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ЕЖЕМЕСЯЧНЫЙ НАУЧНЫЙ ЖУРНАЛ

Медицинские новости Грузии

საქართველოს სამედიცინო სიახლენი

GEORGIAN MEDICAL NEWS

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GMN: Georgian Medical News is peer-reviewed, published monthly journal committed to promoting the science and art of medicine and the betterment of public health, published by the GMN Editorial Board since 1994. GMN carries original scientific articles on medicine, biology and pharmacy, which are of experimental, theoretical and practical character; publishes original research, reviews, commentaries, editorials, essays, medical news, and correspondence in English and Russian.

GMN is indexed in MEDLINE, SCOPUS, PubMed and VINITI Russian Academy of Sciences. The full text content is available through EBSCO databases.

GMN: Медицинские новости Грузии - ежемесячный рецензируемый научный журнал, издаётся Редакционной коллегией с 1994 года на русском и английском языках в целях поддержки медицинской науки и улучшения здравоохранения. В журнале публикуются оригинальные научные статьи в области медицины, биологии и фармации, статьи обзорного характера, научные сообщения, новости медицины и здравоохранения. Журнал индексируется в MEDLINE, отражён в базе данных SCOPUS, PubMed и ВИНИТИ РАН. Полнотекстовые статьи журнала доступны через БД EBSCO.

GMN: Georgian Medical News – საქართველოს სამედიცინო სიახლენი – არის ყოველთვიური სამეცნიერო სამედიცინო რეცენზირებადი ჟურნალი, გამოიცემა 1994 წლიდან, წარმოადგენს სარედაქციო კოლეგიისა და აშშ-ის მეცნიერების, განათლების, ინდუსტრიის, ხელოვნებისა და ბუნებისმეტყველების საერთაშორისო აკადემიის ერთობლივ გამოცემას. GMN-ში რუსულ და ინგლისურ ენებზე ქვეყნდება ექსპერიმენტული, თეორიული და პრაქტიკული ხასიათის ორიგინალური სამეცნიერო სტატიები მედიცინის, ბიოლოგიისა და ფარმაციის სფეროში, მიმოხილვითი ხასიათის სტატიები.

ჟურნალი ინდექსირებულია MEDLINE-ის საერთაშორისო სისტემაში, ასახულია SCOPUS-ის, PubMed-ის და ВИНИТИ РАН-ის მონაცემთა ბაზებში. სტატიების სრული ტექსტი ხელმისაწვდომია EBSCO-ს მონაცემთა ბაზებიდან.

WEBSITE

www.geomednews.com

К СВЕДЕНИЮ АВТОРОВ!

При направлении статьи в редакцию необходимо соблюдать следующие правила:

1. Статья должна быть представлена в двух экземплярах, на русском или английском языках, напечатанная через **полтора интервала на одной стороне стандартного листа с шириной левого поля в три сантиметра**. Используемый компьютерный шрифт для текста на русском и английском языках - **Times New Roman** (**Кириллица**), для текста на грузинском языке следует использовать **AcadNusx.** Размер шрифта - **12**. К рукописи, напечатанной на компьютере, должен быть приложен CD со статьей.

2. Размер статьи должен быть не менее десяти и не более двадцати страниц машинописи, включая указатель литературы и резюме на английском, русском и грузинском языках.

3. В статье должны быть освещены актуальность данного материала, методы и результаты исследования и их обсуждение.

При представлении в печать научных экспериментальных работ авторы должны указывать вид и количество экспериментальных животных, применявшиеся методы обезболивания и усыпления (в ходе острых опытов).

4. К статье должны быть приложены краткое (на полстраницы) резюме на английском, русском и грузинском языках (включающее следующие разделы: цель исследования, материал и методы, результаты и заключение) и список ключевых слов (key words).

5. Таблицы необходимо представлять в печатной форме. Фотокопии не принимаются. **Все цифровые, итоговые и процентные данные в таблицах должны соответствовать таковым в тексте статьи**. Таблицы и графики должны быть озаглавлены.

6. Фотографии должны быть контрастными, фотокопии с рентгенограмм - в позитивном изображении. Рисунки, чертежи и диаграммы следует озаглавить, пронумеровать и вставить в соответствующее место текста **в tiff формате**.

В подписях к микрофотографиям следует указывать степень увеличения через окуляр или объектив и метод окраски или импрегнации срезов.

