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Direct and Indirect Effects Between First Literacy Errors, Visual Perception, and Phonological Awareness Variables

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Abstract: This research is a descriptive study in the survey model to determine the direct and indirect effects between visual perception, phonological awareness, and literacy errors. The design of the study is exploratory correlational design. 552 first-grade primary school students participated in the study. The data were collected using measurement tools named phonological awareness, visual perception, word-sentence writing/spelling, and reading errors. According to the findings, visual perception affects sentence writing/spelling both directly and through word-writing-reading errors. Visual perception affects reading errors both directly and through word-sentence writing errors. The results show that the development of prerequisite skills and reading are mediated by writing, writing/spelling are mediated by reading, and learning develops in a spiral manner. It can be said that children's reading-writing/spelling errors increase because they have difficulty in converting from sound to the letter, from letter to sound, and in synthesizing and analyzing according to their initial level of phonological awareness and visual perception development.

Keywords: literacy, spelling error, reading, perception, phonology.

Introduction

Literacy skill constitutes the framework and essence of science, technology, and education, which are the main triggers of social change. As a result of the 20th-century scientific developments, it is seen that early literacy views have gained weight in research on the acquisition of this skill (see. Commodari et al., 2020; Guldenoglu, Kargin and Ergul, 2016; Floyd, McGrew and Evans, 2008; Foorman and Liberman, 1989; Landerl et al., 2019; Pfost et al, 2019; Ouellette and Senechal, 2017; Schatschneider et al., 2004; Speece et al., 2004; Turna and Guldenoglu, 2019; Zhang and Lin, 2018). However, writing/spelling was less studied until the first quarter of the 21st century (Joshi, Wijekumar and Gillespie Rouse, 2022; Treiman, 2017). Some of the studies focused on the end of kindergarten and first grade of primary school when writing is learned (Kim et al, 2011). Other studies have examined the longitudinal relationships between literacy skills (Lerkkanen, 2003; Leppänen et al., 2009) and reading spelling errors (Desimoni, Scalisi and Orsolini, 2012).

During the decoding process, children may make errors in reading and writing. These errors may indicate language structures that are difficult to decode or proficiency in prerequisite skills. However, while investigating the relationships between reading skills and spelling/writing in the studies, either prerequisite skills were not taken into account or participants' prerequisite skills before first grade were measured. However, learning to read can increase phonological awareness (Scarborough et al., 1998), and the development of visual perception (Tsai, Wilson and Wu, 2008) can continue in the early years of primary school. These prerequisite skills may affect the decoding process. In addition to phonological awareness, visual coding is one of the most basic skills in learning to read and write. Because for visual coding, it is necessary to perceive, analyze and distinguish the properties of graphic symbols.

Literacy/Spelling

A strong relationship between reading and writing/spelling has been found in many studies (Caravolas, Hulme and Snowling, 2001; Juel, Griffith and Gough, 1986; Andersen et al., 2018). In literacy

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model development studies, the sources of reading and writing/spelling were identified. For example, both spelling and word recognition require code-dictionary knowledge (Juel, Griffith and Gough, 1986). According to the same model, code-dictionary knowledge, word recognition, and listening comprehension are components of reading comprehension. Writing/spelling can be realized through phonology. It is understood that this phonological knowledge is an important component of writing as it requires separating the heard words into syllables and sounds (Brynildssen, 2000).

In other studies, theoretical views on the developmental stages of literacy have been put forward (see Ehri, 2005 for details). According to Ehri (2014), children's learning to read words requires phonological awareness and knowledge of writing systems. The ability to read words accurately and automatically involves a developmental process from non-alphabetic visual features to grapho-syllabic connections. In addition, reading and writing require cognitive processes. Some of the studies in the literature suggest that the cognitive processes of reading and spelling may be similar (Berninger et al., 1994; Nikolopoulos et al., 2006). However, writing/spelling skills are based more on memory processes and functions in terms of perceiving sensory data such as letters-sounds, syllables, words, and sentences and requiring the perceived data to be encoded and recalled in memory (Juel, 1994). Accordingly, the amount of information to be retrieved from memory increases for spelling, which requires remembering letters in the correct order, compared to reading (Ferah, 1996). Children who read incorrectly may be more likely to write incorrectly. This may indicate difficulties and levels in the decoding process.

Children have to learn letter-sound correspondences at the beginning of literacy. An incomplete or misspelled language unit may not only indicate the developmental phase of children's literacy learning (Ehri, 2005), but it may also indicate structures that are difficult to encode in memory or remember. In an earlier memory study, it was determined that letters could be confused in short-term memory due to their sound similarities (Conrad, 1964). In another study, it was found that children make mistakes while learning to read and write in Turkish; letter sounds such as "ç, f, t, h, s, k, p, ş, b, d, n, m" and some affixessyllable structures are difficult to encode in memory (Ferah-Ozcan and Ozcan, 2016). Children who read incorrectly may be more likely to write incorrectly. This may indicate difficulties and levels in the decoding process.

Visual Perception and Literacy

Visual perception is the capacity to identify, classify, and interpret visual stimuli in light of prior knowledge (Aral and Erturan, 1999). Visual perception describes the cognitive skills that integrate visual information into higher cognitive functions and processes (Pienaar, Barhors and Twisk, 2014). The ability to discern similarities and differences between groups of objects, such as size, color, and shape, is known as visual discrimination. This improves the person's capacity to match letters (Ferah, 1996). Letter recognition is correlated with visual-sensing abilities (Bellocchi et al., 2017). Children can practice writing by flipping the letters until they learn which way is up (Cubelli and Della Sala, 2009). Additionally, Commadari et al. (2020) discovered that visual analysis and mental imagery have an impact on reading achievement. According to some studies, preschool assessments of visual motor skills are related to future reading success (Franceschini et al., 2012).

