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Correlation of Cognitive and Linguistic Factors with Spoken Language Comprehension in Early Elementary Students

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Spoken language comprehension is essential for effective communication, as it allows individuals to participate in conversations, follow instructions, and engage in various social interactions. Children begin school with varying degrees of proficiency in spoken language comprehension. The aim of the present study was to examine the relationship between language comprehension and rapid automatized naming, phonological awareness, Raven's Colored Progressive Matrices Test, vocabulary, and working memory. In addition, we examined what are the best predictors of spoken language comprehension. To achieve these aims we employed a cross-sectional correlational research design. The participants in the present study consisted of 77 first and second-grade students (40 boys and 37 girls) who were assessed on several linguistic and cognitive variables. The results of this study revealed that the best predictors of spoken language comprehension were non-verbal intellectual functioning and vocabulary. Interestingly, phonological processing skills, rapid automatized naming, and working memory were not statistically significant predictors of language comprehension. However, working memory had an indirect effect on language comprehension mediated by non-verbal intellectual functioning. This research suggests that the most effective strategy to improve language comprehension skills should focus on vocabulary enhancement.

Key words: language comprehension, elementary school students, cognitive and linguistic processing

Introduction

Spoken language comprehension is a process in which a complex acoustic signal is converted into meaning. It is an activity that takes place rapidly in time, in which a listener, after hearing a series of acoustic events, must assign it an immediate interpretation (Marslen-Wilson & Tyler, 1980). Language comprehension is the ability to understand spoken language, mainly sentences, and passage-level oral language (Gough & Tunmer, 1986). According to this definition, language comprehension

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requires remembering words and phrases, parsing the sentence, holding and retrieving information, and relating text information to the listener's background knowledge (Kim, 2016). Emerging research suggests that language comprehension is a multifaceted ability that goes beyond understanding individual words and their various combinations. Rather, it relies on higher-order cognitive skills such as making inferences, theory of mind, and comprehension monitoring (Kim, 2016).

Language comprehension and language production are constituent parts of the language acquisition process. Most researchers agree that language comprehension begins earlier than language production (Benedict, 1979). Language comprehension relies more on recognition memory, which, in turn, is easier for the child than language production. However, there are theories postulating that producing and understanding language are interwoven processes (Pickering & Garrod, 2013) and that there could be asymmetries in the language acquisition process. Some authors have postulated that the language system consists of four separate language subsystems: listening comprehension, oral expression, reading comprehension, and written expression (Berninger & Abbott, 2010), although the latter two systems develop along the education/schooling process. Language comprehension can be viewed as the mental representation of the world (Hirsh-Pasek & Golinkoff, 1999). Although language comprehension comes naturally with development, children differ widely in this ability by the time they start school. Language comprehension can serve as a marker for neuropsychological processes that are crucial for the development of academic skills (Marchman et al., 2018).

Examining factors leading to better language comprehension is important as language comprehension is strongly related to academic outcomes in children. It can be regarded as one of the foundational skills that can impact children's overall academic success. The implications of children experiencing language-related difficulties and subsequently failing to complete their education are substantial and carry significant costs (Dickinson, 2011). However, the process of language comprehension is generally assumed instead of being specifically examined in the literature. Previous studies have identified certain demographic factors that influence language comprehension, including the socioeconomic status and gender of a child (Zambrana et al., 2012). These findings have shown that boys, on average, learn a language at a slower rate than girls, and children from high socio-economic backgrounds have better language abilities. Language comprehension is considered a key component in the development of reading comprehension, which is widely recognized as a critical academic skill during the early grades of elementary school (Stothard & Hulme, 1992).

According to the simple view of reading (SVR), reading comprehension comprises decoding skills and language comprehension (Hoover & Gough, 1990). Although this is one of the most widely examined models of reading, its validity is still questionable (Ripoll Salceda et al., 2014). However, it has been widely demonstrated that the two components of SVR can explain the bulk of variance in reading comprehension (Kendeou et al., 2013; Lonigan et al., 2018). Many studies have examined the predictors of decoding abilities, and factors related to this ability have been firmly established. One of the most widely studied factors in this context has been phonological awareness. Many studies have found that phonological awareness is strongly related to decoding abilities, regardless of orthography (Denton et al., 2000; Memisevic et al., 2019; Wawire & Kim, 2018). In addition to phonological awareness, another factor that has been firmly established to be related to decoding ability is the Rapid Automatized Naming (RAN) (Furnes & Samuelsson, 2011; Powell & Atkinson, 2021). With phonological awareness and RAN, numerous other factors have been associated with decoding skills, such as working memory (Nevo & Breznitz, 2011), intellectual functioning (Levy, 2011), and attention (Facoetti et al., 2010). Besides these cognitive and linguistic factors, it is also important to note some psychological factors, such as motivation, related to reading (Retelsdorf et al., 2011).

