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PECULIARITIES OF CORRELATION RELATIONS OF TEMPORAL CHARACTERISTICS OF VISUAL EVOKED POTENTIALS IN PERSONS WITH DIFFERENT POLES OF COGNITIVE STYLE

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Abstract. ***Introduction.*** It was previously noted that the features of the dissemination of visual information and the activation of a number of structures are influenced by age, functional status, manifestations of cognitive styles, the typological complex of the nervous system and gender. There is no doubt that the effective functioning of the visual sensory system and the patterns of information processing at various levels will largely determine the optimal implementation of voluntary motor activity, depending on gender. ***The purpose of the study.*** To identify the features of the intra-system correlation relationship of latencies of the components of visual evoked potentials to the chess pattern in male and female subjects belonging to different poles of the cognitive style of utility-field dependence, and patterns of implementation of bimanual motor programs. ***Materials and methods.*** The type of cognitive style was determined in the male and female subjects. The level of bimanual voluntary motor activity was assessed by the method of supportmetry. The features of the functional state of the visual sensory system were determined by registering visual evoked potentials in a chess pattern, and the latencies of the corresponding components were evaluated. Sensory-effector relationships were determined by the method of complete correlation analysis with the calculation of the sum of correlation coefficients and correlation relationships. ***Results.*** It has been established that the level and features of the total multilateral correlation of latencies of the components of visual evoked potentials on a chess pattern with the characteristics of bimanual coordination are determined by the lateralization of sensory stimulus input, gender, and belonging to one or another pole of the cognitive style of use-non-dependence. In men, the effective performance of motor tasks is determined by the dissemination of visual information and visual control at the level of speed-time indicators of the implementation of bimanual coordination, especially in people characterized by gender independence. In women, a different strategy of visual sensory support for arbitrary complexly coordinated bimanual movements was revealed, based on the correction of the spread of arousal during the occurrence of a defect in the implementation of the track, i.e., when the system is disturbed. ***Conclusions.*** The established patterns of sensory-effector relationships reflect different strategies for the implementation of motor programs in men and women, taking into account the pole of cognitive style, determined by the peculiarities of the dissemination of visual information in the structures of the central nervous system.

Keywords: hand-eye coordination, voluntary bimanual movements, visual evoked potentials, cognitive style of utility-polenezavisimost

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ОСОБЕННОСТИ КОРРЕЛЯЦИОННЫХ ВЗАИМООТНОШЕНИЙ ВРЕМЕННЫХ ХАРАКТЕРИСТИК ЗРИТЕЛЬНЫХ ВЫЗВАННЫХ ПОТЕНЦИАЛОВ У ЛИЦ С РАЗНЫМИ ПОЛЮСАМИ КОГНИТИВНОГО СТИЛЯ

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Резюме. ***Введение.*** Ранее отмечено, что на особенности распространения зрительной информации и активацию ряда структур влияют возраст, функциональное состояние, проявления когнитивных стилей, типологический комплекс нервной системы и половая принадлежность. Не вызывает сомнений, что эффективное функционирование зрительной сенсорной системы и закономерности переработки информации на различных уровнях будут в значительной степени определять оптимальную реализацию произвольной двигательной деятельности в зависимости от половой принадлежности. ***Цель исследования.*** Выявить особенности внутрисистемных корреляционных взаимоотношений латентностей компонентов зрительных вызванных потенциалов на шахматный паттерн у испытуемых мужского и женского пола, относящихся к разным полюсам когнитивного стиля полезависимость-поленезависимость, и закономерности реализации бимануальных двигательных программ. ***Материалы и методы.*** У испытуемых мужского и женского пола определялся тип когнитивного стиля. Уровень бимануальной произвольной двигательной активности оценивался методом суппортметрии. Особенности функционального состояния зрительной сенсорной системы определялись посредством регистрации зрительных вызванных потенциалов на шахматный паттерн, оценивались латентности соответствующих компонентов. Сенсорно-эффекторные взаимоотношения определялись методом полного корреляционного анализа с расчетом суммы коэффициентов корреляции и корреляционных взаимоотношений. ***Результаты.*** Установлено, что уровень и особенности суммарной многосторонней скоррелированности латентностей компонентов зрительных вызванных потенциалов на шахматный паттерн с характеристиками бимануальной координации определяется латерализацией поступления сенсорного стимула, полом и принадлежностью к тому или иному полюсу когнитивного стиля полезависимость-поленезависимость. У мужчин эффективное выполнение двигательных заданий определяется распространением зрительной информации и зрительным контролем на уровне скоростно-временных показателей реализации бимануальной координации, особенно у лиц, характеризующихся поленезависимостью. У женщин выявлена иная стратегия зрительного сенсорного обеспечения произвольных сложноскоординированных бимануальных движений, основанная на коррекции распространения возбуждения при возникновении дефекта при реализации трека, т.е. при возмущении системы. ***Выводы.*** Установленные закономерности сенсорно-эффекторных взаимоотношений отражают различные стратегии реализации двигательных программ у мужчин и женщин с учетом полюса когнитивного стиля, определяемые особенностями распространения зрительной информации в структурах центральной нервной системы.

