Dynamics of Praxis Function in Children Aged 4-6 Years as an Indicator of School Readiness

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Abstract: Praxis functions are among the least studied in childhood, despite data on the relationship between motor development and school achievement. The conducted neuropsychological study evaluates the status of spatial postural praxis (ideomotor praxis for new movements) in 365 children aged 4-6 years. All children attend public kindergarten. A modified version of the Head sample was used. The test is complex in nature, and its performance correlates with other higher functions such as visual-spatial orientation and movement organization, somatognosis and executive (inhibitory) control. The respondents were divided into age, demographic and gender groups. A three-factor analysis of variance was applied that showed a significant effect of all independent factors on the development of children's spatial postural praxis. The influence of the age factor is associated with a progressive decrease in the incidence of inaccurate and echopraxic gesture performance and the influence of the gender factor with the higher achievement of girls than boys.

The data indicate a positive trend in the development of visual-spatial organization of movements and executive control over the period of 4-6 years. This dynamics is an indicator of improved functioning of the frontal-parietal system and the inferior temporal regions of the left hemisphere. The age of 6 years is the first critical period in the development of spatial postural praxis and related visual-spatial and executive functions. The presence of subgroups of children with varying degrees of postural praxis is the result of individual neuropsychic development rates and has the character of a predictor of school achievement.

Keywords: Spatial postural praxis, visual-spatial orientation and movement organization, somatognosis, executive control, heterochronous development, preschool age, sensitive period.

INTRODUCTION

In recent years, a trend has been developed in pediatric neuropsychology, defined as differential neuropsychology or norm neuropsychology. One of its tasks is to analyze the ontogenetic patterns of higher mental functions in children with typical development and to determine the boundaries of individual differences. Information on patterns of early neuropsychological development is a condition for an objective assessment of children at risk of learning disabilities, the number of which has been noticeably increasing in recent years. The great variety of variants in the individual profiles is a consequence of the heterochronous principle of development and leads to the subgroups being separated within the normal child population. Children from the low-achieving group typically exhibit difficulties in the literacy process. This explains the need to develop tools for complex neuropsychological diagnosis of higher mental functions as predictors of academic achievement [1].

The selection of diagnostic methods has long been the subject of debate due to the high demands on clinical and socio-pedagogical practices, including: objective analysis of the dynamics of underlying gnosis, praxis and linguistic functions and high sensitivity to cases of delay in morphofunctional maturation of the children brain. Maturation is directly related to the idea of preventing learning disabilities and the need to identify “problem children” before entering school. The widespread use of neuropsychological diagnostic tools is also determined by the new goals in the analysis of pediatric development: from close diagnostic to prognostic, from finding deficits to describing the syndrome and developing strategies for therapy. In contrast to other diagnostic approaches, the neuropsychological approach allows for an early assessment of individual information processing strategies and their impact on the child's mental development and education [2].

The state of motor functions is one of the leading criteria in assessing children development, and the maturation of their components (accuracy, speed, coordination) determines the basis for the formation of complex motor skills (praxis). In recent years, interest in the features of motor development has increased because of data on their correlation with other areas of children's mental functioning - cognitive, linguistic and emotional [3]. Commonly commented are cases of motor comorbidity and specific dyslexia [4-6], which proves the need for praxis functions to find a place among school readiness criteria as predictors of learning disabilities. We agree with Piek, Hands &

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Licari [3] that, in contrast to intelligence and language assessment tools, motor development still lacks a gold standard assessment tool. According to them, early identification of specific deficits or delays in motor development will allow to avoid a number of psychosocial and academic problems arising from the peculiarities of children's motor abilities.

A SPATIAL POSTURAL PRAXIS

Diagnosis of praxis functions (manual, oral, verbal) is aimed at the implementation of purposeful and deliberately controlled movements, and their development in childhood is considered as a basis for the formation of school skills and social habits. Samples for the evaluation of spatial postural praxis (ideomotor praxis for new movements) suggest motor imitation and motor coding of visually perceived motion. According to one theory, imitative movements are based on the work of the mirror nervous system. The defective functioning of the system, typically related to disorders of the autism spectrum, is manifested in their characteristic early disorders in imitation, language programming, and "Theory of Mind" [7-9]. Neurodevelopment studies of the mirror nervous system under conditions of observation and observation-execution indicate that the mirror mechanism is involved in imitation as an immediate replica of the observed motor act tool, that is, within the second condition [8].

