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AN EMPIRICAL INVESTIGATION OF INFORMATION AFFORDANCE IN WILDFIRE VISUALIZATION: COMPARING MAP-DESIGN AND DATA RESOLUTION SCALE

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BACKGROUND

Recent investigations in cognitive psychology and cartography have examined the communicative efficiency of animation and static small-multiple visualizations on knowledge construction and apprehension. According to the congruence principle, animation may be the most effective way to represent and apprehend dynamic geographic processes. Although some have suggested animations are often transient and can be overly complex and in turn, overload a reader's working memory. Others have demonstrated that small-multiples facilitate comprehension, inference and learning and afford map-readers interactive capabilities that are unavailable in most conventional animations.

OBJECTIVES

This research investigates inference affordances of animation and small-multiple maps in the context of wildfire visualization. Wildfire is a complex spatio-temporal, geographic phenomenon that threatens the safety of millions of people each year. Unfortunately, to date, most cartographic representations of wildfire fail to help people understand how and why fires spread over time. Our goal is to evaluate how design variables influence map-readers' abilities to apprehend information encoded within both small-multiples and animated displays of wildfire while utilizing a data set displayed at a coarse and fine resolution for each map type. We contend that all of these representational strategies are valid, each has its own particular strengths and weaknesses, and more specifically, each may support different kinds of map tasks better than the other.

METHODOLOGY

We report on the results of a human-subjects experiment used to compare two conditions: map type and data resolution. As a means to evaluate the conditional differences, we measure task accuracy, response time, confidence, and user preferences for each map type and data resolution. The stimuli consist of four maps, which include a fine resolution animation, fine resolution small-multiple map and a coarse resolution animation and a coarse resolution small-multiple map, each illustrating an identical wildfire event. The maps illustrate the hourly progression of a wildfire over a 31-hour period of time. The fine resolution maps contain scenes for all 31 perimeters, while the coarse resolution maps illustrate the dataset down sampled to 9 perimeters.

The maps were designed by adhering to the concepts of informational and computational equivalence. All four maps employ the same data, color scheme, and scale. The animation affords map-readers similar interactive opportunities as the small-multiples, including the ability to play and pause the animation, as well as select a specific scene to view. Participants are asked to view the displays on a computer and complete basic wildfire-related map tasks for each condition.

Fifty participants (25 females, 25 males) viewed the four maps in random order and answered 56 content questions during the test. To eliminate the possibility of a training effect, a random number table was used to generate two different versions of the map sequence. Half (12 females, 13 males) of the participants viewed one sequence, while the other half (13 females, 12 males) viewed a different sequence. Since each subject viewed each of the four maps 14 times, there were four versions of each question in order to avoid the possibility of participants remembering the answers. The alternate versions of the questions were structured the same way and contained the same level of difficulty, except they asked about a different location or time on the map. Test questions were either yes/no or true/false and were designed to evaluate the accuracy of a participant's response to a variety of map-tasks. The map-tasks included questions about polygon, point and line features, scale, and comparisons between scenes. The goal was to mimic the kinds of questions and map-tasks readers would have when viewing a wildfire map.

RESULTS

The preliminary results indicate that data resolution has more influence than the map type. The following table summarizes these preliminary results. Participants were most accurate (90.7%) with the fine resolution small-multiples and were most confident in their responses with both of the fine resolution maps

at 92.6%. Participants had the shortest response time with the coarse resolution small-multiple map with an average of 21.1 seconds per question. Further statistical analysis will be conducted to determine the significance of the design conditions.

	Accuracy	Confidence	Time (seconds)
Fine Resolution Animation	86.3%	92.6%	26.6
Coarse Resolution Animation	74.6%	75.4%	25.6
Fine Resolution Small-Multiples	90.7%	92.6%	22.6
Coarse Resolution Small-Multiples	79.3%	79.5%	21.1

Table 1. Preliminary results of participants Accuracy, Confidence, and Response Time.

CONCLUSION

We propose a research agenda with the intent of providing a better understanding of the apprehension and inference affordance of animation and small-multiple maps as well as the influence of data resolution, specifically in the context of wildfire visualizations. We hope to gain insight on map-readers' cognitive abilities, strategies, and preferences towards using animation and small-multiple maps to explore dynamic geographic processes. Empirical results will set a foundation for developing a consistent and efficient format for wildfire maps used in training and educational materials, as well as help cartographers determine when it may be most effective to use an animation or small-multiple map in their design, based on the resolution of a data set.