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4. *Pis'ma i bumagi imperatora Petra Velikogo*, VIII/1, 289. Peter I's order says among others: "'Tol'ko "dobro," "tverdo" napechatat', kotorye skhodny k pechati, a ne k skoropisi. . . ."

5. Cf., S. L. Hartz, *The Elseviers and Their Contemporaries* (Amsterdam: Elsevier, 1955), p. 76; also

M. Dögen, *Architectura militaris moderna* (Amstelodami: Apud Ludovicum Elzevirium, 1647).

6. Commemorative plates depicting firework displays organized on various occasions such as Peter I's military victories. Cf., Gollerbakh, *op. cit.*, p. 6.

7. A. Shitsgal, *Graficheskaia. . . .*

8. *Ibid.*, 87.

9. *Bol'shaia sovetskaia entsiklopediia*, 2d ed., Vol. XII.

10. V. Ia. Adariukov, *Kniga v Rossii*, Vol. 1: *Russkaia kniga ot nachala pis'mennosti do 1800 goda* (Moskva: Gosudarstvennoe izd-vo, 1924), p. 139.

Directional Consistency in Form Identification

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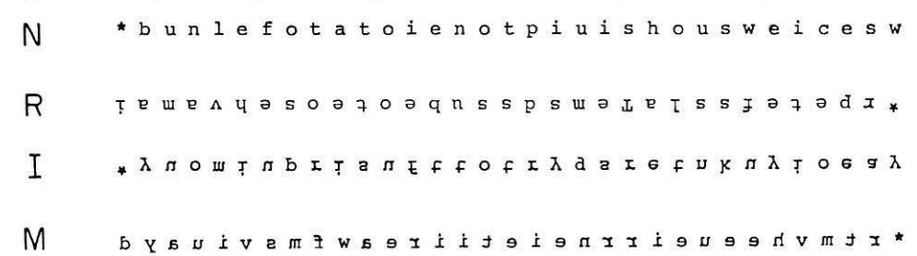
An experiment is reported, the results of which are taken to support Kolers' theory of directional consistency in letter identification. The connection between this effect and a number of studies on the identification of tachistoscopically presented patterns is commented upon. The connection between the effect and the results of experiments on visual search is also noted.

Kolers (1969) has suggested that the differences in the speed with which letters subjected to geometrical transformations can be identified when read from left-to-right or from right-to-left may be accounted for by a hypothesized "directional consistency." In his experiment, subjects read lines of letters which had been transformed as shown in Figure 1. The direction of reading was varied, all transformations being read both left-to-right and right-to-left. Kolers found that left-to-right reading was faster for conditions N and I, right-to-left was faster for condition R, and there was no difference for condition M.

In attempting to account for these findings, Kolers noted that when transformations N and I are read from left-to-right, direction

Figure 1. Examples of the geometrically transformed texts used by Kolers (1969).



of reading is consistent with the direction of the letters, whose distinctive characteristics are to the right of the letter. Similarly, direction of reading and letter direction are consistent for conditions M and R when these are read from right-to-left. When N and I are read from right-to-left, and M and R are read from left-to-right, reading direction and letter direction are inconsistent. He therefore suggested that identification was assisted by directional consistency, defined as "whether the letters face in the direction in which they are named" (p. 158).

This suggestion can be related to a substantial amount of work which has been performed on the facility with which stimuli exposed tachistoscopically across the visual field can be identified. These studies may be summarized by saying that for directional stimuli, those shown in the left visual field are reported more accurately than those shown in the right visual field. This has been found with both right-to-left and left-to-right order of responding. Left-to-right responding gives more accurate responses overall (Bryden 1960; Harcum 1964). For non-directional stimuli—such as open and filled circles or geometric forms—left -to-right report leads to more accurate response to stimuli shown in the left visual field. Right-to-left report tends to produce more accurate responses for stimuli shown in the right visual field (Ayres and Harcum 1962; Bryden 1960; Harcum 1964). The reading habits of the subjects influence the results: those who are used to reading from right-to-left tend to show right-field superiority for both left-to-right and right-to-left report orders (Harcum and Friedman 1963). Both the subjects' reading experience and the nature of the material effects the results of this type of experiment.

The task in these studies differs considerably from that studied by Kolers. The tachistoscopic experiments rely on brief exposures of the stimuli and short-term memory processes. Kolers' procedure is concerned with the identification of lines of stimuli which are processed serially by the subject at his own speed and without memory being involved to any significant extent. Nevertheless, it is interesting that in both types of situation, investigators should have emphasized the influence of stimulus directionality and report order on their data.

The tachistoscopic studies give some support to Kolers' theory,

since they provide further evidence that when directional (pointing right-ward) stimuli are processed in a left-to-right order, response accuracy is greater than when they are processed in a right-to-left order. Further indirect support comes from tachistoscopic studies which have presented stimuli to left or right of the fixation point in successive exposures. Harcum and Finkel (1963) demonstrated that for letters arranged in normal word sequence and in normal orientation, right-field stimuli were identified more accurately than those shown in the left visual field. When mirror-image words were used, left field stimuli were the more accurately identified. This may be interpreted as indicating that more accurate responses occur when scanning direction and stimulus direction are consistent. Harcum (1966) showed words (1) with letters in normal sequence and orientation, (2) with reversed orientation and reversed sequence, (3) with correct sequence and reversed orientation, and (4) with correct orientation and reversed sequence. The stimuli were exposed successively left or right of fixation. Right-field superiority was found for conditions 1, 3, and 4; left-field superiority was found for condition 2. Harcum concluded that "perceptual accuracy is greater when scanning tendencies produced by stimulus characteristics and by reading direction agree in direction" (p. 480).

