de-la-Peña
Journal of New Approaches in Educational Research (2024) 13:13
https://doi.org/10.1007/s44322-024-00013-w

Journal of New Approaches in Educational Research

ORIGINAL RESEARCH Open Access

Eye-tracking contribution on processing of (implicit) reading comprehension

Cristina de-la-Peña[1*]

*Correspondence: cristina.delapena@unir.net

[1] Deparment of Research Methods and Diagnosis in Education, Universidad Internacional de La Rioja, Logroño, Spain

Abstract

Reading comprehension is a fundamental skill to be developed from the early stages of reading acquisition and it is essential for both formative and personal learning. This study examines eye-tracking as a useful and complementary tool in the assessment and improvement of implicit reading comprehension. The aim is to understand the role of eye-tracking in implicit reading comprehension and, complementarily, in intervening skills such as vocabulary, rapid automatized naming, and processing speed. In a final sample of 7–8 year-old 67 students, tests for implicit reading comprehension (literal, inferential, and total), eye-tracking measures, vocabulary, rapid automatized naming, processing speed, as well as tests to control for intellectual and attentional levels were administered. The results of the correlational and regression analyses indicate the existence of predictive relationships between (i) implicit reading comprehension and eye-tracking measures, and additionally, (ii) between intervening skills (vocabulary, rapid automatized naming, processing speed) and eye-tracking measures, and (iii) between implicit reading comprehension and intervening skills (vocabulary, rapid automatized naming, processing speed). In summary, better performance in implicit reading comprehension (literal, inferential, and total) is related to and explained by shorter eye movement times in recognition and access to meaning, larger vocabulary, and faster rapid automatized naming and processing speed. Furthermore, eye-tracking measures are better predictors of implicit reading comprehension. These findings provide promising evidence for the contribution of eye-tracking to optimising the level of implicit reading comprehension, which is applied daily in classrooms.

Keywords: Reading comprehension, Eye-tracking, Vocabulary, Rapid automatized naming, Processing speed

1 Introduction

Reading comprehension constitutes a fundamental competence for learning and must be successfully developed in accordance with the Sustainable Development Goals (SDGs) of the 2030 Agenda to provide quality education (OECD, 2021). In this regard, educational institutions, from the earliest stages, must adapt educational practices aimed at optimising the acquisition and consolidation of reading comprehension for all students, thereby facilitating equitable education for all the students.

This necessity to improve reading comprehension has been highlighted across various educational levels and contexts, from international studies at the primary level such as the results of the Progress International Reading Literacy Study (PIRLS) (Mullis & Martin, 2021), the Programme for International Student Assessment (PISA) (OECD, 2024), or the National Assessment of Educational Progress (NAEP, 2022) to empirical research at the primary (Sufa et al., 2023), secondary and university levels (Author, 2021; Grabe & Stoller, 2019). The results of these studies indicate that despite the fact that students learn to identify explicit details in the text and memorise them during the acquisition of reading comprehension, they do not generate a mental representation that allows them to reflect on the text, and thus, they do not generate inferential and critical knowledge. Furthermore, some studies (Cox et al., 2014) point out students' difficulties in successfully tackling the comprehension of academic texts. The concern of education professionals regarding the level of reading comprehension is due, on the one hand, to the ability to interpret and reflect based on the written text and, on the other hand, to its influence on academic performance and the formative and personal development of students (Andrianatos, 2019; Viramonte et al., 2019).

Reading comprehension refers to all perceptual, cognitive, and motor processing involved in constructing a mental representation of the text's meaning (Van Dyke, 2021). Effective reading comprehension entails the proper functioning of various skills (Duke & Cartwright, 2021) such as word recognition (phonological awareness, visual recognition, and alphabetic principle), language comprehension (verbal reasoning, theory of mind, language structure, and cultural or prior knowledge), bridging processes (reading fluency, vocabulary, and morphological awareness), and active self-regulation (motivation, executive function, and strategy use). In this sense, various studies highlight the relationship between reading comprehension and these different skills, such as vocabulary (Gerth & Festman, 2021; Oakhill et al., 2015), oral comprehension (Peng et al., 2021), fluency (Georgiou & Das, 2014), rapid automatized naming (RAN) (Varizo et al., 2022), phonological awareness (Peng et al., 2021), executive function (Cartwright et al., 2020; Diningrat et al., 2023), processing speed (Christopher et al., 2012), access to cultural or prior knowledge (McCarthy & McNamara, 2021), and motivation (Dewi et al., 2020).

