The Role of Phonological Processing and Language Skills in the Longitudinal Development of Reading Fluency [*]

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Abstract

The acquisition and development of reading fluency, consisting of three components: accuracy, automaticity, and prosody, require the utilization of various language and cognitive skills due to their complex and multifaceted nature. Phonological processing skills are frequently emphasized in the literature, with a clear connection established between phonological processing and fluent reading. Additionally, existing literature indicates that predictors of reading in alphabetic languages are largely universal, but their contributions vary based on the transparency of orthography. In this context, it is important to determine the impact of phonological processing and language-based components on the development of reading fluency, especially in transparent orthographies such as Turkish. This research aims to determine the role of phonological processing and receptive and expressive language mesured in the beginning of first grade in the longitudinal development of text reading fluency over three semesters in first and second grades. The study, conducted in a correlational design, involved 310 participants selected randomly from 45 schools representing lower, middle and upper socioeconomic levels in Ankara. The Passage Reading Test of the Literacy Assessment Battery was used to assess participants' reading fluency, while the Phonological Awareness subtests of the Test of Early Literacy, Object and Color Naming subtests of the Rapid Naming Test, and the verbal memory subscales of the Working Memory Scale were employed to evaluate the phonological processing skills. A measurement model analysis was conducted within the Structural Equation Models, followed by the addition of predictive variables to the longitudinal development model to identify their roles in the developmental

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process. Results indicated that participants' reading fluency performances increased in each semester throughout the study, and the phonological processing and expressive language skills in the beginning of first grade significantly contributed to participants' reading fluency development in first and second grade. These findings suggest that deficiencies in phonological processing and language development observed in the early stages can be considered significant indicators of reading difficulties.

Introduction

Reading, recognized as a fundamental tool for academic and independent learning, is described as a complex task influenced by various cognitive processes (Wong, Graham, Hoskyn, & Berman, 2008). The reading process involves the transformation of written units into corresponding sounds in accordance with decoding rules and alphabet knowledge (Abou-Elsaad, Ali, & El-Hamid, 2016). It is widely accepted that reading consists of three essential components: decoding, fluency, and comprehension (Gough & Tunmer, 1986; Klauda & Guthrie, 2008; Mercer & Pullen, 2005). Decoding encompasses the ability to read words by converting letters into sounds and blending sounds. Fluency involves automatically recognizing and reading words without decoding. Comprehension, on the other hand, refers to reaching an understanding of the meaning of the read words, sentences, and text. Fluency, as a key determinant of the quality of reading performance, facilitates reading with less effort and cognitive resources, directing these resources toward comprehension. Fluency comprises three components: accuracy, automaticity, and prosody. Accuracy involves correctly recognizing a word, automaticity refers to the rapid and immediate recognition of words, and prosody pertains to reading sentences with appropriate tone, emphasis, and timing (Wise et al., 2010). In this context, reading fluency is defined as the accurate reading of a text with proper prosody and at a conversational pace (Hudson, Lane, & Pullen, 2005; Hudson, Pullen, Lane, & Torgesen, 2008).

Reading fluency is closely linked to both linguistic and cognitive processes due to its complex and multifaceted nature (Schaars, Segers, & Verhoeven, 2019). Particularly in longitudinal studies, a causal and reciprocal connection is suggested between sensitivity to the phonological structure of words and progress in reading acquisition (Vandewalle, Boets, Ghesquiere, & Zink, 2012). Furthermore, in studies comparing the development of reading fluency in terms of speed and quality, the structural features of the language are highlighted as significant determinants. Research conducted in transparent orthographies such as Italian, Greek, and Finnish suggests that children learning to read in such orthography can transition from decoding to fluency in the first or second grade. In contrast, in more opaque orthographies like Danish and English, the acquisition of decoding lasts longer, and the transition to fluency occurs much later (Kuhn & Stahl, 2003; Puolakanaho et al., 2008). Research on decoding in different orthographies also suggests that cognitive skills necessary for reading may vary due to reasons such as a phoneme being usually pronounced the same way in transparent orthographies, while in opaque orthographies, a phoneme may have multiple pronunciations, and sometimes a single letter or letter group may have multiple pronunciations (Ziegler & Goswami, 2006). Additionally, in such comparisons, it is indicated that the power of cognitive skills in predicting reading performance may differ based on the orthography (Landerl et al., 2013). While reading fluency occurs faster in transparent orthographies, the development of reading fluency involves the use of skills that increase in difficulty linguistically and cognitively. Therefore, it is evident in the literature that the effects of phonological processing and language skills, which are claimed to contribute to reading fluency, may vary depending on the orthography.

Reading Fluency and Phonological Processing

Reading fluency requires the utilization of various language and cognitive skills. In the literature, phonological processing skills are frequently highlighted among the fundamental skills influencing the development of fluent reading. Phonological processing encompasses three different yet interconnected skills: phonological awareness, rapid naming, and verbal short-term memory. It involves the representation, manipulation, short-term storage, and recall of speech sounds (Lee, 2021; Wagner & Torgesen, 1987). The literature includes comprehensive discussions on whether phonological awareness, short-term memory, and rapid naming are partially different cognitive skills (Pennington, Cardoso- Martins, Green, & Lefly, 2001; Vandewalle et al., 2012). Specific deficiencies in phonological processing skills in children with reading difficulties are based on the early studies of Wagner and Torgesen (1987). In these early studies and numerous others supporting their findings, poor readers were found to experience difficulties in tasks requiring the processing of phonological information (Melby-Lervåg, Lyster, & Hulme, 2012; Vander Stappen & Van Reybroeck, 2022).

Reading Fluency and Phonological Awareness

Phonological awareness, one of the phonological processing skills, stands out as one of the most extensively studied skill related to the development of reading. In various studies conducted in different languages, phonological awareness has been indicated to play a key role in the success of reading fluency (Georgiou, Torppa, Manolitsis, Lyytinen, & Parrila, 2012; Suggate, Reese, Lenhard, & Schneider, 2014). Phonological awareness, in general, is described as the ability to recognize and manipulate the sound structure of oral language, being a part of the phonological component of language (Torgesen, 2000). Awareness of phonemes, one of the phonological awareness skills with increasing difficulty, is emphasized to be essential for developing phonological processing skills, including letter-sound correspondence, blending sounds, and reading words (Vellutino, Fletcher, Snowling, & Scanlon, 2004). Within the widely accepted framework, phonological awareness serves in the formation of representations related to the orthography during reading. These representations in memory enable automatic visual recognition and contribute to fluent reading by allowing the segmentation of words into phonemes based on specific forms related to the orthography or by segmenting whole words into phonemes (Cunningham, Perry, & Stanovich, 2001; Vander Stappen & Van Reybroeck, 2022). Thus, phonological awareness stands as one of the strongest predictors of reading fluency in different languages (Cunningham et al., 2001; Georgiou et al., 2012).

