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Relative Age Effects on Children's Handwriting: Role of Visual-Motor Integration

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Abstract

Background

Previous studies have well documented that oldest students in a given school class typically have better academic performance than their younger mates. However, there are many phenomena regarding the effects of relative age on academic performance of school students that must be considered. Because of its importance in academic performance of primary school children, handwriting would be of interest. The purpose of the present study was to explore the effects of relative age on handwriting of second grade students in primary school with considering the role of visual-motor integration as a possible underlying mechanism.

Materials and Methods: The present study used a descriptive-correlational approach. Based on the guidelines of Krejcie & Morgan, four hundred boys (100 boys from each year-season) in second grade from four regular national primary schools in Gorgan, Iran, in 2019 were selected by a cluster random sampling method and asked to perform a standard handwriting tool and visual motor integration test. Legibility and speed of handwriting were measured to assess handwriting quality.

Results: Means of age of children who were born in fall, winter, spring, and summer were 94.99, 92.12, 89.04, and 85.88 months, respectively. Results demonstrated that older children in comparison to younger children had significantly better handwriting legibility in both copying and dictation, besides, they copied the text faster (P<0.05). Furthermore, older children compared with younger children had significantly higher scores in visual-motor integration (P<0.05).

Conclusion

Based on these results, it seems that relative age affects handwriting performance of children. Furthermore, visual-motor integration might act as a possible underlying mechanism for the effects of relative age on handwriting performance.

Key Words: Children, Handwriting, Legibility, Month of birth speed, Visual-motor integration.

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1- INTRODUCTION

Almost all education systems have a single cut-off date for school enrollment. For example, in most educational systems, a child may be allowed to enter primary school as long as he/she is usually 6 or 7 years old. In a school setting, cut-off date is very important because it causes some children born just after the cut-off date to be older than classmates, even up to 12 months older, who were born just before the cut-off date that coincides with differences in maturation as well as experiences prior to school enrollment in preschool or in the family (1). This phenomenon is known as the relative effect of age (RAE) (2). The RAE refers to the considerable advantages for individuals who are born early over those who are born later in an annual group (2). In other words, individuals who were born in first quartile of an academic year would have various advantages over those who were born in later quartiles. A number of studies documented that the oldest pupils in a given class or cohort typically outperform their youngest mates in academic settings (1-5). Furthermore, it has been shown that the RAE contributes to better performance in literacy at the beginning of formal schooling (i.e., better reading) (1, 4, 6).

These findings demonstrate large differences between students in a class, especially in the early grades of primary school. Several explanations such as more cognitive maturity, much institutionalized support during preschool period, and higher expectations of teacher have been proposed to explain the RAE in school system (1). One of the most important cognitive-motor skills in school is handwriting. However, research investigating the RAE on handwriting performance of school-aged children is particularly limited. Handwriting is considered as a fundamental skill for students at primary school to meet the common demands in classroom work as well as to show competency in academic performance (7-8). Handwriting involves linguistic, cognitive, perceptual, genetic, and motor components which have to be coordinated into an integrated fashion acquired over an extended period of time. It has been shown that poor handwriting is related to lower academic performance, lower mathematics achievement and low verbal Intelligence Quotient (IQ) (9). Therefore, handwriting is an important skill in school which affects children and teachers in their everyday lives. Accordingly, studying the effects of relative age on handwriting performance of school students, particularly in early grades of primary school, is of great importance. Therefore, due to lack of research investigating the RAE on handwriting performance of primary school-aged children, the primary purpose of the present study was to investigate the effects of relative age on handwriting performance of second grade students in primary school. Regarding the underlying mechanisms for handwriting, research has shown that visual-motor integration (VMI) contributes significantly to quality and speed of handwriting (10-15).

The VMI is defined as the ability to copy geometric shapes (16), and includes effective and efficient coordination between the eyes and the hands (e.g., eye-hand coordination), by which children can copy, draw or write. Efficient VMI can occur when the foundations of visual-motor skills are well developed (11). Children with a well-developed VMI may have appropriate handwriting as well as other school skills (10-11). Given the importance of VMI in children's handwriting, it may play an important role in the RAE on handwriting performance in primary school children. Therefore, the second purpose in this study was to investigate whether VMI can play a role as a possible underlying mechanism for the RAE on handwriting performance of primary school children. In the present study, it was hypothesized that 1) children who are born earlier compared with those who are born later would show better handwriting performance; and 2) older children in comparison to younger children would show higher VMI scores.

