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Decoding Abilities in Early Elementary School Bosnian Children: Towards a Better Understanding of Reading

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Abstract: Acquiring mastery in reading is considered one of the primary academic skills during the early years of elementary school. Additionally, attaining proficiency in reading during the early grades of elementary school serves as a strong predictor for future academic achievements and overall success in life. This cross-sectional study aimed to examine the effect of several linguistic and cognitive variables on decoding abilities in the Bosnian language. The sample consisted of 153 children in the 2nd to 5th grades of elementary school. To assess decoding abilities, we employed tasks involving reading real words and non-words (pseudowords). The key predictors for both tasks included phonological awareness, rapid automatized naming of letters, working memory, and processing speed. Both models accounted for approximately 64% of the variance in the scores, signifying a substantial advancement compared to existing models of reading in the Bosnian language. The results of this study may contribute to the development of targeted and effective reading interventions in early elementary education.

Keywords: *Bosnian language, decoding abilities, predictors of reading.*

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Introduction

The early grades of elementary school are crucial in fostering reading development. Children who do not acquire literacy skills that are appropriate for their age by the conclusion of the third grade face an increased likelihood of experiencing academic difficulties (Snow & Matthews, 2016). On the other hand, good reading skills in early elementary school grades are good predictors of general knowledge (Cunningham & Stanovich, 1997) and later academic success (Lonigan et al., 2000). Definitions of reading have been focused either on the view of reading as thinking guided by the print (thinking definition) or reading as a translation of written elements into language (decoding definition) (Perfetti, 1984). The decoding definition refers to learning to read, while the thinking definition applies to skilled reading. However, to achieve skilled reading or reading comprehension, one must master decoding skills first. On the other hand, decoding and reading comprehension are strongly dependent on oral language skills (Hjetland et al., 2019).

Reading is a multifaceted skill encompassing two fundamental components: reading fluency and linguistic comprehension. Thus, reading is a multilayered activity and process of Reading as a linguistic activity is a multifaceted and intricate data processing process. It comprises fundamental aspects like reading techniques and more advanced elements like understanding the written content (Omerović, 2023). According to the Simple View of Reading theory (Hoover & Gough, 1990), proficient literacy extends beyond basic reading skills, enabling individuals to use reading for knowledge acquisition, information synthesis, and content mastery (Murnane et al., 2012).

As for the phases of reading abilities, research has shown that the development of reading skills occurs in distinct phases, with varying perspectives on the number of stages preceding automatic reading. An influential theory proposed by Frith (1985) suggests three phases of reading development:

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1. Logographic Phase: Children rapidly recognize familiar words in this initial stage, known as logographic or sight word reading.
2. Alphabetic Phase: The second stage involves alphabetic reading, where children decode words grapheme by grapheme.
3. Orthographic Phase: The final stage, orthographic reading, in which words are automatically analyzed into orthographic units without phonological conversion.

This study focuses on decoding skills as a prerequisite for proficient reading, particularly the development of word-reading skills during the early grades of elementary school. It is essential to understand how novice readers acquire the ability to accurately and automatically recognize words (Ehri, 2005). While much of the research on decoding skills has been conducted in English, questions arise about the applicability of findings from languages with inconsistent orthography to those with more consistent orthographies. Studies have revealed distinct developmental paths in reading skills, with English displaying a slower trajectory than languages like Spanish and Czech (Caravolas et al., 2013). As for the Bosnian language, which is a language with shallow orthography, a limited number of studies examined the effects of various predictors on decoding skills.

However, certain linguistic and cognitive factors appear universal across orthographies, such as Phonological Awareness and Rapid Automatized Naming (RAN), which have shown significance as predictors of reading development in various languages, including English, French, Italian, Bosnian, Finnish, and Turkish (Ergül et al., 2023; Lonigan et al., 2000; Memisevic, Dedic, Biscevic, et al., 2022; Tobia & Marzocchi, 2014; Torppa et al., 2010; Vander Stappen & Reybroeck, 2022). RAN appears to engage a cognitive mechanism with universal applicability across languages, as indicated in studies involving multiple alphabetic languages (Georgiou et al., 2016; Wolff, 2014).