Reading Fluency and Rapid Naming

Rapid naming, another variable in phonological processing, is among the skills closely associated with reading abilities. Rapid naming is defined as the speed of retrieving the sound or name of visual stimuli from long-term memory and is often evaluated through tasks involving naming familiar items presented visually, such as objects, colors, letters, or numbers (Wagner & Torgesen, 1987). Rapid naming is a complex process that involves more fundamental cognitive abilities, showing diversity within itself (Bar-Kochva & Nevo, 2019). In the phonological processing process, rapid naming is suggested to represent the speed of retrieving phonological codes related to letters and words from long-term memory. While it shares a significant portion of its impact on reading-related skills with phonological awareness, there are studies that specifically demonstrate its independent contribution to the performance in reading fluency (Cutting & Denckla, 2001). Its contribution to reading processes is not limited to phonological processes; it also includes perceptual and linguistic processes. Studies have shown that the effects of rapid naming on reading occur both directly and indirectly through phonological awareness, visual processing, working memory, attention, and processing speed (Papadopoulos, Spanoudis, & Georgiou, 2016). Furthermore, it has been suggested that rapid naming assessed in the preschool may be a stronger predictor of the development of reading fluency in children with reading difficulties, especially in transparent orthographies, than phonological awareness and verbal short-term memory (Wimmer, Mayringer, & Landerl, 2000). Results obtained from a study that examined the predictive role of phonological processing skills in Turkish-speaking kindergartners on reading success using structural equation modeling also showed that children progressed over time in

phonological awareness, rapid naming, and phonological memory skills, and these skills made meaningful contributions to reading success at different levels (Ergül, Akoğlu, Akçamuş, Demir, Tülü, & Kudret, 2021; Ergül, Ökçün-Akçamuş, Akoğlu, Bahap Kudret, Kılıç Tülü, Demir, & Okşak, 2021). Indeed, in studies comparing the contributions of phonological awareness and rapid naming to reading, it has been found that phonological awareness is primarily associated with decoding, while rapid naming is strongly associated with reading fluency. In other words, it has been almost universally established that rapid naming contributes significantly more to reading fluency than decoding (Araújo, Reis, Petersson, & Faísca, 2015; Vander Stappen & Van Reybroeck, 2022).

Reading Fluency and Verbal Short-Term Memory

Verbal short-term memory, also named as phonological loop in the literature, is among the phonological processing skills and a strong predictor of reading. Verbal short-term memory involves storing the sound equivalents of letters in memory during reading and facilitating the creation of syllables and words by combining phonemes (Tobia & Marzocchi, 2014). Indeed, a study by McDougall, Hulme, Ellis, and Monk (1994) concluded that verbal short-term memory is closely related to phonological transformation during reading. However, there are also studies suggesting that verbal short-term memory is a relatively weak predictor of reading development in different orthographies (opaque vs. transparent) (Caravolas, Lervåg, Defior, Seidlová Málková, & Hulme, 2013). The results of these studies indicate the need for a more in-depth examination of the possible effects of verbal short-term memory on reading fluency, especially considering the structural features of language.

Reading Fluency and Language

Studies focusing on the nature of reading fluency suggest that language skills, in addition to phonological processing skills, can be effective in the acquisition and development of fluent reading (Goldenberg, 1991; Rose & Rouhani, 2012). There are studies in the literature generally showing a consistent relationship between reading and receptive and expressive language (Aguiar & Brady, 1991). Additionally, research results suggest a close relationship between expressive language development and various aspects of reading development (Chaney, 1998; Nation & Snowling, 2004). Longitudinal studies indicate that expressive language skills are generally strong predictors of future reading success (de Jong & van der Leij, 2003; Lyytinen et al., 2004). However, it is noteworthy that studies on this topic often focus on the relationship between reading comprehension and language skills. Nevertheless, studies indicating various limitations in language skills for children experiencing reading difficulties suggest that these limitations can be reflected in all reading skills (Papadimitriou & Vlachos, 2014). In Turkey, studies examining the relationship between language and reading fluency are quite limited. In a review study conducted by Güldenoğlu, Kargın, Gengeç, and Gürbüz (2019), it was emphasized that the development of language-based skills, including vocabulary, phonological awareness, morphological awareness, syntactic knowledge and skills, and oral language/listening comprehension, forms the foundations of reading in early childhood. In a study conducted by Kuzucu Örge, Babür, Börkan, and Haznedar (2021), relationships between reading fluency and linguistic and cognitive skills were examined in second-grade students. The researchers found that in poor readers, reading fluency were related to phonological awareness and rapid naming, while in good readers, reading fluency were related to phonological awareness and morphological awareness. Considering the results of existing research and the limitations of relevant studies in Turkish, it is beneficial to explore the possible relationships between reading fluency and language skills in-depth.

