth	240		92.2%	16.9%		92.3%	16.1%		74.7%	17.9%		86.4%	12.7%
Propor. Symbol	240		73.9%	19.7%		68.6%	24.5%		82.4%	20.2%		75.0%	14.9%
Blk. Cartogram	240		92.9%	15.9%		87.2%	20.8%		88.0%	18.4%		89.4%	14.6%
Area Cartogram	240		67.9%	19.2%		88.2%	19.7%		78.8%	20.2%		78.8%	13.4%
Saturated	480		80.9%	21.5%		83.9%	23.1%		81.9%	20.0%		82.2%	15.2%
Desaturated	480		82.5%	20.6%		84.3%	21.7%		80.8%	19.6%		82.5%	14.9%
Accenting	480		81.4%	21.7%		82.1%	23.0%		80.3%	20.8%		81.3%	16.0%
No Accenting	480		82.0%	20.5%		86.0%	21.6%		82.4%	18.6%		83.5%	13.9%
Factorial ANOVA	df	Mean Sq	F	p	Mean Sq	F	p	Mean Sq	F	p	Mean Sq	F	p
Map Type	3	62.38	120.93	0.00	42.56	64.28	0.00	11.68	19.98	0.00	153.11	55.78	0.00
Colour	1	0.94	1.82	0.18	0.08	0.13	0.72	0.46	0.79	0.38	0.34	0.12	0.73
Accenting	1	0.15	0.29	0.59	5.86	8.85	0.00	1.75	2.99	0.08	17.07	6.22	0.01
Residuals	947	0.52			0.66			0.56			2.74		

***Table 1**: Table displays* accuracy *descriptive statistics (top) and factorial ANOVA (bottom) for the three studied factors. Table includes results separated by question type and overall. Colour indicates significance: $p < 0.10$, $p < 0.05$, $p < 0.01$.*

Results for the other two factors were less straightforward. Visual accenting of swing states produced quicker responses but decreased accuracy. These results were strongest for comparison questions, suggesting some users read accented states as higher in value, and made quick, inaccurate judgements. Additionally, users preferred maps without accenting. However, accenting is best studied as a technique for interactive maps (Robinson 2011), and I tested static maps. Most election maps are interactive, indicating an opportunity for continued research. Colour saturation did not influence accuracy or speed, although users preferred saturated colours.

Overall, for reaction questions, users gave higher ratings to conventional design choices for American election maps (choropleth, no accenting, saturation). However, accuracy and speed results do not perfectly align with reaction results. Therefore, I suggest news organizations should provide flexibility in election maps, allowing users to explore multiple representations. However, many users will view only the default presentation. Block cartograms performed best overall and for general questions, and ranked second for preference questions. Therefore, news organizations should display block cartograms first for American presidential election maps. I also suggest continued research into election map design is necessary, particularly to test these design techniques with non-American audiences and for non-American elections.

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