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Research Article

**TEMPO INDICATORS OF MOTOR AND NON-MOTOR STUDY  
SKILLS OF LEFT-HANDED PRIMARY SCHOOL-AGE  
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**Abstract:**

*This article provides the results of the empirical investigation which was conducted into tempo indicators of motor and non-motor study skills of left-handed primary school-age children. 325 young school-age children (at the age of 7-8 y.o.) took part in the research. Based on the criteria of lateralization, two following groups were formed: left-handed and right-handed primary school-age children. The methods of the study were: «the technique of automated research on individual lateralization» (studio «ViEl»); experimental tasks; functional neuropsychologic probes of research on dynamic praxis functions. As a result of the study, significant level decrease of motor (writing, drawing) and non-motor (reading, mental arithmetic) study skills of left-handed primary school students relative to right-handed children. It was established that the higher accuracy of motor skills, the higher coordination of motor ones. Practical importance of the obtained results is that considering tempo indicators of motor skills is necessary in the adaptation stage of left-handed children' education.*

**Key words:** motor study skills, non-motor study skills, lateralization, left-handedness, right-handedness, primary school age.

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**INTRODUCTION:**

For the latest ten years the content of Russian education system is changing (rising the complexity and differentiation of education programs), the education changes its form (multimedia educational technologies (electronic diaries, electronic trainers, distance learning lessons and etc.) are introduced), but besides the problem of teaching left-handed children is unattended. This is especially actual for primary school-age children, because the motivation of teaching children directly depends on successful formation of study skills which in its turn is connected with individual variation of mental development, including laterality. According to the most researchers' opinions, progress in studies and social adaptation of left-handed children are lower than the same indicators of right-handed children.

The scientific researches show that there is a general population-level tendency towards a rising number of left-handed children. In Russia this number has increased from 3-4 to 8-12 % for the latest 15 years [1-3]. The estimates for prevalence of left-handedness in other countries show the same results increasing to 20%. [4,5].

The modern neurocognitive studies show that the processes of teaching left-handed and right-handed primary school-age children are different. Many authors point out that there is decrease in left-handed children's neuro-psychic activity indicators relative to the same characteristics of right-handed, which results in lower indicators of progress in study at primary school [6,7].

The primary school age is exactly sensitive for formation interhemispheric communication [8,9]. In relation to this, the features of brain lateralization will define tempo indicators of motor and non-motor study skills of children at primary school age.

Lateralization of brain function is determined by qualitative difference of including of left and right hemisphere in realization of each higher psychological function (HPF). In different classification systems differentiation on sensory (group of inequalities of sense organs, including lateralization of visual and auditory analyzers); motor (manual asymmetry, asymmetry of legs, half a body, facial asymmetry by formation of general motor behavior) and mental asymmetry ([10,11]. Taking into account partial character, each lateralization is divided into many types [12].

The purpose of investigation was to study motor and non-motor study skills of left-handed primary school-age children.

**Conditions, materials and methods of research**

The study was conducted consequently at three stages. At the first stage the assessment of sensomotor lateralization was made to form research groups. The purpose of the second stage was to investigate qualitative and quantitative characteristics of motor (writing and drawing skills) and non-motor (reading, mental arithmetic skills) study skills of primary school age children, depending on sensomotor lateralization. At the third stage interconnection of indicators of motor and non-motor skills of primary school-age children was evaluated with lateralization.

325 primary school-age children (at the age of 7-8 y.o.) took part in the research. All people were the pupils of comprehensive schools and pass single educational program.

As a result of evaluation of sensomotor lateralization two following groups of participants were formed: young school-age children with lateralization of brain function and dominant right hemisphere (left-handed) – 52 people; children who have dominance of left hemisphere due to brain lateralization (right-handed) – 50 people.

The assessment of lateralization was made by using the technique of automated research on individual lateralization, studio «ViEl», including pretesting and final testing. Pretesting consisted of 12 screening probes to determine lateralization of motor and sensor functions (arms, legs, hearing and vision), each probe was applied thrice. According to the results of the probe lateralization is preliminarily determined. The main testing included computerized tests for investigation of functional asymmetry: asymmetry of arms (test of annet, speed and reaction test), asymmetry of legs (speed and reaction tests), asymmetry of vision (haploskipie), asymmetry of hearing (dichotic listening) and hemispheric asymmetry (Klimov' test, Pavlov's test).