Besides these two well-known predictors of reading, research has established many other factors that play a role in reading to a smaller or larger extent. Cognitive factors such as processing speed significantly affect reading fluency (Gerst et al., 2021). It has also been found that general intellectual abilities have a large and consistent (across grades) relationship with reading (Carver, 1990). Working memory, probably more than any other cognitive skill, has been researched in relation to reading. Numerous studies have shown poor readers' deficits in working memory (Dawes et al., 2015; S. Wang & Gathercole, 2013), thus indicating its important role in reading.

We mentioned several important factors contributing to reading success. However, in what measure and how exactly they impact reading is still an elusive question. The answer to this question is of great importance, as it will help researchers and practitioners create better reading interventions. Reading difficulties are common in school-aged children. In a study by Bhakta et al. (2002), the authors reported a prevalence of reading difficulties to be 8.2%, while in a study by Cecilia et al. (2014), the authors found a prevalence of 11%. Given the high prevalence of reading difficulties, finding the factors contributing to reading success is central in educational psychology and reading research. Examining the cognitive correlates of reading development is an important topic as it helps understand the nature of cognitive processes underlying reading (Araújo et al., 2015).

However, despite the growing body of research on reading in Bosnian, it is important to note that there is still a significant gap in the literature compared to studies conducted in more widely spoken languages. Most of the existing research has focused on languages such as English (Hulme et al., 2002), Spanish (Kim & Pallante, 2012), Chinese (Y. Wang et al., 2015), and French (Massonnié et al., 2019), which has contributed significantly to our understanding of reading development. In the context of Bosnian, research efforts are gradually gaining momentum (Memisevic et al., 2019). While the existing studies have shown that similar factors contribute to reading development in Bosnian as in other languages (Memisevic, Dedic, Biscevic, et al., 2022), it is essential to acknowledge the need for more comprehensive research.

Our current study builds upon this foundation by exploring additional variables, such as general intellectual abilities and various working memory tasks, to further investigate the predictors of reading in Bosnian-speaking children. We conducted our research with children in Grades 2 to 5, evaluating the impacts of Phoneme Deletion Task, RAN of Objects, RAN: Letters, Digit Span Backwards Task, Letter-Digit Substitution Task, and Raven's Colored Matrices on children's Word Reading and Pseudoword Reading abilities.

By expanding our knowledge in this underrepresented area, we aim to contribute insights to the field of reading research and education. Understanding how these factors influence reading abilities in the Bosnian language can provide educators and researchers with efficient tools for literacy development in this language.

Methodology

Participants

The study included a sample of 153 children, comprising 85 boys and 68 girls, distributed across Grade 2 (35 students, with a mean age of 7.4 years, SD- 0.38), Grade 3 (36 students, with a mean age of 8.5 years, SD- 0.41), Grade 4 (46 students, with a mean age of 9.5 years, SD- 0.43), and Grade 5 (36 students, with a mean age of 10.4 years, SD- 0.36). Based on the records from the children's school, there were no indications of developmental disabilities, neurological disorders, or any

other health conditions that could impact their learning. Moreover, none of the children received any type of specialized educational support at school.

Procedure

We employed a cross-sectional study design to evaluate reading variables in children. Two conveniently selected elementary schools in Canton Sarajevo were selected. We asked teachers to give consent forms to the parents, and we left our contact information for parents who might have additional questions. We received 153 consent forms for children in Grades 2 to 5. Individual testing of children was conducted during morning hours in available classrooms. The testing sequence was standardized for all participants. Ethical approval for this study was granted by the Ministry of Education of Canton Sarajevo and the Faculty of Educational Sciences at the University of Sarajevo. Participation in the study was limited to children whose parents had provided written consent.

Measures

The majority of the measures utilized in this study had previously been employed in a research investigation focused on third-grade students in Bosnia and Herzegovina to assess reading predictors (Memisevic, Dedic, Biscevic, et al., 2022). It is important to note that the applicability and validity of these measures extend beyond third-grade and encompass children ranging from second to fifth grade of elementary school.

1. Outcome Variables

We employed word reading and pseudoword reading tasks as the dependent variables in our study. These tasks are recognized as effective measures of proficient and precise word-level reading skills in alphabetic writing systems (Caravolas, 2018). In the word reading task, children were instructed to orally read a list of real words, which progressively increased in complexity and length. The list starts with 3-letter-words. The number of words children read in 1 minute was used as the first measure of decoding skill. The reliability of this task type is documented to exceed .90. (Georgiou et al., 2012). The same procedure was used for a pseudoword reading task. Children were required to read aloud a list of pseudowords gradually increasing in length. The list also starts with a 3-letter pseudowords. The number of words read in 1 minute was used as the second measure of decoding skills.

