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The Effects of Map Reading Expertise and Map Type on Eye Movements in Map Comparison Tasks

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Comparing maps of different geographical phenomena, or maps of the same geographical phenomenon at different points in time, is a frequent task in many disciplines. The process of map comparison has been studied occasionally by cartographers since the 1970s, but recent improvements in neuropsychological testing equipment and in geographical information system (GIS) technology had us review this topic in a new light. We propose a cognitive approach using eye movement recording to understand the process of comparing two static maps displayed simultaneously on a screen.

Two groups of subjects with different levels of expertise with map reading were shown pairs of maps and asked to judge their similarity or difference. We used three types of maps that differed in their spatial granularity: (A) randomly generated, 64-by-64 pixel, black-and-white images, (B) grayscale choropleth maps representing socio-economic variables for counties in lower Michigan, and (C) land-use maps of the surroundings of selected Canadian cities in different years resulting from classified satellite imagery. Subjects were asked whether two maps presented on the screen were similar (tests A and B) or different (test C).

Response times, fixation durations and fixation counts differed significantly for the three map types. Land-use maps required the longest response times indicating that they were most difficult to compare. At the same time, land-use maps required more fixations than the other two types of maps, while the duration of these fixations was not different from the other map types. When comparing two maps of the same type, saccades between the two maps provide information on the subject's decision-making process. We found that for the land-use maps, the number of these cross-saccades was significantly smaller than for the two other map types.

Pairs of land-use maps were characterized by a fine raster grid and fewer pixel-by-pixel differences between the two maps, while both, random grids in test A and county maps in test B consist of clear-cut spatial units. We conclude that whenever spatial units can be distinguished on a map and corresponding units on a second map can be found easily, subjects will tend to compare the two maps in a unit-by-unit approach. In contrast, if maps consist of smoother spatial patterns, subjects will try to memorize patterns on one map (usually the one on the right-hand side), and make fewer saccades to compare these patterns with those on the other map. The results from this experiment could be used to provide context-adaptive tools for map comparison in GIS.

The behavioral differences between groups (experts vs. novices) in this experiment were mostly not significant. This supports the notion of developing standard GIS tools that are offered to users with a wide range of expertise.