The most scientifically validated model of reading comprehension is up to now Kintsch's construction-integration model (1998). According to this model, to achieve effective reading comprehension, the student must generate a situational model of the text being read. This involves the creation of a mental representation of the written information that engages various cognitive processes (Kucer, 2016) which align with the reader's prior knowledge. To construct this situational model, the reader goes through different phases or stages: initially, a literal analysis of the written text is performed, identifying explicit data to constitute a literal level of reading comprehension; subsequently, semantic content is added, creating a network of ideas or micropropositions that combine and relate to form abstract ideas and construct macropropositions; finally, prior knowledge and experiences (Van den Broek et al., 2016) are incorporated, along with inferential processes, producing the situational model that constitutes the deep level of reading comprehension, which facilitates the critical understanding of the texts previously read.

Following the aforementioned model of reading comprehension and in light of previous research results, the general concern focus on the fact that students frequently remain at a literal level of reading comprehension. Thus, there exists a general interest in elucidating why students may have more or less success in reading comprehension. One useful tool in assessing and improving reading comprehension is eye-tracking while reading. Although much more research is needed, studies (Méziére et al., 2023) indicate the predictive capacity of eye movements in the execution of reading comprehension tasks and in the cognitive processes involved, such as word reading (Kuperman et al., 2018), working memory, or inferences (Eilers et al., 2018); studies are also being conducted on prior or cultural knowledge (Vela-Candelas et al., 2022), the effect of task type (Kaakinen & Hyönä, 2007), and the medium or reading modality (Jian, 2021).

Eye-tracking is a technique used as an indicator of cognitive processing in the reading process, providing information on a variety of parameters, including fixations —moments when information is acquired and the eyes are stationary between two saccadic movements, saccades — rapid eye movements from one word to another, and regressions— instances when the eyes return to a word to reread it. Additionally, general data (e.g., mean fixation duration, average fixation durations) provide information on the overall behaviour of the reading process, and specific data (e.g., first fixation, go-past time) relate to pre-lexical reading processes such as lexical recognition and post-lexical processes such as syntactic, semantic, and pragmatic integration. Researchers (Parshina et al., 2022) indicate that efficient eye movement involves few and short fixations, longer saccades, and no regressions. Therefore, as efficiency decreases due to various reasons (more complex text, lower reading ability, etc.), readers will make longer fixations, shorter saccadic movements, and more regressions. Kaakinen et al. (2015) indicate that the least skilled readers and those with dyslexic difficulties have longer fixations, different saccadic movement patterns, and pay less attention to relevant parts of the text compared to the most skilled readers.

One of the most influential models of eye movement in reading is the E-Z Reader model (Reichle, 2003), which predicts fixation duration and saccades between words. This serial attention model of words argues that when the reader fixes their attention on a word, attentional resources are allocated that allow for the lexical recognition of the individual word. Subsequently, a signal is sent to the oculomotor systems to program the next saccade to the next word, while simultaneously continuing with the post-lexical access of the word (its meaning is integrated into a higher-level representation) and shifting attention to the next word to be processed. In this way, comprehension occurs at the word, sentence, and text levels. This model indicates that with familiar words, the duration of fixation decreases as the post-lexical access ends before the programming of the saccade to the next word; however, the duration of fixation increases with unfamiliar words because the post-lexical access takes longer, delaying the saccadic programming signal and processing of subsequent words. Therefore, frequent words receive shorter fixations and infrequent words receive longer fixations and longer fixation times (Rau et al., 2015; Tiffin-Richards & Schroeder, 2015), reflecting the greater or lesser ease in lexical processing. In this sense, for instance, having a larger lexical size or vocabulary would imply faster eye movement times (Verhoeven et al., 2011), and Gerth and Festman (2021) show that lexical size or vocabulary predicts reading comprehension in first and second-grade students.

The interest in the application of eye-tracking in reading comprehension is generating research based on an explicit format, that is, indicating that questions will be asked after reading. Southwell et al. (2020), using general eye movement measures, predicted reading comprehension performance in multiple-choice tasks with a text read silently, relating more and shorter fixations to better explicit reading comprehension scores. A similar result was found by D'Mello et al. (2020). Méziére et al. (2023) found that adults' eye movements predict the pre-lexical and post-lexical processes involved in reading comprehension. Inhoff et al. (2018) recorded eye movement data from students reading sentences and then answering yes/no and fill-in-the-blank questions, relating the rate of regressions to better reading comprehension performance. Krstić et al. (2018) found that students with good reading comprehension have greater saccade amplitude and focus on relevant sections of the text using monitoring and synthesis strategies, compared to students with poor reading comprehension who use memorization strategies. There are few studies related to eye movement, reading comprehension, and involved skills; Gordon et al. (2020) related RAN in university students, finding that it was associated with shorter fixation durations and regressions in the first pass, and greater benefit from parafoveal processing, contributing to processing speed in the reading process.

