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DISTURBANCES OF ACTIVE VISUAL PERCEPTION WITH LESIONS OF THE FRONTAL LOBES

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Elaboration of complex visual information is an active process of selection of the most informative parts of the visual object, comparison of several details perceived, elaboration of hypotheses concerning the meaning of the whole and eduction of an appropriate meaning from several possible alternatives (Bruner, 1957). It is known that the process of selection of important visual information includes active ocular movements which are a most important component of every perception of complex visual objects (Yarbuss, 1961; Zinchenko et al., 1962). These ocular movements can be changed by appropriate instructions reflecting changes in investigatory activity evoked by these instructions.

We can illustrate this phenomenon by some results obtained in special experiments (Yarbuss, 1961).

A well known Russian picture by I. E. Repin, "Unexpected Return," is shown to a normal subject. The picture shows a revolutionary who, after a long imprisonment, unexpectedly returns home where he is met by his family.

The subject observes the picture for 3 minutes, and his ocular movements are recorded by a special device. A small mirror is fastened to the cornea; a beam of light is reflected by this mirror. The reflected light and thus all eye movements are recorded on a photo-sensitive paper (Luria, Vinarskaya and Yarbuss, 1963).

After a period of free observation (Figure 1a) the subject is asked several questions and ocular movements during every following observation period are recorded. Is the family poor or rich (1b)? How old are the people in the picture (1c)? What was everybody doing before the man returned home (1d)? What kind of clothes

are they wearing (1e)? What pieces of furniture are in the room (1f)? How long was the man absent (1g)?

As will be seen in Figure 1, the pattern of the eye movements changes greatly from one observation period to the next. In a normal subject a careful observation of a complex visual object (picture,

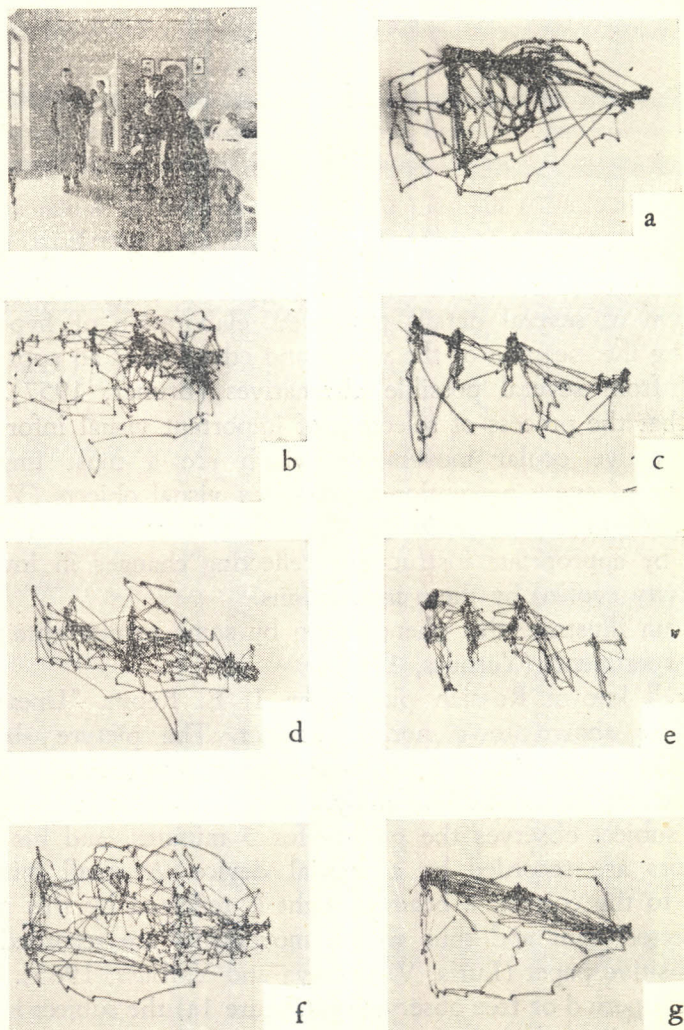


Fig. 1 — Eye movements of a normal subject during 3 min. of observation of Repin's picture "Unexpected Return."

a: Free observation.

b-g: Observation with special instructions (see in text).

situation) is accompanied by active scanning eye movements, fixation of certain informative units and comparison of these units. The figures indicate a series of steps in the scanning process which is necessary in order to form a hypothesis of the general meaning of the whole picture. It is easily seen that systematic changes in these scanning eye movements correspond to the different questions put to the subject.