7. Фамилии отечественных авторов приводятся в оригинальной транскрипции.

8. При оформлении и направлении статей в журнал МНГ просим авторов соблюдать правила, изложенные в «Единых требованиях к рукописям, представляемым в биомедицинские журналы», принятых Международным комитетом редакторов медицинских журналов - http://www.spinesurgery.ru/files/publish.pdf и http://www.nlm.nih.gov/bsd/uniform_requirements.html
В конце каждой оригинальной статьи приводится библиографический список. В список литературы включаются все материалы, на которые имеются ссылки в тексте. Список составляется в алфавитном порядке и нумеруется. Литературный источник приводится на языке оригинала. В списке литературы сначала приводятся работы, написанные знаками грузинского алфавита, затем кириллицей и латиницей. Ссылки на цитируемые работы в тексте статьи даются в квадратных скобках в виде номера, соответствующего номеру данной работы в списке литературы. Большинство цитированных источников должны быть за последние 5-7 лет.

9. Для получения права на публикацию статья должна иметь от руководителя работы или учреждения визу и сопроводительное отношение, написанные или напечатанные на бланке и заверенные подписью и печатью.

10. В конце статьи должны быть подписи всех авторов, полностью приведены их фамилии, имена и отчества, указаны служебный и домашний номера телефонов и адреса или иные координаты. Количество авторов (соавторов) не должно превышать пяти человек.

11. Редакция оставляет за собой право сокращать и исправлять статьи. Корректура авторам не высылается, вся работа и сверка проводится по авторскому оригиналу.

12. Недопустимо направление в редакцию работ, представленных к печати в иных издательствах или опубликованных в других изданиях.

При нарушении указанных правил статьи не рассматриваются.

REQUIREMENTS

Please note, materials submitted to the Editorial Office Staff are supposed to meet the following requirements:

1. Articles must be provided with a double copy, in English or Russian languages and typed or compu-ter-printed on a single side of standard typing paper, with the left margin of **3** centimeters width, and **1.5** spacing between the lines, typeface - **Times New Roman** (**Cyrillic**), print size - **12** (referring to Georgian and Russian materials). With computer-printed texts please enclose a CD carrying the same file titled with Latin symbols.

2. Size of the article, including index and resume in English, Russian and Georgian languages must be at least 10 pages and not exceed the limit of 20 pages of typed or computer-printed text.

3. Submitted material must include a coverage of a topical subject, research methods, results, and review.

Authors of the scientific-research works must indicate the number of experimental biological species drawn in, list the employed methods of anesthetization and soporific means used during acute tests.

4. Articles must have a short (half page) abstract in English, Russian and Georgian (including the following sections: aim of study, material and methods, results and conclusions) and a list of key words.

5. Tables must be presented in an original typed or computer-printed form, instead of a photocopied version. **Numbers, totals, percentile data on the tables must coincide with those in the texts of the articles.** Tables and graphs must be headed.

6. Photographs are required to be contrasted and must be submitted with doubles. Please number each photograph with a pencil on its back, indicate author's name, title of the article (short version), and mark out its top and bottom parts. Drawings must be accurate, drafts and diagrams drawn in Indian ink (or black ink). Photocopies of the X-ray photographs must be presented in a positive image in **tiff format**.

Accurately numbered subtitles for each illustration must be listed on a separate sheet of paper. In the subtitles for the microphotographs please indicate the ocular and objective lens magnification power, method of coloring or impregnation of the microscopic sections (preparations).

7. Please indicate last names, first and middle initials of the native authors, present names and initials of the foreign authors in the transcription of the original language, enclose in parenthesis corresponding number under which the author is listed in the reference materials.

8. Please follow guidance offered to authors by The International Committee of Medical Journal Editors guidance in its Uniform Requirements for Manuscripts Submitted to Biomedical Journals publication available online at: http://www.nlm.nih.gov/bsd/uniform_requirements.html
http://www.icmje.org/urm_full.pdf
In GMN style for each work cited in the text, a bibliographic reference is given, and this is located at the end of the article under the title "References". All references cited in the text must be listed. The list of references should be arranged alphabetically and then numbered. References are numbered in the text [numbers in square brackets] and in the reference list and numbers are repeated throughout the text as needed. The bibliographic description is given in the language of publication (citations in Georgian script are followed by Cyrillic and Latin).

9. To obtain the rights of publication articles must be accompanied by a visa from the project instructor or the establishment, where the work has been performed, and a reference letter, both written or typed on a special signed form, certified by a stamp or a seal.

