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The Structural Relationship Between Fluent Reading, Reading Comprehension and Eye Movements[1]

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Abstract

Since reading and meaning-making are basic skills that students continuously use in their academic lives, efforts are made to help students acquire these skills from an early age. However, it is frequently stated in various studies and reports that students still have reading and comprehension problems. Studies for the solution of these problems firstly depend on revealing the reasons that may be related to the problems. In this sense, different direct or indirect measurements have been made for years. However, today, with the development of technology, more detailed data has started to be produced in the field of reading as in every field. For example, tracking eye movements with high accuracy while reading is an important achievement of technology in this field. Eye movements, which are still a new field of study, and their relationship with different variables of reading have become the focus of researchers' attention. However, how eye movements occur in the reading process and how this affects reading and reading comprehension is not sufficiently known in terms of both national and international literature. In In this study, students were asked to read texts aloud using an eye-tracking device, and their reading comprehension and fluency skills were measured. The study group of the research consists of 284 third grade primary school students and the study was conducted in the survey model. The measurement results obtained from the research aimed to reveal how students' eye movements during reading affect reading fluency and comprehension. As a result of the research, significant relationships were found between fluent reading skills, reading comprehension and eye movements. Accordingly, a positive relationship was found between fluent reading and reading comprehension. A negative relationship was found between fluent reading and eye movements. On the other hand, no significant relationship was found between eye movements and reading comprehension. In the context of other studies in the literature, the research findings were examined and analyzed.

Key Words

Eye-tracking
Reading fluency
Reading comprehension
Eye movements

About Article

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Introduction

Reading is an important component of individuals' knowledge acquisition and learning process; it is considered as the cornerstone of academic success and lifelong learning. Reading involves not only decoding the text, but also the process of making sense of it quickly and effectively. Today, the complex cognitive and neurological mechanisms underlying the reading process can be better analysed through research (Ye et al., 2022). The relationship between fluent reading, reading comprehension and eye movements has become an important field of study for researchers in recent years (Castelhano & Rayner, 2008).

When a person reads without comprehension and with dysfunctional literacy, he/she cannot use the information related to the text in his/her own life. Until recently, the high number of illiterate individuals was one of the most important problems of education systems (UNESCO, 2005). In the latest PISA 2022 report, it is seen that most of the students in Türkiye are at an inadequate level in reading comprehension (OECD, 2023). As in the rest of the world, reading comprehension is one of the common educational problems in Türkiye and there is not enough research on the causes of this problem. Especially as a preventive approach, eliminating the causes of reading problems is a very important issue.

The ability to read and make meaning is a skill that is tried to be acquired by children from an early age. One of the reasons why reading skills are so important is that it has a decisive place in students' academic lives. This situation has been addressed in many studies in terms of both academic life and motivational variables (Chevalier et al., 2017; Koç and Arslan, 2015; Urška, 2013; Ünal and İşeri, 2012; Yıldız, 2013). In order to make more detailed inferences about the quality of reading skill, this skill should be directly observed. Especially in studies on affective and motivational variables of reading, it is not possible to observe these variables directly. Variables such as accurate reading, reading speed and prosody constitute the directly observable aspect of reading. It is theoretically possible to say that direct observation produces clearer data than indirect observations. Therefore, it is possible to argue that new variables should be added to the observable dimension of reading or new data should be produced through detailed analyses. With the development of technology in recent years, it has become possible to produce more detailed data in the field of reading as in every field. For example, tracking eye movements with high accuracy while reading is an important achievement of technology in this field.

The reading comprehension process is influenced by many cognitive, linguistic and environmental factors. Cognitive factors include phonological awareness (Wagner et al., 2013), working memory capacity (Nouwens, et al., 2021) and attention processes (Duke et al., 2021). Linguistic factors include vocabulary (Smith et al., 2021), morphological awareness (Kotzer et al., 2021) and syntactic skills (Mackay et al., 2021); while environmental factors include reading experience (Kaban & Karadeniz, 2021), educational interventions (Donegan & Wanzek, 2021) and family support (Buckingham et al., 2013). Wade-Woolley et al. (2021) examined the effect of prosodic reading on reading comprehension and empirically supported the role of prosodic reading in the comprehension process.

