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FEATURES OF INFORMATION DISSEMINATION IN THE VISUAL SENSORY SYSTEM DEPENDING ON THE PROCESSES OF VISUAL PERCEPTION

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Abstract. According to the properties of the percept image, the information processing rate in the sensory system and, as a result of this, its dissemination in the analyzer depends on a person's individual qualities. **The goal of the research** is to study the features of visual information distribution depending on the pole of cognitive style: field-dependence/ field-independence (FD/ FID). **Materials and methods of the research**. The study involved 60 healthy right-handed (according to self-report) males and females. Visually evoked potentials for chess pattern (VEPCP) were registered, and the test "Gottschaldt figure" was used to study individual perception features by the cognitive style FD/ FID. **Results and discussion**. The study of both linear and curvilinear correlation relations in the system of VEPCP components allows us to characterize the intra-system connections of the visual analyzer, and reflect individual characteristics as well. The analysis of the connections revealed have showed that males are characterized by a continuous adjustment of visual attention directed at a geometric object, which is confirmed by a high number of curvilinear connections; in females, the primary zone of the visual cortex is mainly involved in the processing of visual information, and a high number of linear relations between the latencies of VEPCP components. Field-independent males and females have initially a greater number of intra-system connections of component latencies, which is characterized by a large amount of subcortical and cortical structures being involved in the processing of visual information received directly during attention concentration.

Keywords: visually evoked potentials, cognitive style, field-dependence/ field-independence

Urgency of the research

Visual perception denotes the complex of systemic psychophysiological processes of ambient space reflection on the basis of information entering the brain by the visual sensory system conductors. Visual perception begins with the analysis and isolation of general and particular properties of the visual object, its position in space, and ends with the identification of the object as a result of comparing the available image within the memory, assessment of the image significance in relation to the dominant motivation and the goal of identification [3, 5, 8].

It has been noted that according to the properties of the percept image, the information processing rate in the sensory system and, as a result of this, its dissemination in the analyzer depends on a person's individual qualities. Males and females have been determined to have significant differences in information processing in the visual sensory system. The dependence on the lateralization of stimulus entry and the asymmetry of the temporal-amplitude response of the visually evoked potentials in the group of males and females have been revealed [8]. However, despite the large amount of scientific studies in the field of sensory systems physiology there is no reliable information concerning the features of excitation propagation in the analyzer, depending on

its individual perceptual characteristics. Individual differences form some typical forms of cognitive response, in relation to which groups of people are similar and differ from each other, which in psychophysiology are called cognitive styles [4,5].

To study the processes of sensory integration and perception mechanisms, it is necessary to take cues from the perceptual peculiarities of various objects and study the characteristic signs of information dissemination in the visual analyzer, with account of individually unique ways of information processing about one's environment in the form of individual differences in perception, analysis, structuring, categorization, and evaluation of what is happening, a person's characteristics, i.e. cognitive styles.

The goal of the research is to study the peculiarities of visual information dissemination depending on the pole of the cognitive style field-dependence/ field-independence (FD/ FID). The research is devoted to the assessment of information dissemination in the visual sensory system (analyzer) according to the data of visually evoked potentials for chess pattern (VEPCP) in research male and female subjects, depending on the individual parameters of visual attention. The study of the visual sensory system by means of VEPCP registration is one of the most important areas of their application. The particular interest shown in these evoked potentials is determined by the fact that according to a number of authors, this type of responses to visual stimulation is to a greater extent associated with specific visual functions [1,3]. To assess the characteristics of visual attention, the cognitive style indicators field-dependence/ field-independence (FD/ FID) have been chosen.

Materials and research methods.

On grounds of voluntary informed consent, 60 healthy right-handed (according to self-report) males and females took part in this study.

Registration of visually evoked potentials for chess pattern was carried out with the use of neuromioanalyzer NMA-4-01 "Neuromian" (Taganrog, Russia) with the appropriate software in leads O1-FZ, O2-FZ, OZ-FZ with silver-silver chloride cup electrodes, which were fixed in the corresponding projections according to the international system "10-20%". The latencies values of the components N75, P100, N145 and P200 were estimated [1,3].

