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THE GEOGRAPHER'S CONTRIBUTION TO EVALUATING MAPS AS VEHICLES FOR COMMUNICATING INFORMATION

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INTRODUCTION

It is well recognized that cartography and geography have always had a special relationship. This is no more clearly expressed than by Eduard Imhof (1955: 1963, 14) in these terms:

> "The people who are drawing the surface of the earth must observe and study it. The geographer also does this; this is a geographical task. In this respect there is a very close relationship between geography and cartography. To a certain degree the cartographer is a geographer; he is a graphic geographer or a geographic artist".

Another aspect of the relationship is that at least in English language texts there is a noticeable difference between those concerned with topographic maps and charts and "those devoted primarily to geographers and others who are interested mainly in special-subject maps" (Keates, 1973, xi), although this has arguably been detrimental to the development of a unified subject.

A further tendency is for cartographers not to include geographers among specialist map users along with geologists, archaeologists, planners, engineers and biologists. Perhaps this is because geographical training at nearly all levels has included map reading, albeit principally topographic map reading. And geographers, as distinct from cartographers, are interested not so much in maps for their own sake, but as devices for portraying the real world, all its aspects without any marked specialization. Geographers, frequently initiate maps to illustrate their arguments about distributions and relationships.

It is generally accepted that geographers are good at map reading, but this is perhaps because of their training rather than because those who are good map readers become geographers. They have more opportunity to practise the arts and skills of map reading, and have more need to! Distributions and spatial relationships are central to geography in a way that they are not to other sciences.

Maps play an important role in hypothesis generation (Thomas, 1960; Taaffe, 1970). They are employed analytically for example for displaying patterns of residuals from regression, which may itself have been developed from the comparison of patterns. Claval and Wieber (1969, 103) draw a distinction between the croquis analytique which presents a selection of phenomena from the croquis synthetique which explicitly displays relationships between patterns. More recently Muehrcke (1972, 53) has reinforced the advantages maps have for the visual and mental processing of spatial (geographical) data.

Inescapably the conclusion is that to improve the quality of hypothesis generation in geography (and other sciences interested in spatial patterns), maps should be as good as possible. But to make any worthwhile assault on the problem it is first necessary to understand the processes of communication by maps and more particularly how map reading is achieved. For example Muehrcke suggests that "cartographers know relatively little about the traditional procedure of visual map reading beyond the fact that it is subjective and leads to qualitative map description and comparison (1972, 53). Perhaps he could say the same for geographers, who have even less grounds for complacency.

In the last decade there have been a number of notable attempts to codify the process of cartographic communication (Kolacny, 1968; Ratajski, 1973; Morrison, 1974, 1975; Robinson and Bartz Petchenik, 1975). These have paid comparatively little attention to map reading (decoding of Robinson and Bartz Petchenik, 1975). This paper will attempt to supplement the views expressed by these authors and emphasize map-reading processes, starting from the excellent basis provided by Morrison,(1975).

Figure I shows the progressive reduction of data elements by the processes of selection, classification and simplification, until these can be symbolized graphically as the map. This is based directly on Morrison (1975, Fig. 4). Note the presence of data elements D of which the map maker is unaware, contrary to what is commonly believed. Miller (1953, 43) echoes many a geographer in writing, "We must never forget that we can only get out of a map what the surveyor and cartographer have put into it".

MAP READING

Although (as with map making) the processes involved in map reading are set down sequentially and distinctively, in reality they may often take place concurrently, or in a different order.

Sensing the symbols in a map concerns the physiological responses to the stimuli presented. In normal maps these are visual responses. Detection and discrimination take place within a number of constraints imposed by the environment of the map user (illumination, reading angle and distance), user characteristics (visual acuity, fatigue) and the physical form of the map itself (clarity of printing, degree of detail, quality of paper).

Responses are characteristically, "Something is printed here". or, "There is a blank area there". in the detection phase. Discrimination involves the user in being able to tell that there are differences between what is printed (or not printed) in various parts of the map. At this stage no reading is done and communication is at a minimum since at best only the statement, "This appears here and something else appears there". can be made. Provided that the locations here and there may be specified even roughly, a little geographical information is transferred from the map to the reader.