The question arises: does this kind of scanning eye movements remain unchanged in some cases of local brain injuries, or do different kinds of local brain injuries result in different changes in the scanning eye movements?

Some observations published previously (Luria, 1965a) show that brain lesions from different areas are accompanied by very different syndromes of visual perception.

Patients with parieto-occipital lesions retain their active scanning eye movements, but these movements become disturbed as a result of such symptoms as "simultaneous agnosia" (Luria, Vinarskaya and Yarbuss, 1963).

Patients with lesions in frontal lobes do not suffer such disturbances of visual perception, but their general inactivity results in severe disturbance of the active observation of the visual object; that is why their active scanning activity suffers. They do not begin a systematic process of visual analysis of the decisive details of the picture, do not compare those details, and their ultimate hypothesis does not appear as a result of a complex investigatory-orienting activity. Thus, the meaning of a complex visual picture is often the result of an immediate impression evoked by the perception of single fragments of the picture (Luria, 1965a, 1965b).

The disturbances of visual perception in patients with a massive frontal lobe syndrome were studied in a series of publications. However, the changes of scanning eye movements in these cases have not been described. The present study represents data from our first attempt to study this important problem.

CASE-REPORT

Patient Usk (Neuro-Surgical Institute, case 38798), 54 years old, railroad worker, entered in the Burdenko Neuro-Surgical Institute, September, 1964, with a suspected tumor of the right frontal lobe.

In May, 1958, he had his first epileptic attack without any aura but with general seizures and loss of consciousness. Similar attacks were observed during the next months. Sometimes he had minor attacks without seizures. Marked behavior changes appeared; the patient became excitable, talkative, euphoric. He had to retire from his work, but no emotional reaction to the disease was observed.

Neurological examination showed moderate papilloedema; vision = 1.0; no visual field defects. Central paresis of the left 7th nerve; slight left-sided paresis with extrapyramidal changes of tonus. Reflexes of the left side exaggerated. Bilateral Marinesco symptom and sucking reflex. C.S.F.: pressure 250 mm., protein 0,49%, cythosis 7.3. EEG: pathological slow waves in the right frontal region. X-ray examination of the cranium without any pathological signs. Right carotid arteriography: lower parts of anterior and medial cerebral arteries displaced downwards; anterior cerebral artery displaced to left; fronto-callosal artery with marked displacement to right; frontal peri-callosal arteries show signs of strain and less curved than usual. No veins in the right post-frontal region observed.

General neurological conclusion (Prof. M. Yu. Rapport). Glioma of the right frontal lobe with growth towards convexy as well as towards medial parts of the brain. Very possible that the anterior parts of the tumor are situated in the right pre-frontal area and that the tumor is growing to the deep parts of the frontal lobe. In spite of the large size of the tumor, no symptoms of cerebral hypertension.

Operation 15.1.65 (Dz. I. N. Vinogradova). In the upper frontal convolution signs of compression; brain tissue: yellow. Transection of the brain tissue parallel to the sagittal line, 2-3 cm. deep: tumor, grey-red in colour, smooth with a large zone of perifocal reaction. The size of the tumor is $4 \times 5 \times 4$ cm. The tumor is growing from the lower anterior parts of the falx and with intensive vascularization. Tumor with the area of perifocal reaction of the brain tissue removed.

Neuropsychological analysis

The patient, examined during Sept.-Oct., 1964, was in good physical state and co-operative. No defects in orientation in space and time. He was very hyper-reactive, excitable and talkative. He had a tendency to enter into the conversation of physicians; he

showed no self-control and no emotional reaction to his own tactless behavior. He was euphoric, but sometimes emotionally unstable. A marked instability of attention was observed; he could be distracted by every external stimulus and was unable to concentrate on a given task.