The experimental tasks connected with motor actions and not were used to assess the level of study skill formation. Such tasks were offered to a Participant with verbal vision instruction. (Figure 1)

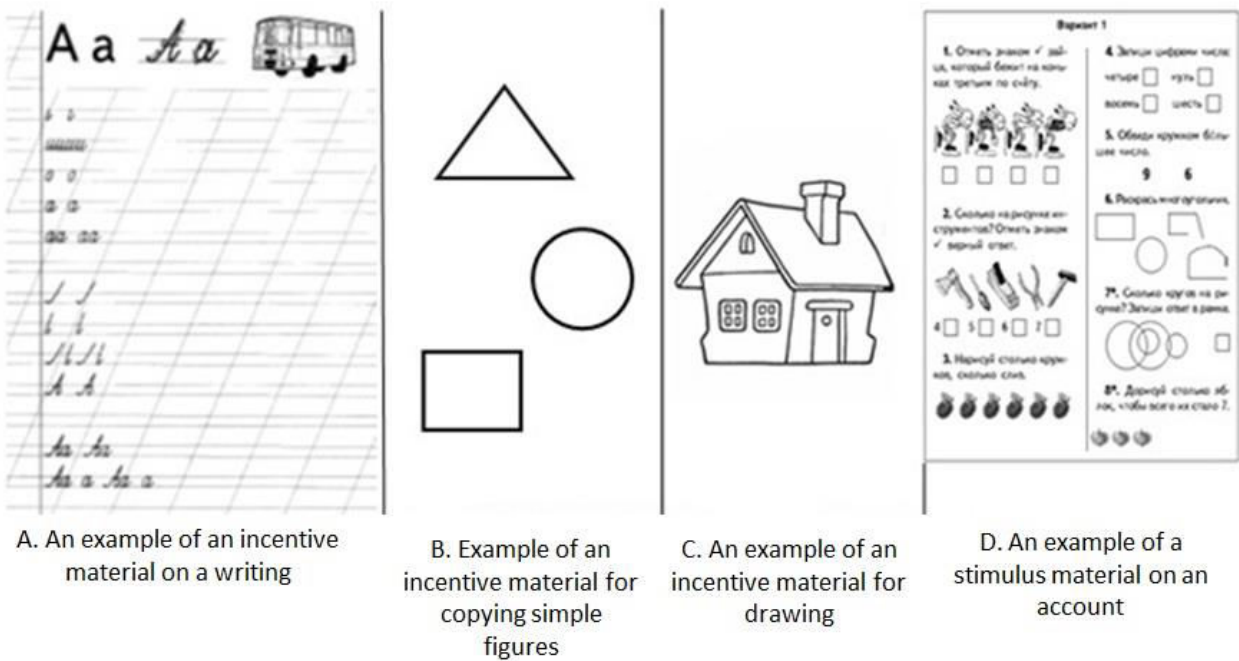


Figure 1. Stimulus materials of tasks to assess level of study skill formation

To diagnose writing skills a grid sheet was showed to a Participant with the examples of writing of separate letter element and letters, then the dictation was taken (separate words, syllables and single-syllable word). Assessing the drawing skills firstly the visual samples were given to a Participant, which then they should reproduce with verbal instruction (simple flat geometric figures and holistic volumetric image) (Figure 1B-1C). To evaluate reading skills a Participant should read aloud the text, which consisted of 105 words. The assessment of mental

arithmetic skills was as following: a Participant should accomplish tasks according to the visual sample (Figure 1D).

The qualitative evaluation of experimental tasks to investigate the level of motor study skill formation with verbal visual instruction was made according to 4 score scale (from 0 to 3) based on the criteria of accuracy, tempo and coordination. The criteria of quantitative assessment of the level of writing and drawing skill formation are provided in Table 1.

