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PRINT: ISSN 0975-1122 ONLINE: ISSN 2456-6322
Int J Edu Sci, 27(1-3): 70-77 (2019)
DOI: 10.31901/24566322.2019/27.1-3.1105

Creative and Cognitive Perception of the Planar Images

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KEYWORDS Binocular Eye Tracker. Depth and Volume Creativity. Eye Movement. Relief Planar Images

ABSTRACT The present paper continues the investigation of the possibility of space perception in flat images (3D phenomenon). An attempt is made to interpret the new characteristics of visual perception in the analysis of eye movement. Selected experimental results applying stationary and portable binocular eye trackers, and also the conditions proving the perception of three-dimensional attributes of planar images, are provided. 3D raster images are employed to recognize the depth and volume perception. Many pieces of research were conducted on a statistical sample, including 80 respondents aged from 14 to 22 years, using a portable eye tracker. The teaching of students manifests the possibility of improving relief levels. It is shown that the students with the highest indices of relief have high levels of creativity. The eye movement results of third-year students show the perception of spatial attributes in planar images that possess some elements of a monocular pattern of images.

INTRODUCTION

According to Gusev, although a large number of exciting studies are devoted to it, and many excellent results have been achieved, the problem of space perception remains relevant (Schiffman 2001; Gusev 2007). Nowadays, new stimuli and conditions are emerging in the modern visual environment for the development of visual perception. Other laws of information transformation and thinking development are probably being formed. Gregory (1997) believes that the paintings of distant primitive ancestors stimulated the development of speech and abstract thinking. The laws of perspective, which was adopted by artists to transfer spatial relationships on the plane, emerged in European culture in the Renaissance (Gusev 2007; Schreuder 2014; Ignatov and Mosin 2014; Vetter and Newen 2014; Petrova et al. 2015; Wilson and Soranzo 2015).

Nowadays, the paintings should be considered not only works of painting, but also a variety of computer images that affect the perception of TV, movies, computer screens, digital advertising panels, concert events, and any printed products. All modern paintings are determined to use planar images. The software utilizes three-dimensional modeling and can produce the illusion of three-dimensionality by employing well-known monocular features (Gusev 2007; Gibson 2014; Hackett 2014; O'Connor 2015; Kornienko et al. 2015; Monty et al. 2017; Phillips 2019).

The principle of the stereoscopic visual system, binocular disparity (stereopsis), probably "prevents" the scientists from achieving a real perception of space on any planar images (including paintings). It was previously believed that space could only be perceived by observing three-dimensional objects using both eyes. It is the perception of three-dimensional objects from two observation points (two eyes) that forms the three-dimensional perception attributes of the environment. The alternative is to employ the stereo industry methods and send images captured from two observation points to each eye (Lappin 2014; Rychkova 2015; Deas and Wilcox 2015; Caziot et al. 2015; Kim et al. 2016).

The present paper introduces the results of studies that indicate the capability of visual perception to overcome the weaknesses of stereopsis and develop the capacity to observe the depth, volume, and spatial perspective of most modern planar "pictures." The presented results are related to the student surveys conducted in secondary schools on the first stages of the development of a 3D phenomenon, and approbation of the training system in the educational process at Kazan University. Furthermore, the possible impact of the 3D event on creativity is discussed.

Objectives

The aim of this study is to investigate the possibility of space perception in flat images

(3D phenomenon). An attempt is made to interpret the new characteristics of visual perception in the analysis of eye movement.

METHODOLOGY

The work of Antipov et al. (2010) represents the teaching system of the development of the 3D phenomenon, which involves six stages. The system is based on the training to recognize the stereoscopic depth of different types of stereograms and generalized stereoscopic projections (GSP). It is believed that long-term training to observe the stereoscopic depth of stereograms and GSP leads to the initiation of novel principles of the perception of the planar images. For instance, the first author of the paper Antipov and Zhegallo (2014).