10. Articles must be signed by all of the authors at the end, and they must be provided with a list of full names, office and home phone numbers and addresses or other non-office locations where the authors could be reached. The number of the authors (co-authors) must not exceed the limit of 5 people.

11. Editorial Staff reserves the rights to cut down in size and correct the articles. Proof-sheets are not sent out to the authors. The entire editorial and collation work is performed according to the author's original text.

12. Sending in the works that have already been assigned to the press by other Editorial Staffs or have been printed by other publishers is not permissible.

Articles that Fail to Meet the Aforementioned Requirements are not Assigned to be Reviewed.

ავტორთა საყურადღებოდ!

რედაქციაში სტატიის წარმოდგენისას საჭიროა დავიცვათ შემდეგი წესები:

1. სტატია უნდა წარმოადგინოთ 2 ცალად, რუსულ ან ინგლისურ ენებზე,დაბეჭდილი სტანდარტული ფურცლის 1 გვერდზე, 3 სმ სიგანის მარცხენა ველისა და სტრიქონებს შორის 1,5 ინტერვალის დაცვით. გამოყენებული კომპიუტერული შრიფტი რუსულ და ინგლისურენოვან ტექსტებში - **Times New Roman (Кириллица)**, ხოლო ქართულენოვან ტექსტში საჭიროა გამოვიყენოთ **AcadNusx.** შრიფტის ზომა – 12. სტატიას თან უნდა ახლდეს CD სტატიით.

2. სტატიის მოცულობა არ უნდა შეადგენდეს 10 გვერდზე ნაკლებს და 20 გვერდზე მეტს ლიტერატურის სიის და რეზიუმეების (ინგლისურ, რუსულ და ქართულ ენებზე) ჩათვლით.

3. სტატიაში საჭიროა გაშუქდეს: საკითხის აქტუალობა; კვლევის მიზანი; საკვლევი მასალა და გამოყენებული მეთოდები; მიღებული შედეგები და მათი განსჯა. ექსპერიმენტული ხასიათის სტატიების წარმოდგენისას ავტორებმა უნდა მიუთითონ საექსპერიმენტო ცხოველების სახეობა და რაოდენობა; გაუტკივარებისა და დაძინების მეთოდები (მწვავე ცდების პირობებში).

4. სტატიას თან უნდა ახლდეს რეზიუმე ინგლისურ, რუსულ და ქართულ ენებზე არანაკლებ ნახევარი გვერდის მოცულობისა (სათაურის, ავტორების, დაწესებულების მითითებით და უნდა შეიცავდეს შემდეგ განყოფილებებს: მიზანი, მასალა და მეთოდები, შედეგები და დასკვნები; ტექსტუალური ნაწილი არ უნდა იყოს 15 სტრიქონზე ნაკლები) და საკვანძო სიტყვების ჩამონათვალი (key words).

5. ცხრილები საჭიროა წარმოადგინოთ ნაბეჭდი სახით. ყველა ციფრული, შემაჯამებელი და პროცენტული მონაცემები უნდა შეესაბამებოდეს ტექსტში მოყვანილს.

6. ფოტოსურათები უნდა იყოს კონტრასტული; სურათები, ნახაზები, დიაგრამები - დასათაურებული, დანომრილი და სათანადო ადგილას ჩასმული. რენტგენოგრამების ფოტოასლები წარმოადგინეთ პოზიტიური გამოსახულებით **tiff** ფორმატში. მიკროფოტოსურათების წარწერებში საჭიროა მიუთითოთ ოკულარის ან ობიექტივის საშუალებით გადიდების ხარისხი, ანათალების შეღებვის ან იმპრეგნაციის მეთოდი და აღნიშნოთ სურათის ზედა და ქვედა ნაწილები.

7. სამამულო ავტორების გვარები სტატიაში აღინიშნება ინიციალების თანდართვით, უცხოურისა – უცხოური ტრანსკრიპციით.