Table 1 - The indicators of quantitative assessment of the results connected with task accomplishment

Criteria	Scores			
	0	1	2	3
Accuracy	Full satisfaction of the requirements	Addressing to the requirements but with slight mistakes in performance (only one mistake is available) and self-correction	Failure in performing the separate actions of the program (pass, doubling, replacement of accomplished operations)	Impossibility of performing the target sequence of operations
Tempo	The stability of tempo of task accomplishment	Irregularity of tempo of task accomplishment (combination of acceleration and deceleration of tempo)	Acceleration of tempo, long pauses between the actions, periodical refusals to perform operation	Acceleration of tempo, leading to the impossibility to select a separate operation; long pauses, resulting in the impossibility of further accomplishment.
Coordination	Correct accomplishment of separate actions; Right location of the arm relative to work space	Isolated mistakes in accomplishment of separate operations with self-correction	The mistakes on accomplishment of separate operation are not corrected, thus leading distortion of both realization process of motor program and final result	Serious mistakes in the separate actions leading to the impossibility to finish the task/

The qualitative assessment of study skills which are not connected with motor actions, were made on a basis of such criteria as tempo and accuracy. The quantitative evaluation of study skill formation was made by counting coefficients of accomplishment of motor and non-motor skills (separately each skill: writing, drawing, reading, arithmetic) (Table 2).

Table 2- The procedure of defining coefficients of motor and non-motor study skills

Motor study skills	Non-motor study skills
$KM_1 = \frac{\Sigma \text{correct}}{\Sigma \text{total}} * 100\%$ KM <sub>1</sub> – coefficient of motor writing skill; $\Sigma$ correct – a number of right reproduced elements of letters, letters, syllables, words; $\Sigma$ total – general number of elements of letters, letters. Syllables, words in the experimental task;	$KM_2 = \frac{\Sigma \text{correct}}{\Sigma \text{total}} * 100\%$ V <sub>k</sub> KM <sub>2</sub> – coefficient of motor drawing skill; $\Sigma$ correct – a number of reproduced images; $\Sigma$ total – general number of the images in the experimental task;
$KN_1 = \frac{\Sigma \text{words}}{\Sigma \text{total}} * 100\%$ KN <sub>1</sub> – the coefficient of non-motor reading skill; $\Sigma$ words – a number of words which are read without mistakes; $\Sigma$ total – general number of words in the text;	$KN_2 = \frac{\Sigma \text{correct}}{\Sigma \text{total}} * 100\%$ KN <sub>2</sub> – the coefficient of motor arithmetic skill; $\Sigma$ correct – a number of accurately accomplished tasks; $\Sigma$ total – general number of experimental tasks.

To determine randomness of serial movement organization the assessment of dynamic praxis function was made by using functional neuropsychologic probes «Zabor» and Ozereckiy's probe. Qualitative and quantitative evaluation of the results of probe accomplishment was made according to 4 score scale, provided by Vasserman, Dorofeeva.

Statistical analysis was done with using describing (the indicators of average value, the indicators of average quadratic deviation), comparative (Mann-Whitney U-test) statistics and the method of correlation analysis (Pearman rank correlation coefficient,  $p \leq 0.05$ ).

### RESULTS AND DISCUSSION:

As a result of the assessment of lateralization based on dominance of left hemispheric or right hemispheric indicators (more than 51% on three from four criteria during preliminary study), the investigation groups were formed. 52 left-handed primary school-age children were included in the experimental group. 50 right-handed children took part in the control group.

According to the results of lateralization assessment, the part of left-handed primary school-age children constituted 16% from the general number of the children. It corresponds to popular general tendency of left-handedness prevalence among children.

