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# Assessment of Lateralization and Handwriting Quality in Young Elementary School Students

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**Abstract:**

Dominant lateralization refers to the phenomenon of having a leading extremity or leading sense during the execution of complex psychomotor activities. Writing represents a complex human ability and simultaneously the most complex form of linguistic activity, which includes knowledge, skills, and the art of proper letter formation. This study explores the relationship between lateralization and handwriting quality with the aim of identifying children with dysgraphic handwriting. The sample consisted of 90 younger elementary school students (third, fourth, and fifth grade), aged 8 to 11 years (AS = 9.93; SD = 0.84), of both genders (46 boys and 44 girls). The Handwriting Dysgraphia Assessment Test was used to assess handwriting quality. Dominant upper extremity lateralization was assessed using tests from the Sovak Test Battery (1979), while visual lateralization was assessed using a test from the General Defectology Diagnostics Practicum. The research was conducted at an elementary school in Trebinje, during February and March 2024. Research results show that a significant percentage of younger elementary school children have dysgraphic (21.1%) or severely dysgraphichandwriting (35.6%). Among the majority of participants, right-handed upper extremity dominance was observed (86.7%) along with right visual dominance (82.2%), with coordinated visual and upper extremity lateralization present in 88.9% of children. The results of investigation of the impact of uncoordinated upper extremity and visual lateralization on dysgraphic handwriting did not demonstrate statistical significance. Although our results did not confirm a link between lateralization and handwriting quality, for younger elementary school children with uncoordinated upper extremity and visual lateralization, exercises focusing on directing, practicing, and stabilizing lateralization are recommended.

**Keywords:** lateralization, handwriting quality, younger elementary school children

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## Introduction

Writing represents the most complex form of of language abilities' manifestation. The writing process involves very complex elements of motor, manipulative, kinesthetic, visual and auditory activities, the ability to reason, as well as the ability to use linguistic and non-linguistic knowledge (Vuković, 2012). Dysgraphia is a disorder of written expression characterized by writing skill that is significantly below expectations, taking into consideration the child's chronological age, intelligence, and appropriate writing training (American Psychiatric Association, 1994). Developmental dysgraphia is typical for the period of younger school age, and is characterized by elements typical for the earlier developmental phase of graphic expression. The diagnosis of developmental dysgraphia is never made before the completion of writing training, in the second, and in our environment in the third grade (where children start school at the age of 6 while the initial literacy begins in the second grade). So, the official diagnosis is made after two years of formal schooling,actually after subjecting the child to conventional writing training (Vuković, Ćalasan, Jovanović-Simić, & Kulić, 2015). There are multiple approaches to considering dysgraphia that have resulted in different definitions. Bojanin (1976) states that the dysgraphic disorder in children of younger school age is manifested by poor organization of graphomotor expression in space, poor shaping of the graphomotor units that make up the graphomotor sequence and mismatched psychomotor organization of the child as a whole. On the other hand, some authors define dysgraphia as a stable inability of a child to master the skill of writing according to the spelling rules of a particular language (Posokhova, 2009). Actually, when a child enters the primary education system, it is possible to single out symptoms that speak about problems in writing of a different quality - from lagging behind to difficulties and disorders and they include: insufficient skills of voice analysis and synthesis, failure to recognize and name letters, insufficient or non-existent "visual dictionary", voice-letter connection difficulties, reverse writing of letters and numbers, mirror writing, significantly extended letter uttering or spelling, dropping, adding, replacing sounds and letters (especially in the group of small printed letters: b, p, d; m, n, u; a, o; š, ž), syllables and even whole words in reading and writing, extended time required for writing, non-compliance with orthographic rules and similar (Vancaš, 2004). The overall appearance of dysgraphic handwriting, as well as the problem of lateralization of the upper limbs in children with dysgraphia, show that these children have difficulties in perceiving spatial relationships and evenly placing graphomotor elements in certain spatial boundaries (Brakus, 2003). According to Bojanin (1985), the term lateralization refers to the connection of limbs and senses of one side of the body, while dominant lateralization means the appearance of a leading limb or a leading sense when performing complex psychomotor activities. The very process of maturation of limb dominance in the manipulative field ends somewhere between the age of six and eight (Bojanin, 1985). Researches show superiority in exerting maximum force in favor of the dominant hand (Aoki & Demura, 2017). It is important to emphasize that there is a whole series of dominance combinations, so we can have a dominant left hand, but a dominant right leg, or a dominant right eye, but a dominant left ear. Also, there are people who can, with the same dexterity, perform specific tasks (writing, drawing) with both hands and they are called ambidextrous people (Kosinac, 2007). It is stated in the literature that any mismatched lateralization of limbs and senses leads to a decrease in the

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functionality of one of the hemispheres and at the same time to difficulties in information processing and learning (Jovanović, Purić, &Ignjatović-Ristić, 2014). Therefore, this paper examined the relationship between lateralization and handwriting quality, with the aim of identifying children with dysgraphic handwriting.

