Visual Storytelling with Maps:
Update and Outlook from an Empirical Study

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Introduction

Here, we present and reflect upon empirical research reported in Song, Roth, et al. {, 2022 #66} on the design of maps that support visual storytelling. In the following, we use *story* to describe an account of specific events, places, and people and *narrative* to describe the structure and presentation of this content that shapes the meaning of the story (Pearce 2008). Despite both scholarly and practical advancement in the history, application, and critique of narrative and story in cartography and related fields, there remains relatively limited empirical research on the intentional *design* of visual stories, particularly on map-based strategies and techniques, and the subsequent interpretation of these designs by their audience. We addressed this gap through an empirical study providing the first assessment of four design considerations for visual storytelling with maps: story map themes and their constituent narrative elements, visual storytelling genres, visual storytelling tropes, and individual audience differences.

Background

Themes & Narrative Elements: Vujaković {, 2014 #78: 15} characterizes seven "news maps" *themes* and 18 sub-themes that capture unique knowledge domains. Map-based visual stories covering very different themes can share similarities in their design if using the same narrative structure {Phillips, 2012 #91} and constituent *narrative elements*. We selected the case studies of *U.S. presidential campaign donations* and *U.S. coastal sea-level rise* to exemplify Vujakovic's "Politics, Internal" versus "Environment and Science" themes, two timely topics in American media outlets

Genres: a *genre* is a category of literature, music, or other form of artistic expression that exhibits similarity in structural and stylistic elements {see \Cartwright, 1999 #30 for the first reference to genres related to storytelling in cartography}. Roth {, 2021 #201} extended Segel & Heer {, 2010 #45} to identify seven visual storytelling genres that differ by the visual or interactive technique used to enforce continuity of elements in the narrative sequence. We

examined differences between two visual storytelling genres: *longform infographic*s and *dynamic slideshows*.

Tropes: *Tropes* are literary or rhetorical devices used to advance a story, much like a figure of speech {Smith, 1996 #148}. Roth {, 2021 #201} established seven visual storytelling tropes that capture a range of design techniques used not to represent information, but to advance the narrative and develop narrative elements. We narrowed into design techniques used to focus *attention* {a trope first described by \Gershon, 2001 #51} on important or unusual information that should not be missed by the audience. Specifically, we investigated differences between two visual attention strategies commonly used in cartography and information visualization {e.g.`, \Robinson, 2011 #165;Griffin, 2015 #202}: *leader lines* and *color highlighting*.

Individual Audience Differences: Visual stories are presented from a situated perspective and invite the audience to draw from personal backgrounds and experiences to derive meaning from the story {Pearce, 2014 #48}. We describe variable audience characteristics as *individual differences* and collected background on expertise, motivation, and prior beliefs on a number of topics related to visual storytelling to examine the influence of these differences on the visual story designs.

Method

We recruited 125 participants to an online map study using Amazon Mechanical Turk in March 2017. See Song, Roth, et al., {, 2022 #66} for deeper description of the recruitment process, and limitations therein, with Amazon Mechanical Turk.

The visual story content was constructed as a nine-panel sequence following the three-act narrative elements summarized in Roth {, 2021 #201} (Figure 1). The visual story designs then were modified following a 2x2x2 factorial design for the visual stories {Montello, 2012 #208}, varying themes (*U.S. presidential campaign donations, U.S. coastal sea-level rise*), genres (*longform infographic*, *dynamic slideshow*), and tropes (*color highlighting*, *leader lines*), while holding other design dimensions constant. Themes and tropes were assigned within subjects and genres were assigned between subjects, with each participant viewing two unique visual stories.

Participants responded to retention, comprehension, and reaction questions for each visual story. The retention page included 12 multiple choice questions built from benchmark map reading tasks {Roth, 2013 #211}. The comprehension page include a single, open-ended question to capture qualitative and potentially more meaningful engagement and interest with the visual story {after \Kosara, 2013 #32;Figueiras, 2014 #210}. The reaction page included a series of seven-point Likert scales on self-reported core affect, including audience arousal (activated vs. deactivated) and hedonic valence (pleasant vs. unpleasant) {Griffin, 2012 #62}, and additional interests and beliefs in the visual story.