Fluent reading skills have an important place in students' academic success as well as reading comprehension. Recent neuroimaging studies have revealed the relationship between the development of fluent reading skills and brain activation. Lee and Stoodley (2024) stated that the brain activation patterns of fluent readers differ from individuals with reading difficulties. Locher and Pfost (2019) put forward the concept of "Matthew Effect" and stated that students who acquire fluent reading skills in the early period improve their skills by practicing more reading over time, while students who have difficulty in this skill avoid reading and the problem deepens over time. Kang and Shin (2019) emphasised the importance of systematic and regular interventions in the development of reading fluency skills. Similarly, Duke et al. (2021), in a meta-analysis study examining the effectiveness of strategies used in fluent reading instruction, stated that repeated reading and supported reading strategies showed significant effects. These strategies stand out as effective tools for students to improve their fluent reading skills. Ecalle et al. (2020) stated that the relationship between reading fluency and reading comprehension has strengthened over time and that these two skills support each other and increase the overall reading performance of the reader.

Eye movements during the reading process provide us with clear data to better understand and make inferences in the areas of reading comprehension and reading fluency. Hindmarsh et al. (2021) state that eye movements in the reading process consist of three basic types of movements: Saccadic movements (forward jumps), fixations (focussations) and regressions (returns). Each of these movements provides important information about how the reader processes the text. Saccadic (leap) movements refer to rapid transitions of the eye from one point to another. The movement of the eye to the right and left, during which the eye does not perceive new information, is called a saccade. When this movement progresses forward, it is referred to as a progressive saccade, and when it moves backward, it is called a regressive saccade. The eye movement from the end of one line to the beginning of the next is known as a return sweep. Lastly, the movement in which the eye remains stable and perceives new information is called fixation (Ayhan, 2019). Fixations are the moments when the eye is fixed at a certain point and visual information is processed during this time. The average fixation duration is 200-250 milliseconds (Castelhano and Rayner, 2008). Regressions are the movements of the eye back to the previous words or sentences during reading, that is, eye movements in the opposite direction to normal reading. Regressions constitute 15-25% of eye movements during normal reading (Rayner and Pollatsek, 1989).

Although eye movements allow a microscopic examination of the reading process, they play a crucial role in understanding reading behavior. Advances in eye-tracking technologies have enabled us to study readers' eye movements and their role in the comprehension process in detail (D'Mello et al., 2020). Ye et al. (2022) and Jamil et al. (2023) examined the relationship between eye movements and brain activation in detail using fMRI technology and provided evidence supporting this relationship. It is seen that eye movements are a sensitive indicator of cognitive movements in the reading process and are therefore closely related to the comprehension process (Castelhano and Rayner, 2008). Studies in this field show that eye movements will be useful in explaining not only word tracking on the text but also processes such as reading fluency, reading comprehension and processing.

Researchers are particularly interested in eye movements, a relatively new area of study, and how they relate to various aspects of reading. Studies have investigated the relationship/interaction between eye movements and variables such as homophones (Jared and Bainbridge, 2017), reading practices in adults (Mantei and Kervin, 2016), dyslexia and other language-related processes (Huettig & Brouwer, 2015), and memory and attention (Hernandez et al., 2017). The importance of eye movements in the reading process is not only limited to individual reading skills, but also contributes to the development of reading instruction and intervention programmes (Fella vd., 2023). The fact that the studies conducted are mostly in clinical settings is an indication that they are addressed after the problem occurs. However, conducting earlier and predictive studies periodically can provide an opportunity to take precautions before many problems arise. From this point of view, investigating the explanatory and predictive relationships between eye-tracking technology and variables related to students' reading and comprehension provides a unique resource for educators at the point of planning educational environments and taking measures. When the studies in Türkiye on the subject are examined, it is seen that eye-tracking technology is mostly focused on information systems, web design, e-commerce (Akgüngör et al., 2011; Bayram and Yeni, 2011; Özdoğan, 2008; Yeniad et al., 2011). In the studies on reading, on the other hand, topics such as italic writing-plain writing, reading texts (Karaman et al., 2016), the effect of page design on the directivity of reading in newspaper reading behaviour (Onursoy et al., 2010) were studied. However, the process of learning reading skills and the subsequent process of forming the purpose of reading to obtain information is a time interval that is decisive on the future of our children. The number of studies conducted with children during this time interval, where different variables of reading are examined in detail, is nearly nonexistent. More studies are needed to reveal the extent to which the variables of eye-tracking obtained with the support of technology have an effect on reading skills or to make inferences about what kind of problems they can be used to predict.

The role of eye movements in the reading process helps us to understand how readers interact with the text. In particular, eye movement parameters such as fixation duration, saccade length and regression number reveal the reader's difficulties and strategies in the process of making sense of the text (Bouma, 2022). While Hautala et al. (2024) emphasised the effect of saccadic movements on

reading speed, Veenendaal et al. (2016) examined the effect of eye movements on reading prosody, phonological awareness and comprehension. Moreover, readers' eye movement patterns vary depending on the difficulty of the text and the reader's knowledge (Van den Broek and Helder, 2017). When we look at the subject from different perspectives, the eye movements of individuals with reading difficulties show significant differences from normal readers. Students with dyslexia exhibit more regression and longer fixation periods, indicating that these students have more difficulty in the reading process (Bonifacci et al., 2023).