One factor that may either directly or indirectly affect decoding is visual perception, particularly in regular languages where alphabetic principles are introduced in the first grade of elementary school. But only a small amount of research has been done on the topic of visual skills (Bellocchi et al., 2017). It has been determined that children with high levels of visual perception at the beginning of the first grade also have high levels of reading and reading comprehension (Memiş and Sivri, 2016). It was also found that children's writing (Ferah, 1996) and reading errors (Memiş and Sivri, 2016) were related to their visual perception development in the first grade. Keskinova and Ajdinski, 2018 reported that one of the variables predicting Finnish children's reading skills in first grade was visual motor skills. It can be considered that visual perception may be one of the variables that may directly or indirectly affect decoding, especially in regular languages where alphabetic principles are taught in the first grade of primary school. Children with specific learning disabilities, such as those who have dyslexia-dysgraphia, can also exhibit deficiencies in motor coordination development (Keskinova and Ajdinski, 2018). Children who struggle with visual analysis often misspell letters and letter groups when writing or write them incorrectly (Ferah, 1996). Inadequate discrimination abilities could lead to more people writing letters backwards (mirror image). This is why early support for the development of visual perception is important.

Phonological Awareness and Literacy

The ability to recognize, comprehend, and manage the fact that language is made up of smaller units like words, syllables, and sounds is known as phonological awareness (Trawich-Smith, 2013). Some studies on reading have found strong evidence that phonological awareness is one of the important variables predicting children's literacy skills in primary school (Abbott and Berninger, 1993; Lerkkanen et

al., 2004; Muter et al., 1997; Pfost, 2015; Sandoval, Briceño and Bargas, 2014; Zarić, Hasselhorn and Nagler, 2021; Stahl and Murray, 1994). In some studies, it has been determined that this skill is developed by learning real words through reading (Lerkkanen et al., 2004; Leppänen et al., 2009; Scarborough et al., 1998). Moreover, it has been determined that general and word-specific orthographic knowledge contributes to reading and spelling performance beyond phonological awareness (Zarić, Hasselhorn and Nagler, 2021). In one study, phonemic awareness with phoneme errors in word writing, stress awareness was determined to be related to accent errors in word/sentence writing. Based on this result, it has been suggested that prosodic awareness may also be related to learning to spell words (Gutierrez-Palma et al., 2019). Recent studies show that phonological awareness directly affects spelling, and its effect on reading is through invented orthography (Albuquerque and Martins, 2022). It has been found that children's invented spelling predicts their subsequent spelling and reading performance (Ouellette and Sénéchal, 2017, Treiman et al., 2019) and contributes to their learning to spell and read (Ouellette and Sénéchal, 2017). These spellings reveal children's knowledge of how letters are combined rather than reflecting a lack of alphabet knowledge or phonological awareness (Treiman, Kessler and Pollo, 2022). Reading has also been reported to predict phonological awareness (Burgess and Lonigan, 1998). However, researchers have not yet found sufficient evidence on the effects of this variable on visual perception and literacy errors in Turkish.

Present Study

In Turkey, formal learning of reading and writing begins in the first grade of primary school. Since Turkish has few syllable structure possibilities and each letter corresponds to a sound, it is known that letter-sound matching and spelling skills are acquired rapidly, and some children learn to read and write towards the end of the first semester of the first grade (Durgunoglu and Oney, 1999; Erdogan, 2012). Therefore, it can be expected that the effect of phonological awareness skills on literacy skills at the transition stage (Ehri, 1986) is relatively low. However, until reading and writing become automatic, both reading and writing errors continue to be made (Ferah, 1996; Ruotsalainen et al., 2022). The results of a study conducted with primary school first-graders aimed at learning two languages (Finnish-Estonian) whose spellings (orthography) are similar also revealed that there are students who cannot learn to decode in the spring semester (Ruotsalainen et al., 2022). In Turkish, it can be said that some of the first-grade students' writing/spelling achievements may also be low due to the mistakes made in letters/sounds that are difficult to encode, especially in the transition phase.

Children learning to read and write in regular languages spend very little time in the preliminary and partial alphabetic phases after learning the letter-sound relationship; however, letter name and shape knowledge is also fundamental for these phases (Ehri and McCormick, 1998). However, since children in Turkey are not taught alphabetic knowledge in the preschool period, it can be predicted that automaticity in letter-sound matching may progress more slowly in some children. The relatively low correlation of phonological awareness with first literacy skills when measured at the beginning of the first grade in Turkish first literacy teaching (Erdogan, 2012) and the correlation of these skills with visual perception (Ferah, 1996; Memiş and Sivri, 2016) requires taking into account the effect of visual perception as well as phonological awareness on literacy skills. Therefore, we predict that visual perception may have a direct effect on the acquisition of literacy/spelling skills in regular languages such as Turkish, as well as an indirect effect through phonological awareness as decoding continues. Analyzing these relationships may also clarify the educational measures that can be taken for children who have difficulties in the literacy learning process.

In this study, we focused on the mediating relationships between phonological awareness and visual perception variables and initial literacy/spelling errors in Turkish, a regular and highly transparent language, in the first grade of primary school. It was hypothesized that it would be possible to determine the levels of literacy/spelling errors in Turkish through a measurement tool that includes the letters, sounds, and affixes that children confuse when learning to read and write for the first time. This study can be said to be one of the first studies in the literature in terms of its target group being first-grade students, taking into account the effect of visual perception as well as phonological awareness in early literacy acquisition and focusing on the direct and indirect relationships of literacy errors made during the decoding process with prerequisite variables. No related study was found by the researchers in terms of this context and the variables addressed, and the analyzes performed. However, it is known that both in the period before the start of primary school and the process of first reading and writing, certain competencies and skills that form the basis of reading and writing (the concept of printing, visual perception, phonological awareness, etc.), affect academic performance in the first reading, writing, and learning process. For example, phonological awareness is one of the strongest predictors of reading skills (Ehri et al., 2001; Pfost, 2015; Sandoval, Briceño and Bargas, 2014; Zarić, Hasselhorn and Nagler, 2021). It is thought that the results

obtained from the study will shed light on the understanding of the literacy process in regular languages.

Purpose of the Study

The first aim of this study is to determine the possible multiple mediating roles of reading and word writing errors and phonological awareness in the effect of visual perception on sentence writing errors; the second aim is to determine the possible multiple mediating variable relationships of visual perception, phonological awareness, reading speed, word and sentence writing errors in the effect of visual perception on reading errors. In line with these aims, the research questions were determined as follows:

- Do phonological awareness, word writing, and reading errors have significant multiple mediating roles in the effect of visual perception on sentence writing errors?
- Do reading speed, phonological awareness, word and sentence writing errors have significant multiple mediating roles on the effect of visual perception on reading errors?