Current Study

In studies focusing on the structural features of Turkish, findings suggest that the orthographic transparency and suffix-based structure of the language enable Turkish-speaking students to learn word decoding faster and read more accurately in the first grade compared to English-speaking students (Durgunoğlu, 2017; Durgunoğlu & Öney, 1999; Öney & Durgunoğlu, 1997; Öney & Goldman, 1984). In line with these features of Turkish, the initial literacy instruction in Turkey follows the phonics-based sentence method, and the curriculum emphasizes the characteristics of this method (Ministry of National Education, 2019). According to the curriculum, the phonics-based sentence method begins with listening and progresses through stages such as feeling, recognizing, and distinguishing sounds, reading words, forming sentences from words, text reading, and independent reading. The initial literacy instruction includes five letter groups, and decoding skills are taught by sequentially introducing these letter groups, paving the way for fluent reading. Moreover, the program is implemented in conjunction with listening, speaking, and comprehension skills, highlighting its alignment with the characteristics of the Turkish language. Therefore, it is anticipated that the phonics-based sentence method may be particularly interactive with the phonological processing, especially the phonological awareness component. Indeed, a study by Kuzucu Örge et al. (2021) emphasized the effectiveness of Turkish's phonologically transparent orthography in early decoding acquisition. Additionally, it was suggested that the transparent orthography of Turkish could facilitate fluent reading by providing readers with the opportunity to learn decoding more quickly. However, while numerous studies in the literature explore the contribution of phonological processing components to reading skills in different orthographies, the number of studies conducted in Turkey is quite limited. These studies consistently demonstrate the relationship between phonological awareness (e.g., Babayiğit & Stainthorp, 2007; Karakelle, 2004; Öney & Durgunoğlu, 1997), rapid naming (e.g., Babayiğit & Stainthorp, 2010), verbal short-term memory (e.g., Babayiğit & Stainthorp, 2007), and reading success in Turkish-speaking children. In a study conducted by Seçkin Yılmaz and Baydık (2020), it was found that third-grade students with reading difficulties performed lower than their peers in phonological processing skills, including rapid naming, phonological memory, and phonological awareness. Another recent study examined the longitudinal development of phonological processing skills in Turkish-speaking children during the fall and spring semesters of kindergarten. The study found that children's performance in phonological awareness, rapid naming, and verbal short-term memory skills increased over time, and these skills contributed to reading skills at various levels (Ergül, Ökçün-Akçamuş, Akoğlu, Bahap Kudret vd., 2021). Furthermore, recent research highlights the importance of assessing reading fluency in the early identification of reading difficulties (Speece ve Ritchey, 2005), as early reading performance are associated with future reading comprehension and academic success (Kim, Petscher, Schatschneider, & Foorman, 2010). However, due to the limited number of studies focusing on the variables that may affect reading fluency and determining their relative effects, it is believed that identifying the longitudinal effects of these variables can contribute both to the literature and practice. The results of this study are expected to contribute to the practices of child development specialists, classroom teachers, special education teachers, and professionals involved in the identification and intervention of reading difficulties. In this context, the aim of this research is to determine the role of early phonological processing (phonological awareness, rapid object and color naming, verbal short-term memory) and receptive and expressive language skills in the longitudinal development of reading fluency in first and second grades. Based on this, the following questions were addressed:

1. How does the longitudinal development of participants' reading fluency progress over three semesters (fall and spring semesters of first grade and fall semester of second grade)?

2. To what extent do participants' early phonological processing (phonological awareness, rapid object and color naming, and verbal short-term memory), receptive language, and expressive language skills contribute to the longitudinal development of reading fluency in first and second grades?

Method

The research was conducted as part of a larger project aiming to determine the developmental profile of language, early literacy, and cognitive skills of Turkish-speaking children attending kindergarten and the predictive power of these skills on reading abilities. A longitudinal research design was employed to determine the longitudinal development of participants' reading fluency, while a correlational research design was used to determine the role of phonological processing, receptive language, and expressive language skills in the longitudinal development of reading fluency (Fraenkel, Wallen, & Hyun, 2012).

Participants

The research was carried out in 45 randomly selected schools representing lower, middle and upper socio-economic levels in Ankara, Turkey. Two classes were randomly selected from each school, and six children were randomly selected from each class to participate in the study. If selected children did not meet the inclusion criteria (being a native Turkish speaker, having no diagnosed disabilities, not experiencing school attendance problems, and gender distribution suitability), another child from the same class was randomly chosen to participate. Some of the children identified and included in the study while in kindergarten left the study over the next three years due to various reasons such as changing schools, moving to another city, or quitting the study. The analyses of the study were initiated with a total of 335 students, but the data of 25 children with extreme values were excluded from the dataset, and the analyses were conducted with 310 participants' data. Accordingly, 168 participants were female (54.2%), and 142 were male (45.8%). Eight participants were in the lower socio-economic level (2.6%), 78 in the lower-middle (25.2%), 115 in the middle (37.1%), 59 in the upper-middle (19.0%), and 27 in the upper socio-economic level (8.7%). The average age of the participants in the beginning of first grade was 78.54 months (SD=3.30). Additionally, the non-verbal cognitive competencies assessed with the TONI-3 Nonverbal Intelligence Test were found to be consistent with their ages.

Data Collection Instruments

To determine the participants' socio-economic characteristics, the Socio-Economic Status (SES) Index Parent Information Form was used. Non-verbal cognitive competencies were assessed using the TONI-3 Nonverbal Intelligence Test. Assessment of working memory performance in the beginnng of first grade were completed using the Working Memory Scale. Phonological awareness skills were assessed using the Test of Early Literacy, and rapid naming performance was evaluated using the Rapid Naming Test. The Turkish Early Language Development Test was used for the assessment of receptive and expressive language skills. Participants' reading fluency in the first and second grades were assessed using the Literacy Assessment Battery.

SES Index Parent Information Form (Ergül & Demir, 2017): This form was utilized to determine the socio-economic levels of participants' families. It includes 23 variables related to socio-economic status including parents' educational levels, occupations, income, home ownership, book ownership, and participation in cultural activities. The form defines five SES levels as lower, lower-middle, middle, upper-middle, and upper. Data were collected from parents of a total of 2411 children from kindergarten to fourth grade. The analyses confirmed the form's five-factor structure, explaining 57% of the variance in the SES index.

Working Memory Scale (WMS; Ergül, Yılmaz, & Demir, 2018): WMS aims to measure working memory performance of children aged between 60-125 months in two dimensions as verbal and visual memory. The verbal memory dimension includes Digit Recall, Word Recall, and Nonword Recall subscales to assess verbal short-term memory; and Backward Digit Recall and First Word Recall subscales to assess verbal working memory. The visual memory dimension includes Dot Matrix and Block Recall subscales to assess visual short-term memory; and Odd_One Out and Spatial Span subscales to assess visual working memory. Each subscale consists of increasing numbers of sequences

with two trials in each. If the child succeeds in at least one trial for each sequence, the next sequence is introduced. If the child fails in both attempts, the subscale is terminated. One point is awarded for each correctly repeated/marked sequence. Standard scores are provided for verbal memory, visual memory, and working memory, and children's performances can be categorized as very low, low, moderate, high, or very high based on these scores and age. Furthermore, verbal/visual short-term memory and verbal/visual working memory scores can be obtained, and the alignment of these scores with age can be assessed. In the validity study of the scale, it was found that factor loading values of the scale items ranged between .49 and .93, item total correlation values ranged between .21 and .60, item discriminant validity varied between .32 and .82, and criterion validity for subscales ranged between .62 and .94. In the reliability analyses, the internal consistency coefficients of the subscales were between .74 and .99, and test-retest correlation values ranged between .59 and .83. In this study, verbal short-term memory as a component of phonological processing was evaluated using the verbal short-term memory subscales of the WMS.