8. სტატიას თან უნდა ახლდეს ავტორის მიერ გამოყენებული სამამულო და უცხოური შრომების ბიბლიოგრაფიული სია (ბოლო 5-8 წლის სიღრმით). ანბანური წყობით წარმოდგენილ ბიბლიოგრაფიულ სიაში მიუთითეთ ჯერ სამამულო, შემდეგ უცხოელი ავტორები (გვარი, ინიციალები, სტატიის სათაური, ჟურნალის დასახელება, გამოცემის ადგილი, წელი, ჟურნალის №, პირველი და ბოლო გვერდები). მონოგრაფიის შემთხვევაში მიუთითეთ გამოცემის წელი, ადგილი და გვერდების საერთო რაოდენობა. ტექსტში კვადრატულ ფჩხილებში უნდა მიუთითოთ ავტორის შესაბამისი N ლიტერატურის სიის მიხედვით. მიზანშეწონილია, რომ ციტირებული წყაროების უმეტესი ნაწილი იყოს 5-6 წლის სიღრმის.

9. სტატიას თან უნდა ახლდეს: ა) დაწესებულების ან სამეცნიერო ხელმძღვანელის წარდგინება, დამოწმებული ხელმოწერითა და ბეჭდით; ბ) დარგის სპეციალისტის დამოწმებული რეცენზია, რომელშიც მითითებული იქნება საკითხის აქტუალობა, მასალის საკმაობა, მეთოდის სანდოობა, შედეგების სამეცნიერო-პრაქტიკული მნიშვნელობა.

10. სტატიის ბოლოს საჭიროა ყველა ავტორის ხელმოწერა, რომელთა რაოდენობა არ უნდა აღემატებოდეს 5-ს.

11. რედაქცია იტოვებს უფლებას შეასწოროს სტატია. ტექსტზე მუშაობა და შეჯერება ხდება საავტორო ორიგინალის მიხედვით.

12. დაუშვებელია რედაქციაში ისეთი სტატიის წარდგენა, რომელიც დასაბეჭდად წარდგენილი იყო სხვა რედაქციაში ან გამოქვეყნებული იყო სხვა გამოცემებში.

აღნიშნული წესების დარღვევის შემთხვევაში სტატიები არ განიხილება.

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THE STUDY OF SPATIAL REPRESENTATIONS OF CHILDREN WITH DIFFERENT DEGREES OF INTERHEMISPHERIC INTERACTION

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Abstract.

Aim: The paper discusses the results of neuropsychological tasks aimed at the study of spatial representations of primary school children with different degrees of interhemispheric interaction (II). The degree of II formation was assessed using bimanual motor tests. The dependence of the state of interhemispheric interaction and spatial representations on such factors as age, sex, manual preferences are traced.

Materials and methods: The research was performed in the research laboratory of the Faculty of Special and Inclusive Education at the Armenian State Pedagogical University after Kh. Abovyan and Armenian state institute of physical culture and sport. A total of 73 children aged between 8 and 11 years participated in the study.

We emphasize that we were interested in which of the various spatial components of different mental functions showed maximum dependence on the state of II in the motor sphere. To answer the set questions 73 children were examined in general education schools of Yerevan. Their ages ranged from 8 to 11 years old. 12 children from the examined group had distinct manifestations of left-handedness or ambidextrousness; the rest of the children were right-handed. To analyse the age dynamics of the state of spatial representations and the degree of formation of interhemispheric interaction, the children were divided into 2 age subgroups: 8-9 years old (31 people), 10-11 years old (42 people). Such division was connected with the fact that these age periods are all without exception extremely significant for the formation of the aspects of the organization of brain work in general. Thus, it is in 8-9 years old that the mechanisms of interhemispheric transfer are already in full force, the main motor and sensory asymmetries are stabilized, and the predominant control of the right or left hemisphere over the course of a particular mental process at the operational level is formed.

The age of 10-11 years is, according to many authors, crucial for the formation of a stable individual II modus and for "microstructural changes in the ensemble organization of the frontal area". In adolescence the anterior parts of the corpus callosum (CC) actively mature, providing CC at the level of the frontal lobes, and intensive rearrangements in the work of the dominant hemisphere of the brain continue. In addition to age indicators, we also analysed differences in the degree of CC formation and in the state of spatial representations in children of different sexes, academic performance, and in children with different manual preferences. The following results were obtained.

Results: Reciprocal coordination disorders were detected in 41% of the children who performed the test. Among the detected disorders, failures in the left hand or lagging of the left hand predominated. These symptoms could vary in severity and stability: in some subjects they were observed only at the initial stages of task performance or occurred during exhaustion, while in others they were stable. Among the detected disorders, failures in the left hand or lagging of the left hand predominated. These symptoms could vary in severity and stability: in some subjects they were observed only at the initial stages of task performance or occurred during exhaustion, while in others they were stable. Failures in both hands r sequential execution of movements with the right and left hands were much less frequent.