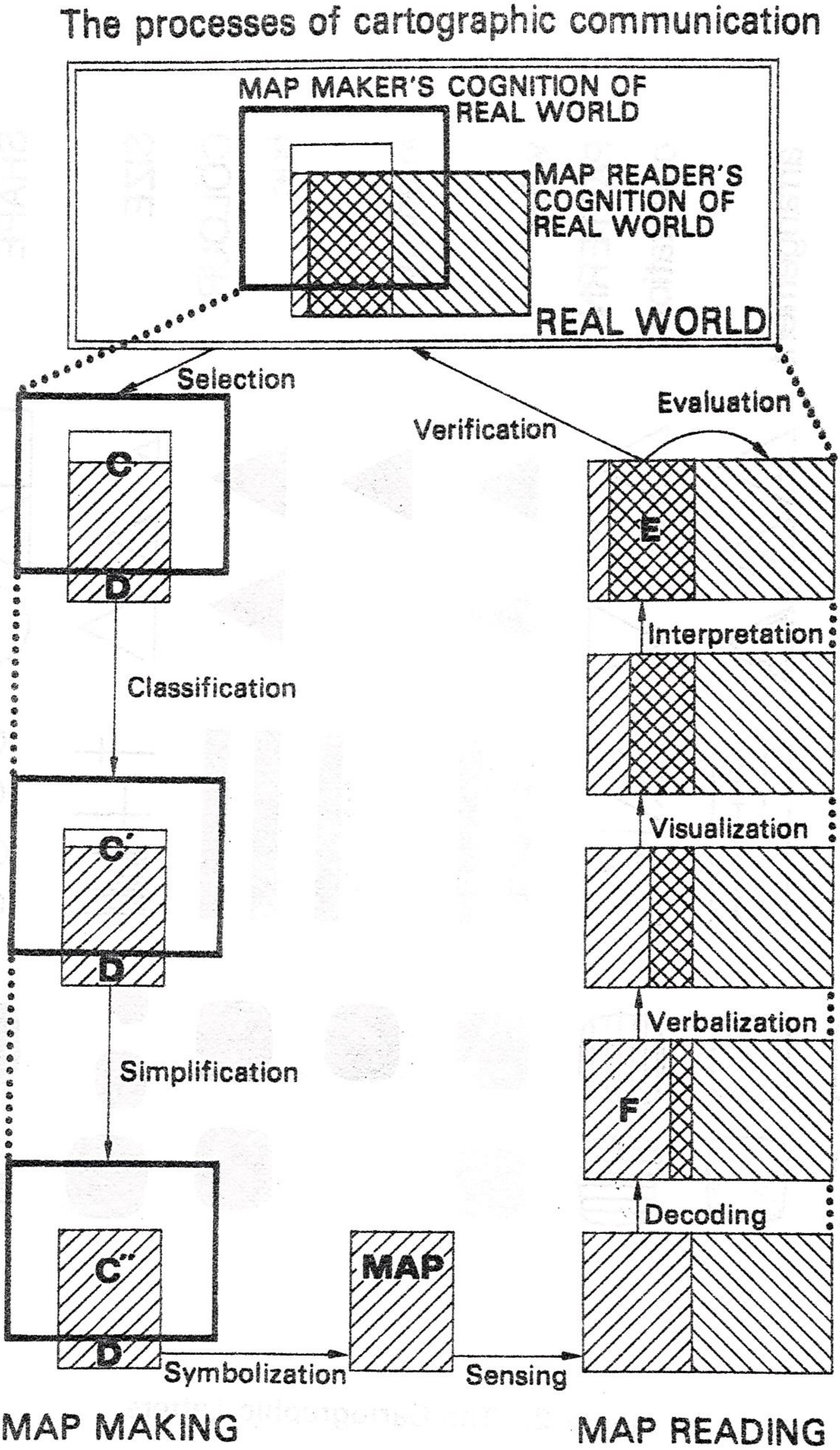
The processes of cartographic communication
MAP MAKER'S COGNITION OF REAL WORLD
MAP READER'S COGNITION OF REAL WORLD
REAL WORLD
Selection
Verification
Evaluation
C
D
E
Classification
Interpretation
Visualization
C'
D
Verbalization
Simplification
F
Decoding
C''
D'
MAP
Symbolization
Sensing
MAP MAKING
MAP READING

Figure 1.