TONI-3 Nonverbal Intelligence Test (Bildiren & Korkmaz, 2018): TONI-3, developed by Brown et al. (1997) and adapted to Turkish by Bildiren and Korkmaz (2018), aims to measure the nonverbal cognitive competence of individuals aged between 6-89. It includes two parallel forms, A and B, each containing 45 items ranked by difficulty. Each form of the test includes six possible answer choices. A dichotomous scoring is applied with "1" point for each correct answer and "0" points for each incorrect answer. The test administration is terminated after three incorrect answers within five consecutive items, and the test takes approximately 15-20 minutes to complete. For the Turkish version of the test, the reliability coefficient for the A form ranges from .86 to .95, for the B form it ranges from .90 to .93, and the parallel form reliability coefficient is .80. The test-retest reliability coefficient for the A form is .65, and for the B form, it is .70. Criterion-related validity was established through the Raven Standard Progressive Matrices Test, revealing correlations of .79 for the A form and .82 for the B form. Other criterion-related validity correlations include .52 between academic achievement and TONI-3 A form, .49 between academic achievement and TONI-3 B form, .31 between the Wechsler Children's Intelligence Scale, Block Design subtest and TONI-3 A form, .38 between Block Design and TONI-3 B form, .47 between Similarities and TONI-3 A form, and .57 between Similarities and TONI-3 B form (Korkmaz, Bildiren, Demiral, & Çulha, 2018). In this study, participants' nonverbal cognitive competencies were evaluated using the B form.

Test of Early Language Development (TELD; Güven & Topbaş, 2014): The test, adapted into Turkish by Güven and Topbaş (2014), aims to measure the receptive and expressive language skills of children aged 2–7. The test comprises two subtests: Receptive Language and Expressive Language, with a total of 76 items measuring semantics, morphosyntactic knowledge, and syntax. Regarding the reliability of the Receptive Language subtest, test-retest reliability was found to be .96, inter-rater reliability was .99, and internal consistency coefficient was .94. The validity data indicated a correlation between parallel forms ranging from .64 to .96 and a correlation between the total test score and item scores ranging from .87 to .91. Similarly, for the Expressive Language subtest, test-retest reliability was .93, inter-rater reliability was .99, and the internal consistency coefficient was .92. The validity data showed a correlation between parallel forms ranging from .60 to .97 and a correlation between the total test score and item scores ranging from .87 to .91. Standard scores for receptive language, expressive language, and overall language development are obtained from the test. In this study, both receptive and expressive language scores of the participants were used in the analysis.

Test of Early Literacy (TEL; Kargın, Ergül, Büyüköztürk, & Güldenoğlu, 2015): TEL aims to assess early literacy skills of children attending kindergarten and identify those at risk due to poor performance in early literacy. It consists of 102 items in seven domains, including Vocabulary in Receptive Language, Vocabulary in Expressive Language, Category Naming, Function Knowledge, Letter Knowledge, Phonological Awareness, and Listening Comprehension. TEL's validity ve reliability was investigated in 403 children aged 5-6 attending kindergarten. The validity studies demonstrated high content and structural validity, with factor loading values ranging from .33 to .93. Reliability analyses showed an internal consistency coefficient of .94 for the entire test, ranging between .65 and .90 for the subtests, and test-retest correlation coefficients between .56 and .89. In this study, only the Phonological Awareness subtests, including Rhyme Awareness, Matching Initial Sound, Matching Ending Sound, Word Segmentation, Syllable Segmentation, Syllable Blending, Initial Sound Deletion, and Ending Sound Deletion, were used to assess children's phonological awareness skills.

Rapid Naming Test (RNT; Ergül & Demir, 2018): RNT developed by Ergül & Demir (2018) and the test aims to assess rapid naming skills of children aged 60-125 months from kindergarten to the fourth grade. It assesses how fast children retrieve and name phonological representations of familiar objects, colors, letters, and digits stored in their long-term memory. It consists of four subtests, including Object, Color, Letter, and Digit Naming. In each subtest five familiar items (visuals of color, object, letter, or digit) are presented in a mixed and repeated manner. The total naming time in seconds for each subtest is considered as the performance score. During assessment, the performance scores of children who make more than six naming errors in any subtest are not taken into account. The validity and reliability studies of the RNT were conducted by Ergül and Demir (2017), establishing norms for six-month age intervals between 60 and 125 months. Exploratory and confirmatory factor analyses were conducted for the structural validity of the RNT, revealing that the subtests explained a variance of 67.53% together and under a single factor. The test was also found to have discriminant validity according to grade levels. Test-retest coefficients ranged from .83 to .95. In this study, only the Object and Color Naming subtests of the RNT were administered, considering that participants were not yet familiar enough with letters and numbers in the beginning of first grade.

Literacy Assessment Battery (LAB; Ergül, Ökçün-Akçamuş, Akoğlu, Kılıç-Tülü, & Demir, 2021): Developed to assess the reading, reading comprehension, and writing skills of children from the first to the fourth grade, LAB consists of a total of 10 tests, including four tests related to reading, three related to comprehension, and three related to writing. The tests were designed with consideration for the structural features of Turkish and have parallel A and B forms. Each test is administered individually. Validity and reliability studies indicated that LAB comprises three factors: reading, comprehension, and writing. Significant pathways were found between the tests and the relevant factors. The fit indices of the three-dimensional structure, consisting of reading, writing, and comprehension, were found to be high. In terms of discriminant validity, there were significant differences between lower and upper groups in all tests, and effect sizes (eta-squared) indicated high discriminant validity with values ranging from .53 to .71. Regarding criterion validity, scores obtained from LAB were significantly correlated with phonological awareness, working memory, rapid naming, language, and vocabulary at levels between .10 and .44 (*p*<.01). Cronbach's alpha internal consistency coefficients for LAB ranged from .67 to .85, test-retest correlation coefficients ranged from .86 to .96, and correlation coefficients for the equivalence of A and B forms of all tests ranged from .82 to .96. Cut-off scores and intervals for each grade level and semester within LAB were determined to assess performance as "very low, low, moderate, high, and very high." In this study, the Passage Reading Test was used to assess the reading fluency of the participants.

Passage Reading Test: This test is used to determine children's passage reading fluency. The number of correct words read in one minute in grade-level narrative and informative passages is determined. It has parallel A and B forms, and for each grade level, one narrative and one informative passage are used for assessment. The font size varies according to the grade level. For first and second grades, 18-point the TTKB Basic Uppercase Font is used while for third and fourth grades, a 14-point form is used. In the test, the performance score is the average of the correct words read in one minute in a narrative and a informative passage. In this study, only the scores obtained from narrative passages were used.