Citing earlier studies (Wapner S & Cirillo L, 1968), according to which early in life, children tend to imitate others as a mirror, Iacoboni and Dapretto [10] emphasize the crucial importance of the mirror nervous system for the early imitative behavior of the children. Summarizing data from various f MRI studies, the authors highlight the role of a core circuit for Imitation, bringing together the connections of three major regions: the superior temporal sulcus providing a high level of visual description of the observed action; the parietal divisions of the motor mirror system responsible for the motor aspects of the action; the frontal sections of the mirror system corresponding to the purpose of the imitative action.

Other studies [11] also link the cortical neural network of the inferior frontal, anterior inferior parietal and posterior superior temporal lobes to the imitation processes and draw attention to the controversial issues surrounding its lateralization. The authors accept that, unlike language, the visual and motor components of the human mirror nervous system have a bilateral organization. Functional MRI data from imitation tasks also reveal bilateral activity of the frontal-parietal regions (lower and upper parietal cortex, lower frontal and prefrontal motor cortex), with more pronounced lateralization in the left parietal cortex [12]. The role of the parietal and frontal lobes as determinants of motor imitation is emphasized by other authors [13].

A classic tool for evaluating spatial postural praxis is the Henry Head sample, developed in the 1920s. The ideomotor praxis of posture (postural praxis) is closely related to the schema of the body and the awareness of the corporeal. It involves recognizing the position of some parts of the body (mainly those of the fingers and wrists) with respect to others. Aaccording to Head and Holmes's theory of the "postural model," any new sensation of changes in the position of parts of the body is realized by correlating them with those of past experience and has a direct connection with proprioception. For this reason, the study of postural praxis relies on recognizing and imitating the interposition of fingers and wrists or their position with respect to other parts of the body [14].

We can summarize that the Head sample has a complex character, combines motor components and sensory synthesis, and requires thoughtful spatial reorientation (spatial transcoding) of the observed movement. The latter helps to overcome the trend of mirror performance. The leading defects in the form of echopraxic symptoms (replacement of the right hand with left and back) are the result of impaired spatial synthesis and are most often due to lesions of the parietal-occipital or inferior-parietal divisions of the left hemisphere.

In our opinion, the complex nature of the sample is associated with the integrated involvement of a number of complex cortical functions - visual-spatial orientation and movement organization, somatognosis (body diagram) and executive control (inhibition). The latter is a function of the prefrontal cortex and part of the supervisory attentional system [15]. The performance of the sample is considered as a criterion for the proper functioning of the connections between structures of the parietal cortex and the dorsolateral prefrontal cortex, which in turn is related to the regions of motor control - the basal ganglia and the anterior cingulate cortex [16]. Neurophysiologic studies [17] show that, as major vectors of executive functions, programming and control are the result of the interaction of prefrontal departments with subcortical regulatory structures (mainly the thalamus). Significant changes in the bioelectric activity of the infant brain resulting from the maturation of the frontal-thalamic nervous system are recorded over a period of 5-8 years, which is considered as one of the critical in the development of executive functions [18]. Other studies confirm the importance of the period as a time of important transformations in the dynamics of mental function and highlight its key place in childhood development [19].

The age range of 5-8 years is transitional in that it combines the end of pre-school and the beginning of the school period. The intense changes in the cortical organization and the hierarchical structure of the mental systems in the preschool age are crucial for the neuropsychic development of the child and the subsequent schooling.

Assessment of spatial postural praxis in pre-school children is an objective criterion for the condition and maturation of the cortical neural network related to mimicking spatial movements. The accuracy of linking the kinematic characteristics of what is observed with one's own action is an indicator of the child's ability to acquire new motor skills [20]. The lack of data from studies of complex praxis functions (in particular spatial postural praxis) in childhood leaves unanswered a number of questions regarding their early ontogeny.

