THE BENEFITS OF COMPUTER ASSISTED CARTOGRAPHY FOR MAP READING

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It may be maintained by some that a discussion of the benefits of computer assisted cartography for map reading is premature, and in fact, it may correctly be pointed out that the testing by cartographers of map reading abilities on computer produced maps has not even begun as yet in a systematic way. This state of affairs is especially true of the testing of map reading abilities on 'temporary maps' appearing on CRTs. On the other hand, some may maintain that the benefits for map reading of computer assisted production environments are obvious and that it is not necessary to take the time to call attention to them.

The intent of this paper is to attempt to direct our thinking about map reading in a computer assisted environment. It is now an appropriate time to proceed to a more detailed level in the evaluation of the use of computer assistance in cartography. The technological revolution in cartography, which computer assistance represents is no longer in its infancy; although it continues at a fairly rapid pace. The beginning phase of the revolution is past and the results will be part of the technology of the discipline of cartography for years to come. There remain technological advances on the horizon, but the current commitment of the federal mapping programs to digital cartography is so tremendous that "now" is the time to begin to appraise the output of these computer-produced products with regard to their design and to appraise map readers' abilities to perceive these products.

Do computer produced products and reader's performances on them differ substantially from the manually produced products which map readers are currently reading? For much of the history of computer assisted cartography, cartographers have been trying to replicate what was previously done manually. Relatively less attention has been given to new products. For computer produced maps that seek to replicate conventional maps there may indeed be little evidence to lead one to suspect that map reading capabilities have changed substantially, especially when the replicated products are printed. Cartographers have not tested this hypothesis, however. But a more interesting question is: Can map reader capabilities to receive information from a map be enhanced or increased over present conventional methods with the aid of computer assistance? Although a tentative "yes" can be given to this question, cartographers need to systematically experiment to obtain evidence to back up this tentative answer.

Some of the potential improved capabilities for map readers made possible by computer assistance can be demonstrated by citing three examples. These examples are certainly not exhaustive and are perhaps only the most obvious but serve to illustrate the point. First, computer assistance allows a cartographer to clarify the use of symbols. What cartographers have learned from psychophysical experimentation for the most part, pertains to rather simple maps without what one might term 'background noise.' On a CRT screen each distribution portrayed by one type of symbol can be shown individually. Such a presentation could easily make use of the results of psychophysical experimentation by presenting few carefully scaled symbols. Several individual displays could then be used to display the information that has normally been put on a single printed map sheet. This splitting of the map information would only allow for the presentation of 'here is' information and for display of the intradistributional relationships amongst those data similarly symbolized. More complex relationships would have to be built or synthesized by the map reader. This leads to a second example.

Computer assistance, thinking primarily about maps displayed on CRTs, allows for real time interaction between the map display and the map reader. After viewing simple distribution maps for intradistributional relationships and 'here is' information, the map reader (now cartographer) can elect to overlay or combine several distributions in order to look at interrelationships. This capability allows the map reader to bring to bear on intradistributional relationships ideas of possible interdistributional relationships. On most printed maps cartographers have 'biased' or limited the map reader's possibilities in this regard by selecting which distributions to portray. Computer assistance can remove that type of bias, and this means that simultaneously it is also lessening the control which the cartographer has over the information given to the map reader.

A third example illustrates the advantages of the tremendous data processing and manipulation capabilities of the computer. Raw data can be converted by statistical processing into rather complex interrelationships which can then be mapped by rather simple methodologies. Take the concept of a manufacturing belt in the north-eastern United States as an example. Figure 1 is a map that might appear in an atlas of the United States. It gives detailed data on U.S. manufacturing. By informing the map reader that one must integrate this information into a 'manufacturing belt,' most adults probably will be able to visually do so. Figure 2, on the other hand, is a nominally scaled portrayal of the 'manufacturing belt.' It is visually much simpler; less information is presented more clearly. Rather complex statistical processing has gone into the delineation of Figure 2 however. Computer assistance has enabled the calculations needed to produce Figure 2 to be accomplished routinely. The data portrayed in Figure 1 are not lost in the process, but remain readily available.

These examples point out some of the possible benefits of computer assisted cartography for map readers.

