The Impact of Reading Modalities and Text Types on Reading in School-Age Children: An Eye-tracking Study

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Article

The Impact of Reading Modalities and Text Types on Reading in School-Age Children: An Eye-tracking Study

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Abstract: This study examined the eye movement patterns of 317 elementary students across reading conditions (audio-assisted reading (AR) and reading-only (R)) and text types (fiction and non-fiction), and identified eye movement parameters that predict their literal comprehension (LC) and inferential comprehension (IC). Participants, randomly assigned to either reading condition and either text type, answered questions assessing their LC and IC. Average fixation duration (AFD), total fixation duration (TFD), and scanpath length were used as eye movement parameters. There were main effects of age on all parameters and interaction effects between age and reading condition on TFD and scanpath length. Controlling for age, TFD had a positive impact on LC of both text types in the AR, while under the R, it affected negatively on IC of both text types. Longer scanpaths predicted IC of fiction in the AR, LC and IC of non-fiction under the AR, and LC of non-fiction within the R. AFD influenced negatively on IC of fiction in the AR, LC and IC of non-fiction in the AR, and LC of non-fiction under the R. These eye movement patterns and predictors indicate children employ different reading strategies based on reading modalities and text types.

Keywords: eye-tracking; reading modality; audio-assisted reading; text type; reading comprehension; school-age children

1. Introduction

Reading is a critical ability in current society, as it enables individuals to successfully acquire information through media and provides opportunities for personal growth as well as emotional development through vicarious experiences [1,2]. The importance of reading during the school-age years is particularly prominent, not only because this phase corresponds to the development of one's self-system, which is closely intertwined with reading proficiency [3], but also because reading skills predict academic achievement due to the utilization of text-based educational materials in schools [4].

Reading comprehension is an intricate skill that integrates various linguistic and cognitive components [5,6]. Kim [7] suggested that reading comprehension has a direct relationship with listening comprehension as well as word reading skills, which is influenced by linguistic factors, such as phonology, orthography, and semantics, and higher-order cognition and oral language skills, including but not limited to inferring, reasoning, monitoring, syntax and vocabulary, respectively. Reading comprehension is divided into two types: literal comprehension and inferential comprehension. Literal comprehension involves understanding specific events explicitly presented in the text, while inferential comprehension is achieved through deducing information from the text [8]. Literal comprehension begins to develop at the beginning of school age, primarily supported by word reading and vocabulary skills [9–11]. Inferential comprehension, building upon literal comprehension, is known to be an advanced reading comprehension skill that evolves throughout

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the school age, as it requires the facilitation of background knowledge and integration of information beyond simple word reading [12–14].

Audio-assisted reading (AR), in which individuals read text while listening to the corresponding audio, is one of the reading modalities proposed to enhance the reading comprehension of poor readers. Previous studies have demonstrated that audio assistance helps them engage more effectively with the text and utilize their cognitive strengths with improved semantic chunking. Under the AR condition, automatic reading, facilitated by the reduced cognitive load in decoding words, allows them to allocate more of their attention to understanding the content of text as compared to the reading-only (R) condition [15–18]. However, there remains a debate about whether all school-age children can benefit from AR, as the AR condition could potentially lead to an increased cognitive load by necessitating the simultaneous processing of visual and auditory stimuli [19,20].

The type of text, broadly consisting of two types—fictional (narrative) and non-fictional (expository)—is also acknowledged to have an impact on reading comprehension [21–23]. Fictional text that young readers typically encounter from early childhood is often presented in a sequential manner. This inherent structure helps young children to understand the story more easily, given the similarity between the narrative progression and the development of real-life events they experience [24]. On the other hand, non-fictional text requires more time for reading and comprehension compared to fictional text due to the unfamiliarity of the subject matter and the complexity of sentence structures [25,26]. Hence, reading comprehension of fictional text tends to be comparatively simpler for school-age children than for non-fictional text [22]. Additionally, as children grow older, their comprehension of fictional text can readily improve compared to that of non-fictional text, because recognizing the causal relationship between events is often sufficient for comprehension. In contrast, non-fictional text demands more structured training, including syntactic comprehension and background knowledge, to be effectively comprehended beyond merely understanding causality [27,28].

Chung et al. [29] investigated the impact of various story presentation methods (audio-only, audio-with-text, and text-only) and story types (fiction and non-fiction) on the comprehension of first- and second-grade students. Consistent with previous research, children demonstrated better comprehension of the fictional stories than of the non-fictional stories, and performance on literal comprehension tasks exceeded that on inferential comprehension tasks. Regarding the story presentation methods, overall comprehension scores of the fictional stories in the audio-only condition and the audio-with-text condition were found to be significantly greater than those in the third condition. In terms of non-fictional stories, only the audio-with-text condition exhibited higher comprehension scores compared to the condition with reading only. These results suggest how 6- to 8-year-old children can benefit from AR with both fictional and non-fictional stories, surpassing the R condition. Moreover, the effects of the story presentation methods may differ depending on the text type.

The eye-tracking technique involves analyzing the dynamic traces created by eye movements to detect one's attention and cognitive processes [30]. This method was developed from the Eye-Mind Theory, which suggests that visual processing occurs at a site where gazes are fixated [31]. When utilized in reading comprehension tasks, the eye-tracking technique provides insights into the process of information acquisition from text.

Previous research explored the relationship between eye movement patterns and reading proficiency, revealing that shorter fixation duration and fewer fixation counts are indicators of proficient reading [32]. Many studies examined the connection between reading skills and eye movement patterns by comparing children across various age groups and demonstrated that older students exhibit shorter fixation per word, shorter average fixation durations [33,34], and more frequent long saccades [35] compared to their younger counterparts. However, only a few studies consider spatial aspects of eye movement patterns, and research that investigates a wide age range to observe continuous changes in eye movement patterns over time is limited.

There is scant research related to reading and auditory input using eye-tracking technology. Conklin et al. [36] studied the links between reading proficiency and eye movement patterns under

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different reading conditions, AR and R, by comparing speakers of first language (L1) and second language (L2). They found that L2 readers showed more frequent fixations and longer fixation durations than L1 readers in the R condition, while there were no significant differences in eye movement parameters between L1 and L2 readers in the AR condition, thus demonstrating the positive effect of audio assistance for developing readers. However, it needs to be discussed whether these differences in eye movement patterns under the AR condition directly indicate improved reading comprehension.

Park et al. [37] aimed to determine whether language competency affects the relationship between eye movement patterns and reading comprehension with different reading modalities. They examined reading comprehension of typically developing (TD) children and children with language impairment (LI) in Grades 1 and 2 according to reading modalities (AR and R) and the correlations between reading comprehension and eye movement parameters of both groups in each reading condition. Both in the AR and R conditions, TD children performed better in reading comprehension than children with LI. Total fixation duration in the screen, total fixation duration within Areas of Interest (AOIs), or sentence areas in the screen, and scanpath length were selected as the eye movement parameters for the study. Total fixation duration within AOIs and scanpath length had significant positive correlations with story comprehension in the AR condition among TD children, whereas among children with LI, only scanpath length emerged as a significant variable that had a positive correlation with story comprehension. Under the R condition, total fixation durations in the screen and within AOIs showed negative correlations with comprehension scores in the TD group. In contrast, in the LI group, no significant correlations between reading comprehension and eye movement parameters were observed. This disparity in the correlations between comprehension scores and eye movement parameters based on the reading modality implies that children with varying levels of language proficiency may process information in text differently depending on the availability of audio assistance.

Several studies uncovered how readers approach text based on its difficulty level. In the case of challenging texts, such as those with an enactive style, readers tend to exhibit longer reading time, extended fixation durations, increased fixation counts, and reduced word skipping [38,39]. Also, they engage in more frequent retrospective glances and allocate more time to revisit prior sentences compared to easier texts [40]. Nevertheless, there are limited studies that examine how text type influences the eye movements of school-age children and how these eye movement patterns impact their reading comprehension.

In this study, we aimed to identify the differences in eye movement patterns, both temporal and spatial, among elementary school students ranging from Grades 1 to 6, based on reading conditions (modalities), AR and R, and text types, fiction and non-fiction. Additionally, we sought to understand the impact of these eye movement patterns within each reading condition and text type on their literal and inferential reading comprehension. Therefore, the research questions are as follows:

1. Are there differences in eye movement parameters (average and total fixation durations and scanpath length) among different age groups according to reading conditions and text types?
2. Which eye movement parameters can predict literal and inferential reading comprehension in elementary school children within each reading condition and text type?