## Methods

*Participants*

The sample consisted of 90 students of younger school age (the third, fourth and fifth grade), aged 8 to 11, of both sexes (46 boys and 44 girls). The average age of the male respondents was AS=10.03; SD=0.87, and female AS=9.83; SD=0.82. When it comes to school age , the sample included 30 students of the third class (18 girls and 12 boys ), 30 students of the fourth class (13 girls and 17 boys ) and 30 students of the fifth class (13 girls and 17 boys). The sample included children with the typical language development, without difficulties in intellectual development, with normal hearing and vision and children who did not have severe motor impairments.
The research was carried out during February and March 2024, in the Public Institution Elementary School "Jovan Jovanović Zmaj" in Trebinje.

*Instruments*

The assessment of handwriting quality in this research was carried out using two scales: the Scale for assessing the maturity of handwriting and the Scale for assessing the dysgraphicness of handwriting. Both scales were constructed by the French authors Ayiriagerra and Ozias (1992), and were adapted to our speaking area (according to Ćordić & Bojanin, 2011). Assessment of the dominant lateralization of the upper extremities was performed using the test from the Battery of Tests according to Sovak (1979), while the visual lateralization was assessed by using the test from the Practicum of General Defectology Diagnostics (Povše Ivkić & Govedarica, 2000). The scale for assessing handwriting maturity has 30 features divided into two parts. The first part of the scale is marked with the letter F and has 14 features that characterize infantile forms of handwriting, typical for children who start to learn to write. The second part of the scale (M) contains 16 features, which identify malformations or bad forms of handwriting. These are called "infantile" malformations. The scale for assessing handwriting dysgraphicness contains 25 features (D1 to D25), divided into three groups. The first group consists of seven characteristics that identify the poor spatial organization of the manuscript as a whole, the second group has 13 characteristics that represent clumsy execution of letters, and the third group consists of five characteristics that assess errors in the form and proportions of the letters. During evaluation, 0, 0.5 or 1 point can be given for each feature. The obtained point is multiplied by the coefficient given for each feature. Based on the total number of points, the quality of the manuscript is concluded. A score below 10 indicates a harmoniously developed manuscript; a score between 10 and 13.5 indicates inconsistent/hard-to-read handwriting; a score between 14 and 18 points represents dysgraphic handwriting; while a score of 19 or more points is an indicator of extremely dysgraphic handwriting. Dominant lateralization of the upper extremities was assessed based on the following tests: a) assembling samples (sticking 20 plastic pins into a

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perforated plastic board, with one hand and then the other), b) assembling the hands, c) passing the thread through the needle, d) arranging the cubes, e) drawing (the child draws a house on half of the paper with one hand and then on the other half with the other hand). Four out of the five mentioned tests performed with the left or right hand indicate the dominance of that hand.

Dominant visual lateralization was assessed on the basis of four tests from the Practicum of General Defectology Diagnostics: a) looking through an opening on a cardboard held by the subject himself, b) choosing one of two spaced openings on the cardboard, c) looking through a paper tube, d) looking through one opening on the cardboard held by the examiner. Three out of four tests performed with the left or right eye indicate the dominance of that eye.

*Procedure*

The written parental consent was requested and obtained for each child who participated in the research. The researcher guaranteed the anonymity of the obtained data. The handwriting sample was taken in three forms: dictation, transcription and free composition, by group testing of the third, fourth and fifth grade children. After that, an individual assessment of the dominant lateralization of the upper extremities and vision was performed.

*Statsitical analysis*

Data processing was performed using the SPSS package (SPSS 20.0.), intended for social sciences. Descriptive statistics methods (arithmetic mean, standard deviation, frequency) were applied. The t-test was used to assess the significance of the differences between the examined variables. The data are presented in the following tabular form.