With these examples in mind one can envisage a continuum from perceptually simple tasks to complex cognitive tasks which map readers can be asked to perform on maps. Alternative symbolization schemes can present the same data in manners such that the map reading task is in one case simple and in other cases, complex. A second continuum can be envisaged consisting of the complexity of the ideas on a map. This second continuum ranges from the presentation of simple ideas to complex ideas. A two dimensional table of the complexity of idea presented vs. the complexity of the symbolization or map reading task required for the map reader to receive can be established. In Figure 3 both axes increase in complexity away from the origin at the upper left. Point 1 designates the portrayal of a simple idea with a simple symbology. An example is the differentiation of land from water using a screened tint for water and white land as shown in Figure 4. Point 2 in Figure 3 designates a simple idea using a complex symbology system. Recreation land near Munich is a fairly simple concept but the symbolization employed in Figure 5 is complex. It breaks the amount of land shown by graduated circles into segments representing seasons and includes historical data as well. Point 3 in Figure 3 represents a complex idea by using a simple symbology. Figure 2, the U.S. Manufacturing Belt, is presented simply but the idea is one of a dense concentration of "value added" by manufacturing (itself an involved concept), employment in manufacturing and number of manufacturing establishments relative to total population and area. Finally Point 4, in Figure 3 designates a complex idea which is symbolized by complex symbols in Figure 6. Types of Employment broken into 12 categories is symbolized by divided squares placed at county of place of work.

In this foregoing discussion there is nothing new that cartographers have not known for years. What computer assistance offers this scenario is to give the cartographers increased flexibility. In manual map production the cartographic problem was to select a point in the plane shown in Figure 3 for each potential map. The rule of thumb that cartographers adhere to is to select as simple a means of portrayal that will be consistent with the 'purpose' of the map i.e., the idea to be presented. 'Purpose' has usually at best only been vaguely defined for thematic maps and rarely defined even for reference maps. It is safe to say that most maps produced today rarely have a single purpose and it is even rarer that a manually produced map is used by all map readers for a single purpose.

Computer assistance relieves the cartographer of the need to specify one point in Figure 3 for each map. A complex idea can be either (1) presented simply, and the synthesis so presented, or if needed, can then be analytically broken into the parts used to create the synthesis, or (2) presented complexly and then analyzed into its constituent parts. Alternatively simple ideas can be presented and the map reader can systematically synthesize a 'whole' from them. In short the cartographers approach to the communication of information has been made more flexible by computer assistance. The question, originally posed; What are the possible benefits to map reading from computer assisted cartography?, can then be replaced by the question; How can cartographers and map readers take advantage of computer assistance to enhance communication in maps?

At the same time that cartographers have gained greater flexibility they have lost control over the map reader when they employ computer assistance. The problem of training in map use and reading thus becomes more important than ever before. Cartographers, in a computer assisted environment, have an obligation to train map readers in the use of computer assisted cartography. Yet cartographers know little about how to train map readers in either a computer assisted or a traditional map reading environment. Cartographers cannot even answer the obvious question of whether a map reader's responses to CRT maps are the same as they are to electrostatically printed maps or to the more traditional printed maps. Before cartographers can hope to move into a position to take more complete advantage of computer assistance, they must redirect their thinking, for a moment at least, and concentrate on new approaches to an analysis of map reading in a computer assisted environment.

How many studies are most cartographers aware of that have integrated information from conventional map reading psychophysical experimentation with information on cockpit simulator informational displays? How many studies have been done by medical researchers on the human analysis of x-rays or brain scans etc.? These are relevant to map reading.

Cartographers can initially approach the problem of map reading in the computer assisted environment in two ways: (1) by intervention in the development of the display system to be used by the reader, or (2) by preparing the reader to use all possible display capabilities. From a scientific point of view the latter approach is favored, but perhaps initially cartographers need to gain some control through the first approach.

To control map reading programmatically, the cartographer simply puts limits on the possible options a map reader can request from a display system. For example, if in a thematic mapping situation the user wants a black/white choropleth map, then programmatically he is limited to say from one to six categories. The available equipment may limit the user to 16 or 64 categories and there may be legitimate uses for 16 or 64 categories, but to aid in the reading of a choropleth map on a CRT a user would programmatically be limited to six categories. Similarly cartographers could programmatically disallow gray tones to be used for nominally classed areas. Graduated circles would be limited to the ability to produce circles whose differences are separated by at least one 'least practical difference' (lpd). In fact one could speculate on a series of mapping system levels that could be made available to users depending upon the readers' sophistication. Level 1, with fewest options (much programmatic control), would be generally available. Higher levels with more options (less programmatic control) would be available only to prescribed individuals on more sophisticated equipment.