Table 3 - The importance of differences between qualitative indicators of formation of left-handed and right-handed primary school-age children' motor skills (Mann-Whitney U-test,  $p \leq 0.05$ )

Probe	Leading arm			Not leading arm		
	Tempo(time of performing, sec.)	Accuracy (a number of mistakes)	Coordination	Tempo (time of performing, sec.)	Accuracy (a number of mistakes)	Coordination
Letter	0.012*	0.010*	0.015*	0.015*	0.019*	0.012*
Drawing simplegeometric figures	0.022*	0.024*	0.027*	0.029*	0.029*	0.021*
Drawing the images of whole objects	0.014*	0.009*	0.021*	0.011*	0.014*	0.012*

\*- statistical importance of differences

Table 4 - The importance of differences between indicators of formation of left-handed and right-handed primary school-age children' non-motor skills (Mann-Whitney U-test,  $p \leq 0.05$ )

Tempo (time of performing, sec.)	Reading		Arithmetic				Coordination of accuracy	Coordination of tempo
	Accuracy		according to the visual instruction		according to the verbal instruction			
	The number of words	The number of mistakes	Tempo (sec.)	Accuracy (the number of mistakes)	Tempo (sec)	Accuracy (the number of mistakes)		
0.034*	0.029*	0.018*	0.031*	0.029*	0.021*	0.034*	0.042*	0.044*

\*- statistical importance of differences

Table 5 - The importance of differences between the indicators of formation of left-handed and right-handed primary school-age children' dynamic praxis function (Mann-Whitney U-test,  $p \leq 0.05$ )

Probe	Leading arm			Not leading arm		
	Tempo(time of performing, sec.)	Accuracy (the number of mistakes)	Coordination	Tempo(time of performing, sec.)	Accuracy (the number of mistakes)	Coordination
Graphicprobe «Zabor»	0.031*	0.022*	0.019*	0.012*	0.024*	0.020*
Probe «fist-rib-palm»	0.029*	0.024*	0.008*	0.012*	0.037*	0.024*

\*- statistical importance of differences

The results of the investigation showed that the level of motor skill formation of young school-age children with sensomotor lateralization and dominant right hemisphere (left-handed) is greatly lower on such criteria as tempo, accuracy, coordination than the same indicators of primary school-age children with lateralization and dominance of left hemisphere (right-handed). The level of non-motor skill formation of young school-age children with sensomotor lateralization and dominant right hemisphere (left-handed) significantly decreased in tempo and accuracy compared to the same characteristics of primary school-age children with lateralization and dominance of left hemisphere (right-handed).

The assessment of interconnections between the indicators of formation of left-handed and right-

handed children' motor and non-motor study skills was carried out by defining Pearman rank correlation coefficient,  $p \leq 0,05$ . In the group of left-handed primary school-age children directly proportional statistically significant interconnections were found out between the indicators of coordination of motor drawing skill and accuracy of non- motor arithmetic skill ( $r=0.56$ ), between the indicators of coordination of motor writing skill and indicators of accuracy ( $r=0.54$ ) and tempo indicators ( $r=0.61$ ) of non-motor reading skills; between the indicators of accuracy of motor drawing skill and tempo indicators of non-motor reading skill ( $r=0.53$ ); between tempo indicators of motor drawing skill and the indicators of accuracy of non-motor arithmetic skill ( $r=0.67$ ) (Figure2).