The examples of some features training of the 3D phenomenon are given in the following. The group of respondents consisted of 12 students- a one-semester training course: Five full-time classes were held, and three sets of independent study materials were distributed. At the end of the semester, nine students (approximately 75%) mastered both depth observation methods at the GSP. One student (approximately 8%) obtained the capability to perceive nearly all flat images with full volume effects. Four of them (about 33%) observed cognitive depth in the color of images (particularly red and blue colors). Three more students (approximately 25%) recorded single depth effects (Minzaripov et al. 2009).

For the presentation of cognitive visual perception, technology was used by employing plastic rasters with cylindrical lenses and images built on the GSP principle. However, the imposition of projections is necessary for some variants of depth perception of plastic rasters. A specialist who installed three-dimensional plastic rasters was able to acquire the ability to perceive cognitive (or creative) depth between the red and yellow color of words printed against a green background after about 10 hours of work with a new version of overlaying projections. Master, professionally engaged in photo art, and the manufacture of 3D raster images (Minzaripov et al. 2009). The human visual system in modern habitat independently obtains the minimum primary elements of the 3D phenomenon - for example, a color image of the Physical World Map. The image format was A4. Humans are confined to the subjective indicators of relief perception. Approximately 91 percent of the 283 respondents declared that they recognized the relief when they looked at the map.

Sixty-nine percent of respondents from a statistical sample of 630 people responded positively to the question about the observation of relief in flat images in the environment. The survey was conducted in two schools between grades 7-11. The 3D raster image in the A5 format of Physical World Map was an analog (or sample) of relief effects. All students pointed to a raster projection in response to the question: "Which of the two images is perceived with greater depth?" The eye fixation point is outside the image plane when perceiving the depth and volume of the planar image under the conditions of the 3D phenomenon.

In a study by Antipov and Zhegallo (2014), the statistical information of the right (XR) and the left (XL) eye X-coordinate – difference histogram or the distribution function $\Delta X = XL – XR$ was analyzed when conducting eye movement studies utilizing the eye tracker. The equation must be satisfied in the conditions of planar image perception: $\Delta X = 0$.

In the perception process of three-dimensional attributes, the distribution function ΔX is located outside the area of zero values. Positive values of ΔX identify the position of the eye-fixation point behind the screen. Figure 1a presents the distribution function for the depth perception of the 3D phenomenon in Figure 1b, which indicates the distribution function for the perception of the coded image of Figure 1c, which shows the distribution function for the depth perception of the raster image of Figure 1. Distribution functions were obtained for an experienced test subject. The distribution function (Fig. 1b) indicates that the eye movement of the encoded image is located in the corresponding interval of ΔX values with the space perception of the raster image. Alternatively stated, the visual system of the experienced subject perceives the space to be no less than the depth of the raster image.

Observation of three-dimensional characteristics on a paper (coded) printout refers to the circumstances for the formation of perception at

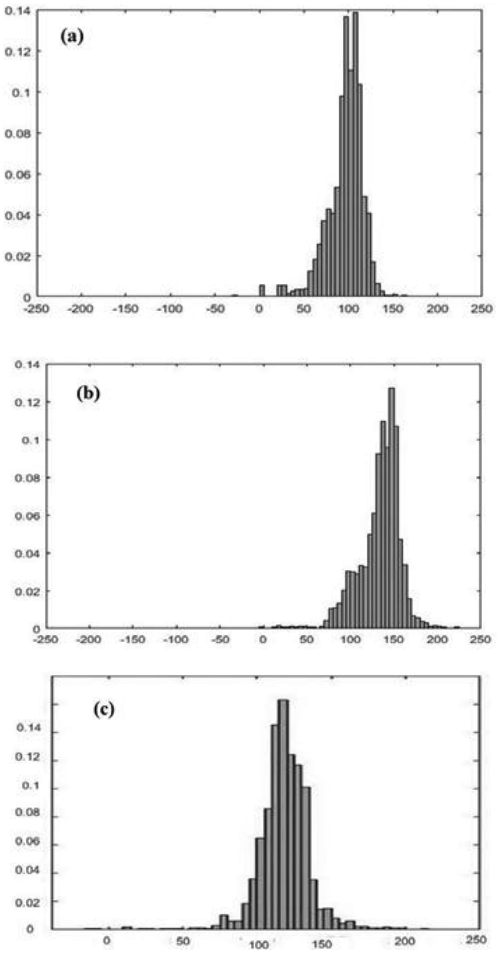


Fig. 1. Distribution functions in the perception of different variants of the watercolor termed as "Kazan University": a) flat image; b) coded image; c) raster image