2- MATERIALS AND METHODS

2-1- Study design and population

This study utilized a descriptive-correlational approach. Participants were four hundred boys (100 boys from each year-season) in second grade from four regular national primary schools in Gorgan, Iran in 2019. This amount of participants was selected based on the guidelines of Krejcie & Morgan (17). To select the participants, after obtaining the necessary permits and coordination with the education departments of the mentioned city, a statistical sample was selected by a cluster random sampling method from four regular national schools. It is of note that, in Iran, schools are opened in October and will end in June. Therefore, within a school cohort, children who are born in fall are considered as older children compared with those who are born in winter, spring, and summer, and so on. Means and standard deviations of age of children who are born in fall, winter, spring, and summer were 94.99, 92.12, 89.04, and 85.88 months, respectively. All children were right handed and used no hearing-aid.

2-2- Measuring tools

2-2-01. Handwriting tool: The handwriting task was adopted from Persian Handwriting Assessment Tool (PHAT) for primary school-aged children (18). This tool is a standard tool in Persian that evaluates writing performance in second grade students in primary school. The authors examined the validity of this instrument and reported internal consistency of .84 to .99. The PHAT includes demographic and handwriting parts. Demographic part involves information such as class, gender, hand-dominance, using eyeglass and hearing-aid, and school. Handwriting part includes copying and dictation. In copying, children were asked to copy words as accurately and as fast as possible on a sheet of paper in which the words were printed on the top of the paper. Speed and legibility dimensions including formation, size, space, alignment, and text slant were assessed for written words. The time (in seconds) it took the child to write the words on paper was measured as speed of handwriting and was recorded by using a digital chronometer. All dimensions of legibility (except size) were assessed by a five-point Likert scale ranging from very poor (scored as 1) to very good (scored as 5). To calculate the total score, we averaged the scores of all participants. Final score ranged from 1 to 5.

Here, scores higher than 4 mean that the children wrote the word very well. Size was assessed by a five-point Likert scale ranging from very small (scored as 1) to very big (scored as 5). To calculate the total score, we averaged scores of all participants. Final score ranged from 1 to 5. Here, scores between 2 and 3 mean that the children wrote the words with an appropriate size. In dictation, an experimenter read the words loudly and children were asked to write them on a paper sheet as accurately as possible. Two independent judges blinded to children's birth month assessed legibility of handwriting. The evaluation was performed by using an evaluation form designed specifically for this test (18). Both raters evaluated all handwriting performances of the children. Inter-rater reliability for two reviewers was $r > .70$ for all legibility dimensions. The data from first reviewer was used for further analysis.

2-2-2. Visual-motor integration: We used VMI test (16) designed for children ranging from 2 to 15 years-old. This test consisted of 24 geometric forms, in which the child had to draw a form exactly like the one presented in the test booklet. Each form was scored from 1 to 4 points for a total of 50 points. Scores are calculated by adding the scores of forms that are copied successfully until the child fails to correctly copy three consecutive forms. Reliability of this test was measured by its designers and was reported to have a valid reliability (16).

2-3- Inclusion and exclusion criteria

Inclusion criteria included being a boy, studying in second grade in Gorgan primary schools, and consent to participate in study.

2-4- Ethical approval

Protocol was approved by the university's Research Ethical Committee (ID-code: IR.IAU.AK.REC.1398.012). The participants voluntarily participated in the present study and written informed consent was obtained from the subjects and their parents.

2-5- Data analysis

One-way analysis of variance (ANOVA) was used to analyze differences between SEASONs for legibility and speed of handwriting as well as VMI scores. Tukey test was used as post hoc test. Linear regression analyses were applied to identify whether VMI is a possible predictor of handwriting quality and speed. Significance level was set at $p < .05$.

3- RESULTS

3-1- Copying

Means and standard deviations of legibility dimensions as well as speed of handwriting in copying are presented in **Table.1** and **Figure.1**. As it is obvious, the children who are born earlier had better scores in formation, space, alignment, and speed in comparison to those who are born later. Results of ANOVA showed a significant main effect for SEASON in formation, F (3, 396) = 44.78, p = .000, η^2 = .25. Follow-up test revealed that fall group performed better than other groups; winter group performed better than summer group; and spring group performed better than summer group, all $p < .01$. Moreover, results demonstrated a significant main effect for SEASON in space, F (3, 396) = 28.10, p = .000, η^2 = .17. Follow-up test revealed that fall and winter groups performed better than spring and summer groups, and summer group performed better than spring group, all $p < .05$. In addition, results indicated a significant main effect for SEASON in alignment, F (3, 396) = 22.07, p = .000, η^2 = .14. Follow-up test showed that fall group performed better than other groups; winter group performed better than summer group; and spring group performed better than summer group, all $p < .05$. With regard to size, results showed no significant main effect for SEASON, F (3, 396) = 1.95, p = .121.