Materials and Methods

In this study, explanatory relational research design, one of the survey models, was used. Considering that the possible mediating factors between the success in the first literacy learning process and the reading/writing errors made by children and visual perception/phonological awareness variables are questioned, it can be said that the explanatory relational design is suitable for the purpose of the study (Creswell, 2013).

Population and Sample

Considering human resources, material resources, and time, it was decided to research the sample (Buyukozturk et al., 2012). The population of the study consisted of 69487 first-grade primary school students in Istanbul in the 2018-2019 academic year. However, considering the research costs (transportation, the printing of measurement tools, etc.) and time, the research was conducted on a sample expected to represent the population. The sample group of the study consisted of 552 first-grade students selected by convenience sampling from six schools in three districts of Istanbul. First, three easily accessible districts were determined. Considering time and cost, six schools from these districts were included in the study. Two of the schools were from regions with less socioeconomic development, two were from medium and two were from regions with more socio-economic development. Applications were carried out with first-year students whose parents' consent was obtained from the determined schools. It was observed that 47.8% (n=264) of the students in the sample were female, and 52.2% (n=288) were male. It was found that the number of samples representing 69487 people was 382 according to the formula of Krejcie and Morgan (1970), taking the ratio of the universe (p) 0.5, degree of accuracy (d) 0.05 and X^2=3.841 (at the level of 0.05).

Data Collection Tools

The Mountain Shadows Phonological Awareness Scale (MS-PAS), developed in 1998 (Watkins and Edwards, 2004), was adapted to Turkish culture by Buyuktaskapu (2012). Both the original and adapted forms consisted of 20 items, and both the same and different sound categories were used. Since the structure of the scale was known before the analyses, and it was desired to examine whether the available data set fit the predicted structure, CFA was conducted (Brown, 2015). Model fit indices were found to support data-model fit. χ^2/sd value less than 2 and RMSEA value less than 0.05 indicated a good fit (Schermelleh-Engel, Moosbrugger and Müller, 2003). CFI and TLI values greater than 0.95 indicated a good fit (Hu and Bentler, 1999). The factors were considered as a total due to their strong relationship with each other (0.882) (Cohen, Swerdlik and Sturman, 2013). It can be said that the reliability of the data obtained from the MS-PAS scale in terms of internal consistency is at an adequate level (McDonald omega coefficients 0.94 for the whole scale, n=552). Since the data set was dichotomized, CFA was conducted with a (1-0) tetrachoric correlation matrix.

The Word and Sentence Writing Errors Scale were developed by the researchers. The primary school word and sentence writing skills scales were aimed to include some language structures of Turkish. The targeted language structures are, respectively, low frequency (f, ç, h, v, ğ) and potentially confused (b, d, p, m, n) sounds; front-to-final open syllable, closed syllable, consonant-consonant and vowel-consonant syllable structures and some construction, inflection and possessive suffixes (-cı, -çi, lı, -luk, -lük, -çü, suz, (-ğ)im). The sentences were organized as four, five, and six words, and the words as one, two, three, four, and five syllables, and it was determined that the scales adequately sampled the scope in line with the expert opinions. Types of typing errors were arranged according to expert opinions, and in the grading scale of word and sentence writing errors, words written without any errors were scored in three categories no errors (3), 1-3 errors partially wrong (2), and 4 or more errors wrong (1). The word

writing errors scale consisted of 10 items, and the rating scale for evaluating sentence writing errors consisted of 15 items. The dictation study was conducted with puppets and scenarios, and sentences were dictated in the form of phrases by dividing them into two meaningful parts to exclude the short-term memory effect. The Word and Sentence Writing Skills scale were administered in a single session during the same class period in March.

McDonald Omega coefficients (0.93 for sentence writing errors and 0.93 for word writing errors) were used in the reliability analysis. Exploratory factor analysis (EFA) was performed to reveal the structure of the word and sentence writing scales, and it was found that the data obtained from the scales had a unidimensional structure; therefore, a total score could be obtained from the scale (KMO 0.91 for sentence writing errors, χ^2= 2931.4; sd=15; p=0.00, the variance explained by a single factor was 74.95%, and the factor loadings of the variables were found to be between 0.59 (plot 6) and 0.92 (plot 4). For word writing, KMO was 0.88, χ^2= 2364.8; sd=6; p=0.00, the variance explained by a single factor was 89.54%, and the factor loadings of the variables were between 0.91 (plot 4) and 0.95 (plot 3).

The distribution of the total scores obtained from the sentence and word writing errors was examined, and it was observed that they were normally distributed (Skewness coefficient -0.48, kurtosis coefficient -1.72 for the lower group for sentence writing errors, skewness coefficient 1.03, kurtosis coefficient -0.58 for the upper group; For word writing errors, the coefficient of skewness for the lower group was -0.75, the coefficient of kurtosis was -1.42, the coefficient of skewness for the upper group was 0.37, the coefficient of kurtosis was -0.83). As a result of the independent samples t-test, it was observed that the average score obtained from the upper group for sentence writing errors (3.99) was statistically significantly different from the average score obtained from the lower group (-6.35) ($t(154,70)=-20.73$, $p<0.01$). For word writing errors, the mean score obtained from the upper group (2.51) was statistically significantly different from the mean score obtained from the lower group (-4.19) ($t(151,96)=-16.21$, $p<0.01$). On the other hand, item analysis was conducted for the parceled items of sentence and word writing errors, and the corrected item-total score correlation was examined for this purpose. It was observed that all item means differed between the lower and upper groups for both sentence and word writing errors; on the other hand, item-total correlations for sentence writing errors ranged from 0.57 (parcel 6) to 0.87 (parcel 5). Item-total score correlations for word writing errors ranged from 0.88 (parcel 4) to 0.91 (parcel 2). Accordingly, it was determined that the item discriminations were at a sufficient level and that the items discriminated against individuals with and without the trait measured in the item. In addition, it can be stated that the item parcels showed a sufficient relationship with the test as a whole.