Data Collection Process

In this research, ethical committee approval was obtained initially, followed by obtaining written consent from parents indicating their permission for their children to participate in the research. As stated in the written consent forms, participation in the study was based on the willingness of both parents and children, and the right to withdraw from the study was reserved.

Assessments of participants' non-verbal cognitive abilities, receptive and expressive language, working memory, phonological awareness, and rapid naming skills were completed in the beginning of first grade. Participants' passage reading fluency performances were individually assessed using LAB 's Passage Reading Test in the fall (from November 15th to December 30th) and spring (from April 15th to May 30th) semesters of first grade and the fall semester of second grade (from November 15th to December 30th). This longitudinal assessment allowed tracking participants' passage reading fluency from the beginning of first grade to the spring semester of second grade. The assessments were carried out individually for each participant by research assisstants who were master's and doctoral students with training on the administration of the tests. All assessments were conducted in a quiet room at school, totaling two sessions, with each session lasting an average of 25 minutes.

Data Analysis

In this study, data from 335 students were analyzed. Firstly, preliminary analyses were conducted to determine whether the assumptions of planned analyses were met. In order to do this, data were initially examined for missing values and outliers. The missing data rate for all variables was below 1%, and the Little's MCAR test confirmed that the missing data was completely random ($p>.05$). Next, the dataset was examined for univariate outliers, and upon removing the data of 16 students with outliers, 319 student data remained. For multivariate outliers, nine students creating multivariate outliers were excluded from the analysis, resulting in a dataset with 310 students' data for analysis. The assumptions of the dataset for analysis were examined, including normal distribution, multicollinearity, multivariate normality, and absence of linearity problems.

In the research, first, a measurement model analysis was conducted within the framework of Structural Equation Modeling (SEM). SEM is a statistical method that allows the examination of latent structures through observed variables, encompassing various statistical techniques (Kline, 2011). In this context, a four-dimensional structure for phonological processing (phonological awareness, rapid naming of objects and colors, verbal short-term memory) was tested. In the second stage, a longitudinal latent variable model was tested, and unconditional models (Model 0 and Model I-quadratic) were defined. Models 0 (linear) and Model I (quadratic) were evaluated to determine the shape and speed of change over time. Then, predictor variables were added to the longitudinal development model to identify their roles in the developmental process. In a well-fitting model, a conditional model was created to determine the extent to which the variability in the variances of developmental factors (intercept, slope, quadratic) was explained by phonological processing, receptive, and expressive language scores measured in the beginning of first grade. This model was denoted as Model II. The fit of the SEM models was evaluated based on the chi-square divided by degrees of freedom ($X2/df$), root

mean square error of approximation (RMSEA), goodness-of-fit index (GFI), and comparative fit index (CFI) values (Kline, 2011). SPSS and MPLUS 8 (Muthén & Muthén, 1998-2017) software packages were used for data analysis, and a significance level of .05 was adopted.

Findings

As part of the analyses, descriptive statistics for the variables of phonological processing, language, and reading fluency were initially examined. The results are presented in Table 1.

Table 1. Descriptive Statistics for Research Variables

Variables	N	Mean	Median	Mode	SD	Skewness	Kurtosis
Phonological awareness	310	17.97	17.00	17.00	4.77	.313	.724
Rapid naming (Object)	310	61.04	59.00	53.00	13.37	.744	.514
Rapid naming (Color)	309	68.04	65.00	60.00	16.85	.593	.053
Verbal short-term memory	310	2.95	3.00	2.00	1.24	.839	.739
Receptive language	310	31.05	31.50	34.00	3.10	-.499	-.490
Expressive language	310	33.19	33.00	32.00	2.75	-.388	.017
Reading fluency (Fall of 1st grade)	310	14.07	12.50	14.00	9.52	1.391	2.648
Reading fluency (Spring of 1st grade)	310	48.50	45.00	39.00*	18.37	.533	-.003
Reading fluency (Fall of 2nd grade)	310	66.77	67.00	58.00*	20.65	-.164	.004

*There are multiple modes, and the lowest value is presented in the table.

As seen in Table 1, the means, medians, and modes for all variables were quite close to each other. The average reading fluency scores for students were 14.07 (SD: 9.52) in the fall of first grade, 48.50 (SD: 18.37) in the spring of first grade, and 66.77 (SD: 20.65) in the fall of second grade. Students' reading fluency scores increased over the semesters, but also standard deviations increased, indicating a growing heterogeneity within the group. Skewness coefficients for all variables ranged from -.164 to 1.391, and kurtosis coefficients ranged from -.003 to .739. Only for the variable of reading fluency in the fall of first grade, the kurtosis coefficient exceeded the acceptable range with a value of 2.468. For this variable, the proximity of mean, median, and mode values, along with the histogram analysis, suggested that the distribution reflects the expected pattern (more students clustering towards lower scores). In addition, analyses were conducted to explore the relationships among reading fluency scores across three semesters. The results are presented in Table 2.

Table 2. Correlations Among Reading Fluency Scores Across Semesters

Variables	1	2	3
1. Reading fluency (Fall of 1st grade)	1		
2. Reading fluency (Spring of 1st grade)	.525*	1	
3. Reading fluency (Fall of 2nd grade)	.530*	.719*	1

N=310, *p<.01

As noted in Table 2, the highest correlation was between the reading fluency scores observed in the spring of first grade and the fall of second grade (r=.72), while the lowest correlation was between the reading fluency scores observed in the fall of first grade and the spring of first grade (r=.53).

Another analysis conducted in the study was the measurement model analysis of the four-dimensional structure (phonological awareness, rapid object and color naming, verbal short-term memory) for phonological processing using Structural Equation Modeling (SEM). The results indicated that the model fits the data very well (phonological processing, $\chi 2(6)=37.698$, p=.00, CFI=1.00, TLI=1.00, RMSEA=.00, 90% CI [.00, .11], SRMR=.02). All factor loadings in the models were statistically significant (λs ≥|.20|, p<.05). The results are summarized in Figure 1.
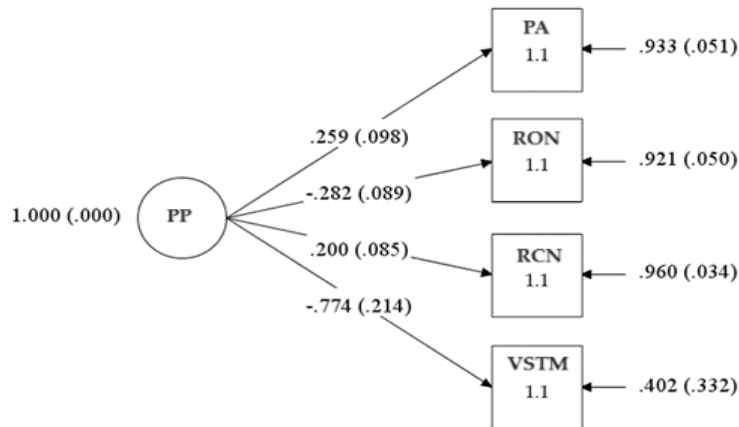

Figure 1. Measurement Model and Factor Loadings Tested for Phonological Processing (PP: Phonological Processing; PA: Phonological Awareness; RON: Rapid Object Naming; RCN: Rapid Color Naming; VSTM: Verbal Short-Term Memory)

Based on these findings, the results of the analyses conducted to answer the research questions are presented below in order.