Ключевые слова: зрительно-моторная координация, произвольные бимануальные движения, зрительные вызванные потенциалы, когнитивный стиль полезависимость-поленезависимость

INTRODUCTION

The problem of manifestations of differences in the functioning of the human body and ways to diagnose them today has an interdisciplinary character and combines physiology, psychology, pedagogy and other disciplines. It is important to establish the regularities of functioning of the central nervous system taking into account gender, maturity of mechanisms of higher nervous activity [1–4]. Undoubtedly, the most informative method of determining the peculiarities of functioning of the central structures of the visual sensory system is the method of visual evoked potentials for a flash of light and for a reversing checkerboard pattern [1, 5–7].

A number of studies have shown that in female subjects the temporal characteristics of visual evoked potentials are smaller than in males, while the amplitudes, on the contrary, are characterized by larger values. It has been noted that the peculiarities of visual information propagation and activation of a number of structures will be influenced by sex, age, functional state, manifestations of cognitive styles, and typological complex of the nervous system [1, 2, 5].

There is no doubt that the effective functioning of the visual sensory system and patterns of information processing at various levels will largely determine the optimal realization of arbitrary motor activity with its sex-related characteristics [3, 8-12]. It is characteristic that men have a more complex information architecture compared to women and show greater stability, which, obviously, determines greater efficiency of arbitrary bimanual coordination [7, 13]. A number of studies note that the realization of cognitive processes such as attention, resistance to monotony, perception, and memory will also depend on the peculiarities of excitation propagation in the visual sensory system [14, 15]. Cognitive features related to visual perception, in turn, can determine the level of voluntary motor activity [16, 17]. Currently, more than 15 different cognitive styles are described, which are not united into a common system. We are interested in the phenomenon of field-dependence-polynodependence, which determines the features of holistic or detailed attention during the perception of various objects [17–20].

AIM

The aim of the study was to reveal the peculiarities of intrasystem correlation relations of latencies of components of visual evoked potentials for the checkerboard patternin male and female subjects belonging to different poles of the cognitive style of field-dependence-field-independence and regularities in the execution of bimanual motor programs.

MATERIALS AND METHODS

A total of 95 male and female subjects (41 males and 54 females) participated in the study on the basis of informed consent. The peculiarities of information dissemination in the visual system were evaluated by means of registration of visual evoked potentials per checkerboard pattern (VEPCP) in the Oz-Fz derivation using a neuromyoanalyzer NMA-4-01 “Neuromian” (Taganrog, Russia) with the corresponding software according to the standard method [1, 5]. The latencies of the components N75, P100, N145, P200, as well as their differences depending on the lateralization of stimulus arrival were evaluated during the analysis. The level of bimanual coordination was assessed by caliperometry [4, 16] using the author's software[1]. During the performance of six motor tracks, we recorded the total time of task performance (TT), time on track contour (TOC), time out of contour at failure (OTC), and the number of errors-failures (EF); on their basis we calculated the speed of task performance (SP), reaction speed at error correction (RS), and the integral index of coordination (IC) as a as a measure of the efficiency of the motor program implementation. The subjects’ cognitive style was determined using the author's computer program.[2] The index of field-dependence-field-independence was calculated according to the standard formula. If the index was equal to or greater than 2.5, the subject was classified as a field-independent type, and less than 2.5 as a field-dependent type. In statistical processing, using the Kolmogorov-Smirnov criterion, all primary data were tested for normality of distribution and homogeneity of variance. Full correlation analysis with calculation of the linear correlation, correlation relationships and curvilinearity criterion was performed using the Excel 2019 program and STATISTICA (version 13.0). The significance of differences was assessed by the standard formula using Student’s t-test. To assess the significance of correlation of the characteristics, the total multilateral correlation coefficient was calculated as $\sum r+\eta$ [4].