The predictors of language comprehension have been much less investigated than decoding abilities in relation to reading. The reason for this might lie in the fact that comprehension abilities are often regarded as the single comprehension system which underlies both written and oral language (Gernsbacher et al., 1990), and that predictors for reading comprehension are the same for spoken language comprehension. The existing research has mainly focused on prelinguistic predictors of later language comprehension. The results of these studies have shown that conventional gestures used early in life predicted later language comprehension (Watt et al., 2006). In addition, language comprehension abilities were investigated in children with various disabilities, such as hearing disability (Marschark & Wauters, 2008; Pisoni & Geers, 2000), cerebral palsy (Vaillant et al., 2020), and autism (Tesink et al., 2009). The results of these findings have generally stressed the central importance of language comprehension for educational interventions. However, regardless of its importance, there are only sporadic studies examining linguistic and cognitive predictors of language comprehension. The only exception is working memory, as many studies examined the relationship between working memory and language comprehension, which was significant in most studies (Daneman & Merikle, 1996; Pratt et al., 1989). Actually, according to the theory proposed by Daneman and Carpenter (1980), language comprehension is almost entirely a function of working memory; that is individual differences in language comprehension reflect individual differences in working memory capacity. Also, phonological skills were found to be correlated with language comprehension in children with cerebral palsy (Bishop et al., 1990). Some studies examined language comprehension abilities in a second language (Burgoyne et al., 2009). These findings with children learning a second language have shown that comprehension difficulties are related to lower levels of vocabulary knowledge. However, there are only a few attempts to create models explaining spoken language comprehension in terms of cognitive and linguistic predictors, and this area lags significantly behind the research on decoding abilities. One such study (Kim, 2016) examining predictors of language comprehension in a sample of first-grade children showed that language comprehension is directly predicted by working memory, grammatical knowledge, inference, and theory of mind and is indirectly predicted by attention, vocabulary, and comprehension monitoring. These results support a complex structure of language comprehension and indicate that this ability is dependent on both cognitive and linguistic factors.

Thus, in this study, we wanted to expand the knowledge base of the role of linguistic and cognitive predictors on spoken language comprehension. In particular, we examined some of the predictors that were found to be related to decoding abilities but were not examined as predictors of language comprehension, together with some of the predictors that were found to be related to language comprehension (e.g., working memory).

This study aims to address the following research questions:

1. What is the relationship between Language Comprehension and Rapid Automatized Naming, Phonological Awareness, Raven's Colored Progressive Matrices Test, Vocabulary, and Working Memory?
2. Which variables (Rapid Automatized Naming, Phonological Awareness, Raven's Colored Progressive Matrices Test, Vocabulary, Working Memory) have the greatest impact on Language Comprehension?

Based on these research questions we formulated the following hypotheses to guide our investigation:

Hypothesis 1: There is a statistically significant correlation between Language Comprehension and Rapid Automatized Naming, Phonological Awareness, Raven's Colored Progressive Matrices Test, Vocabulary, and Working Memory.

Hypothesis 2: Cognitive variables (Raven's Colored Progressive Matrices, Vocabulary, and Working Memory) will have a more significant impact on Language Comprehension than linguistic variables (Phonological Awareness and Rapid Automatized Naming).

Method

Procedure

In this study, we employed a cross-sectional correlational research design. After selecting a target school, we provided teachers with consent forms for the children's parents. We delivered 100 forms in total and received 77 signed consent forms. The order of testing was the same for all children. Children were tested individually, in the morning hours, in the classrooms that were available at the school. This study was approved by the Canton Sarajevo Ministry of Education and the Faculty of Educational Sciences at the University of Sarajevo. Only children whose parents signed the consent forms were included in the testing.