Prior to eye-tracking technology, researchers have neglected the relevance of certain eye movement behaviours during reading to text decoding and comprehension. For instance, readers allocate approximately 10% to 15% of their reading time to regressions in eye movements. The average fixation duration within a word or saccade length varies according to the function of the word (novelty, familiarity, strangeness, ambiguity, or relevance) (Rayner, 1993). In relation to these eye movement parameters, readers are categorised as: a) proactive readers (long saccades, many regressions) and b) conservative readers (short saccades, few regressions). The reading strategies used by both are related to low or high levels of reading experience, respectively (Koornneef and Mulders, 2017; Vorstius et al., 2014).

Most eye-tracking research on reading has focused on textual (i.e., literary) comprehension and is usually assessed by reading sentences (Barnes and Kim, 2016; Booth and Weger, 2013; Rayner, 1993; Vorstius et al., 2014). On the other hand, longer studies (i.e. fairy tales, scientific reports) and inferential questions are also used to investigate reading comprehension (Koornneef and Mulders, 2017). However, proactive readers show higher reading comprehension than conservative readers, despite the length of the text (short or long) and the complexity of the question (literary, textual or inferential). Related to the subject, Krstić et al. (2018) conducted a study to assess eye movement during reading with 15-year-old students with low and high reading skills in the PISA test; scores in reading speed (number of words read per minute) and reading comprehension capacities were used to classify reading skills. According to the results of the study, it was found that students with high reading skills performed better on text-dependent and inferential comprehension questions than students with low reading skills. As in other studies, saccade width (length) and regression percentage were found to be higher in students with higher reading skills (Koornneef and Mulders, 2017). According to eye movement patterns, the groups differed according to the complexity of the texts and questions. On the other hand, the eye movements of readers with low reading skills showed more variability and irregularities were observed.

Although these studies have established a link between eye movements and reading skills at a certain level, it is not clear enough how fluent readers' eye movements are and how this situation is related to comprehension. In this context, this study investigated the causal relationship between the eye movements of 3rd grade primary school students during reading and how they affect reading fluency and reading comprehension. Students' reading speed, reading comprehension skills and eye movements during reading were analysed by means of "eye-tracking device".

In terms of scope, third grade primary school students were asked to read a narrative text; reading and monitoring were carried out individually. In the study, students' fluent reading skills, reading comprehension and eye movements during reading were evaluated; possible relationships between the variables of reading aloud, fluent reading, reading comprehension and the variables of focusing time, time until the first focusing, duration of the first focusing, number of focusing, the coordinate of each focusing point on the screen in pixels, the distance of the user to the screen during recording were investigated.

Method

Research Design

The research was conducted in the survey model. Firstly, the students were made to read aloud over the given text through the eye-tracking device. The eye-tracking device is integrated with a computer and a monitor. The students read on the computer screen (monitor) and the application was carried out individually for each student. The duration of the application for a student was approximately 4-8 minutes. In the second stage, students were given comprehension questions about the text they read.

After the data were collected, the data obtained from reading aloud, reading comprehension and eye-tracking device were analysed comparatively and causally.

Participants

The study was conducted with 284 third grade students studying in a public primary school in Istanbul. The necessary permissions for the study were obtained from the Provincial Directorate of National Education. Through the measurement results obtained from the research, it was aimed to reveal how the eye movements of 3rd grade primary school students during reading affect reading fluency and reading comprehension. The study was conducted with third-grade primary school pupils, as they are in the critical age range for observing the development of reading behavior.

Data Collection and Analysis Process

Within the scope of the study, a 200-word narrative text was used to collect data. The students read the texts aloud and their reading was recorded with an eye-tracking device. From these records, students' eye movements during reading, reading speed and correct word recognition percentages were measured. After the eye-tracking device recording, students' reading comprehension was measured with questions prepared for the reading text. The applications were carried out individually and the eye-tracking device was calibrated separately for each student at the beginning of the application to ensure that the data of the study was reliable. In order not to distract the students' attention, the applications were carried out in a simple and quiet environment, and a structure suitable for the natural reading styles of the students were created.

The "Error Analysis Inventory" adapted into Turkish by Akyol (2013) was used to analyse the student's reading and comprehension levels. For this inventory, the student's reading speed, correct reading and comprehension percentage are calculated according to the following formulae.

