Type Variation and the Problem of Cartographic Type Legibility

PART ONE: *Cartographic Typography as a Medium for Communication; The Cartographic View of Legibility*

Barbara S. Bartz

An analysis of the varied functions of lettering on the map suggests that typographic appearance and arrangement on the map may be viewed with respect to a symbolic-analogic continuum. Type is considered to be: 1. Symbolic; 2. Analogic—a. Locative analogy, b. Quality analogy, and c. Quantity analogy (or value analogy). A review of the cartographic literature having to do with the conception and treatment of "legibility" reveals that its content is derived primarily from typographic research done in non-cartographic context. Since it can be shown that type use on maps is unique in several ways, the applicability of that research is questioned.

Although problems in the selection and arrangement of lettering are among the most complex of those confronting the cartographer as he designs the map, there is a notable lack of literature on the subject to which he can turn for guidance. There is general agreement that above all, the lettering[1] must be "legible." Yet this term is not often defined, nor are objective, behavioral criteria given for assessing it. It seems clear that there is a need for consideration of several things.

In the first place, we need to understand better the purposes of cartographic typography as a medium for communication. We need to know in what ways the type employed on a map is similar to or different from type as it is used in other contexts, particularly that of running text. Success of typographic arrangements in both situations is now judged primarily in terms of what is called "legibility," but the criteria for success would appear to be quite different from what legibility ordinarily connotes.

Further, because the term itself is used in such a variety of ways, it seems that for all practical evaluation purposes, the term legibility must either be objectified or abandoned entirely and

replaced with a more useful terminology. In order to decide which of these alternatives to select, it is necessary to determine (a) what cartographers have thought and written about the legibility of type, and (b) what psychologists, educators, and typographers have produced on the subject of type legibility.

Finally, the definitions provided by these groups appear to provide inadequate grounds for assessing legibility in cartography; consequently a new rationale is developed to assist in cartographic choice. In order to determine how well the proposed rationale functions, its utility is examined in the experimental setting.

This sequence of ideas provides the basic structure for this series of four articles.

Cartographic Typography as a Medium for Communication

In ordinary language, certain sounds are used to represent objects. These sounds can then be represented by a series of conventionalized geometric forms arranged in a prescribed manner, that is, the letters of the alphabet and the words formed by grouping portions thereof. The objects represented can either be considered unique, and labeled accordingly (e.g., William L. Smith, Jr.), or they can be considered members of a class of objects which share certain agreed-upon characteristics and a general name (a man).

In cartography an arrangement of graphic elements (limiting ourselves here to the case of maps printed in ink on paper) represents some reality, where arrangement in space is of special concern or interest. Such an arrangement would be difficult or impossible to represent and convey in the word-sentence-paragraph sequence of everyday language. The set of possible graphic elements which can be used in cartography to do this is almost infinitely varied, and thus is considerably more complex than the usual 26-character alphabet of the English language. The lettering on a map (which is a sub-set of all the graphic elements) can be used in a far greater variety of ways than can the letters which make up conventional text, and the reasons for this will soon become apparent. We can refer to a few of the ways in which type "functions"[2] to illustrate this point.

The major distinctions which must be made between cartographic use of labels (or words) and the use of words in ordinary speech is that

while most speech is concerned with *classes* of objects (and ideas are here considered similar to a class of objects, since the notion of generality is inherent in the term "idea"), maps are usually not so concerned. Rather, the kind of reality depicted on maps has to do with specific, unique place-labeling. That is, we are concerned with "Chicago," not with "city." It would be exceedingly unhelpful to have a map which simply showed "city" and "road" and "river" in various places. While we do depict classes of information on a map (e.g., all cities are equated with a black dot symbol), we usually remove each place from its class by labeling it with a name which encodes its uniqueness in location and character.

Further, the place labels themselves have no essential connection with one another, nor can any of them be combined to form new "ideas." That is, while a word may take on different meanings and grammatical functions from its varying arrangements with other words, names are not so affected. Associations or verbalizations which different individuals might make about a city name would vary, but the essential referent is still unique and unchanged. Thus place labels (although they are words in the sense of being permitted, pronounceable sequences of letters) are conspicuously different from the more general labels (nouns and pronouns) found in ordinary speech and text.

In addition, both the physical characteristics of the letter shapes (type style) and the arrangement of the shapes on the map may encode considerable information. This is a rare occurrence in non-cartographic typography. The implications of this coding will be examined in more detail below.

While it may seem that we are belaboring the obvious, there is good reason for making these points. The applicability to cartographic problems of research into the legibility of letter, word, and text is plainly brought into question by the distinctions just drawn. This becomes even more apparent when the nature of the reading process is analyzed.

At the most basic level of consideration, the map type codes sounds (which are place names) in conventional arrangements of letters. In this respect it is identical with all other possible type uses. Note, too, that at this level one is very little concerned with the

physical form of the type; in a sense, it is "transparent" for we wish to sound out the name as a unit, but do not want to consciously dwell on the circularity of the O, on the straight line and curves of the B, and so on. In reading text, for example, if we are consistently conscious of the type, it must be poorly chosen.

In the following passage, Polanyi makes clear the transparency of both language and typography. He also makes a point about the nature of reading which seems to be directly relevant to a distinction which attains great importance in cartography. "Even *while* listening to a speech or reading a text, our focal attention is directed towards the meaning of the words, and not towards the words as sounds or as marks on paper. Indeed, to say that we read or listen to a text, and do not merely see it or hear it, is precisely to imply that we are attending focally to what is indicated by the words themselves. But words convey nothing except by a previously acquired meaning. . . . Thus the meaning of a text resides in a focal comprehension of all the relevant instrumentally known particulars, just as the purpose of an action resides in the co-ordinated innervation of its instrumentally used particulars. This is what we mean by saying that we *read* a text, and why we do not say that we *observe* it."[3]

The map user is not expected to look "through" the lettering; he frequently does, but the map maker does not expect him to. More accurately, perhaps, he is expected to look both *through* and *at* the lettering. The reason for this is obvious; names—that is, the type—on a map are expected to encode a great variety of information. The variety is such that we will even find it hard at times to generalize at the level of discussing "lettering in cartography"—and it may be useless, as well as difficult. For the purpose of the following analysis, let us consider a rather densely-lettered place name reference map, such as we might find in an atlas.

Map Type Characteristics Analogous to Reality: Location. The arrangement of the type on a map is physically analogous (in varying degrees) to the location of items on the surface of the earth. This is in contrast to the orderly and conventionalized arrangement of type in a linear sequence which is analogous to the manner in which it is spoken (a time analogy, not a spatial one). This restriction on cartographic

type naturally introduces complications in both the analysis and use of map type. One complication is that the same place name (that is, a real place on the earth's surface) will rarely, if ever, occur (a) in the same place relative to the map page edges, and (b) in exactly the same place relative to other names on the map, as one goes from map to map. Scale changes, projection changes, and extent of area mapped will all affect the location of the type. Though it may be very brief, *the locating of any name on a newly-encountered map will require a period of search.*

Although all name locations on a map are analogous to feature locations on the earth, some are considerably more so than others. The arrangements of the letters of a place name may indicate:
(1) point location
(2) linear and areal extent
(3) shape and orientation of a feature.