Therefore, eye-tracking is a non-invasive technique that provides direct information on the online cognitive processing involved during reading comprehension. In this context, eye movements reflect the greater or lesser efficiency of readers in encoding and understanding texts. Consequently, this research aims to address an educational concern and need for improving the level of reading comprehension in students who are developing this competence, in line with SDG 4 on quality education. To this end, a study is proposed with second-grade students (7–8 year-olds) to evaluate the level of implicit reading comprehension. A novel aspect of this research is the assessment of implicit reading comprehension and the distinction between literal and inferential reading comprehension, as all existing studies focus on explicit and general reading comprehension with oral or silent reading. At the level of eye movements, there are no qualitative differences between these types of reading (Laubrock & Kliegl, 2015). According to theoretical models and previous research, it is expected that eye-tracking parameters can adequately predict the accuracy of reading comprehension. The findings will provide an evidence-based response and open a potential pathway for the educational development of reading comprehension in classrooms, as implicit comprehension predominates during school time and in daily life. Eye-tracking could be a useful tool for monitoring and improving reading comprehension from early stages.

2 Methods

2.1 Design

Up to now, after an exhaustive review, there are no studies that assess implicit reading comprehension, that is, not notifying that questions will be asked after reading, and examining eye movements and/or intervening skills. Based on this lack of studies and the theoretical models, implicit reading comprehension is investigated, distinguishing between literal, inferential, and total comprehension (sum of literal and inferential reading comprehension), eye movement measures, and three intervening skills in reading comprehension (Duke & Cartwright, 2021): vocabulary (known lexical size), RAN (speed of naming stimuli), and processing speed (speed of completing a cognitive activity). It is hypothesised that better performance in implicit reading comprehension is related to and explained by shorter eye movement times in recognition and access to meaning, larger vocabulary, and faster RAN and processing speed.

The general objective is to understand the involvement of eye-tracking in implicit reading comprehension; and additionally, the involvement of eye-tracking in vocabulary, RAN, and processing speed, and their role in implicit reading comprehension. To this end, the following specific objectives (SO) are operationalised:

> SO1. To analyze the relationship between eye-tracking measures and implicit reading comprehension (literal, inferential, and total) and their predictive capacity.
> SO2. To analyze the relationship between implicit reading comprehension (literal, inferential, and total) and vocabulary, RAN, and processing speed, and their predictive capacity.
> SO3. To analyze the relationship between eye-tracking measures and vocabulary, RAN, and processing speed, and their predictive capacity.

The hypotheses (H) proposed are:

> H1. There is a significant and predictive relationship between eye-tracking measures and implicit reading comprehension (literal, inferential, and total).
> H2. There is a significant and predictive relationship between vocabulary, RAN, and processing speed, and implicit reading comprehension.
> H3. There is a significant and predictive relationship between eye-tracking measures and vocabulary, RAN, and processing speed.

This research adopts a quantitative methodology with a non-experimental, ex post facto design. The variables used in the study include reading comprehension (literal, inferential, and total), vocabulary, RAN, processing speed, and eye-tracking measures, such as first fixation duration, time to first whole fixation, gaze duration (sum of all fixations until the eye leaves the text), and total fixation duration. The durations and times of eye-tracking are provided in milliseconds. The data for all variables are quantitative.

2.2 Sample

The study's participants are 83 s-grade students, of whom 13 were excluded: six because their parents did not sign the consent form, two due to learning difficulties, two because their native language was Chinese and were still learning Spanish as a second language, and three due to issues with eye-tracking measurement, leaving a final sample of 67 students (46% female, 54% male). The students are from two public schools with Spanish as their mother tongue. All students are in the second grade of Primary Education ($M = 7.32$; $SD = 0.47$), with an appropriate cognitive functioning for their age and from a middle-class social environment.

The sample selection is incidental and non-probabilistic due to accessibility. Inclusion criteria are studying the second grade of Primary Education, having informed parental consent, attending all test sessions, having an intelligence quotient (IQ) above seventy, having Spanish as the mother tongue, and not being diagnosed with any learning difficulties or sensory and/or neurological problems.

All parents signed the corresponding written consents, having the freedom to allow their children to participate and withdraw them at any time from the study. This research is approved by the Ethics Committee of International University of La Rioja (Spain) (PI019/2023) and follows the ethical guidelines of the Declaration of Helsinki.