Reading Speed: (1 min X Number of words read correctly) ÷ (Time to read the whole text)

Accuracy Percentage: (Number of words read correctly X 100) ÷ (Total number of words in the text)

Percentage of Understanding: (Points received X 100) ÷ (Full points)

Comprehension questions consist of two types of questions as surface and deep comprehension. In the students' responses to simple comprehension-level questions, 2 points were awarded for complete answers, 1 point for partial answers, and 0 points for unanswered questions. Similarly, in their responses to deep comprehension-level questions, 3 points were awarded for complete and effective answers, 2 points for slightly incomplete answers that still contained the expected response, 1 point for partial answers, and 0 points for unanswered questions.

The eye movements of the student during reading aloud were recorded with the SMI device and these were transcribed and converted into analysis data for analysis. The data obtained from reading speed, correct word recognition, reading comprehension and eye movements were analysed using descriptive and comparative tests and structural equation modeling using AMOS 23.0 software.

Findings

Table 1. Frequency and percentage distribution for the gender variable

Gender	f	%
Female	130	45.8
Male	154	54.2
Total	284	100.0

Of the students participating in the study, 45.8% (n=130) were female and 54.2% (n=154) were male. A total of 284 third grade primary school students participated in the study.

Table 2. Descriptive statistics of the variables analysed in the study

	N	Mean	Std. Deviation
Reading Speed	284	87.51	32.48
Accurate Reading	284	94.98	5.03
Simple Comprehension	284	3.2	2.29
Inferential Comprehension	284	3.7	1.34
Total Comprehension	284	6.83	3.09
Focusing Time	284	245.85	65.51
Saccading Time	284	249.52	68.42
Average Blink Duration	284	294.48	441.88
Total	284		

Table 2 shows the descriptive statistics of the students participating in the study regarding the variables in the study. Accordingly, the mean reading speed of the students was 87.51, the mean accurate reading rate of the students was 94.98, the mean simple comprehension level was 3.2, the mean inferential comprehension level was 3.7, and the mean total comprehension level was 6.83. Accordingly, the reading speed of the students is at an average level according to the grade level. On the other hand, students' accurate reading levels are below the expected level. In addition, students' reading comprehension levels are low. According to the measurement tool used in the research, the min-max score range that students should get is between 0-15. The mean focusing time of the students during reading was found to be 245.85; the mean saccading time was found to be 249.52; and the mean blinking time was found to be 294.48.

Table 3. Correlational relationships between fluent reading, reading comprehension and eye movements

1.	Reading Speed	r	1	2	3	4	5	6	7	8
2.	Accurate Reading	r	.454**	1						
3.	Simple Comprehension	r	.240**	.245**	1					
4.	Inferential Comprehension	r	.326**	.333**	.402**	1				
5.	Total Comprehension	r	.320**	.327**	.917**	.734**	1			
6.	Focusing Time	r	-.372**	-.348**	-.096	-.162**	-.142*	1		
7.	Saccading Time	r	-.360**	-.347**	-.091	-.149*	-.132*	.992**	1	
8.	Average Blink Duration	r	-.130*	-.052	-.037	-.046	-.047	.191**	.171**	1
		N	284	284	284	284	284	284	284	284

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 3 shows the correlational relationships between the variables in the study. Accordingly, medium-level (r = .46) and significant relationships were found between reading speed and accurate reading; low-level (r = .24) and significant relationships between reading speed and simple comprehension; low-level (r = .33) and significant relationships between reading speed and inferential comprehension; and low-level (r = .32) and significant relationships between reading speed and total comprehension. All relationships were positive. Accordingly, as reading speed increases, reading accuracy, simple comprehension, inferential comprehension and total comprehension levels also increase.

There were medium (r= -.37) and significant relationships between reading speed and focusing time; low (r= -.36) and significant relationships between reading speed and saccading time; low (r=-.13) and significant relationships between reading speed and blinking time. All relationships were negative. Accordingly, as reading speed increases, focusing time, saccading time and blinking time decrease.

Low level (r= .25) and significant relationships were found between accurate reading and simple comprehension level; low level (r= .33) and significant relationships were found between accurate reading and inferential comprehension level; low level (r= .33) and significant relationships were found

between accurate reading and total comprehension level. All relationships were positive. Accordingly, as the percentage of correct reading increases, simple comprehension, inferential comprehension and total comprehension levels also increase.

Low level (r= -.35) and significant, low level (r= -.35) and significant, low level (r= -.05) and insignificant relationships were found between accurate reading and focusing time, saccading time and blinking time. All relationships were negative. Accordingly, as the percentage of accurate reading increases, focusing time, saccading time and blinking time decrease.

