TRANSACTIONS OF THE HIGHER SCHOOLS OF THE LITHUANIAN SSR
PEDAGOGICS AND PSYCHOLOGY, XI, 1971

ON THE PSYCHOLOGICAL ANALYSIS OF VISUAL SEARCH[1]

A. GUČAS, E. RIMKUTĖ

Although many studies deal with mathematical models of various sensory processes, at present stress is laid more often on the importance of investigation of specific human activity and its individual and typical peculiarities (B. F. Lomov, 1966). Our approach was to study the process of visual search without restrictions usually found in mathematical models.

Visual search is a behavioural effort to overcome certain perceptive difficulties. Essential characteristics of the visual search are perceptive operations in which, due to the difficult conditions of search, reasoning processes are brought out. Situations with one figure embedded in others were used by J. P. Guilford (1959) as one of the mental ability tests. Search always implies detection which essentially is either recognition or identification, depending on the type of instruction.

For the study of quantitative and qualitative characteristics of visual search we used the method of film registration of eye movement. For this purpose an experimental device consisting of a black cabin and other components was constructed. The S was shown a field in which it was necessary to detect a definite geometrical figure. Eye movements effected during the solution of the task were registered by a film camera equipped with a teleobject invisible to the S and placed at a distance of two metres. Filming was done at the speed of 24 shots per second.

Before the experiment and during the intervals between the demonstrations of the experimental material a "fixing point" was projected into the centre of the screen and the S was told to fix on it. Each task included the following procedure: first, a target pattern to be memorized would appear at the centre of the screen, and then the corresponding scanned field in which the target pattern was situated. The eye movements were recorded only when S was searching for the target pattern, however the position of the eye before and after the search was also fixed. Failure to perform the task in seven seconds meant bringing the experiment to a halt and switching off the whole system.

The experiment consisted in performing perceptive tasks of two kinds presented at random. In all cases Ss had to detect as quickly as possible the symbol presented earlier. Instead of the generally preferred symbols, such as numerals or letters, we used definite geometrical figures, the dimensional span

[1] Paper presented at XIX International Congress of Psychology, London, 27 July—2 August 1969.

of which was from 4°35′ to 8°52′ (horizontally and vertically). In the tests of the first type (A) the scanned field included 18 contour geometrical figures of various dimensions and shapes placed at random in the field (Figure 1). The scanned field of the second type of tests (B) consisted of complex structures comprising secants and patterns adjacent to each other or containing, one another (similar to Gottschald's figures) (Figure 2). Cyclogrammes of the eye movement indicated the dynamics of search.

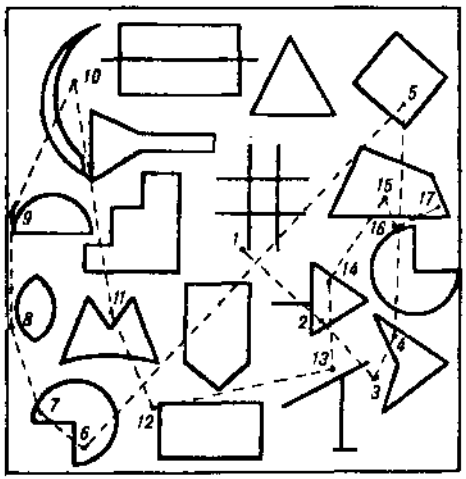

Figure 1. Test structure belonging to task A. Dotted line indicates the trajectory of eye-movements (numbers indicate the order of fixations without reference to their duration).

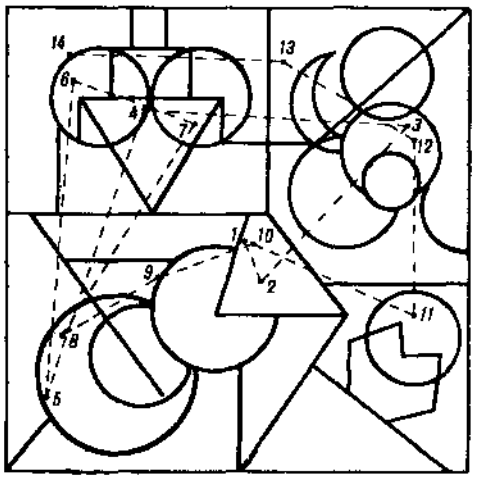

Figure 2. Test structure belonging to task B. Dotted line indicates the trajectory of eye-movements (numbers indicate the order of fixations without reference to their duration).

The experiment was performed with 48 Ss, who were undergraduates and post-graduates of Vilnius University, aging from 24 to 30, with normal eyesight. As a result, 114 cyclogrammes were selected for analysis.

In the mathematical description of the informational search (V. P. Zinchenko, 1967) it is accepted that the fixing on target and non-target elements of the scanned field is identical both in the number of fixations received by them and their duration. The authors of the mathematical models also assume that the fixation on the target pattern invariably brings in its train identification and that the search ends at the first hit of the glance on its area.