a minimum by means of the vertical elements of visual information processing in the brain visual centers. It is believed that diffraction consequences in the eye's neural structures may be included in imaging (Hubel 1995; Antipov and Fazlyyyakhmatov 2018). Recent studies on a statistical sample, including 11 bachelors of the Institute of Physics KFU, indicated similar outcomes to the results of Figure 3. The data presented in Figure 3 partially prove the hypothesis of the probability of the diffraction effects on the eye neurons (Antipov and Fazlyyyakhmatov 2018).

The authors assume that the process of visual perception transformation of flat images takes place in the modern visual environment. Alternatively stated, it refers to the learning of the capacity to perceive any flat images with the effects of volume, depth, and spatial perspective. The perspicacity in this definition is the process of the 3D phenomenon and the distribution of three-dimensional qualities of the surrounding space to any planar images.

RESULTS AND DISCUSSION

The Physical World Map and images were selected, which the authors of the present study employed to investigate the depth and volume perception on the binocular eye tracker to conduct the first survey (2018). The total number of respondents is equal to 169. All test images were previously applied in the educational process of Kazan University.

Respondents were asked the question: "Do you observe the relief on the presented planar images?" and the answer was either yes (1) or no (0). Nine questions were asked, and images were indicated in static and dynamic states. The 3D raster images of the Physical World Map and a fragment of the painting "Number 1, 1950 (Lavender Mist)" by Jackson Pollock (Born: 1912 – Died: 1956) was an analog of the concept of relief (Landau 1989). A two-minute episode of a documentary about J. Pollock was used to reveal the dynamic state of perception of a fragment of a picture. The camera moved throughout the canvas at the shooting episode.

A graph of the distribution of the responses is presented in Figure 2. The relative value of answers to questions about observing relief is plotted on the horizontal axis. The vertical axis displays the relative values of the responses of the total number of respondents. It can be observed that the vast majority of respondents (nearly 17% each) answered affirmatively to 3-7 questions. Furthermore, approximately the equivalent number of respondents (42%) answered affirmatively to five or more questions, and 58 percent of them answered affirmatively to 4 or fewer questions.

Figure 2 presents the distribution of answers for each question. The highest value (95%) was obtained throughout the demonstration of the

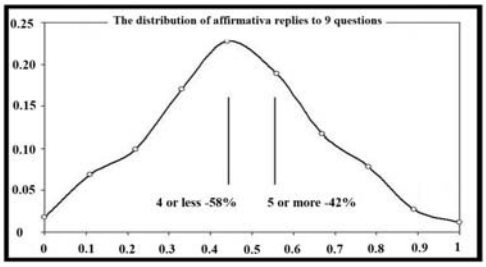


Fig. 2. The students' response distribution

Physical World Map (column 1). The following columns exhibit the relief perception of a fragment of the painting "Lavender Mist" under static (column 2) and dynamic (column 3) display circumstances. It is noteworthy that 1.7 times more respondents perceived the relief in the dynamic state than under static conditions.

The subsequent two columns indicate the perception of the spatial construction of horizontal lines of the text (column 4 is 41%) and the separation of horizontal lines of words on the screen from a white background (column 5 is 25%). Column 6 is the indicator of the relief perception of the stone tile photo image (71%). The next two columns present the state of relief observation by the color palette and the depth perception of its layers. Approximately 13 percent and 22 percent of respondents recognize depth in a static state and the head movement conditions, respectively. The last column indicates the relief effects on flat images in the habitat (63%). This figure will unquestionably become higher since some of the 37 percent remaining respondents stated that they did not pay attention to the relief effects (Minzaripov et al. 2009).