2.3 Instruments

The following tests were administered for the study:

Reynolds Intellectual Assessment Scales (RIAS) (Reynolds & Kamphaus, 2009): This test evaluates the general functioning level through verbal and non-verbal IQ. It was used to ensure that all students are within the same intellectual range without variabilities that could influence subsequent results. The test takes 40 min and includes guessing, categories, verbal analogies, and incomplete figures, scored according to the scale norms. The total score provides verbal, non-verbal, and general IQ.

Attention Test from the NEPSY-II Child Neuropsychological Battery (Korkman et al., 2014): This test evaluates the students' attention levels to exclude attentional difficulties that might affect the results. The task involves touching a red circle among three others (blue, green, and black) while hearing different words, including the mentioned colors, for about six minutes. Each correct touch of the red circle scores a point, corrected and scaled according to the test norms.

PPVT-III Peabody (Dunn et al., 2010): This test assesses receptive vocabulary by showing students images and asking them to identify the one that best represents a given word. Used as an indicator of lexical size, it takes about 15 min, and scoring is one point per correct answer, with standardization according to the test norms.

Naming Test from the DST-J (Fawcett & Nicolson, 2016): This test evaluates RAN by asking students to name various everyday objects as quickly as possible. The test duration depends on how long it takes the student to name all objects, with the score being the time taken, evaluated in percentiles according to age-appropriate norms.

Coding Test from the WISC-V Battery (Wechsler, 2015): This test measures processing speed by making students write symbols under numbers. The more symbols completed, the better the processing speed. The test uses Form A and B depending on age (7 or 8 years) and lasts two minutes. Each correct response scores one point, while incorrect ones score zero.

Reading Comprehension Test (PROLEC-R) (Cuetos et al., 2014): This test evaluates reading comprehension through reading 1 expository texts and answering four questions suitable for the sample's age. For this study, one text (about okapis) was selected, with corresponding open-ended questions distinguishing between literal and inferential questions. Each correct answer scores one point, and incorrect answers score zero. This test (text and questions) was used in the eye-tracking experiment as it is validated and widely used for these ages.

Eye-Tracking Experiment: First, the selected text and questions were administered using a validated reading comprehension test (PROLEC-R) for children of the same ages as the sample. None of the children had read the text (about okapis) before or been evaluated with this reading comprehension test. The text, an expository paragraph with seventy-five words, was read aloud. It was displayed on a computer screen in black Times New Roman font, size 11, on a white background with 2 cm line spacing. Data from eye movements were collected from the 67 students in the sample.

2.4 Procedure

The administration of the study's tests took place in March, April, and May of 2024, during two sessions of fifty minutes each, conducted in well-lit and quiet rooms at the educational centers. The tests were administered individually to each student, maintaining the same order for all participants: IQ and attention on the first day, and vocabulary, RAN, processing speed and reading comprehension with eye-tracking on the second day. All procedure is approved by the Ethics Committee of International University of La Rioja (PI019/2023) and is part of the research project "Early literacy: intervening variables in plurilingual educational contexts" with reference (PP-2023-05).

For recording eye movements during the text reading, a Tobii Spark device with a 60 Hz frequency was used, connected to a computer with a screen resolution of 1920 × 1080 pixels. The students were seated at a viewing distance of 62 cm, with no additional support utilised. Before initiating the experiment, the calibration task and text reading were explained to the students, instructing them only to read the text aloud. Subsequently, a five-point calibration was performed, and recalibration was necessary for seven participants to ensure eye movement accuracy. Once validated, the reading started. After the reading, without prior notice, the students were asked two literal and two inferential reading comprehension questions. For the literal questions, the answers were explicitly stated in the text, whereas for the inferential questions, the students needed to make inferences to provide the correct answers. The material is not available in this article due to copyright restrictions.

2.5 Data analysis

The non-experimental nature of the study requires an initial descriptive analysis of the IQ and attention test statistics to verify that all students have an adequate level of cognitive and attentional functioning for their age, thereby avoiding influences on the results of reading comprehension and eye movements. Secondly, descriptive statistics of the vocabulary test, reading comprehension responses, RAN and, processing speed, and eye movement parameters are analyzed. Thirdly, the normality of the variables is assessed, indicating non-normality, and the non-parametric Spearman correlational statistic is applied to the vocabulary, RAN and processing speed, reading comprehension responses, and eye movement scores. The eye-tracking measures analyzed include: i) first fixation duration (initial fixation duration on a word); ii) gaze duration (sum of all first-pass fixations on a word); iii) total fixation duration (final duration); and iv) time to first whole fixation. Subsequently, for significant correlations, a linear regression analysis is employed to evaluate the predictive relationship, using R^2 as the proportion of explained variance between related variables. A significance level of 0.05 (two-tailed) is used.