For the exploratory factor analysis (EFA) conducted with the data obtained from the sentence and word writing errors, it was observed that the correlations between some variables were high, so item parceling was created to overcome the multicollinearity problem. The sentence writing data set was formed by grouping 15 items into 6 parcels, and these 6 variables were standardized and converted into z scores. For the exploratory factor analysis (EFA) conducted with the data obtained from word writing errors, 43 participants with significant Mahalanobis distance values (α = 0.001) were excluded from the data set, and the analyses continued with a data set of 509 participants. The word writing data set was created by grouping 10 items into 4 parcels, and these 4 variables were standardized and converted into z scores. Therefore, since the word and sentence writing data set was continuous, EFA was conducted using the Pearson Product Moment correlation matrix.

While identifying reading errors, a literature review was conducted, and possible errors were listed. In the classification of errors, similar to the study of Dessimoni, Scalisi and Orsolini (2012), a classification was made as letter/syllable/word omission, letter/syllable/word insertion, and stress-tone-stop-sound quality. A 10-item rating scale was created in line with expert opinion. The rating scale is scored in 3 categories (1-Wrong, 2-Partially Wrong, 3-No Error). First, exploratory factor analysis (EFA) was performed with the reading error variables (KMO value 0.91, χ2= 6249.6; sd=45; p=0.00), and it was seen that the factor loads of the items ranged between 0.37 (item 6) and 0.87 (item 3). It can also be stated that the data obtained from the scale has a unidimensional structure, and therefore a total score can be obtained from the scale (explained variance 58.21%, McDonald Omega coefficient 0.92). Since the observed variables were skewed, the unweighted least squares (ULS) method was used as the factor extraction method in EFA. Since the data set was scored with three categories (1-3), EFA was performed with a polychoric correlation matrix. Factor 10.10 software (Lorenzo-Seva and Ferrando, 2019) was used in EFA for word writing, sentence writing, and reading errors. For reading speed, a text consisting of 117 words was given to the students, and their reading speed was measured in seconds, and the number of words they read per minute was determined by subtracting the words they read with errors from the total words they read.

The adaptation of the Frostig Visual Perception test (Maslow et al., 1964) to Turkish culture was

conducted by Aral and Butun (2016). Since the structure of the scale was known from previous studies (Aral and Butun, 2016), evidence for construct validity was sought with CFA. After modification, the χ^2/sd value was found to be 5.63 and did not show an acceptable fit, while the RMSEA value was found to be 0.092, indicating a moderate fit. CFI and TLI values showed a very good fit. When the model-data fit is evaluated in general, it can be stated that the established measurement model is supported by the data. As a result of the reliability analysis of the data obtained from the Visual Perception Test, the McDonald Omega coefficient was found to be 0.87. According to the Mahalanobis distance, the data belonging to 6 people were excluded from the data set because it was significant at $\alpha = 0.001$ level. Maximum likelihood (ML) was selected as the estimation method in CFA using the Pearson correlation matrix for continuous data, and CFA was performed using Mplus software (Muthén and Muthén, 2012) for phonological awareness and visual perception.

Data Analysis

To answer the research questions, the mean scores of visual perception, phonological awareness, reading and writing (word and sentence) errors, and reading achievement test total scores were taken. While addressing the visual perception variable, standardization was performed to eliminate the effect of age. For this reason, the visual perception variable was examined as a percentage, and since the z values of the skewness and kurtosis values of the variables showed that the normality assumption was not met, the analyzes were carried out through the Spearman rank difference correlation coefficient. The results were interpreted according to the criteria of low correlation coefficients up to 0.30, medium correlation coefficients between 0.30 and 0.70, and high correlation coefficients above 0.70 (Buyukozturk, 2011). To answer the multiple mediation questions of the study, the Process plugin for SPSS prepared by Hayes (2018) was used in the mediation analysis. Comments on the mediation effect were made by taking into account the conditions presented by Baron and Kenny (1986). According to this, X's Y M, the effect of variable X on variable Y is analyzed by means of M. 1) Variable X statistically affects variable Y significantly predicted, 2) Variable X is statistically equivalent to variable M significantly predicted, 3) When variable X is kept under control, variable M, Y variable at a statistically significant level, 4) M variable control variable X is a statistically significant predictor of variable Y or there should be a reduction in the amount of association.

Results

As a result of the descriptive statistics of the research (n=552), visual perception (x=63.80, ss=32.12, min.=1, max.=100), phonological awareness (x=0.65, ss=0.25 min.=0, max.=1), reading error (x=2.40, ss=0.45, min.=1, max.=3), reading speed (x=39.09, ss=19.49, min.=0, max. =108), morphological features (x=2.10, ss=0.67, min.=1, max.=3), word writing error (x=2.53, ss=0.50, min.=1, max.=100), sentence writing error (x=2.51, ss=0.54, min.=1, max.=3) variables' mean, standard deviation, minimum and maximum values were calculated.

Spearman rank difference correlation coefficient was used to examine the relationships between students' visual perception, phonological awareness, reading achievement, word writing error, and sentence writing error levels (Table 1).

Table 1

Correlations between variables

Variable	Visual perception	Sentence writing error	Word writing error	Phonological awareness	Mean Total Scores for Reading Error, Overall, and Reading Speed
Visual perception	1,00	0,34*	0,36*	0,02	0,49*
Sentence writing error		1,00	0,70*	0,09*	0,62*
Word writing error			1,00	0,07	0,60*
Phonological awareness				1,00	0,02
Mean Total Scores for Reading Error, Overall, and Reading Speed					1,00

*p<0,05

When the correlations between the variables are analyzed, it can be said that the scores obtained from the phonological awareness scale have no relationship with other variables. Reading achievement is positively and moderately correlated with sentence writing errors and word writing errors. Visual Perception is positively and moderately related to reading achievement and word and sentence writing errors. A significant positive correlation was found between sentence writing errors and word writing errors. Although the relationship between sentence writing error and phonological awareness variable is statistically significant, it is at a very low level.