To study the individual peculiarities of perception according to field-dependence/ field-independence cognitive style, the test "Gottschaldt figure" was used. The registration of characteristics and calculation of the indicator was carried out by the copyrighted program Gottschaldt 1.0. [9]

Prior to statistical processing all primary data were tested for normal distribution and equality of general variances. When statistically processing the results, mean arithmetic values (M) of the parameters under consideration with their errors (m) were calculated. Statistical significance in arithmetic means (test of differences validity) was calculated using the generally accepted formula and was assessed using the table of Student's criteria for a predetermined threshold of the probability of fault-free estimations (0.95; 0.99; 0.999). When performing the correlation analysis, the coefficients of linear correlation (r) with the error (m), the correlation ratios of the characteristics under consideration (η) with the error (m), as well as the curvilinearity criterion ($F\xi$) were calculated [Plokhinskiy].

The calculation was performed with the Excel and STATISTICA computer software. To assess the relationship significance of the correlating characteristics, the coefficient of the total polygonal correlation as $\sum r + \eta$ was calculated while the sign was ignored [2,6,8]. We estimated the presence of significant differences and factorial influences according to a critical level of reliability (p) less than 0.01.

Results and discussion

When analyzing the mean values difference of the latencies in VEPCP components under right-sided and left-sided stimulation of field-independent males and females, no significant differences were revealed. A similar picture was observed in the group of field-dependent and field-independent males.

When comparing the components latencies of field-dependent and field-independent females it was found that when stimulating the right entry of the visual analyzer in field-dependent females, the latency of N75 indicator in lead O1-FZ is 20% higher ($p < 0.05$). In lead O2-FZ, the latency of this indicator is 21% higher in field-dependent females ($p < 0.05$). A similar picture was observed under stimulation of the left eye in leads O1-FZ and O2-FZ, where the N75 latency is respectively 17% and 16% higher ($p < 0.01$-0.05).

Comparative analysis of the average latencies when stimulating the right sensory input of the visual analyzer has not revealed any significant difference in indicators values in the group of field-dependent males and females, however, when stimulating the left input of the visual analyzer, in lead O1 only an increase in the average latency of P100 component by 24% was recorded in males ($p < 0.05$) compared with the group of field-dependent females.

When evaluating the coefficients of variation, it has been estimated that all the differences in the coefficients of latencies variation in VEPCP indicators of field-dependent males and females with stimulation of both the right and left inputs of the visual sensory system are significant ($p < 0.001$). At the same time, the latencies indicators in females are less stable and differ by greater variation in field-dependent females than in males. The coefficients of latencies variation are significantly higher in field-dependent females: N145 when stimulating the right eye in lead OZ-FZ by 43%, when stimulating the left eye in lead OZ-FZ by 42.3%, as well

as by 42% when stimulating the left eye in lead O1-FZ, in the last indicated lead, the coefficient of variation in females P100 indicator turns out to be higher by 74%.

When analyzing the coefficients of variation in the group of field-dependent and field-independent males, it has been noted that, upon stimulation of the left sensory input of the visual analyzer, the coefficient of latency variation in P100 and N145 components in leads OZ-FZ in field-dependent males is significantly higher by 56% and 40%, respectively ($p < 0.001$- 0.05). The coefficients values of latencies variation in P100 and N145 components are lower when the left eye is stimulated in lead O2-FZ in field-independent males respectively by 55% and by 13% ($p < 0.01$-0.05) than in the corresponding group of polar females. A large variation coefficient in lead O2-FZ by 55% in field-independent males is characteristic for P100 indicator ($p < 0.05$). When stimulating the right eye in lead O1-FZ, the P100 latency differs by 55.1% ($p < 0.001$) in the highest value of variation coefficient of latencies in the group of field-independent males in comparison with field-dependent males. In the lead O2-FZ, upon stimulation of the same sensory input, the latencies N75 and P100 in field-dependent males differ in less variability by respectively 58.5% and 55.12%, ($p < 0.05$), compared with the group of non-polar females.