2. Explaining Variables

Phonological awareness. As a measure of phonological awareness, we used a phoneme deletion task (Memisevic, Dedic, Biscevic, et al., 2022). In this exercise, children were presented with a list of 16 objects and instructed to name each object while omitting the initial sound. To ensure comprehension, they were initially given three demonstration items. During the demonstration, children were shown images of a dog ('pas' in Bosnian), a trumpet ('truba' in Bosnian), and a book ('knjiga' in Bosnian) and were instructed to provide the name without the first phoneme ('as' instead of 'pas,' 'ruba' instead of 'truba,' and 'njiga' instead of 'knjiga'). All children demonstrated a clear understanding of the task. The time taken to correctly name the objects was utilized as a measure of phonological awareness. This task proved to be the most reliable predictor of reading proficiency in the Bosnian language (Memisevic, Dedic, & Malec, 2022).

Rapid Automatized Naming- Letters (RAN: Letters). This task consists of five lowercase letters (a, d, o, p, s) randomly arranged and repeated 10 times within an array of five rows, resulting in a total of 50 stimulus items (Wolf & Denckla, 2005). The psychometric characteristics of Rapid Automatized Naming (RAN) tests are notably robust. As specified in the RAN manual, the test-retest reliability for RAN: Letters was .90, and the inter-rater reliability was .98 (Wolf & Denckla, 2005). The time required to name all the items served as the metric for assessing RAN letters.

Rapid Automatized Naming- Objects (RAN: Objects). This task comprises five stimuli (hand, book, dog, star, and chair) that were randomly repeated 10 times within an array of five rows, resulting in a total of 50 stimulus items (Wolf & Denckla, 2005). The time taken to name all these items served as the metric for assessing RAN: Objects. According to the RAN manual, the test-retest reliability for RAN: Objects was .84, with an interscorer reliability of .99 (Wolf & Denckla, 2005). Previous research has indicated that the RAN: Letters task exhibits a higher level of automatization compared to the RAN: Objects task (Wolf et al., 1986). Consequently, we sought to investigate the impact of both of these measures on decoding skills.

General intellectual abilities. We administered the Raven's Colored Progressive Matrices Test (RCPM) (Raven, 1986). The RCPM is among the most commonly used assessments for evaluating non-verbal facets of general intelligence. It is considered a culturally unbiased measure of intellectual aptitude, as indicated by Cotton et al. (2005). This test exhibits robust validity and reliability measures, as reported by Kazem et al. (2007). The RCPM comprises 36 items grouped into three sets, with items within each set progressively escalating in difficulty, necessitating increasingly advanced cognitive abilities for problem-solving.

Processing speed. For assessing processing speed, we employed a computerized version of the letter-digit symbol substitution test from the Psychological Experiment Building Language (Mueller & Piper, 2014). In this task, nine letters

and nine digits are displayed at the top of the screen, and children are instructed to press the corresponding digits on the keyboard as the letters appear randomly. The task encompasses 30 trials and typically takes approximately 3 minutes to complete. Substitution tests are primarily utilized to gauge information processing speed, which reflects the pace at which fundamental cognitive processes are executed (Van der Elst et al., 2012). Time was measured in milliseconds, with shorter times indicating superior performance.

Working memory. We utilized a Digit Span Backwards Test (DSBT) as a measure for assessing working memory. It is a widely accepted task for evaluating working memory capacity (Hilbert et al., 2014). In this task, children were presented with a series of random numbers at a pace of one per second and subsequently asked to recite the numbers in reverse order. The test commenced with a two-number sequence, and each accurately recited series was succeeded by a sequence containing one additional digit. In instances where children faltered during their initial attempt, they were given a second opportunity with a fresh set of random numbers. If they were unsuccessful during the second attempt, the test was terminated, and their score was calculated based on the longest series they successfully completed. The DSBT boasts favorable psychometric characteristics, including strong test-retest reliability and internal consistency (Waters & Caplan, 2003).