Participants

The sample for this study consisted of 77 children attending the first and second grade of elementary school. (40 boys, 37 girls; mean age = 6.9 years, *SD* = 0.6 years; 41 first-grade children and 36 second-grade children). All of the children spoke Bosnian as their first language. The elementary school from which the children were recruited was conveniently selected for this study, but there is no reason to believe that it differs in any systematic way (school's demographic characteristics, curriculum, and language education practices) from other schools in the area in terms of the characteristics of the student body or the quality of the educational program. The decision to use convenience sampling and select the school conveniently was made in light of practical considerations, given the time and resource constraints associated with conducting research in educational settings.

The teachers reported, based on information extracted from the educational records of the children, that none of the children had any developmental disability or neurological condition.

Measures

As an outcome measure for this study, we created a Test of Language Comprehension, as there is no validated test available in the Bosnian language. In this experimental task, children listened to the audio story presented via computer. The story consisted of 20 sentences about a children's visit to the zoo. After they heard the story, children were asked ten questions regarding their understanding of the text. Five questions were literal (answers were contained in the story), and five were inferential questions (answers were not contained in the story but could be inferred). The possible range of scores on this test was from 0 to10.

As the explanatory variables in this study, we used:

1. *Rapid Automatized Naming of Objects* (RAN: Objects). This task comprises five stimulus items (hand, book, dog, star, and chair) that are randomly repeated ten times in an array of five rows for a total of 50 stimulus items (Wolf & Denckla, 2005). Time to name all the items was used as a measure of RAN: Objects. According to the RAN manual, the test-retest reliability for the RAN: Objects was .84 and interscorer reliability was .99. (Wolf & Denckla, 2005). We used RAN: Objects as it is a less automatized category than letters, numbers, and colors.

2. *Phonological Awareness Task* (Memisevic et al., 2022). In this task, children were shown a list of 16 objects and were asked to name the objects without the first sound. Three demonstration items were given prior to the task. In the demonstration, children were shown three pictures: a dog ("pas" in Bosnian), a trumpet ("truba" in Bosnian), and a book ("knjiga" in Bosnian) and told they need to name them without the first phoneme ("as" instead of "pas," "ruba" instead of "truba," and "njiga" instead of "knjiga"). All children understood the task. Time to correctly name the objects was used as a measure of phonological processing skill. Many previous studies have established the importance of phonological awareness in reading across languages (McBride-Chang & Kail, 2002). This task was also the best predictor of reading speed in a study regarding decoding abilities in Bosnian language (Memisevic et al., 2022).

3. *Raven's Colored Progressive Matrices Test* (RCPM) (Raven, 1986). This is one of the most widely used tests for non-verbal components of general intelligence. It is regarded as the culture-free measure of intellectual functioning (Cotton et al., 2005) and has a great potential for nonbiased assessment of nonverbal intelligence (Valencia, 1984). The test has good validity and reliability indices (Kazem et al., 2007). The RCPM consists of 36 items organized in three sets. Items in a set increase in difficulty, requiring greater cognitive skills in order to solve the problem.

4. *Vocabulary*. To measure receptive vocabulary, an experimental test was developed that was similar to the widely used Peabody Picture Vocabulary Test (PPVT) (Dunn & Dunn, 1997). The PPVT test has very good psychometric properties with internal consistency ranging from .92 to .98, and test-retest reliability ranging from .91 to .94. Due to the lack of a psychometrically validated test for measuring this construct in Bosnian, the experimental task was designed based on the PPVT, which ensured good content validity. In this test, children were told to pick a picture that best describes the term spoken by the examiner. As in the original version, there was one target picture and three distractor pictures on each page. There were total of 75 target pictures, and potential scores ranged from 0 to 75.

5. *Working Memory*. As a measure of working memory, we used a digit span backward test. This is a commonly used test to assess working memory capacity (Hilbert et al., 2015). In this test, children were asked to repeat a series of digits backward. Each level (2, 3, 4, 5, 6 digits) has two trials, and the task ends when children make two consecutive errors at a given level. Higher scores indicate better performance. This test is often part of comprehensive neuropsychological assessment batteries, including Wechsler Intelligence Scales for Children (Wechsler, 2003).

Statistical Analysis

We first presented descriptive results for all variables (means and standard deviations).