City names are usually compactly placed as closely as possible to the point symbol which represents the city itself. Numbers might be carefully placed on the point representing a spot elevation. Linear and areal extent are familiar to any map user, for country names are usually spread from border to border. Shape and orientation can be illustrated with the familiar example of "Appalachian Mountains." It would be quite unusual to find that name arranged any other way than along the southwest-to-northeast axis of the map page.

It is important to notice that we have not termed the above uses of cartographic type "symbolic." "Analogous" seems a better word, for there is a physical (rather non-arbitrary) resemblance between the real location and arrangement of the mapped feature and the location and arrangement of the cartographic type which names it on the map.

Map Type Characteristics Analogous to Reality: Quality and Quantity. There are additional ways in which type can be considered analogous to some characteristics of the reality it identifies. While the situations described above can be considered *locative analogy*, we can also observe other uses of type which might be called *quality analogy* and *quantity (or value) analogy*. What is meant by these terms will become clear from some examples.

Perhaps the most common use of a type characteristic which might be considered a quality analogy is the very traditional use of italic type for labeling various classes of hydrographic features. There seems to be fairly general agreement that this type came to be used in this fashion because it looks wavy and more "flowing" than other forms of type.[4] Very often, too, hydrographic type is not only italic, but is also blue.[5] Both of these choices of type characteristics are somewhat related to associations with or perceptions of physical reality characteristics, and thus are not completely arbitrary symbols. If the hydrography were depicted in fluorescent pink Times Roman type, it would be very difficult to imagine that this choice was analogous to any physical reality—it would therefore become purely symbolic, where arbitrary associations are made between the class of objects represented and the character of the physical representation system. In other words, type is often thought to have visible characteristics which are like those of the object or class of objects named; a physical, quality analogy is established. Such type variations are then used to distinguish one class of mapped data from another, and this can be considered to be a nominal scaling procedure, though it may introduce ordinal scaling as well.

Quantity or value analogies are very common in any map user's experience. One would be quite surprised, for example, to look at a map of the United States in any atlas, on which 24-point type had been used for Waupaca, Farmersville, and Suring, while 4-point type had been used for New York, Chicago, and Los Angeles. The height or boldness of city names is usually scaled relative to population. This is a simple example of quantity analogy.

Value Analogy. Value analogy is somewhat more complicated. In the terminology of scaling procedures, quantity analogy as used here would involve interval and ratio scaling; value analogy would involve primarily ordinal scaling procedures. In value analogy, the cartographer is concerned to give the map user some idea of relative importance, where the phenomena depicted are not strictly comparable in a numerical way. This will be clearer if we consider a practical example. For the purposes of a particular reference map, let us say, countries are more "important" than cities, which in turn

are more "important" than rivers. Thus the type used for country names is 24-point, that for cities 12-point, and that for rivers 4-point, though the type styles used might vary from category to category. Quantity analogy would be used to approximate variations *within* a class, where numerical comparisons would be possible, e.g., from one city population to another. But value analogy would occur when comparisons of magnitude are made *among* classes of information, or when arbitrary hierarchies of intellectual importance are established within a category, e.g., one could imagine a world map, made in Switzerland, where the name Switzerland would be set in the largest typeface, and all other country names would be smaller type.

Map Type Characteristics: Non-Analogous (Symbolic). But type can be used in far more arbitrary fashion than the ways just described; when it seems that the association between the appearance of the type and any perceptible physical characteristics of the class of information being mapped is completely arbitrary, we can consider the use of type to be purely *symbolic.* For example, in choosing a typeface into which the name United States will be set on a map, there would be no basis in physical analogy for selecting, say, 8-point Century Schoolbook over 8-point Times Roman. The arbitrary assignment of either face to the class of political unit names is considered *symbolic* in this discussion.

For our purposes of analysis here, then, we are establishing a continuum against which type selection can be evaluated. This continuum ranges from purely symbolic to purely analogic. There are certain type variations which are associated with positions near the ends of the continuum. Type arrangement, boldness, and height are usually used to indicate some sort of analogy between the features named and the type which names it. Type style and form (capitals, lower-case) are more often used in purely symbolic fashion. It seems more appropriate to illustrate this point than to discuss it further.

If a map shows five categories of city size, and if each of these categories is depicted in its own typeface, there are infinitely many ways in which the type for each category can be chosen. In practice, however, there would be two schemes which would illustrate the

range from *symbolic* at one extreme of the continuum to *analogic* at the other. In the case of the symbolic extreme, the largest cities (in population) could be labeled in 8-point Futura, the second largest in 8-point Optima, the third largest in 8-point Times Roman, the fourth largest in 8-point Baskerville, and the smallest in 8-point Bodoni, with there being no apparent physical connection or analogy between the type style chosen and the city population it represents. Assuming that all the styles had approximately equal visual weight, there would be no possible way for the map-user to determine which style represented which city-size class.

At the analogic end of the continuum, the largest city-size class could be depicted in 24-point Univers, the next largest in 20-point, the next in 16-point, the next in 12-point, and the smallest in 6-point. While the choice of the Univers type style for cities is symbolic, the choice of type size is analogic, since the population scale corresponds to the variation in the height of the type. In practice, of course, the cartographer usually combines these two possible kinds of variations, in more or less systematic ways. He is often aware of the scaling problems involved only at the intuitive level, and he can consequently do things which seem natural to him, but which are, in fact, quite arbitrary and even irrational.

Map Type as Scale-Indicator. There is one other way in which there is no apparent comparison between type as used on a map and type as it is used in text. The complex of type on a map somehow provides a crude sensation of scale. The relative sizes and weights of type appear to produce subtle cues of scale, and we become aware of the phenomenon only when we sense that there is something wrong with the way the map looks, in comparison to the approximate scale range in which we know it to be. There is no definitive research on this subject yet, though this author has conducted an informal research project which showed quite clearly that even for relatively unsophisticated map users, type is a possible scale-indicator.[6] It also showed that the matter warrants a great deal more investigation. The point is made here only to suggest that there is yet another variable which might affect comparisons made between type as it is used and evaluated in text material, and type as it is used in cartography.

Summary. The type on a map is similar to type in other uses in that the 26 letters of the alphabet are used to code sounds, which in turn are codes for unique or general referents. Map type, however, is normally concerned only with coding unique referents, that is, place names. Further, map type can represent arrangement in space of the referents, depending upon whether it is related to a point location, an areal or linear extent, or the shape and orientation of the named feature. In addition, the physical characteristics of the type itself may be thought to denote some characteristics of the mapped feature, and therefore can be considered to function in analogic fashion. The analogy may be of a qualitative or quantitative nature. If the type is used in a purely arbitrary fashion to code an aspect of the mapped feature, we consider that it functions then in a purely symbolic capacity. Additionally, map type seems to provide cues of scale.