Longitudinal Growth of Participants' Reading Fluency Across Three Semester

To examine the longitudinal development of reading fluency, different models were tested within the longitudinal structural model framework. The analysis of the first model revealed that the fit of the data to Model 0 (linear) was low: $\chi 2(3)=352.880$, p<.001, CFI=.69, TLI=.54, RMSEA=.042, 90% CI [.035, .048], SRMR=.204. The analysis of Model-1 (quadratic) showed that the fit of the data to the model was excellent: Model 1 (i s q): $\chi 2(3)=352.880$, p<.001, CFI=1.00, TLI=1.00, RMSEA=.000, 90% CI [.000, .010], SRMR=.01. The high fit of the quadratic model to the data indicated that the development was not linear but quadratic, meaning that the rate of development changed over time. The longitudinal growth curves of students' reading fluency across three semester (fall of 1st grade – spring of 1st grade – fall of 2nd grade) are presented in Figure 2.
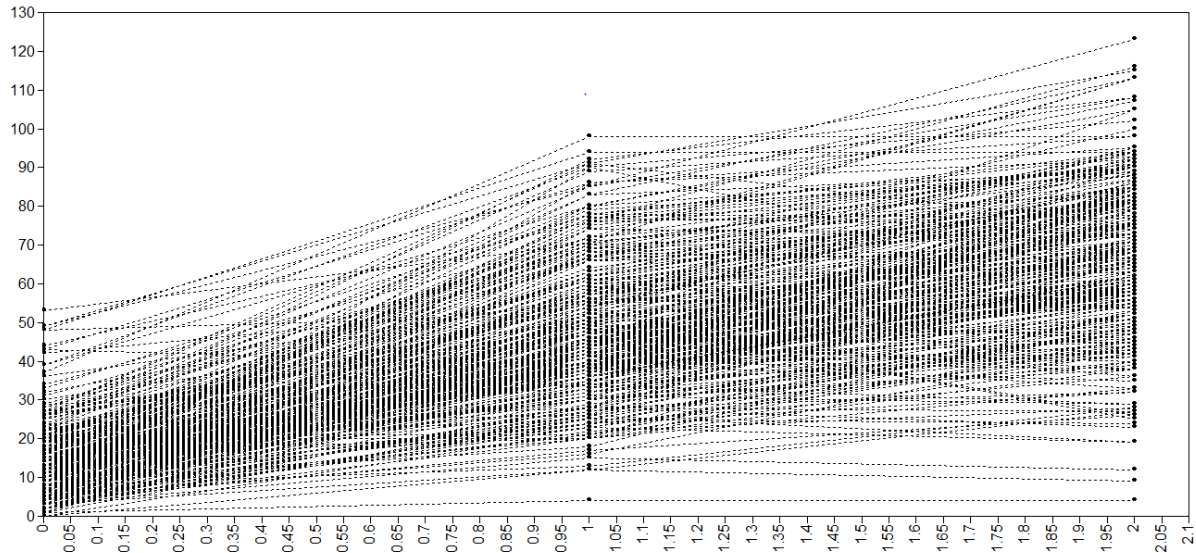
Figure 2. Longitudinal Growth Curves of Students' Reading Fluency Across Three Semester

In Model 1, the mean value of the intercept (i) parameter was 14.071 and significant ($p<.05$). This value represented the mean of reading fluency that children had in the beginning. The variance of the intercept parameter was 70.179 and statistically significant ($p<.05$). This value indicated that children's initial levels of reading fluency were not homogeneous, showing individual differences. The mean of the slope (s) parameter was 41.814 and significant ($p<.05$). Accordingly, children's reading fluency performance showed an average increase of 41.81 units from semester to semester. The variance of the slope parameter was 70.672 ($p<.05$), and it was statistically significant, indicating a significant difference among children in terms of changes in reading fluency performance over time. The mean of the quadratic growth factor was -7.764 and significant ($p<0.05$). Thus, the quadratic growth factor was significant for children, and its negative value suggested that the steepness of the common developmental curve for children decreased as the time progressed. In other words, the rate of development decreased over time.

Contribution of Phonological Processing and Language Skills to the Longitudinal Development of Reading Fluency

In the analyses conducted by adding predictor variables to Model-1 in the longitudinal development model, which perfectly fits the data, predictor variables were added, and the explanatory power of these variables on children's longitudinal development of reading fluency in three semesters was examined. The results showed that the fit of the data to the model was weak: $\chi 2(35)=724.322$, p<.001, CFI=.85, TLI=.75, RMSEA=.13, %90 CI [.11, .15], SRMR=.10. The visual representation of the predictive power of phonological processing and receptive and expressive language skills in the fall of first grade for the longitudinal development of reading fluency is presented in Figure 3.
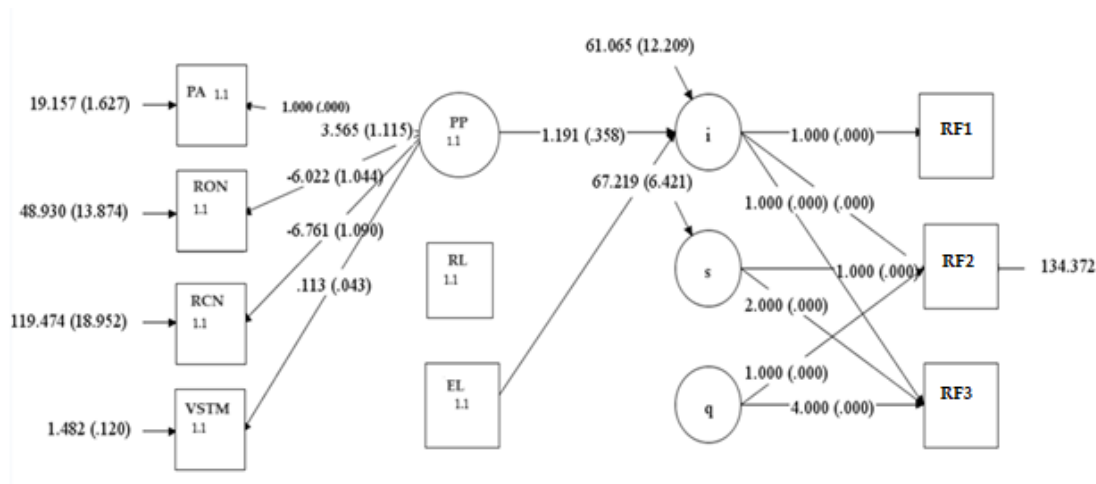
Figure 3. Predictive Power of Participants' Phonological Processing and Receptive and Expressive Language Skills in the Beginning of First Grade on the Longitudinal Development of Reading Fluency (PA: Phonological Awareness; RON: Rapid Object Naming; RCN: Rapid Color Naming; VSTM: Verbal Short-Term Memory; PP: Phonological Processing; RL Receptive Language; EL: Expressive Language; RF: Reading Fluency)