After that, we calculated the Pearson's correlation coefficients among the variables. We next examined the effects of the five explanatory variables on the language comprehension skills through the stepwise linear regression. We also examined the possible impact of working memory on language comprehension. Lastly, we compared the mean scores on Language Comprehension Test between boys and girls. An alpha level of .05 was used for all statistical tests. The statistical analysis was performed with a computer program SPSS v. 27 for Windows (IBM, 2020).

Results

Descriptive Data

We first present descriptive data for all variables in the study. These results are shown in Table 1.

Correlations between all the Variables in the Study

The first research question was to examine the relationship between all the variables in

Table 1 *Means and SD of Language Comprehension Task, RAN: Objects, Phonological Awareness, Raven Colored Matrices, Vocabulary, and Working Memory*

	Mean	SD
Language Comprehension	4.7	2.1
Vocabulary	65.6	3.2
RCPM	19.6	5.0
Phonological Awareness*	142.3	57.4
Working Memory	4.0	0.6
RAN: Objects*	68.6	18.5

Note. *time in seconds, lower time indicates better performance. RCPM – Raven's Colored Progressive Matrices Test.

Table 2 *Pearson's correlation coefficients between Language Comprehension, Vocabulary, RCPM, Phonological Awareness, Working Memory, and RAN: Objects*

	1	2	3	4	5	6
1. Language Comprehension	-					
2. Vocabulary	.41**	-				
3. RCPM	.41**	.57**	-			
4. Phonological Awareness	-.03	-.08	-.04	-		
5. Working Memory	.24*	.42**	.32**	-.19	-	
6. RAN: Objects	-.22	-.33**	-.19	.34**	-.44**	-

Note. *$p < .05$; **$p < .01$. All other correlations were not statistically significant. RCPM – Raven's Colored Progressive Matrices Test.

the study. These results are presented in Table 2.

As can be seen from Table 2, language comprehension was statistically correlated with Vocabulary, RCPM, and Working Memory. Language Comprehension was not statistically significantly correlated with Phonological Awareness and RAN: Objects. Thus, our first hypothesis of significant correlations between Language Comprehension and explaining variables was partially supported by these results. The strongest overall correlation was between RCPM and Vocabulary. Interestingly, Phonological Awareness was statistically correlated only with the measure of RAN: Objects, and with all other measures the correlation was not statistically significant.

Regression Models Predicting Language Comprehension

We next present a stepwise multiple regression model explaining the variance in Language comprehension scores with the five explanatory variables: Vocabulary, RCPM, Phonological Awareness, Working Memory, and RAN: Objects. The stepwise model is presented in Table 3. Only statistically significant predictors are shown in the model.

The model presented in Table 3 was statistically significant $F(2) = 10.1$, $p < .01$. It explained between 19% and 22% of the variance in language comprehension. However, only two predictors were statistically significant: RCPM and Vocabulary. Our second hypothesis was supported by the data given that cognitive variables had a stronger effect on language comprehension than linguistic variables. However, the hypothesis was not fully supported as working memory was not a statistically significant predictor of language comprehension in the model.

Working Memory and Language Comprehension

Given that working memory was widely reported to affect language comprehension but was not a significant predictor in this model (although statistically significantly correlated with language comprehension), we examined a potential indirect effect of working memory on language comprehension through fluid reasoning (as measured by Raven's Colored Progressive Matrices). The proposed mediation model demonstrated an excellent fit and provided insight into the role of working memory in language comprehension. We present the mediation model in Figure 1, where the standardized regression coefficients are shown above the arrows. Table 4 reports the fit indices for this model.

As can be seen from the model presented in Table 4. it is possible that working memory has an indirect effect on language comprehension through fluid reasoning as measured by the Raven Colored Progressive Matrices task. The indices assessed to evaluate the model's fit were all satisfactory, indicating that the model fit the data well. Specifically, the model was deemed acceptable based on commonly used criteria, with a Comparative Fit Index (CFI) value greater than 0.95 and a Root Mean Square Error of Approximation (RMSEA) value less than 0.05 (Hu & Bentler, 1995).

Table 3 *A stepwise multiple regression for predicting language comprehension*

Predictors	B	SEB	*β*	*t*	*p*
RCPM	.11	.05	.26	2.11	.041
Vocabulary	.17	.08	.26	2.08	.038

Note. $R^2 = .22$, $R^2_{(adj)} = .19$. RCPM – Raven's Colored Progressive Matrices Test.

