Visualization in Thematic Cartography: Towards a Framework

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Abstract

A thematic map (or any map) shall be designed so that the intended visualization operations (or any intended map-use operations) can be performed. To such operations correspond problems of cartographic transcription. These problems are subsumed under objectives of transcription. How well such objectives can be achieved depends on background factors which relate to conditions of optimal transcription. Where a relevant condition is not met, the map maker faces a constraint. Objectives of transcription and background factors are the two basic components of a conceptual framework which permits to systematize transcription problems and their solutions. For the field of thematic cartography, ten objectives of transcription and eight background factors are identified.

1. Introduction

1.1 Problem and Background

When making a thematic map, one proceeds in the following six basic steps. (1) One decides, first, how the prospective map user shall read the map, or, put differently, what he shall get out of it. (2) One decides on the information to be entered, considering items as well as relations between them. One then procures (3) the necessary data as well as (4) a base with the required geometrical characteristics. Afterwards one (5) selects the appropriate graphic means and transcribes the thematic information and (6) explains the transcription in the legend.

The present paper is concerned with the fifth step, the transcription of the thematic information.[1] A professional map maker is supposed to transcribe (as far as possible) in such a manner that map users are enabled to carry out one or more map-use tasks[2] (or map-use operations) as intended. To a map-use task, then, corresponds a transcription problem (or mapping problem),[3] i.e. the problem of transcribing with a view to facilitating the relevant task. The map maker identifies such problems, develops solutions, and deals with attendant constraints (the latter to be covered in s. 3[4]). All aforementioned processes are processes of sign production; accordingly it is a task of cartosemiotics to make such problems, solutions, and constraints explicit and, further, to propose guidelines for adequate transcription.

[1] Creating a base or using an existing one (the fourth step) also involves a transcription or the acceptance of a transcription - that of the plan information (as defined in the second part of this section). This point will be considered later as a factor which influences thematic mapping.

[2] In the literature also referred to as map-using tasks or map-reading tasks. For stylistic convenience, I shall further speak of (map) reading (in a wide sense of "reading") and, accordingly, of map readers.

[3] North American cartographers may prefer to speak of a problem of map design.

[4] In cross-references, "s." stands for "section" and "ss." for "subsection".

Among the (numerous and diverse) map-use tasks, the subset of visualization tasks is particularly important in geographical cartography. It is this subset with which the present study is concerned. It bears reminding that visualization is a fundamental and traditional concern of cartographers and has been considered important long before the current emphasis on visualization developed under the influence of computer science.

In thematic mapping one encounters numerous mapping problems which relate to visualization. Some remain to be solved; in other cases solutions and related guidelines are found dispersed through the literature.[5] It would be very useful - for both experienced and novice map makers and in both practical and theoretical terms - if the relevant findings were systematically collected and presented. To be sure, such collections of problems and solution exist, but usually as unpublished case notes.

One important reason for this state of affairs is the following fact: the subject of study is both extensive and complex, so that one easily loses orientation. To start with, one needs a plausible and manageable framework in which each problem - along with its solutions - has its place.[6] Such a framework is suggested in the present paper. The focus will be on problems, although at some places solutions and guidelines will also be presented.

1.2 Introductory Clarifications

It may be helpful to start with some clarifying notes on typography, terminology and background.

1. As is customary, an expression (sign vehicle) is cited between slashes, a content (meaning, item of information) in single quotation marks.

2. In a map one finds concrete tokens (instances, occurrences) of abstract types. Assume that ten patches of meadow and one vineyard are shown; then there are ten tokens of the type /meadow/ and one token of the type /vineyard/. Analogous statements can be made about the corresponding contents. Some map-reading operations are aimed at types, others at tokens.

3. The cartographic information is conveniently divided into plan-related information (or simply plan information) about mapped objects (their location, size, shape, etc.) and plan-free information (which, by definition, does not relate to the plan).