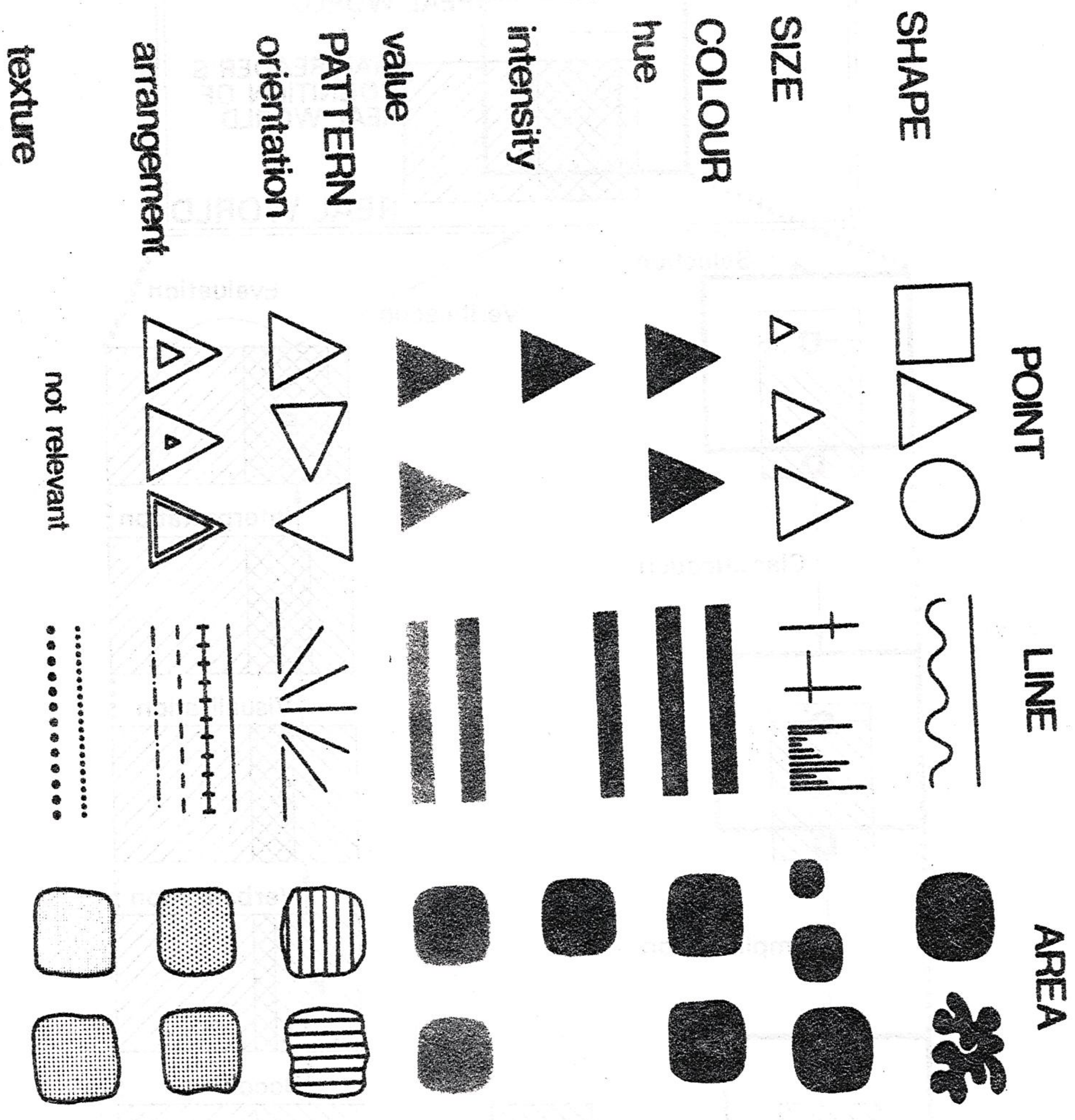

Figure 2. The Cartographic Letters.

