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Can multivariate maps be effective and easy to read? About map users' preferences

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Abstract:

The presentation of multiple data sets simultaneously allows the user to infer a given phenomenon in the context of other issues presented. Combining cartographic representations on a single map is supposed to increase the informativeness of the map (Dent, Torguson & Hodler 2009; Huber et al. 2007; Nelson 2020) and to make it easier for the user to see new features and information about the presented phenomena. Provided with this kind of map, a user can compare the presented phenomena; look for relations between them, as well as interrelationships (Slocum et al. 2022; Kraak et al. 2020), coexistence (positive correlation) or exclusion of phenomena (negative correlation). One can also analyse different features of a phenomenon (phenomenon structure) or its changes over time (phenomenon dynamics).

Combining information can be applied for various kinds of data: qualitative, ordinal as well as quantitative. Qualitative information can be presented using symbols with multiple variables or features shown simultaneously, such as Chernoff's faces (Chernoff 1973). Combining cartographic representations to show information at the ordinal level can be implemented by using two ordinal choropleth methods, a choropleth method and proportional or graduated symbols, or two diagrams. Quantitative data can be shown by combining the choropleth method, proportional or graduated symbols, and the dot method. It is also possible to combine cartographic representations expressed using different levels of measurement, further expanding the set of results (Šašinka et al. 2019, 2021, Stachoň et al. 2023).

Considering the fact that multivariate maps are a challenge, both for a user (Nelson 2020; Korycka-Skorupa, Nowacki 2019), previously conducted user studies on multivariate maps mostly involved experienced users, e.g. cartographers or graduated experts in geodomain (Korycka-Skorupa, Gołębiowska 2021). However, less qualified and less experienced users were seldom included in evaluation of multivariate thematic maps. It is worth looking closely at the readability of multivariate maps by non-cartographers, and consider conditions of presenting more than two data sets at different measurement levels, using different cartographic representations (qualitative, ordinal and quantitative data).

The overarching **research question** is:

Does the use of multivariate maps facilitate the search for relationships between the phenomena presented for non-professional map users?

Is this related to the type of task, the cartographic representation, level of data measurement or the number of data sets presented on the map?

In the reported study there have been compared the effect between using qualitative information in the background and qualitative (map A & B) or quantitative (map C & D) thematic information, presenting the different number of thematic data sets (one on map A & C and two on maps B & D) (Figure 1) applied as independent variables. The following data have been measured as dependent variables: response time, response accuracy, subjective rating on graphical complexity, information complexity, readability, preferences as well as eye tracking metrics, namely: total fixation time, fixation count, number of saccades, time and place of first fixation.

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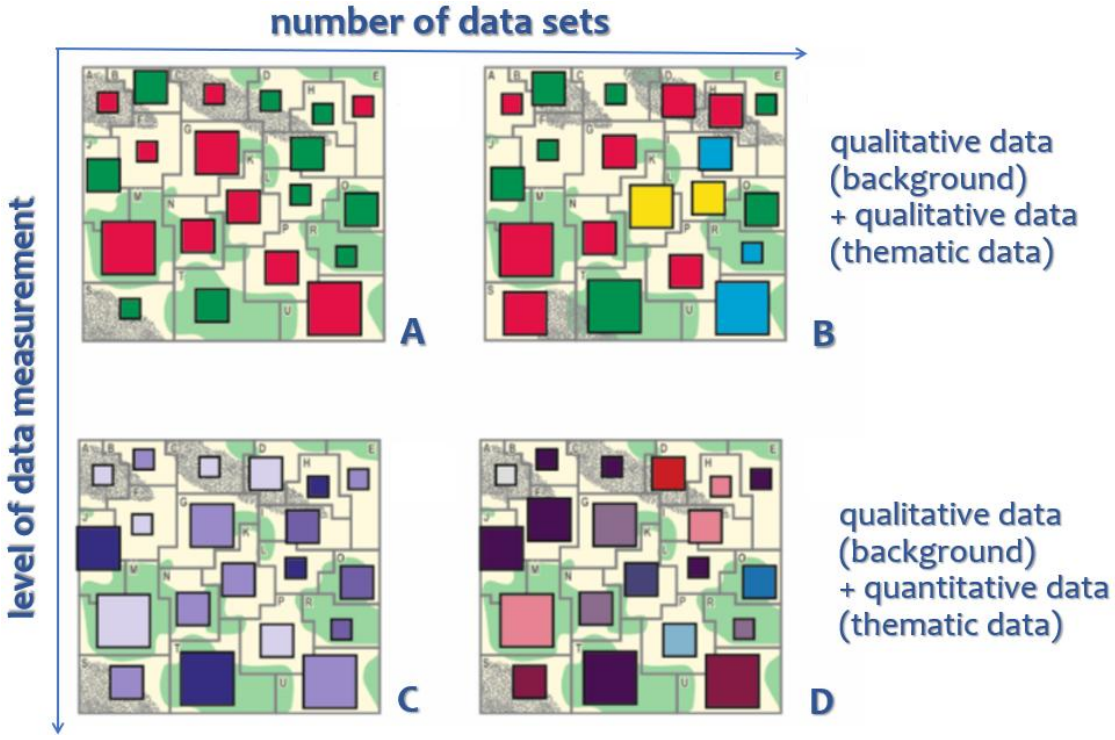

Figure 1. Examples of maps tested in the study. Source: own elaboration.

The research study was conducted on a group of 42 undergraduate students at University of Warsaw. The initial results showed that non-cartographers prefer maps with simple graphics and simple legends. They prefer the presentation of one data set using one cartographic representation as well as comparing tasks rather than identifying data or looking for relations.

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