To answer the research question "The mediating role of word writing error, phonological awareness and reading error in the effect of visual perception on sentence writing error," "multiple mediation effect" was examined. Direct effects between variables were examined (Table 2)

Table 2

Direct effects of visual perception on phonological awareness, word writing error, reading error, and sentence writing error

Predictor Variable	Predicted Variable	Ba	SEb	βc
Visual Perception	Phonological awareness	,03	.04	,03
Visual Perception	Word Writing Error	,46	,04	,46*
Phonological awareness		,05	,04	,05
Visual Perception		,24	,03	,24*
Phonological awareness	Reading Error	-,00	,03	-,00
Word Writing Error		,60	,03	,60*
Visual Perception	Sentence writing Error	,03	,02	,03
Phonological awareness		,02	,02	,02
Word Writing Error		,71	,03	,71*
Reading Error		,20	,03	,20*

p<.05 Unstandardized parameter estimation b Standard error c Standardized parameter estimation

As a result, the total effect of visual perception on sentence writing error (c=0.46; SE=.04; t=12.29; p=.00<.05) was found to be significant. The direct effect of visual perception on the mediating variable phonological awareness (B=.03; β=.03, SE=.04; t=0.80; p=.43>.05) was not significant. The direct effect of visual perception on word writing error (B=,46; β=,46; SE=,04; t=12,08; p=,00<,05) and reading error (B=,24; β=,24; SH=,03; t=7,53; p=,00<,05) was found to be significant. The direct effect of the mediating variables reading error (B=,20; β=,20; SE=,03; t=6,64; p=,00<,05) and word writing error (B=,71; β=,71; SH=,03; t=24,92; p=,00<,05) on sentence writing error was significant, while the direct effect of phonological awareness (B=,02; β=,02; SE=,02; t=1,17; p=,24>,05) on sentence writing error was not significant. When the direct effect of visual perception and mediating variables on sentence writing error at the same time was analyzed, the effect of visual perception on sentence writing error was not significant (B=,03; β=,03; SE=,02; t=1,40; p=,16>,05). When the effects of the mediating variables among themselves are analyzed, it can be stated that the effect of phonological awareness on word writing error (B=,05; β=,05; SE=,04; t=1,29; p=,20>,05) and the effect of phonological awareness on reading error (B=-,00; β=-,00; SE=,03; t=-,12; p=,91>,05) is not significant. The effect of word writing error on reading error was significant (B=,60; β=,60; SE=,03; t=18,64; p=,00<,05).

The indirect effects of visual perception on phonological awareness, word writing error, reading error, and sentence writing error were examined. The results are shown in Table 3.

Table 3

Indirect effects and specific indirect effects of visual perception on phonological awareness, word writing error, reading error, and sentence writing error

		Bootstrap 95% Confidence Interval		
Indirect Effects	Point Estimate	SE	Low	High
Total	,43	,04	,36	,50
Intermediary Value 1: Phonological awareness	,00	,00	-,00	,01
Intermediary Value 2: Word writing error	,33	,04	,25	,40
Intermediary Value 3: Reading Error	,05	,01	,02	,08
Intermediary Value 4: Phon. Aw. and Word. Wri. Er.	,00	,00	-,00	,01
Intermediary Value 5: Phon. Aw. and Read. Er.	,00	,00	-,00	,00
Intermediary Value 6: Word. Wri. Er. and Read. Er.	,05	,01	,03	,08
Intermediary Value 7: Phon. Aw., Word. Wri. Er. and Read. Er.	,00	,00	-,00	,00
C1 (Intermediary Value 1 – Intermediary Value 2)	-,33	,04	-,40	-,25
C2 (Intermediary Value 1 – Intermediary Value 3)	-,05	,01	-,08	-,02
C5 (Intermediary Value 1 – Intermediary Value 6)	-,05	,01	-,08	-,03
C7 (Intermediary Value 2 – Intermediary Value 3)	,28	,05	,18	,37
C8 (Intermediary Value 2 – Intermediary Value 4)	,33	,04	,25	,40
C9 (Intermediary Value 2 – Intermediary Value 5)	,33	,04	,25	,40
C10 (Intermediary Value 2 – Intermediary Value 6)	,27	,04	,19	,36
C11 (Intermediary Value 2 – Intermediary Value 7)	,33	,04	,25	,40
C12 (Intermediary Value 3 – Intermediary Value 4)	,05	,02	,02	,08
C13 (Intermediary Value 3 – Intermediary Value 5)	,05	,01	,02	,08
C15 (Intermediary Value 3 – Intermediary Value 7)	,05	,01	,02	,08
C17 (Intermediary Value 4 – Intermediary Value 6)	-,05	,01	-,08	-,03
C19 (Intermediary Value 5 – Intermediary Value 6)	-,05	,01	-,08	-,03
C21 (Intermediary Value 6 – Intermediary Value 7)	,05	,01	,03	,08

The statistical significance of the indirect effects in the model is examined using the bootstrap technique. Results were obtained with 95% confidence intervals. The total indirect effects of visual perception on phonological awareness, word writing error, reading error, and sentence writing error were statistically significant (point estimate=.43; 95% CI[.36 - .50]). In the indirect effect of visual perception on sentence writing error, phonology (point estimate=,00; 95% CI[-,00 - ,01]), phonology and word writing error (point estimate=,00; 95% CI[-,00 - ,01]), phonology and reading error (point estimate=,00; 95% CI[-,00 - ,00]), phonology and reading error (point estimate=,00; 95% CI[-,00 - ,00]), and phonology, word writing error, and reading error (point estimate=,05; 95% CI[,02 - ,08]), while the mediation of reading error (point estimate=,05; 95% CI[,02 - ,08]) and word writing error (point estimate=,33; 95% CI[,25 - ,40]) was not significant. The significant pairwise comparisons of the mediating variables are shown in Table 2. For example, word writing error is a stronger mediator than phonological awareness, and word writing error is a stronger mediator than reading error. Also, reading error is a stronger mediator than reading error and phonological awareness. In summary, word writing error and reading error mediate the effect of visual perception on sentence writing error.

To answer the research question “The mediating role of reading speed, phonological awareness, word and sentence writing errors in the effect of visual perception on reading errors,” firstly “multiple mediation effect” was examined. Direct effects between variables were examined (Table 4).