Conclusion: Thus, our results suggest that in left-handed schoolchildren characterized by significant difficulties in the formation of the spatial sphere and interhemispheric relations, the state of spatial praxis and projective representations is closely related to the qualitative features of CC at the level of both posterior and anterior brain regions.

Key words. Spatial representations, interhemispheric interaction, motor sphere, children, tests, corpus callosum, left-handed, right-handed.

Introduction.

Among various aspects of the problem of interhemispheric interaction (II), which has been in the centre of attention of modern neuroanatomy and neuropsychology for the last decades, the peculiarities of those neuropsychological symptoms and syndromes, which are observed in IM deficiency, attract special interest of researchers. These syndromes often combine specific motor and spatial disorders. An example is the "split brain" syndrome described in patients who have undergone partial or complete transection of the corpus callosum (CC) [1-3]. The following symptoms are observed: anomia (inability to give a verbal account of the signals received by the right hemisphere); impaired reciprocal asymmetrical hand movements; dyscopia-dysgraphia (inability to write with the left hand and draw with the right); left-sided neglect; "mirror" errors in writing and drawing. Similar patterns of symptoms can be seen in agenesis (congenital absence) of CC [4,5]. However, the question of how CC develops in normal ontogenesis is still open.

The progressive and heterochronic nature of CC formation is certainly beyond doubt, but very little is still known about the specific temporal parameters of this process, about the sequence of folding of various CC components in childhood. The question of the role of CC in the development of various mental functions remains practically unexplored. Does the success of cognitive sphere development depend on the degree of CC formation? In what empirical facts can we see evidence of such dependence? To find an answer to these questions, we have attempted to solve such research tasks as:

1) analysing the state of CC in the sphere of arbitrary movements and peculiarities of spatial components of various mental processes (so-called spatial representations) in children of 8-11 years old.

2) search for possible interrelations between the degree of CC and spatial representations.

These tasks, in our opinion, need a detailed justification. First, it is important to understand why the sphere of arbitrary movements was chosen to analyse the II state. The point is that numerous literary sources contain references to the fact that some types of voluntary movements (praxis) are a rather sensitive indicator of the CC state.

For example, it is widely known that it is II that plays a priority role in providing complex bimanual coordination of movements. Such coordination requires a rapid exchange of information between the cerebral hemispheres. II can participate in the transmission of motor commands and efferent information from one hemisphere to the other, in the implementation of sensory feedback [6-9]. When the anterior part of the II is cut, the performance of tasks requiring coordinated movements of both hands to draw lines varying in degree of slope is impaired. Normal subjects are able to draw smooth lines in trials requiring both equal and different speeds of hand movements (even in the absence of visual feedback). Partial commissurotomy subjects have significant difficulty drawing lines in trials requiring asymmetrical hand movements, and their performance is significantly impaired when visual feedback is unavailable. These findings suggest that the anterior II plays a fundamental role in the interhemispheric regulation of motor responses, in the acquisition of new bimanual skills, and in the successful use of these skills.

There is also evidence that the acquisition of similar motor skills in children is associated with II myelination [9,10,11]. Subjects aged 10-11 years performed similar tasks without difficulty, while 8–9-year-old children demonstrated results similar to those of adults who had undergone a commissurotomy. The 8–9-year-old children worked more slowly and made more errors than the older children. This was mainly observed when different hand speeds were required when drawing slanting lines. Bimanual coordination deficits may have been associated with inefficient transfer of motor information between the hemispheres when II myelination is incomplete [8,12]. Bimanual performance impairments have also been reported in children with reading disorders [5,11,13]. In tasks requiring asymmetrical hand movements, they returned to symmetrical bimanual movements in the absence of visual control.

In children with congenital or acquired CC anomalies, the temporal organisation of different bimanual programmes is altered [7]. Patients with II agenesis and with commissurotomy were asked to perform the following tasks:

1) drawer opening in which one hand slides the drawer open while the other hand picks up a small object.

2) rhythmic rotational movements of the hands, which are performed in parallel or in opposite directions.