Reading sensu stricto begins with decoding where the processes of recognition and identification allow the user to "transliterate" the symbols. Morrison uses the term "map reading" for this part of the communication process. Others have referred to it as "map spelling" (Wooldridge & East, 1951, 72) or "grammar" Miller, 1953, 45, referring to reading contours).

By recognizing printed marks (symbols) is meant that one has seen them before (e.g. they are square, circular, triangular, red, blue or like a tree or cogwheel). Once the map user is able to recognize marks he is then able to proceed to the identification of particular ones and usually to associate a meaning with them. Frequently this is achieved by matching marks on the map with similar marks in the legend, or to some referrent stored in the user's memory.

Thus decoding is concerned with the transliteration of the 'letters' of the cartographic alphabet (Ratajski, 1975). Ratajski suggests that there are 15 such letters derived from cross tabulating 3 symbol dimensions with 5 forms of expression. On Figure 2 these are further elaborated to derive potentially three times eight or twenty-four "letters" except that one is quite unsuitable. There are also problems in distinguishing between area and point or line symbols, since some point and line symbols can display other properties when they are large enough to appear as areas.

Verbalizing may be thought of as the integration of assemblages of symbols into familiar combinations. This is most commonly found in reading contour maps where in due course the novice learns to recognize arrangements of contours as particular land forms (See Sylvester 1952, 36-39, which gives a short atlas of contoured land forms). C.E. Montague was I believe the first to express this in plain English.

> "As in the reading of printed words or a musical score, precision and speed in the reading of maps can pretty rapidly be carried further and further. Soon the map is read, as it were, not word by word, but phrase by phrase; the meaning of whole passages of it leaps out; you see, with something like the summary grasp your eye would get of the actual scene, the long facades of precipice and hanging glacier that there must be where the blue contour lines crowd up closely together right under a peak of twelve thousand feet, with a northern exposure.........So the reader of maps is freed, before long, from the need to go through a conscious act of interpretation when gazing at the mapped contours of a mountain he has never seen......The notation once learnt, the map conveys its own import with an immediateness and vivacity comparable with those of the score or the poem". When the map is in tune pp. 40-41 of The Right Place a book of pleasures (London, Chatto & Windus 1924).

The experienced map reader clearly does not decode consciously, continually flitting from legend to symbol and back again, but sees significant patterns at a glance.

Summarizing thus far, decoding and verbalizing progressively transfer data information from the map to the cognition (Morrison's cognitive realm) of the map reader. A proportion of data elements remains outside the map reader's cognition because either they may not have been seen (sensed); or they may have proved too difficult to decode. This difficulty may have been created in a number of ways. There may be insufficient time or light in which to read the map. It may be too far from the reader's eyes. There may be confusion between similar symbols. The map may be overcrowded with detail, sometimes called "visual clutter" (Taylor and Hopkin, 1975, 199). Or maps may be badly drawn or printed, frequently the case in automated cartography.

Further transfer of elements in Set F to those in Set E may be achieved by more elaborate forms of map reading, termed visualization and interpretation. Visualization of the three dimensional form of a landscape from a two-dimensional representation is widely regarded as one of the objectives of a course on topographic map reading. Sylvester (1952, p.59) goes as far to suggest that "the final test of map reading is the visualization of landscape from map". This activity has been tested by Phillips et al (1974) and De Lucia (1972) amongst others. Little attention has so far been paid to thematic maps, the geographer's most characteristic way of displaying aspects of the data he is concerned with. A notable exception is provided by Jenks (1975) who has tested map readers' ability to visualize clusters of proportional circles in the context of comparing different mapped patterns. However much of Cuff's work (1972) aims at testing how map readers' visualize 'highs' and 'lows' on thematic maps employing various colour schemes.

Some studies involving map comparison may properly be considered to concern visualization since the map readers tested by McCarty and Salisbury (1961) were asked to "estimate the degree of similarity between maps" (p.11). Rimbert (1973) also used a similar methodology to compare line-printer maps of social distributions. Visualization, as Claval and Wieber (1969, 183) remind us, is basic to developing an argument by visual integration of cartographic symbols to explain distribution patterns.