Statistical Analysis

Initially, we provided descriptive statistics, including the mean and standard deviation, for all variables. Subsequently, we conducted correlation analyses among the variables. Following this, we verified that the assumptions required for conducting regression analysis have been met and have conducted two stepwise regression analyses to identify the factors influencing performance on both word-reading and pseudoword reading tasks. All statistical tests adhered to a significance level of .05. The data analysis was carried out using the SPSS software, version 27 for Windows (IBM, 2020).

Findings/Results

Table 1 displays the means and standard deviations for all variables, while Table 2 presents the correlations among these variables. In Table 1, you'll find the means and standard deviations for each variable, and Table 2 showcases the intercorrelations between them.

Table 1. Means and SD of Word-Reading, Pseudoword Reading, Phoneme Deletion Task, RAN: Objects, RAN: Letters, Digit Span Backwards Task, Letter-Digit Substitution task, and Raven's Colored Matrices Test

Variable	Mean	SD
Word-reading	45.9	18.7
Pseudoword reading	30.9	11.6
Phoneme deletion task	87.4[a]	48.5
RAN: Objects	51.9[a]	13.3
RAN: Letters	28.8[a]	9.1
Digit Span Backwards Task	4.6	0.8
Letter-digit substitution Task	3525.1[b]	970.9
Raven's Colored Matrices Test	24.7	5.2

Note. [a] time in seconds, [b] time in milliseconds.

Table 2. Correlations Between Word-Reading, Pseudoword Reading, Phoneme Deletion Task, RAN: Objects, RAN: Letters, Digit Span Backwards Task, Letter-Digit Substitution Task, and Raven's Colored Matrices Test

Variable	1	2	3	4	5	6	7	8
1. Word-reading	1.00	0.91	-0.63	-0.52	-0.68	0.39	-0.61	0.38
2. Pseudoword reading	-	1.00	-0.63	-0.53	-0.72	0.34	-0.59	0.33
3. Phoneme deletion task	-	-	1.00	0.47	0.50	-0.30	0.43	-0.35
4. RAN: Objects	-	-	-	1.00	0.69	-0.31	0.63	-0.30
5. RAN: Letters	-	-	-	-	1.00	-0.22	0.64	-0.32
6. Digit Span Backwards Task	-	-	-	-	-	1.00	-0.18*	0.23
7. Letter-digit Substitution Task	-	-	-	-	-	-	1.00	-0.49
8. Raven's Colored Matrices Test	-	-	-	-	-	-	-	1.00

Note. *p < .05; all other correlations are p < .01.

We can see that all variables are statistically significantly correlated. The lowest overall correlation, although still statistically significant, was between the variables Digit Span Backwards Test and Letter-digit Substitution Task. Especially relevant to this study is the high correlation between word reading and pseudoword reading, indicating a possible single construct. Thus, we next present correlations between word reading and pseudoword reading for each Grade separately. In Grade 2, the correlation was r = .91, in Grade 3 r =89, in Grade 4 r = 78, and in Grade 5 r = 79. Although

there is not a perfect trend, it is evident that this relationship is significantly smaller in Grades 4 and 5 than in Grades 2 and 3. Also, as seen from the correlation table, the predictor variables were not highly correlated, thus allowing us to create regression models. The variance inflation factor (VIF) values were in the range of 1 (phoneme deletion task) to 2.9 (RAN: Objects). Values higher than 5 are the cause for concern in regression models (Menard, 2002). Regardless of the high correlation of outcome measures, we performed two regression analyses.

Tables 3 and 4 present stepwise regression models for predicting word reading and pseudoword reading. We only presented a final, statistically significant, model. Omega squared was used as a measure of an effect size of individual predictors. The criteria for interpreting the ω^2 effect sizes are as follows: .01 indicates a small effect, .06 denotes a medium effect, and .14 suggests a large effect, according to Cohen (1988).

Table 3. A Stepwise Multiple Regression Predicting Word- Reading

Variable	B	SEB	β	t	p	ω^2
Phoneme deletion task	-0.12	0.02	-.31	-5.25	< .01	.068
RAN: Letters	-0.70	0.14	-34	-4.95	< .01	.066
Digit Span Backwards	4.55	1.26	.19	3.60	< .01	.034
Letter-digit substitution	-0.01	0.01	-.23	-3.48	< .01	.030

Note. $R^2 = .64$ (unadjusted); $R^2 = .63$ (adjusted).