2. Materials and Methods

2.1. Participants

A total of 364 children (187 males and 177 females) from Grades 1 to 6, who were enrolled in a private elementary school in Seoul, participated in this study. The study obtained written consent from both parents and children through notices sent to parents. Among them, 40 children were excluded from the research due to not meeting the language proficiency criteria after screening. An additional seven were excluded from the study for not meeting the criteria for non-verbal intelligence after screening. Consequently, the final eligible sample consisted of 317 children who successfully completed the tasks.

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The study's inclusion criteria were as follows: (1) Enrollment in Grades 1 to 6 in an elementary school, (2) Achievement of a 10th percentile or higher in both receptive and expressive vocabulary as measured by the Receptive & Expressive Vocabulary Test [41] (3) Attainment of a standard score of 85 points or higher in the nonverbal intelligence test component of Kaufman Brief Intelligence Test-2nd edition [42], (4) Demonstration of appropriate reading abilities suitable for engaging with the text in the reading tasks, and (5) No reports from parents or teachers indicating any presence of intellectual, visual, auditory, emotional, behavioral, or neurological problems.

All eligible children participated in two reading tasks, conducted under both the AR and R conditions. The text types employed for these tasks differed depending on the reading condition. For example, if a child was provided fictional text in the AR condition, non-fictional text was presented during the R condition, and vice versa. These combinations of text types and reading conditions were randomly assigned to participants.

As a result, the initial total sample size amounted to 634 participants. However, due to missing values, attributed to calibration issues or fatigue, a total of 65 samples were excluded from the analysis. Participants' characteristics in each group are presented in Table 1.

Table 1. Participants' characteristics. Values are presented as mean (SD). AR: Audio-assisted reading, R: Reading-only.

Grade	Reading condition	Text type	N	Age	Non-verbal intelligence[1]	Receptive vocabulary[2]	Expressive vocabulary[2]
1	AR	Fiction	11	81.73	115.25	80.64	83.09
			(M=1, F=10)	(3.07)	(23.29)	(14.12)	(13.16)
		Non-fiction	27	81.33	118.47	87.19	84.44
			(M=13, F=14)	(3.55)	(13.31)	(17.77)	(19.18)
	R	Fiction	26	81.38	118.47	86.92	84.69
			(M=13, F=13)	(3.61)	(13.31)	(18.06)	(19.52)
		Non-fiction	12	81.25	115.00	80.25	83.42
			(M=2, F=10)	(3.36)	(21.79)	(13.53)	(12.60)
2	AR	Fiction	28	94.21	119.13	96.64	94.82
			(M=16, F=12)	(3.52)	(14.99)	(13.93)	(8.97)
		Non-fiction	27	94.37	120.06	103.37	97.26
			(M=15, F=12)	(3.58)	(13.79)	(17.31)	(15.41)
	R	Fiction	26	94.23	120.00	104.50	98.50
			(M=11, F=15)	(3.41)	(14.65)	(16.96)	(15.69)
		Non-fiction	26	94.54	120.22	97.50	95.46
			(M=12, F=14)	(3.54)	(14.75)	(13.98)	(9.31)
3	AR	Fiction	27	108.00	123.04	120.26	117.74
			(M=13, F=14)	(3.26)	(13.47)	(16.74)	(19.61)
		Non-fiction	21	108.95	122.71	123.81	117.57
			(M=13, F=8)	(4.48)	(12.28)	(19.32)	(19.91)
	R	Fiction	22	108.82	123.45	123.18	117.59
			(M=13, F=9)	(4.41)	(12.47)	(19.08)	(19.43)
		Non-fiction	29	107.52	123.32	118.14	116.97
			(M=15, F=14)	(3.14)	(14.47)	(16.43)	(19.93)
4	AR	Fiction	24	119.13	120.65	133.63	137.67
			(M=13, F=11)	(3.38)	(11.16)	(15.31)	(20.62)
		Non-fiction	32	119.91	121.84	130.50	129.78
			(M=18, F=14)	(3.16)	(11.66)	(16.66)	(21.39)
	R	Fiction	34	119.94(3.08)	122.15	131.09	130.24
			(M=20, F=14)		(11.49)	(16.66)	(21.26)
		Non-fiction	26	119.46	121.00	133.81	136.08
			(M=14, F=12)	(3.52)	(10.89)	(15.15)	(20.56)

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5	AR	Fiction	20 (M=10, F=10)	133.85 (3.13)	121.16 (14.25)	141.10 (16.68)	149.65 (16.19)
		Non-fiction	25 (M=14, F=11)	132.20 (2.48)	119.08 (11.60)	147.76 (16.53)	151.68 (17.55)
	R	Fiction	25 (M=14, F=11)	132.32(2.64)	119.64 (11.38)	148.48 (17.70)	149.56 (16.73)
		Non-fiction	19 (M=9, F=10)	133.89 (3.21)	121.00 (14.64)	140.47 (16.90)	148.74 (16.10)
6	AR	Fiction	29 (M=14, F=15)	146.28 (4.46)	124.07 (11.32)	154.38 (14.62)	151.31 (13.19)
		Non-fiction	15 (M=10, F=5)	146.47 (3.48)	120.60 (8.34)	157.67 (16.38)	150.93 (14.38)
	R	Fiction	15 (M=10, F=5)	146.47 (3.48)	120.60 (8.34)	157.67 (16.38)	150.93 (14.38)
		Non-fiction	23 (M=10, F=13)	146.09 (4.61)	122.57 (11.59)	154.13 (12.04)	151.78 (12.07)

[1] Standardized scores, assessed using the Korean Kaufman Brief Intelligence Test-2 [42], are presented. [2] Raw scores, assessed using the Receptive & Expressive Vocabulary Test [41], are presented.

2.2. Reading tasks

Six different scripts were used for this study, including three fictional and three non-fictional texts, in order to prevent sharing information about the script among children, as all participants attended the same school. Scripts were randomly assigned to the participants. All scripts were composed by the researchers with reference to the list of recommended books for the first to second graders and were reviewed by a professor of communication disorders and six graduate students in master's and doctoral programs in communication disorders. The KReaD analysis [43], which gauges text difficulty and provides an objective reading level assessment, was performed for each script. The results showed that the fictional texts had a KReaD index of 2.78 grade level and non-fictional texts had a KReaD index of 5.29 grade level. The length of scripts differed across text types, while the number of sentences within each text type remained consistent. For fictional texts, the average word counts were 803.67 words, 801, 804, and 806 words for the respective texts, comprising a total of 73 sentences. Non-fictional texts had an average word count of 419.67 words, 425, 420, and 414 words for each script, and consisted of 37 sentences. The scripts were displayed on a monitor equipped with an attached eye tracker. Each fictional text was divided into 11 slides and the non-fictional text was divided into 6 slides, with each slide containing 10 lines of text.

In the AR condition, participants were presented with both the visual script and auditory narration that corresponded to the text simultaneously. They were instructed to read the text while listening to the audio. Once the audio for the slide was complete, the next slide was automatically displayed along with the corresponding audio. The audio files were recorded by a research assistant who held certification as a kindergarten teacher. In the R condition, only visual scripts were provided, and children were required to read the text silently on their own. The researchers observed the child's eye movements, and once they confirmed the completion of the reading, they manually advanced to the next slide.

2.3. Reading comprehension tasks

Following reading or reading while listening to each text, children were to answer questions asked to them about the text to assess their reading comprehension. One professor of communication disorders and six graduate students in master's and doctoral programs participated in the development and review of reading comprehension questions. Additionally, two Level 1 speech-language pathologists evaluated the validity of the questions. If the validity score was 3 or lower on a 5-point scale, the corresponding question was replaced with an alternative. Reading comprehension assessment questions, created as Microsoft Office PowerPoint files, were displayed on a computer or

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tablet screen. The researchers read the questions aloud from the screen, and the child provided answers.