There were no defects in the postural and spatial organization of movements. Reciprocal co-ordination of hand movements (left hand extension, right hand flexion with simultaneous changes of this position to the opposite) was very defective. He showed many impulsive reactions in every motor test. Mistakes were corrected only after a delay and as a reaction to special indications. In repetition of the physicians' movements echopractic mirror-reactions were observed. Rhythmical tapping was reproduced inadequately, with marked perseverative disturbances in changing from one rhythmical structure to another. The patient was unable to reproduce a rhythm according to verbal instructions.

Trying to draw a series of figures according to verbal instruction (for example: "Two crosses and three circles"), he simplified the program given and drew three crosses and three circles; no reaction to the mistake was observed.

His speech remained normal, but in repetition of series of 4 or 5 words he changed the order of words and showed a tendency to perseverate in an error once he made it. No good progress in learning a series of 10 words was observed, and the learning curve was very inactive and flat; he was unable to retain more than 5 words. Reading and writing of separate letters and words were preserved, but reading of a paragraph was very defective with a series of impulsive paralectic mistakes and without any correction. The same defects were seen in repetition of a paragraph: there were marked contaminations and perseverations of stereotyped interpretations as well as impulsive mistakes.

Solving of arithmetical problems was markedly disturbed; instead of a discursive process he gave impulsive answers, and no systematic program of problem solving was possible.

Complex visual perception and scanning eye movements

Perception of simple visual objects was unimpaired. No symptoms of visual agnosia were observed. Only when the image of an object

could be differently interpreted would he show symptoms of an insufficient analysis of the important cues of the object and his evaluation would begin to err. If, for example, a picture of a cap was presented, he could tell he was seeing a kind of a plate, etc. Severe disturbances of visual perception could be seen when complex visual objects, e.g. pictures with complex scenes, were presented. The patient thoroughly observed the picture. He never tried to evaluate the important cues in the picture, to match several cues or to construct a hypothesis after comparing several details. No real analysis of the picture was made. Instead of such analysis he attended to one part of the picture and deduced the meaning of the whole picture from one immediate impression. Every statement the patient made easily became a fixed stereotype and every time the picture was given he repeated the same statement. If doubts concerning his statements were expressed, he never turned to a careful examination of the picture; he moved to a different detail and gave a new hypothesis, paying no attention to the contradictions of his statements.

Marked disturbances of the analytical phase of perception of complex pictures and impulsive statements which replaced a systematic observation were basic symptoms of the pathological changes of visual perception.

Some examples may illustrate these disturbances in visual perception of pictures.

A picture representing a man who has fallen through the broken ice on the river and drowned was given to the patient. A sign "Caution" is nearby. A crowd is seen on a shore. In the background is a church, surrounded by a wall. The patient looks at the picture, sees the sign "Caution," and says immediately: "There is some infection! You see, there is a sign 'Caution!'" (Are you sure?) "Of course..." (Please look once more.) The patient looks to the church in the background. "Oh! a church! That's the Kremlin!" (And why a sign "Caution?") "There is a dangerous place... It is high water..." "Look, there is snow..." "Yes, it's winter..." (And you said there is high water?) "Right, there is high water..." (You are wrong! Please look once more and tell what is happening.) The patient looks towards the crowd; he sees one man in the crowd in military uniform: "All right, it is wartime!" (What has happened here?) "It's a dangerous place, there is poison there... We had such cases in the railroad..." (Is that so?) "Oh, a church... a small forest... perhaps a garden... and a church..." (And what has happened?)

“‘Caution’... and here somebody is swimming... ‘Caution’... Sure, it’s a dangerous place...”

It is easy to see that the patient does not analyze the picture, that all his statements are impulsive and his hypotheses arise from isolated impressions.

It was quite impossible for him to overcome such impulsive statements and no careful observations with matching of separate cues and with a discursive activity was observed.

All these data suggest the principal question: does this impulsive type of evaluation of the picture correspond to any impairment in the patient’s eye movements? Do the patient’s eye movements reflect a systematic observation of the picture, or do they differ from those observed in normal subjects?