The Cartographic View of Legibility

So far we have described only the ways in which map type *may* function, but have not considered the next logical step which is to ask a two-fold question: (1) Does the map type actually function for the map user as the cartographer imagines that it should? (2) Are there ways of assessing the *degree* of success the cartographer achieves as he uses type to convey a great variety of information? How can one ever say, "The lettering on this map is better than the lettering on that map?" and have it be anything other than a purely subjective opinion? Such statements are frequently made, but on what basis? If this question were to be answered, "Why, this type is more legible, of course," one would have then a tautology, not an explanation.

In common usage, legibility refers to a feeling that something can be read easily, or that one thing seems clearer than another. But reading, in the ordinary sense of the word, refers to the acquisition of meaning from continuous text. If one merely pronounced the word "wortuysak," with no comprehension of its meaning, the process would not be called reading. Yet in a sense, this is what happens with a newly encountered map, for unfamiliar names are nonsense words—pronounceable, but having no associations or meaning. From this example it should become quite apparent that the bases for evaluating typographic legibility of running text (most often with

speed-of-reading tests) and the bases cartographers might have for evaluating legibility of cartographic type must necessarily be different. Yet cartographers do not seem to have given the matter much attention, either philosophically or experimentally. This will become very clear as we review the cartographic literature which is relevant to lettering in general and legibility of lettering in particular. We shall find that there are no experimental data at all that we can use to answer either of the two major questions asked above.

This scarcity of material is somewhat concealed by two things: (a) rather assertive statements in the literature about what is *believed* to create cartographic type legibility, and (b) freely applied data from typographic research done in non-cartographic contexts, with no empirical verification of its applicability.

Though the following passage comes from a design journal, it is applicable to cartography as well. "As *Design* discovered in its own recent analysis of the Univers typeface, there is no real body of knowledge about graphic design—slogans substitute for fact; 'Sans serifs are unreadable,' 'Baskerville is best,' and so on."[7] How prevalent such slogans are in cartography is illustrated in a 1964 article called, "Map Design and Typography." "Scientific investigation has shown sans serif to be the worst of all type styles for word recognition."[8] This is a substitute for a fact, but is not a fact itself.

In cartographic literature, legibility is very often an Alice-in-Wonderland word, which can mean whatever one decides it should mean. It seems necessary here to point out that there are two broad and very different (yet often intermingled) senses in which the word is used. Neither is identical to the more common use of the word "legibility" in connection with printed text materials.

One use of the word has to do with the map as a total display, while the other is confined to the type which occurs on the map. When the term is used in reference to the entire map, it usually means that the map gives the viewer an impression of graphic and/or conceptual clarity. The complex relationships of figure-ground networks embedded in and superimposed upon one another which make up the graphic display that we call a map often provoke an mpression of clarity or lack of clarity. The map which is somehow clearer is referred to by the user as more legible. It seems to him that

the map would be easy to use, easy to "read," easy to make sense of.[9] We can cite some examples of the term as it has been used in cartographic literature to describe such a feeling.

In the English summary of an article by Eduard Imhof[10] there is the sentence: ". . . for legibility and clearness of a map essentially depend on a good position of names and spot elevations." Another such example is the following sentence from Arthur H. Robinson's *Elements of Cartography*: "A greater use of well-formed lower-case letters will improve the legibility of a map."[11] Both of these sentences illustrate the lack of distinction between the legibility of a map (as a whole) and the legibility of the type (as it might be assessed in text or display situations). Throughout the remainder of these articles, we will be concerned with the second notion of the legibility of cartographic type itself, rather than with the overall legibility or clarity of the map as a whole. It seems likely that increased type legibility would contribute to increased overall map legibility, but that is not part of this study.

With this general introduction in mind, we can proceed to an examination of the available cartographic literature on lettering, emphasizing particularly the treatment of the notion of type legibility.

Material in Books. The most complete summary of material to the year 1921 is contained in Eckert's *Die Kartenwissenschaft* (Volume One).[12] The chapter "Kartenschrift und Kartennamen" is only eighteen pages long (compared with the total 639 pages in the first volume), but it contains a variety of material.

Eckert tends to emphasize maps where accurate and detailed portrayal of the terrain is of major concern. His use of the word "clarity" can often be taken to mean that which does not obscure the terrain drawing.[13] Eckert does not agree with those who believe that the best map lettering is no lettering at all (a point of view we shall encounter in more recent times in the work of Erwin Raisz). Eckert notes: "Therefore the name is not an element which is strange to the map, but rather an integral part of it. . . ."[14] He quotes others who call the names on the map "a necessary evil," "an unpleasant necessity," and "a strange element." Eckert makes a great many pronouncements, but offers little in empirical evidence to support his

points of view. He offers a "rule" for the size of type in the map title (for example, $h=2.1\sqrt{I}$, where h=height of letters in mm., and I=paper surface in cm.^{2})[15] with absolutely no rationale for doing so.

Most recent textbooks in cartography offer very little on the subject of lettering. Hinks' *Maps and Survey*, for example, contains only seven pages on the subject of lettering, and the material simply consists of practical techniques and styles in hand-lettering.[16] He makes an interesting comment on the complexity of lettering as it is used on maps: "The student should examine carefully the characteristic sheet of the International Map . . . to learn how very much information can be conveyed by careful variation in the lettering of names; most of which escapes the uninstructed user of the map."[17] Since most map users in this country are relatively uninstructed, we can carry this one step further and assume that much careful variation in cartographic type does indeed escape the users.

Erwin Raisz is a cartographer best known for his carefully drawn landform maps. One would expect that he would be most interested in place-labeling which would not obscure his drawing. Such is indeed the case, and he is either famous or infamous for his statement, "The development of expressive cartography has been hindered more by lettering than by any other cause."[18] He would no doubt feel differently about the matter if he had worked for a road map company, where there would be very little to express if it were not for the place names.

Names and lettering are peripheral to maps in Raisz' view: "People are more critical of lettering and spelling than of the actual content of maps."[19] It seems difficult to believe that one could separate names and content in such a manner. He himself says at another point: "Map publishers have found by experience that maps without names do not sell. An unnamed feature will not be remembered easily."[20] If a feature were to be so unimportant to man as to never have received a name, it is unlikely that it would be important enough to be mapped in a recognizable way.

Two books by Robinson contain considerably more material on the subject of cartographic lettering. In *The Look of Maps*,[21] he treats lettering as one of the three visual components of cartographic technique—lettering, structure, and color. The book contains three

chapters, "The Importance of Lettering," "The Style of Lettering," and "The Employment of Lettering." He stresses the point that the lettering is an intrinsic part of the map, in contrast to the point of view noted above. "To put it simply, cartography is a medium of presentation for spatial data and it follows that when such data require identification, then the identification becomes an integral part of the map. The identification of data and locations has always assumed an important place in cartographic technique."[22] Not only are names an intrinsic part of the map, but he suspects that the lettering is one of the more striking visual aspects of the map: "Although no tests have been made, so far as we know,[23] it is reasonable to postulate that for most small-scale maps, the first reaction of the reader, consciously or unconsciously, is to the lettering."[24]

Robinson is the first cartographic textbook author to point out the value of and need for empirical research relating to cartographic type selection. He uses the term legibility to refer only to type, though he does not define it nor is he always consistent in using it. Within the following paragraph, for example, its meaning seems to shift somewhat. "The technique of lettering on maps covers a wide range. Perhaps the first question of choice facing the cartographer is that of the form of typeface. There are an infinite number of possibilities. . . . They vary in legibility, appropriateness, texture, and even in the general character or mood they represent. Next the cartographer must decide on size, for after all, the best typeface is of little concern if it cannot be read. The relative sizes are of great significance in a map in terms of comparative emphasis and legibility. Inherent in the above question is that of the color of the lettering and of the background on which it appears, for this constitutes one of the major controls of legibility."[25]

Type must surely be visible before it can be legible, but it does seem in the paragraph above that visibility and legibility are almost synonymous.