As can be seen from Table 3, the most significant predictors of word-reading were Phoneme deletion task, followed by RAN: Letters, Letter-digit substitution, and Digit span backwards tasks.

Table 4. A Stepwise Multiple Regression Predicting Pseudoword Reading

Variable	B	SEB	β	t	p	ω^2
Phoneme deletion task	-0.07	0.01	-.31	-5.23	< .01	.069
RAN: Letters	-0.55	0.08	-43	-6.35	< .01	.099
Digit Span Backwards	1.98	0.78	.13	2.54	< .05	.018
Letter-digit substitution	-0.01	0.01	-.15	-2.35	< .05	.017

Note. $R^2 = .641$ (unadjusted); $R^2 = 631$ (adjusted). We put three decimal places to indicate that models were not exactly the same.

In Table 4, we can see that the best predictors of pseudoword reading were RAN: Letters, followed by Phoneme deletion task, Letter-digit substitution, and Digit Span Backwards task.

The model for word reading was highly statistically significant ($F(4, 152) = 65.7$; $p < .001$) and it explained around 64% of the variance in the scores. The model for pseudoword reading was virtually the same in size ($F(4, 152) = 65.9$; $p < .001$), and both shared the same statistically significant predictors. In addition, the amount explained variance was virtually the same. We mentioned above that the correlation between two decoding measures was high ($r = .91$) and we expected to find similar, but not virtually the same models. The main differences between the models were in the individual effect size of predictors contributing to decoding.

Discussion

The objective of this study was to evaluate the influence of various factors on decoding skills. We investigated the effects of phonological awareness, rapid automatized naming of letters and objects, working memory, processing speed, and general intellectual abilities on decoding abilities, as assessed through word reading and pseudoword reading tasks. Our statistical models yielded highly significant results, explaining approximately 64% of the variance in the scores. Notably, we confirmed that phonological awareness and RAN: letters had the most substantial impact on both word reading and pseudoword reading. In addition, processing speed and working memory were significant predictors in both models. The previous model of decoding skills in Bosnian explained around 40% of the variance for word reading and even less for pseudoword reading (Memisevic, Dedic, Biscevic, et al., 2022). According to that model, significant factors for word reading are phonological awareness and RAN: Letters, while for pseudoword reading, besides these two factors, there was a significant effect of processing speed. In that previous study, working memory did not significantly affect decoding skills. A probable explanation for these different findings lies in the working memory task used; one task is relevant for decoding, while the other is not. In this study, we used a Digit Backwards Span task, while in the previous study, the authors used Corsi Block-Tapping backward test. This finding further confirms Baddeley (2000) notion of two working memory subsystems: visuospatial and phonological. Research on these two working memory assessments has suggested that the Corsi Block-Tapping backward test primarily depends on processing within the slave systems of working memory. Conversely, the Digit Span backward test is more closely associated with the central executive component of working memory (Kessels et al., 2008). Like Baddelay, Kessels et al. (2008) also found evidence of two working memory factors: verbal and spatial. It seems that verbal working memory plays a significant role in decoding, contrary to spatial working memory, whose effect on decoding is much smaller. Educators need to be aware of the role working memory

plays in reading, as it has been shown that interventions aimed at working memory might help struggling readers improve their skills (Dahlin, 2011).

Phonological awareness and RAN: Letters were the strongest predictors of decoding skills in this study, a finding which seems to be universal across alphabetic languages, regardless of their orthography (Furnes & Samuelsson, 2011; Landerl et al., 2019). These two predictors were similar in their effect-size for word decoding, while the effect of RAN: Letters was somewhat higher for pseudoword reading. Phonological awareness is a complex skill that plays a crucial role in children's reading development (Goswami, 2000). In this study, we used a phoneme deletion task as a proxy for phonological awareness. This task is related to reading across languages (Newman et al., 2011). Given the strong association between phonological awareness and reading, many researchers have long wondered whether phonological awareness abilities can be enhanced and whether it will improve reading abilities. Since Bradley and Bryant (1983) found a causal link between phonological awareness and reading, interventions on phonological awareness have skyrocketed. It is clear that phonological awareness can be improved through various intervention programs and consequently improve children's reading abilities (Blachman, 2000). RAN tasks have also long been established as predictors of reading success. But what RAN exactly measures is a difficult question. Some authors regard it as a part of phonological processing (Wagner et al., 1993). On the other hand, it has been consistently shown that RAN contributes to reading independently from phonological processing and memory (Denckla & Cutting, 1999). In this study, we also found an independent contribution of RAN: Letters to decoding abilities. The correlation between phonological awareness and RAN: Letters was moderate in size (r = .50), sharing 25% of the common variance, indicating different constructs. Finally, processing speed also had a statistically significant effect on decoding skills, although small. Relationships between processing speed and reading have been established in other studies as well (Gerst et al., 2021; Leonard et al., 2011).