The reading comprehension questions encompass 10 literal questions and 8-9 inferential questions for each text. All items were evaluated on a 2-point scale (0, 1 point) or a 3-point scale (0, 1, 2 points) depending on question complexity and structure. Fictional texts were assigned a total of 34, 35, and 33 points, and non-fictional texts were scored out of 32, 31, and 32 points, respectively. Regarding short-answer questions, 1 point was given if the answer precisely mentioned the relevant information. For open-ended questions, the score ranged from 0 to 2 points. When all contents of the answer were accurate, 2 points were awarded, and if only parts of them were included, 1 point was granted.

After the initial scoring, three research assistants in doctoral programs conducted a reassessment of the entire dataset. An evaluation of inter-rater reliability was performed among evaluators for a randomly selected 10% of the complete dataset, yielding a high level of reliability (r=.98).

2.4. Eye-tracking measurements

The eye-tracking device utilized in this study was the REDn Eye Scientific developed by SMI in Germany, with a sampling rate of 60Hz, an accuracy of 0.4°, and a spatial resolution of 0.03°. The eye-tracking data of the participants during the reading tasks were recorded on a laptop equipped with SMI BeGaze 3.7, the data analysis software. To enhance the accuracy of data collection, all participants underwent calibration for five points on the monitor prior to beginning the task, ensuring that calibration values were within 0.6° before proceeding with the tasks.

Eye-tracking data analysis was conducted using SMI BeGaze 3.7 software. In the reading tasks, the sentences within the presented slide were designated as AOIs. Employing temporal and spatial eye-tracking variables, gaze exploration processes and the cognitive processing of children during reading were examined [44]. Time-related variables included the total fixation duration (TFD) and average fixation duration (AFD) within the AOI. For a spatial-related variable, the scanpath length was utilized. Fixation refers to sustained gaze on an AOI for about 180-330ms [45]. The TFD represents the total time (ms) that the AOI was fixated during the reading task, and the AFD is calculated by dividing the TFD within the AOI by the number of fixations. Scanpath length represents the sum of the lengths (in pixels) of gaze movement paths during the tasks, which encompass both progressive and regressive saccades. These fixation durations and scanpath lengths have been shown to be linked to the type of stimuli presented and an individual's reading proficiency [46–48].

2.5. Data analysis

In order to minimize the potential influence of variations in content among different scripts, the average and standard deviation were computed for each group based on the text type and reading condition, and individual performance was then standardized using Z-scores.

Statistical analysis was conducted using *R* (version 4.3.0; R Core Team, 2023). A three-way analysis of variance (ANOVA) was conducted to investigate the differences in eye movement patterns (AFD, TFD, and scanpath length) according to age (first to sixth grades), reading conditions (AR and R), and text types (fictional and non-fictional). Moreover, forward stepwise multiple regression analysis was performed to investigate the eye movement factors that can predict children's literal and inferential comprehension under each reading condition when reading either fictional or non-fictional text, considering age as a controlled variable.

3. Results

This study aimed to explore the differences in eye movement patterns (AFD, TFD, and scanpath length) across age groups, reading conditions (AR and R), and text types (fictional and non-fictional). Furthermore, predictive models were developed to identify the eye movement variables that predict reading comprehension, both literal and inferential, and to investigate whether these predictors varied according to reading conditions and text types while controlling for age. Table 2 displays the

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reading comprehension performance and eye movement variables based on age, reading conditions, and text types.

Table 2. Descriptive statistics of literal and inferential comprehension and eye tracking variables. Values are presented as mean (SD). All scores are reported in Z-scores. AR: Audio-assisted reading, R: Reading-only, AFD: Average fixation duration, TFD: Total fixation duration.

Grade	Reading condition	Text type	Literal comprehension	Inferential comprehension	AFD	TFD	Scanpath length
1	AR	Fiction	-0.64 (1.04)	-0.62 (1.07)	0.82 (1.25)	-0.31 (0.81)	-0.81 (1.20)
		Non-fiction	-1.03 (0.90)	-1.24 (0.81)	0.61 (1.13)	-0.13 (1.14)	-0.79 (0.66)
	R	Fiction	-1.15 (1.31)	-1.21 (1.00)	0.70 (1.36)	0.66 (1.87)	0.20 (1.03)
		Non-fiction	-1.07 (1.36)	-1.30 (0.89)	0.32 (0.76)	0.29 (1.04)	0.40 (1.41)
2	AR	Fiction	-0.34 (0.94)	-0.38 (0.97)	0.13 (1.01)	0.52 (1.01)	-0.38 (0.96)
		Non-fiction	-0.35 (0.82)	-0.42 (0.76)	0.13 (0.95)	-0.01 (0.92)	-0.36 (0.79)
	R	Fiction	0.23 (0.50)	-0.20 (0.95)	0.37 (1.27)	0.25 (0.80)	0.18 (0.83)
		Non-fiction	-0.75 (0.85)	-0.69 (0.90)	0.36 (1.30)	0.30 (1.08)	-0.06 (0.97)
3	AR	Fiction	0.25 (0.70)	0.25 (0.84)	-0.16 (0.87)	0.09 (0.93)	0.29 (0.82)
		Non-fiction	0.14 (0.74)	0.14 (0.63)	0.06 (0.77)	0.04 (0.89)	0.13 (0.83)
	R	Fiction	0.26 (0.72)	0.25 (0.79)	0.02 (0.81)	-0.10 (0.75)	-0.14 (1.24)
		Non-fiction	0.20 (0.68)	0.27 (0.72)	-0.15 (0.64)	-0.06 (1.10)	-0.19 (1.04)
4	AR	Fiction	0.31 (0.62)	0.46 (0.42)	-0.13 (0.78)	0.01 (0.79)	0.29 (0.73)
		Non-fiction	0.49 (0.56)	0.61 (0.47)	-0.35 (0.70)	0.12 (1.14)	0.41 (1.15)
	R	Fiction	0.39 (0.50)	0.62 (0.44)	-0.27 (0.61)	-0.35 (0.51)	-0.27 (0.96)
		Non-fiction	0.46 (0.57)	0.41 (0.58)	-0.19 (0.83)	-0.24 (0.84)	0.09 (0.98)
5	AR	Fiction	0.52 (0.31)	0.29 (0.61)	-0.03 (0.94)	-0.17 (1.11)	0.32 (0.68)
		Non-fiction	0.67 (0.47)	0.65 (0.46)	-0.41 (1.00)	-0.28 (0.89)	0.44 (0.95)
	R	Fiction	0.36 (0.65)	0.45 (0.60)	-0.55 (0.60)	-0.36 (0.68)	-0.14 (0.85)
		Non-fiction	0.40 (0.64)	0.59 (0.45)	-0.31 (0.60)	-0.21 (0.82)	0.06 (0.81)
6	AR	Fiction	0.42 (0.53)	0.57 (0.46)	-0.09 (0.95)	-0.12 (1.04)	0.13 (1.04)
		Non-fiction	0.68 (0.49)	0.83 (0.24)	-0.37 (0.62)	0.13 (0.83)	0.55 (0.90)
	R	Fiction	0.49 (0.38)	0.58 (0.47)	-0.50 (0.49)	-0.23 (0.27)	-0.02 (0.97)
		Non-fiction	0.70 (0.44)	0.77 (0.32)	-0.38 (0.55)	-0.26 (0.70)	0.12 (0.84)

3.1. Comparison of average fixation duration according to age, reading conditions, and text types

A main effect of age on average fixation duration (AFD) was observed ($F(5, 545)=14.976$, $p<.001$), with a trend towards shorter AFD among older students compared to younger students (see Figure 1). According to the subsequent Bonferroni post hoc test, within the AR condition, a significant difference in AFD between Grade 1 and Grade 3 was observed while reading fictional text ($p=.041$). When engaging with non-fictional text in the AR condition, significant differences in AFD emerged between Grade 1 and Grade 4 ($p<.001$), Grade 1 and Grade 5 ($p<.001$), and Grade 1 and Grade 6 ($p=.013$). In the R condition, age-related differences reached statistical significance only when participants were reading fictional text. Significant differences in AFD were observed between Grade 1 and Grade 4 ($p<.001$), Grade 1 and Grade 5 ($p<.001$), Grade 1 and Grade 6 ($p<.001$), as well as between Grade 2 and Grade 5 ($p=.005$), and Grade 2 and Grade 6 ($p=.047$).

