ALTERNATIVE RESEARCH STRATEGIES AND MAP READING

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Increased technological expertise, advances in methods of data compression and innovative hardware designs have produced substantial benefits for those cartographers interested in the automation of map production. At the same time these advances have proven of interest to cartographers investigating processes involved in the perception and reading of maps since automation has forced the purveyor of cartographic communication to reconsider and sometimes reformulate conventional mapping theory.

Perhaps, the most useful aspect of the automation of map production is that it has forced many cartographers to realize that their knowledge of how maps work lags far beyond the ability to create the product. Fortunately, however, the division of labor generated by automation should provide the cartographer with more time to consider the nuances of the product (map) since less time needs to be devoted to the product's construction.

Additionally, many cartographers, realizing that the equipment available to them is inadequate for state of the art research in automation, are turning their energies towards questions of map reading and design. In a sense the evolution of a new technology is helping to build more complete and robust underpinnings for the theory of cartography.

Significant breakthroughs toward understanding matters related to map reading and perception, however, will likely require the cartographer to step outside the traditional research paradigms and adopt research designs unique and perhaps controversial in respect to traditional cartographic experimentation. In the paper that follows, a brief review of some of the more promising strategies is presented.

Performance Approaches

The traditional approach to determining the superiority of one symbol system over another has relied on the accuracy of test results as a measure of the competence of the variables being tested. In such a situation equifinality in the results (the same accuracy but from different symbol sets) is taken as an indication that neither symbol system has obvious advantages over the other. While in many situations this may be the case, there is actually no way of determining whether accuracy and performance are related unless there is a measure of the ease of processing. By analogy, the accuracy of solving simultaneous equations with pencil and paper can be equivalent to a computed solution using a programmed calculator. While the accuracies may be equivalent, the methods of solution require different levels of performance. In this sense, we might consider that measures of the ability to perform a task are as significant as the accuracy of task solution. Indeed, an efficient performance with a moderate level of accuracy may be (in reference to some tasks) more valuable than higher degrees of accuracy that require more strenuous performances.

Although the measurement of performance can lead to unusual and exotic measures (EEG, EGR, etc.) it would be reasonable to assume that the various interactions necessary to process and respond to mapped information can be adequately measured by the speed of performance (Dobson, 1979b). The utilization of reaction time or latency measures, as a consequence, should be a useful research tool in cartographic studies.

Reaction time or latency measures, of course, would have value only in comparative studies (e.g. alternative symbologies or designs). Without such measurements, however, there is no method of estimating the ease of processing information during map reading tasks. When suitably combined with accuracy of response measures, reaction time-latency measurement would allow for a valid estimation of the suitability of various design alterations for specific types of map tasks.

For example, I am currently conducting research on the use of redundant stimulus dimensions for value estimation map tasks. Subjects are required to perform one of three value extraction tasks while examining maps symbolized with graduated circles. One set of maps employs black circles of various sizes to show the data. On the alternative set magnitude is shown not only by size but also by increasing tone. Performance on the task is measured by a combined accuracy-latency measure. A reaction timer measures the length of time it takes the subject to search the map and solve the question. Recommendations concerning the more appropriate symbol systems for the tasks will be based on the accuracy performance measure.

Processing Approaches

Analysis of the processing of cartographic information allows one to go beyond the data available in performance measures by concentrating on the parameters influencing performance at the level of perceptual activity. It is probable that research in this area will provide substantial evidence on the factors that influence performance and, in the process, lead to a powerful theory of graphic design.

Cartographers traditionally attempt to improve the success of cartographic communication through improved design or reader training. It is only reasonable to assume, however, that a map reader's ability with respect to visual information processing (vision, information handling, storage capacities, memory instructions, etc.) moderate the decodability of a map by acting as a filter for design and training variables. There are obvious limitations on the ability to process symbolic visual information that stem from shortcomings of the human's visual information processing system, and knowledge of these inadequacies would allow more specific and efficient map designs that link the abilities of the perceiver with the content of the mapped message. As a consequence, research utilizing eye movement recording, tachistoscopic presentation, and reaction time measurement should be undertaken in an attempt to isolate the salient factors influencing the processing of mapped information.

Eye movement studies will probably prove of most value, not in respect to locus of attention studies (i.e. fixation point analysis) but as indicators of processing load. Measurement of eye movement variables (e.g. the number of fixations, average fixation time, scanpath length, etc., see Dobson, 1977) provide evidence of the depth and difficulty of visual processing. While these variables also serve as performance measures, they are, typically, indications of the need of the perceptual mechanism to sample the display and acquire information.

Recent research in my laboratory has provided some evidence that eye movement variables trend with the informativeness of the display (Dobson 1979, 1980a, 1980b). It seems fairly obvious that eye movement variables provide a tool for measuring the input-output relationships of visual processing. If correctly utilized, eye movement recording may provide significant information on the effects of display complexity on visual processing.