Relative location of cartographic symbols becomes extremely important in the process of visualization, whereas the previous levels of map reading were concerned with the existence of features and phenomena. The map reader exercising his powers of visualization pays particular attention to the spatial arrangement of symbols, not only with respect to one another but to the topographical framework of the area being depicted. In the simplest cases this might be a national boundary or the oriented frame of a map. Hence although Muller argues that a pattern of dot symbols remains invariant under rotation amongst other things, the rotated pattern has an entirely different relation to the outline of France. Consequently the symbolized distribution must mean something else in geographical terms (Muller, 1975, 405; Fig. 2).

By integrating the concept of location and the process of visualization the map reader is able to use the map for the analysis of geographical co-variation. As Preston James (1954, 11) pointed out "cartographic analysis brings to light different kinds and degrees of areal relationship between phenomena". In particular he drew attention to the varying degree of correspondence in accordant relations characterising two common instances as coincidence where boundaries of distributions exactly coincide and in-situ correspondence where two distributions occupy roughly the same location but do not have boundaries that exactly coincide with one another. (James, 1952, 216-17). He also defined (graphically) ex-situ correspondence as the occurrence of similar distributions in mutually exclusive locations. Although he recognizes that areal correspondence in itself was not evidence of causal connection, it was valid "to map phenomena for the purpose of discovering causal connections" provided that this was supposed by a study of process to link two or more distributions.

McCarty (1956) recognizing the need to give greater precision to the use of maps in assessing the degree of areal association, devised a coefficient of linear association for pairs of isolines representing values of two distributions given that they were drawn to the same level of generalization. Pursuing this line of investigation Thomas (1960, 324) concluded that maps were unsuitable for hypothesis testing but good for hypothesis generation and proposed the use of a research system where the visual comparison of maps was supplemented by regression analysis and the examination of maps of residuals from regression to aid the identification of further variables. McCarty and Salisbury's experimental research on the visual comparison of isopleth maps (1961) was very much part of the interest in the role of maps in geographical investigations at Iowa State University.

As it is employed in this paper the interpretative component of visualization is limited to the recognition and identification of geographical features and phenomena. Thus because McCarty and Salisbury"s maps "were derived hypothetically, so that previous knowledge of specific distributions would not enter into a respondent's decisions" (p.14) their map readers were forced to visualize without interpreting. With normal maps however, the map reader usually brings some previous knowledge of the distribution or similar distributions, the location or comparable locations, to bear on the spatial pattern of interest.

Interpretation therefore is restricted in this paper to the sense of the map reader's visualizing meaningful patterns. As Pierce (1961, 122) writes, "the meaningfulness of language depends not only on grammatical order and on a workable way of associating words with collections of objects, qualities, and so on; it also depends on the structure of the world around us". Similarly the interpretation of mapped patterns depends very much on the map reader's understanding of the class of object, symbolized on the map, and its relations with other objects. Hence the geographer will often detect a significant pattern of spatial co-variation of patterns of symbols on maps.

Such co-variation may be detected by comparing one map with another side by side, or superimposing one upon another. Alternatively, the map reader may compare a pattern on a single map with the mental image of another pattern and detect an association between the two. The following examples illustrate these approaches.

Visual correlation of agricultural patterns and climatic "limits" has been a standard technique certainly since the classic research on North America by O.E. Baker between 1926 and 1933. Baker (1926) outlined the method in a paper richly illustrated by dot maps on which climatic and soil "boundaries" had been superimposed.

Map comparison is frequently employed to illustrate regional texts. Regional, national and thematic atlases where collections of maps at the same scale are presented to the reader often enable such comparisons to take place. However, as Salichtchev (1960, 19) points out, many national atlases used cartodiagrams when dot maps would have made maps clearer (and easier to compare). An example from Cole's work on South Africa (1961, 168-9) shows how difficult it is to compare the essence of the distribution of maize production with climatic 'controls' without superimposing one on the other even when individual maps are clear.

As a consequence many books on map interpretation recommend the reader to generalize one pattern and superimpose it on another (Dury, 1952, 3; Stamp 1960, 56). However this is map analysis in the sense understood by Dury (1952, 2-3) if not also by Morrison (1975, 14). The synthesis and understanding are achieved by re-assembling patterns artificially separated either by the map maker or the map user.

