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Cognitive Three-dimensional Perception of Planar Images of the Person in Its Educational Activity

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***Abstract*—In this paper, the research results on the development of the visual system and the acquisition of the ability to perceive planar images with three-dimensional attributes (3D phenomenon) have been presented. The authors presented studies with the participation of the Kazan Federal University students. The portable eye tracker "The Eye Tribe" has been used. Finally, a statistical confirmation of the previously made data with one experienced participant has been obtained.**

***Keywords*—eye movement, cognitive perception, visual system, eye tracker, creativity, planar images**

I. Introduction

Binocular depth perception, which is also named as stereopsis or spatial vision, is an advanced visual function based on binocularity disparities. Recently, an increasing number of researches begin to study stereopsis in psychology, especially its deficit in some neuropsychiatric diseases [1].

In this paper, we continue to present the research results on the development of the visual system and the acquisition of the ability to perceive planar images with three-dimensional attributes (3D phenomenon). The first information on the 3D phenomenon was published at the 5th International Conference on Cognitive Science [2]. The experiments were carried out with one participant while registering the direction of the X-coordinate of the right and left eyes on the binocular eye tracker SMI High Speed. In the work, we used the eye trackers of the Center for Experimental Psychology of the Moscow State University of Psychology & Education and the Physiology of Vision Laboratory of the Institute of Physiology of the Russian Academy of Sciences [3]. The main obtained results with one participant were presented in the paper [4].

We presented studies with the participation of the Kazan Federal University students at the International Conference on Cognitive Research at the Present Stage [5]. We used the portable eye tracker "The Eye Tribe". The main aim of this work is a statistical confirmation the possibility of cognitive three-dimensional perception of planar images of the person.

II. Methods

We selected the stimulus 2D images [6,7], for which the elements of depth and volume perception were fixed earlier (when working on the SMI High Speed stationary eyetracker [4]). We displayed the stimulus images on the laptop screen and recorded the X-coordinates of the right and left eyes direction. Then the coordinate difference $\Delta X = X\ (Ra) - X\ (Le)$ was calculated and the difference histograms were constructed. The location of the difference histogram contour (in the ΔX scale) was used to determine the location of the depth and volume perception of the stimulus images. The reliability of the volume perception of the color palette of stimulus images was verified by recording the eyes movement when viewing 3D raster images made using the same stimulus images. The recording time of the eyes movement was 60 seconds. In another of our research papers, the method is described in more detail [8].

The experiment involved about 80 respondents. The respondents are bachelors and masters of Kazan Federal University and schoolchildren's of Kazan city gymnasium. The paper presents the results of stimulus images perception of some respondents.

III. Results and Discussion

Fig. 1 shows the stimulus image illustration of "Golgotha" picture. Fig. 2 shows the difference histogram of the one student. Fig. 3 shows the histogram obtained by the same student when perceiving the 3D raster stimulus image (fig. 1).

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Fig. 1. Stimulus image "Golgotha"

The width of the difference histogram contour shows in what interval the depth effects of the stimulus images are perceived. Comparing the ranges of eye movements in the "format" of the difference histograms, we find that in fig. 2 the range is not less than in fig. 3. It should be noted that similar results were obtained for the experienced participant on the SMI High Speed eye tracker. In other words, the eye movement (fig. 2) confirms the depth and volume perception of the stimulus image (fig. 1). In this case, the perception of depth occurs behind the plane of the stimulus image.

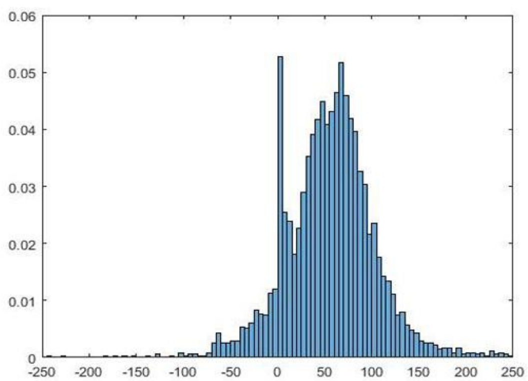

Fig. 2. The difference histogram of fig. 1 perception by the one student

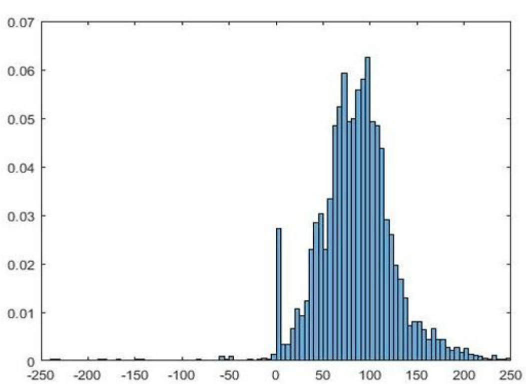

Fig. 3. The difference histogram of fig. 1 3D raster perception by the same student

Fig. 4 shows another stimulus image fragment of illustration "Lavender Fog". The location of the difference histogram contour (fig. 5 and fig. 6) shows that the depth perception is realized both before and behind the plane of the stimulus image.