A corollary of the directional consistency hypothesis is that where there is no directional consistency; i.e., where the stimuli have no directionality, processing sequence—which in the case of Kolers' procedure means order of identification—should not produce differences in performance.

The tachistoscopic experiments mentioned above are also relevant here. With non-directional stimuli (geometric forms), Bryden (1960) found that there was no difference between overall accuracy scores for left-to-right and right-to-left reporting. Ayres (1966) reports that with vertical lists of binary elements equal scores are obtained for top-to-bottom and bottom-to-top responding. For horizontal patterns, however, the left-to-right sequence gave more accurate responses than the right-to-left sequence.

Aim

Directional consistency means that letter direction and reading direction are the same. It follows that if directional consistency is a

determinant of identifiability, then where letters have no direction, reading direction should not effect the ease with which the letters can be identified. Due to previous reading experience, it may be that with both types of stimuli left-to-right reading is superior to right-to-left. But in this case the directional consistency hypothesis predicts that the difference between performance with the two reading directions will be less for non-directional stimuli.

Method

Eight of the upper-case letters which are non-directional (in that they are vertically symmetrical) were used to form displays containing forty letters. The letters used were X H Y M O T V W. Each occurred five times in the lists, of which there were two. In each, the order of letters was decided by a randomization process. Two further lists were made up from eight of the directional letters. The ones used were R L E F P B K D. The displays consisted of four lines of ten letters, typed on white cards. Examples of these displays are shown in Figure 2.

The lists were administered to 32 subjects who read one directional and one non-directional list in each reading direction. The subjects formed two groups, one of which performed the tasks in the order

List A

R E L R P P F K D B
L P R K L E D D R P
E B E D B F P D L B
F K F R L E F B K K

List B

R L E F E P B K L R
E R K D R P L B E L
P E D F F P F K D E
D B D R L K B P B K

List C

H M X O V X H Y W Y
T M T T X O M O Y X
W M W Y H V V H X H
Y T M W O V O T V W

List D

H V Y T M W H X M O
M X W T O M V H W V
X H T X Y W V Y O T
O Y M O X H T V Y H

Figure 2. Displays of directional and non-directional letters.

DNND, the other having the order NDDN. The pairing of list and reading direction was counterbalanced so that each list was read an equal number of times in each direction.

The subjects read the lists aloud, letter by letter, and the time taken was recorded.

Results

For each subject, the difference between the times taken to read the directional lists in the two reading directions and between the times taken to read the non-directional lists in the two reading directions were calculated. The null hypothesis states that the difference between left-to-right and right-to-left reading times for directional lists should exceed the difference between left-to-right and right-to-left times for non-directional letters of 50% of occasions. The observed frequency falls well above this: 23 of the 32 subjects showed a greater difference between reading times on directional than on non-directional lists. The data was analyzed using the chi-square test, and it was found that the observed frequencies differed significantly from those expected on the null hypothesis. It may therefore be concluded that there was a significant tendency for reading direction to have a greater influence on directional than on non-directional letters.

Discussion

The results of this experiment lend support to Kolers' hypothesis concerning directional consistency. For the majority of subjects, reading direction had a greater effect on directional than on non-directional letters.

Brown and Strongman (1966) report that in a visual search task, search times are shorter for horizontal rows of letters in which the letters are normally oriented than for rows in which the letters are turned through 90° in an anticlockwise direction. This finding can also be taken as support for the notion that stimulus directionality affects task performance.

Brown and Strongman also found that with vertical lists, those with correctly oriented letters (D) were searched more rapidly than ones with rotated letters ($\frac{D}{T}$). The former arrangement is counter

to directional consistency, the letters being right-pointing in the horizontal plane, the list being vertical. It is therefore to be expected, on the directional consistency hypothesis, that vertical lists with normal orientation will be searched less rapidly than normally-oriented letters in horizontal lists. This result was obtained by Brown and Strongman. If we consider the two vertical lists, the one with rotated letters is more counter to directional consistency than the other. Subjects had to search the lists from top to bottom. With the letters in the particular rotated orientation chosen, the direction of the letters was opposite to the direction of search. In the correctly oriented vertical lists, the divergence between letter-direction and search-direction was only 90°. Hence the directional consistency hypothesis would predict that the correctly oriented lists would be scanned more rapidly than the rotated letter lists. This result was also obtained by Brown and Strongman. One would predict that were the lists scanned from bottom to top, directional consistency would favour the incorrectly oriented vertical lists over the correctly oriented ones. Alternatively, had the letters been rotated in a clockwise direction and top-to-bottom search been employed, the incorrectly oriented lists would be searched more rapidly than the correctly oriented ones. We are at present testing these hypotheses experimentally.

Conclusion

The experiment reported gives support to Kolers' hypothesised directional consistency effect. The effect seems to have some resemblance to phenomena found in the identification of tachistoscopically presented patterns, and with the results obtained in an experiment on visual search. It is suggested that the directional consistency effect influences performance in these three kinds of tasks.

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