

A map alone or with a company? User study on redundancy in maps and other forms of data visualization

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Abstract:

A map is an essential medium for spatial data presentation. It is currently often supplemented with other forms of data visualizations, e.g. graphs, diagrams, or tables, designed as geodashboards or multiple views geovisual analytics tools. In solutions when multiple forms present the same input data, it might be considered as repeating information to some extent, therefore interpreted as redundancy. Redundancy has been long debated and considered as a solution increasing visual complexity and cognitive load, but also has positive aspects. It has been indicated that various forms of data presentation emphasize different aspects of presented data, therefore support users differently. Empirical evaluations of tools with multiple forms applied rather basic tasks like retrieving values or comparing entities, whereas tasks requiring multiple analyses and calculations were not often involved. Moreover, redundancy was empirically evaluated in terms of applying multiple visual variables to show the same data on a single map (e.g. value and size) compared to using one visual variable or to investigate the process of users' work with geodashboards showing the same data in the linked views.

The reported here study aims to fill this gap in comparing the effect of using a single map (SM) and a map accompanied with other forms of data presentation showing the same data (i.e. many forms – MF) with a focus on task difficulty. The study was conducted to investigate the effect of redundancy, expressed through the duplication of information via various data presentation forms, i.e. comparing the effect of using a thematic map presented alone (SM) and a map accompanied with three other forms of the same data presentation (MF), namely a table, a graph and a text (Figure 1). Participants solved three tasks requiring analysis of multiple attributes of increasing complexity in terms of required operations: analysis of temporal changes, finding extremes in the selected scope of data, and recalculating values of quantitative data.

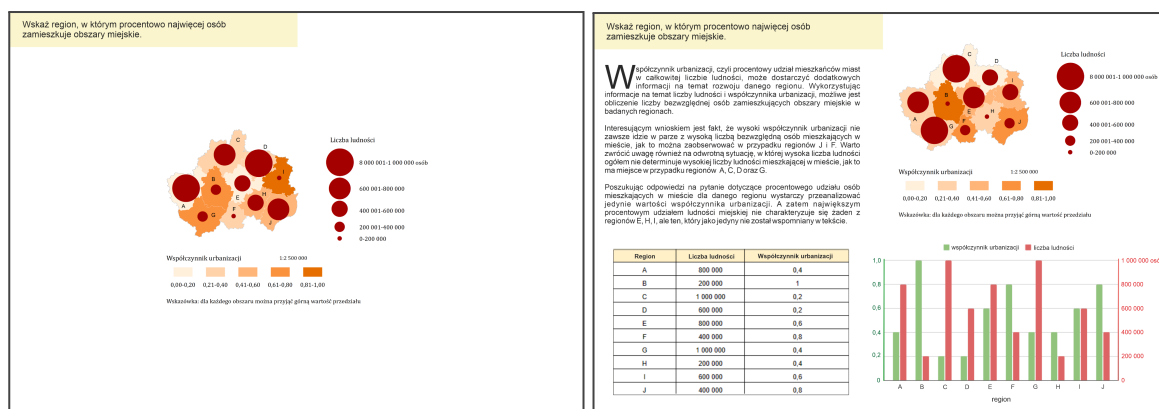


Figure 1. Tested materials: a single map (SM) and multiple forms (MF) presenting the same data.

The within-subjects study design was applied with redundancy as an independent variable, whereas usability performance metrics and eye tracking metrics were applied as dependent variables. Forty-one undergraduate students of geography or spatial management at the Faculty of Geography and Regional Studies, University of Warsaw took voluntarily part in the study.

The results showed a twofold effect of redundancy on usability performance metrics. Participants had statistically longer response times while using MF rather than SM. Whereas in terms of the answer correctness and rating of task difficulty, the complexity of the solved task moderated the effect of redundancy. When the task was simple (i.e. task 1), MF resulted in statistically higher response accuracy than SM. Conversely, for more difficult tasks (i.e. task 3), MF was perceived as more challenging and resulted in statistically lower answer correctness than SM. The results support the outcome of the study by Matsukawa et al. (2009) indicating the existence of factors influencing a perception of redundant content, e.g. the type of content presented, the context and the individual characteristics of users. Moreover, eye tracking data also showed the difference in visual attention between users of SM and MF. MF resulted in statistically longer total and average fixations durations, as well as a number of fixations compared to SM. At the same time, the same eye tracking metrics were statistically lower for the map AOI in MF and map in SM, showing that users of MF take advantage of other available visualization forms.

Among the four analyzed presentation forms, text was the least frequently chosen form for finding the answer, similar to the study by Liu et al. (2011). The other visualization forms brought the participants' attention differently depending on the task type, supporting the results of previous studies: when tested visualization types separately (Koua et al. 2007) or visible at once as visual analytics tools (Edsall 2003, Gołębiowska et al. 2016).

This study confirms that redundancy in data presentation differentially impacts the user's perception of the map and the efficiency of information acquisition, underscoring the need for further research into optimizing the design of various presentation forms.

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