There were medium level (r= .40) and significant relationships between simple comprehension and inferential comprehension level, and high level (r= .92) and significant relationships between simple comprehension and total comprehension level. All relationships are positive. Accordingly, as the students' simple comprehension level increases, their inferential comprehension and total comprehension levels also increase.

Low level (r= -.09) and insignificant relationships were found between simple comprehension and focusing time; low level (r= -.09) and insignificant relationships were found between simple comprehension and saccading time; and low level (r= -.03) and insignificant relationships were found between simple comprehension and blinking time. All relationships were negative. Accordingly, focusing time, saccading time and blinking time were not significantly related to simple comprehension.

A positive, high level (r= .73) and significant relationship was found between inferential comprehension level and total comprehension level. Accordingly, as the inferential comprehension level of the students increases, their total comprehension level also increases.

Low level (r= -.16) and insignificant relationships were found between inferential comprehension and focusing time; low level (r= -.15) and insignificant relationships were found between inferential comprehension and saccading time; and low level (r= -.04) and insignificant relationships were found between inferential comprehension and blinking time. All relationships were negative. Accordingly, as inferential comprehension increases, focusing time, saccading time and blinking time decrease.

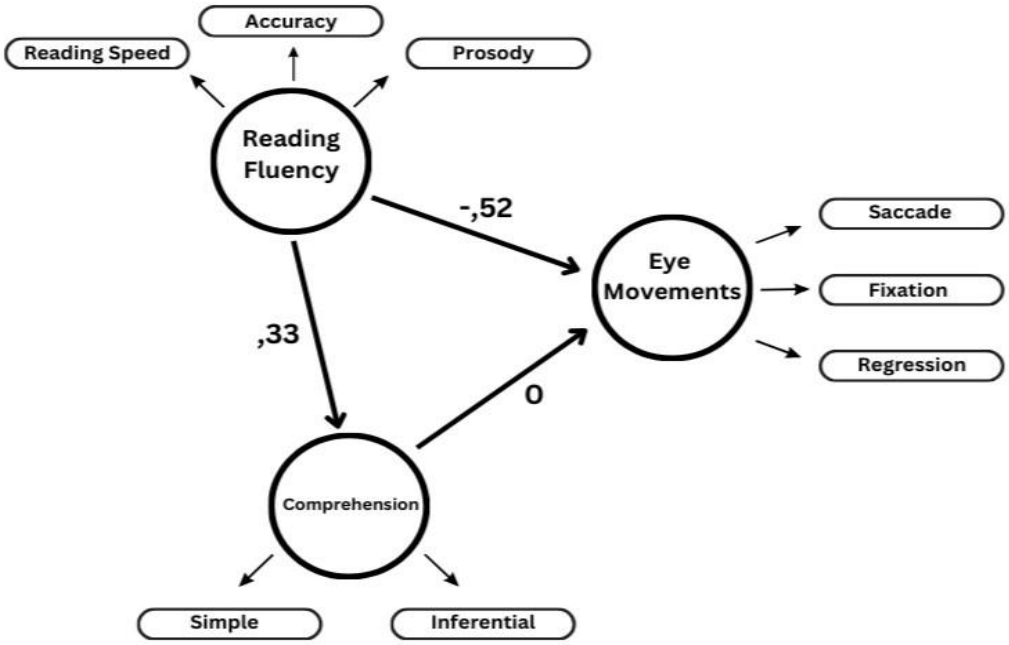

Figure 1. Structural model

Table 4. Fit indices and acceptance intervals for the structural relationship model between reading fluency, eye movements and reading comprehension

Fit Indices	Good Fit	Acceptable	Structural model
RMSEA	0<REMSEA<0.05	0.05 ≤ RMSEA ≤	0.048
NFI	0.95 ≤ NFI ≤1	0.90≤ NFI ≤ 0.95	0.99
GFI	0.95 ≤ GFI ≤1	0.90≤ GFI ≤ 0.95	0.99
AGFI	0.90 ≤ AGFI ≤1	0.85≤ AGFI ≤ 0.9	0.97
χX2/df 0<χX2/df<3 0<χX2/df<5 10.121 /11=.92; (p=.000).			

*Schermelleh-Engel, Moosbrugger, and Müller (2003).

Table 4 shows the fit indices of the model. Accordingly, the RMSEA value for the model was found to be 0.04. Among the other indices, NFI was .99, GFI was .99 and AGFI was .97. These values show that the fit values of the model are acceptable and have good fit.