In addition, results showed a significant main effect for SEASON in slant, F (3, 396) = 20.52, p = .000, η^2 = .13. Follow-up test revealed that fall group performed better than winter and spring groups; winter group performed better than spring group; and summer group performed better than spring group, all $p < .05$. Finally, results demonstrated a significant main effect for SEASON in speed, F (3, 396) = 19.34, p = .000, η^2 = .12. Follow-up test demonstrated that fall group copied the text faster than other groups; and winter group copied the text faster than spring and summer groups, all $p < .05$. No significant difference was observed between spring and summer groups, p>.05.

Table-1: Means of handwriting legibility and speed scores in copying across seasons.

Item	Range	Fall	Winter	Spring	Summer	P-value
Formation	1<score<5	4.45 ± .53	4.17 ± .45	4.04 ± .49	3.62 ± .55	0.000*
Space	1<score<5	4.38 ± .51	4.56 ± .42	3.81 ± .74	4.07 ± .75	0.000*
Alignment	1<score<5	4.05 ± .58	3.72 ± .55	3.63 ± .66	3.37 ± .60	0.000*
Size	1<score<5	2.77 ± .45	2.78 ± .57	2.92 ± .44	2.80 ± .53	0.121
Slant	1<score<5	3.66 ± .84	3.35 ± .83	2.78 ± .77	3.45 ± .86	0.000*
Speed (in second)	1<score	61.52 ± 16.95	74.73 ± 29.38	86.62 ± 26.28	84.18 ± 28.93	0.000*

*Significant at P<0.001.