[1] Certificate 2020615226 Russian Federation. Certificate of official registration of computer programs. Information system for processing the results of the experiment “Support 2.0”. P.V. Tkachenko, N.I. Sokolova, E.V. Petrova, S.V. Krivolapov; right holder Federal State Budgetary Educational Institution of Higher Education “Kursk State Medical University” (RU). No. 2020615226; avv. 03.04.2020; publ. 19.05.2020.

[2] Certificate 2017615838 Russian Federation. Certificate of official registration of computer programs. Information system for collecting and processing the results of the experiment to identify pole dependence-field dependence “Gotschild Test 1.0”. V.V. Shvanov, P.V. Tkachenko, N.I. Sokolova, S.V. Krivolapov; right holder Federal State Budgetary Educational Institution of Higher Education “Kursk State Medical University” (RU). No. 2017615838; avv. 03/27/2017; publ. 05/25/2017.

RESULTS

In field-dependent men, the system of correlations between the temporal characteristics of the visual evoked potentials for the checkerboard pattern recorded during right-hand stimulation and the indicators of bimanual coordination is summarily correlated at the level ∑r+η 28.41. Here, the correlation of the indicators of the first task has a value of 4.11, the second has a value of 6.61, the third has a value of 3.71, the fourth has a value of 9.45, the fifth has a value of 3.56 and the sixth has a value of 0.97.

Consideration of the internal structure of correlation relations has shown that in this system curvilinear relations between the considered indicators predominate. It should be noted that among the characteristics of the fourth most correlated task performance, the temporal indicators of track realization (TT, TOC and OTC), as well as the calculated ones (SP and IC) are closely correlated with the latencies N75 and P100, which determines the first ranks in the level of interrelations between the latencies of these components. The system formed based on the latencies obtained during stimulation of the left eye is summarily correlated with the coordination indices of all six tasks at the level ∑r+η 44.98. In this system of characteristic relationships, the indices of the first task are correlated with the values of latencies at the level of 5.38, the indices of the second task are at the level of 7.35, the indices of the third task are at the level of 9.05, the indices of the fourth task are at the level of 9.48, the indices of the fifthtask are at the level of 6.71 and the indices of the sixth task are at the level of 7.01. A closer relationship should be noted here as compared to the previous one. Here also curvilinear relations are dominant, having bilateral character, i.e. dynamics of both the first trait by the second and the second by the first is observed. In the matrix under consideration the greatest level of mutual relations shifts to the area of latencies of components P100 and N145 due to the correlation with indicators of fulfillment of the third and fourth tasks for bimanual coordination whose general level of total mutual relations is at one statistically not differing level (tab. 1). It should be noted that, as in the previous system, the correlational relationships belong to the temporal performance of the passage of the third and fourth tracks. However, the comparisons of P100-IPK and N145-IPK acquire a pronounced rectilinear character.

In male subjects of the field-independent type, in the system of correlations of latencies caused by the arrival of a sensory stimulus through the right input, the sum of correlation coefficients and correlation relationships with coordination indices amounted to ∑r+η 54.64. In this system, the indicators of the first caliper-metric task are summarily correlated at the level of 12.42, the indicators of the second correlated at the level of 12.75, the indicators of the third correlated at the level of 10.61, the indicators of the fourth correlated at the level of 5.3, the indicators of the fifth correlated at the level of 3.09 and the indicators of the sixth ∑r+η 10.41. When considering the internal correlation structure, we should note a significant increase

Table 1

The total multilateral correlation of the latencies of the characteristics of visual evoked potentials on a chess pattern with the indicators of bimanual coordination in men

Таблица 1

Суммарная многосторонняя скоррелированность латентностей характеристик зрительных вызванных потенциалов на шахматный паттерн с показателями бимануальной координации у мужчин

Полезависимые / Field dependent				
Стимуляция справа / Stimulation on the right				
Показатель / Indicator	N75	P100	N145	P200
∑r+η	12,44	7,47	2,56	5,94
Ранг / Rank	I	II	IV	III
Стимуляция слева / Stimulation on the left				
∑r+η	5,9	10,89	18,67	9,52
Ранг / Rank	IV	II	I	III
Поленезависимые / Field independent				
Стимуляция справа / Stimulation on the right				
∑r+η	12,29	16,69	14,91	10,75
Ранг / Rank	III	I	II	IV
Стимуляция слева / Stimulation on the left				
∑r+η	15,32	10,39	15,08	9,81
Ранг / Rank	I	III	II	IV

