Clues to a Letter's Recognition: Implications for the Design of Characters

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Several experiments are reviewed in which orientation of letters and direction of reading were manipulated. The results imply that skilled readers recognize letters by selecting clues to their identity and with these clues construct a subjective representation of the letters. The clue-seeking seems to be directed toward the right-hand side of letters. This finding suggests that typefaces might be redesigned to avoid bold strokes weighted on their left or heavy strokes that are all of equal weight. Some indication of where a character begins and a sharpening of the useful detail on the characters' right could facilitate the sampling that yields recognition. A second implication is that character-transmitting devices need not examine or transmit all of a character. Reconstruction, if needed, could be performed by the receiving instrument from the clues provided by a representation of the character's linear extent and its right-hand markings.

Several efforts to establish criteria for type design on an empirical basis have been made. I shall summarize the results of experiments on skilled readers of English that suggest some new principles for the design of type.

Under ordinary circumstances it is very difficult to learn much about the operations skilled readers go through when they read. The reason is that, by virtue of their skill, they process the material too rapidly for ordinary observation to make out the details. Many of the operations that are visible in a beginning reader are performed so smoothly by the skilled reader that Huey's (1908, 1968) analogy must be considered seriously as a first approximation to the process. His argument is that the reader engages in a complex perceptual-motor processing of information that is similar in many ways to the performance of a skilled athlete. The analogy emphasizes the automaticity and smoothness of performance, the inferences, predictions, and assessment of partial cues that characterize both the skilled reader and the skilled tennis player, say. These hallmarks of skill, automaticity and prediction, establish reading as a complex process that goes far beyond the mere apprehension of letters on a page or the appreciation of meaning from a word-by-word uptake of the collected letters. It is worth noting Huey's remarks on this process.

The complexity and the automaticity make the study of reading difficult under ordinary circumstances. Thus, if we wish to study the process, we must change the circumstances. The scientist's method, when he is faced with complexity, calls for distorting reality. He creates artificial conditions that make a stage on which selected variables can act out their roles. The scientist builds his theory by studying the relations between those aspects of the complexity that he or his colleagues have chosen to manipulate. The scientific method, because it *selects* variables for manipulation and study, does not and cannot reproduce the complexity of reality. What it does do is study the influences that are deemed to be the most important for any situation. The success of the theory depends in large measure on the good taste expressed in the original selection of variables.

I begin with these well-hallowed truisms of the scientific method because the experiments I shall describe utilized many "unnatural" arrays of text. Saying these things now, I hope to forestall the criticism sometimes made of this work that, because the text was not normal, the results have little to say about normal reading. In rebuttal I would say that just because the situations are abnormal the principles revealed by behavior in them can be used to understand the way printed text is normally read, for the behavior reveals preferred or habitual modes of responding to printed text.

The experiments will show, first, that reading is carried on by an information-processing activity that builds up a considerable inertia or sweep, and that is strikingly dependent upon sequences of skilled movement. Next I will discuss some effects of unfamiliar orientation upon the recognition of text, and thirdly, upon the recognition of individual letters. At the end I will discuss the implications these results have for design of type.

observed. The results obtained with this pair do not contradict our hypothesis, however; therefore for the moment let us allow them to lie dormant while we explore its implications.

One idea advanced by Kolers and Perkins is that people do not need to see all of a letter in order to recognize it; rather, the recognition is accomplished by the person's constructing a representation in his own mind of what he is looking at, based on the use of a few clues to its identity. As I shall show below in more detail, the most helpful clues to a normal letter's identity appear on its right. Some notion of where the letter begins and some indication of its righthand extension provide a great deal of the information needed for recognition. How does it happen then that in at least one case the leftward scanning direction takes less time than the rightward? The answer we suggested is that the scanning is done within the context of a frame of reference or orientation set. Our subjects, we allege, are able to perform a mental transformation that enables them to do on the left of a letter that is named leftward the same things they would do on the right of a letter named rightward. They develop a set or attitude which not only allows them to perceive physically transformed objects, but enables them to transform the actions they must perform in a manner that is consistent with their set.