In *The Look of Maps* Robinson includes much of the traditional cartographic point of view on lettering, but he also introduces material from typographic and psychological literature and attempts to relate it to cartography. He stresses the need for research in cartographic typography. "Unfortunately the tests which have been made

are meager, although they show results of significance. They are not, in all cases, directly related to the problems of cartographic technique since legibility and perceptibility of maps are not the same as for ordinary reading practice."[26] He adds: "Although the above enumerated general bases for the evaluation of the lettering technique apparently are sound, the data necessary for detailed objective evaluations are meager. Further research is clearly necessary, *aimed at the special requirements of cartography*."[27] There has been no change in the "lack of data" situation since those words were written in 1952.

In his textbook, *Elements of Cartography*, Robinson includes more material on lettering than had any such textbook previously. He treats lettering as one of the symbol systems which are contained in the map, and as an important element of the design of the map. The terms "legibility," "visibility," and "perceptibility" occur throughout this book in connection with type selection, but they are not defined.[28]

Periodical Literature. Periodical literature relating to map typography is neither extensive nor original. It is largely a potpourri of oft-repeated conventions, personal opinions, and preferences on matters of artistic taste, and some casually interpreted versions of psychological and other literature on typographic legibility. There is some recognition of a need for new empirical research and validation of traditional procedures, but even a master's thesis in cartography which stresses such a need fails to produce experimentation which would contribute specifically to cartography. The following survey of the periodical literature is arranged in chronological order.

The oldest article on map lettering cited is also one of the most complete and interesting.[29] Captain Withycombe began with a brief history of lettering forms, and described the relation of typography to engraving and printing processes. Among the things which he finds are essential to aim at in map lettering is, "*Legibility*. The letters must not only be legible when standing alone but also when superimposed upon the detail of a map."[30] In another paragraph: "The subject of Lettering is inseparable from that of general decoration, for writing is one of the chief factors which distinguish a fine map having a distinct aesthetic value from a mere diagram. . . . There is no merit

in ugliness, and as I have tried to show, good lettering makes for legibility and efficiency. . . . Clear, readable type, harmonizing with the map itself should always be used. . . ."[31]

Although 26 years elapsed between Withycombe's article and one by Dawson in 1955, the articles are very close in the assumptions they share. Dawson pleads for a return to hand-lettering, and even concludes optimistically: ". . . and it may be that Captain Withycombe's dream of high quality freehand map lettering executed by trained draftsmen, using alphabets designed by penmen, for penmen, will at least be partially realized in future Australian cartography."[32] In the late 1960's such a remark appears almost medieval. To judge from the report of this Australian writer, there had been little cartographic research during the period from 1929 to 1955.

This lack of research is also noted by Keates in an article which appeared in 1958. He writes: "Despite the great development in the use of typeset names on maps, and the attention given to methods of type composition and stickup, relatively little interest has been shown by cartographers in the actual selection and control of suitable typefaces. On their part, professional typographers, schooled in the requirements of normal book and display work, do not seem to have contributed very much to the special problems of type on maps. In general, this aspect of cartographic design has been neglected, which is strange when one remembers the acrimonious arguments about the beauty of hand-lettering as opposed to type."[33]

Keates lists a few obvious differences between normal use of type in text and its use in cartography; for example, on maps the usual problem of leading does not exist; individual letters are more important, typefaces are used as classifying elements (and therefore the map must nearly always mix types), and the alignment of the type may be irregular. He goes on to list characteristics (on a subjective, analytical basis) which he would like to see incorporated in the design of a typeface strictly for map use.

So far we have considered only the literature that was primarily relevant to the question of selecting typefaces. A very practical, how-to article on positioning names on the map by Eduard Imhof appeared in 1962. He says (in translation): "The names should, in spite of their incorporation in the dense graphic structure of the other

map contents, be easily readable, easily discriminated, and easily and quickly located. *Legibility* depends not only on the type form, type size, and type color, but also considerably on the position or arrangement of the other names."[34] Of particular interest in this statement is the equating of legibility with the quality of being "easily and quickly located." This is often taken for granted, but is usually not explicitly mentioned.

A good source for establishing the variety of non-cartographic literature which might be applied to the problems of typography in cartography is a master's thesis by Saito.[35] This thesis makes no attempt to establish whether or not such literature does in fact have application in the cartographic context; it is useful as a summary of much that is conventional in cartographic type usage.

Summary. Cartography has not developed its own body of research findings which would assist the cartographer in making his type-selection decisions. To be sure, he is admonished that the type should be legible, but he is neither told precisely what this might mean, nor told how it might be objectively assessed. While there is a substantial body of experimental literature on the legibility of type in text usage, as well as considerable literature on the nature of reading itself, we must question the utilization of this material in cartography until it can be established that type functions in an equivalent manner on maps.

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1. Virtually all maps produced in this country today are mechanically lettered in one way or another, not hand-lettered as was the custom for most maps until the latter half of the nineteenth century. Consequently, it seems reasonable to use the terms "type" and "typography" throughout this article, interchangeably with the term "lettering."

2. It is not strictly correct to speak of type "functioning" on a map; the type itself does nothing at all but exist. However, certain of its visible characteristics and its spatial arrangement may enable the map user to draw various inferences from it. In that sense, the type functions by implication.

3. Michael Polanyi, *Personal Knowledge* (New York: Harper and Row, 1958), p. 92.

4. I have heard children describe italic type as "the wavy letters" and "the curly letters."

5. Presumably this is due to the perception (by early cartographers) of the Mediterranean waters as blue. In this country, a currently more analogous choice of color might be slime green, roily brown, or pollution black.

6. About 25 college-educated adults were presented with a series of three pieces of white $8\frac{1}{2} \times 11$-inch paper, in the center of each of which there was printed the name "Chicago." On the first day, the subjects were given the sheet with the name printed in letters .2 inches high, and told: "In 30 seconds, draw a sketch map that incorporates the name as you see it in front of you on this sheet." The procedure was repeated (to the subjects' surprise) with the .1 inches lettering on the second day, and with the .6 inches lettering on the third day. Subjects were not allowed to see what they had done previously, nor did they see each other's work. The maps produced by them were remarkably similar in scale range, with each size of lettering.