4. Imagine a simple dot map. At each place, the same plan-free information is realized, e.g. '500 inhabitants'. This is an invariant item of information or an invariant (BERTIN 1983, p. 16). Likewise the marks carry constant graphic traits, except for position. More often one maps sets of terms which alternate between places (i.e. which are alternants) and have something in common, like the terms 'iron', 'copper', 'gold' in a map of mineral resources, which share the component 'metal', or a set of

[5] For reasons of space, I cannot cite more than a few relevant sources. Most of them are referred to later in this study. In addition, the works on transcription planning by SPIESS (1978) and BOS (1984) deserve to be mentioned.

[6] "Manageable" implies that the framework is not so highly differentiated as to be cumbersome.

numerical values which share the component 'temperature in ºC, rounded to the nearest degree'. Such a set of alternants is here called a file. Alternant contents are expressed by alternant expression terms, which are values of graphic variables.

5. The sign unit under analysis is the topeme, the smallest self-contained entry in the map. Its complex content is the concept of a place on the earth's surface. To this place normally corresponds a locator, i.e. a visually unified symbol which indicates the location of the place. Within a topeme there are assembled minimal signs. Visualization problems are, in the first place, problems of choosing and arranging items which serve as expressions of minimal signs. In doing so, a map maker has much freedom, but this freedom is limited by the exigencies of the intended map-use operations.[7]

6. Further, a terminological note on the following section (s. 2) is in order. There are many visualization tasks and many corresponding mapping problems. These tasks and problems, respectively, are assigned to groups. For stylistic convenience, I shall at some times refer to visualization tasks or groups thereof and at other times to mapping problems or groups thereof; that is, I shall speak of different sides of the same coin. The common core of a set of mapping problems is called an objective of transcription. Currently ten such objectives (or ten problem groups) are identified; their number may change somewhat with future research. In addition to the objectives of transcription, one must recognize background factors which influence the transcription (covered in s. 3).

7. At several places in this article I am speaking, in the abstract, of map users or map readers. This is, of course, just a convenient simplification. In practice, one assumes a specific level of education, interest, and experience. For example, the map readers whom I have in mind in this discussion are junior university students who have had at least a rudimentary exposure to maps and do not suffer from unusual visual defects.

8. How specific representations are read has in some cases been established by psychological tests; in other cases the map maker must try out solutions and rely on his own impressions until more solid knowledge becomes available.[8]

9. A given solution to a mapping problem may be clearly good and another one clearly unsuitable. Quite often, however, one finds that there are several solutions, each having advantages and disadvantages, so that one can only recommend: "Make a choice and know what you are doing". Also, one may have to settle for a "second-best" solution, because a perfect one is not available or not attainable, owing to certain limitations[9] (see s. 3).

[7] A detailed discussion of the topeme is found in SCHLICHTMANN 2001.

[8] BERTIN often seems to have relied on such introspection; still, most of his opinions on mapping solutions have been found convincing.

[9] Where the representation within the map face is only "second-best" or "least bad", especially where the rendering of the content structure is at issue, one can often make matters clearer and improve understanding by a suitable design of the legend. Stratigraphic maps are familiar examples: an age sequence of deposits cannot usually be reproduced by a clear tone sequence in the map face, but it can be rendered by the sequence of entries in the legend.

2. Objectives of Transcription

A first subdivision of the field of interest is derived from the three functions of the expression material: signification, clarification, and emphasis.[10],[11] Clarification is a single objective, and so is emphasis. Under the heading of signification, however, I tentatively subsume eight objectives.

2.1 Clarification

A first objective is clarification, i.e. keeping the map image clear, so that it can be read without avoidable distraction. Among the relevant map-use tasks are the detection of an entry and the discrimination of an entry from neighbouring ones in the map face. Talking of these, one will be concerned with minimum symbol size, figure-ground contrast, and avoidance of clutter. I tentatively include a third operation: deciding whether or not two entries belong to the same type, regardless where in the map face they are found.[12] This is the task of distinction (as opposed to signification) within the sign system. All tasks considered here relate to expression tokens.

2.2 Emphasis

By emphasizing one makes entries stand out in order to attract attention to them. A very simple example: in a regional atlas, the territory mapped appears white and the adjacent territories grey, so that they recede into the background.

