

MENTAL TRANSFORMATION IN A VISUAL RECOGNITION TASK

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Abstract. Rectangular geometrical patterns with equal number of lines, identical relations between their vertical and horizontal components, identical angles, line crossing knots and free ends of lines were presented tachistoscopically to human subjects with a restricted recognition time caused by backward masking. Symmetrical linear transformation with respect to the Y or X axes and rotations of the patterns were performed and the correctness of their reproduction was measured in psychophysical experiments. A mental pattern transformation was a fast operation (under 100 ms) not directly linked to a graphic or a verbal expression of the results of reproduction. Mental transformation is probably determined by the recognition process. Symmetrical transformations are easier than rotational, whereas the most difficult is a detection of a pattern differing in its form from those considered within a predetermined group of samples.

It is known (2, 4, 9) that a mental transformation of visual patterns influences their identification, comparison and reproduction. The reproduction of a pattern is a complex mental process with perceptual, verbal and motor components. It remains unclear, however, whether various mental transformations are performed with different speed and accuracy and in which stage of the whole reproduction process do these transformations occur. The present paper is an attempt to study these problems. It is desirable to fulfill certain methodological requirements for this type of study: all the test-patterns should be constructed from

identical elements as this condition is important in form discrimination (1, 8, 10, 11); the influence of pattern transformation on recognition should be studied under the conditions of restricted time; special attention should be devoted to the significance of verbalization (and communication in general) during the reproduction.

Eighteen male and female university students (ten in Experiment 1 and eight in Experiment 2), aged 19–24, with normal visual acuity, served as subjects. They sat comfortably during the experiment in a sound-proof chamber (4 m × 1.8 m). The level of illumination in the chamber was 0.1 lx, to which the subjects were sufficiently adapted.

Visual stimuli were presented by means of a tachistoscope. The white projection screen was placed 2.3 m from the subjects' eyes. Five types of test-patterns were used:

1. samples – SAMP (Fig. 1),

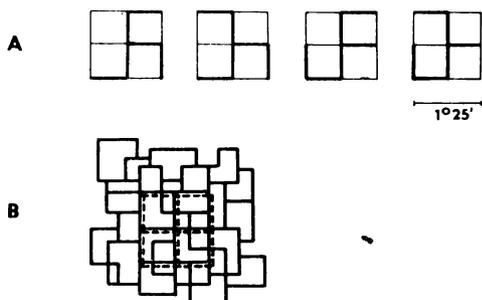


Fig. 1. A, test-patterns; B, masking patterns. For details see text.

2. patterns symmetrical with respect to the Y axis – SYM↑,
3. symmetrical in relation to the X axis – SYM→,
4. rotated $\pm 90^\circ$ with respect to the samples – ROT,
5. forms differing from the samples – DIFF. Four different sample patterns were used (Fig. 1A), all patterns being constructed according to the following principles: (i) equal number of lines, (ii) equal relationship between vertical and horizontal lines, (iii) equal number of angles and line crossing knots, (iv) equal number of free ends of lines. The masking pattern (Fig. 1B) was located on the screen in such a way, that contour marked in the figure by dotted lines was aligned with the lines of the testing pattern. First the testing pattern was exposed for 10 ms with an illuminance of 12 lx, followed, after an interstimulus interval of 40–90 ms (determined individually), by the 500 ms masking pattern with a 48 lx illuminance. The length of the interstimulus interval was established for each subject separately before the experiment proper, as the shortest interval permitting 80–90% of correct recognitions of the sample stimuli. This backward masking design limited the time

available for processing of the visual information. The testing patterns were presented with irregular intervals of 6–8 s.

Two experiments were performed. In the first one the subjects were trained before the session proper to reproduce the test-stimuli by drawing them. In the second experiment they had to name each sample by a predetermined verbal expression. The samples were named by the subjects using their own expressions, for example: the first sample in Fig. 1A was named “a chair” by one subject and “a tower” by another subject, etc. In the experimental session the test-patterns of the types 1–4 (see above) had to be identically called by the same subject, independently from the pattern transformation. The test-patterns of the fifth (DIFF) group had to be named during the experimental session. In this case the answers were considered to be correct when the subject repeatedly gave the same name to a certain pattern. After selecting the appropriate individual interstimulus interval, all test-patterns were shown to the subject. His task was, in Experiment 1, to draw everything he has seen on the screen and, in Experiment 2, to describe it verbally.

Altogether 320 test-patterns were presented in each experiment. The design of the experiments was such that each test-pattern was presented 16 times in a randomized order, i.e. 64 test-patterns were presented to every one of the five groups tested.

The numbers of correct answers (drawn or verbal) were counted and expressed statistically. Confidence limits (at the 0.95 level) were computed on the basis of the binomial distribution law.

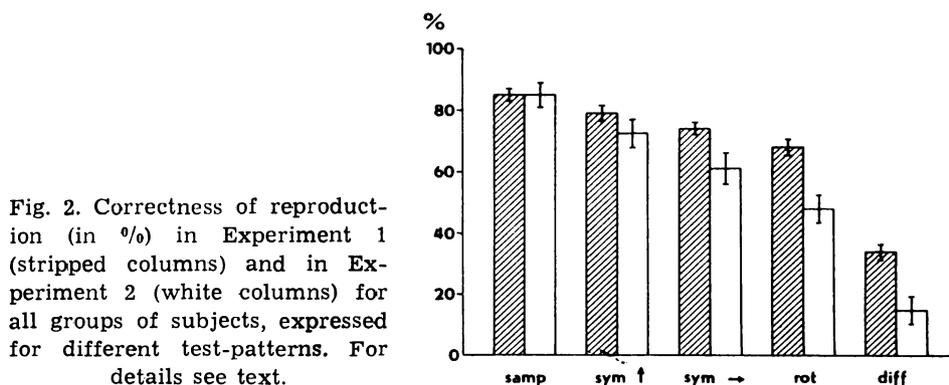


Fig. 2. Correctness of reproduction (in %) in Experiment 1 (stipped columns) and in Experiment 2 (white columns) for all groups of subjects, expressed for different test-patterns. For details see text.

Averaged results of both experiments for all groups of subjects are shown in Fig. 2 (stipped columns—Experiment 1, white columns, Experiment 2). The correctness of reproduction decreases in the order: SAMP > SYM ↑ > SYM → > ROT > DIFF, in a similar way in both

experiments. The differences in the percentages of correct answers among the tested groups are significant, $P < 0.05$. This order is independent from the mode of communication of the result of reproduction. The percentage values are, however, lower for the verbal answers. Symmetrical transformation is apparently an easy mental operation, the most difficult one being to detect a pattern differing with respect to its form from those considered within the predetermined group of samples.

All mental transformations tested seem to be considerably fast processes, being performed even by the slowest subjects in a majority of cases within less than 100 ms. It may be assumed that linear mental transformations are performed prior to the onset of the verbal and motor processes. Mental transformations are likely to be determined by the recognition process, as they are realized within 100–200 ms (5, 7). In this respect our results agree with the Cohen and Granstrom's (3) conclusion, that verbal components which seem to form an integral part of the reproduction do not play any role in recognition. The speed of transformation process might be a parameter individually typical for different subjects. According to Hatta (6) the subdominant (right) hemisphere might be responsible for mental transformations. This hypothesis is, however, yet to be proved experimentally.

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