Table 5. Regression weights

			Estimate	S.E.	C.R.	P
Eye Movements	<---	Reading	-1.522	.249	-6.112	***
Comprehension	<---	Eye	.002	.001	1.717	.086
Comprehension	<---	Reading	.033	.006	5.135	***
Reading Speed	<---	Reading	1.000			
Accurate Reading	<---	Reading	.147	.020	7.434	***
Focusing Time	<---	Eye	1.000			
Saccading Time	<---	Eye	1.008	.017	58.350	***
Blink Duration	<---	Eye	1.403	.376	3.728	***
Inferential Comprehension	<---	Comprehension	1.000			
Simple Comprehension	<---	Comprehension	1.251	.256	4.892	***

Table 5 shows the path coefficients of the model tested in the study. Accordingly, the relationship between fluent reading and reading comprehension and eye movements is significant. However, the path coefficient from eye movements to reading comprehension was not significant.

Discussion, Conclusion and Suggestions

This study was conducted to examine the structural relationship between focusing, fluent reading and reading comprehension through eye-tracking devices. Within the scope of the research, although it was initially aimed to examine the relationship between fluent reading and reading comprehension and focusing, other eye movement data from the eye-tracking device were also handled during the research process and blinking and saccading movements were also examined along with focusing. All of these components together were evaluated as “eye movements” in the research.

Accordingly, positive relationships were found between accurate reading, reading speed and reading comprehension. A positive development in one of these skills also showed an increase in the others. These results coincide with other studies in the literature (Baştuğ and Akyol, 2012; Baştuğ and Keskin, 2012; Foorman et al., 2015, Padeliadu and Antoniou, 2013, Price et al., 2016; Quirk and Beem, 2012; Yıldırım, 2013). In these studies, positive relationships were found between fluent reading skills and reading comprehension. This is explained on the basis that students read the words in the text with a certain automaticity and allocate the necessary number of mental resources to comprehension (LaBerge and Samuels, 1974). The development of fluent reading skills points to the development of reading comprehension skills.

When the results related to the model between fluent reading, eye movements and reading comprehension skills were analysed, the paths between fluent reading, eye movements and reading comprehension were found to be significant. On the other hand, the path between eye movements and reading comprehension was not significant. Concerning the model, the fit indices are at an acceptable

level. The relationships in this direction were analysed in detail. Accordingly, significant negative relationships were found between eye movements and reading accuracy and reading speed. As students' fluent reading skills increase, the functionality in eye movements decreases. As reading speed increases, the number and duration of focussing, blinking and saccading decreases. This suggests that as reading speed increases, students spend less time focusing, blinking, and saccading on each word and sentence. Similarly, as students' accuracy in reading improves, their focusing, blinking, and saccading times decrease. As the correct reading percentages increase, the parameters of the students' eye movements decrease. Readers with low reading fluency skills make more regressions during reading and their looking on what they read is damaged (Barnes and Kim, 2016; Booth and Weger, 2013; Koornneef and Mulders, 2017; Vorstius et al., 2014). On the other hand, no relationship was found between students' reading comprehension skills and eye movements. Accordingly, the patterns of eye movements in reading do not seem to be related to reading comprehension. This may be due to the fact that reading comprehension is related to other variables such as vocabulary, comprehension strategy, and affective factors in reading besides reading fluency and eye movements.

Eye movements play a critical role in explaining word recognition and text comprehension processes (Rayner, 1998; Raney et al., 2014). Blythe and Joseph (2019) state that it is possible to evaluate eye-tracking technology as an objective tool that can be used in the early diagnosis of reading difficulties. It has been observed that strategies to be developed for students in reading skills and reading fluency increase students' success (Bigozzi et al., 2017). Southwell et al. (2020) study shows that eye movements play an important role in reading comprehension. Accurate analysis of eye movements can help to develop effective strategies in the education of individuals with reading disorders or reading difficulties.

Eye-tracking technology has revolutionised the field of reading research by providing precise and real-time data on eye movements that serve as indicators of cognitive processes during reading. This technology allows researchers to measure various eye movement parameters during reading, such as focusing time, saccade length, and regression rates, which can help explain some of the cognitive mechanisms involved in reading (Çorbacı and Kahraman, 2022). Today, we can say that there are two types of eye-tracking devices, one of which is wearable in the form of glasses, and the other is a device that works simultaneously with a computer and a screen.