Comparative analysis of latencies variation coefficients in VEPCP components in females with different poles of the cognitive style have shown that latencies variation coefficients in VEPCP differ significantly when the right eye is stimulated in leads OZ-FZ and O1-FZ of P200 component, what is more, it is 17% higher in two types of leads in field-dependent females ($p < 0.05$). When stimulating the left eye in lead OZ-FZ only, the amplitude variation coefficient of P100 and P200 components is also greater in field-dependent females by respectively 40% and 10% ($p < 0.001$ - 0.05), if compared with the group of non-polar females.

The study of both linear and curvilinear correlations in the system of VEPCP components makes it possible to characterize the intra-system connections of the visual sensory system components and their individual peculiarities. Distinctive features of excitation propagation in the visual centers obviously depend on the characteristics of visual perception, which have been considered by the test that determines the cognitive style in groups of research subjects (table).

Table

Total endogenous relationship of components latencies in leads of VEPCP depending on peculiarities of perception

	Males FID		**Males FD**		**Females FID**		**Females FD**	
latencies	Right eye stimulation	Left eye stimulation	Right eye stimulation	Left eye stimulation	Right eye stimulation	Left eye stimulation	Right eye stimulation	Left eye stimulation
Oz-Fz	9,52	9,62	5,22	5,24	7,38	**15,18**	**10,68**	4,2
O1-Fz (on the left)	9,82	**20,38**	5,8	**10,58**	4,68	**15,08**	8,76	**10,64**
O2-Fz (on the right)	4,75	4,72	**11,84**	4,66	4,14	**14,34**	7,1	2,42
TOTAL	**58,81**		43,34		**60,8**		43,8	

Note: FID-field-independent, FD-field-dependent; the table shows the total values of linear correlation r (the sign is ignored) and the curvilinear ratio; only the reliable coefficients of correlation and curvilinear ratio were summed up according to the table of Student's criteria for a predetermined threshold of the probability of fault-free estimations (0.95; 0.99; 0.999).

It follows from the data obtained that the predominance of intra-systemic connections in information dissemination along the left hemisphere during ipsilateral stimulation is observed in field-independent males. When analyzing the given lead, the latency of P100 component has the largest number of relationships, both linear and bilateral curvilinear (Fig. 1). It is significantly that P100 latency ($p < 0.05$) is the most interrelated component in lead OZ-FZ lead, characterized by a high number of curvilinear connections among other latencies of VEPCP components.

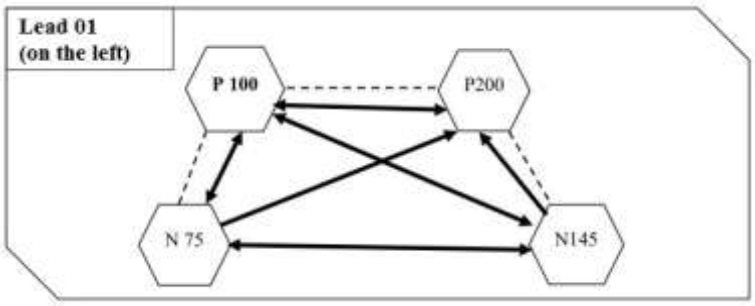

*Fig.*1 Intra-system relationship of latencies in field-dependent males when stimulation on the left in the lead O1

Note: 0,62-0,72 – – – – – , 0,73-0,83 – ——— , 0,84 and more – ▬▬▬ ; arrows indicate curvilinear relations.

Having analyzed the latencies correlation relations of VEPCP components of field-dependent males we have revealed other intra-systemic relationships (Fig. 2, 3). Thus, the largest number of interconnections is characteristic for the communication system of lead O2-FZ, while they are both of linear and curvilinear character. The greatest tightness is observed in the latency of P100 component ($p < 0.05$), as in the previous lead.