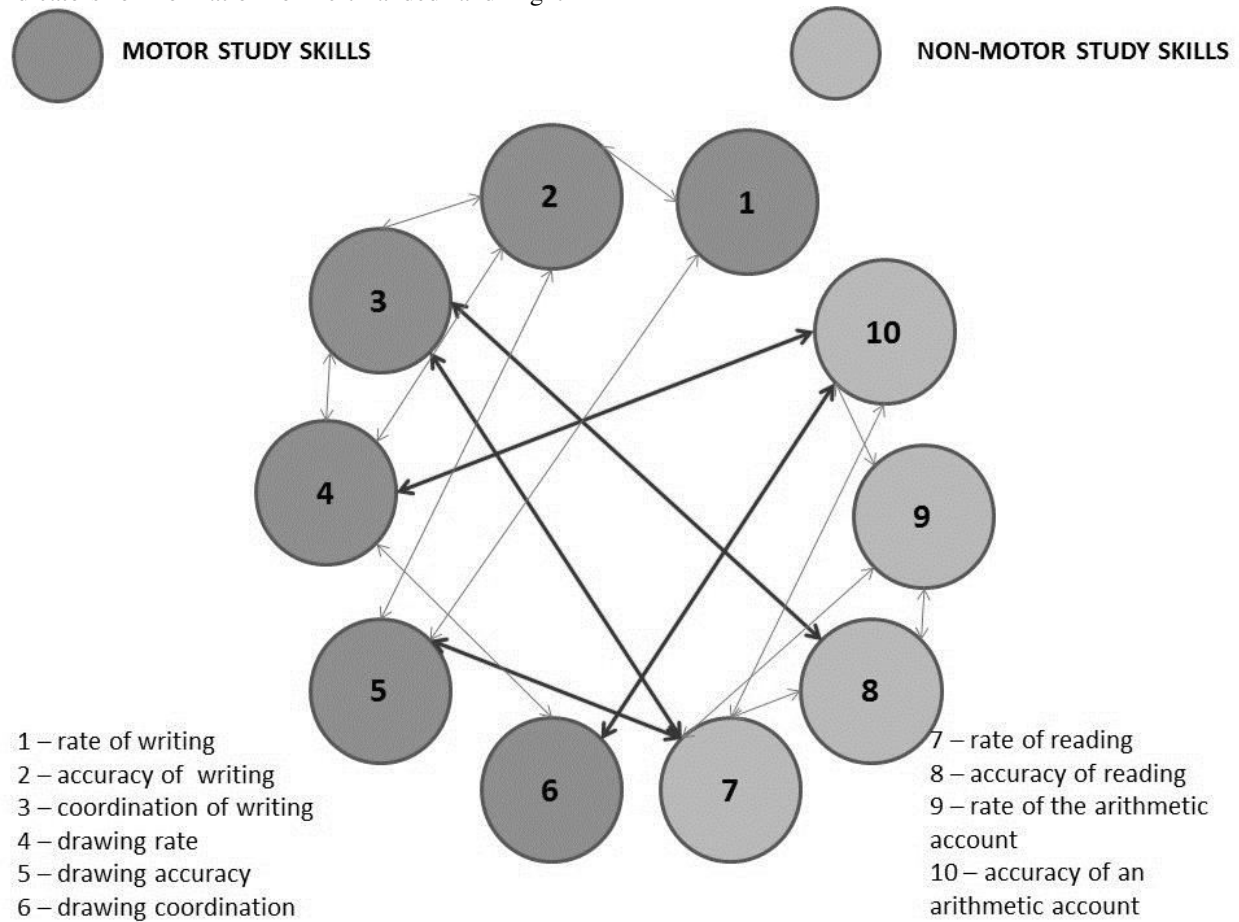


Figure 2. The structure of interconnections between the indicators of left-handed primary school-age children' formation of motor and non-motor study skills

In the group of right-handed primary school-age children directly proportional statistically important interconnections were found out between the tempo indicators of motor writing skill and indicators of accuracy of non-motor reading skills ( $r=0.62$ ); between indicators of accuracy of non-motor arithmetic skills and tempo indicators of motor drawing skills ( $r=0.59$ ); between indicators of coordination of motor drawing skill and tempo indicators of non-motor arithmetic skills ( $r=0.57$ ); between the indicators of coordination of motor writing skill and indicators of accuracy of non motor arithmetic skills ( $r=0.69$ ) (Figure3).