Table 4

Direct effects of visual perception on phonological awareness, word writing error, reading error, and sentence writing error

Predictor Variable	Predicted Variable	Ba	SEb	βc
Visual Perception	Reading Error	,02	,02	,02
Reading Speed		,61	,03	,61*
Sentence writing Error		,15	,04	,15*
Word Writing Error		,20	,04	,20*
Phonological Awareness		,01	,02	,01
Visual Perception	Word Writing Error	,05	,02	,05
Reading Speed		,07	,03	,07*
Phonological Awareness		-,00	,02	-,00
Sentence writing Error		,81	,03	,81*
Visual Perception	Sentence writing Error	,16	,04	,16*
Reading Speed		,56	,04	,56*
Phonological Awareness		,06	,03	,06
Visual Perception	Phonological Awareness	,03	,05	,03
Reading Speed		,00	,05	,00
Visual Perception	Reading Speed	,55	,04	,55*

p<.05 Unstandardized parameter estimation b Standard error c Standardized parameter estimation

As a result, it was observed that the total effect of visual perception on reading errors (c=.52; SH=.04; t=14.19; p=.00<.05) was significant. The direct effect of visual perception on the mediating variables of reading speed (B=,55; β=,55, SH=,04; t=15,34; p=,00<,05) and sentence writing error (B=,16; β=,16; SH=,04; t=4,12; p=,00<,05) was significant. The direct effect of reading error on the mediating variables phonological awareness (B=,03; β=,03; SH=,05; t=,66; p=,51>,05) and word writing error (B=,05; β=,05; SH=,03; t=1,90; p=,06>,05) was not significant. The mediating variables reading speed (B=,61, β=,61, SH=,03; t=21,15; p=,00<,05), word writing error (B=,20; β=,20; SH=,04; t=4,65; p=,00<,05) and sentence writing error (B=,15; β=,15; SH=,04; t=3,42; p=,00<,05), while the direct effect of phonological awareness (B=,01, β=,01, SH=,02; t=,32; p=,75>,05) on reading errors was not significant. When the direct effects of visual perception and mediating variables on reading errors at the same time were analyzed, the effect of visual perception on reading errors was not significant (B=,02; β=,02; SH=,02; t=,98; p=,33>,05). When the effects of mediating variables among themselves were examined, it was found that reading speed had no significant effect on phonological awareness (B=,00; β=,00; SH=,05; t=,02; p=,99>,05), phonological awareness had no significant effect on sentence writing errors (B=,06; β=,06; SH=,03; t=1,96; p=,05>,05) and the effect of phonological awareness on word writing error (B=-,00; β=-,00; SH=,02; t=-,11; p=,92>,05) was not significant. The effects of reading speed on sentence writing error (B=,56; β=,56; SH=,04; t=14,47; p=,00<,05), sentence writing error on word writing error (B=,81; β=,81; SH=,03; t=29,29; p=,00<,05) and reading speed on word writing error (B=,07; β=,07; SH=,03; t=2,36; p=,02<,05) were significant.

The indirect effects of visual perception on reading errors through reading speed, phonological awareness, and word and sentence writing errors were examined. The results are shown in Table 5.

Table 5

Indirect effects of visual perception on reading errors via reading speed, phonological awareness, word, and sentence writing errors[1]

		Bootstrap 95% Confidence Interval		
Indirect Effects	Point Estimate	SH	Low	High
Total	,49	,04	,41	,57
Intermediary Value 1: Reading Speed	,33	,03	,28	,38
Intermediary Value 2: Phonology	,00	,00	-,00	,00
Intermediary Value 3: Sentence Writing Error	,02	,01	,01	,05
Intermediary Value 4: Word Writing Error	,01	,01	,00	,02
Intermediary Value 5: Reading Speed and Phonology	,00	,00	-,00	,00
Intermediary Value 6: Reading Speed and Sen. Wri. Er.	,05	,02	,01	,08
Intermediary Value 7: Reading Speed and Wor. Wri. Er.	,01	,00	,00	,02
Intermediary Value 8: Phonology and Sen. Wri. Er.	,00	,00	-,00	,00
Intermediary Value 9: Phonology and Wor. Wri. Er.	,00	,00	-,00	,00
Intermediary Value 10: Sen. Wri. Er. and Wor. Wri. Er.	,03	,01	,01	,05
Intermediary Value 11: Reading Speed, Phonology and Sen. Wri. Er.	,00	,00	-,00	,00
Intermediary Value 12: Reading Speed, Phonology and Wor. Wri. Er.	,00	,00	-,00	,00
Intermediary Value 13: Reading Speed, Sen. Wri. Er. and Wor. Wri. Er.	,05	,02	,02	,08
Intermediary Value 14: Phonology, Sen. Wri. Er. and Wor. Wri. Er.	,00	,00	-,00	,00
Intermediary Value 15: Reading Speed, Phonology, Sen. Wri. Er. and Wor. Wri. Er.	,00	,00	-,00	,00

[1] The numbers in the third or next digits of the mediator variables Word Writing Error (CI [,0004 - ,0212]), Reading Speed and Word Writing Error (CI [,0003 - ,02]) are greater than one or more than one. Therefore, the mediator role was interpreted as significant. Since the numbers were given in two digits, the third digits of the numbers were not written in the tables in order not to disrupt the order.

The statistical significance of the indirect effects in the model is examined using the bootstrap technique. The results were obtained with 95% confidence intervals. The total indirect effect of visual perception on reading errors through reading speed, phonological awareness, and sentence and word writing errors was statistically significant (point estimate=.49; 95% CI[.41 - ,57]). In the indirect effect of visual perception on reading errors, reading speed (point estimation=.33; 95% CI[,28 - ,38]), sentence writing error (point estimation=.02; 95% CI[,01 - ,05]), word writing error (point estimate=.01; 95% CI[.00 - .02]), reading speed and sentence writing error (point estimate=.05; 95% CI[.01 - .08]), reading speed and word writing error (point estimate=.01; 95% CI[.00 - .02]), sentence writing error and word writing error (point estimate=.03; 95% CI[.01 - .05]), reading speed , sentence writing error and word writing error (point estimate=.05; 95% CI[.02 - ,08]) are significant. As seen in Table 5, it was concluded that the mediation effect of other mediating variables and their associations was not significant. It was observed that 85/105 of the pairwise comparisons showing the power of the mediating variables for specific indirect effects were significant. In general, it can be stated that reading speed has a stronger mediation effect than the other 14 mediating variables. There is no significant difference between the mediator variables of sentence writing error and word writing error. In summary, when all conditions are taken into consideration, reading speed, sentence writing error, reading speed and sentence writing error, reading speed and word writing error, sentence writing error and word writing error have a mediating effect on the effect of visual perception on reading errors. This result is important in terms of revealing that visual perception affects reading errors both directly and through other literacy components.