Tachistoscopic studies (that is the use of short-term visual presentation simulating fixation) could be useful in cartographic research in terms of studies aimed at analyzing the amount of information that can be processed during fixation, the influence of foveal and peripheral vision on symbol acquisition and the conspicuity effect of design variables in respect to visual processing (Dobson, 1980c). Research designs using tachistoscopic presentation should provide information on the active factors capturing visual and cognitive attention and may provide valuable insights of the visual efficiency of design strategies.

Reaction time studies (utilizing a signal-response system and some sort of millisecond timer to record the duration between the event and the response to the event) provide a diagnostic measure of the ease of processing. For instance, such apparatus could be used in an experiment to investigate the effect of symbol variability on the speed of search. The reaction time measures would indicate the influence of increased variability on processing and, simultaneously provide data on memory restrictions, information handling capacities, and perceptual load. The application of reaction time measurement may prove to be the most beneficial of the approaches described in this article. Since the physical device is relatively inexpensive ($400-$600), there are no obvious reasons why this method cannot be readily adopted in cartographic research.

Simulation-Gaming Approaches

Although simulation-gaming may sound an odd area for cartographic research, it is possible that many human factors-attitudinal choice problems can be adequately solved in this manner. Consider, for example, implementing a game involving map use and played on a graphic tube. The object of a game could be the maximization of performance on some search task. The cartographer would provide the player with a basic map and a repertoire of map elements; say city names of various sizes and styles such that the map could be overlayed with specific type by a menu command. The subject is then asked to perform a search task for which he will be rewarded or debited on the basis of the speed and accuracy of performance. Such simulation-game playing could lead to the setting of limited parameters for further testing using more specific analysis. In a sense this type of approach could be a useful way to conduct user preference surveys and, at the same time, refine research designs.

Psychophysical Approaches

Psychophysical studies have been part of the cartographers research repertoire for a number of years. The psychophysical studies that have been reported are all of a type that we might call immediate response-psychophysics since the reported reaction to the stimulus is an immediate response. Map use, however, often requires a subject to compare a map currently being inspected with the image of a display previously seen. Various psychological literature suggests that size relationships alter while held in memory (e.g. Schioldborg (1972) indicates that size contrasts degrade in as little as 10 seconds).

If psychological processes alter the memory trace of size relationships and if maps are made to leave the reader with an image of the display, then it may be necessary to pursue memory psychophysics (Kerst and Howard, 1978). This concept obviously does not require alteration of psychophysical methods, rather it merely obliges the research design to accomodate the concept of memory comparisons. While this activity may seem extreme, it should be examined to determine its practicality and applicability to various map storage and retrieval tasks.

Presentational Approaches

The typical method of presenting maps is to have the reader view one display at a time. There is some possibility, however, that unique image presentation systems may be particularly appropriate to specific map tasks. (The reader should note that the methods that follow are not for common map reading situations but for activities where speedy information output for decision making are desirable (government, military, etc.).

Tachistoscopic presentation could be a technique capable of maximizing information transfer during map use. For instance, a tachistoscope could be used to present several views of a map all centered on the same fixation point. In this situation the reader would not be required to move his eyes, rather the subject would only have to redirect his attention. In a sense, the sequence of events on the tachistoscope simulates visual search while the observer merely attends to the sequence of events. Since the reader does not have to actively search he may be able to pay more attention to critical image elements. The lack of the need to analyze peripheral location as potential fixation points may generate more specific memory of the sequential images than would be the normal case with eye movements.

A somewhat more unusual approach would be to determine whether people can compare mapped patterns on the basis of sequential afterimages (the image left on the retina as the result of previous stimulation). There exists in the literature of psychology a considerable body of information on afterimages, masking and metacontrast. It seems possible that the masking effect on one afterimage on another would highlight the areas of noncompatibility. Although considerable research would be required to investigate the validity of this approach, it could lead to massive increases in the ability to make map comparisons.

Another interesting possibility would be the application of real time map reading. Utilizing a graphics display system, one could let the reader see the map as it is drawn. By starting at specific areas and hierarchically sequencing through the display in terms of the importance of various information, one could structure map reading and at the same time eliminate active visual search. Although at present most technology is not well suited to such a situation, it will certainly not be long before quality graphics units are available at reasonable prices. Since NSF has already funded research on the Electronic Journal concept this may be an area of useful and timely cartographic research.

Summary

The various approaches discussed in this paper represent only a few of the numerous alternative strategies to contemporary research on map reading and map use. Whether or not these approaches have any value in cartographic situations will remain questionable until they are thoroughly analyzed. It is my suspicion, however, that such methods and strategies will be required if cartographers are to acquire a sound understanding of the perceptual nature of affective design.

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