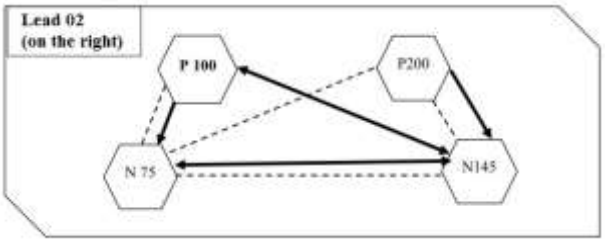

FIg. 2 Intra-system relationship of latencies when stimulation on the right in field-dependent males
Note: see fig. 1

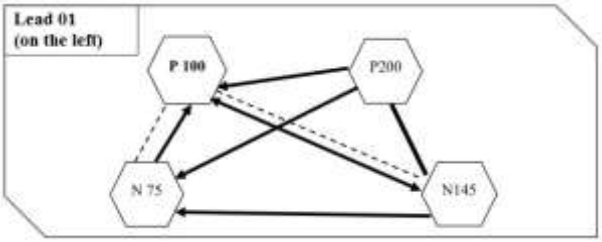

Fig. 3 Intra-system relationship of latencies when stimulation on the left in field-dependent males
Note: see fig. 1

The largest number of connections is also revealed by the latency P100 component, characterized by linear connections with N75 and N145 components, as well as curvilinear connections with all the VEPCP components in the lead under consideration.

According to table 1 data, some peculiarities in dissemination of visual sensory information determined by the types of stimulation (stimulus lateralization) are revealed in field-independent females. Thus, under left-sided stimulation, a high number of intra-systemic connections of components latencies in leads OZ-FZ, O1-FZ, O2-FZ has been established (Fig. 4). Having analyzed the correlation coefficients and correlation ratios of the latencies of VEPCP components in field-independent females we have revealed some different relationships than in males. Thus, when stimulating the left sensory input in lead OZ-FZ, it has been found that the relationships between the components latencies are both of linear and bilateral curvilinear character, with the highest total correlation in the latency of P100 component. It should be noted that the interconnections of components latencies in the lead are represented mainly by linear connections, which may be indicative of a firmly determined adjustment of the visual sensory system.

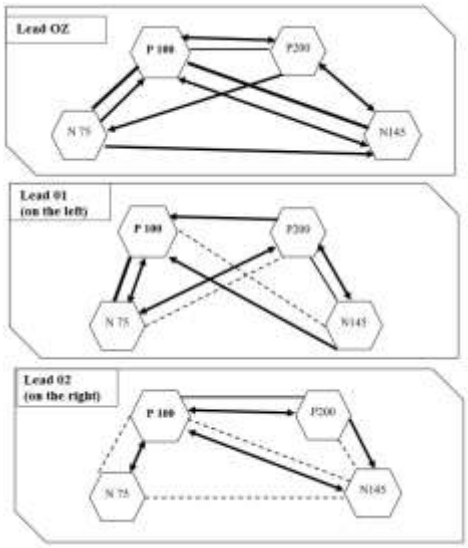

Fig. 4 Intra-system relationship of latencies in field-independent females when stimulation on the left
Note: see fig. 1

The latencies of VEPCP components in field-dependent females are distinguished by a high number of internal connections in lead Oz-Fz under right-side stimulation, as well as in lead O1-Fz lead (fig. 5.6). It should be noted, P100 component plays a special role in all the leads, which is characterized by a large amount both of linear and curved connections

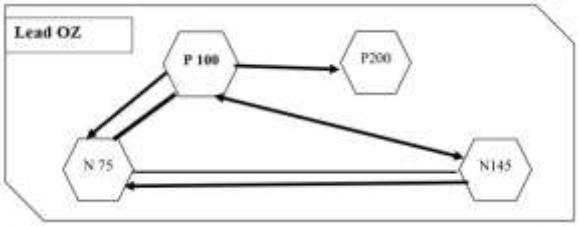

Fig. 5 Intra-system relationship of latencies in field-dependent females when stimulation on the right
Note: see fig.1