2.3 Signification

2.3.1 Types of Entries

Under the heading of signification (conveyance of information), the first map-use task is this: to recognize the identity of a type, i.e. to read an entry as a token of a specific type. The information extracted may be plan-free or plan-related. In the first case, the process of reading may or may not involve the use of the legend.

Where a map maker chooses expressions for plan-free content traits, a one-to-one rule applies: barring exceptions, wherever a given content type appears, the same expression type appears as well. That is, one avoids synonymies as a matter of principle.

2.3.2 Sets of (Different) Types of Entries: Commonality and Oppositions

Often one maps sets of terms which are organized in files (as defined in ss. 1.2, point 4). Between alternants in a file there hold opposition relations (or oppositions for short), such as "different from", "more important than", and several others. Two transcription problems arise.

[10] A similar trichotomy appears in RADER 1989, (e.g. on p. 57), where it is applied to the function of colour in cartographic design.

[11] For the sake of perspective, three additions may be made: (1) a given entry may serve more than one function; (2) some entries have no detectable function; (3) occasionally functions are in conflict. These points will not be discussed further.

[12] From this operation one must distinguish the identification of a specific type, which is the subject of ss. 2.3.1.

First, it furthers understanding if one spontaneously recognizes that, e.g., at all places under study there are deposits of metal ores. That is, a set of different types shall be read as belonging together or as being alike (and thus as being subsumable under a common concept). Hence the graphic means employed shall signal the unity of the set. Such reading is facilitated if the topeme expressions studied by a map user share constant traits or/and contain values of associative variables (in the sense of BERTIN 1983, p. 65). Constant traits - abstract or pictorial ones - may be carried by separate marks, like RATAJSKI's "guiding signs" or "primary morphemes" (1971, p. 157; 1976, p. 60).[13],[14] Concerning graphic variables, normally a one-to-one rule (like that noted in ss. 2.3.1. for individual types) is observed: one graphic variable - or two redundant ones - correspond(s) to one and the same set of oppositionally organized content terms.[15]

Second, content oppositions are very often rendered according to rules like "What is different is shown by different entries", "What is ranked is shown by ranks of visibility" (reworded after IMHOF 1972, pp. 24f. and SPIESS 1970, p. 280). One reproduces the content oppositions by oppositions between expression traits. Conversely, the map reader can spontaneously retrieve the content oppositions. The same holds for the relation of alikeness (considered in the preceding paragraph). It is this class of reading operations which has attracted particularly wide attention in the cartographic literature.

Rules like those mentioned before are based on the transcription principle of homology (one of several such principles, but a very important one).[16] They may be called homology rules. The map maker's problem is to find the right graphic variable which permits to convey the differentiation according to a specific opposition or (occasionally) to a combination of oppositions. Sometimes, incidentally, there is no satisfactory solution.

2.3.3 Cross-Relations

The complex contents which are associated with places may further be structured (1) by sense relations which underlie branching hierarchies (or hierarchies for short), (2) by various kinds of inter-file implications,[17] or (3) by correlations between quantities or ranks. Such relations link terms of different files.[18] As it were, they cut across files and, for want of a better term, are here called cross-relations.[19]

If such phenomena are considered in the transcription, it is mainly where conceptual branching hierarchies are mapped. Even then one usually does not reproduce the

[13] Such an constant entry is, in the first place, a formal device, used to visually signal the unity of a set of terms. In addition, it may (but need not) convey a superordinate concept. The latter situation is familiar from figurines and other marks which, when they are entered into the map, come already endowed with some meaning.

[14] RATAJSKI (1971, pp. 153-157) shows how subordinate concepts are expressed by adding modifying marks (with appropriate traits); ARNBERGER (e.g. 1974, pp. 24f.) describes this process as "group formation".

[15] Visually motivated deviations from this rule are found where many terms in a rank sequence are to be mapped (see SPIESS 1970, p. 288).

[16] It has been discussed in detail in SCHLICHTMANN 1985, pp. 26f.; 1994a, pp. 55-57; and 1998, pp. 50f.