Discussion

Literacy studies in recent years have focused on the effect of oral language skills on literacy skills. However, our research results reveal that visual perception's effect on literacy in transparent languages should be considered. The findings of the study showed that visual perception affects sentence writing errors both directly and indirectly through the mediating variables of word writing and reading errors in the learning of the Turkish language, which is a transparent language. Findings that writing skills at the decoding level predict reading support our research (Anderson et al., 2018). Word writing error is a stronger mediating variable in the effect of visual perception on sentence writing. Reading error is also stronger mediating variable than reading error and phonological awareness. These results point to the importance of spelling development. According to literacy development models, spelling is a low-level skill for writing (Juel, Griffith and Gough, 1986). Children's sentence writing errors indicate that they are not yet automatized in decoding letter-sound correspondences rather than a phonological awareness deficit (Treiman, Kessler and Pollo, 2022). In order to learn to read and write, the letter-sound connection must be established correctly. Even if children can decompose spoken language into units, they continue to make reading and writing errors unless the ability to recognize and remember the letter corresponding to the sound is automatic. It can be said that more mistakes are made, especially in writing, than in reading. Research on made-up spellings supports this conclusion (Ouellette and Sénéchal, 2017).

In a very transparent language such as Turkish, letter knowledge is given during literacy instruction. In the first semester of school, the teaching of all letters and sounds is completed. However, as new letters-sounds continue to be taught without thoroughly reinforcing the previously learned letter and sounds, especially similar letters and sounds can be confused. The reason for this is the difficulty in coding the visually similar (such as b-d, p-b), hard-to-hearing (such as f-v-h-g), or less-used letters and sounds in Turkish. Visual memory is affected by the ability to perceive, distinguish and recognize the physical features of perceptual stimuli. This skill is also affected by our previous experiences (Lupyan et al., 2020). In addition, the visual perception was found to have a strong effect on reading speed but a weaker effect on sentence writing errors and word writing errors, respectively. These results suggest that the contribution of phonological awareness to the reduction of reading, word and sentence writing errors in the transition phase of children who learn to read and write in a regular language in the first grade of primary school decreases over time, while the effect of visual perception continues, albeit limited. The results of studies examining the relationship between children's word recognition, reading comprehension, spelling, writing success, writing/spelling errors and visual perception variables also support this conclusion (Cayir, 2017; Clutten, 2009; Ferah, 1996; Memis and Sivri, 2016; Pienaar, Barhors and Twisk, 2014). It can be said that the difficulty in analyzing a letter within the letter groups directly affects the visual coding and writing skills in the decoding process.

The second result of the study on multiple mediation relationships revealed that both word and sentence writing/spelling errors and reading speed play a mediating role in the effect of visual perception on reading errors. When phonological awareness skill was measured in the first semester of the first grade of primary school, it was determined that its effect on reading speed, reading errors, and word and sentence writing/spelling errors measured in the second semester was very weak or had no significant effect. The reason for this may be the early development of phonological awareness skills in Turkish, which is a regular language, and the fact that the letter-sound matching training given in the first semester led to an increase in phonological awareness tasks (Erdogan, 2012; Durgunoglu and Oney, 1999). The importance of phonological awareness skills, which has a high contribution at the beginning, decreases at the end of the transition period.

The conclusion that the effect of phonological awareness on reading, word and sentence writing errors is not significant is supported by some research results (Erdogan, 2012; Guldenoglu, Kargın and Ergul, 2016) that examine the relationship between phonological awareness development and reading-writing/spelling in regular and irregular languages (Burgess and Lonigan, 1998; Vaessen and Blomert, 2013; Juel, Griffith and Gough, 1986). For example, according to the results of a study conducted with Finnish-speaking children, phonological awareness skills and letter-sound matching skills contribute to spelling skills (Vaessen and Blomert, 2013). The results of a study on Turkish spelling skills also showed that the underlying evidence for spelling is phonological awareness, while reading is fast automatic naming skills (Babayigit and Stainthorp, 2010). This may have been due to the difference in the time when these skills were measured and the variables considered. In addition, it can be thought that the power of phonological awareness, which was initially effective in the relationship between reading and writing/spelling, gradually weakened, and decoding and phonological processing skills became more effective in the transition phase (Vaessen and Blomert, 2013). However, phonological processing skills were not

measured in this study.

According to other results obtained in the study, the fact that spelling errors are effected by visual perception requires careful examination of memory beyond perception. Because sounds must be translated into visual symbols in order to be replicated when writing. Our current study is partially supported by the finding that preschool children's early decoding skills are related to their capacity to copy designs (Cameronet al., 2012). Children who struggle to make the effort necessary for developing early literacy skills because their motor and cognitive needs conflict may find it challenging to write letters (Traversoet al., 2022). It might be beneficial to plan actions and activities that enhance visual short-term memory or activate visual processing memory in light of the connection between perception and memory.