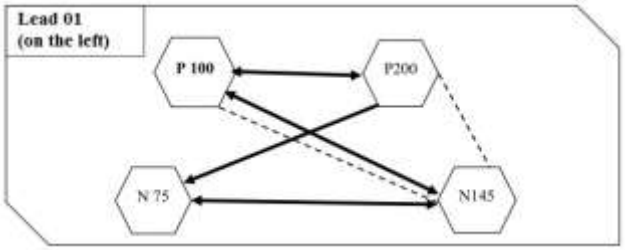

Fig. 6 Intra-system relationship of latencies in field-dependent females when stimulation on the left
Note: see fig.1

Conclusion. The obtained data concerning the mean values, the coefficient of variation, linear and curvilinear correlations characterize the adjustment of the visual analyzer and the peculiarities of excitation propagation along it, depending on the polarity of perception. It should be noted that the potential latency characterizes the rate of information propagation and irradiation about the stimulus in various parts of the visual analyzer. Thus, the component N75 is the stimulation result of predominantly macula retinae and represents the potential of the near-field occipital cortex; P100 is the largest in its amplitude and most reproducible component of VEPCP and is predominantly generated by the striatal cortex; N145 component has a wide topography along the midline regardless of the left or right visual field stimulation, which supports the hypothesis that this component is generated by the associative area of the visual sensory system (predominantly fields 18 and 19);

P200 component is sensitive to the state of consciousness, is generated by the thalamus nonspecific nuclei and the limbic-reticular complex, characterizes the relationship between the occipital and parietal cortex [1]

Keeping in mind the topography and origin of VEPCP components, we have established that in the group of field-dependent males there is a higher amount of latency components than that in the same group of females. In the group of females with different polar styles, field-independent females are characterized by lower latencies. The smallest variation coefficients are characteristic of latencies in the group of field-dependent males and women, which indicates that the rate of information dissemination through the visual sensory system in field-independent females and males is higher than that in the group of research field-dependent subjects. The established interrelations of the latencies in VEPCP components in research field-independent subjects provide parallel channels for information transmission and processing (sensory funnels), which develops the accuracy, detail of signals and high reliability of information dissemination in the visual sensory system.

The obtained data concerning intra-systemic interconnection of latencies in VEPCP components have revealed significant differences in excitation propagation of the visual sensory system, depending on its polar style. Thus, during the dissemination of visual information in males, it has been noted that the excitation irradiation in the visual sensory system is formed mainly in the associative areas. In field-independent males the dependence of visual information dissemination on the type of stimulation is in the forefront. Thus, the largest number of connections is due to left-sided stimulation, i.e. in such a case, information dissemination is especially active in the left hemisphere. The right-cellular pathway with the striatal cortex involvement plays an important role in the dissemination of information. The latencies of VEPCP components are characterized by a high number of intra-system interconnections, which is probably due to a large amount of information simultaneously processed for a more complete image perception.

In field-dependent males the largest number of relationships is characteristic of the latencies in leads under ipsilateral stimulation, thus, under right-sided stimulation the largest number of connections is in lead O2, while under the left-sided one in lead O1. This characterizes the high number of structures involved in information dissemination along the specific structures in the associative areas of the cortex, i.e. likely with the predominant involvement of the magnocellular pathway.

In field-independent females there is a tendency for excitation propagation along the visual sensory system to depend on the type of stimulation. Thus, the left-sided input of the visual sensory system contributes to the information dissemination both along the right and left hemispheres, as well as into the primary cortex for more accurate processing of visual information.

In field-dependent females, a special role in the information dissemination is assigned to the primary zone of the occipital region in the cerebral cortex under right-sided stimulation. Field-independent females as well as field-independent males initially have a larger number of intra-systemic relations, which is characterized by a large number of subcortical and cortical structures involved in the processing of visual information that comes directly during concentration.

The analysis of the connections revealed has shown that males are characterized by a more continuous adjustment of visual attention focused on a geometric object, which is confirmed by a large number of curvilinear connections; in females, the primary zone of the visual cortex is necessarily involved in the processing of visual information, and a high number of linear relations has also been noted

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