7. Dennis Cheetham, Christopher Poulton, and Brian Grimbly, "Graphics: The Case for Research," *Design*, CVC (1965), 48.

8. (No author), "Map Design and Typography," *The Monotype Recorder*, XLIII (1964), 45.

9. In an unpublished report of research conducted by this author (Barbara S. Bartz, "What About Illinois? or, Children and A Reference Map," Field Enterprises Educational Corporation, Chicago, 1967, 71 pp.), it is noted that when grade school children were asked to compare two reference maps of Illinois in various ways, they almost always pointed out typographic clarity contrasts. One particularly felicitous choice of words was, "This map is blur-ish, and that map is clear."

10. Eduard Imhof, "Die Anordnung der Name in der Karte," *International Yearbook of Cartography*, II (1962), 128.

11. Arthur H. Robinson, *Elements of Cartography*, Second Edition, (New York: John Wiley and Sons, 1960), p. 249.

12. Max Eckert, *Die Kartenwissenschaft*, Vol. I, (Berlin and Leipzig: Walter de Gruyter and Co., 1921).

13. *Ibid.*, p. 342.

14. *Ibid.*, p. 346.

15. *Ibid.*, p. 343.

16. Arthur Hinks, *Maps and Survey*, Fourth Edition, (Cambridge: The University Press, 1942).

17. *Ibid.*, p. 26.

18. Erwin Raisz, *General Cartography* (New York: McGraw-Hill, 1948), p. 133.

19. *Ibid.*, p. 58.

20. *Ibid.*, p. 51.

21. Arthur H. Robinson, *The Look of Maps* (Madison: University of Wisconsin Press, 1952).

22. *Ibid.*, p. 26.

23. An unpublished report by this author (citation in Footnote 9) contains testing which shows this can certainly be true. Over 100 ten- to thirteen-year-old children were being questioned about three place name reference maps of Illinois, and they were asked, "What do you *first* notice about this map—what catches your eye first?" and names and lettering characteristics were nearly always mentioned in first place. Later the maps were turned over, and again names and lettering were items which were particularly outstanding in their memory.

24. Robinson, *The Look of Maps*, p. 26.

25. *Ibid.*, p. 29.

26. *Ibid.*, pp. 48–49.

27. *Ibid.*, p. 51.

28. Robinson, *Elements of Cartography*, p. 246.

29. Captain J. G. Withycombe, "Lettering on Maps," *The Geographical Journal*, LXXIII (1929), pp. 429–446.

30. *Ibid.*, p. 432.

31. *Ibid.*, pp. 434–435.

32. William H. Dawson, "The Lettering of Maps," *Cartography*, I (1955), p. 88.

33. John S. Keates, "The Use of Type in Cartography," *Surveying and Mapping*, XVIII (1958), p. 75.

34. Imhof, "Die Anordnung . . ., p. 94.

35. George Kazuo Saito, *An Investigation of Some Visual Problems of Cartographic Lettering*. Master's Thesis, University of Washington, 1962.

The Sweep of the Eye

The skilled reader of English has, of course, learned to read from left to right. The same is not true of readers of other languages, who may read from top to bottom (classical Chinese), from right to left (Hebrew and Arabic), or in almost any other direction possible (Diringer, 1948; Gelb, 1963), including boustrophedon arrangements in which alternate lines are read in alternate directions.[1]

Because visual space is asymmetric (Braine, 1968; Kolers, 1968a; Takala, 1951), a question arises whether, neurologically-speaking, some directions are easier for the nervous system to cope with than others. In the present experiment I was concerned with a less subtle aspect of performance, however: the demonstration that reading involves a sweep of the eyes, a learned information-processing skill.

The method required university undergraduates, skilled readers of English, to read aloud as rapidly and as accurately as they could pages of material that had been altered in various ways. The original text had all come from a single source, the polished and gracious prose in G. A. Miller's (1962) *Psychology, the Science of Mental Life*. Eight pages of typewritten text, about 310 words per page, were prepared for the experiment, two pages in each of the four arrangements shown in Figure 1. The top-most sample in the figure is, of course, normal English. The second sample is also English prose, when the lines are read from right to left. In the third sample the words from "Presented" to "manipulated" contain a sentence, but in scrambled word-order. The fourth sample preserves the lengths of words of the original and the frequency with which individual letters appeared in it, but the ordering of the letters has been scrambled.

1. There are two main types of boustrophedon, rotation and reflection. In rotation, the second and other even-numbered lines are written with their characters rotated through 180° in the plane of the writing surface. In reflection, the even-numbered lines are written with their characters in a mirror-reflection transformation of the odd-numbered lines. In both cases the eye moves continuously, either rightward and then leftward and then rightward again, or the reverse, rather than always beginning at a single margin. The regularity of succession of lines is not a requirement of the style, however. In some cases a few lines may read in one direction only, followed by one or more in the other, or some other alternation (Guarducci, 1967).

If we wish to be certain that our indicant of anxiety is valid, how should we proceed? A direct approach is to ask people to introspect on their anxiety, to report verbally how much anxiety they

ton seod sriaffa fo etats gniyfsitas eht taht edam eb nac esac gnorts A eht tahw enimreted lliw rehtar tub ,nrael lliw lamina eht tahw enimreted eriuqca lliw slamina taht deugra sah tsigolohcysp enO .od lliw lamina

Presented experimental the the order in the defense were to booklets do in for the with witnesses and the had six prosecution the for twelve which six manipulated. Recent that were most followed favoring

Mgiikehhbr chupn ni Issseo sian rrm aip drt aehtoao he bwtr asco aseoab r or coh ete erai fna slson iginls doe Emtu adnee eoee. Eneoh sap rooolef tc etahbg aaseki dh ds ssord

Figure 1. Four samples of text that were used to study the effect of directional reading habits.

For brevity I shall refer to these four samples as, respectively, N, rM, Scrambled, and Pseudowords. The subjects read each page from left to right, and from right to left. For example, half the subjects first read "If we wish to be certain . . ." and the other half first read "dilav si yteixna . . ."; they then switched tasks and read in the opposite direction. In one condition, Scrambled, the leftward reading was always of whole words, however, as "booklets to were defense the. . . ." The reason is that in Scrambled we were studying the influence of direction on the naming of grammatically isolated words.

Table I summarizes the amount of time the subjects needed to read pages of each of the four types in each of the two directions. They needed 1.28 minutes to read a page of N aloud in the rightward direction, and 9.96 minutes to read it aloud in the leftward direction.

TABLE I. *Reading Time for Two Directions (in Min.)*

Direction →	*Time*	*Direction* ←	*Time*
Normal	1.28	Normal	9.96
rM	5.72	rM	6.91
Scrambled	1.76	Scrambled	2.10
Pseudowords	5.54	Pseudowords	9.44

N, of course, makes no sense in the leftward direction and the absence of sense could be an important fact here. Therefore consider the results for rM, which read rightward is identical nonsense to N read leftward, but makes sense when read leftward. Even here, the subjects perform more rapidly in the rightward direction. Thus it is not the lack of meaning alone that causes subjects to take so long on N read leftward; the unfamiliarity of the *direction* of reading also plays a powerful role.