The applications of eye-tracking technology in reading research are diverse. Van Der Sluis and Van Den Broek (2022) state that eye-tracking technology is effective in determining the comprehension and interest levels of individuals more accurately during reading. Their research used the participants' eye movements during reading as an important indicator of how much they interacted with the text and their interest in the text in certain sections. In particular, it is emphasised that as the difficulty of the text increases, the eye movements of the participants increase. By analysing eye movements, researchers can gain insight into how readers distribute their attention, how they process information and how they make inferences during reading, thus expanding our understanding of the reading process.

As a result of this research, basically three hypotheses were tested. The first of these hypotheses is that there is a positive and significant relationship between fluent reading skills and reading comprehension. This hypothesis was confirmed. This finding is consistent with many studies in literature. In the longitudinal study conducted by Kim and Wagner (2015), it was revealed that reading fluency has a direct effect on reading comprehension. Similarly, Rasinski et al. (2016) stated that reading fluency is a strong predictor of reading comprehension. In studies conducted in Türkiye, Yıldız and Çetinkaya (2017) found that fluent reading skills explained approximately 25% of reading comprehension performance. This shows that the automatisation of word recognition in the reading process allows the reader to direct cognitive resources to the comprehension process. In their large-scale experimental study, Ecalle et al. (2020) stated that first-grade students' reading comprehension skills were also strengthened immediately after they became fluent readers after the intervention. Fuchs et al. (2012) stated that interventions for reading fluency are especially important for beginning students. It is also emphasised that there is a strong relationship between reading fluency and reading comprehension. By improving students' reading skills, they can better understand what they read. In this context, increasing reading fluency can help students understand the text more effectively.

The relationship between reading fluency and comprehension is particularly striking. Studies have shown that fluent readers tend to understand texts better than their less fluent peers. This interaction between fluency and comprehension emphasises the need for targeted instructional strategies that develop both skills simultaneously. The automaticity theory proposed by LaBerge and Samuels (1974) also supports this finding. According to this theory, when word recognition becomes automatic in the reading process, the individual can allocate more cognitive resources to extract the meaning of the text. This situation contributes to an increase in reading comprehension levels. Other studies in the literature (Baştuğ and Akyol, 2012; Foorman et al., 2015) also support these findings. In these studies, it is seen that fluent reading skills have a strong effect on reading comprehension and that these two skills support each other. Kim et al. (2012) show that the interaction between reading fluency and reading comprehension increases significantly from 1st to 2nd grade. In particular, it was observed that as reading fluency increased, students' reading comprehension skills also improved. This suggests that students' reading speed and accurate reading skills support their comprehension processes and facilitate comprehension. It was also emphasised that understanding this relationship would be useful in recognising students' reading difficulties and developing teaching strategies.

The second hypothesis of the study was that there is a significant negative relationship between fluent reading skills and eye movements. This hypothesis was also confirmed. This finding can be interpreted as the fact that as the reading speed increases, readers focus less on each word and sentence and make less backtracking. This shows that individuals who have a higher fluency in the reading process can scan the text faster and more fluently. In a study conducted by Schotter et al. (2012), it was found that individuals with advanced reading skills exhibited more effective eye movements and had fewer backward movements in reading. Similarly, Vorstius et al. (2014) found that the eye movements of fluent readers were less complex and more regular. Cheng et al. (2021) stated that as reading fluency increases, fewer reversals in eye movements and faster reading are observed. These findings suggest that eye movements are an important indicator for analysing reading skills and support the negative relationship found in this study.

Temereanca et al. (2012) emphasise in their study that fluent readers exhibit efficient eye movement patterns, characterised by longer eye movements and shorter fixations, which facilitate faster word recognition and comprehension. This efficiency is important for maintaining reading flow as it minimises cognitive load and allows readers to devote more cognitive resources to text comprehension. They also stated that deficits in eye movement control can lead to impaired reading skills, especially in individuals with dyslexia and other reading disorders, and that interventions aimed at improving eye movement coordination will contribute to reading fluency and overall reading comprehension.

Other studies have shown that increased sentence complexity leads to longer fixation durations and more regressions, resulting in greater cognitive load on the reader (Dirix et al., 2020). Similarly, researchers have used eye-tracking tools to investigate the effects of word frequency and predictability on reading behaviour and found that high-frequency words are processed faster, leading to shorter fixations (Kaakinen and Hyönä, 2010). These experimental studies allow researchers to link eye movement measurements to reading outcomes, providing valuable insights into the cognitive processes involved in reading fluency and comprehension. It is observed that as the reading speed of readers increases, their fixation time naturally decreases (Yıldız et al., 2024). Repeated reading exercises in which the same text is read multiple times can increase fluency and reduce fixation times, allowing more cognitive resources to be allocated to comprehension tasks. Language skills can significantly affect the regularity of eye movements during reading. In particular, individuals with high language skills process sentences faster and more accurately, while individuals with low language skills spend more time and attention in the reading process (Kuperman and Dyke, 2011).