Table 1 enables the authors to conclude that the dynamic conditions significantly increase the perception of the static state of relief (column 2) for demonstrating images (column 3). The results of columns 7 and 8 confirm that 22 percent of respondents are familiar with the objective skill of perceiving planar images with volume elements. A similar survey was conducted as the second survey in another educational institution (Gymnasium). Respondents are students in grades 8-11, and the total number of respondents is 339. The plot movement of the fragment of the painting "Lavender Mist" raises the number of students recognizing the relief by 1.5 times (column 3). The depth of perception of the color palette layers of the stone tile photo image (column 7, 8) was recorded to be 23 percent and 19 percent, respectively. In this educational institution, the D. Torrens test for creativity was carried out for students with the highest number of responses on the relief perception. The following ranked positions were achieved for 46 respondents: "excellent level" - 50 percent of respondents, "high level" –30 percent of respondents, "higher than normal" - 17.5 percent, and "normal" - 2.5 percent of respondents. In other words, the proposed system for determining various levels of subjective assessment of relief provides the scientists to demonstrate that it further identifies the creativity of thinking. Figure 3 presents the distribution functions for the perception of the photo image of the painting "Golgotha," which were obtained for three students of the Gymnasium. Registration of the gaze direction and distribution functions reveals that students perceive the ambiguous position of the sensation of the color palette of the painting "Golgotha."

Table 1: Relative response values for different images

Number of question	*Relative response value (%)*
Question (1)	94.5
Question (2)	47.8
Question (3)	81.5
Question (4)	40.3
Question (5)	26.4
Question (6)	70.9
Question (7)	13.1
Question (8)	21.2
Question (9)	62.2

Surveys in Higher Education

Here are some survey results at three institutes of KFU: Engineering Institute (II) Institute of Psychology and Education (IPE), and Institute of Physics (IP). In II, the data on the relief was obtained for the 1st and 4th-year bachelor, and in the 1st and 2nd-year master students. In IPE, the relief was defined for the 4th year bachelors (specialty "Psychology and Pedagogy"). The 3rd year bachelors and the 1st year master students were tested in IF (Antipov and Fazlyyyakhmatov 2018).

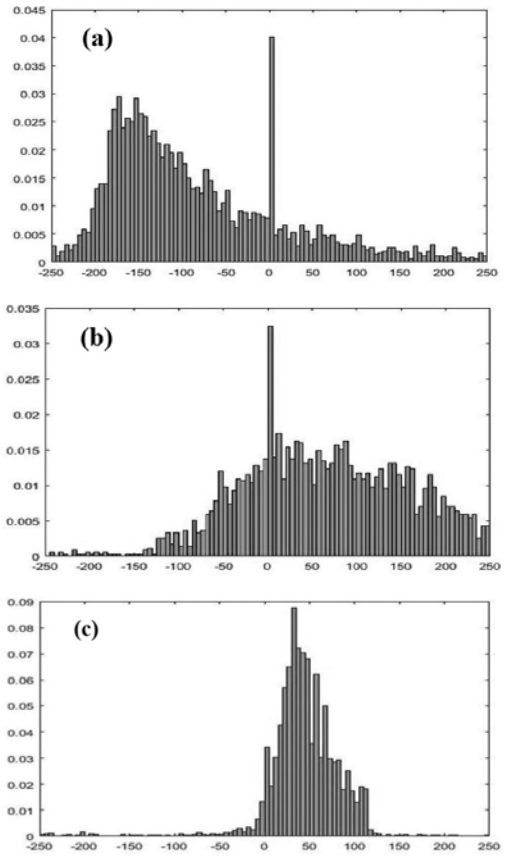


Fig. 3. Depth perception of the "Golgotha": a) in front of the screen; b) both in front and behind the screen; c) behind the screen

Four images were displayed to respondents: color Physical World Map; the fragment of the painting "Number 1, 1950 (Lavender Mist)"; photo image of painting "Golgotha"; and the stone tile photo image. All the images were supposed to show the perception of relief by color scheme. If the respondents perceived the relief, then they either voted or recorded any sign in the related column in the questionnaire. The relief effect was also illustrated by the example of the 3D raster image of the painting "Golgotha." The subjective indicator of the magnitude of the relief was also assessed by the raster image of the painting "Golgotha." The depth level of the raster image was equal to 20-25 cm. The depth perception on the raster was higher than the relief of the planar image on average seven times when interviewing the bachelors of IPE. The comparison scatters interval was equal to values from 1 to 10. Only one student asserted that the depth perception of the raster and the screen was similar (Kim et al. 2016).