We applied factorial ANOVA to assess the influence of the three factors on retention, comprehension, and reaction, as well as the pairwise interaction effects between factors to establish independence. We also used multiple linear regression (MLR) and ordinal linear regression (OLR) models to assess the influence of individual differences on retention,

comprehension, and reaction scales. Complete analyses are supplied in Song, Roth, et al. {, 2022 #66}, with key findings from this analysis reported below.
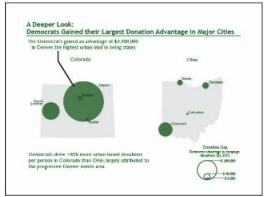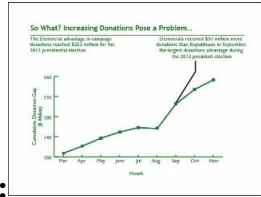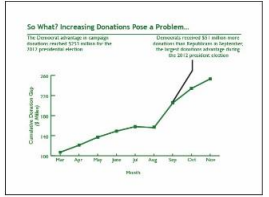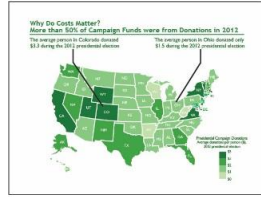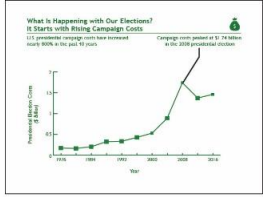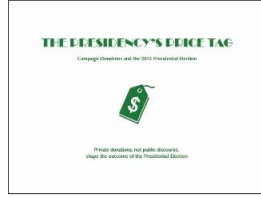
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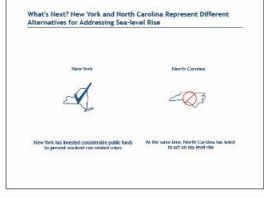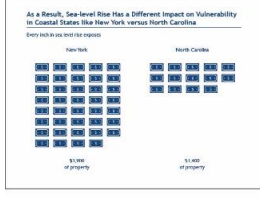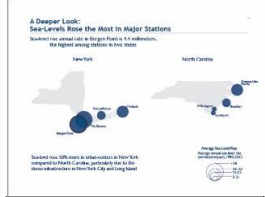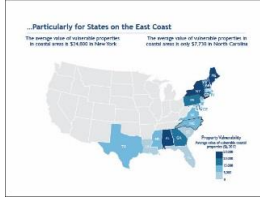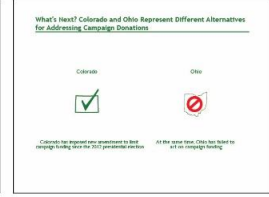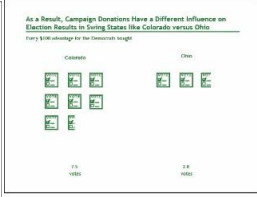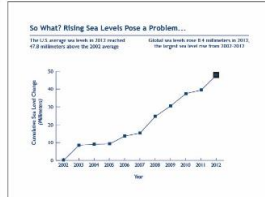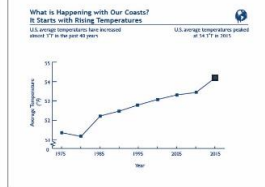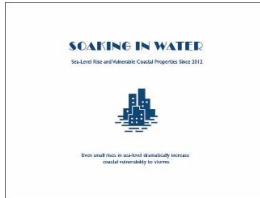
B:

Figure 1: Visual Story Design. Both visual story themes were designed as nine-panel sequences that could be presented as either a *longform infographic* or *dynamic slideshow*. **A:** The *U.S. presidential campaign donations* theme using *color highlighting*. **B:** The *U.S. sea level rise* theme using *leader lines*. High resolution versions of tested materials are available in Song, Roth, et al. {, 2022 #66}.

Results and Discussion

Themes & Narrative Elements: Story map themes did *not* significantly influence total retention or total comprehension, providing initial evidence that a three-act narrative and its constituent narrative elements can be applied consistently and effectively across visual story themes. This finding points to the need for establishing a research and education agenda on map-based visual storytelling in both cartography and data journalism, as the efficacy of some design decisions are based not on the story content, but on the intentional design of the narrative structure and presentation. Interestingly, participants discussed the spatial and temporal setting significantly more frequently for the *U.S. presidential campaign donations* and the cause more frequently for the *U.S. sea-level rise* story, potentially indicating that, while themes may not influence total comprehension, some individual narrative elements may be more or less germane to understanding a given visual story. In contrast, story themes did influence audience reaction, with participants feeling significantly more concerned about and upset with the *U.S. presidential campaign donations* story, and they ultimately agreed more with this story, perhaps because of the increased negative hedonic reaction.