Table 2

The total multilateral correlation of the latencies of the characteristics of visual evoked potentials on a chess pattern with the indicators of bimanual coordination in women

Таблица 2

Суммарная многосторонняя скоррелированность латентностей характеристик зрительных вызванных потенциалов на шахматный паттерн с показателями бимануальной координации у женщин

Полезависимые / Field dependent				
Стимуляция справа / Stimulation on the right				
Показатель / Indicator	N75	P100	N145	P200
∑r+η	23,26	14,21	9,12	10,07
Ранг / Rank	I	II	IV	III
Стимуляция слева / Stimulation on the left				
∑r+η	15,9	8,65	6,36	18,4
Ранг / Rank	II	III	IV	I
Поленезависимые / Field independent				
Стимуляция справа / Stimulation on the right				
∑r+η	8,2	20,14	14,82	18,0
Ранг Rank	IV	I	III	II
Стимуляция слева / Stimulation on the left				
∑r+η	6,09	14,66	14,23	17,2
Ранг / Rank	IV	II	III	I

in the total aggregate level of correlation relationships due to an increase in both the number of predominantly curvilinear correlations and their significance. Here, the structure and closeness are determined by the characteristics of the performance of the first and second tasks, which are strongly correlated with the latencies of the components of the VEPCP components P100 and N145. Of interest is the fact of the presence of rectilinear inversely directed relationships in the comparison of the characteristics of the defect in the performance of the OTC and EF task of the first and second tracks with the latencies of the P100 and N145 components. In a system of relationships defined by contralateral signal input, the overall level of relationship was ∑r+η 50.6. The characteristics of the first task with the latencies of the VEPCP correlated a total of 16.39, the second task 12.69, the third task 8.31, the fourth task 5.27, the fifth task 2.11, and the sixth task 5.83. The internal structure of the correlations is also described by preferential curvilinear relationships. As in the previous system, the characteristics of realization of the first two tracks, correlating with latencies of all components of the VEPCP, among which the first ranks are occupied by N75 and N145, being at statistically identical level of mutual relations, show the greatest closeness of connections. It should be noted that there are linear positive correlations in the comparisons of TT and TOC with N75 and N145 in the systems of both tasks and linear inversely directed in the pairs PKI-N75.

In women characterized by field dependence, the total level of the relationship between the latencies of the considered evoked potentials obtained during stimulation of the right eye and the characteristics of coordination is at the level ∑r+η 56.66 (Table 2). Here, the performance of the first task is correlated with latencies at the level of 6.87, the second task at 7.98, the third task at 13.26, the fourth task at 7.3, the fifth task at 7.55, and the sixth task at 12.7. The internal structure of multilateral relations in the system under consideration is reflected by exclusively curvilinear relations of practically all characteristics of supportometry with the latencies of the components of visual evoked potentials. At the same time, we should note the most pronounced bilateral correlations of the latency of the early component N 75 with the indices of TT, OTC, EF, RS, and IC registered during the realization of the third and sixth tasks. In the system of relationships caused by contralateral stimulation, the considered characteristics are correlated at the level ∑r+η 49.31. The level of relationships of the indicators of the first task in this correlation system is 11.06, the second — 5.99, the third — 6.9, the fourth — 7.27, the fifth — 12.18, and the sixth — 5.91. This system shows general patterns similar to the previous system. However, two-way curvilinear correlations of the latency of the P200 component with the defect characteristics of the OTC and EF track realization. Here the general total correlation is formed by interrelations of indices of performance of the first and fifth motor tracks.