Based on another result of the study, the direct effect of word writing errors on sentence writing errors is stronger than the direct effect of reading errors. The result the basic dynamics of writing are partially differentiated from reading. In addition, this finding of the study does not coincide with Lerkkanen's (2003) finding that reading achievement at the end of first grade predicts spelling performance unidirectionally. This is because writing/spelling errors also have a direct effect on reading errors. The fundamental dynamics of writing may differ slightly from reading. Andersen et al. (2018) found strong effects between reading-writing skills. They argued that effective decoding can free up cognitive resources for writing by facilitating spelling, that literacy skills should be measured at different times at the word-sentence level, and that writing can support reading. These results are also consistent with the results of our study. For this reason, teaching should be focused on writing as well as reading (Graham and Herbert, 2011). Our research contributes to the literature by measuring literacy errors at the primary school first-grade level at the sentence and word level. It also reveals visual perception's direct and indirect effects on these errors with other mediating variables. The importance of visual perception skills in the process is also explained. İt can be said that reading speed has a strong effect on reading-writing errors. This is because words are read repeatedly, and orthographic coding is performed; thus, the read word is accessed directly and quickly from memory. Because reading requires visual analysis of strings of letters and retrieval of word representations from memory (Bellocchi et al., 2017). This will facilitate syllable and word recognition. According to some studies, first-graders have morphological awareness, which influences how they spell words (Allen and Lembke, 2022; Apel and Werfel, 2014).

According to the other result obtained in the study, the direct effect of reading speed on sentence writing errors is significant and strong. The strongest variable that directly affects reading errors is reading speed; the other variable is visual perception. Although the effect of word and sentence writing errors on reading errors was significant, it was observed that their power was slightly lower than the other variables. Children who make reading errors will make more effort to decode words and read more slowly. According to the other result obtained in the study, the strongest variable that directly affects reading errors is word writing errors; the other variable is visual perception. When children cannot activate their initial sound/letter awareness while learning to read and write, they have difficulty applying the rules of sound-to-spelling and spelling-to-sound conversion and may make errors. The role of visual perception on word writing errors is an important finding in terms of showing the relationship between both literacy and decoding skills and decoding skills with visual perception. Sound-syllable forgetting errors show that the syllable concept has not developed in written language. Syllables are formed by differentiating the properties of letters over time and by letter-sound blending. In addition to not having basic knowledge and skills related to grammar rules about language elements and lexical rules, word splitting and merging errors show that children have not yet separated spatial relations from objects and that they differentiate and generalize spatial relations slowly (Ferah, 1996).

It can be thought that the basic evidence underlying the transition phase of literacy is beginning to differentiate. In Turkish, which is a transparent language, the effect of phonological awareness decreases in the transition phase of literacy. The effect of visual perception continues. Normally, children learn to read and write by discovering information about word meanings and the connections between sounds and letters (Share, 2004). However, it is also known that word reading requires skills such as phonological encoding and orthographic processing (Bellocchi et al., 2017). Reading requires the analysis, recognition, visualization, activation and use of visual stimuli (letter, syllable, word, etc.) (Commodari et al., 2020). Therefore, word writing errors and visual perception has a direct impact on reading errors. Children must analyze the graphic characteristics of letters, encode language units like letters and words, and possess phonological skills like breaking language down into its constituent sounds, blending sounds, and recognizing rhymes in order to learn to read. Visual spatial abilities are one of the most significant indicators of children's reading development (Zhang and Lin, 2018).

Conclusions

In this study, the authors focus on the relation between visual perception and the mistakes made by first-year students in writing and reading while gaining the first literacy skill. First, the effects of visual perception on sentence spelling errors indirectly through reading, word writing and phonological awareness variables, were determined. Secondly, the impact of visual perception on reading errors indirectly, through reading speed, word-sentence spelling errors, and phonological awareness variables was determined. The results show that visual perception directly affects sentence writing and reading errors. As a result, it has been determined that visual perception indirectly affects sentence spelling errors through word writing, reading errors and phonological awareness tool variables. The relationships among the mediating variables show that word writing errors are the strongest variable that directly affects sentence writing errors. In addition, it has been observed that visual perception indirectly affects reading errors through reading speed, word-sentence writing, and phonological awareness. The relationships between mediator variables show that reading speed is the strongest variable that directly affects reading errors. This research also indicates that visual-spatial skills contribute to developing reading and writing in a very transparent language like Turkish. Although reading seems to mediate writing, its fundamental dynamics differ. Writing also directly affects reading. Particular attention should be given to teaching writing in the transition phase. Although studies in recent years have revealed the importance of oral language skills in literacy acquisition, the results show that visual perception effects are more significant in transparent languages. Visual perception is one of the early literacy skills. Children with insufficient visual perception development may also have difficulty acquiring reading and writing. For this reason, visual perception development should be supported at an early age. Writing is a different skill from reading skill. For this reason, not only reading but also writing teaching should be included in the lessons.

Recommendations

The fact that perception is affected by information indicates that the relationship between literacy errors and memory (processing and long-term memory) should also be examined. Considering the increase in children's word recognition skills during the transition phase of literacy, the contribution of variables such as visual perception and morphological and syntactic awareness can be taken into account. Although the evidence for the effect of phonological processing skills on the automatization of reading gains importance, it can be said that searching for the underlying evidence of literacy in morphological and syntactic awareness tasks, which are real-life skills, may be more beneficial to the field. It can be suggested that teachers and practitioners organize additional activities for visual perception in lessons and give importance to writing activities. In addition, the following recommendations can be made for future research: Research can be designed to investigate the relationship between the variables discussed in this study and early literacy skills such as phonological processing skills, visual-spatial copying, etc. In a study to be conducted in the same context, longitudinal studies can be conducted in which students are followed in terms of related skills. In addition, mixed method studies in which both qualitative and quantitative methods are used together can be used to reach more in-depth and comprehensive data, and studies that can lead to multidimensional discussions can be conducted.

In this study, the Confirmatory Factor Analysis of the MS Phonological Awareness Scale was conducted by taking the total score due to the high correlation between the factors. The fact that it was not investigated whether a second-order factor structure could explain the scale is a limitation of this study. For this reason, conducting second-order factor analyses for the MS Phonological Awareness Scale may be recommended in future studies. In this study, a limitation is that the study was conducted through sampling due to time and cost constraints. In future research, repeating the study with a sample representing the whole of Istanbul may be recommended.

Statements and Declarations

Declaration: This study is based on the first author's doctoral dissertation. All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Author 1. The first draft of the manuscript was written by Author 1 and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Conflict of interest

The authors have no relevant financial or non-financial interests to disclose.

Ethical Statement

This study was ethically approved by University Human Research and Ethics Committee with the decision numbered 2018/215 and dated 21.11.2018.

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