The results showed no significant main effects for reading condition ($F(1, 545)=0.313$, $p=.576$) and text type ($F(1, 545)=0.805$, $p=.370$). Additionally, significant interactions between age and reading condition ($F(5, 545)=0.925$, $p=.464$), age and text type ($F(5, 545)=0.279$, $p=.925$), or reading condition and text type ($F(1, 545)=0.700$, $p=.043$), as well as a three-way interaction involving age, reading condition, and text type ($F(5, 545)=0.989$, $p=.424$) were not found.

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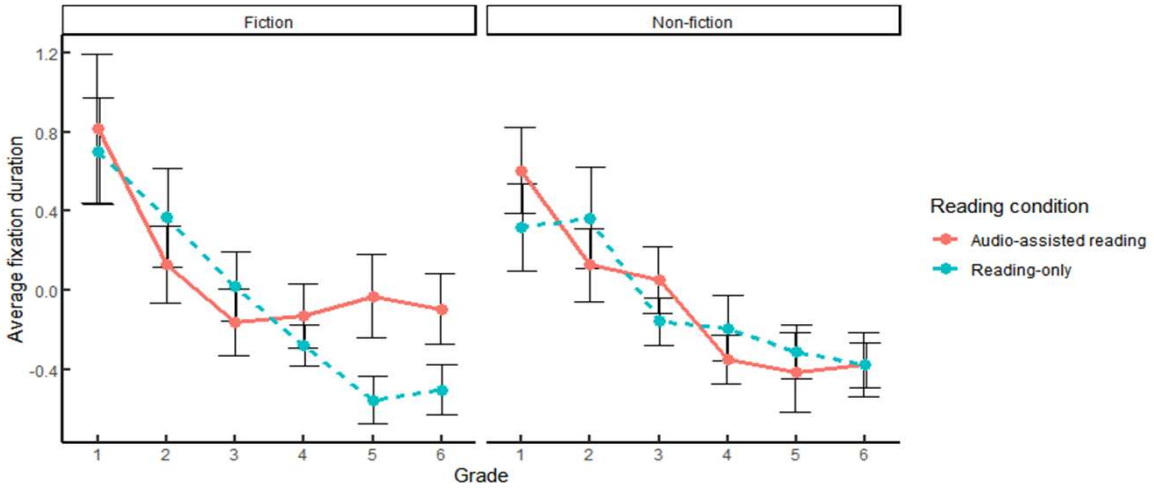

Figure 1. Average fixation duration in each reading condition when reading fictional and non-fictional text.

3.2. Comparison of total fixation duration according to age, reading conditions, and text types

A main effect of age (F(5, 545)=4.086, p=.001) along with an interaction effect between age and reading condition (F(5, 545)=2.638, p=.023) on total fixation duration (TFD) were observed. A simple main effect test was followed due to the significant interaction effect. The main effect of age was significant when reading fictional text under both AR (F(5, 545)=2.77, p=.046) and R (F(5, 545)=5.22, p<.001) conditions. Within the R condition, age-related differences were observed, showing a decline in TFD with an increase in age. Similarly, while reading fictional text, the AR condition exhibited these age-related differences, with the exception of the first grade, where the shortest TFD was observed, deviating from other age groups (see Figure 2). The Bonferroni post hoc test revealed significant differences in TFD between Grade 1 and Grade 4 (p=.001) and Grade 1 and Grade 5 (p=.003) in the R condition while reading fictional text. The interaction effect between age and reading condition was derived from the significant difference between AR and R conditions in the first grade, with the AR condition demonstrating lower TFD compared to the R condition (p=.006).

Main effects of reading condition (F(1, 545)=-0.527, p=.468) and text type (F(1, 545)=0.054, p=.816) were not significant. There were no significant two-way interactions between age and text type (F(5, 545)=0.497, p=.779) and reading condition and text type (F(1, 545)=0.174, p=.677), while a three-way interaction among age, reading condition, and text type (F(5, 545)=0.853, p=.513) also did not reach statistical significance.

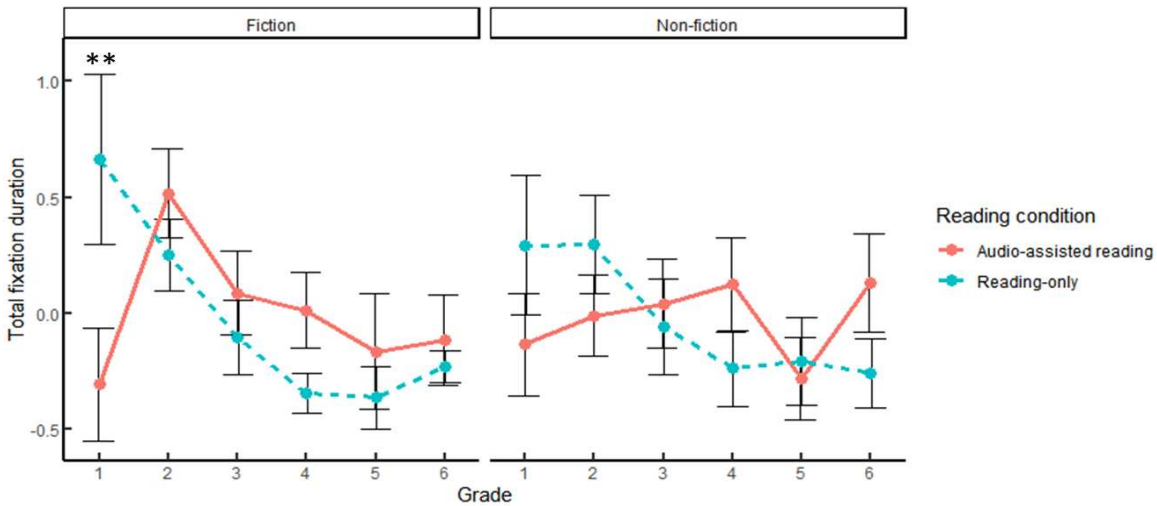

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Figure 2. Total fixation duration in each reading condition when reading fictional and non-fictional text. **p<.01.

3.3. Comparison of scanpath length according to age, reading conditions, and text types

A three-way ANOVA revealed a significant main effect of age (F(5, 545)=3.286, p=.006) and an interaction effect between age and reading condition (F(5, 545)=8.634, p<.001) on scanpath length. Subsequently, a simple main effect test was performed in response to the observed interaction effect. Irrespective of the text type, a significant main effect of age emerged within the AR condition (Fictional text: F(5, 545)=4.38, p<.001, Non-fictional text: F(5, 545)=8.66, p<.001). In the AR condition, there was a trend of escalating scanpath length as age increased, whereas this age-related tendency was absent within the R condition. Among younger children, the scanpath length was observed to be shorter in the AR condition in comparison to the R condition, regardless of the text type, which is deemed to contribute to the interaction effect between age and reading condition (See Figure 3). The Bonferroni post hoc test was conducted in order to examine the differences in scanpath length across age and reading conditions. Within the AR condition when reading fictional text, there were significant differences in scanpath length between Grade 1 and Grade 3 (p=.017), Grade 1 and Grade 4 (p=.021), and Grade 1 and Grade 5 (p=.023). In the context of non-fictional text under the AR condition, the scanpath length in Grade 1 showed a significant difference compared to Grade 3 (p=.013), Grade 4 (p<.001), Grade 5 (p<.001), and Grade 6 (p<.001). Similarly, the scanpath length in Grade 2 also exhibited a significant difference compared to Grade 4 (p=.027), Grade 5 (p=.036), and Grade 6 (p=.044). When reading fictional text, significant differences in scanpath length between the AR and R conditions were observed in Grade 1 (p=.003), Grade 2 (p=.031), and Grade 4 (p=.025). Regarding non-fictional text, however, it was only within Grade 1 that the significant difference in scanpath length between the two conditions appeared (p<.001).

Both reading condition (F(1, 545)=0.409, p=.523) and text type (F(1, 545)=1.23, p=.268) did not have any significant main effects on scanpath length. Two-way interaction effects between age and text type (F(5, 545)=0.78, p=.562) and reading condition and text type (F(1, 545)=0.01, p=.919), as well as a three-way interaction effect among age, reading condition, and text type were not statistically significant.