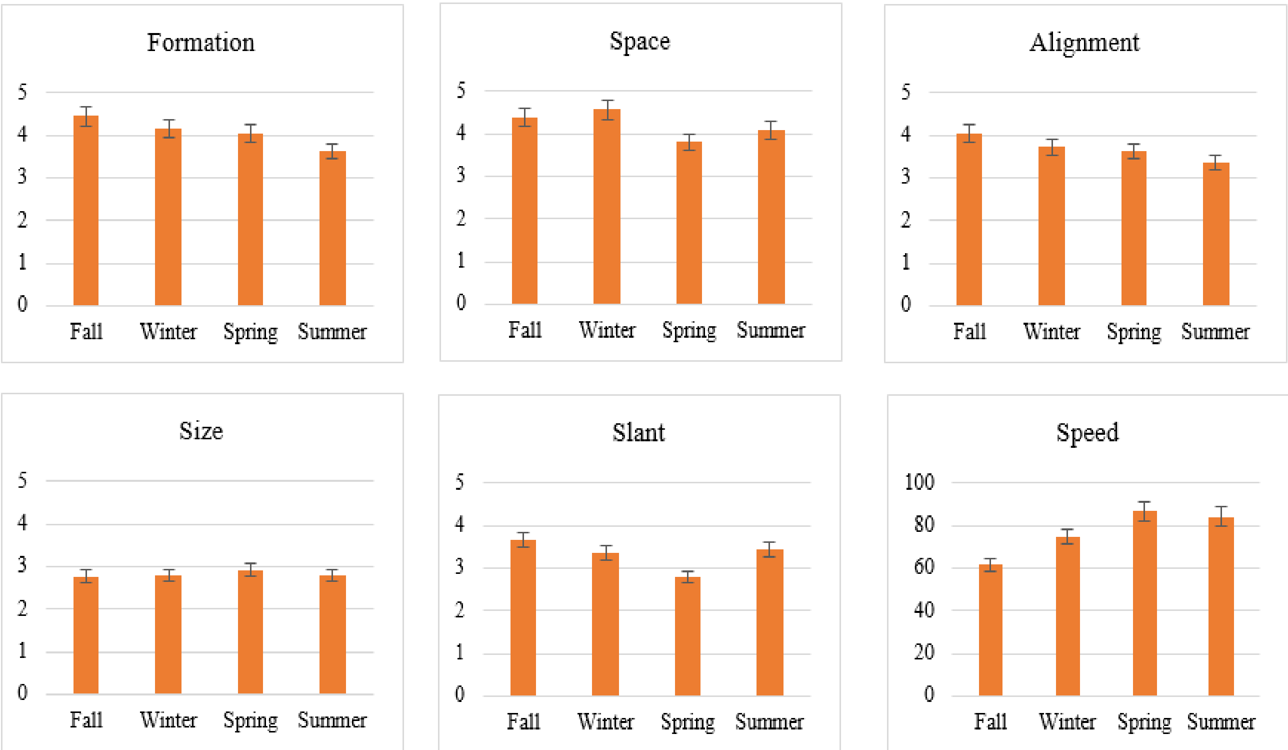

Fig.1: Handwriting legibility and speed scores in copying across seasons in children.

3-2- Dictation

Means and standard deviations of legibility components in dictation are presented in **Table.2** and **Figure.2**. As is evident, children who are born earlier showed better scores in formation, space, and alignment in comparison to those who are born later. Results of ANOVA demonstrated a significant main effect for SEASON in formation, F (3, 396) = 31.21, p = .000, η^2 = .19. Follow-up test revealed that fall and winter groups performed better than spring and summer groups, all p < .001. In addition, results showed a significant main effect for SEASON in space, F (3, 396) = 30.89, p = .000, η^2 = .19. Follow-up test revealed that fall and winter groups performed better than spring and summer groups; and summer group performed better than spring group, all p < .01. Additionally, results indicated a significant main effect for SEASON in alignment, F (3, 396) = 40.53, p = .000, η^2 = .23. Follow-up test revealed that winter group performed better than all other groups; fall group performed better than spring and summer groups; and spring group performed better than summer group, all $p < .01$. Moreover, results showed no significant main effect for SEASON in size, F (3, 396) = 1.61, p = .185. Regarding slant, results showed a significant main effect for SEASON in slant, F (3, 396) = 20.52, p = .000, η^2 = .13. Follow-up test revealed that fall group performed better than spring group; winter group performed better than spring and summer groups; and summer group performed better than spring group, all p<.05.

Table-2: Means of handwriting legibility scores in dictation across seasons.

Item	Range	Fall	Winter	Spring	Summer	P-value
Formation	1<score<5	4.45 ± .42	4.45 ± .55	3.94 ± .67	3.88 ± .57	0.000*
Space	1<score<5	4.65 ± .38	4.47 ± .46	3.88 ± .81	4.18 ± .67	0.000*
Alignment	1<score<5	4.11 ± .48	3.39 ± .48	3.87 ± .49	3.63 ± .57	0.000*
Size	1<score<5	2.92 ± .53	2.81 ± .61	2.95 ± .39	2.93 ± .38	0.185
Slant	1<score<5	3.69 ± .81	3.91 ± .80	2.94 ± .81	3.59 ± .89	0.000*

*Significant at P<0.001.