[17] SCHLICHTMANN 1989, pp. 18-25.

[18] Links of this sort may also extend to invariants.

[19] How these relate to combinatorial relations (which underlie the local syntax) will not be considered here.

sense relations which define the three specific hierarchies,[20] but rather super- and subordination, i.e. formal relations between hierarchy levels. In particular, the graphic means expressing the superordinate concepts must be visually more prominent than the means that express the subordinate content terms.[21]

2.3.4 Local Syntax

Into a further class fall the transcription problems which relate to the local syntax, i.e. to the combination (assemblage and arrangement) of lower-order units within topemes.[22] The local syntax encompasses a number of different combination phenomena, therefore its scope is difficult to outline in a short summary (for a provisional overview see SCHLICHTMANN 1994b). In the context of the present study, the crucial point is this: how expressive items are combined and arranged depends not only on the underlying combinatorial content structure but also, and sometimes in the first place, on visual requirements and on characteristics of the graphic material. The influence of perceptual characteristics may be quite pervasive. In the extreme case, combinations of graphic means evoke certain contents, simple or complex ones.

Visualization problems that relate to combination and impinge on map design are mainly (but not exclusively) encountered (1) when both patch size and tone are varied (a problem familiar from choropleth maps; see, e.g., IMHOF 1972, p. 176f.), (2) in the mapping of addable and non-addable quantities (see ss. 2.3.7 below), and (3) in the rendering of relations between universes of addable quantities.[23]

2.3.5 Local Ensembles

Where the expression of a topeme contains more than one mark, one notices a second objective which relates to local combination. A map user must be enabled to recognize a local complex or ensemble of entries and, where applicable, to correctly read traits of complexes which have been brought about by the very act of combining.

As for the first point, one must signal that the marks assembled in the expression token of a topeme relate to the same place. The relevant means are usually gestalt phenomena, such as proximity and schematic arrangement, although one occasionally uses enclosing or linking lines as stopgap devices.

The second problem is exemplified by bar diagrams used as map symbols. Let each bar correspond to a farm-size class, and let its length stand for the number of farms in that size class. Now, the compound, i.e. the diagram as a whole, has an overall size, which corresponds to the total number of farms; it also has a shape, which images the statistical distribution of the farm sizes. By combining bars, one produces new expression traits which characterize the compound as a whole. If such a trait can

[20] I.e. the relations "kind-of", "part-of", and "attribute-of".

[21] Guidelines for mapping conceptual hierarchies have been formulated by LEBLANC (1990).

[22] This subsection covers the building-up and the (internal) structure of complexes. Global characteristics of the resulting complexes are the subject of ss. 2.3.5.

[23] In the third case, we find homological transcription: relations between universes are reproduced as congruence relations between symbols (overlap, inclusion, etc.; see SCHLICHTMANN 1994b, pp. 41f.). Still, homology plays but a minor role in rendering the internal combinatorial structure of topemes.

reasonably be coupled with a content, one derives information about the local ensemble.[24]

2.3.6 Multilocal Ensembles: Phenomena of Spatial Distribution

Ss. 2.3.5 related to an ensemble reading at a place, and one aim of reading was to discover a statistical distribution. The present subsection relates to an ensemble reading involving many places, and the aim of reading is the discovery of spatial distribution phenomena. In either case one derives new information from the graphic representation. The reading of spatial ensembles deserves a study of its own; here I can do no more than briefly consider four important visualization problems.

1. Let a map of mineral resources show deposits of various metal ores, various kinds of coal, etc. Let us ask: "Where are (all) the copper deposits?" To answer this question, we must spontaneously see all tokens of the same type and must abstract from the tokens of other types (in particular from related ones). To permit such reading, the relevant graphic variable must be selective. Its terms must not only be different, but different to a rather high degree. (On this crucial graphic property see, e.g., BERTIN 1983, pp. 66f.; 1979, pp. 20f.).

2. Now let us ask instead: "Where are (all) the metal-ore deposits?" In this case we must filter out tokens of different types (again abstracting from other entries), and still realize that the different types belong to a common class of higher order. A graphic variable which permits to realize such commonality may be called cohesive. All of BERTIN's associative variables (BERTIN 1983, p. 65) are more or less suitable.