**Results**

Table 1. Results of handwriting assessment

| | **Well-developed handwriting** | | **Incoherent/difficult to read handwriting** | | **Dysgraphic handwriting** | | **Extremely dysgraphic handwriting** | |
|---|---|---|---|---|---|---|---|---|
| | N | % | N | % | N | % | N | % |
| *Third grade* | 2 | 2.2% | 7 | 7.8% | 4 | 4.4% | 17 | 18.9% |
| *Fourth grade* | 11 | 12.2% | 8 | 8.9% | 4 | 4.4% | 7 | 7.8% |
| *Fifth grade* | 7 | 7.8% | 4 | 4.4% | 11 | 12.2% | 8 | 8.9% |
| *Total* | 20 | 22.2% | 19 | 21.1% | 19 | 21.1% | 32 | 35.6% |

Table 1 shows the results of the dysgraphic assessment of handwriting. Looking at the table, we can see that among third-grade children, 2 respondents (2.2%) have harmoniously developed handwriting, 7 (7.8%) of them have inconsistent/hard-to-read handwriting, while dysgraphic and extremely dysgraphic handwriting have 4 (4.4 %) and 17 (18.9%) respondents.

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When it comes to fourth-grade children, 11 respondents (12.2%) have harmoniously developed handwriting, 8 (8.9%) have inconsistent or hard-to-read handwriting, 4 (4.4%) respondents have dysgraphic handwriting while extremely dysgraphic handwriting has 7 children (7.8%).
In fifth-grade children, the situation is as follows: 7 respondents (7.8%) have harmoniously developed handwriting, 4 respondents (4.4%) have inconsistent/hard-to-read handwriting, 11 (12.2%) have dysgraphic handwriting and 8 respondents (8.9%) have markedly dysgraphic handwriting.
When it comes to the overall result of children in the third, fourth and fifth grades, a total of 20 respondents (22.2%) have coherent handwriting, 19 (21.1%) respondents have inconsistent/hard-to-read handwriting as well as digraphic, while 32 (35, 6%) of the respondents have a distinctly dysgraphic handwriting.

Table 2. Results of assessment of dominant lateralization of the upper extremities

| **Dominant lateralization upper ones extremities** | Total | |
|---|---|---|
| | **N** | **%** |
| DLGE | 78 | 86.7% |
| LLGE | 12 | 13.3% |
| Total | 90 | 100% |

∗ DLGE = Right lateralization of the upper extremities.
∗ LLGE = Left lateralization of the upper extremities.

Table 2 shows the results of the assessment of dominant lateralization of the upper extremities. By looking at this table, we can see that in 78 (86.7%) subjects, the dominant right lateralization of the upper extremities is present, while 12 (13.3%) of them have the dominant left lateralization of the upper extremities.

Table 3. Results of assessment of dominant lateralization of vision

| **Dominant lateralization of vision** | Total | |
|---|---|---|
| | **N** | **%** |
| DLV | 74 | 82.2% |
| LLV | 16 | 17.8% |
| Total | 90 | 100% |

∗ DLV = Right lateralization of vision .
∗ LLV = Left lateralized vision.

Table 3 shows the results of the assessment of dominant lateralization of vision. By looking at this table, we can see that in 74 (82.2%) subjects, the dominant right-sided lateralization of vision is present, while in 16 subjects (17.8%), left-sided vision is dominant.

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Table 4. Correspondence of lateralization of vision and upper extremities

| **Correlation of vision lateralization and GE** | Total | |
|---|---|---|
| | **N** | **%** |
| Aligned | 80 | 88.9% |
| Mismatched | 10 | 11.1% |
| Total | 90 | 100% |

∗□GE = Upper Extremities.

Table 4 shows the results of assessment of conformity or non-conformity of dominant lateralization of vision and upper extremities in third, fourth and fifth grade children. By looking at the table, we can see that 80 subjects (88.9%) have matched and 10 (11.1%) have mismatched lateralization of vision and GE.

Table 5. Examination of the influence of dominant lateralization of the upper extremities on handwriting

| | **Well-developed handwriting** | | **Incoherent/difficult to read handwriting** | | **Dysgraphic handwriting** | | **Extremely dysgraphic handwriting** | | **χ2** | **df** | **p** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | % | N | % | N | % | N | % | 1.705 | 3 | .636 |
| DLGE | 18 | 23.1% | 15 | 19.2% | 16 | 20.5% | 29 | 37.2% | | | |
| LLGE | 2 | 16.7% | 4 | 33.3% | 3 | 25% | 3 | 25% | | | |
| In total | 20 | 22.2% | 19 | 21.1% | 19 | 21.1% | 32 | 35.6% | | | |

∗□DLGE = Right lateralization of the upper extremities.
∗□LLGE = Left lateralization of the upper extremities.