THE PRESENT STUDY

The dynamics of complex brain functions are an indicator of the neuropsychic development of children and a prognostic sign of learning difficulties. The study of the spatial postural praxis (ideomotor praxis for new movements) in the period of 4-6 years is part of the procedure for standardization of the battery for early neuropsychological diagnostics. It relies on the childhood-leading heterochronous principle and the associated variety of individual neuropsychic development profiles. Among the main objectives of the study are: a) analysis of trends in the development of spatial postural praxis during the pre-school childhood; b) analysis of the influence of biological and socio-cultural factors on the development of children's praxis; c) differentiation of subgroups of children with different levels of spatial organization of movements and greater risk of academic difficulties.

METHODS

Participants

365 typically developing children without motor impairment signs participated in the study. All children are 4-6 years old, attend state children's kindergartens and have Bulgarian as their mother tongue. According to the education system in Bulgaria children aged 3-6 years attend state or part-time kindergartens. School education starts after the age of 6. In the last year of kindergarten, children go through the so-called school-preparatory group.

The study considers the influence on the development of the praxis functions of three factors - age, socio-demographic conditions (type of settlement) and gender. The following groups were formed in this connection: three age groups: 4-year-olds (116 children), 5-year-olds (128 children) and 6-year-olds (121 children); three demographic groups: - 195 children from the capital (1 300000 inhabitance), 90 children from the big city (80 000 inhabitance) and 80 children from the small town (11 000 inhabitance). The proportion according to gender is 173 male and 192 female.

Procedure

A modified version of Head's sample for ideomotor praxis for new movements was used by Alexander Luria and referred to by him as "spatial postural praxis (posture praxis)". The sample activates the visual-spatial organization of the manual movements in the reproduction of different positions in the coordinate space of the face (horizontal, frontal, sagittal). It allows assessment of both the visual-spatial orientation and the somatognosis (the scheme of the body). The sensitized version of the sample was used, in which the examiner and the child were seated opposite each other, and the implementation involves the transcoding of the spatially oriented components of the observed movement on one's body.

The sample consists of two parts, including motions of increasing difficulty. The first part involves performing 10 movements with one hand (right or left), and the second - performing 3 bimanual movements. The second part is informative both with regard to the complex forms of visual-spatial orientation and the state of the interhemispheric volume. It can only be accessed when the last three tasks of Part One have been completed. Below we describe the movements of the two parts.

First part (one-handed movements):

1. Right hand (palm) on the right cheek;
2. Right hand (nape) on left cheek;

3. Left hand (palm) on the right cheek;
4. Right hand (nape) to right cheek;
5. The dorsal part of the wrist with the right hand to the chin, fingers extended forward;
6. The left hand points to the chin and the outstretched fingers touch it;
7. Right hand (horizontal, with palm open) in front of forehead;
8. Left hand (vertical, palm facing right) in front of the forehead;
9. Right hand curled into fist;
10. Left hand (in fist) lateral to left cheek.

Second part (bimanual movements):

1. Left hand (palm) on the right cheek - the back of the right hand rests on the left elbow;
2. Right hand in fist - the back of the left hand on it;
3. The left hand holds the right ear - the right part of the right hand to the left cheek.

Due to the early age of the children and the different complexity of the movements, a separate instruction is given for each part of the sample. Instructions for the first part: “Raise your right hand. Look where your right hand is, and look where my right hand is (the researcher raises his right hand) - they are back. Now raise your left hand. Look at where your left hand is and where my left hand is (the researcher raises his left hand). Now I'm going to show you different hand movements. What I do with my right hand, you will do with your right hand (the researcher touches the child's right hand), and what I do with my left hand - you will do with your left hand (we touch the child's left hand). Watch and do like me".

Instruction to Part Two: “It has done very well so far. Now I will show you movements with both hands. Watch and monitor what the right hand does and what the left hand does. Do like me".

When each stimulus is perceived, the child is confronted with the need to overcome the tendency of mirroring the posture. Echopraxic repetitions indicate an inability to transcode the perceived motor model as a result of the inferior functioning of the lower temporal compartments.