This conclusion is brought out even more clearly by comparing Scrambled and Pseudowords in the two directions. Scrambled, which preserves the recognizability of words in both directions of reading, suffers an impairment of almost 20% in time when it is read leftward. The impairment for Pseudowords is much greater: read rightward, Pseudowords takes about the same amount of time as rM read rightward, and read leftward Pseudowords takes about the same amount of time as N read leftward.

We see then in three tasks—reading sensible prose, scrambled prose, and pseudowords—that the reader's skill is expressed not only in the recognition of the alphabetic elements of words and in forming their approximate sounds, but also in the inertia or momentum that carries him more rapidly in one direction than in the other. This directional reading bias is independent of the sense of the message he is reading, as shown by performance on Scrambled where there is no message, and on Pseudowords where there is no sense; the bias represents the action of an information-processing skill. Neither letters nor words are processed one-at-a-time in normal reading (Kolers, in press); the results on Scrambled and Pseudowords show that the sweep or skilled sequencing is expressed independently of the material read. This skill is, in a certain sense, content-independent for it manifests a high degree of transfer across various reading tasks.

The sweep of the eye illustrates a linked perceptuo-motor component in reading. But many other skills, and other psychological processes, characterize reading. Of particular interest to designers of typefaces is the problem of orientation of characters. I shall describe two experiments in which orientation was manipulated.

If the sweep of the eye were the decisive variable in reading, skilled readers of English would always read more rapidly in the rightward direction. In point of fact this does occur, but its significance is hard to estimate when we realize that precisely that behavior is the one on which skill was acquired. Are there some other aspects to orientation that should be considered; is the alphabet we now use the optimal one?

Pages of text were again taken from Miller's book, but now they were prepared in the eight transformations shown in Figure 2. On each of eight test days, 32 male undergraduates from Harvard University and the Massachusetts Institute of Technology read one page in each of the eight transformations illustrated. They read aloud as rapidly and as accurately as they could; they read different pages on each of the test days; and they read the transformations in different orders, to minimize the influence practice on any one transformation exerted on performance on another.

The upper four transformations (N, R, I, M) rotate lines of print around the principal axes of three-dimensional space. N is normally oriented text; R is a rotation of 180° in the plane of the page; I is a rotation of 180° on the horizontal axis of each line; and M is a similar rotation on the vertical axis, or mirror reflection. (The asterisk shows where each pair of lines begins.) The lower set of four transformations reproduces the upper and, in addition, reverses every letter, making rN, rR, rI, and rM. We recorded two aspects of performance, time required to read a page in each of the transformations, and errors made in the reading. I shall discuss some aspects of time here.

The amount of time the 32 subjects required is shown in Figures 3A and 3B, the former for the rotations and the latter for rotations whose letters had been reversed. The salient fact of the figures is that transformations which may be regarded as geometrically equivalent rotations in space are not equivalent for the reader: I and M take far

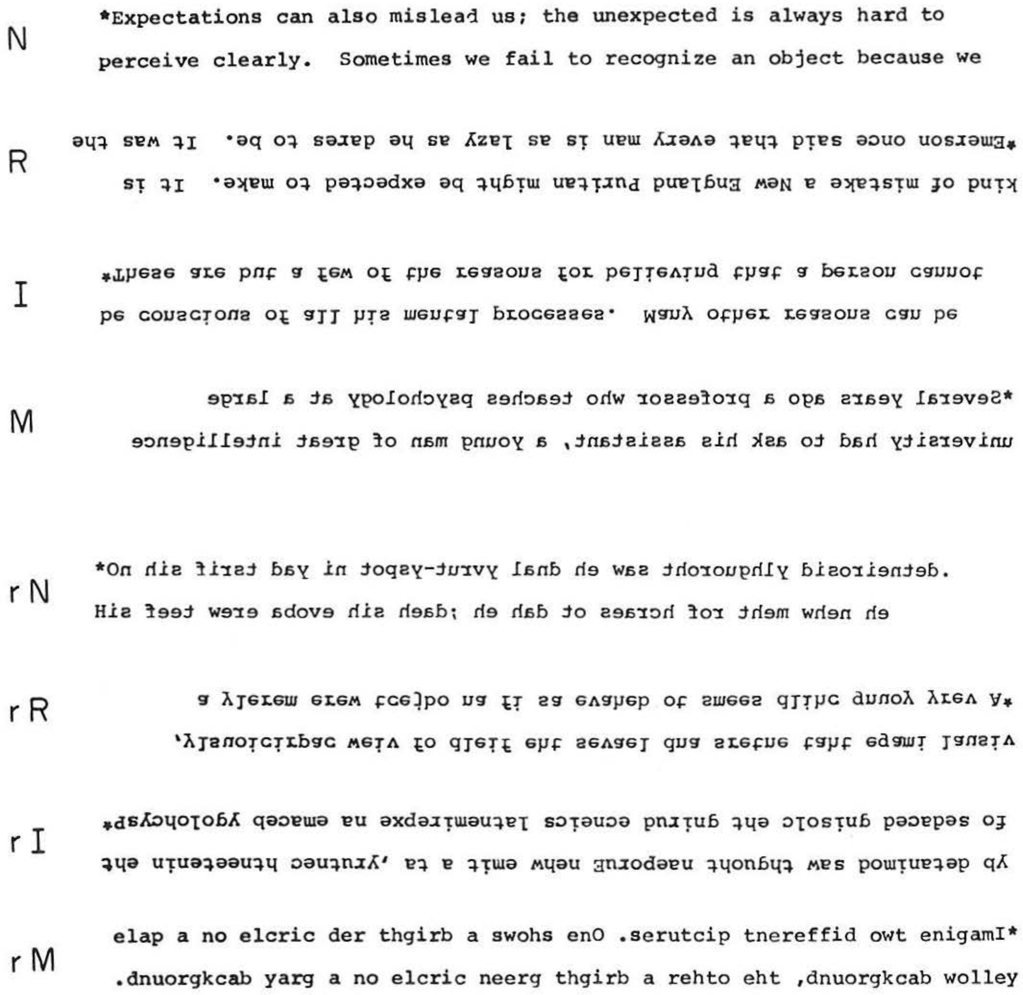


Figure 2. Eight samples of geometrically transformed text. The asterisk shows where to begin reading each pair.