Table 5 shows the results of the examination of the influence of dominant lateralization of the upper extremities on dysgraphic handwriting . By looking at the table, we can see that there is no statistically significant difference when it comes to the relationship between dominant lateralization of the upper extremities and dysgraphic handwriting.

## Discussion

Based on the analysis and discussion of the obtained results, it can be concluded that a considerable number of students of younger school age show difficulties in writing. Actually, the summary results of children in the third, fourth and fifth grades show that a total of 20 respondents (22.2%) have a coherent handwriting, 19 (21.1%) respondents have an inconsistent/hard-to-read handwriting while 32 (35.6%) respondents have a dysgraphic handwriting. Compared to the results of the earlier conducted researches, it can be said that the frequency of dysgraphia in children of younger school age has increased significantly. Vuković and associates (2015) in their study, which also dealt with the assessment of dysgraphia in children of the younger school age, state that dysgraphia occurs in 12.2% of respondents, while

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inconsistent/difficult to read handwriting was identified in 8.3% of the examined population. In another study, where the sample included 461 children of the younger school age, dysgraphia was found in 9.1% of respondents (Ćalasan, Vuković, Mastilo, Vuković, Bakoč, & Zečević, 2017). The trend of increasing the frequency of dysgraphia is also indicated by the data of the research conducted in five elementary schools in Belgrade (Golubović, Vuković, Dimić, Petrović-Lazić, Jovanović-Simić, 2005). At the same time, this research showed a difference in the frequency of dysgraphia between the schools where the examination was carried out, where, for example, in one school 5.7% of children with dysgraphia were identified, while in another school dysgraphia was found in as many as 25.1% of the respondents. In the results of a foreign study (Van Hartingsveldt, De Groot, Aarts, & Nijhuis-Van Der Sanden, 2011), it is stated that 27% of school-aged children have difficulties in writing.

The results of our research show that in the majority of respondents, the right dominant lateralization of the upper extremities (86.7%) and vision (82.2%) prevail. These results are consistent with the results of other studies, which state that about 90% of respondents are right-handed and that the percentage of the respondents with the right dominant eye is 70-90% in whom these elements are not present (8.1%). The existing differences in the results can be explained by the different age of the subjects included in the research (preschool and younger school age). Brakus (2003) states that the first appearance of dominant lateralization occurs in the tenth month, then it is fixed in the twelfth month and becomes more and more consolidated in the eighteenth month, when the speech itself develops to a full extent. The developmental path from movement ambivalence to choosing the right or left hand as dominant is the result of maturation, which ends between the age of six and eight (Brakus, 2003). It is clear that this process is not complete in preschool children, where the ambivalence of movement is still present. However, any ambivalence after this period represents a slowness in the maturation of structures and functions that determine the lateralization of movement (Bojanin, 1985). On the other hand, if we start from the fact that the direction of lateralization can be done from the fourth to the tenth year of a child's life, in this developmental period we can only follow the process of choosing the dominant lateralization that is realized spontaneously, whichever- the right- or left-sided dominance is in question (Jovanović and associates., 2014). These authors state that any mismatched lateralization of limbs and senses leads to a decrease in the functionality of one of the hemispheres, and thus to difficulties in information processing and learning. Beaton (Beaton, 1986) also finds a negative impact of mismatched lateralization on the ability to read, which precedes the ability to write. Similar data have been stated by Mepls (Maples, 2002), according to whose results a significant difference in reading achievements was found in favor of children with coordinated lateralization. In the light of the above, although our results did not confirm the connection between lateralization and handwriting quality in younger school-age children with uncoordinated lateralization of the upper extremities and the sense of sight, it is necessary to do exercises to direct, practice and stabilize lateralization.

## Conclusion

A considerate number of children of younger school age have a dysgraphic handwriting. In the majority of children of this age, right-sided lateralization of the upper extremities (86.7%) and vision (82.2%) predominate and mismatched lateralization between vision and upper extremities

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is present in a relatively small percentage (11.1%). No connection was established between the dominant lateralization of the upper limbs and vision (as well as their coordination) and the quality of handwriting in children of younger school age.

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