The study is individual in nature, and the results of the implementation are recorded in the protocol with "yes", "no" or "mirror". The primary assessment of the sample shall be based on the following criteria:

- Correct performance - 2 points;
- Mirror Type (spatial error type) - 1 point;
- Malfunctioning (somatotopic error type) - 0 points.

The maximum individual point count of the two parts of the sample is 26.

Statistics

For the reliability of the results obtained, the following statistical processing methods were used: three-factor analysis of variance (F-criterion) and Post-Hoc analysis (Duncan test) to check for differences between the compared means in the dispersion complex. Three-way ANOVA is explained by the separation of 3 independent factors - age, location and gender. The two factors (age and locality) are established at three levels and gender is established at two levels. Significantly considered are those cases where the F-criterion values are high and the guarantee probability levels P are less than 0.05 ($p < 0.05$).

RESULTS

The statistical processing of the data was carried out in two stages: 1. a general evaluation of the performance of the sample by all criteria: correct, mirror and incorrect performance, and 2. evaluation by the criterion for correct performance. The latter is of particular importance for the qualitative analysis of the state and dynamics of the spatial organization of movements in the 4-6 years age range.

1. Results of the Overall Assessment of Sample Performance

Analysis of variance (Table **1**) showed a significant effect on the spatial postural praxis of three independent factors: Age ($F = 23.44$; $p < 0.000$), City ($F = 8.142$; $p < 0.000$), and Gender ($F = 6.640$; $p < 0.010$). There was also a significant effect on the dual interaction Age * City ($F = 6.766$; $p < 0.000$).

The profile of the Age factor (Figure **1**), which has the highest statistical influence, shows a gradual increase in the overall score from the group of children

Table 1: Sample Results for Spatial Postural Praxis as a Dependent Variable

	SS	Degr. of - Freedom	MS	F	p
Intercept	84853.45	1	84853.45	3479.999	0.000000
Age	1143.28	2	571.64	23.444	0.000000
Settlement	397.05	2	198.52	8.142	0.000351
Gender	161.91	1	161.91	6.640	0.010383
Age*Settlement	659.95	4	164.99	6.766	0.000030
Age*Gender	68.73	2	34.36	1.409	0.245714
Settlement*Gender	89.75	2	44.88	1.840	0.160302
Age*Settlement*Gender	104.06	4	26.01	1.067	0.372755
Error	8436.58	346	24.38		

from 4 years to the group of children from 6 years. What is striking is the sharp rise in the average of the total score in children 6 years of age. The Duncan test of differences between the compared means in the dispersion complex showed statistically significant differences between each of the two age averages (Table **2**).

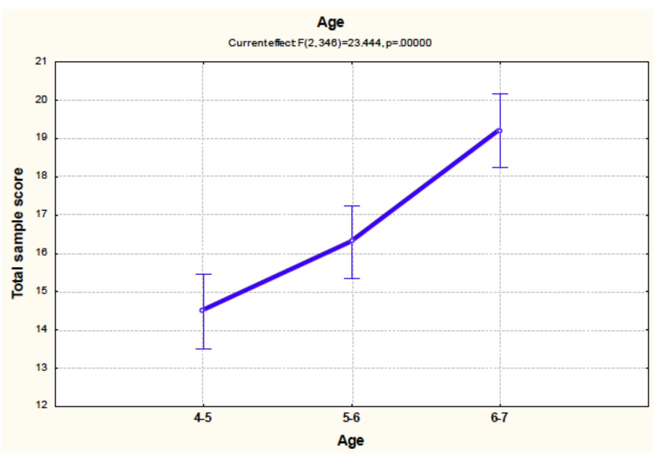

Figure 1: Influence of the Age factor on the total score for spatial postural praxis.

Table 2: Significance of Differences in Mean Scores for Spatial Postural Praxis between Children of Different Age Groups

Age	{1} - 13.635	{2} - 15.929	{3} - 19.205
4 ages		0.000305	0.000011
5 ages	0.000305		0.000009
6 ages	0.000011	0.000009	

The influence of the Settlement factor on the sample implementation indicates the highest overall score for children from the big city and the lowest overall score for those from the capital (Figure **2**). The results of small-town children are closer to the average in the big city. This is also confirmed by the statistical significance check between the compared averages, according to which significant differences are not recorded only between the average scores of children from big and small cities (Table **3**).