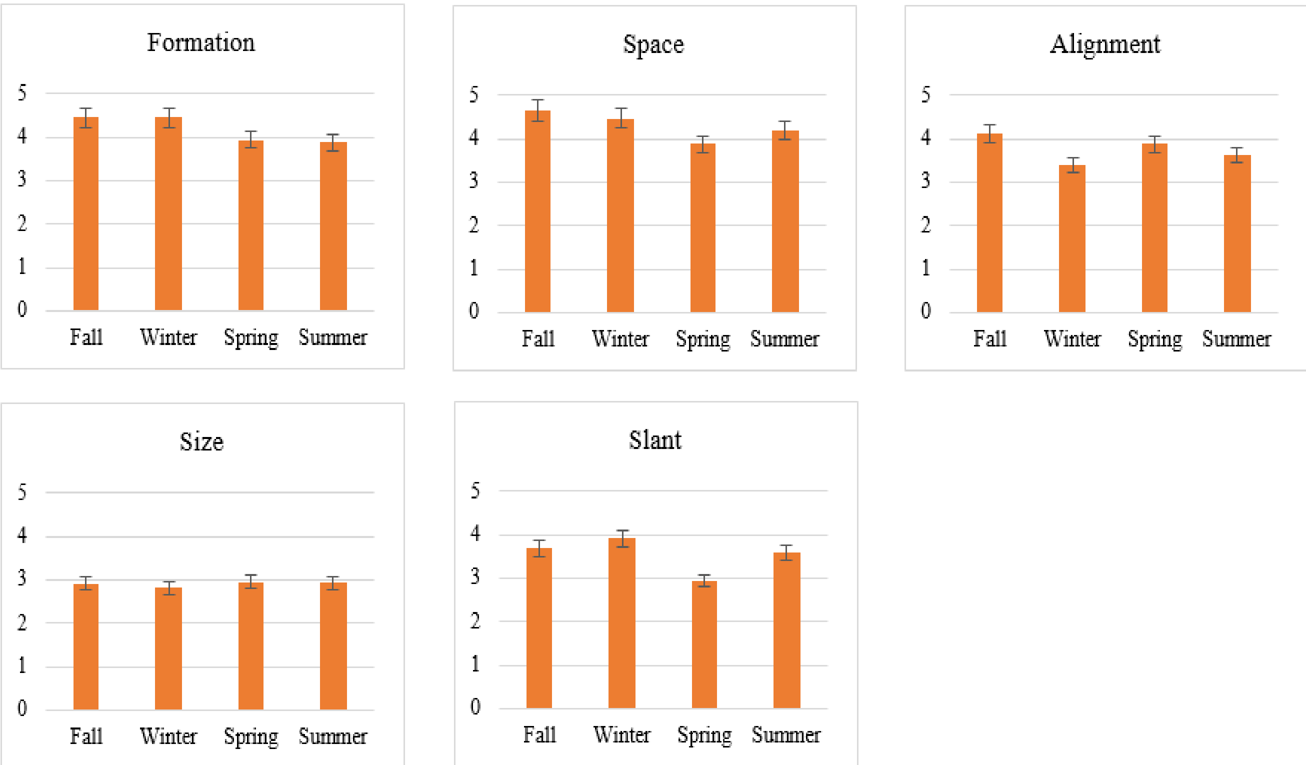

Fig.2: Handwriting legibility scores in dictation across seasons in children.

3-3- VMI (Visual-motor integration)

Means and SDs of VMI scores across seasons are presented in **Table.3** and **Figure.3;** as it appears, children who are born earlier showed higher scores in VMI in comparison to those who are born later. Results of ANOVA showed a significant main effect for SEASON in VMI, F (3, 396) = 12.84, p = .000, η^2 = .08. Follow-up test revealed that fall and winter groups performed better than spring and summer groups, all $p < .05$. However, no significant differences were observed between fall and winter groups (p > .05) as well as between spring and summer group (p > .05).

Table-3: Means of VMI scores across seasons.

Item	Range	Fall	Winter	Spring	Summer	P-value
VMI	1<score<5	31.29 ± 4.66	30.16 ± 4.92	28.26 ± 4.69	27.56 ± 4.83	0.000*

*Significant at P<0.001. VIM: visual-motor integration.

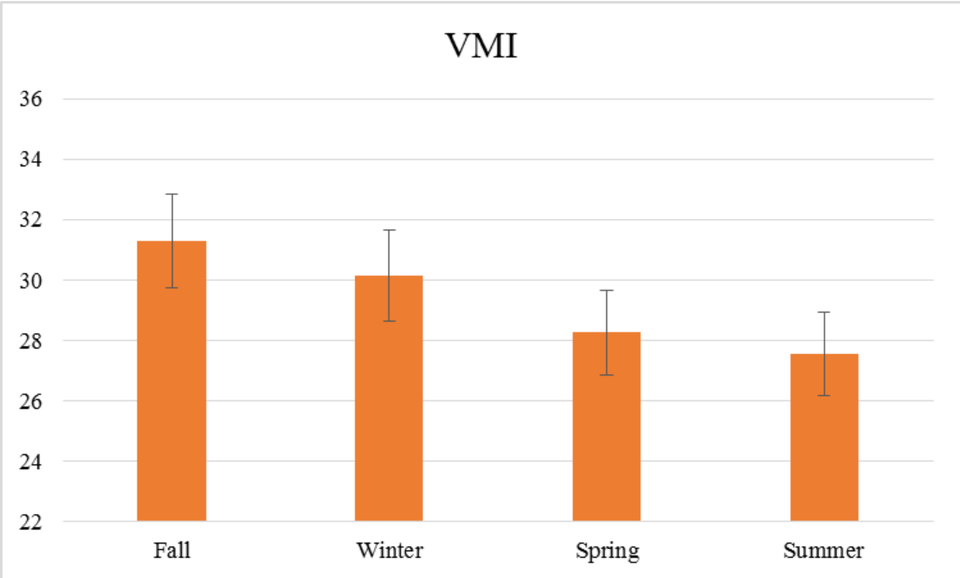

Fig.3: VMI scores across seasons in children.
VIM: visual-motor integration.