All statistical analyses are conducted using Statistical Package for the Social Sciences (SPSS) version 27 (IBM, 2016), and the analysis of eye-tracking metrics is performed with Tobii Pro Lab software (Tobii Technology AB, n.d).

3 Results

Firstly, a preliminary analysis verifies that all students have an adequate level of cognitive functioning ($M = 215$; $SD = 31.18$) and attentional functioning ($M = 28$; $SD = 1.83$), which does not interfere with the study results.

Secondly, Table 1 presents the descriptive statistics for reading comprehension, vocabulary, RAN, and processing speed, and eye-tracking measures. The data indicate a higher level of literal reading comprehension compared to inferential comprehension, with an overall improvement in general, literal, and inferential reading comprehension. The results from the vocabulary, RAN, and processing speed tests are within the normal range for the students' age but could be optimised.

The eye-tracking measures' data are not comparable among themselves or with reference standards, but it is observed heat maps for reading two sentences of the text of all students (Fig. 1). Pre-lexical (recognition) and post-lexical (access to meaning) is slower in unfamiliar words, for example, "okapi" versus "selva" (familiar words).

Screenshot of the reading of two sentences from Tobii Pro Lab software. Red colours represent areas where students take longer to read. Green colors represent areas of shorter fixation time to read.

Table 1 Descriptive statistics results

Variables	Means	Desviation	Minimum	Maximum
Literal reading comprehension	1.8	.3	0	2
Inferencial reading comprehension	1.2	1	0	2
Total reading comprehension	3.1	.7	0	4
Vocabulary	87.5	9.9	46	108
RAN	45.8	12.1	28	120
Processing speed	45.5	13.2	17	65
Time to first whole fixation	9055.5	6381.4	3624	52,420.2
First fixation duration	349.3	145	169.7	1098.9
Gaze duration	830	636.2	271.9	5154.7
Total fixations duration	697.1	332.5	231.4	2167.9

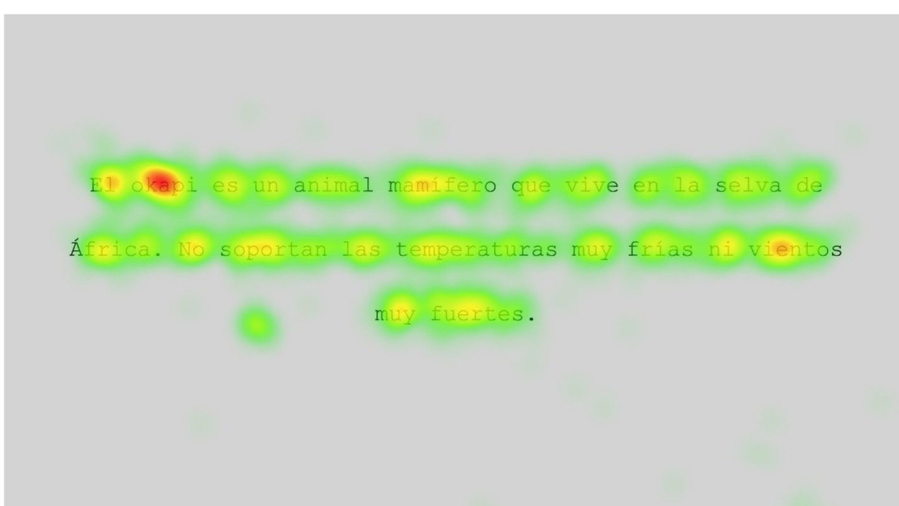

Fig. 1 Heat maps for reading two sentences of the text

Thirdly, Spearman correlations (a non-parametric test) were performed to analyze the relationships between reading comprehension levels, eye-tracking measures, and scores for vocabulary, RAN, and processing speed, as shown in Tables 2, 3, and 4. A stepwise linear regression analysis was conducted between the indicated variables.