We believe that letters are not perceived through a passive uptake of their physical characteristics; rather, they are interpreted within the framework of a person's sense of orientation in space and some notion of what he is doing. (In the case of letters such as b, d, p, q this is clearly obvious, since one cannot identify any of these letters correctly with more than chance frequency unless he knows what the orientation is of the page he is looking at.) Our assertion, therefore, is that not only is a sense of orientation of the self and the page necessary for correct identification of letters, but also that the identification is performed by the visual system through the exercise of skilled sampling or scanning strategies. One novel feature of these ideas is that we suggest also that such skilled scanning strategies or motoric movements can themselves be transformed appropriately to accommodate a transformation of the test materials.[5]

5. As is well-known, the "secret script" of Leonardo Da Vinci, who was left-handed, was only a leftward writing and leftward facing of ordinary letters. In some

These matters of spatial orientation are somewhat removed from the main point of this paper, however; I have discussed them only to provide a rational basis for the data I have presented. More germane to this paper are the assertions that the important parts of a letter in the Roman alphabet are on its right, that people look for clues to a letter's identity rather than look at a whole letter, and the implications of these facts for type design.

The Design of Letters

I am told that the designer of letters learns to make his downstrokes heavy and his upstrokes and curves light. The faces that result are not read easily when they appear on the television screen or on the screen of the television-telephone (PICTUREPHONE®) now under development. Some special compensatory adjustments are sometimes made for television transmission (Bass, 1967; Shurtleff, 1967).

Weighted downstrokes have esthetic appeal; heavy curves or upstrokes make letters look top-heavy or clumsy. But because letters have the shapes they do, the major downstroke for Roman letters tends to be at the left edge. B, D, F, K, and so on, among capital letters and small, have heavy strokes at their left; their distinguishing marks, however, are on their right. This is seen easily in Figure 6, which is taken from the Bureau of Public Roads' (1966) *Standard Alphabets for Highway Signs*. (I choose this source as an example; almost any other standard source would do.) The heavy stroke at the left acts as a trap or moat for the eye, for it requires a good deal of visual processing to be apprehended, yet it conveys very little information. The lack of information is easily confirmed by sectioning the letters as I have done in Figures 7A and 7B.

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preliminary experiments I have carried out on handwriting, I have found that right-handed people who are requested to write with their left hands can usually do so at least as well (and usually better) if they write in mirror image script like Leonardo's than if they write in a rightward direction. I have even found that when people try to write simultaneously with both hands, they usually find it easier to move their hands in opposite directions (one hand normal, the other in mirror-image script) than to move both hands in the same direction.

A B C D E F G H I J K L M

N O P Q R S T U V W X Y Z

a b c d e f g h i j k l m

n o p q r s t u v w x y z

Figure 6. One alphabet recommended by the Bureau of Public Roads.

In Figure 7A the right halves of the letters in the Standard Alphabet have been obliterated and in Figure 7B the left halves have been obliterated. Both kinds of mutilation impair the identification of the letters, of course; but it seems quite clear that retaining only right halves allows more letters to be identified unambiguously than retaining only left halves.

Similar mutilations performed upon upper and lower halves of letters are shown in Figures 8A and 8B. Among capital letters, retaining the lower half seems to be more advantageous, but among lower-case letters retaining the top half provides more of the information needed for their correct identification.[6]

I have used the Bureau of Public Roads font for these mutilations because that source conveniently lays the letters out on a matrix.

6. E. B. Huey (1908, 1968) noted some years ago that obscuring the lower half of a line of print interfered less with its legibility than obscuring the upper half. This finding now seems to depend upon the fact that a line of print contains many more lower-case than upper-case letters.