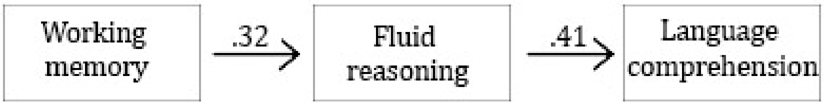

Figure 1 A model of an indirect effect of working memory on linguistic understanding.

Table 4 *Summary of fit of the model of an indirect effect of working memory on language comprehension*

Model	CFI	TLI	RMSEA	SRMR	ChiSquare
Working memory model	.99	0.97	0.048	0.035	1.2*

Note. df = 1; **p* = .28

Discussion

The present paper aimed to examine the effects of several cognitive and linguistic variables on spoken language comprehension in a sample of first and second-grade children. The statistically significant model with two predictors, RCPM and vocabulary, explained around 20% of the variance in language comprehension scores. These two measures, RCPM and vocabulary, were moderately correlated but had an independent and significant effect on language comprehension. These results indicate a potential two-factor structure of language comprehension, one depending on non-verbal intellectual functioning and the other on receptive vocabulary. Thus, the results reported here support the notion of an integrative model of language comprehension, one relying on higher-order cognitive skills (fluid reasoning) and the other relying on lexical capacity (vocabulary). Although a plethora of studies have examined the effects of fluid intelligence on reading comprehension (Johann et al., 2020), not many studies have examined the relation between fluid intelligence and spoken language comprehension. One such study has also found a significant correlation between RCPM and language comprehension (Goharpey et al., 2013). Furthermore, neuroanatomical investigations have revealed that brain regions associated with receptive language exhibit activity when individuals are engaged in a RCPM task, thus indicating potential shared neural networks between fluid intelligence and language comprehension (Prabhakaran, 1997).

Similarly, numerous studies have examined the relationship between vocabulary and reading comprehension (Ma & Lin, 2015), with few studies examining the relationship between vocabulary and spoken language comprehension. In a study by Adams et al. (1999), the authors found that language comprehension was most significantly related to vocabulary, followed by non-verbal ability and verbal fluency. It is important to note that in Adams et al.'s study, children were slightly younger (mean age = 58 months) than in our sample (mean age = 83 months). Vocabulary has been shown to be related to language comprehension when learning a second language (Atas, 2018).

A significant amount of variance (around 80%) in language comprehension scores was not accounted for by our model. Contrary to our expectations, the working memory task used in this study did not significantly affect spoken language comprehension. Although previous studies have found a strong effect of working memory on language comprehension (Daneman & Merikle, 1996), our study did not confirm these findings. There are several potential explanations for this finding. First, it is possible that the relationship between working memory and language comprehension depends upon a working memory modality and that the digit span backwards task taps some other form of working memory that is not crucial for language understanding. In a study by Adams et al. (1999), the authors found that language comprehension was associated with listening span and phonological memory and not with visuospatial memory. Secondly, as shown in the indirect effect model, it is possible that the working memory task indirectly affected language comprehension through non-verbal ability (RCPM task), as digit span and RCPM were significantly correlated. It is possible that working memory exerts its influence on language comprehension through general intellectual abilities, such as those tapped by fluid reasoning task. Finally, it is also possible that our study's findings were sample-specific and not generalizable across all first and second-grade children.

Another finding in our study was a lack of relationship between phonological awareness and language comprehension. Earlier studies have shown phonological awareness's critical role in learning to read (Ziegler & Goswami, 2005). Several studies examined the effects of spoken language on phonological awareness (Cheung et al., 2001; Cooper et al., 2002). These studies revealed a strong influence and possible relationship of general oral language and phonological awareness. It seems intuitively logical that the ability to discriminate and process phonemes should have an impact on spoken language comprehension. However, it might be possible that in our study there was not much variability on phonological awareness task and thus no relationship was found. Another potential explanation for the lack of relationship is the type of task that was used as a measure of phonological awareness. Phonological awareness is a complex ability and various tasks tap into this ability such as rhyme detection, blending and segmenting sounds, etc. It might be the case that the type of phonological awareness task we used is not related to language comprehension. On the other hand, there are studies that are in alignment with our findings. In a study by Bianco et al. (2010), the authors found that phonological training improved phonological awareness skills but not comprehension skills. Likewise, comprehension-skill training improved oral comprehension but not phonological awareness. These findings, along with ours, support the idea that these two constructs, phonological awareness and language comprehension are separable.