Only in 40% of the cases in our experiments did the search end at the first hit of the glance on the area of the target pattern. On the whole this area is distinguished by a rather big number of fixations (on average 2.2 fixations for the target pattern in test A, and 2.5 for the target pattern in test B) and by their longer duration. This provides us with ground for dividing the entire process into two stages: (1) from the beginning of the search to the hit of the glance on the area of the target pattern and (2) from the fixation on the target pattern to the end of the search (fixation on target pattern can be either immediately followed by decision, or between the fixation and decision there can be further search ending either on target or non-target pattern). What is characteristic

of the search that follows the fixation on the target pattern is that the observer already possesses certain information, conscious or unconscious, about the target pattern. Therefore, the functions of these movements may be different from those at the beginning of the search.

Certain quantitative data of the experiment are represented in the table (time is given in seconds).

Types of tests	Mean time of fixations at the first stage of the search	Mean time of fixations at the second stage of the search			
		Correct decisions		Incorrect decisions and refusals	
		Fixation on target pattern	Fixation on non-target pattern	Fixation on target pattern	Fixation on non-target pattern
A	0.22	0,32	0.19	0.19	0.45
B	0.29	0.44	0.32	0.29	0.33

Differences in the mean time of fixations reflect not only the differences in the performance of tasks of various types but also testify to the diversity of search processes during solution of the same problem. The longest fixations pertain to the target pattern. This coincides with the data of J. D. Gould and A. Schaffer (1967).

In the case of correct judgements the differences between the duration of fixations belonging to the target and non-target patterns are statistically significant at 0.05 level. It seems to us that making of final decision by S differs in structure from his examination of other emerging hypotheses. This is confirmed also by the fact that in cases of incorrect judgements or refusals to give an answer the duration of fixations that belongs to the target pattern is not essentially different from the fixations belonging to the non-target patterns in correct answers (somewhat larger but statistically insignificant duration of the latter fixations during the second stage of the search can be explained if we take in consideration the time of fixations in incorrect decisions; in this case with the appearance of a false target pattern, the duration of the fixations belonging to the objectively indifferent spots also correspondingly increases).

Besides, in the correct solutions as mentioned the number of fixations belonging to the target pattern is larger than for other areas.

Though the differences in time in a number of fixations of the first stage are not great (the mean SD for A — 0.072, for B — 0.139), nevertheless, there is a tendency towards the accumulation of longer fixations on separate patterns or definite areas of complex structures of the scanned field. These areas contain elements identical with the composite elements of target patterns. It suggests a very delicate dosage of fixation time characteristic of human search.

The qualitative analysis of the films shows that from the very beginning uneven leaps are characteristic of eye movement (from 2° to 28°; the most frequent cases — from 5° to 7°). Frequently, as a result of great leaps certain areas of the field are scanned without fixation and the eye of the observer is compelled to return to them later, sometimes immediately after such a leap. It would seem that such eye behaviour is conditioned by the striving of the subject to shorten the search. It is a manifestation of heuristic behaviour in perceptive actions. The elements of the scanned field perceived by peripherical vision serve as a direct regulator of heuristic activity of this kind, particularly in test B. The regulating role of peripherically perceived signals manifests itself in another way as well: they enable the observer to dispense with active direct research of definite areas in the scanned field. This

is valid even for cases of refusal when the critical portions of the field peripherically perceived are regarded as improbable and no longer worthy of search.

An analysis of the second stage of search brought out a number of psychological factors usually not taken into consideration in mathematical models. First, the search ends (answer is given) with the first hit of the glance on the area of the target pattern only in 40% of cases (A — 58.8%, B — 30.3%). In 25% of cases (A — 19%, B — 28.8%) the trajectory of the searching eye ends on the target pattern performing a repeated fixation. Between these fixations the indifferent spots of the scanned field are fixed on.

The third possible result of the search is when the trajectory of the eye comes to an end not in the critical but in the indifferent area of the scanned fields. Such cases comprise 35% (A — 24%, B — 40.9%). This kind of the search completion is linked both with correct and incorrect answers and also with refusal to answer.

The fact that the fixation of target pattern is still followed by fixations of other areas of the scanned field suggests that an important role in making human decision concerning identity is played by a feeling of confidence which is a function of the number of the checked (scanned) areas of the field. This is supported by the tendency of the more unfolded trajectories at the second stage to appear after the folded trajectories at the first stage. Besides, they occur more frequently in the more difficult tasks, i. e. in tests B.

The decision concerning identity is made by man after processing not only positive information obtained from the critical area, but also information stored from the indifferent sectors of the scanned fields (failing to locate the target pattern the observer chooses the most probable of all the available alternatives). Moreover, the trajectories of the second stage do not always reflect the search for additional information to confirm a likely hypothesis. In cases of incorrect judgements and refusals as well as in certain cases of the correct judgements the first fixation on the critical spot does not lead to any hypothesis. In these cases the fixations belonging to the trajectories of the second stage of search represent further attempts to locate the target pattern.

Vilnius State University
Department of Psychology

Received
in November 1969

REFERANCES

1. J. D. Gould, A. Schaffer, Eye-movement parameters in pattern recognition. J. of experimental Psychology, 1967, v. 74. No. 2.
2. J. P. Guilford, Three faces of intellect. The American Psychologist, 1959, v. 14, No. 8.
3. Ломов Б. Ф., Инженерная психология в системе наук о человеке, В кн.: Человек и общество. Изд. ЛГУ, 1966, стр. 63—67.
4. Запорожец А. В., Венгер А. А., Зинченко В. П., Рузская А. Г. Восприятие и действие. Изд. «Просвещение», М., 1967.