Children with mostly optimal performance on the first task but showed a strong tendency to desynchronise rotational movements, especially those performed in opposite directions. However, only a few patients experienced such problems. Apparently, compensatory mechanisms can be used to regulate temporal synchronisation in bimanual movements [14]. In isolated CC lesions, apraxia in the left limbs may be observed [7,10,13]. All these data clearly confirm the opinion that the state of various bimanual movements is a sensitive indicator of II quality. Therefore, in our study we used bimanual neuropsychological techniques: transfer of finger postures according to a kinesthetic pattern and a test for reciprocal coordination (so-called Ozeretsky's test). When performing the first technique, the subject must close his eyes; then a certain pose of fingers on the left or right hand is set; the subject must reproduce this pose with the other hand [15].

The second technique consists in a repeated simultaneous change of position of the right and left hands: when one hand is clenched into a fist, the other hand is placed palm downwards; then the position of both hands is changed [15]. The test for transferring finger poses according to a kinesthetic pattern is aimed at analysing the state of the II provided by the posterior (primarily parietal) parts of the brain; the test for reciprocal coordination allows us to assess the quality of the CC at the level of the anterior (posterior frontal) parts. Second, it is necessary to provide a more detailed argumentation of our appeal to the study of spatial representations.

It is known that the sensorimotor level of mental processes, an essential component of which is the motor sphere, serves as a foundation for the formation of both behaviour in general and many aspects of the cognitive sphere in normal and abnormal ontogenesis [3,6,16]. The choice of spatial representations as the object of analysis is also related to the fact that in the symptom-complex of CC disorders, manifestations of spatial disorders are quite common (or even dominant). As mentioned above, in the "split brain" syndrome and in II agenesis, symptoms of left-sided inattention or neglect, "mirror" errors in graphic tests can be observed. These data suggest that there are links between the state of II in the motor sphere and the nature of functioning of spatial representations. We can only speculate about the mechanisms of these connections.

Materials and Methods.

We have undertaken a study of a variety of spatial functions. Of course, it would be logical to assume that the CC indicators in the motor sphere will be primarily interrelated with the parameters of spatial organisation of movements. Therefore, we analysed the state of spatial praxis - a special type of arbitrary movements, when performing which the subject must reproduce spatially organised poses of various complexity according to a visual model accompanied by a corresponding verbal instruction. However, we investigated not only the possibility of the influence of II in the motor sphere on the spatial organisation of movements, but also on other mental processes in which spatial components play a significant role. Therefore, we also analysed drawing and auditory-verbal memory. In assessing the features of drawing, we paid attention to the possibility of using in graphic activity the ideas about the basic coordinates of space (right-left, top-bottom). For this purpose, we used such a test as drawing two and three geometric figures connected by spatial relations according to a verbal instruction. The subjects were asked to draw a triangle to the right of a square; a cross under a circle; a triangle to the right of a circle but to the left of a square. Metric representations were studied, which ensure the possibility of correct transfer of the image size when copying from a sample, as well as the adequate size of one's own drawing.

Failure to form or violations of such representations are usually expressed in the appearance of macro- or micrographs. Finally, the analysis of spatial representations in drawing implied the consideration of projection representations (i.e. the ability to convey in an independent drawing or when copying from a sample the volume, perspective, depth of the image). As for auditory-verbal memory, we analysed the possibility of remembering the order of auditory-verbal stimuli. It should be noted in passing that in fact this is not only a spatial, but also a temporal characteristic; however, in Russian neuropsychology it is common to treat disturbances in the order of stimuli during reproduction as a manifestation of spatial disorders.

To study this aspect of auditory-verbal memory, we used the method of memorising a number of words, in which the subject had to reproduce auditory-verbal stimuli in the sequence in which they were presented for memorisation [3]. To summarise the above, we emphasise that we were interested in which of the various spatial components of different mental functions showed maximum dependence on the state of II in the motor sphere.

To answer the set questions 73 children were examined in general education schools of Yerevan. Their age ranged from 8 to 11 years old. 12 children from the examined group had distinct manifestations of left-handedness or ambidextrousness; the rest of the children were right-handed. To analyse the age dynamics of the state of spatial representations and the degree of formation of interhemispheric interaction, the children were divided into 2 age subgroups: 8-9 years old (31 people), 10-11 years old (42 people). Such division was connected with the fact that these age periods are all without exception extremely significant for the formation of the aspects of the organisation of brain work in general. Thus, it is in 8-9 years old that the mechanisms of interhemispheric transfer are already in full force, the main motor and sensory asymmetries are stabilised, and the predominant control of the right or left hemisphere over the course of a particular mental process at the operational level is formed.