Perhaps the most complex form of map interpretation is illustrated by attempting to organize visually sets of symbols such as those on the maps of farming enterprises in England and Wales, applying this new information to that already in the map reader's cognition. Sometimes it is the absence of a symbol that characterises such a region, as for example the virtual disappearance of dairying east of the railway between Sevenoaks and Hastings. (Ministry of Agriculture, 1972). Further examination of the map shows a predominance of yellow associated with orange, green and violet symbols suggesting a more arable agricultural economy, probably including many horticultural enterprises. Livestock farming is based on non-dairy cattle or sheep for which a number of explanations could be suggested (more compatibility with an arable/horticultural economy; a drier, more continental climate). Maps such as these raise more questions than they answer.

Morrison however argues that map reading ends with cognition of the information on the map and "map analysis or interpretation takes place within the cognitive realm of the map reader and not in the communication channel between the two cognitive realms" (map maker's and map reader's) (1975, 14). However useful such a division is we should not forget that map reading, like reading texts, is cumulative and each act of sensing involves some reference to the cognition of the map reader. Interpretation is the final stage in attempting to make sense of the mapped pattern in terms of one's experience at the time of reading. For geographers this often includes information in the form of complex mental maps, often generated by previous map reading as well as observations in the field.

If we accept that interpretation is a form of map reading it must also embrace the activities grouped under the term cartometry, (Ratajski, 1968). The present author has called these measurement and has drawn attention to the fact that measurement can take place at different levels (Board, 1975, 5). Morrison (1975, 14-15) uses the term estimation pointing out that it assumes that detection, discrimination and recognition have been successful.

Purely visual map reading is without doubt estimation since English usage is to exclude actual enumeration or measurement (shorter Oxford English Dictionary). Hence estimation involves the map reader in tasks requiring visual judgment. Psycho-physical studies tend to be based on visual judgments, comparing responses to an objective standard obtained by direct measurement. It is now a commonplace to urge that such visual judgments of cartographic symbols should be done in a real map context, but the judgments to be made should also bear a close relationship to realistic map reading tasks (Board, 1975).

Increasingly, however, geographers have recognized the inadequacies of visual comparison for the rigorous analysis of spatial relationships (Abler, Adams and Gould, 1971, 120: Chisholm 1971, 18). There has grown up an arsenal of methods for measuring symbols on maps, especially in cases where the data exist only in map form e.g., land utilization or land forms. Such quantitative map analysis has spread from physical to human geography and includes a variety of sampling techniques as well. Occasionally maps form an integral part of quantitative analysis: for example trend-surface maps, (Chorley and Haggett, 1965) are the outcome of sophisticated surface-fitting techniques and often provide the input for further analysis.

Two more activities remain to be mentioned in this discussion of the processes of cartographic communication. Neither truly takes place in the channel of communication for they occur after information has been transferred from the map to the cognition of the map reader: hence in Figure 1 there is neither an addition to the elements in Set E nor a reduction of elements in Set F.

The process of evaluation is the search for an answer to the question, "How effective is the map for the user's (reader's) purpose?" This requires the investigator to establish what the map will be used for, how it will be used and by whom and whether correct information and appropriate graphic elements (symbols) were employed. Satisfactory answers to these questions demand empirical research and carefully controlled experimental designs. Critiques are no longer adequate and the generalized claims of advertisements do not necessarily carry conviction. Nevertheless objective studies of relatively subjective preferences for particular styles of maps hold out some promise (Taylor, 1974). Naturally, if those involved in such investigators as 'subjects' are given the kinds of task that allow them to cull further information from the map, the process of evaluation will to that extent enlarge their cognition. However, many measures of performance require subjects to work as quickly as possible or only to see a portion of a complete map. As a result a negligible quantity of additional information is obtained.

Verification is the term applied to the process of evaluating a map in the field and is characteristic of finding one's way or directing another using a map. However navigation is not the only instance of verification. Wooldridge and East (1951, 76) see parallels between air navigation and geographical map reading in the field. They argue that the map reader should work from ground to map pointing out the dangers, especially in an aircraft, of self-deception. Despite this good counsel both good navigation and good field work depend very much on map reading before travelling or going into the field (Shemyakin, 1962;

Taylor, 1976; Wooldridge & East, 1958, 163-5). For motorists towing in unfamiliar country to read a road-planning map or road atlas are necessary preliminaries but once on the journey other maps at larger scales are likely to be needed. Before going into the field the geographer undoubtedly prepares likely routes and selects possible viewpoints from maps. Hence navigation or geographical field map reading in effect is a constant oscillation of attention from map to ground and back again.