The same picture by Repin, “Unexpected Return,” was given to the patient, and his eye movements were recorded during 3 min. of observation, using the technique described above. After a free observation of the picture, the standard questions were given to the patient and his eye movements during the subsequent observation — each 3 min. period — were recorded. Free observation of the picture brought the following comments: “Well... that’s a room... and a soldier comes back from the army... In the Tsar’s times the service was very long for soldiers... and his wife meets him... It’s a long service... perhaps 25 years... and here she is standing...” It is noteworthy that the eye movements of the patient during this observation of the picture (Figure 2a) were quite irregular. He sticks to one fixation point, and no scanning movements, similar to those of the normal person, are seen.

The same type of eye movements was present when various questions were given to the patient. The most important findings are that *changes of verbal instruction do not result in significant changes in the process of observation and that his eye movements preserve the same irregular unorganized character; no organized scanning eye movements are seen, the patient’s gaze does not reflect the meaningful structure of the picture.*

The patient was told: “Please tell me if the family is rich or poor.” The patient answered: “How can I tell? Not poor... but not rich... they are middle level farmers... a nice house... and children...” (Figure 2b).

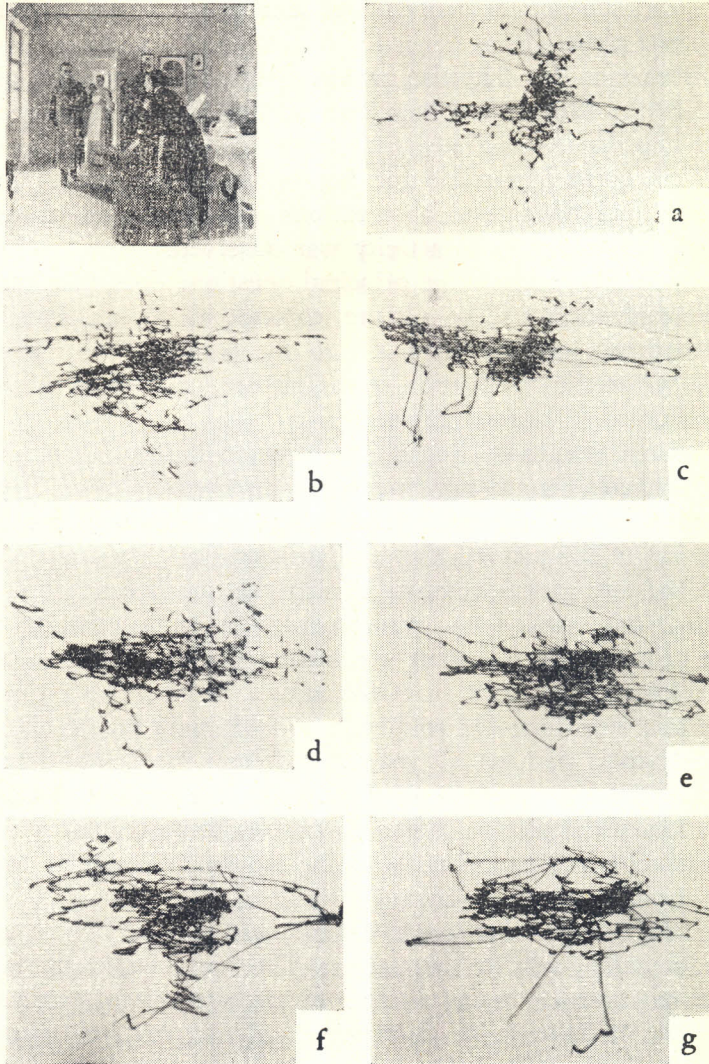


Fig. 2 — Eye movements of patient Usk (tumor of the right frontal lobe) during 3 min. of observation of Repin's picture.

a: Free observation.

b-g: Observation with special instructions (see in text).

Question no. 2. "Please tell me how old every person in the picture is." "Oh, that was a long service... perhaps 25 years... He was 18 when he started his service... He might be 40-42 now, and the woman... she is old... perhaps 60... and the children... 7-8

perhaps..." It is obvious that these answers are mostly superficial, not being a result of careful study of the persons; only a very slight trace of comparative analysis is seen in his eye movements record (Figure 2c).