Objective 1: "To analyze the relationship between eye movement tracking measures and implicit reading comprehension (literal, inferential, and total) and their predictive capacity." The results presented in Table 2 indicate that literal reading comprehension inversely correlates significantly with all eye-tracking measures. Inferential reading comprehension also inversely correlates significantly with all eye-tracking measures. Total reading comprehension shows a significant inverse correlation with all eye-tracking measures. The regression analysis reveals that total reading comprehension is explained by 49.8% by time to first whole fixation (B = -0.70; $R^2 = 0.49$; $p < 0.001$), 47.2% by first fixation duration (B = -0.68; $R^2 = 0.47$; $p < 0.001$), 47.7% by gaze duration (B = -0.69; $R^2 = 0.47$; $p < 0.001$), and 47.6% by total fixation duration (B = -0.69; $R^2 = 0.47$; $p < 0.001$). Taken together, the four variables explain 67.2% of total reading comprehension ($R^2 = 0.67$; $p < 0.001$), indicating that shorter time to first whole fixation and total fixation duration predict better total reading comprehension.

Table 2 Correlations between reading comprehension and eye-tracking scores

	Literal reading comprehension *r* **significance**	**Inferential reading comprehension** *r* **significance**	**Total reading comprehension** *r* **significance**
Time to first whole fixation	-.51 < .001*	-.78 < .001*	-.85 < .001*
First fixation duration	-.41.001*	-.60 < .001*	-.66 < .001*
Gaze duration	-.50 < .001*	-.81 < .001*	-.87 < .001*
Total fixations duration	-.40 .001*	-.80 < .001*	-.81 < .001*

* $p < .05$

Table 3 Correlations between reading comprehension and vocabulary, RAN, and processing speed

	Literal reading comprehension *r* **significación**	**Inferential reading comprehension** *r* **significación**	**Total reading comprehension** *r* **significación**
Vocabulary	.27.024*	.35 .004*	.40 .001*
RAN	-.23 .057	-.49 < .001*	-.51 < .001*
Processing speed	.09 .453	.31 .009*	.28 .018*

* $p < .05$

Table 4 Correlations between eye-tracking scores, vocabulary, RAN, and processing speed

	Vocabulary *r* **significance**	**RAN** *r* **significance**	**Processing speed** *r* **significance**
Time to first whole fixation	-.47 < .001*	.51 < .001*	-.31 .009*
First fixation duration	-.44 < .001*	.35 .003*	-.18 .144
Gaze duration	-.45 < .001*	.49 < .001*	-.33 .006*
Total fixations duration	-.40 .001*	.44 < .001*	-.27 .022*

* $p < .05$

Literal reading comprehension is explained by 52% by time to first whole fixation (B = -0.72; $R^2 = 0.52$; $p < 0.001$), 35.3% by first fixation duration (B = -0.59; $R^2 = 0.35$; $p < 0.001$), 50% by gaze duration (B = -0.70; $R^2 = 0.19$; $p < 0.001$), and 10.6% by total fixation duration (B = -0.32; $R^2 = 0.10$; $p = 0.007$). Together, these four variables explain 52.1% of literal reading comprehension ($R^2 = 0.52$; $p < 0.001$), indicating that shorter time to first whole fixation predicts better literal reading comprehension.

Inferential reading comprehension is explained by 20% by time to first whole fixation (B = -0.45; $R^2 = 0.20$; $p < 0.001$), 26.8% by first fixation duration (B = -0.51; $R^2 = 0.26$; $p < 0.001$), 19.5% by gaze duration (B = -0.44; $R^2 = 0.19$; $p < 0.001$), and 50.5% by total fixation duration (B = -0.71; $R^2 = 0.50$; $p < 0.001$). Taken together, the four variables explain 67.2% of inferential reading comprehension ($R^2 = 0.67$; $p < 0.001$). These findings support hypothesis H1, "There is a significant and predictive relationship between eye movement tracking measures and implicit reading comprehension (literal, inferential, and total)." All eye movement tracking measures significantly and inversely correlate with implicit, total, literal, and inferential reading comprehension and predict them. The findings indicate that the less time taken to recognise a word and access its meaning and the fewer fixations a word receives, the better the scores in literal reading comprehension, particularly in inferential and total reading comprehension.

Figure 2 shows the comparative heat maps of two students, one with low implicit reading comprehension and another with high performance implicit reading comprehension. The student with greater reading comprehension has a faster pre-lexical and post-lexical process, even skipping words, and with a greater fixation on the unfamiliar word "okapi". The student with lower reading comprehension has a slower pre-lexical and post-lexical process, reading all the words and with a greater fixation on several familiar and unfamiliar words.

Screenshot of the reading of low and high implicit reading comprehension from Tobii Pro Lab software. Red colours represent areas where students take longer to read. Green colors represent areas of shorter fixation time to read.