3. Let a map show, for a set of municipalities, the out-commuters as a percentage of the resident labour force. We ask: "In what direction, if any, does the percentage increase?" This is a question about spatial gradation (change of intensity in space). Similarly, if we want to visualize the spread of a city, we need to recognize a gradation in terms of age. The relevant graphic variables must be ranked.

4. Studying a large-scale land use map, one may ask: "What specific land uses, if any, tend to be associated?" In such a case the interest is directed to the arrangement of tiles in a mosaic.[25] Here again selectivity is important: it facilitates the spontaneous discovery of repeated associations.

Point 1, it may be added, concerns the distribution of tokens which instantiate the same type. Within this general frame, a geographer could ask more specific questions, depending on what distribution characteristic is at issue. So one may want (1) to determine an area of distribution, in particular where the relevant items register as points or area patches; (2) to study the size, shape, and orientation of such a distribution area; (3) to recognize the spatial arrangement (pattern) of points or area patches, which is based on distances between such items; (4) to note the dispersion or (5) the density of those items. As for sets of linear features, one is often interested in overall shape, especially if these features are assembled in a network.

[24] In other cases the overall size of the bar diagram may be meaningless (see ss. 2.3.7).
[25] Further examples are the ecotope patterns familiar from landscape studies.

To repeat: the map-use operations outlined above amount to the recognition of spatial distributions and thus are crucial in geographical map use. In this context, homological transcription is important: it is a prerequisite for the recognition of distribution phenomena. For example, as noted above, the discovery of spatial gradation presupposes a ranked variable.

2.3.7 Addable and Non-Addable Quantities

In ss. 2.3.4, the phenomenon of evocation was mentioned; it is observed where quantities and/or ranks are locally combined. Small wonder that it is encountered again when one looks at ensembles of addable and non-addable quantities.[26]

Think of a set of places to which values of a quantitative variable are assigned. Does one express these values by symbol sizes or by tones? Handbook authors (e.g. BRUNET 1987, pp. 168-171) recommend to use sizes for absolute and tones for relative quantities. More appropriately, one should say: use sizes only if quantities are addable (interlocally addable in this case).[27] The rationale is as follows. If symbols vary in size, we notice spontaneously that a greater or lesser part of the map face is covered up by these symbols, i.e. we visually add up the symbol sizes (at least if the marks are equally dark).[28] The aggregate of the symbol sizes evokes the sum of the mapped values. Such visual adding-up is appropriate if quantities are addable, otherwise it is not. In the latter case one will generally employ tone values.[29]

The present point obviously concerns the reading of ensembles. But it is not a matter of spatial distribution, even though the distribution and the aggregate of the symbol sizes are perceived together. Therefore it is treated under a separate heading.

The above problem arises not only with multilocal ensembles but also with local ones. In principle, the same rules should apply in either case; in practice, however, the mapping of local ensembles meets more limitations. As an example take a set of bar diagrams, where each bar corresponds to a census year, and where its length stands for the number of people counted. The overall shape of the diagram visually indicates the population development (and does so most efficiently), but no meaning can be attributed to its overall size. So map users must learn to ignore the size.

2.3.8 The Surface Illusion

A final set of mapping procedures - stemming from topographic mapping but adopted in thematic cartography - aims at creating the illusion of a surface. One does so in various ways: (1) by creating an effect of varying darkness (which may, e.g., depend on the more or less close spacing of contours); (2) by using illumination and shadowing (i.e. introducing photographic elements into the map); and (3) by employing line assemblages which suggest a land surface as seen from an elevated point. Characteristic are special means like the modulated area-shade symbol, the relief contour, and the inclined trace. The relevant visual traits - darkness of shade,

[26] Technically one usually speaks, respectively, of extensive and intensive quantities.
[27] I leave aside the special case of pixel representations (BRUNET, ibid.).
[28] This phenomenon is familiar from of dot maps.
[29] When is it appropriate to render values of a quantitative variable by tones? This question is more complicated than is usually realized. It has as yet no generally accepted answer.

position of inclined trace - can, to some extent, be taken to "mean" something (which is why the present objective is dealt with under the heading of signification), yet such meaning is usually trivial and may be awkward to put into words.[30] In general, the conveyance of information about specific places is less important than the creation of a particular visual impression.