The respondents were asked the following questions: 1. "Do you observe individual relief effects (volume) of the color palette of images?"; 2. "For those who perceive relief, are there any other effects of image perception?" Table 2 presents a comparison of the relative answers of gymnasium students and the total answers of students in KFU.

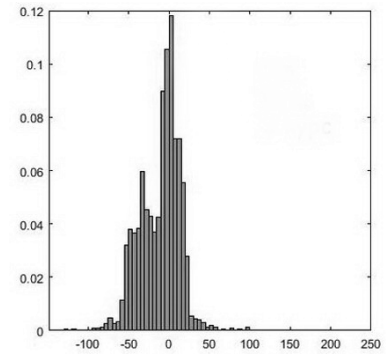
According to Table 2, it can be concluded that the majority of respondents are familiar with the relief effect. Nevertheless, the elevation indices are considerably lower than the depth of the displayed raster images. Only one student among the 200 people studying at KFU claimed that the depth of images is identical on both the raster and plane (Deas and Wilcox 2015).

Table 2: The total results of student surveys

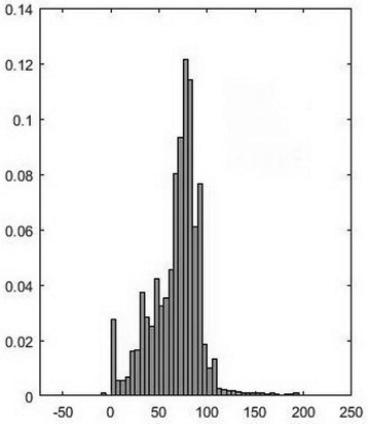
Educational institution	*Relief*			
	Physical world map	*"Lavender Mist"*	*Stone tile*	*Addition effects*
Gymnasium	0.95	0.48	0.71	0.11
KFU	0.87	0.61	0.66	0.17

It is possible to identify the objective indicators of depth perception by using the binocular eye tracker. Figure 4 presents the distribution functions related to the four respondents. Two of respondents are studying at the KFU Institute of Physics (Fig. 4a is related to the third-year Bachelor student; Fig. 4b is related to the first-year master student), one at the Engineering Institute KFU (Fig.4c is related to the first-year master student), and the last (Fig. 4d) is an experienced researcher, whose perception is presented in the study of Antipov and Zhegallo (2014).

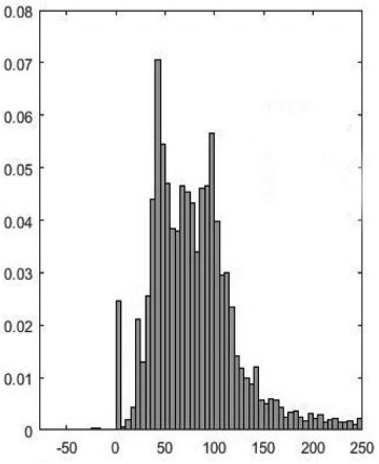
All of the respondents claimed volume perception in the color image of "Lavender Mist" before the process of eye movement registering via the eye tracker. The image was displayed on the computer screen. As can be seen, the bachelor perceives the color palette of the image in the spatial column, including the location of the



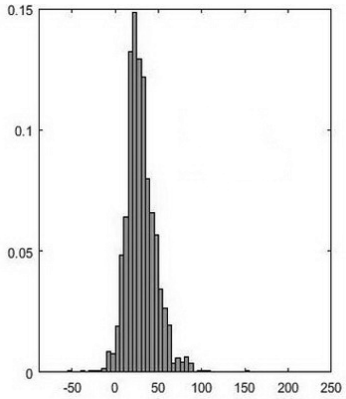
(a)



(b)



(c)



(d)

Fig. 4. Distribution functions of respondents' depth perception of the color

computer screen. The remaining respondents perceive the depth beyond the image plane. It is noteworthy that the first-year master student perceives volume in an interval more considerable than that of the experienced researcher.