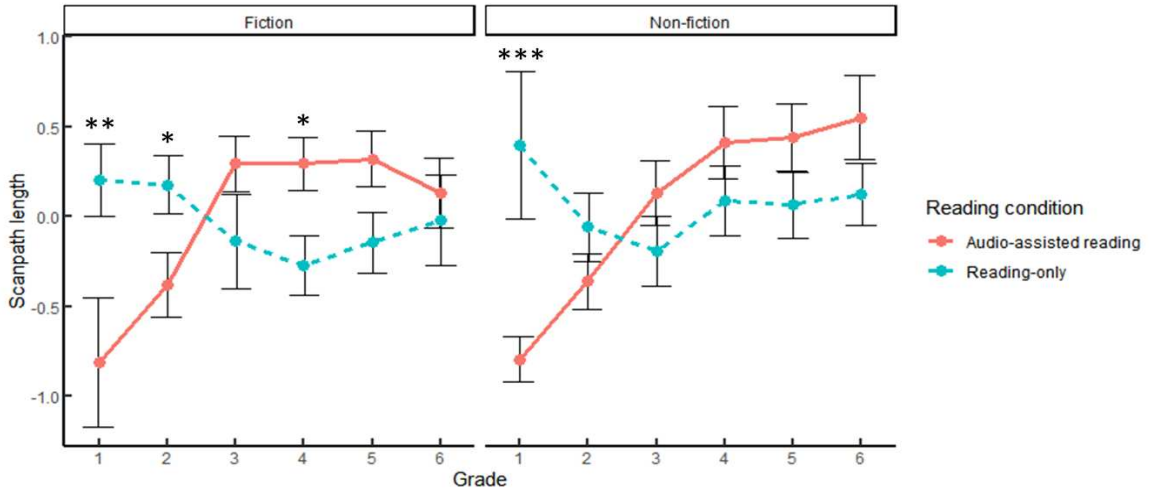

Figure 3. Scanpath length in each reading condition when reading fictional and non-fictional text. *p<.05, **p<.01, ***p<.001.

3.4. Eye movement predictive models for reading comprehension by reading conditions and text types

First, within the AR condition, while reading fictional text, a predictive model that includes age and TFD significantly accounted for 22% of the variance in literal comprehension (F(2, 136)=20.96, p<.001). Both age (β=0.46, t(136)=6.13, p<.001) and TFD (β=0.21, t(136)=2.73, p=.007) had a significant positive impact on literal comprehension. For inferential comprehension, on the other hand, a

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predictive model yielded a significant explanation of 27% of the variance (F(3, 135)=16.37, p<.001). The variables encompassed in the model were age (β=0.39, t(135)=5.08, p<.001), scanpath length (β=0.15, t(135)=1.81, p=.073), and AFD (β=-0.14, t(135)=-1.76, p=.081). Age exhibited a significant positive influence on the inferential comprehension scores. Although scanpath length was also positively associated with inferential comprehension, this relationship did not reach statistical significance. AFD negatively affected inferential comprehension, but this effect did not attain statistical significance.

Second, considering literal comprehension under the AR condition engaging with non-fictional text, a predictive model significantly explained 45% of the variance with all three eye movement parameters involved (F(4, 142)=30.75, p<.001). Age (β=0.55, t(142)=7.62, p<.001) and TFD (β=0.14, t(142)=2.06, p=.041) significantly and positively affected literal comprehension. Scanpath length (β=0.11, t(142)=1.42, p=.159) also displayed a positive impact on literal comprehension, but it was not statistically significant. AFD (β=-0.13, t(142)=-1.72, p=.088) had a non-significant negative impact on the literal comprehension scores. A model that predicts inferential comprehension included scanpath length and AFD, significantly accounting for 56% of the variance (F(3, 143)=63.34, p<.001). Age (β=0.61, t(143)=9.60, p<.001) and scanpath length (β=0.15, t(143)=2.27, p=.025) exhibited a positive and significant impact on inferential comprehension, while AFD (β=-0.12, t(143)=-1.89, p=.061) had a negative and non-significant impact on it.

Next, within the context of fictional reading under the R condition, a predictive model concerning literal comprehension exhibited a statistically significant explanation of 22% of the variance (F(1, 146)=40.66, p<.001), with no inclusion of eye movement parameters. Only age significantly and positively influenced the variable (β=0.47, t(146)=6.39, p<.001). Regarding inferential comprehension, a predictive model significantly accounted for 37% of the variance (F(2, 145)=43.70, p<.001). The model encompassed age (β=0.50, t(145)=7.13, p<.001) and TFD (β=-0.22, t(145)=-3.21, p=.002) as predictors. Both factors were statistically significant, with age displaying a positive and TFD exerting a negative effect on the inferential comprehension scores.

Finally, under the R condition during non-fictional reading, a predictive model for literal comprehension significantly explained 38% of the variance (F(3, 131)=27.31, p<.001). In this model, age (β=0.53, t(131)=7.32, p<.001) and AFD (β=-0.19, t(131)=-2.63, p=.010) emerged as significant predictors while scanpath length (β=0.12, t(131)=1.73, p=.086) did not reach statistical significance. Age and scanpath length demonstrated positive associations with literal comprehension, whereas AFD showed a negative impact on the variable. A model predicting inferential comprehension accounted for 47% of the variance (F(2, 132)=59.56, p<.001), wherein age and TFD arose as significant factors. Age (β=0.61, t(132)=9.50, p<.001) exhibited a positive influence on the inferential comprehension scores, while the impact of TFD (β=-0.21, t(132)=-3.24, p=.002) on inferential comprehension was negative.

The predictive models for literal and inferential comprehension according to reading conditions and text types are presented in Table 3.

Table 3. Eye movement predictive models for reading comprehension in each reading condition and text type. AR: Audio-assisted reading, R: Reading-only, F: Fiction, NF: Non-fiction, TFD: Total fixation duration, AFD: Average fixation duration.

	Dependent variables	Predictors	β	Std. β	t	p	R^2	Adj. R^2
AR_F	Literal comprehension	Age	0.02	0.46	6.13	<.001	0.24	0.22
		TFD	0.16	0.21	2.73	0.007		
	Inferential comprehension	Age	0.02	0.39	5.08	<.001	0.27	0.25
		Scanpath length	0.13	0.15	1.81	0.073		
		AFD	-0.12	-0.14	-1.76	0.081		
AR_NF	Literal comprehension	Age	0.02	0.55	7.62	<.001	0.46	0.45
		Scanpath length	0.10	0.11	1.42	0.159		
		TFD	0.13	0.14	2.06	0.041		
		AFD	-0.13	-0.13	-1.72	0.088		
	Inferential comprehension	Age	0.03	0.61	9.60	<.001	0.57	0.56
		Scanpath length	0.14	0.15	2.27	0.025		
		AFD	-0.12	-0.12	-1.89	0.061		

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R_F	Literal comprehension	Age	0.20	0.47	6.39	<.001	0.22	0.21
	Inferential comprehension	Age	0.02	0.50	7.13	<.001	0.38	0.37
		TFD	-0.21	-0.22	-3.21	0.002		
R_NF	Literal comprehension	Age	0.02	0.53	7.32	<.001	0.38	0.37
		AFD	-0.21	-0.19	-2.63	0.010		
		Scanpath length	0.12	0.12	1.73	0.086		
	Inferential comprehension	Age	0.03	0.61	9.50	<.001	0.47	0.47
		TFD	-0.20	-0.21	-3.24	0.002		

4. Discussion

The study aimed to examine the effects of reading conditions, audio-assisted reading and reading only, in fictional and non-fictional texts on 6- to 12-year-old elementary school students' eye movement patterns and their literal and inferential comprehension.

4.1. The impact of reading condition and text type on eye movement patterns across age groups

First, the AFD, which indicates the speed at which a reader processes a word or a semantic chunk—comprising a group of words—was analyzed based on age, reading conditions, and text types. The main effect of age showed that, regardless of the reading condition and text type, AFD decreased as age increased in general. This aligns with previous studies that have explored the relationship between age and fixation duration [49,50].