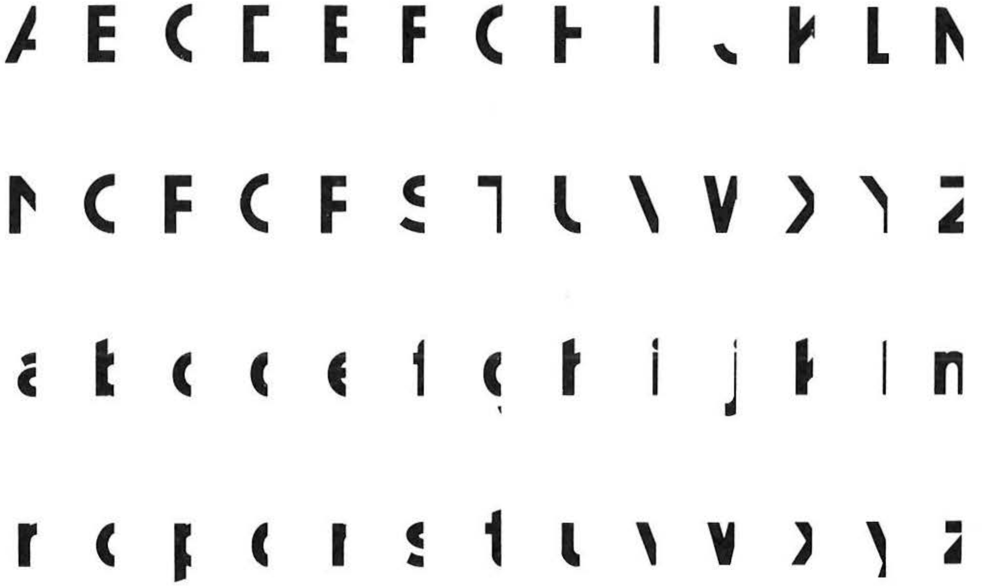


Figure 7. Vertical halving of the alphabet of Figure 6. A. right halves obliterated; B. left halves obliterated.