The initial analysis of the distribution functions reveals that there is no unambiguous depth perception for different respondents. Otherwise stated, there is no single and stationary location relevant to the screen sensations of the bulk of these images (Monty et al. 2017).

The relief relates to the modern state of visual perception of the higher majority of respondents in this approach. The eye fixation point occurs for them not only on the image plane but also in the range of values of the eye-fixation point coordinates.

The eye fixation point is placed at a significant distance (20-130 cm) beyond the plane of the image (Figs. 3 and 4) as for the conditions of the 3D phenomenon. The indicator of the relief and the state of the 3D phenomenon may not be the position of the eyes focus plane, but the "memory" of the oculomotor muscles, which provides certain positions of the vergence angles and accommodation. Such memory is obtained for a 3D phenomenon under circumstances of a long-term training of recognizing the stereoscopic depth of different types of stereograms. Furthermore, the training is conducted in static and dynamic conditions for observing stereoscopic depth.

CONCLUSION

It is assumed that the development of a new ability relates to the conditions for structuring intuitive-creative thinking. The primary reason is that the new visual environment and the profound influence of flat images were not previously in the habitat. It is evident that there is a conversion of 3D-information of the phenomenon to the level of automatism. It is common knowledge that the thinking processes that occur at the level of automatism in the future and can be transformed into morphogenic structures. It is noteworthy that the 3D phenomenon is the first stage in the emergence of new capabilities. The relief recognized for about 1500 respondents refers to the circumstances for the spread of the first stages of 3D phenomenon development among the population. After that, the third stage of the Darwinian theory of evolutionary alterations should be their consolidation at the level of the genetic structure. In other words, the proposed material may be subjected to the conditions of the evolution of human mental levels in the modern habitat, including the initial stage of a fundamental transformation of visual perception. Such assumptions are partially subjected to the author's definitions of the formation of new meta-tools and their transformation into long-term structures. The authors add that if the development of the ability to perceive any planar images with three-dimensional attributes occurs under the control of a new visual environment, it is entirely acceptable to adopt the concept of incubation and insight in a different category in comparison with the proposals. The authors of the paper highlight that the right hemisphere is activated, and the cortical activity of the brain is increased in the conditions of spatial perception of planar images.

RECOMMENDATIONS

It is suggested that the content of this research paper be considered in light of other aspects of this topic and to provide a general overview, interpretation of the other characteristics of visual perception in the analysis of eye movement of flat images and sketches such as drawings and paintings should be considered.

Int J Edu Sci, 27(1-3): 70-77 (2019)

ACKNOWLEDGEMENTS

The work is performed according to the Russian Government Program of Competitive Growth of Kazan Federal University. The authors are grateful to Olga Baklashova, Director, and Lyudmila Ovchinnikova, Psychologist (Gymnasium No. 6, Privolzhsky District of Kazan) for helping to conduct student surveys and discuss the obtained results. Special thanks to Ph.D. Alexander Zhegallo, Researcher of the Institute of Psychology of the Russian Academy of Sciences, Senior Researcher of the MSUPE for the invaluable assistance in carrying out the research with a binocular eye tracker.

REFERENCES

Antipov VN, Fazlyyyakhmatov MG 2018. Evaluating model of conditions for forming a volumetric visual perception of flat images. *Siberian Journal of Psychology,* 67: 149–171 (In Russian).

Antipov VN, Grachev PV, Antipov AV, Pavlova OA 2010. Intuitive, creative training for specialists of PIAR-technologies. *Education and Self-Development,* 5: 153–158 (In Russian).

