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How do experts and novices read thematic maps? – An eye-tracking and EEG study

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Abstract:

Understanding how our brain interacts with maps is a long-standing scientific challenge for cartography and cognitive science. A better understanding of map users' behaviours and cognitive processes will also help to design better and more usable maps. Existing research on map cognition mainly focuses on the overt aspects of map users' cognitive processes, using eye-tracking and other conventional empirical methods. However, covert aspects (e.g., neuronal activities) of the cognitive processes, which are not visible from outside and need to be investigated using brain imaging techniques like electroencephalogram (EEG) and Functional magnetic resonance imaging (fMRI), are largely ignored in map cognition research.

Via a user experiment, this study aims to empirically compare the cognitive processes of experts and novices when solving various thematic map tasks, employing an integrated research approach with eye-tracking and EEG. Specifically, we will address the following two research questions:

- RQ1: How do expert map users' cognitive processes when solving tasks on thematic maps differ from those of novice map users, as reflected in their eye movements and neural activities (EEG)?
- RQ2: How does the level of task difficulties influence expert and novice map user's cognitive processes?

To answer these questions, a user experiment with a 2x2 factorial design is implemented, using two independent variables (i.e., factors): two levels of cartographic expertise (expert – people with cartographic training vs. novices – people without cartographic training) and two levels of task difficulties (easy – involving univariate thematic maps vs. difficult – involving bivariate thematic maps). For the level of expertise, a between-subject design is applied, while for the task difficulties, a within-subject design is employed. More specifically, a group of participants, consisting of 50% experts and 50% novices, are recruited to solve a set of 40 tasks on thematic maps, including 20 univariate-proportional symbol maps and 20 bivariatechoropleth-symbol maps. Throughout the experiment, participants' eye movements are recorded using eye-tracking ET device, and their brain activity is recorded with EEG. The collected ET and EEG data are then synchronized to enable an integrated analysis.

Currently, we are analyzing the collected ET and EEG data to answer the two research questions, following a similar approach in Qin et al. (2024). Specifically, EEG data will be cleaned by removing non-cerebral activities (e.g., eye blinks, muscles), employing Independent Component Analysis methods. We will then segment the processed data according to the stimulus onset. We will focus on frequency-based metrics of the theta/alpha/beta bands, e.g., event-related desynchronization/synchronization (ERD/ERS), frontal alpha asymmetry (FAA). Similarly, ET data will be processed to derive blink/fixation/saccade and pupil sizes, as well as their spatio-temporal distribution within each task. These metrics will be used to compare the cognitive processes of experts and novices in solving different various thematic maps tasks.

References

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