It is important to note that word reading and pseudoword reading had a high correlation, indicating that decoding words and pseudowords seems to be almost the same process in children in early grades. However, we could see some evidence of the lexicality effect, that is the increasing difference in reading words and pseudowords, from Grade 2 to Grade 5. There is a larger difference in reading words and pseudowords in higher grades. The greatest lexicality effect was observed between 3rd and 4th Grade.

Our findings suggest that phonological awareness plays a crucial role in decoding abilities, consistent with previous research. Also, we found the unique role of RAN as a predictor of reading, distinct from phonological processing and memory. Additionally, we found that processing speed, although a relatively small effect, also significantly impacts decoding skills. This adds to the growing body of evidence on the relationship between processing speed and reading. This information might be useful for educators and researchers alike, as it sheds light on the dynamics of reading development in the Bosnian language.

In terms of potential impact on reading research, our study contributes to the broader understanding of reading processes in languages with consistent orthographies, such as Bosnian. While much research has focused on languages with inconsistent orthographies like English, our work highlights the universality of certain cognitive and linguistic factors, such as phonological awareness and RAN, in predicting reading abilities across different linguistic contexts. This knowledge can inform the development of effective literacy interventions tailored to Bosnian-speaking children and potentially benefit reading education in similar languages with transparent orthographies.

Conclusion

In the context of the Bosnian language, our study highlighted the role of several key factors in predicting decoding abilities. Specifically, phonological awareness, rapid automatized naming of letters, working memory, and processing speed emerged as critical determinants of reading ability. Collectively, these factors accounted for a substantial 64% of the variance observed in both word reading and pseudoword reading performance among the participants. Additionally, our findings indicated that general intellectual abilities and rapid automatized naming of objects did not have a significant influence on decoding abilities within the Bosnian language. This underscores the language-specific nature of these predictors, emphasizing the unique dynamics at play in Bosnian reading development. These results carry practical implications for educators and intervention programs. Given the substantial contribution of phonological awareness and working memory to reading success, educators have valuable tools at their disposal for enhancing literacy outcomes among Bosnian-speaking students. By incorporating targeted interventions that focus on strengthening these foundational skills, educators can empower learners with the tools necessary to excel in reading within the Bosnian linguistic context.

Recommendations

The results of this study emphasize the significant importance of phonological awareness and RAN in the development of decoding skills in Bosnian-speaking students. It is crucial for educators to recognize the impact of working memory and processing speed on reading abilities. Given the strong associations found in this study, interventions targeting phonological awareness and working memory may hold promise in enhancing reading proficiency. Further research with a larger and more diverse sample is warranted to validate these findings across the population of early elementary school students in Bosnia. Additionally, future studies could benefit from employing multiple measures per construct to provide

a comprehensive assessment. These insights can inform the development of effective reading interventions tailored to the specific needs of Bosnian-speaking students.

Limitations

Several limitations of this study should be acknowledged. The first is a relatively small sample size, so the model might be sample-specific and could not generalize across the population of children in early elementary school grades. The study's design was cross-sectional; we examined children from Grade 2 to Grade 5. It would be informative to expand the grade range of children, enabling a fuller picture of developmental trends in reading. Although the measures we used are widely used in the field, we used only one measure per construct. Future studies should use more measures to capture the construct.

Ethics Statements

This study was approved by the Faculty of Educational Sciences, University of Sarajevo. Only children with written parental consent forms were included in the study.

Conflict of Interest

Authors declare no conflict of interest.

Authorship Contribution Statement

All authors of this manuscript have contributed equally to the conception, design, execution, and analysis of the research, as well as the drafting and revision of the manuscript. We have collectively and actively participated in every phase of this study, and we endorse the final content presented in the manuscript.

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