Question no. 3. "What was everybody doing before the man returned?" "Sure, they did their farmer's work... You know what a farmer's work is like... A cow... some chickens..." (Why do you think it is a farmer's house?) "There are plenty of children... It is a large family... and they couldn't become rich... I also have many children..." Figure 2d shows that the fixation point is shifted to the left side (the door, the figure of the man) and that no organized scanning movements are present.

Question no. 4. "What kind of clothes are they wearing?" "The son... he came back wearing his own coat... with a big collar... and the old woman is looking... he returned to his family..." No scanning movements are observed (Figure 2e).

Question no. 5. "What pieces of furniture do you see in the room?" The patient tells some names of the furniture. He is still sticking to the middle of the picture (Figure 2f).

Question no. 6. "How long was the man absent?" "I have told you, there used to be a very long term for a soldier's service... perhaps 20-25 years... It was in the old days... He married and then came a long service..." No scanning eye movements were observed too (Figure 2g).

The data show that *the gaze of the patient does not reflect the structure of the picture, and no scanning activity of the gaze, different in different instructions, is observed.*

DISCUSSION

The results of our observations clearly show the significant differences in the structure of the perceptive processes, as well in the record of the eye movements, between a normal subject and a patient with a massive lesion in the frontal lobes. As was shown,

the perception of a complex visual object in a normal subject is a result of an intensive analysis of information received; scanning eye movements are an active part of the process of singling out important cues, comparing them, matching them with several hypotheses. The evaluation of the meaning of the whole picture comes to an end when cues perceived come in correspondence with this hypothesis. No such complicated and active process is observed in a patient with massive injury to the frontal lobes.

The patient with a severe frontal lobe syndrome does not try to find the important cues which give decisive information about the meaning of the whole picture. He does not compare these cues nor does he match his hypothesis with these cues. The structure of his cognitive process is different. An immediate impression of some detail leads him to an immediate, impulsive hypothesis. If the patient is asked to make a detailed observation, he starts with another impression leading to a different impulsive statement. No real analysis is performed; no complex observation takes place.

The dissolution of complex cognitive processes is reflected in the registration of the patient's eye movements. No organized scanning gaze movements are seen. The patient's eyes fixate on a certain region of the picture; they remain fixed in this region wandering around haphazardly. No organized eye movements reflecting the structure of the picture are seen, no changes of gaze are observed after different verbal instruction. How can we best interpret these data? The first possibility is that these disturbances are a result of some primary defect in the patient's ocular movements themselves. The data obtained are contradictory to such an assumption. It was shown in special experiments that visual fixation of a point as well as visual tracing of a moving spot do not show any disturbances in our patient. Experiments with recording of horizontal eye movements by a photoelectric technique (Vladimirov and Homskaya, 1961; Luria and Homskaya, 1962) show that tracing of a moving spot was possible, although had some saccadic character; typical for patients with lesions of the pre-motor parts of the brain. Otherwise, active ocular movements, following an instruction such as "Look to your right and to your left as fast as your can," were disturbed in our patient: they were irregular, and exhaustible. It could be said that *active control of the patient's eye movements* — which are highly important in the process of scanning — *was disturbed*. This shows that the

disturbances observed are limited to the process of *active displacement of eyes during the process of observation of a complex visual object*.

It should be mentioned that the same can be seen not only in ocular movements but in other forms of a scanning activity of our patient. When the patient, being in a dark room, had to analyze a complex picture by a small lantern, throwing a small beam of light (1 cm in diameter) he did not move this luminous spot, projected to the surface of the picture, systematically singling out informative cues and comparing them. His hand traced the edges of the picture, and then made monotonous movements, which did not at all reflect the structure of the picture and which did not have an exploratory scanning character.

These data lead to the conclusion that the *complex process of exploratory, scanning activity is disturbed in lesions of frontal lobes* and that this part of the brain plays an important role in *programming complicated forms of active cognitive processes*, as well as of complicated forms of behavior. The registration of ocular movements in the course of the observation of complex visual objects opens new ways in an objective analysis of the structure of cognitive processes and their disturbances with local lesions of different parts of the brain.

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(R) = in Russian

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