Genres: *Longform infographics* outperformed *dynamic slideshows* for both retention and comprehension, although this difference was not significant for total comprehension. However, we did observe a significant difference in comprehension of the problem—or central confrontation, obstacle, or setback driving the story and therefore perhaps the most important narrative element of the story—with nearly all participants discussing the problem in their open-ended responses when viewing *longform infographics*. Taken together, *dynamic slideshows* exhibited the worst of both worlds, causing participants to forget specific information (total retention) *and*, for some, to miss the overall point of the visual story (problem comprehension). The poorer performance with *dynamic slideshows* likely is attributed to the manner by which the genre enforces continuity and doses information, as *longform infographics* enabled continuous scrolling at an audience-controlled pace, whereas *dynamic slideshows* discretely dosed information in a designer-controlled pace. While the genre had a weaker influence on reaction than the story theme, participants where more upset with stories presented as *dynamic slideshows*, potentially a reaction attributed more to the broken nature of the genre structure than the story content.

Tropes: Retention significantly improved when narrative elements were accented by *leader lines* instead of *color highlighting*. This difference by visual accenting technique extends Griffin and Robinson's (2015) recommendations for using leader lines for visual accenting across multiple representations, as *leader lines* are not just an alternative to *color highlighting* when using color elsewhere in design, but are a more salient focusing attention technique generally. The benefit of *leader lines* over *color highlighting* increased as the question difficulty grew, suggesting more salient visual accenting techniques are needed as task complexity increases. As with other

factors, there was not a significant difference in total comprehension between focus attention strategies. As with genres, tropes had a weaker influence on reaction than the story theme, but we did observe a significant difference in reported interest by tropes, with *leader lines* better focusing audience attention on important or unusual information in the story and avoiding distraction from other design elements or split attention with other tasks.

Individual Audience Differences: Familiarity with the internet and familiarity and interest with print versus online news sources most impacted retention. While familiarity and interest with online news sources remained influential on comprehension, prior beliefs that the topic is worthy of discussion also influenced comprehension. Notably, interaction effects regarding prior beliefs and comprehension were observed for the *U.S. sea-level rise* theme only, suggesting that the visual storytelling theme matters when considering individual differences. Whereas differences in genres and tropes designs directly influenced retention and comprehension—with some variability by individual differences—individual differences, *not* the visual story design, appeared to have a greater overall influence on participant reaction to the visual stories. Familiarity with maps and information graphics, familiarity with the theme, and prior beliefs that the theme was worth discussing particularly influenced participant reaction.

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References

Cartwright, W. 1999. Extending the map metaphor using web delivered multimedia. *International Journal of Geographical Information Science* 13 (4): 335-353.
Figueiras, A. 2014. How to tell stories using visualization. Paper read at *18th International Conference on Information Visualisation*.
Gershon, N., and W. Page. 2001. What storytelling can do for information visualization. *Communications of the ACM* 44 (8): 31-37.
Griffin, A., and J. McQuoid. 2012. At the intersection of maps and emotion: The challenge of spatially representing experience. *Kartographische Nachrichten* 62 (6): 291-299.
Griffin, A. L., and A. C. Robinson. 2015. Comparing color and leader line highlighting strategies in coordinated view geovisualizations. *IEEE Transactions on Visualization and Computer Graphics* 21 (3): 339-349.

Kosara, R., and J. Mackinlay. 2013. Storytelling: The next step for visualization. *Computer* 46 (5): 44-50.

Montello, D., and P. Sutton. 2012. *An Introduction to Scientific Research Methods in Geography and Environmental Studies*. Thousand Oaks: SAGE.

Pearce, M. W. 2014. The last piece is you. *The Cartographic Journal* 51 (2): 107-122.

Phillips, J. 2012. Storytelling in earth sciences: The eight basic plots. *Earth-Science Reviews* 115 (3): 153-162.

Robinson, A. C. 2011. Highlighting in geovisualization. *Cartography and Geographic Information Science* 38 (4): 373-383.

Roth, R. E. 2013. An empirically-derived taxonomy of interaction primitives for Interactive Cartography and Geovisualization. *Transactions on Visualization & Computer Graphics* 19 (12): 2356-2365.

———. 2021. Cartographic design as visual storytelling: Synthesis and review of map-based narratives, genres, and tropes. *The Cartographic Journal*. 58 (1): 83-114.

Segel, E., and J. Heer. 2010. Narrative visualization: Telling stories with data. *IEEE Transactions on Visualization and Computer Graphics* 16 (6): 1139-1148.

Smith, J. M. 1996. Geographical rhetoric: modes and tropes of appeal. *Annals of the association of American geographers* 86 (1): 1-20.

Song, Z., R. E. Roth, L. Houtman, T. Prestby, A. Iverson, and S. Gao. 2022. Visual storytelling with maps: An empirical study on story map themes and narrative structures, map-based storytelling genres and tropes, and individual audience differences. *Cartographic Perspectives* 100.

Vujaković, P. 2014. The State as a 'Power Container': The Role of News Media Cartography in Contemporary Geopolitical Discourse. *The Cartographic Journal* 51 (1): 11-24.