While navigating from maps information is being added to the cognition of the map reader. The geographer in the field is a special case since he is primarily reading the ground rather than the map. In the traveller's case some information is culled from either the map or the ground traversed, but it is only the habitual traveller who needs to build up a mental map of the zone through which he moves. This is called into use when he is diverted or his way is blocked by an accident or roadworks (Tuan, 1975). Even for flight (or other travel) preparation the navigator map should be a peripheral aid highlighting distinctive features relevant to navigation. For high-speed flight and modern motoring especially in heavy traffic, the main features need to be memorised before setting out, or disaster will follow (Taylor, 1976). This part of map reading is in effect visualizing the terrain over which travel is to take place and it is only the en route checking that can properly be called verification.

Thus there remains a set of elements F that are present on the map, not within the map reader's cognition. If we could measure the ratio between elements in set E to those in set F we might be nearer to devising an index of efficiency of cartographic communication.

Thus there remains the set of elements F representing information on the map not communicated to the map reader or a part of the map not understood by him. A proportion lies within the cognition of the map maker and represents information consciously included in the map but not communicated because of, either the cartographer's poor map making ability or the map user's inadequate skill at map reading. Failures of communication could easily arise from using unconventional methods or symbols easily confused with others (Taylor, 1975). Clearly also psychophysical aspects of symbol legibility must also be taken into account as a source of misunderstanding.

The remainder of the elements in set F which are outside the cognition of both the map reader and map maker represent information unconsciously included in the map but which remains latent, undetected for the present by any map reader. The geographer makes use of the fact that information such as this will exist when he compiles thematic maps to display single or related distribution patterns. After careful study he hopes to detect this latent information. Information of the same sort may be undetected in the pages of atlases or on topographic maps until the map reader with just the right knowledge or intuition looks at it. Many geomorphological studies were principally based on mapped drainage patterns. W.M. Davis's study of English rivers (1895) began by an intensive investigation of maps and relevant literature before he ventured into the field to look at them. Perhaps the most spectacular case was the discovery of the fit between the Atlantic coasts of South America and Africa attributed to various scientists including even Francis Bacon, but more reliably to Alexander Von Humboldt and Snider-Pellegrini (Hallam, 1973). It is not too fanciful to suggest that these observations played a major part in the development of a theory of continental drift (Wegener, 1912) and its general acceptance today.

Fewer obvious examples come from human geography, perhaps because human geographers have a less thorough understanding of the processes and response surfaces involved. However an early example is the discovery of an "axial belt" of industrial employment and high potential and high potential for industrial development (Taylor E.G.R, 1938) on a series of maps submitted as evidence to the Barlow Commission on the Distribution of the Industrial Population (United Kingdom, 1940).

Geographers and other scientists whose data is often found in map form (geologists, meteorologists, oceanographers, etc) are nolens volens deeply involved in map reading at all levels and have been as long as their sciences have existed. We cannot expect cartographers to be experts in map reading as well as map making.

CONCLUSION

The inescapable conclusion is that geographers and other scientists with their experience of map use will always have an important role to play in evaluating the effectiveness of maps. This reinforces Salichtchev's argument that cartography cannot afford to sever its ties with the sciences of nature and society because the aim of producing effective maps cannot be attained "without knowledge of the system being modelled and without the support of the sciences - primarily geography - that study them" (Salichtchev, 1973, 110).

This ought to encourage geographers to participate more in the evaluation process, undertake training in graphicacy by basic map reading progreammes to be "entrusted to geography teachers provided the latter's alienation from cartography has not advanced too far" (Ormeling, 1972, p.9). And accepting that "all maps have as their aim the transfer of images of the geographical milieu" (Robinson & Bartz Petchenik, 1975, p.14) it follows that cartographers and geographers have many years of fruitful collaboration before them.

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