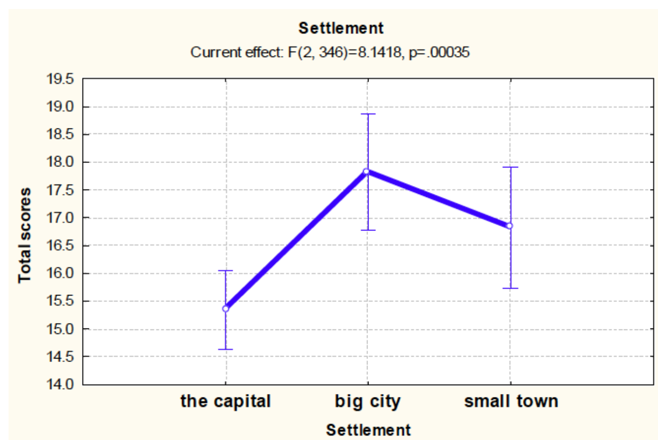

Figure 2: Influence of the Settlement Factor on the total score for spatial postural praxis.

Table 3: Significance of Differences in Mean Scores for Spatial Postural Praxis between Children from Different Settlement

Settlement	{1} - 15.402	{2} - 17.700	{3} - 16.912
The capital		0.001127	0.027192
Big city	0.001127		0.249477
Small town	0.027192	0.249477	

The influence of the Gender factor shows significantly higher mean scores in girls than in boys and is an indicator of differences in the maturation dynamics of the cortical departments responsible for praxis functions (Figure **3**).

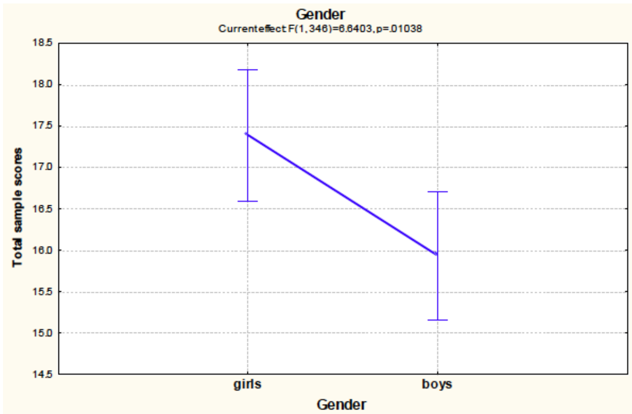

Figure 3: Influence of the Gender factor on the total score for spatial postural praxis sample.

2. Results of the Evaluation on the Criterion of Correct Sample Performance

In this part of the analysis, the values of the F-criterion (Table **4**) again show a statistically significant influence on the correct performance of the sample of the three independent factors "Age" (F = 17.36; p <0.000), "City" (F = 10.54 ; p <0.000) and "Gender" (F = 9.21; p <0.002). The influence of the dual interaction Age * City (F = 4.811; p <0.000) and City * Sex (F = 3.42; p <0.034) also proved to be significant.

The Age factor profile is similar to the profile of the overall assessment of the results and shows a gradual increase in correct performance from children 4 to 5 years and a sharp increase in those 6 years. This is complemented by data on statistically significant differences between the two age averages (Table **5**).

Similar to the above are the profiles of the influence of the factors Settlement and Gender on the correct implementation of the sample. The influence of demographic conditions on the spatial organization of children's movements is associated with the highest grade point average for large-city children and the lowest grade point average for children in the capital. Statistically significant according to the Duncan test are the differences between the average of the children from the capital and the big city and the children from the small and big city. There is no statistical difference between the average scores of children from a small town and the capital (Table **6**).

The significantly higher girls' GPA for correct sample implementation strongly confirms the influence of the Gender factor on the development of visual space orientation and movement organization during the pre-school childhood. The observed trend complements the data for earlier maturation of brain structures and formation of functional brain systems in female children.