3-4- Linear regression analyses

In copying, results showed that VMI significantly predicted formation, F (1, 398) = 9.53, p = .002, Adjusted R^2 = .021, β = .153, space, F (1, 398) = 6.52, p = .011, Adjusted R^2 = .014, β = .127, and speed, F (1, 398) = 11.10, p = .001, Adjusted R^2 = .025, β = - .165. Furthermore, in dictation, results demonstrated that VMI significantly predicted formation, F (1, 398) = 18.18, p = .000, Adjusted R^2 = .041, β = .209, space, F (1, 398) = 11.62, p = .001, Adjusted R^2 = .026, β = .168, and alignment, F (1, 398) = 7.54, p = .006, Adjusted R^2 = .016, β = .136.

4- DISCUSSION

The RAE has been well documented in academic setting. However, there are many phenomena regarding the RAE in school system that must be considered. Because of its importance in academic performance of primary school children, handwriting would be of interest. The focus of this study was, therefore, to investigate the RAE on handwriting performance of second grade students in primary school. Moreover, the VMI was investigated as a possible underlying mechanism for the RAE on handwriting. In this study, it was hypothesized that: 1) children who are born earlier compared with those who are born later would show better handwriting performance; and 2) older children in comparison to younger children would show higher VMI scores.

Regarding handwriting performance, results of the present study showed that older children in comparison to younger children performed significantly better in most of the legibility dimensions in both copying and dictation parts. In addition, older children compared with younger children wrote the words significantly faster. These results generally support the first hypothesis of this study and might indicate that the relative age affects handwriting performance of second grade students in primary school. The results are consistent with previous research indicating existence of the RAE in academic setting (1-6). According to the results of this study and previous studies, it seems that being older within a school cohort would lead to greater academic performance and literacy skills. As noted in introduction, more cognitive maturity, much institutionalized support during preschool period, and higher expectations of teacher might affect greater performance of older children within a school cohort (1). However, to find a possible underlying mechanism, we measured the VMI in the participants of this study. With regard to VMI, results of this study demonstrated that older children in comparison to younger children had higher VMI scores. These findings are consistent with those of Ercan, Ahmetoglu, and Aral (19) who found that 67-72 month-old children in comparison to 60-66 month-old children have higher visual-motor-integration scores. These findings support second hypothesis of the present study. Moreover, results of regression analyses showed that the VMI significantly predicted legibility dimensions and speed of handwriting in primary school children. Based on previous research, the VMI contributes significantly to quality and speed of handwriting (11, 12, 14, 15). According to the results of the present study, it might be possible that the VMI acts as an underlying mechanism for the RAE on handwriting in primary school children. Among this study's limitations, we used only boys from second grade in primary school. However, the RAE on handwriting of girls as well as students of different ages in primary school was not investigated. Future research should focus on these issues. In addition, we used Persian that is phonologically and orthographically different from English. Future research is needed to focus on English and other languages to find any RAE on handwriting of different languages. Finally, we measured the VMI as a possible underlying mechanism of existence of the RAE in handwriting in children. Future studies should investigate other related factors to handwriting performance such as self-regulation skills, visual perception, working memory, motor planning, and kinesthetic awareness as possible underlying factors for the RAE on handwriting.

5- CONCLUSION

To summarize, the present study is, to the best of our knowledge, first to investigate the RAE on handwriting in school setting. Our results showed that the RAE exists in handwriting legibility and speed in primary school children and the VMI might act as an underlying mechanism for the RAE on handwriting. These results have some educational and occupational implications, too. First, given the existence of the RAE in handwriting in primary school children, teachers should pay particular attention to younger students within a school class and provide age-appropriate instructions when teaching cognitive-motor skills such as handwriting. Here, a possible intervention method for improving handwriting performance in children might be autonomy-based interventions (20). Second, given the possible importance of the VMI on handwriting performance in primary school children, we suggest that, in order to improve quality of handwriting, interventions for younger children in a class should focus on improvement of the VMI.

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7- CONFLICT OF INTEREST: None.

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