Objective 2: "To analyze the relationship between implicit reading comprehension (literal, inferential, and total) and vocabulary, RAN, and processing speed, and their predictive capacity." The results presented in Table 3 indicate that literal reading comprehension significantly positively correlates with vocabulary. Inferential reading comprehension significantly inversely correlates with RAN and positively with vocabulary

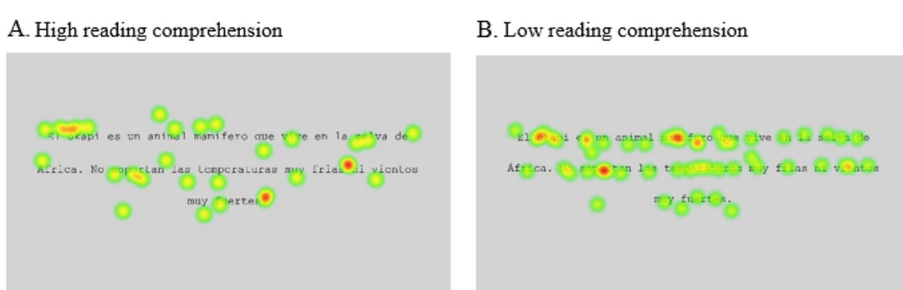

Fig. 2 Heat maps for low and high implicit reading comprehension

and processing speed. Total reading comprehension significantly inversely correlates with RAN and positively with vocabulary and processing speed. The regression analysis reveals that total reading comprehension is explained by 21.7% by vocabulary (B = 0.46; $R^2 = 0.21$; $p < 0.001$), 10% by processing speed (B = 0.31; $R^2 = 0.10$; $p < 0.001$), and 28.8% by RAN (B = 0.53; $R^2 = 0.28$; $p < 0.001$). Together, these three variables explain 38.5% of total reading comprehension ($R^2 = 0.38$; $p < 0.001$), indicating that slower RAN, greater vocabulary, and faster cognitive processing predict better total reading comprehension.

Literal reading comprehension is explained by 23.8% by vocabulary (B = 0.48; $R^2 = 0.23$; $p < 0.001$). Together, the three variables explain 34.2% of literal reading comprehension ($R^2 = 0.34$; $p < 0.001$), indicating that slower RAN and greater vocabulary predict better literal reading comprehension.

Inferential reading comprehension is explained by 8.5% by vocabulary (B = 0.31; $R^2 = 0.08$; $p = 0.010$), 9% by processing speed (B = 0.31; $R^2 = 0.09$; $p < 0.001$), and 13.5% by RAN (B = -0.36; $R^2 = 0.13$; $p = 0.002$). Together, the three variables explain 13.5% of inferential reading comprehension ($R^2 = 0.13$; $p = 0.002$). These findings support hypothesis H2, "There is a significant and predictive relationship between vocabulary, RAN, processing speed, and implicit reading comprehension." The three skills significantly correlate with the three types of reading comprehension, except for RAN and processing with literal reading comprehension, and have predictive capacity for implicit reading comprehension. The findings indicate that a larger vocabulary predicts better scores in literal, inferential, and total reading comprehension; faster RAN predicts poorer scores in literal, inferential, and total reading comprehension; and better processing speed predicts better scores in literal, inferential, and total reading comprehension.

Objective 3: "To analyze the relationship between eye movement tracking measures and vocabulary, RAN, and processing speed, and their predictive capacity." The results presented in Table 4 indicate that vocabulary significantly negatively correlates with all eye-tracking measures. RAN significantly positively correlates with all eye-tracking measures. Processing speed significantly inversely correlates with time to first whole fixation, gaze duration, and total fixation duration. The regression analysis reveals that vocabulary is explained by 38.5% by time to first whole fixation (B = -0.62; $R^2 = 0.38$; $p < 0.001$), 35.5% by first fixation duration (B = -0.59; $R^2 = 0.35$; $p < 0.001$), 35.9% by gaze duration (B = -0.60; $R^2 = 0.35$; $p < 0.001$), and 15.6% by total fixation duration (B = -0.39; $R^2 = 0.15$; $p = 0.001$). Together, the four variables explain 38.5% of vocabulary ($R^2 = 0.38$; $p < 0.001$), indicating that shorter eye movement times predict better vocabulary.

RAN is explained by 67% by time to first whole fixation (B = 0.81; $R^2 = 0.67$; $p < 0.001$), 43.8% by first fixation duration (B = 0.66; $R^2 = 0.43$; $p < 0.001$), 68% by gaze duration (B = 0.82; $R^2 = 0.68$; $p < 0.001$), and 8.1% by total fixation duration (B = 0.28; $R^2 = 0.08$; $p = 0.020$). Together, the four variables explain 70% of RAN ($R^2 = 0.70$; $p < 0.001$), indicating that shorter times in recognition and access to meaning predict faster RAN.