In Figure 3, only the paths that were statistically significant are shown. As can be seen in the figure, phonological processing and expressive language scores of children in the beginning of first grade had a significant impact on the intersection of children's longitudinal development of reading fluency. While expressive language was a significant predictor of children's longitudinal development (β = .459, p < .05), receptive language was not a significant predictor of reading fluency development (β = -.00, p > .05). The coefficients of the rapid object and color naming, comprising the phonological processing variable, were negative and significant (β=-6.02, p<.05; β=-6.761, p<.05, respectively). The negative coefficients indicated that as the naming speed decreased, there was an increase in reading fluency. Additionally, the coefficients of the phonological awareness and short term verbal memory (β=3.565, p<.05; β=.113, p<.05), as components of phonological processing, were positively significant.

Discussion, Conclusion, and Recommendations

The results of this study revealed that longitudinally assessed reading fluency skills of participants increased from first grade to second grade, indicating a continuous development. When examining the variables contributing to the development of reading fluency, the impact of phonological processing and expressive language scores assessed in the beginning of first grade was found to be significant.

While the observed increases in mean scores of the reading fluency skills across grade levels and semesters are not surprising, the results related to phonological processing and expressive language skills as predictors of fluency development are crucial to allow for a prediction of potential risks in the early stages of reading acquisition. Studies in different languages have emphasized the significance of the first grade in reading development due to the use of strategies based on visual analysis of words. Children performing well in the first grade are generally capable of recognizing words in the text accurately and rapidly, thereby developing oral reading fluency (Speece & Ricthey, 2005). Early studies examining the longitudinal development of reading fluency with growth curve models have demonstrated that this skill is a gradually developing complex ability (Bast & Reitsma, 1997).

Skills related to phonological processing, particularly phonological awareness, were found to be influential in the development of reading fluency. In some longitudinal studies, a causal and reciprocal connection between sensitivity to the phonological structure of words and progress in reading acquisition has been shown. It is noted that the relationship between phonological skills and

reading achievement is associated with reading proficiency (Vandewalle et al., 2012). In other words, existing reading proficiency can play a significant role in the development of phonological skills as well. In this study, it has been observed that phonological awareness skills have an impact on reading fluency. However, along with the acquisition of reading in the first grade, progress is also observed in more general skills based on the phonological system of language and phonological awareness skills. Furthermore, in the literature, it has been noted that phonological awareness skills tend to be more crucial in the early stages of reading development and have a stronger correlation with reading accuracy (Verhagen, Aarnoutse, & van Leeuwe, 2008). However, the result of this study has shown that phonological awareness was an effective variable in reading fluency in all three semesters, indicating that phonological awareness is not only effective in the early stages of reading acquisition but also generally contributes to the development of reading fluency. Additionally, previous studies indicate that the role of basic skills related to the phonological system of language in reading acquisition is influenced by the consistency of letter-sound correspondences in the orthography used (Sprenger-Charolles, Siegel, Béchennec, & Serniclaes, 2003). Generally, it is stated that phonological awareness skills contribute more strongly and for a more extended period to reading fluency in opaque orthographies (Vander Stappen & Van Reybroeck, 2022). In studies conducted in languages with more transparent orthographies (e.g., Finnish), it has been shown that phonological awareness plays a crucial role, especially in the early stages of reading, and contributes to reading accuracy and fluency (Torppa, Lyytinen, Erskine, Eklund, & Lyytinen, 2010). Similar results have been encountered in studies conducted in Turkish, which has a transparent orthography, revealing that early skills in kindergarten, such as "word segmentation," "syllable blending," "matching by initial sound" (Ergül, Ökçün-Akçamuş, Akoğlu, Kılıç-Tülü et al., 2021); "phoneme deletion"; "phoneme change" are among the strongest predictors of word reading fluency (Babayiğit & Stainthorp, 2011). However, studies examining the relationships between phonological awareness and reading fluency and development in the formal reading learning process in Turkish could not be found. In this context, it is essential to investigate the possible mutual relationship between phonological awareness and text reading fluency longitudinally and in-depth, considering the structural features of Turkish.

It has been found that another phonological processing variable, verbal short-term memory, also influences the development of reading fluency. Verbal short-term memory is a cognitive system involving processes of receiving, storing, and manipulating verbal input. Also referred to as phonological memory, this component encompasses the use of short-term memory for phonetically coded materials (Kibby, Lee, & Dyer, 2014). Given the direct association of the tasks employed in this study with verbal short-term memory, it is possible to suggest that the skills based on the phonological coding in the early stages of first grade is expected to correlate with later reading fluency. In literature, readers with lower verbal short-term memory capacity are noted to struggle with phonological processes such as blending phonemes to read words and segmenting words into phonemes necessary for efficient reading. Conversely, readers with higher verbal short-term memory capacity are reported to excel in cognitive processes requiring the use of resources like creating semantic associations, analysis, encoding information into memory, and retaining salient information to facilitate comprehension (Sesma, Mahone, Levine, Eason, & Cutting, 2009). In this context, it is conceivable that the participants' performance in decoding during the first months of first grade, as utilized in this research, reflects on the development of reading fluency. Indeed, previous findings suggest that the ability to store word patterns in memory depends on the intricate relationships between phonetic components and visual representations (letters) of words (Wimmer & Mayringer, 2002). Particularly in transparent orthographies, the increasing word decoding skills during reading instruction enhance the consistency of connections between letters, phonemes, and semantics, facilitating efficient storage and recall of written words from memory (Schaars et al., 2019). Consequently, children learn to store and retrieve written words efficiently from memory (Plaut, McClelland, Seidenberg, & Patterson, 1996). This process affects the specificity and quality of mental representations related to phonology, spelling, semantics, and their interactions, thereby facilitating progression to later stages of reading development (Perfetti, 2007). In Turkish literature, diverse results can be found on this subject. In a study by Özata