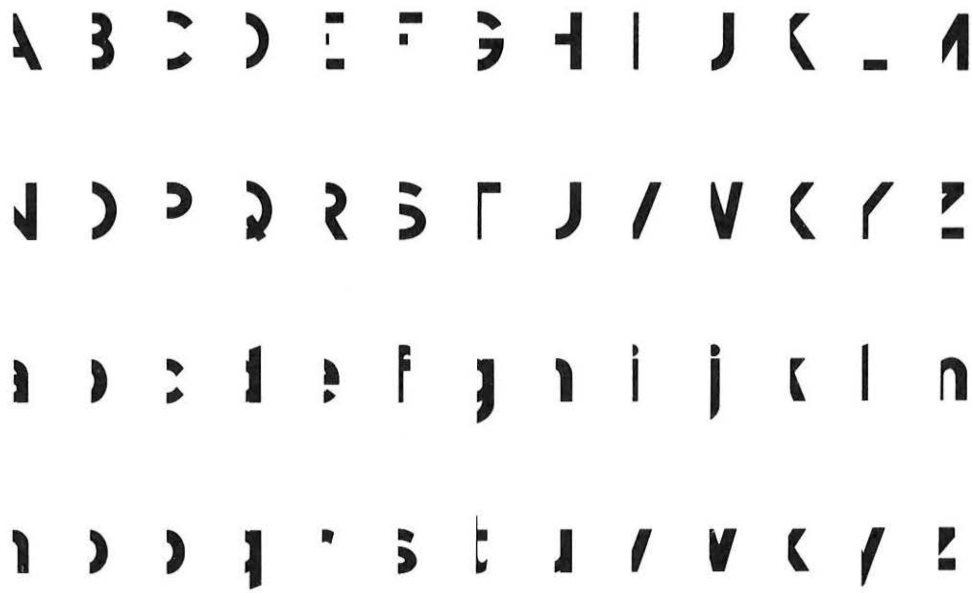
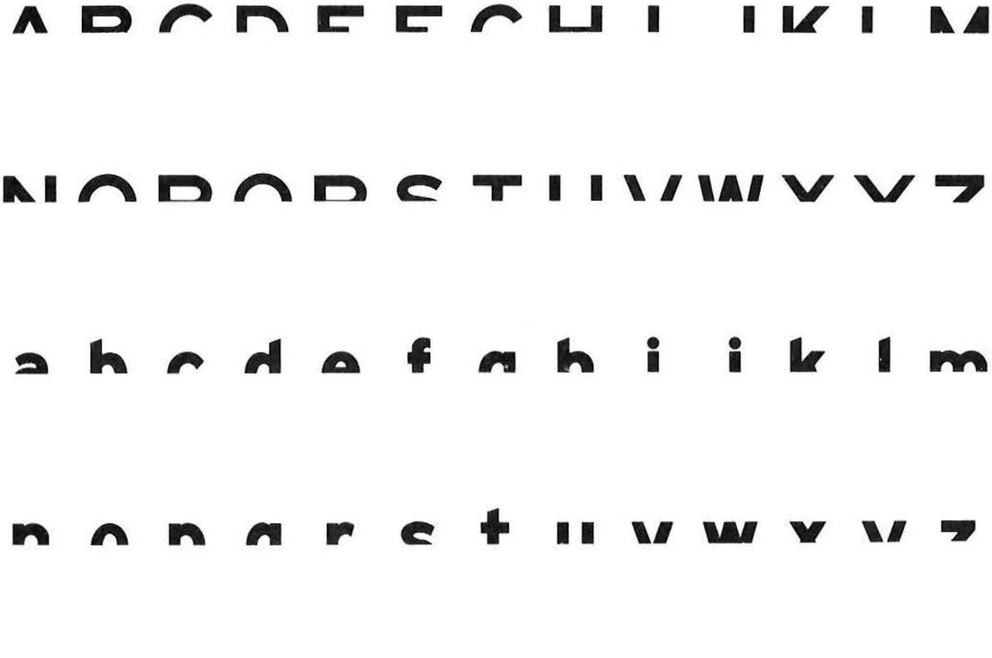


Figure 8. Horizontal halving of the alphabet of Figure 6. A. upper halves obliterated; B. lower halves obliterated.



Sectioning the letters is therefore an easy matter, for in order to halve a letter we need only count the number of cells to its linear extent and divide by two. Sectioning letters from commonly used faces is not quite so simple; letters on a typewriter, for example, are not usually centered in this geometrically exact way. I have found with several faces that the place indicator on the typewriter coincides only rarely with the geometric center of the letter. The designer of faces for the typewriter seems to offset his letters somewhat. Figure 9 illustrates the IBM Courier typeface used for the experiments I have described. The thin vertical lines above and below the letters represent the lines on a page of graph paper with which the centering indicator of the typewriter was aligned. In Figures 10A and 10B the results of halving that typeface are visible. Again both mutilations make some letters illegible, but the advantage lies clearly with retaining the right half of letters.

The conclusion seems clear that typefaces that emphasize bold downstrokes for the Roman alphabet, however elegant the letters esthetically, impede their smooth visual processing. As I have shown, the skilled reader needs to look more to the right than to the left; hence the typeface designer concerned to facilitate reading should emphasize the distinguishing marks of letters rather than the informationally impoverished downstroke. Distinguishing marks appear on a letter's right.

Not all alphabets are polarized spatially in the way the Roman alphabet is. The Sinhalese and Thai alphabets come to mind as directionally ambiguous examples. (Chinese, on the other hand, used to be written in vertical arrays that were scanned downward and then leftward; and the lower half of Chinese logograms tends to contain more information than the upper.) It should be possible to take advantage of the spatial location of clues to design a typeface that is pleasant in appearance and yet lubricates the path of the eye along the line of print.