The third hypothesis of the study is that there is a significant negative relationship between eye movements and reading comprehension. This hypothesis could not be confirmed. This shows that eye movement parameters alone are not sufficient to explain reading comprehension. While this result contradicts some research findings, it is consistent with some others. Pan et al. (2022) argue that eye movement patterns can predict reading comprehension performance. As Perfetti and Stafura (2014) stated in their reading systems framework theory, the reading process is not limited to visual perception and eye movements but involves the interaction of multiple components such as word recognition,

syntactic processing, and meaning construction. The reading comprehension process is under the influence of many variables such as vocabulary knowledge, comprehension strategies and affective factors. Therefore, although eye movements provide some clues about the comprehension process, they are not sufficient to explain all the components of this process. Abundis-Gutiérrez et al. (2018) also supported this finding and revealed that eye movements do not have a direct effect on reading comprehension. Medland et al. (2010) investigated the interaction between reading speed, comprehension and eye movements and found that these factors are intricately linked. In their study, the relationship between reading speed and comprehension is complex because while increased speed usually leads to increased fluency, it is not always associated with higher levels of comprehension. It appears that eye movement measures can be helpful in understanding the development of reading skills and reading difficulties, but a broader evaluation and consideration of other factors is needed.

Understanding eye movement patterns during reading can significantly improve instructional strategies in educational settings. Eye-tracking studies have revealed that individual differences in eye movement behaviours such as fixation duration and regression rates are related to reading proficiency and comprehension outcomes. For example, in this study, children with stronger vocabulary knowledge were able to read the text faster and made fewer regressions. In contrast, children with weaker vocabulary knowledge showed more pauses and regressions. This suggests that vocabulary knowledge is directly related to reading speed and efficiency (Luke et al., 2015). By analysing eye movement patterns, specific areas where students may need additional support can be identified and more personalised and effective reading instruction can be provided. Raney et al. (2014) investigated the effect of sentence complexity on eye movements and found that more complex sentences lead to longer fixation times and increased regression rates. Their research showed that when readers encounter syntactically complex structures, they often need to devote additional cognitive resources to decoding the information, leading to a slower reading speed. This increased cognitive load can lead to eye movement behaviours such as more frequent regressions to re-read sections of text for clarification.

Integrating eye movement training with traditional reading interventions can create a comprehensive support system for struggling readers. For example, combining eye movement training with phoneme recognition training or vocabulary development can allow us to address multiple aspects of reading difficulties simultaneously (Krieber et al., 2016). This holistic approach not only targets the mechanical aspects of reading, but also promotes a deeper understanding of the text, ultimately improving overall literacy skills. Furthermore, researchers should examine the impact of technologies such as digital reading platforms on eye movements and reading comprehension. As reading increasingly takes place in digital formats, it is important to understand how these platforms influence reading behaviours and outcomes (Tsou, 2011).

The results of the research show that by using eye movement analyses in reading instruction, students' reading difficulties can be better understood and personalised instructional strategies can be developed. In particular, training programmes aimed at developing fluent reading skills can positively affect students' reading comprehension levels by increasing their reading speed and accuracy. However, given that eye movements do not have a direct effect on reading comprehension, it is concluded that other components of reading skills should also be focused on. The findings of the study show that the reading process has a multifaceted structure and that components such as reading fluency, reading strategies and eye movements are in complex relationships with each other in this process. For this reason, it is recommended to develop approaches for the individual needs of students in reading instruction and to support these approaches with technology-based methods.

Despite advances in eye-tracking technology and its applications in reading research, several challenges and limitations remain. One important challenge is the variability in individual reading skills and strategies that can influence eye movement patterns. For example, differences in cognitive skills such as working memory and language proficiency can lead to variability in how individuals process text and how they are distracted (Tywoniw, 2023). This variability can complicate the interpretation of eye movement data because it can be difficult to determine whether observed differences are due to experimental manipulation or to individual differences between participants.

The results of this study showed that while fluent reading skills affect eye movements and reading comprehension, eye movements have no role in reading comprehension. The results of the research brought a new perspective on reading comprehension and reading fluency, especially theoretically, through the variable of eye movements. Conducting similar studies at different grade levels and with larger sample groups on different variables will increase the generalisability of the findings. Secondly, it is suggested that sub-variables (e.g. working memory, vocabulary) that may affect the relationship between eye movements and reading comprehension should be examined. Finally, a comparative analysis of eye movements of students with and without reading difficulties will contribute to the diagnosis and intervention processes.

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