Antipov VN, Zhegallo AV 2014. Three-dimensional perception of flat images in the computerized environment. *Experimental Psychology (Russia),* 7(3): 97–111 (In Russian).

Caziot B, Valsecchi M, Gegenfurtner KR, Backus BT 2015. Fast perception of binocular disparity. *Journal of Experimental Psychology: Human Perception and Performance*, 41(4): 909-916.

Deas LM, Wilcox LM 2015. Perceptual grouping via binocular disparity: The impact of stereoscopic good continuation. *Journal of Vision,* 15(11): 11-19.

Gibson JJ 2014. *The Ecological Approach to Visual Perception.* Classic Edition. London, UK: Psychology Press.

Gregory RL 1997. *Eye and Brain: The Psychology of Seeing.* London, UK: Oxford University Press.

Gusev ÀÍ 2007. *General Psychology: T.2 Sensation and Perception.* Kazan, Russia: Academy.

Hackett P 2014. *Fine Art and Perceptual Neuroscience: Field of Vision and the Painted Grid.* London, UK: Psychology Press.

Hubel DH 1995. *Eye, Brain and Vision.* New York: W. H. Freeman.

Ignatov I, Mosin OV 2014. Photoreceptors in visual perception and additive color mixing. Bacteriorhodopsin in nano-and biotechnologies. *Advances in Physics Theories and Applications*, 27: 20-37.

Kim HG, Lee SI, Ro YM 2016. Experimental investigation of the effect of binocular disparity on the visibility threshold of asymmetric noise in stereoscopic viewing. *Optics Express,* 24(17): 19607-19615.

Kornienko M, Kukhta M, Fofanov O, Kukhta E 2015. Experience of visual perception in the design education. *Procedia-Social and Behavioral Sciences*, 206: 365-368.

Landau EG 1989. *Jackson Pollock*. London, United Kingdom: Thames and Hudson.

Lappin JS 2014. What is binocular disparity? *Frontiers in Psychology*, 5: 870.

Minzaripov RG, Antipov VN, Chitalin NA, Shaposhnikov DA, Baltina TV, Skobel'tsina TV, Yakushe RS 2009. On the application of the development of volumetric creative cognitive vision in the innovative educational space. *Uchenye Zapiski Kazanskogo Universiteta. Seriya Estestvennye Nauki*, 151(3): 266-277 (In Russian).

Monty RA, Fisher DF, Senders JW 2017. *Eye Movements: Cognition and Visual Perception*. London, UK: Oxford University Press.

O'Connor Z 2015. Colour, contrast and gestalt theories of perception: The impact in contemporary visual communications design. *Color Research & Application*, 40(1): 85-92.

Petrova EG, Mironov YV, Aoki Y, Matsushima H, Ebine S, Furuya K, Petrova A, Takayama N, Ueda H 2015. Comparing the visual perception and aesthetic evaluation of natural landscapes in Russia and Japan: cultural and environmental factors. *Progress in Earth and Planetary Science*, 2(1): 6-15.

Phillips WL 2019. Cross cultural differences in visual perception of color, illusions, depth, and pictures. *Cross Cultural Psychology: Contemporary Themes and Perspectives*, 9(1): 287-308.

Rychkova SI 2015. Frequency thresholds for stereopsis in the case of alternative presenting the left and right images of stereopair in children with ophthalmopathology. *Human Physiology*, 41(2): 115-122.

Schiffman HR 2001. *Sensation and Perception: An Integrated Approach*. USA: John Wiley & Sons.

Schreuder DA 2014. *Vision and Visual Perception*. Bloomington, Indiana: Archway Publishing.

Vetter P, Newen A 2014. Varieties of cognitive penetration in visual perception. *Consciousness and Cognition*, 27: 62-75.

Wilson CJ, Soranzo A 2015. The use of virtual reality in psychology: A case study in visual perception. *Computational and Mathematical Methods in Medicine*, 151702-151702.

Paper received for publication in October, 2019
Paper accepted for publication in December, 2019