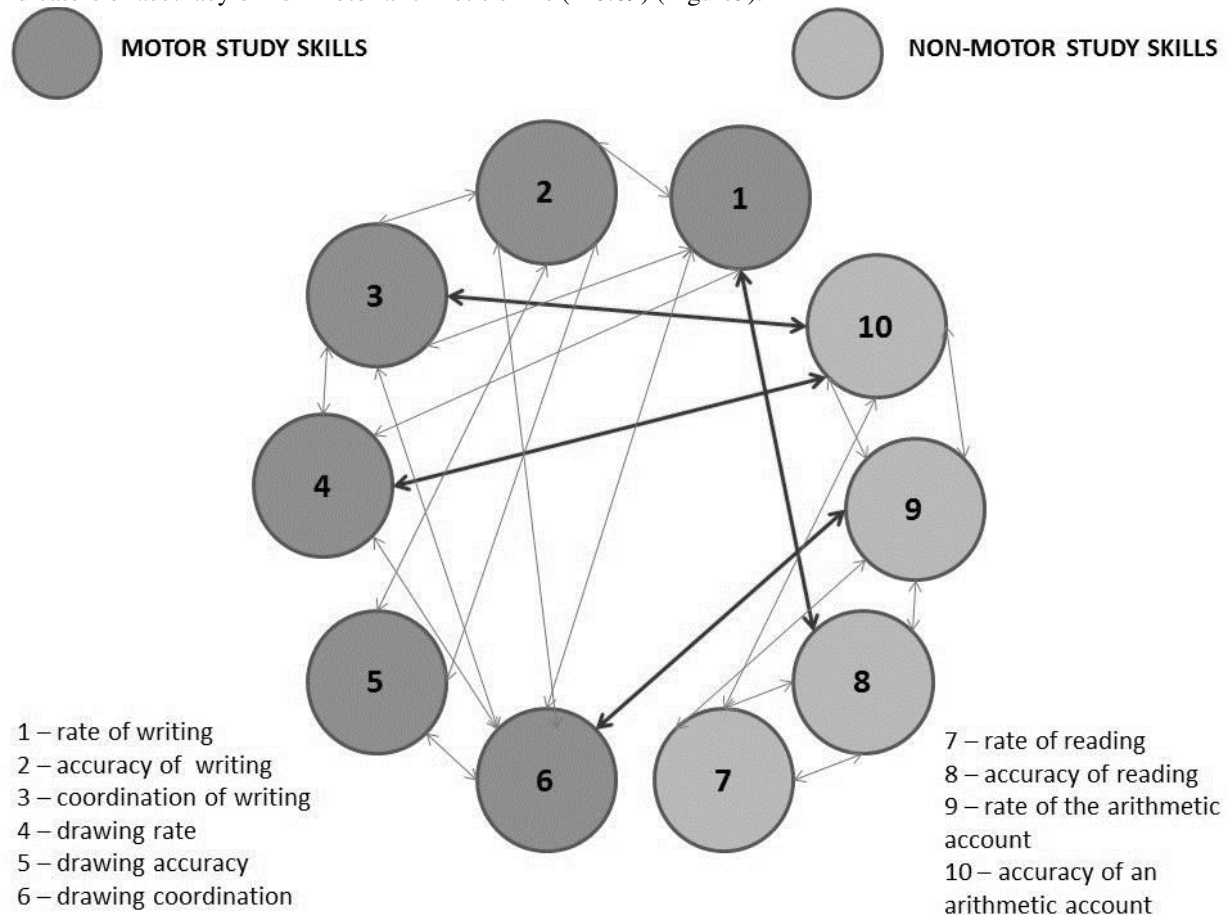


Figure 3. The structure of interconnections between the indicators of formation of right-handed primary school-age children's motor and non-motor study skills

The general tendency towards the assessment of interconnections between the indicators of formation of left-handed and right-handed primary school-age children's motor and non-motor study skills is that there is directly proportional interconnections between tempo indicators and indicators of accuracy of motor and non-motor skills.

### CONCLUSIONS:

16% primary school-age children with lateralization and dominant right hemisphere were determined during the investigation. This result corresponds to the general tendency of left-handedness prevalence among children (Boiko, 2012; Carter, 2015).

The significant decrease in the level of left-handed young school-age children's motor (writing and drawing) and non-motor (reading and mental arithmetic) skill formation on such criteria as tempo, accuracy, coordination in contrast with the same indicators of right-handed children. It was also discovered that indicators of left-handed young

school-age children's dynamic praxis function of a leading arm are low.

The structure of interconnections between the indicators of both left-handed and right-handed children's motor and non-motor skills is characterized by significant directly proportional indicators of tempo and accuracy. The feature of left-handed primary school-age children is significant directly proportional interconnections between the indicators of coordination of motor skills and the indicators of non-motor ones. The higher accuracy of non-motor skills is, the higher coordination of motor skills becomes.

Thus, motor skills are a basis of study skill formation. Tempo indicators of left-handed children' skill formation should be considered in adaptation stage of their education process.

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