The age of 10-11 years is, according to many authors, crucial for the formation of a stable individual II modus and for "microstructural changes in the ensemble organisation of the frontal area" [7,8,17]. In adolescence the anterior parts of the corpus callosum actively mature, providing CC at the level of the frontal lobes, and intensive rearrangements in the work of the dominant hemisphere of the brain continue. In addition to age indicators, we also analysed differences in the degree of CC formation and in the state of spatial representations in children of different sexes, academic performance, and in children with different manual preferences. The following results were obtained.

Results.

Reciprocal coordination disorders were detected in 41% of the children who performed the test. Among the detected disorders, failures in the left hand or lagging of the left hand predominated. These symptoms could vary in severity and stability: in some subjects they were observed only at the initial stages of task performance or occurred during exhaustion, while in others they were stable. Failures in both hands r sequential execution of movements with the right and left hands were much less frequent. Disorders of kinaesthetic pose transfer were found in 22% of children, with difficulties in transferring from the left hand to the right-hand predominating. Bilateral errors and synkinesias were much less frequent. In 10 per cent of children, violations were observed in the performance of both reciprocal coordination and transfer of poses according to a kinaesthetic pattern. In addition, it turned out that the state of CC in the motor sphere varies in different subgroups of subjects.

The data in table 1 and 2 show that the spatial organisation of arbitrary movements (spatial praxis) is one of the most vulnerable components of spatial representations in different subgroups of subjects. Among the identified violations, difficulties in re-coding and/or "mirror" errors in performing "crossed" poses prevailed. In some children, difficulties at this stage of activity had the character of single manifestations, while in others there were multiple errors. In addition, some subjects showed impulsiveness, exhaustion, and underdosed movements (such disorders were typical of the younger age subgroup). Positive age dynamics can be traced in the performance of spatial praxis tests, gender differences and differences related to manual dominance are revealed (Tables 1 and 2).

Table 1. *Data on the frequency of spatial perception disorders in different age and gender subgroups of subjects (in per cent; 100% - all children in the corresponding subgroup who performed the test).*

Indicators	Ages		Gender	
	8-9 years	10-11 years	boys	girls
Spatial praxis	41	32	35	38
Coordinate representations	38	22	32	28
Projection representations	35	26	28	33
Metric representations	42	31	36	37
Word order	36	37	31	42

Table 2. *Data on the frequency of spatial perception disorders in children with different manual preferences (in per cent; 100% - all children in the corresponding subgroup who performed the test).*

Indicators	Ages		Manual preferences	
	8-9 years	10-11 years	left-handed	right-handed
Spatial praxis	35	26	31	42
Coordinate representations	36	37	32	28
Projection representations	32	41	28	33
Metric representations	42	31	36	37
Word order	38	22	35	38

Among spatial representations in drawing, apparently, the most difficult for junior schoolchildren are projection representations, and metric and coordinate representations are relatively established at this age. Among metric errors, micro- and macrographies were encountered with approximately equal frequency. These errors could be single manifestations or a

constant characteristic of the drawing. A number of children had both types of errors. Metric errors were also observed when copying complex figures and were expressed in incorrect transfer of their proportions.

Table 3. *Indicators on the frequency of spatial representations disorders in children with manual preference in different gender groups.*

Indicators	**Ages 8-11 years**		**Gender**	
	left-handed	right-handed	boys	girl
Spatial praxis	0,19±0,04	0,23±0,04	0,22±0,04	0,2±0,05
Coordinate representations	25,0±2,95	23,44±2,61	23,18±2,54	26,93±3,82
Projection representations	76,48±7,8	75,59±9,34	76,43±8,47	79,0±8,37
Metric representations	112,16±6,7	113,97±6,05	122,85±6,67	106,79±6,59
Word order	65,3±7,07	65,26±7,99	64,83±8,31	70,55±7,47

Significant differences were revealed between successful and unsuccessful pupils, between left-handed and right-handed children. Difficulties in reproducing word order, indicating unformed or deficient spatial representations in the sphere of auditory-verbal memory, are found in most children at the initial stages of memorisation.

Starting the discussion of the obtained results, we will first of all touch upon the features of CC in the examined children. We proceeded from the assumption that the quality of performance of the reciprocal coordination test is an indicator of CC formation at the level of the anterior (premotor) parts of the brain, and the test for transferring poses according to a kinesthetic pattern - at the level of the posterior (parietal) parts of the brain.