In female subjects of the opposite field-independent pole of cognitive style, the temporal characteristics of evoked potentials recorded at the arrival of a sensory stimulus from the right correlate with the coordination indices of six motor tasks in ∑r+η — 61.16. Among them, the indices of the first task are correlated at a sum of 10.89, the second task at 12.92, the third task at 11.72, the fourth task at 10.15, the fifth task at 4.93, and the sixth task at 10.56. The internal structure of correlation relations in the considered system is characterized by the expressed curvilinearity, as in the previous cases. However, it should be noted that expressed relations characterize the indices of bimanual coordination of practically all supportometry tasks (except for the fifth), correlating with the latencies of the components of evoked potentials, among which P100 and P200 show expressed relations. Besides, it is necessary to note the few, but important rectilinear inversely directed interrelations in comparisons of the specified parameters with the characteristics of EF, RS and IC. In the system of comparisons conditioned by contralateral visual stimulus input, the sum of all correlation coefficients and correlation relations equals the value ∑r+η 52.18. Consideration of the total multilateral correlation of supportometry indicators by tasks in the above system of interrelations showed that the characteristics of the first task correlate at the level of 12.12, of the second at the level of 9.15, of the third at the level of 5.01, of the fourth at the level of 7.28, of the fifth at the level of 4.9, and of the sixth at the level of 11.26. Here, as well as in the previous system, the first ranks in the level of correlation show the latencies of the components P100, N145, and P200, the latter being reliably the most closely correlated. Curvilinear relationships, including bilateral ones, are observed with the characteristics of the realization of the first two and the last sixth tasks. There are also a few linear negative relationships with the characteristics of TT, TOC, EF, RS and IC.

DISCUSSION

The results obtained clearly indicate that the level of multilateral total correlation between various latencies of components of visual evoked potentials to a checkerboard pattern and indicators of motor activity points to the importance and complexity of the processes occurring in certain structures of the central nervous system related to the visual processing system and involved in ensuring voluntary bimanual coordination [8, 9, 14–16]. In addition, it has been shown that belonging to one or another pole of the cognitive style field dependence-field independence determines the characteristics and effectiveness of the spread of sensory information in critical structures of the nervous system [15, 16]. It is also worth noting the levels of multilateral relationships between indicators of voluntary motor activity of the hands depending on the type of track proposed for execution and the group of male or female subjects with different cognitive styles under consideration [4, 8].

Thus, in male subjects belonging to the field-independent style, the N75 component has the highest level of interaction in the system of connections. The physiological interpretation of the origin of this component suggests that the spread of excitation arising from stimulation of the macula and causing a response in the nearby field (17 according to Brodmann) is significant in this system [5]. In terms of supportometry, the track composed of angular and semicircular elements shows the highest level of relationships, which reflects the complexity of bimanual coordination. It should be noted that the dominance of curvilinear connections in the structure of correlation relationships, mainly with temporal indicators of supportometry and IC, indicates the attunement of the coordination process under the control of vision, aimed at achieving a useful result. Similar patterns, described by us earlier, can also be seen in this study [4, 8, 13, 14].

The arrival of a sensory stimulus through the left sensory input enhances the total multilateral correlation in the system by increasing the level of interaction between the latencies of components P100 and, especially, N145, which indicates an expansion of the topography of central structures in ensuring voluntary activity, including Brodmann areas 17 and 18, as well as the involvement of midline structures. In this case, we may be talking about processes of contralateral information dissemination with effective duplication. In addition, it should be noted that the high level of interaction is demonstrated by the characteristics of both the fourth and third tasks, consisting of semicircular elements, which are obviously the most difficult to perform. In this system, as in the previous one, attunement is associated with the correction of temporal and speed indicators of coordination. The established linear relationships in the P100-IPK and N145-IPK pairs clearly indicate an increase in the overall level of bimanual coordination with enhanced effective duplication of information. The features of the field-dependent pole in men identified in our study indicate the lateralization of functions in the hemispheres and pronounced individual differences in organization, including the visual sensory system.

In field-independent men, in the system of relationships between latencies caused by stimulation on the right side, the involvement of a wide range of central nervous system structures in the process, along with the striate cortex, has a significant impact on ensuring voluntary bimanual hand movements. It should be noted that the highest level of correlation is found in the performance indicators for the first training task and the second most difficult task, according to our previous studies [4, 8, 14]. A sharp increase in the

total multilateral correlation in the systems under consideration in subjects with a polene-independent style is noteworthy, which clearly indicates a restructuring of the system associated with the decoupling of perception from external landmarks. The performance of subsequent tasks with the achievement of a useful adaptive result is probably based on effective learning during the implementation of certain elements of the track. The connections found in the comparisons of the characteristics of the task performance defect in the first and second tracks with the most interrelated latencies of the P100 and N145 components are significant, indicating the role of the speed of information propagation in the error-free performance of bimanual actions.

When stimulated on the left side in pole-dependent men against a background of high levels of total interactions in the process of sensory-effector coordination, the convexital area, which extends to the surface of the visual cortex, is also significantly activated. As in the previous system, there is a pattern of high levels of inter-system interactions between the characteristics of the first two motor tracks. Against the background of a large number of curvilinear connections indicating the attunement of the systems, there are also positive relationships between the temporal characteristics of task performance and the IC with the most correlated latencies, which confirms the existence of a formed strategy of bimanual coordination based on control and effective implementation of speed-time characteristics.