and Haznedar (2019), it was determined that second-grade students' word reading fluency and phonological memory skills were correlated, but regression analysis indicated that phonological memory did not contribute to reading fluency. It is considered that the assessment of reading fluency at the word level in this study could have an impact on these results. Similarly, in a study by Seçkin Yılmaz and Yaşaroğlu (2020), which investigated the performance of third-grade students with and without learning difficulties in reading comprehension, vocabulary, and verbal working memory, positive and moderate correlations were found between picture-word vocabulary, verbal short-term memory, and reading fluency in both groups. The findings of the current study align with those in the literature, demonstrating that the phoneme-grapheme relationships acquired in the first months of first grade by the participants interacted with other language components, leading to the appropriate encoding, storage, and recall of information in memory, and gradually progressing towards more advanced reading fluency skills.

The results have shown that rapid object and color naming, which were phonological processing variables, were also effective in the development of reading fluency. As the time for rapid naming decreased, there was an increase in reading fluency. In other words, an increase in naming speed corresponded to an increase in the number of crrect words read in one minute. Rapid naming represents the timing mechanism required for the formation and integration of written and phonological codes (Bar-Kochva & Nevo, 2019). Previous studies suggest that this process plays a role in recalling phonological codes, enabling the integration of familiar letter patterns as a result of naming various symbols, and thus, rapid naming performance may be an indicator of the ability to recognize letters (Puolakanaho et al., 2008; Vander Stappen & Van Reybroeck, 2022). Furthermore, prior findings has often indicated that phonological awareness is associated with decoding (Wagner et al., 1997). However, when it comes to reading fluency and comprehension skills, studies suggest that rapid naming is a stronger predictor compared to phonological awareness (Young & Greig Bowers, 1995). In this study, it was observed that rapid naming performance was a robust predictor of reading fluency development across three semesters. Longitudinal studies following the acquisition of reading skills in various languages suggest that the importance of phonological awareness and rapid naming performances differs over time depending on the reading skill examined, correlating with cognitive and linguistic dynamics of reading development (Vaessen & Blomert, 2010; Vander Stappen & Van Reybroeck, 2022). Particularly in studies conducted on opaque orthographies like English, it is mentioned that phonological awareness generally has a stronger contribution to reading accuracy, and this contribution lasts for a relatively longer period, while in transparent orthographies, it is relatively shorter (Babayiğit & Stainthorp, 2010; Holopainen, Koch, Hakkarainen, & Kofler, 2020; Moll et al., 2014). In a study conducted by Seçkin Yılmaz and Baydık (2020) comparing the language skills of children with and without reading difficulties, participants' rapid naming skills and other phonological processing skills were assessed. The results indicated that students experiencing difficulties in reading fluency exhibited lower performance in rapid naming, phonological awareness, and verbal short-term memory when compared to their peers without difficulties. Considering all results, the researchers suggested that children with better phonological processing skills usually exhibit higher performance in reading accuracy and fluency. However, it is worth noting that the implementation of the phonics-based sentence method in literacy instruction in Turkey is highly compatible with the transparent orthography of Turkish. Research has indicated that this method may provide an advantage in the development of reading fluency, as the transparency of Turkish orthography allows for faster coding of words, facilitating fluent reading (Kuzucu Örge et al., 2021). Therefore, in this study, it is suggested that the specific features of the Turkish orthography should not be overlooked when considering the contribution of increased rapid naming performance to the development of reading fluency.

The study highlights the role of expressive language development as a longitudinal predictor of reading fluency, while similar results were not obtained for receptive language. In the literature, varying results are reported regarding the impact and/or contribution of receptive and expressive language skills to reading processes. Specifically, expressive language skills are noted to be associated with reading skills. Longitudinal studies suggest that expressive language skills, in conjunction with processes such as phonological awareness, short-term memory, naming speed, and nonword repetition, constitute robust predictors of future reading (de Jong & van der Leij, 2003; Lyytinen et al., 2004; Nation & Snowling, 2004). However, in a study examining the predictors of early reading skills in English-speaking monolingual children, it was found that receptive language skills did not serve as a predictor, unlike phonological awareness and letter knowledge (Speece, Mills, Ritchey, & Hillman, 2003). The finding in this study showing that expressive language skills were among the variables predicting the development of reading fluency implies that beyond being aware of the meanings of words during reading, the ability to use these words helps readers benefit from contextual relationships, thus recognizing subsequent words more quickly and reading fluently. In the literature, it is noted that one of the clear indicators distinguishing good and poor readers is reading fluency. Poor readers are reported to read both slower and less accurately when encountering words they know and do not know, while good readers read equally fast and accurately in both cases (Lyytinen et al., 2004). However, some studies suggest that students' receptive vocabulary in first and second grades predicts decoding and reading fluency and accuracy at the end of the year and development curve in reading fluency and accuracy in connected text in the first grade (Lane et al., 2009). The differences in the results of prior studies underscore the need for a deeper investigation into which components of language have what kind of impact on the development of reading fluency. Therefore, it is beneficial to consider the results of this study in the context of these discussions.

When the results obtained from this study are considered together, it is evident that phonological awareness, verbal short term memory and rapid naming performances, and expressive language skills measured in the beginning of first grade were significant predictors of reading fluency development in first and second grades. Indeed, deficiencies in phonological processing are widely recognized as a fundamental cause of reading difficulties (Kibby et al., 2014; Sprugevica & Hoien, 2004). The findings of this study regarding the contribution of phonological processing skills to the development of reading fluency emphasize the importance of assessing these skills during the early stages of literacy acquisition, providing valuable findings for both clinical and practical fields in terms of early identification of reading difficulties.

Additionally, the results of the study indicate a need for a more in-depth investigation into potential linguistic variables and the structural features of the Turkish language that may affect reading fluency. The study is limited to data obtained from first and second grades. The results are important in terms of revealing the phonological processing and expressive language as predictors of reading fluency development in the same grade level and beyond. Understanding the potential effects of phonological processing and expressive language skills on reading fluency and as well as on other variables affected by reading fluency, such as reading comprehension, in subsequent grade levels can guide preventive interventions for reading difficulties.

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