Rapid automatized naming tasks have been widely studied in relation to reading comprehension and the relationship between the two constructs has been firmly established (Hjetland et al., 2019; Li et al., 2009; Zhao et al., 2019). Studies have shown that RAN tasks are even better long-term predictors of reading than phonological awareness tasks (Furnes & Samuelsson, 2010). However, no studies, to the best of our knowledge, examined the relationship between RAN tasks and language comprehension. That is surprising given that RAN has long been established as an important factor for predicting reading skills and it taps both, linguistic domain and executive domain (Denckla & Cutting, 1999). Contrary to our expectations, we did not find a significant relationship between RAN and language comprehension task. Recent neuroimaging studies have shown that RAN tasks recruit a brain pathway involved in oral language production (Vander Stappen et al., 2020). This suggests that the role of rapid automatized naming may be more pertinent to language production tasks rather than language comprehension tasks, which may explain the lack of a significant relationship between rapid automatized naming and language comprehension in our study.

The results of this study have important implications for the practice. First, they can help in creating better models of spoken language comprehension. The results reported here do not support the idea that the comprehension system is the same for spoken and written language. Although they might share some components, the fact that phonological awareness and RAN did not have an effect on spoken language comprehension provides some evidence of separable components. We identified two significant factors related to spoken language comprehension – general intellectual functioning and vocabulary. It seems that cognitive variables (fluid intelligence, vocabulary) have a stronger effect on language comprehension than linguistic variables (phonological awareness and RAN). However, caution should be exercised when utilizing categorical determinants such as cognitive and linguistic variables, as there is no definitive demarcation regarding what falls exclusively within each category. For instance, the linguistic variables employed in this study may not solely capture linguistic abilities and might potentially overlap with cognitive variables.

The results of this study indicate the potential targets for future educational interventions, namely fluid intelligence and vocabulary. Although studies claiming to increase fluid intelligence have appeared in the scientific literature (Jaeggi et al., 2008), the evidence for such claims is, at best, inconclusive (Chooi & Thompson, 2012). Therefore, a much better target for improving spoken language comprehension is vocabulary. Attaining an initial vocabulary is a pivotal milestone that lays the foundation for subsequent language growth and development (Laubscher & Light, 2020). Numerous studies have found that vocabulary can be substantially enhanced through training. To date, studies have found that vocabulary can be increased with multi-tier instructional design (Cuticelli et al., 2015), storybook reading (Hickman et al., 2004), and assistive technologies (Pontikas et al., 2020).

It is certain that other factors besides non-verbal intelligence and vocabulary contribute to language comprehension. It has long been shown that language comprehension is dependent on complex psycholinguistic processing skills (Nelson, 1976). Identifying the cause of difficulty in language comprehension might suggest different treatment options. For example, if the difficulty in language comprehension is a consequence of underlying input timing-based speech reception deficit, then the efficient remediation strategy might be the temporal processing training coupled with exposure to acoustically modified speech in critical periods for speech and language development (Tallal et al., 1996). The benefits, as in many other treatment modalities, will be greater if the intervention starts earlier and lasts longer.

There are several limitations to this study worth mentioning. As we used only one measure (task) per construct, it is possible that we did not capture the full construct (domain), but only a segment of it. Thus, future studies should employ more measures per construct to examine whether the findings still hold. Similarly, as we used experimental tasks to measure language comprehension and vocabulary, further research is needed to establish the reliability and validity of these new experimental tasks. In future studies, it may be useful to incorporate a broader range of measures, including those that assess visual working memory, cognitive processing speed, verbal intelligence, and other relevant constructs. The sample size of students in this study was relatively small and consisted of participants from a single school, which may limit the generalizability of the findings to other populations. We did not collect some sociodemographic information that might be relevant to this study such as the socioeconomic status of the children. Thus, future studies need to employ larger and more diverse sample of children.

Conclusions

Non-verbal intellectual functioning and receptive vocabulary were significant predictors of spoken language comprehension. Working memory, phonological awareness, and rapid automatized naming were not statistically significant predictors of spoken language comprehension. These factors might have an indirect effect on spoken language comprehension, as shown in the case of working memory. The best target for improving spoken language comprehension in children is vocabulary, and there are numerous evidence-based strategies for enhancing vocabulary in children.

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