2.4 Retrospect

Ten objectives of transcription have been presented. They can be grouped from various points of view, two of which are of major importance. One of these has already been stated at the start of this section: the function of the expression material. The other one is what I shall call the overall aim of a map-use operation: learning about a place, discovering a distribution in space, or finding out something else (abbreviated: reading for place or space or neither). These aims will be exemplified for signification.

1. Assume someone asks: "Where are (all) the copper deposits?" or "In what direction(s) does population density increase or decline in the mapped territory?" Such questions pertain to spatial distribution and call for multilocal reading. This reading takes place at the overall level - or the level of the ensemble - in BERTIN's sense (BERTIN 1983, p. 141, also pp. 156-159; 1979, p. 21).

2. Now consider the following questions: "Does this village have a police post?" or "What branches of industry are found in this town?" A question of this sort pertains to a place, that is, it is local in scope. It relates to a detail or to several details and requires an item-by-item reading at BERTIN's elementary level (ibid.).

3. Further, let us ask: "What is the statistical distribution of farm sizes in this municipality?" This question still pertains to a place, but it aims at a holistic reading of a local ensemble. In other words, when focusing on a place, we may perform tasks of piecemeal reading (as shown above) or, alternatively, tasks of ensemble reading.

4. Finally, consider questions like these: "Do entries A and B belong to the same type?"; "Is A different from B?"; "Is A more important than B?" Here it does not matter whether an entry is associated with this or that place, or even whether it is in the map face or in the legend. Neither are ensembles and distributions at issue. Thus one may say, in an abbreviated manner, that one reads without regard to space or place.[31] Such reading operations, of course, are also important and revealing.

Four overall aims of map-use operations have been noted. It bears repeating that one focuses on places not only to read item-by-item (as is sometimes supposed) but also to learn about local ensembles. In this context it may further be noted that BERTIN's familiar overview of the transcription power of the graphic variables (1983, p. 96) lumps two overall aims together (as do corresponding schemata in his later works). Reading for rank order or for quantitative relations (numerical distance, proportionality) is independent of space and place. Selectivity, by contrast, permits to read for spatial

[30] There are degrees to which a plausible meaning can be constructed: highest with slope hachures, lowest with oblique plastic shading and related means.

[31] This is so even where contents are expressed which are obviously spatial in nature, like plan shape and location.

distribution, and so does spatial gradation.[32] GEELS (1987; 1988, p. 18) has revised BERTIN's schema in order to keep the two aims separate; MACEACHREN (1995, p. 279) has also made relevant suggestions.

3. Background Factors

So much about the ten objectives of transcription. Now, given a specific mapping problem, to what extent can a successful solution be achieved? This question takes us back to the constraints mentioned earlier (ss. 1.1).

There are background factors which relate to conditions of optimal transcription. Other things being equal, a mapping solution is the more successful in facilitating specific map-use operations, the better such conditions are fulfilled. If a condition is not met or is met insufficiently, the map maker faces a constraint or limitation. He then must choose between three courses of action: to make no map, to change the conception of the project so far as to remove the limitation, or, finally, to proceed as planned and to settle for a less-than-optimal transcription.

Certainly one must elaborate and recommend mapping solutions. But it is also realistic to consider, right from the start, under what conditions a solution is attainable and what limitations may arise - in other words, to consider the background factors. In addition to the objectives of transcription, the said factors constitute the second basic component of the proposed framework. For space reasons, I only list them and afterwards add a few details for clarity.