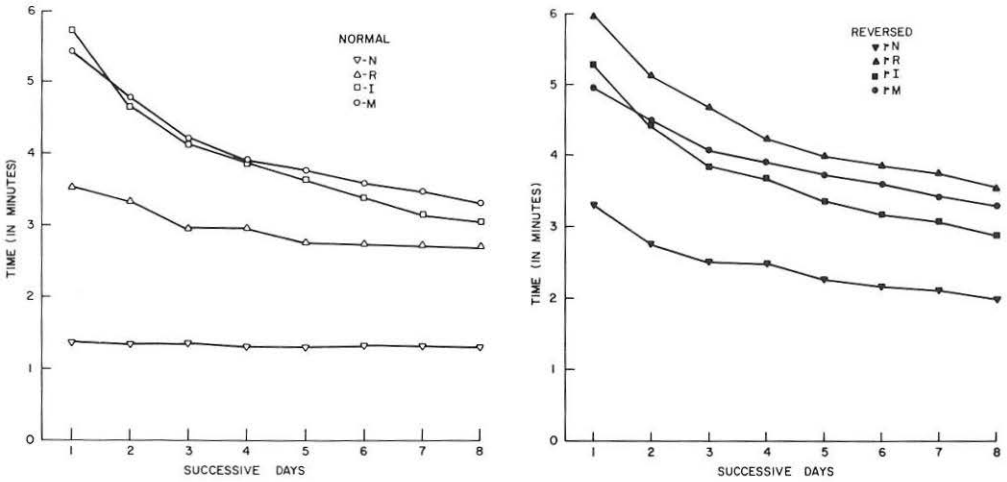
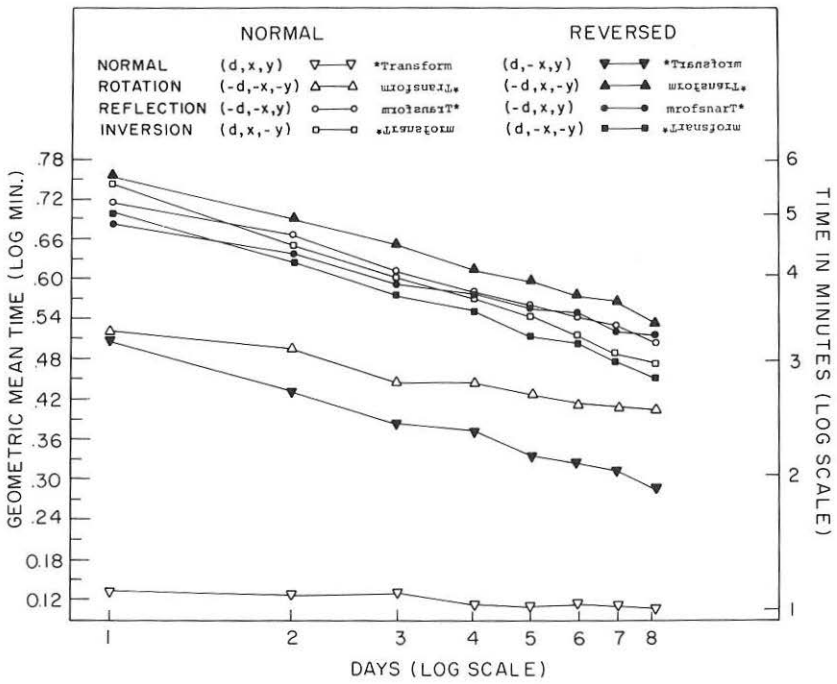


Figure 3. The amount of time taken to read pages in the transformations illustrated in Figure 2. A. the upper four transformations; B. the lower four.

Figure 4. The data of Figure 3 replotted on log-log co-ordinates to show the order of their difficulty.



more time than R. A second aspect of the data is that reversing letters affects the transformations differently. For example, reversing normal letters creates a transformation that is read quite rapidly (rN); rotation in the plane of the page (R) is also read rapidly; but reversing rotated letters creates the transformation that takes the longest time (rR). On the other hand reversing inverted text (rI) creates a transformation that is read more rapidly than text that is only inverted (I).

These and other facts can be seen more easily in Figure 4, where the data of Figure 3 are replotted on log-log co-ordinates. (The left ordinate shows not the arithmetic average of the measured time, as in Figure 3, but the arithmetic average of the logarithms of the measured time. The measured time equivalents are shown on the right ordinate, on a logarithmic scale.) The inset legend illustrates the transformations; it also expresses them in terms of the (x,y) co-ordinates of a Cartesian graph and the direction of reading (d).

Earlier I showed there is a skilled sweep to the eye that enables the reader to apprehend words more rapidly in the rightward direction. In Figure 4 we see again that normally-oriented text read in the rightward direction is the easiest to read; but some other relations qualify the interpretation of the idea of skilled sweeping movements. The chief qualification is suggested by the observation that transformation R, which is read leftward, is among the easiest to read, far easier than two others that are read rightward (I and rI). I do not yet have a complete explanation for this fact but have offered some conjectures elsewhere (Kolers, 1968a; Kolers and Perkins, in press).[2] We may explore it in another context.

Transformations analogous to those shown in Figure 2 were made of Hebrew text, and native readers of Hebrew unfamiliar with right-

2. An explanation based only on past experience is not sufficient. We may all have read other people's newspapers in the bus and subway, and even perhaps read other people's mail across their desks; we have also read store-window signs from inside the store (transformation M). We are very unlikely to have read inverted text (transformation I), yet it takes less time than M. Furthermore, few people are likely to have encountered transformation rN before the experiment, yet it is actually the easiest to read except for N.

going languages were tested.[3] Our interest was two-fold in making this test. First, to find whether the order of difficulty of the transformations, shown in Figure 4, was related to the direction of reading or to some other variable; and second, to make a specific comparison between performance on transformations I and R. Consider the latter problem first.

A rotation in the plane of the page of English text creates letters that are upside down and that face and are read leftward. An inversion of English creates letters that are upside down and are read rightward. A rotation of Semitic texts, which are normally read leftward, creates letters that are upside down and are read rightward; an inversion of Semitic text creates letters that are upside down and are read leftward. Thus the geometric arrangement of rotated English is identical to the arrangement of inverted Hebrew or Arabic, and the arrangement of inverted English is identical to rotated Hebrew or Arabic. Symbolically, $R_e = I_h$ and $I_e = R_h$. (I use "h" because the experiment was carried out in Israel on readers of Hebrew.)

The question of interest is whether native readers of Hebrew have more difficulty with rotated than with inverted Hebrew, or whether, like the American subjects, they find rotation easier to cope with than inversion. The former outcome would be predicted by a strict interpretation of hypotheses that assume that directional preferences are innate in the human visual system (for example, Smith and Smith, 1962); the latter is consistent with the notion that people possess preferred ways of coping with objects that have been transformed in space, but the preferences are expressed relativistically. Our finding with native readers of Hebrew was that they, too, found rotation easier to deal with than inversion, even though the base to which the transformation was applied was different in direction, proceeding from right to left in Hebrew rather than from left to right as in English. The order of difficulty of the transformations was substantially similar in the two languages. That is, the operations performed on the text created problems of similar magnitude among

3. This and the preceding experiment are described in greater detail in Kolers, 1968 (b).

readers of English and readers of Hebrew. It is not the geometry of the characters or the direction of scanning them that creates the major problem; it is the transformation to which the characters have been subjected.

Therefore, as powerful as the sweep of the eye is, performance must be understood in terms of a more complex variable, the ability of the human visual system to recognize familiar objects that have been transformed geometrically. I will discuss this problem again in the next section, but before doing so will pause for a historical footnote.