Results from the Bonferroni post hoc test, which examined differences in AFD across age, revealed variations depending on reading condition and text type. Age differences in AFD were prominent in the R condition when reading fictional text. Significant differences in AFD were observed between Grade 1 and Grades 4 through 6, as well as between Grade 2 and Grades 5 through 6. However, these age differences were not apparent when reading non-fictional text in the R condition. When it comes to fictional text, older children tend to quickly extract essential information from the text, while younger children take their time in word reading, including decoding and interpreting the information, and read the text attentively when asked to read on their own. The reduced age-related gaps in AFD when reading non-fictional text show that older children invest more time and attention in challenging text with complicated sentence structures, while younger children may employ a different approach to processing such text. These findings are consistent with prior research suggesting that text type and difficulty can affect readers' AFD [51].

Unlike the R condition, under the AR condition, the impact of age was pronounced when reading non-fictional text, where the differences in AFD between Grade 1 and Grades 4 to 6 were significant. Despite not reaching statistical significance, AFD for older children under the AR condition appeared to be longer than that under the R condition for fictional reading, while the contrast was negligible when reading non-fictional text. When provided with audio assistance for reading fictional text, which is typically an easier and more comprehensible text, older children seem to somewhat synchronize their reading pace with the auditory narration while maintaining their own pace. This reading strategy becomes noticeable from the third grade onward, as indicated by the emergence of a plateau at that point. However, when reading non-fictional text, older children in Grades 4 to 6 adopt a faster reading strategy to enhance their comprehension.

Second, there is a general decrease in overall TFD with age in both text types, as evidenced by the main effect of age. However, the significance was only exhibited in fictional reading. TFD reflects the time a reader dedicates to comprehensively engaging with the entire text. This age-related trend explains the development of reading fluency as a child grows older [50], and this effect is particularly notable during reading fictional text. Furthermore, an interaction effect between age and reading condition was observed, attributed to the substantial drop in TFD observed in Grade 1 under the AR condition, unlike the extended TFD observed in the counterpart, which could potentially stem from different strategies used by children across age depending on the reading modalities.

In the R condition, TFD tends to decrease with age, irrespective of text type, but the age effect was significant only when reading fictional text. The Bonferroni post hoc test revealed that TFD was significantly different between Grade 1 and Grades 4 and 5. This effect arises due to the reduced TFD

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among the first graders when engaged with non-fictional text. Typically, when readers encounter difficult text, there is a tendency for the TFD to rise [52]. However, in the case of young children, text covering unfamiliar topics may affect their focus on the text, potentially leading to a decrease in TFD.

While under the AR condition, the trend of decreasing TFD with age was observed in fictional reading like the R condition, the TFD for Grade 1 children was the shortest among all age groups, and the difference between two reading conditions among first graders was significant. This suggests that first graders actively take advantage of audio assistance during fictional reading. Children in other age groups appear to utilize a combination of visual and audio stimuli, either aligning with the speed of audio narration or pacing at a preferable speed.

However, in the case of non-fictional reading under the AR condition, there was no significant change in TFD with age, and it appears to remain relatively constant across different age groups. Given the observed decrease in AFD among older children in the same condition, it can be inferred that older children might engage in repetitive sentence reading while listening simultaneously. The fact that there were no age-related differences in TFD during non-fictional reading under the AR condition and that there was no discernible drop causing a significant difference between reading conditions in this context, unlike fictional reading, implies that younger children maintained their attention throughout the whole text as much as older children. This finding supports the positive impact of audio assistance on comprehension in reading non-fiction among young children revealed in Chung et al. [29].

Finally, scanpath length was analyzed under the AR and R conditions while reading fictional or non-fictional text. The main effect of age was significant under the AR condition, regardless of the text type, with the scanpath length increasing as age increased. In addition, an interaction effect between age and reading condition emerged due to the difference in scanpath length between the AR and R conditions among first and second graders during fictional reading, and among first graders during non-fictional reading.

Under the R condition, the scanpath length generally remains consistent across age, with the exception of slight increases observed among first- and second-grade children in fictional reading, as well as first-grade children in non-fictional reading. Even though these increases did not achieve statistical significance, the extended scanpath length could suggest a need to revisit the previously read text for better comprehension. Decreased AFD in the first graders under the R condition while reading non-fiction may be attributed to their tendency to read words or chunks quickly and to revisit the information previously read in the text. In both fictional and non-fictional reading, first and second graders exhibited longer scanpaths under the R condition than when they were under the AR condition, and the differences were significant among the first graders during both fictional and non-fictional reading, as well as among the second graders during fictional reading. For younger children, it is more frequent to go back to the text they have read before when reading on their own, compared to when they are aided by the audio.

On the other hand, in the AR condition, there was a trend of scanpath length rising with age, and this difference across age was pronounced during non-fictional reading. The Bonferroni post hoc test demonstrated that in the context of reading fictional text, the differences were only significant between Grade 1 and Grades 3 through 5, while during non-fictional reading, significant differences were observed between Grade 1 and Grades 3 to 6, as well as between Grade 2 and Grades 4 to 6. The shorter scanpath length among younger children might indicate a preference for utilizing audio assistance or a potentially prolonged word-reading duration that hinders them from covering the complete text. However, the latter possibility can be ruled out considering their AFD not being significantly longer under the AR condition. Therefore, it can be inferred that younger, less experienced readers are more inclined to extract information from audio sources rather than the text itself, which aligns with the conclusion by Pellicer-Sánchez et al. [53].

In contrast, older students exhibit a tendency to engage in repeated back-and-forth reading of the text while simultaneously listening to the audio. This suggests that, under the AR condition, older and more proficient readers read at their preferred pace and revisit the same text multiple times as necessary. This could involve revisiting information they consider important, as well as information

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presented in the audio, or both. This strategy of repetitive reading is more frequently employed when reading non-fictional text. Similar to the AFD pattern, a plateau is observed from Grade 3 onward during fictional reading, whereas the scanpath length continues to increase with age during non-fictional reading. When facing easy and predictable text, such as fiction, skilled readers refrain from allocating excessive attention and effort to repetitive reading. However, when it comes to non-fiction, they often invest more energy in the text by adopting a repeated reading approach.

4.2. Eye movement predictive models for literal and inferential comprehension

In order to explore the influence of eye movement patterns on literal and inferential comprehension during fictional or non-fictional reading under two different reading conditions, AR and R, the predictive models were created using stepwise multiple regression analysis while accounting for the age factor.

Under the AR condition when reading fictional text, TFD was included in the predictive model for literal comprehension, which indicates allocating additional time to the entire text results in improved literal comprehension. For inferential comprehension, scanpath length and AFD comprised the predictive model. Even though it was not statistically significant, a longer scanpath length and a shorter AFD were associated with enhanced inferential comprehension, suggesting that implementing the strategy of repeated reading contributes to better inferential comprehension.

During reading non-fiction under the AR condition, apart from TFD, which proved to be a significant predictor, scanpath length and AFD were also included in the predictive model for literal comprehension. Within this context, increased TFD, longer scanpath length, and decreased AFD were related to improved literal comprehension. While non-fictional reading under the AR condition shares the need for comprehensive engagement with the entire text, similar to fictional reading, it also requires the strategic use of repetitive reading while efficiently extracting information within a single gaze. Regarding inferential comprehension, the predictive model encompassed scanpath length and AFD with scanpath length emerging as a significant predictor. As with fictional reading in the same reading condition, the practice of repetitive reading plays a crucial role in achieving improved inferential comprehension. The emergence of scanpath length and TFD as factors that positively impact comprehension under the AR condition aligns with the results found in Park et al. [37].

On the contrary, when reading fictional text under the R condition, the predictive model for literal comprehension did not include any eye movement variables. In this case, the only significant predictor was age. However, for inferential comprehension, a shorter TFD emerged as a significant predictor for better performance. These results imply that children tend to naturally develop the ability to understand fictional stories at a literal level as they mature [27] while advancing to inferential comprehension demands more fluent and efficient reading. This difference can be elucidated by the fact that inferential comprehension is based on successful literal comprehension. Proficient readers with greater efficiency possess the cognitive capacity, left after understanding the factual events in the text, to engage in critical thinking by integrating background knowledge. This skill is crucial for successful inferential comprehension, extending beyond merely comprehending the factual events in the text [28].

The predictive model for literal comprehension of non-fiction under the R condition appeared different from fictional reading. It included AFD as the significant predictor, alongside scanpath length. This indicates that comprehending non-fictional texts, even at a literal level, requires both efficient and repetitive reading of the text. Processing information promptly remains essential for inferential comprehension in this context as well, as evidenced by TFD emerging as a significant predictor in the model. The pattern where shorter temporal factors of eye movements have a positive impact on comprehension in general under the R condition is consistent with the observed negative correlations between TFDs and story comprehension in Park et al. [37].