3.1 Overview and Some Clarifications

With respect to visualization, eight background factors are tentatively identified:

1. Spatial arrangement of the mapped places (close or distant, juxtaposed or overlapping, etc.).
2. Geometry of the map base (as influenced by map alignment, reduction, and projection).
3. Extent of the oppositional and hierarchical differentiation (number of terms in a file,[33] number of kinds of oppositions in a file, number of levels in a branching hierarchy).
4. Extent of the syntactic complexity of the topeme expressions (number of marks and of traits which are required at a place).
5. Number of themes to be accommodated in a map.
6. Characteristics of the expression material which reflect its provenance (as abstract items, figurines, writing marks, etc.).
7. Availability of graphic means (e.g. of chromatic colours).
8. Number of map entries competing for attention at and around the spot on which one concentrates (incl. entries functioning as noise).

For each factor, preferable conditions of transcription can be identified. Thus, for points 3-5 and point 8 in the above list, generally the following holds: visualization is

[32] How the two aims are related has been noted in ss. 2.3.6.
[33] BERTIN's "length" of a component, i.e. of a content variable (BERTIN 1983, p. 33).

easier, if the extent of differentiation or complexity is relatively low. Or, concerning factor 2, for certain mapping problems a specific projection is required. Finally, the notes which follow should make points 1 and 8 clearer.

On Factor 1. The spatial arrangement of mapped places is a matter of (pre-cartographic) fact. Subject to the rules of coordinate transformation, it is reproduced by the arrangement of locators in the map. This arrangement presents the cartographer with several problems. Two of these, which are encountered quite often, are exemplified here.

1. Assume one maps land uses and requires selective perception. Patches of land use X may be close together or else widely scattered (and intermingled with other patches). In the first case, they are easier to filter out as a single set than in the second, since selectivity varies inversely with "the complexity of the topographic distribution" (BERTIN 1979, p. 21, n. 4).[34]

2. Further assume one wants to show the spatial gradation of temperature or of population change and uses area patches which are varied by tone or by tint (colour) and tone together. Such a reading is easier to bring about with chorisograms than with choropleths. This is so because tones which are adjacent in the legend are also adjacent in a chorisogram map but usually spatially separated in a choropleth map (example: BERTIN 1983, pp. 86 f.).

On Factor 8. This point may appear redundant, but it still deserves to be made. Here we are concerned with the purely visual side of map complexity, i.e. with the effects of several causes mentioned before. Note that any distracting entries need not belong to a topeme being studied but may rather be found in its vicinity.

3.2 Retrospect

The eight background factors fall into three groups. The first two factors, which make up the first group, concern the plan information as reflecting the given, quasi-accidental spatial arrangement of places and as transcribed in terms of the geometry of the map base. The next three points, secondly, relate to the differentiation and complexity of the plan-free information insofar as it must be formally expressed. The last three factors, finally, concern the material of (visual) expression.

4. Concluding Remarks

Visualization in thematic cartography entails a number of transcription problems. Such problems, along with the corresponding solutions, are worth of being systematically recorded, so that guidelines can be derived from the accumulated experience. Work of this kind presupposes a plausible and manageable framework. Such a framework has been suggested here. It has two components: objectives of transcription (under which mapping problems are subsumed) and background factors (which relate to conditions of optimal transcription). In a manual of problems and solutions - perhaps taking the form of loose-leaf collection in a ring binder -, the

[34] In addition, selectivity increases with patch size which, in turn, reflects another "given" spatial trait of mapped objects.

objectives would define the main chapters, and the background factors would be considered in each chapter, as applicable.

The framework presented here covers the observed problems reasonably well, although some future expansion and rearrangement is likely. For two reasons, the subject matter of this study is complex and will remain so. (1) There are surprisingly many objectives of transcription. A few are of major importance (such as rendering differentiated content types by homology), others are of only occasional consequence (e.g. accommodating cross-relations). (2) The same graphic item may be the locus of different problems, which thus may be hard to keep apart, at least intuitively. Whoever creates a manual of the sort envisaged here will have to keep the conceptual order clear in spite of the amount and variety of data which must be accommodated.

The ideas formulated above have been developed in numerous university courses of cartography. They are designed to help in solving problems of practical map making. Accordingly, the present study is a contribution to applied cartosemiotics.

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