In contemporary Israel one sometimes encounters people reading newspapers that they hold upside down or even at 90° to the normal. The people are usually Yemenites, Jews from the southern tip of the Arabian Peninsula who grew up in dire poverty but with strong religious inclinations. The religious inclination induced them to study holy books, but the poverty made the books scarce. I am told that the usual mode of study was for boys to take fixed places around a table on which a book was laid out. Thus some boys learned to read pages upside down, others learned to read at other angles. A similar condition, I have read someplace, characterized learning to read in Europe during the Renaissance when books were scarce, and as late as the end of the nineteenth century in some rural parts of America. The Yemenites actually comprise a natural sample for experiments on the legibility of various transformations of text. Can equivalent degrees of skill be attained on any orientation of characters? The question might be answered by studying whether Yemenites who normally read text upside down or at other angles can do so as rapidly as their peers who read rightside up. (One might anticipate some interference in reading for a Yemenite who normally reads upside down as he wends his way through a street of shops whose signs are rightside up.)

A related phenomenon can be observed in contemporary Yugoslavia where children learn two different alphabets to represent approximately the same language. In eastern Yugoslavia (Serbia) the Cyrillic alphabet predominates, and in western Yugoslavia (Croatia) the Roman alphabet predominates. As a matter of fostering national unity, all Yugoslavian children learn to read and write their native language, Serbo-Croatian, in both alphabets. Regrettably,

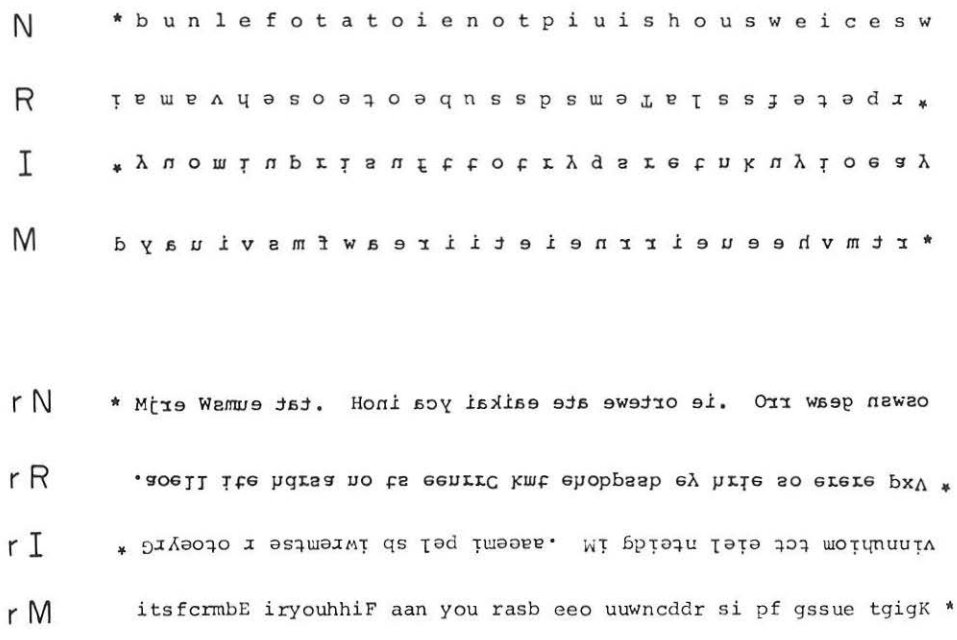


Figure 5. Isolated letters and pseudowords transformed as in Figure 2. Only four samples of each kind are shown.

I am not familiar with the details of instruction or with any studies of interference in learning.

Selecting Clues

I have shown now that the eye's passage along lines of print develops a sweep or inertia, and that this sweep must be understood within the context of a larger frame of reference or sense of orientation. In an experiment in which we required subjects only to name letters that had been transformed, these two concepts come together to yield some suggestions about the design of typefaces.

We studied the way subjects named letters as a simpler instance of the processing of text. Connected discourse and even isolated words have both grammatical and spatial characteristics; isolated letters eliminate the grammatical component. In doing so, of course, they destroy the main function that letters serve—conveying substantive information; nevertheless, something about the processing of words

TABLE II. *Time Taken to Name Transformed Letters (in Min.)*

Transformation	*Letters*	*Pseudowords (800 letters)*
N	4.65	4.51
rM	5.66	6.16
I	7.96	8.77
rR	8.55	9.56
rN	7.06	7.86
M	7.20	8.04
rI	7.16	8.33
R	6.72	7.64

can be learned from a study of the way people recognize isolated characters.

The subjects were 10 undergraduates whose native language was English and whose reading skill was restricted to right-going languages. They named aloud pages of letters that had been transformed geometrically in the manner of Figure 2. On eight pages the letters appeared as isolated characters, preceded and followed by a blank space. These pages contained 26 lines of letters, exactly 32 letters to the line. On another eight pages the letters appeared as pseudowords, clustered according to the distribution of word-lengths in the original page of connected discourse. There were about 1170 letters to each page of pseudowords. The randomizing of letter sequences, performed by a computer for both kinds of pages, preserved the relative frequency of the letters in the initial page of connected discourse. Four examples of Letters and four examples of Pseudowords are illustrated in Figure 5. Notice that for letters considered individually, the eight transformations actually create only four different geometric arrangements. The letters of N and rM are individually identical, as are those of rI and R, rN and M, and I and rR. The difference between N and rM, for example, is not in their geometry but is in the direction in which they were named.

Table II shows the amount of time the subjects needed to name 800 letters of Letters (not counting the first line) and the first 800 letters after the first line on the pages of Pseudowords. The data are

arranged as four pairs of similar transformations; they show the sweeping action of the eye in another way. Subjects take considerably more time to name the letters of rM than the letters of N despite the fact that the letters are geometrically identical in the two cases. The same is true for I and rR, the latter similar in appearance to I but named leftward. In one comparison, rN and M, no significant difference occurs, however; and in the fourth, rI and R, the advantage lies with the leftward direction.[4]

If only the directional sweep of the eye were important in this task, we would expect that the subjects would always name letters more rapidly in the rightward direction. But they do not do so. I shall now show nevertheless that sweep of the eye is important, but that it must be understood within the context of a sense of orientation.

In some of the samples of Figures 2 and 5 letters face leftward, opposite to their familiar direction of facing. One might think that this would interfere with their recognition. If it did, then letters facing in the unfamiliar leftward direction would always require more time to be recognized and named than their right-facing mates. In respect of facing, the transformations can be paired in the following way: N and rN, I and rI, rM and M, and rR and R. The data of Table II show that right-facing letters are named more rapidly than their left-facing mates in only two cases, however. Therefore, neither direction of scanning the lines nor direction in which the letters face can by themselves account for our results. But if we consider these two variables together, we can describe a characteristic of the letters that we may call directional consistency: whether the letters face in the direction in which they are named.

Directionally consistent letters face left when they are named leftward and face right when they are named rightward. Transformations N, R, I, M are directionally consistent, whereas rN, rR, rI, and rM are not. Looking again at the pairings of Table II we find that directional consistency accounts for the advantage of six of the eight transformations. A perfect accounting of data by our hypothesis requires that M be named more rapidly than rN, but this was not

4. This experiment is described in greater detail in Kolers and Perkins, in press, (a, b).