Important for the qualitative analysis is the correlation between the different cases of mimicking spatial movements in children of the three age groups - correct, mirror and wrong (Table **7**). The data presented to the maximum illustrate the trends in the development of functions involved in the formation of the ideomotor praxis for new movements and are consistent with the specified age dynamics. The correlation between the modes of sample implementation shows the following trend: an increase in the number of cases of correct performance, with a sharp jump in children at 6 years; a gradual reduction in echopraxic and irregular cases, most pronounced at the age of 6 years.

Table 4: Score for Correct Execution of the Spatial Postural Praxis Sample as a Dependent Variable

	SS	Degr. of - Freedom	MS	F	p
Intercept	48462.60	1	48462.60	887.1350	0.000000
Age	1896.94	2	948.47	17.3623	0.000000
Settlement	1151.42	2	575.71	10.5387	0.000036
Gender	503.36	1	503.36	9.2143	0.002583
Age*Settlement	1051.27	4	262.82	4.8110	0.000867
Age*Gender	223.99	2	111.99	2.0501	0.130284
Settlement*Gender	373.83	2	186.91	3.4215	0.033771
Age*Settlement*Gender	193.62	4	48.41	0.8861	0.472355
Error	18901.36	346	54.63		

Table 5: Significance of Differences in Mean Scores for Correct Performance of the Spatial Postural Praxis Sample between Children of all Ages

Age	{1} - 8.8696	{2} - 11.276	{3} - 16.000
4 ages		0.011307	0.000011
5 ages	0.011307		0.000009
6 ages	0.000011	0.000009	

Table 6: Significance of Differences in Average Scores for Correct Performance of the Spatial Postural Praxis Sample between Children from Different Settlements

Settlement	{1} - 10.732	{2} - 14.867	{3} - 12.300
The capital		0.000088	0.125534
Big city	0.000088		0.012164
Small town	0.125534	0.012164	

Table 7: Ratio of Implementation Modalities for Spatial Postural Praxis in all Age Groups of Children

Age	Proper performance	Mirror performance	Improper performance
4 ages	34 %	36 %	30 %
5 ages	44 %	35 %	21 %
6 ages	63 %	23 %	14 %

Based on the individual results, subgroups of children with different degrees of spatial postural praxis were formed within each age group, respectively: low, medium and high group (Table **8**). Data are essential both for the analysis of age dynamics and for outlining individual differences in the development of the spatial organization of conscious movements.

Table 8: Age Distribution of Subgroups of Children According to the Degree of Spatial Postural Praxis Development

Age	Subgroups		
	Low group	Medium group	High group
4 ages	63 %	0 %	37 %
5 ages	26 %	49 %	25 %
6 ages	25 %	39 %	36 %

DISCUSSION

The study aims to test the effect of the heterochronous principle of development on some praxis functions in children with typical development attending state kindergarten. The working hypothesis presupposes a specific interaction of biological and social factors, which determines the differences in the development of the spatial postural praxis of children in the period 4-6 years. The results of the study allow us to deduce some peculiarities and tendencies in the formation of praxis functions during the preschool years.

The results of the overall evaluation of the sample implementation showed a significant influence of three independent factors: Age, Settlement (Location) and Gender.

1. Age Influence on the Development of Praxis Functions

The maximum degree of statistical significance of the age factor proves the determinant role of the neurobiological changes of the infant brain in the formation of praxis functions. Significant differences between the two age groups confirm the relationship between somatognosis and the spatial organization of movements and the importance of the period for the development and integration of their brain mechanisms. This is complemented by data on body-related somatotopic errors that decrease from 30% in children 4 years of age to 21% in children 5 years and 14% in 6-year-olds. The low results in children 4 years of age are due to the still underdeveloped scheme of the body, which seriously complicates the reading of the spatial parameters of the hands relative to the coordinate system of the face. Signs of improved integration of body and spatial orientation as an indicator of frontal-parietal neural network function are seen in children as young as 5 years of age. At the same time, the age of 6 is the first sensitive period for the integrative system of spatial postural praxis. This is due to the changed ratio of modes of implementation in favor of cases of correct performance (63%) with a significant decrease in mirror performance (23%) and improper performance (14%).