In women with a field-independent style, when the right eye is stimulated, as in men, the critical level of excitation spread is Brodmann area 17. This response is the first clearly visible on the curve, occurring when the fovea (yellow spot) is stimulated. The established latency connections of this component form a higher level of total interactions in the system compared to men in a similar field-dependent group. At the same time, the highest level of relationships is characteristic of the coordination indicators of the third bimanual task, consisting of semicircular elements, traditionally difficult to implement, and the sixth, having semicircular and angular elements. Exclusively curvilinear connections indicate the tuning and co-tuning of the sensory-effector elements of the system, aimed at the effective performance of tasks. The presence of pronounced connections in the comparisons of the latency of the N75 component with the characteristics of the track implementation defect is noteworthy, which may indicate a different strategy of sensory-effector relationships, unlike men, associated with the need to disturb the system when making a mistake. The arrival of a sensory stimulus on the left involves the process of sensory provision of motor activity in field-dependent women, along with the latency of the N75 component and the latency of P200. This indicates the involvement of the frontal-central region and the pronounced participation of nonspecific systems of the thalamus and brain stem structures, in contrast to men [1, 5, 21, 22]. The highest correlation of the characteristics of the defect in performing the first and fifth tasks (VVC and OTC) with the latency of the P200 component confirms the existence of specific mechanisms of sensory-effector interactions.

In women with a field-independent cognitive style, when the right eye is stimulated, as in men, visual-motor coordination is carried out at the level of the subcortical basal nuclei of the forebrain, which are one of the critical components of the motor system. In addition, nonspecific brain systems and the reticular formation of the brainstem are of significant importance. It is characteristic that belonging to the pole-independent style in women determines an almost identical correlation of all supportometry tasks, which, unlike men, indicates an unstable level of learning in the acquisition of motor skills. Against the background of the dominant curvilinear connections of the described components, linear negative connections have also been identified, indicating sensory-effector coordination based on the occurrence and correction of errors, which forms an integral, lower level of bimanual coordination compared to men.

The system formed with the participation of latencies recorded during stimulation of the left eye in pole-dependent women is characterized by the highest level of correlation between the latencies P100, N145, and P200, which indicates the involvement, as in the previous case, of a wide range of structures in the process of visual-motor coordination. In addition, the associative areas of the cortex (Broden fields 18 and 19) acquire relatively significant importance here [5, 7, 22]. The identified curvilinear and linear relationships between the latencies of the corresponding components and the coordination indicators of the most correlated tasks characterize the corresponding strategy of visual-motor interactions.

CONCLUSION

Thus, the level and characteristics of the total multilateral correlation of the latencies of the components of visual evoked potentials to a checkerboard pattern with characteristics of bimanual coordination are determined by the lateralization of the sensory stimulus, gender, and belonging to one or another pole of the cognitive style field dependence-field independence. The established patterns of sensory-effector relationships indicate that in field-dependent subjects with right-sided stimulation, the geometric structure of the task being performed is of great importance, with the total level of relationships being significantly higher in women than in men, with a pronounced spread of excitation to the primary visual cortex. In men, the arrival of a stimulus through the left

sensory input causes the expansion of the relevant structures of the central nervous system, with the inclusion of the striate and associative cortex in the sensory process. In subjects of the field-independent type, there is a regular strengthening of sensory-effector relationships at the level of implementation of the first two tasks, followed by the implementation of tracks based on learning. In women, the spread of excitation in the structures of the limbic-reticular complex and nonspecific nuclei of the thalamus is involved in the process of visual-motor coordination. The internal structure of correlational relationships indicates that in men, the effective performance of motor tasks is determined by the spread of visual information and visual control at the level of speed-time indicators of bimanual coordination, especially in individuals characterized by pole independence. In women, a different strategy of visual sensory support for voluntary complex coordinated bimanual movements has been identified, based on the correction of the spread of excitation when a defect occurs during the implementation of the track, i.e., when the system is disturbed.

ADDITIONAL INFORMATION

Author contribution. Thereby, all authors made a substantial contribution to the conception of the study, acquisition, analysis, interpretation of data for the work, drafting and revising the article, final approval of the version to be published and agree to be accountable for all aspects of the study.

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