It is not an easy matter to formulate principles on the basis of so few experiments that should guide the design of typefaces intended to facilitate reading; indeed, it is not known even on a theoretical basis how much improvement in speed of reading could be anticipated from such changes. Tinker (1963) compared speed of reading

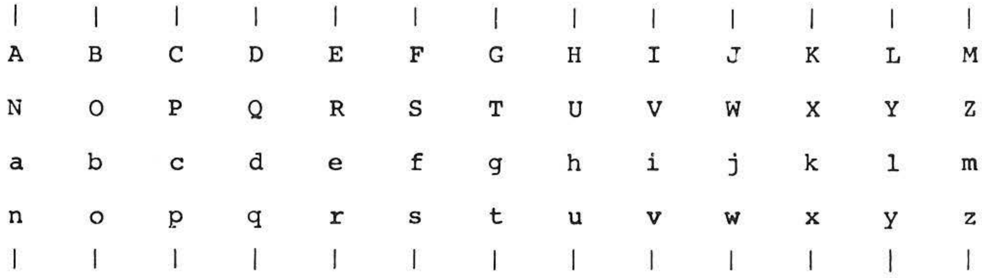


Figure 9. The typeface used in the experiments.

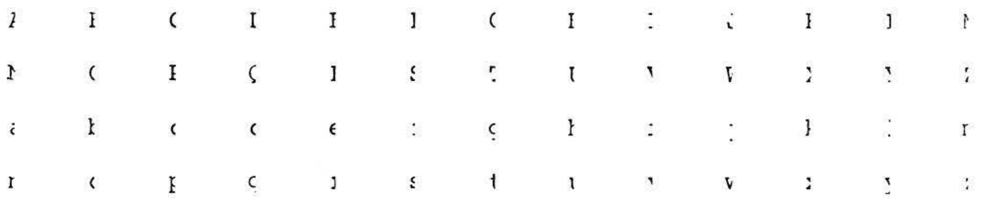


Figure 10. Vertical halving of the alphabet of Figure 9. A. right halves obliterated; B. left halves obliterated.

identical passages on ten common faces, among them Scotch Roman, Garamond, Bodoni, Caslon, and Cloister Black. Using Scotch Roman as a standard, he found that speed on seven of the other faces was affected by less than 2.5%; speed on American Typewriter was 4.7% less; and speed only on the elaborate and unfamiliar Cloister Black was seriously less, 13.6%. Lacking theory, the issue must be settled by empirical tests.

In Figure 11 a face is shown that incorporates some of the recommendations implied by the results of the experiments I have described. Designed by Jerome Abelman of Bell Telephone Laboratories, the face emphasizes the right side of letters and has few heavy lines on the left. I offer it not as prescription but as illustration. In constructing it we have tried to stay within the conventions that define the letters of the Roman alphabet, but there is no reason in principle that these ancient marks cannot be changed. Doing so might lighten the reader's burden and make his performance more efficient.

I have spoken only about the human recognizer of characters, but the results also have an implication for machine recognition of characters. Because characters tend to be distinctively marked on their right, it may be unnecessary for character-transmitting machines to examine or transmit all of a character. The same principles that seem to characterize the human's examination could be made to characterize the machine's, so that the machine examined only the linear extent and the right-hand side of characters, and transmitted only the result of that examination. If presenting the entire character to the recipient were thought to be desirable, the character could be reconstructed by the receiving device, either through a memory unit within itself, or through the intervention of an intermediary processing station, such as a central computer office. Some compression of the bandwidth required for transmission might be effected in this way.[7]

7. The experiments were carried out at the Research Laboratory of Electronics, Massachusetts Institute of Technology. Some of the ideas expressed were worked out in Project Zero, Harvard Graduate School of Education. This paper was prepared at the invitation of the Editor, *Journal of Typographic Research.*

Figure 11. Typeface suggested by the results of reading experiments.

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