The alternative is to train map readers to the point that they can function legitimately with the most highly sophisticated technology available. But how do cartographers do this? There is very little systematic knowledge that cartographers have formulated for map reading. Should cartographers develop methodologies for the finding of 'here is' information? Should there be a methodology for intradistributional relationship specification? Should there be a map comparison map reading methodology for the analysis and specification of interrelationships on maps?

Some of these methodologies could operate in the same way that air photo interpretation keys have operated in the past. Air photo interpretation can be basically described as a systematic analytic approach to the detailed interpretation of air photos which requires considerable mental discipline that is usually attained through practice by the interpreter of the photo. Could not the same hold true for maps?

Finally, with computer assistance most 'here is' information can be readily processed without much effort and, it is not necessary to display it in a map format. Answers to such questions as: What is the name of that town? What soil type? How much precipitation? etc., can simply be specified by a direct answer from the data base. Other 'here is' information, i.e., more complex concepts, can be processed by the computer to arrive at a simple direct answer: for example; Where does soil Type A occur in conjunction with greater than 500mm of annual precipitation? Where are areas inhabited by populations characterized by low income and obesity?

Cartographers need to take advantage of computer assistance to develop a comprehensive map reading training program. Such a program has never been developed for traditionally produced maps. Maybe cartographers should not worry about that fact, and start afresh in a computer assisted environment.

What then are the benefits of computer assisted cartography for map reading? Perhaps the greatest one is that it offers us a new (second) chance to develop a systematic training program for map use and map reading. Such a program could considerably aid in the development of the discipline of cartography.

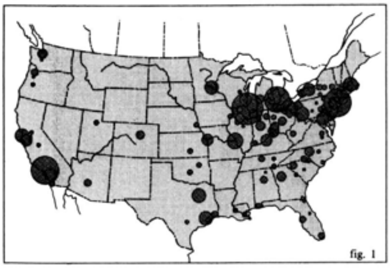

fig. 1

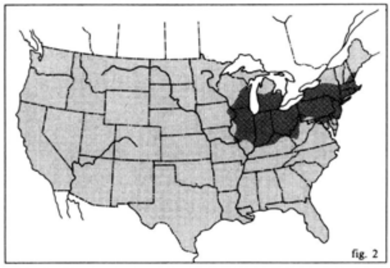

fig. 2

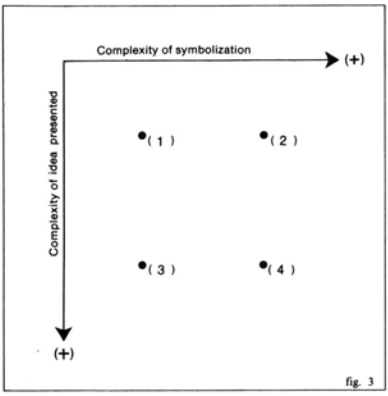

fig. 3

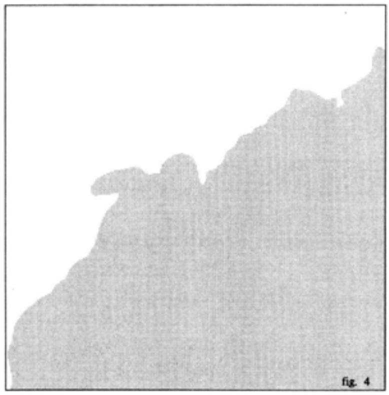

fig. 4

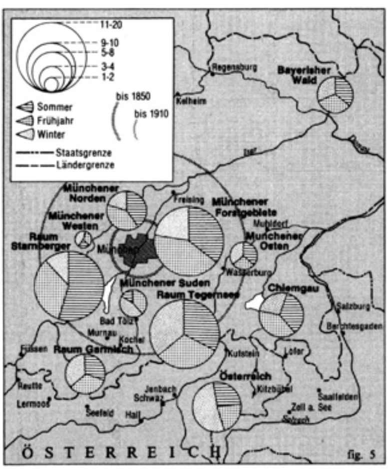

fig. 5

fig. 6

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