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5. Conclusions

The purpose of this study was to identify eye movement patterns in elementary school children under the audio-assisted reading and reading-only conditions while reading fictional or non-fictional text, and to investigate how these eye movement patterns within each condition, when involved with different text types, affect their literal and inferential reading comprehension.

In general, regardless of reading condition or text type being read, there is a consistent decrease in average fixation duration as children mature, which serves as an indicator of the development of the ability to read more swiftly over time. However, under the audio-assisted reading condition when reading fiction, the decline in average fixation duration levels off from Grade 3 onward, suggesting that older and more experienced readers, when encountering easier text accompanied by audio assistance, tend to adopt a more relaxed reading pace. The trend of decreasing total fixation duration with age is predominantly observed during fictional reading. Nevertheless, when reading fictional text under the audio-assisted reading condition, a drop in total fixation duration is observed among the first graders. This phenomenon could be due to their preference for extracting information through audio assistance. Scanpath length exhibits a tendency to increase with age under the audio-assisted reading condition, which is different from the pattern observed in the reading-only condition. This implies that as children's reading skills improve, older individuals tend to employ a strategy of rapidly absorbing information from the text while concurrently revisiting it with the assistance of audio. Similar to average fixation duration, however, this increase plateaus beyond the third grade when reading fictional text, indicating that extensive repeated reading is not considered crucial for older children within this context. These findings underscore that younger and older elementary school children employ different reading strategies based on reading modalities and types of text. Younger children appear to lean toward audio narration assistance under the audio-assisted reading condition, while older children opt for a strategy of rapid and repetitive reading. This preference for audio assistance over text among younger children is more evident in fictional reading compared to non-fictional reading, and older children's attentive and repeated reading under the audio-assisted reading condition is more prominent in non-fiction compared to fiction.

When audio assistance is provided during fictional reading, devoting sufficient time throughout the text can be adequate for literal comprehension. However, when aiming to comprehend inferential meaning, an efficient and repetitive reading approach becomes essential. Similarly, when reading non-fictional text under the audio-assisted reading condition, both literal and inferential comprehensions benefit from reading rapidly and repeatedly. Under the reading-only condition, while children acquire skills to understand literal events in fictional text as they grow up, attaining enhanced inferential comprehension of the text requires further development of rapid and efficient reading abilities. When reading non-fictional text, achieving even literal comprehension calls for efficient reading combined with the revisiting of important information. Furthermore, attaining inferential comprehension in non-fictional text requires quick processing of written information.

In order to improve reading comprehension, it is necessary to provide appropriate types of text along with visual and/or auditory stimuli, taking into consideration the age and reading proficiency of children. The findings of this study could be beneficial for reading instruction among younger children with developing reading skills, as well as for guiding reading strategies among older children.

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References

1. Lerner, J. W. From theories to teaching strategies. In *Learning Disabilities: Theories, Diagnosis and Strategies*, 7th ed.; Houghton Mifflin: Boston, MA, USA, **2000**, ISBN 978-061-822-405-0.
2. Palani, K. K. Promoting reading habits and creating literate society. *Journal of Arts Science & Commerce* **2012**, *3*, 90-94.
3. Bouffard, T. A Developmental study of the relationship between reading development and the self-system. *European Journal of Psychology of Education* **1998**, *13*, 61-74. https://doi.org/10.1007/BF03172813.
4. Muhammet, B. The structural relationship of reading attitude, reading comprehension and academic achievement. *International J. Soc. Sci. & Education*. **2014**, *4*, 931-946.
5. Kamhi, A. G.; Catts, H. W. The language basis of reading: implications for classification and treatment of children with reading disabilities. In *Speaking, Reading, and Writing in Children with Language Learning Disabilities: New Paradigms in Research and Practice*; Butler, K., Silliman, E., Eds.; Lawrence Erlbaum Associates: Mahwah, NJ, USA, **2002**, pp. 45-72, ISBN 978-080-583-366-9.
6. Elleman, A.M.; Oslund, E.L. Reading comprehension research: implications for practice and policy. *Policy Insights from the Behavioral and Brain Sciences* **2019**, *6*, 3-11. https://doi.org/10.1177/2372732218816339.
7. Kim, Y.-S. G. Hierarchical and dynamic relations of language and cognitive skills to reading comprehension: testing the direct and indirect effects model of reading (DIER). *Journal of Educational Psychology* **2020**, *112*(4), 667–684. https://doi.org/10.1037/edu0000407.
8. Kamagi, S. A study on students' ability in literal and inferential comprehension of English texts. *Journal of International Conference Proceedings* **2020**, *3*(2), 140–144. https://doi.org/10.32535/jicp.v0i0.913.
9. Juel, C.; Griffith, P. L.; Gough, P. B. Acquisition of literacy: a longitudinal study of children in first and second grade. *Journal of Educational Psychology* **1986**, *78*(4), 243–255. https://doi.org/10.1037/0022-0663.78.4.243.
10. Florit, E.; Roch, M.; Levorato, M. C. Listening text comprehension of explicit and implicit information in preschoolers: the role of verbal and inferential skills. *Discourse Processes* **2011**, *48*(2), 119–138. https://doi.org/10.1080/0163853x.2010.494244.
11. Verhoeven, L.; van Leeuwe, J. Prediction of the development of reading comprehension: a longitudinal study. *Applied Cognitive Psychology* **2008**, *22*(3), 407–423. https://doi.org/10.1002/acp.1414.
12. Pearson, P. D.; Gordon, C.; Hansen, J. The effect of background knowledge on young children's comprehension of explicit and implicit information, *Journal of Reading Behavior* **1979**, *11*(3), 201–209. https://doi.org/10.1080/10862967909547324.
13. Daneman, M.; Carpenter, P. A. Individual differences in working memory and reading. *Journal of Verbal Learning and Verbal Behavior* **1980**, *19*(4), 450–466. https://doi.org/10.1016/s0022-5371(80)90312-6.
14. Lee, H. J. Listening comprehension ability of school-aged children with specific language impairment using narrative and expository texts. *Journal of Speech-Language & Hearing Disorders* **2015**, *24*(3), 51–62. https://doi.org/10.15724/jslhd.2015.24.3.005.
15. Wong, B. Y. L. Problems and issues in the definition of learning disabilities. In *Psychological and Educational Perspectives on Learning Disabilities*, Eds.; Torgesen, J. K. & Wong, B. Y. L.; Academic Press: Cambridge, MA, UA, **1986**; pp. 1-26, ISBN 978-012-695-490-6.
16. Brown, R.; Waring, R.; Donkaewbua, S. Incidental vocabulary acquisition from reading, reading-while-listening, and listening to stories. *Reading in a Foreign Language* **2008**, *20*(2), 136–163.
17. LaBerge, D.; Samuels, S. J. Toward a theory of automatic information processing in reading. *Cognitive Psychology* **1974**, *6*(2), 293–323. https://doi.org/10.1016/0010-0285(74)90015-2.
18. Chang, A. C.-S.; Millett, S. Improving reading rates and comprehension through audio-assisted extensive reading for beginner learners. *System* **2015**, *52*, 91–102. https://doi.org/10.1016/j.system.2015.05.003.
19. Plass, J. L.; Moreno, R.; Brünken, R. Measuring cognitive load. In *Cognitive Load Theory*; Cambridge University Press: Cambridge, UK, **2010**;, pp. 181-202, ISBN 052-186-023-7.
20. Diao, Y.; Sweller, J. Redundancy in foreign language reading comprehension instruction: concurrent written and spoken presentations. *Learning and Instruction* **2007**, *17*(1), 78–88. https://doi.org/10.1016/j.learninstruc.2006.11.007.
21. Berkowitz, S.; Taylor, B. M. The effects of text type and familiarity on the nature of information recalled by readers. In *Directions in Reading: Research and Instruction*; D. Pearson., Eds.; International Reading Association: Newark, DE, **1981**; pp. 157-161.