It should be noted that even at the age of 11-12 years, CC at the level of the anterior parts of the brain in about a quarter of the examined children has not yet reached the optimal level, indicating that the frontal lobes are still undergoing functional genesis. Another reason for the later development of reciprocal coordination compared to pose transfer may be the different degree of complexity of these bimanual trials. If the transfer of poses according to the kinaesthetic pattern is a largely successful process, the reciprocal coordination, on the contrary, should be, first of all, it requires simultaneous coordinated work of both hands. It should also be recalled once again that, according to our study, the right hemisphere-brain is the most vulnerable part of the MB at the younger school age (at the level of both anterior and posterior parts of the brain). There are also gender differences in the CC state.

Finally, a comparison between children with different manual dominance clearly shows that disorders in the performance of both reciprocal coordination and transfer of postures to a pree anaesthetic pattern are much more common in left-handed children. Apparently, this is due to the peculiar functional dissociation of the brain hemispheres in left-handedness, which is indicated by a number of authors [12,13,17]. The data obtained in the study on the state of spatial components of different spheres of mental activity - motor, optico-constructive, and mnestic - show that spatial praxis (i.e., reproduction of spatially organised movements of different complexity according to a visual pattern) is one of the most late forming types of arbitrary movements in ontogenesis. Even at the age of 10-11 years, almost half of children make mistakes when performing spatial praxis trials. This may be due to the fact that spatial praxis tests are complex, multicomponent. Their performance requires visual-spatial, proprioceptive perception, "body schema", complex motor coordination, programming, and control. The performance of such complex tests relies mainly on the work of tertiary (associative) brain areas. In drawing, projective representations, i.e. the ability to convey perspective, volume, and depth of an image, are established most late. One of the reasons for such late formation of projective representations may be that they are provided by the coordinated work of both hemispheres of the brain. On the contrary, metrical representations, which ensure adequate dimensionality of the drawing (or correct reproduction of the sample size, if we are talking about copying), are formed much faster. The fact that these representations are provided predominantly by the right hemisphere may play a role in this. Earlier opinions were expressed that it is metric representations that are formed later than other representations in ontogenesis [16]. However, in fact, such divergent conclusions are explained by the nature of the techniques used. In our study we used drawing of two and (or) three simple geometric figures connected by spatial relations, drawing of a house, a table on four legs, copying of a cube, while in the works of the authors of the study the following methods were used. It is possible that the development of this component of spatial representations is not a linear progressive process, and regressive tendencies may occur in some children at certain age periods.

The analysis of children of different ages' reproduction of the order of stimuli when memorising 5 words also demonstrates ambiguous dynamics. Thus, both at the stage of immediate and delayed reproduction, the maximum number of permutations is allowed by children aged 8-9 years, and then the frequency of order violations is practically unchanged. In general, this fact seems somewhat unexpected: it is known that the functional role of the right hemisphere in childhood is very great, and it is it that is associated with the provision of this component of auditory-verbal memory. However, we should not think that the dominance of one or another hemisphere must necessarily lead to an optimum. A comparison of the state of spatial representations in right- and left-handed children shows that the latter are more likely to have disorders of spatial praxis, coordinate, projection, and metric characteristics of drawing. At the same time, right-handed children are slightly more likely to make mistakes in reproducing word order. These data suggest that the main difficulties in left-handed children are observed in the visual processing of spatial information. Modern research suggests that among the levels that can be distinguished in the development of complex functional systems of the psyche, the highest is the level of hierarchical integration [4]. Here, in the presence of a variety of interrelationships, the elements of the system are in flexible and variable relations with each other, being relatively free from the influence of the whole, as well as factors of the external environment. It is at this level that the system acquires such a unique quality as heterogeneity.

Conclusion.

Thus, our results suggest that in left-handed schoolchildren characterized by significant difficulties in the formation of the spatial sphere and interhemispheric relations, the state of spatial praxis and projective representations is closely related to the qualitative features of CC at the level of both posterior and anterior brain regions. Of course, we are not yet able to judge with sufficient certainty what specific causes determine the presence or absence of correlations between the components of spatial representations and CC. We can only assume that the processes leading to the formation of the above-mentioned level of hierarchical integration depend on the sequence of development of the diverse components of these mental spheres in ontogenesis, on the contribution of genetic and environmental determinants that determine their special brain organization.

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