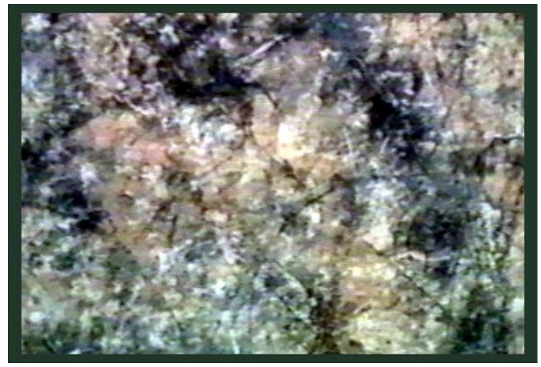

Fig. 4. Stimulus image "Lavender Fog"

Fig. 5 and fig. 6 show a different location of depth perception. However, for this student, the coincidence of the observation field the depth of the raster image and the depth of the plane stimulus image is unambiguously obtained. It should be noted that fig. 2 - 3 and fig. 5 - 6 were obtained by recording the eye movement of third-year students at the Institute of Physics of Kazan Federal University.

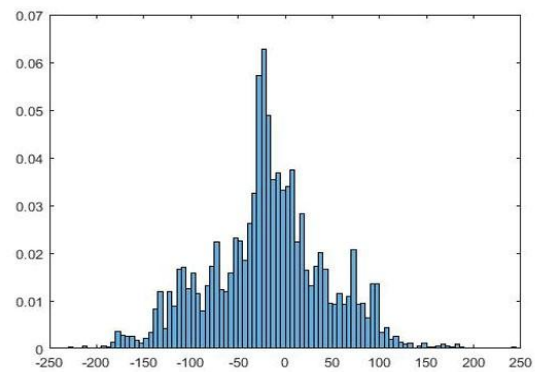

Fig. 5. The difference histogram of fig. 4 perception by the one student

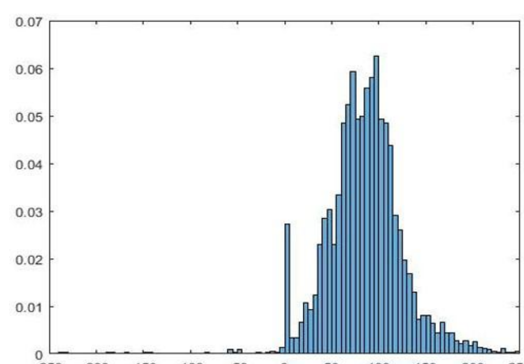

Fig. 6. The difference histogram of fig. 2 3D raster perception by the same student

Fig. 7 and fig. 8 show the difference histograms of the first-year students of the Engineering Institute of Kazan Federal University at the perception of the static and dynamic state of the stimulus image in fig. 2.

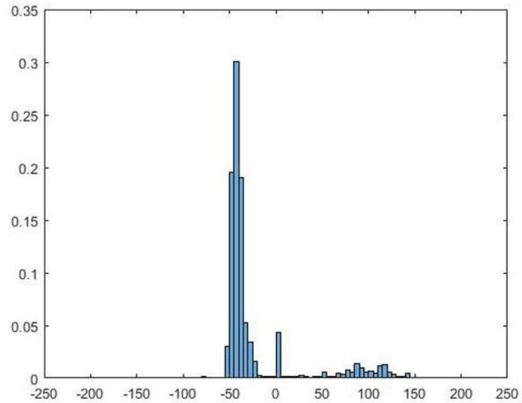

Fig. 7. The difference histogram of stimulus image "Lavender Fog" statically perception

The dynamic state of the stimulus image was obtained at 60 sec. video recording of the plot from a documentary about the artist D. Pollock. In the plot, the operator moved the camera through the artist's painting.

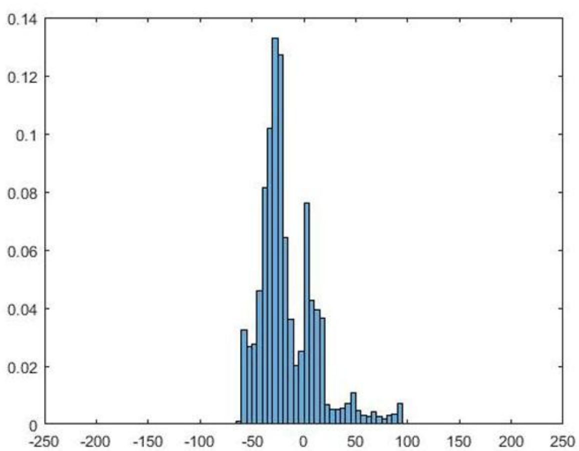

Fig. 8. The difference histogram of stimulus image "Lavender Fog" dcally perception

The difference histograms in fig. 7 and fig. 8 indicate that the perception of depth under dynamic conditions is substantially greater than the static perception. In this case, the depth is observed between the eyes and the plane of the stimulus image.

IV. Conclusions

The work shows that the eye movement allows to get information about the perception of the depth and volume of planar images (fig. 1 and fig. 4). Data of the difference histograms when observing raster 3D images (fig. 3 and fig. 6) confirm this conclusion. If three-dimensional perception occurs, the maximum of the histogram of the difference shifts relative to zero values. Registration of eye movement held among young people of school and college age. The total number of survey participants is about 80 people. We emphasize that the perception of depth occurs without the participation of the principle of binocular disparity.

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