The age distribution of the modes of performance was further processed by the Plochinski T-test for comparison of percentages. The results for correct sample performance show significant differences between each age group of children: 4 and 5 years ($p \leq 0.001$); 4 and 6 years ($p \leq 0.001$); 5 and 6 years ($p \leq 0.001$). Comparison of mean scores for mirror (echopraxic) performance showed significant differences between children 4 and 6 years ($p \leq 0.001$) and children 5 and 6 years ($p \leq 0.001$) and no differences between children 4 and 5 years ($p \geq 0.05$). Comparison of mean scores for maladjustment also shows significant differences between each of the two age groups of children: 4 and 5 years ($p \leq 0.001$); 4 and 6 years ($p \leq 0.001$); 5 and 6 years ($p \leq 0.001$).

The data show that there are significant differences between the results of each age group on the criteria for correct and incorrect performance. The same is not valid for mirroring cases only for children aged 4 and 5 years. This leads to the conclusion that children's skills for mental transcoding and spatial synthesis of the observed movements become possible after the age of 6 years. On the other hand, the positive dynamics in the development of spatial postural praxis indicate improved inhibitory control and supplement information on trends in the maturation of the mirror nervous system.

The analysis of the results leads to the conclusion that the period of the sixth year is a time of significant transformation in the neurophysiologic mechanisms of the spatial organization of movements, which is consistent with the data for stabilizing the connections of the frontal-thalamic nervous system and improving the executive functions [18]. Prior to this age, most children were unable to transcode the spatial elements of movements. It is reasonable to assume that the assessment of spatial postural praxis is of objective diagnostic value only in children over the age of 6 years. Some developments in the field of child neuropsychology are relevant to this [21]. It is accepted that the disorders and difficulties in the formation of the sensorimotor repertoire of children are pathognomonic for the dysontogenesis of early maturing sub-cortical brain systems and have a special place in the analysis of deviant development.

2. Impact of the Demographic Factor on the Development of Praxis Functions

The influence of socio-cultural and demographic factors shows interesting dependencies that need further research. It is noteworthy that the highest sample results are achieved by children from smaller settlements: for 4-year-olds, they are children from a small town, and for 5- and 6-year-olds, children from a big city. It is surprising that the lowest scores are shown by the age groups in the capital. The results indicate a specific impact of socio-cultural conditions on the maturation of the infant brain and the formation of horizontal (frontal-parietal) and vertical (frontal-thalamic) neural networks of praxis functions. This is supported by the view that the configuration of the nerve structures and the neuropsychological status of the child invariably reflect some factors, including the objective environmental conditions and socio-cultural characteristics [21, 22].

The reason for the better results in small settlements can be found in the specific action of some social and demographic factors. Children from these regions have sufficient space for movement and outdoor games, leading to richer sensorimotor optimization and early somatognosis formation and spatial orientation. To this should be added the preserved traditions of children to participate in the work activities of the family, which has an additional effect on the maturation of praxis mechanisms.

3. Impact of the Gender Actor on the Development of Praxis Functions

The influence of the gender factor is associated with a faster formation of somatognosis and the spatial organization of movements in girls, which speaks of the outstripping rates of maturation of the frontal-parietal connections of the left hemisphere in this category of children. In parallel, the data support the thesis that gender differences in childhood brain development are expressed. A possible cause may be the fact that the lateralization of the female brain is less lateralized and the greater plasticity associated with it is formed in the formation of neural networks of functions. On the other hand, the better development of praxis functions in girls may also be explained by their typical interest in activities and games related to predominantly manual manipulation. They have a stimulating effect on the formation of neural mechanisms of praxis functions and the development of inhibitory control.

Of interest are the data on the reliability of differences between girls and boys from different settlements. According to Duncan's test, there are only significant differences between the results of girls and boys from a small town. In the more populated settlements, the results of children of both sexes are similar and there are no significant differences between them. In our opinion, the presence of pronounced gender differences in neuropsychiatric development in children from small settlements raises a number of questions that are the subject of future research.