22. Lehto, J. E.; Anttila, M. Listening comprehension in primary level grades two, four and six. *Scandinavian Journal of Educational Research* **2003**, *47*(2), 133–143. https://doi.org/10.1080/00313830308615.
23. Olson, M. W. Text type and reader ability: the effects on paraphrase and text-based inference questions. *Journal of Reading Behavior* **1985**, *17*(3), 199–214. https://doi.org/10.1080/10862968509547540.
24. Kim, E. S.; Hwang, B. The Effects of language intervention based on story grammar for comprehension of written stories in children with intellectual disabilities. *Journal of Speech-Language & Hearing Disorders* **2011**, *20*(3), 89–104. https://doi.org/10.15724/jslhd.2011.20.3.006.
25. Bensoussan, M. EFL reading as seen through translation and discourse analysis: narrative vs. expository texts. *English for Specific Purposes* **1990**, *9*(1), 49–66. https://doi.org/10.1016/0889-4906(90)90028-b.
26. Sáenz, L. M.; Fuchs, L. S. Examining the reading difficulty of secondary students with Learning Disabilities. *Remedial and Special Education* **2002**, *23*(1), 31–41. https://doi.org/10.1177/074193250202300105.
27. Graesser, A.; Golding, J.; Long, D. L. Narrative representation and comprehension. In *Handbook of Reading Research*; Barr, R., Kamil, M. L., Mosenthal,P. Pearson, P. D. Eds.; Erlbaum: Mahwah, NJ, **1991**; Volume 2, pp. 171-205, ISBN 978-080-585-342-1.
28. McNamara, D. S.; Levinstein, I. B.; Boonthum, C. ISTART: interactive strategy training for active reading and thinking. *Behavior Research Methods, Instruments, & Computers* **2004**, *36*(2), 222–233. https://doi.org/10.3758/bf03195567.
29. Chung, H. E.; Song, H. S.; Cho, Y. R.; Oh, Y. R.; Kim, A. Y.; Joo, H. J.; Yim, D. Story comprehension skills of school-aged children by passage type and question type according to story conditions. *Journal of Speech-Language & Hearing Disorders* **2023**, *32*(2), 49-60. https://doi.org/10.15724/jslhd.2023.32.2.049.
30. Lai, M.-L.; Tsai, M.-J.; Yang, F.-Y.; Hsu, C.-Y.; Liu, T.-C.; Lee, S. W.-Y.; Lee, M.-H.; Chiou, G.-L.; Liang, J.-C.; Tsai, C.-C. A review of using eye-tracking technology in exploring learning from 2000 to 2012. *Educational Research Review* **2013**, *10*, 90–115. https://doi.org/10.1016/j.edurev.2013.10.001.
31. Just, M. A.; Carpenter, P. A. A theory of reading: from eye fixations to comprehension. *Psychological Review* **1980**, *87*(4), 329–354. https://doi.org/10.1037/0033-295x.87.4.329.
32. Rayner, K. Understanding eye movements in reading. *Scientific Studies of Reading* **1997**, *1*(4), 317–339. https://doi.org/10.1207/s1532799xssr0104_2.
33. Rayner, K.; Ardoin, S. P.; Binder, K. S. Children's eye movements in reading: a commentary. *School Psychology Review* **2013**, *42*(2), 223–233. https://doi.org/10.1080/02796015.2013.12087486.
34. Rayner, K. Eye movements and the perceptual span in beginning and skilled readers. *Journal of Experimental Child Psychology* **1986**, *41*(2), 211–236. https://doi.org/10.1016/0022-0965(86)90037-8.
35. Parshina, O.; Lopukhina, A.; Goldina, S.; Iskra, E.; Serebryakova, M.; Vladislava, S.; Zdorova, N.; Dragoy, O. Global reading processes in children with high risk of dyslexia: a scanpath analysis. *Annals of Dyslexia* **2022**, *72*(3), 403–425. https://doi.org/10.1007/s11881-021-00251-z.
36. Conklin, K.; Alotaibi, S.; Pellicer-Sánchez, A.; Vilkaitė-Lozdienė, L. What eye-tracking tells us about reading-only and reading-while-listening in a First and Second Language. *Second Language Research* **2020**, *36*(3), 257–276. https://doi.org/10.1177/0267658320921496.
37. Park. W. J.; Yang, Y.; Jeong, E.; Kim, A.; Yim, D. Correlation analysis between eye movement patterns and reading comprehension skills by reading condition in children with typical development and language impairment. *Communication Sciences & Disorders* **2023**, *28*(1), 39-51. https://doi.org/10.12963/csd.23950.
38. Rayner, K. Eye movements and the perceptual span in beginning and skilled readers. *Journal of Experimental Child Psychology* **1986**, *41*(2), 211–236. https://doi.org/10.1016/0022-0965(86)90037-8.
39. Magyari, L.; Mangen, A.; Kuzmičová, A.; Jacobs, A. M.; Lüdtke, J. Eye movements and mental imagery during reading of literary texts with different narrative styles. *Journal of Eye Movement Research* **2020**, *13*(3). https://doi.org/10.16910/jemr.13.3.3.
40. de Leeuw, L.; Segers, E.; Verhoeven, L. Role of text and student characteristics in real-time reading processes across the primary grades. *Journal of Research in Reading* **2015**, *39*(4), 389–408. https://doi.org/10.1111/1467-9817.12054.
41. Kim, Y. T.; Hong, G. H.; Kim, K. H.; Jang, H. S.; Lee. J. Y. *Receptive & Expressive Vocabulary Test (REVT)*; Seoul Community Rehabilitation Center: Seoul, Korea, **2009**.
42. Moon, S. B. *Korean Kaufman Brief Intelligence Test*, 2nd ed.; Hakjisa Publisher: Seoul, Korea, **2020**.
43. Cho, Y. G.; Lee, K. N. Development of the Korean language text analysis program (KReaD Index). *Korean Reading Research* **2020**, *56*, 225-246.
44. Lai, M. L.; Tsai, M. J.; Yang, F. Y.; Hsu, C. Y.; Liu, T. C.; Lee, S. W. Y.; Lee, M. H.; Chiou, G. L.; Liang, J. C.; Tsai, C. C. A review of using eye-tracking technology in exploring learning from 2000 to 2012. *Educational Research Review* **2013**, *10*, 90-115. https://doi.org/10.1016/j.edurev.2013.10.001.
45. Rayner, K. Eye movements in reading: models and data. *Journal of Eye Movement Research* **2009**, *2*(5), 1-10.
46. Rayner, K. Eye movements in reading and information processing: 20 years of research. *Psychological Bulletin* **1998**, *124*(3), 372-422. https://doi.org/10.1037/0033-2909.124.3.372.
47. Rayner, K.; Pollatsek, A. *The Psychology of Reading*. Prentice-Hall: Hoboken, NJ, USA, **1989**, ISBN 978-080-581-872-7.

48. Kliegl, R.; Grabner, E.; Rolfs, M.; Engbert, R., Length, frequency, and predictability effects of words on eye movements in reading. *European Journal of Cognitive Psychology* **2004**, *16*(1-2), 262-284. https://doi.org/10.1080/09541440340000213.
49. Lee, S. R.; Suh, H. The current status and perspectives of research on reading process using eye-tracker. *Korean Language Education Research* **2013**, *46*, 479-503. https://doi.org/10.20880/kler.2013..46.479.
50. Blythe, H. I. Developmental changes in eye movements and visual information encoding associated with learning to read. *Current Directions in Psychological Science* **2014**, *23*(3), 201-207. https://doi.org/10.1177/0963721414530145.
51. Ko, S. R.; Yoon, N. Y. The characteristics of eye-movement in Korean sentence reading: cluster length, word frequency, and landing position effects. *Korean Journal of Cognitive Science* **2007**, *18*(4), 325-350. https://doi.org/10.19066/cogsci.2007.18.4.001.
52. Bensoussan, M. EFL reading as seen through translation and discourse analysis: narrative vs. expository texts. *English for Specific Purpose* **1990**, *9*(1), 49-66. https://doi.org/10.1016/0889-4906(90)90028-B.
53. Pellicer-Sánchez, A.; Tragant, E.; Conklin, K.; Rodgers, M.; Serrano, R.; Llanes, A. Young learners' processing of multimodal input and its impact on reading comprehension: an eye-tracking study. *Studies in Second Language Acquisition* **2020**, *42*(3), 577-598. https://doi.org/10.1017/S0272263120000091.