4. The Levels of Spatial Organization of Movements and School Readiness

Confirmation of the action of the heterochronous principle is the uneven development of praxis functions in children with typical development. Particular attention should be paid to the data in Table **8** on the distribution of groups of children with different levels of spatial postural praxis. As indicated, the differentiation of three subgroups (low group, medium group and high group) within each age is associated with large differences in registered neuropsychological profiles. The results allow important conclusions to be drawn about the dynamics of the postural praxis and its associated functions of visual-spatial orientation and movement organization, somatognosis and executive control.

The data in the table show that in children 4 years old, only two subgroups are separated - low and high, which is due to the highly polarized results of sample implementation. It is noteworthy that 2/3 of the children of this age are in the low group. The separation of the two groups and the lack of a “golden medium” in the results are associated with the underdevelopment and poor integration of the basic functions that shape the brain architecture of the spatial postural praxis. This is confirmed by the data in Table **7** for a large number of inaccurate cases. These are explained by an underdeveloped body pattern and are referred to as somatotopic error type.

The age of 5 years has a special place in neuropsychic ontogeny as the time of the first leap in the structural and functional maturation of the infant brain related to the appearance of three clearly defined subgroups. Half of the surveyed children fall into the "new" middle group, and the number of children in the low group falls significantly. The reason is the sharp rise in individual results, which leads to an increase in correct performances and a decrease in mirror and incorrect performances. Improved results over a 5-year period should be seen as the first objective signs of positive dynamics in the child's spatial-motor body orientation.

The observed changes are most valid for the period of 6 years, which is sensitive to the cerebral mechanisms of spatial postural praxis. The number of children referred to the high group is increasing, which correlates with cases of sample performance. The data reflect the development and functioning of the neural architecture of praxis functions and general psycho physiological readiness for learning. It has to be concluded that the diagnosis of spatial postural praxis as a complex brain function allows objective conclusions in children over the age of 6 years. Assessment at an earlier age is predominantly indicative and should not be a mandatory element of neuropsychological examination.

Particular attention should be paid to the subgroup of low-achieving (low-group) children who are typically identified as children at risk of learning disabilities. Poor performance of the sample in these cases suggests a delayed development of the cortical mechanisms of the postural praxis and related gnosis and executive functions. The data in Table **8** show a continuation of the trend in the percentage of the low group in children aged 5 and 6, respectively 26% and 25% of cases. This means that ¼ of the children examined go to school with insufficiently developed functions of visual-spatial orientation and movement organization and executive control. The analysis of the results justifies the high diagnostic value of the spatial postural praxis sample as an indicator of children's neuropsychic development and a predictor of learning disabilities.

CONCLUSIONS

The data from the study outline important peculiarities and trends in the development of spatial postural praxis (ideomotor praxis for new movements) during the preschool childhood (4-6 years). The analysis of the results provides additional information about the dynamics of the brain processes that form the functional basis of praxis functions. The conducted research generates the following conclusions and summaries:

- The spatial postural praxis is complex. Its formation is based on the integration of visual-spatial orientation and movement organization, somatognosis (body diagram) and executive control (inhibition).

- The influence of the development of the spatial postural praxis and its related functions is exerted by the independent factors Age, Settlement and Gender.

- The age of 6 years is the first sensitive period in the development of visual space orientation and postural praxis. Indicators are the increased number of cases of correct sample performance and a significant decrease in mirror (echopraxic) and improper performance.

- The diagnosis of spatial postural praxis should only be applied to children over the age of 6 years. The results from it before this age are predominantly indicative.

- The performance of the spatial postural praxis test is indicative of the maturation and functioning of the frontal-parietal and frontal-thalamic brain systems during the preschool childhood.
- Children with typical development but with low test results enter school with underdeveloped visual-spatial orientation and executive control functions and become part of the group of children with learning disabilities.
- The state of spatial postural praxis is an important indicator of neuropsychic development in the preschool period and should find a place in the diagnostic assessment of learning readiness as a predictor of future academic difficulties.

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