Processing speed is explained by 7.7% by time to first whole fixation (B = -0.27; $R^2 = 0.07$; $p = 0.023$) and 6.9% by gaze duration (B = -0.26; $R^2 = 0.06$; $p = 0.032$). Together, the three variables explain 7.7% of processing speed ($R^2 = 0.07$; $p = 0.023$), indicating that shorter times predict better processing speed. These findings support hypothesis H3, "There is a significant and predictive relationship between eye movement tracking measures and vocabulary, RAN, and processing speed." All eye-tracking measures significantly correlate with vocabulary, RAN, and processing speed, except processing speed with first fixation duration. The findings indicate that shorter recognition and access times and fewer fixations on words predict a larger vocabulary and faster RAN and processing speed.

To sum up, eye-tracking measures predict both implicit reading comprehension and vocabulary, RAN, and processing speed. Eye-tracking measures are better predictors of implicit reading comprehension (total, literal, and inferential) than vocabulary, RAN, and processing speed.

4 Discussion

This study aims to investigate the implications of eye-tracking on the level of implicit reading comprehension and certain intervening skills (vocabulary, RAN, and processing speed) in second-grade primary school students who have acquired both phonological and lexical reading pathways. To this end, eye-tracking measures were administered during the reading process of a text, reading comprehension level was assessed through questions (both literal and inferential) raised after reading the text without prior notice to the students, and standardised and validated tests for vocabulary, RAN, and processing speed were administered. The results demonstrate significant relationships and predictions of eye-tracking measures on implicit reading comprehension (literal, inferential, and total), as well as vocabulary, RAN, and processing speed (skills involved in reading comprehension according to Duke & Cartwright's framework, 2021).

The findings confirm Hypothesis 1 (H1), indicating the existence of a significant and predictive relationship between eye-tracking measures and implicit reading comprehension (literal, inferential, and total). This suggests that the temporal speed with which a word is recognised and its meaning accessed, along with the fewer fixations a word receives, are significantly related to and predict performance levels in implicit reading comprehension tasks, both literal and inferential, thereby enhancing the prediction of total reading comprehension (sum of literal and inferential scores). These data align with other studies on explicit reading comprehension (Méziére et al., 2023; Southwell et al., 2020), highlighting the role of eye movements in pre-lexical and post-lexical processes necessary for reading comprehension; Méziére et al. (2023) found that eye movements predict 39% of reading comprehension, while this study shows an increase to 67.2%. Furthermore, D'Mello et al. (2020) predicted reading comprehension using six eye movement measures with a machine learning computational model. Therefore, this study provides additional evidence of the strong association between eye movements and subsequent text comprehension without explicit indication of subsequent questions. Moreover, the predictive power of eye movements is greater for inferential reading comprehension than for literal reading comprehension. This reflects the connection between eye movements and both literal and especially inferential reading comprehension, consistent with the E-Z Reader model (Reichle, 2003) of eye movements and the construction-integration model of Kintsch (1998). Possibly, when we read a text in class or daily life, a situational model of the text is created, even without any explicit demand on it. This is beneficial for students' learning process from early stages of reading acquisition.

The research results confirm Hypothesis 2 (H2), indicating the existence of a significant and predictive relationship between vocabulary, RAN, processing speed, and implicit reading comprehension. This implies that greater vocabulary and faster RAN and processing speed are significantly related to and predict performance levels in literal, inferential, and total reading comprehension tasks. These findings are comparable with other studies analyzing explicit reading comprehension and are consistent with the involvement of vocabulary (Gerth & Festman, 2021; Oakhill et al., 2015) in reading comprehension, RAN (Varizo et al., 2022), and processing speed (Christopher et al., 2012). Thus, these three analyzed skills align with Duke and Cartwright's theoretical framework (2021) regarding the role of various cognitive and linguistic skills in reading comprehension. It can be inferred that children with limited vocabulary due to difficulties or lack of stimulation, as well as those who are slow in naming and processing stimuli, will be less skilled in reading comprehension. This has practical implications for stimulating this group of students. For example, in children diagnosed with dyslexia, Santos and Capellini (2020) found improvements in reading comprehension by training RAN.

The study's results confirm Hypothesis 3 (H3), indicating the existence of a significant and predictive relationship between eye-tracking measures and vocabulary, RAN, and processing speed. This suggests that the temporal speed with which a word is recognised and its meaning accessed, along with the fewer fixations a word receives, are significantly related to and predict a larger vocabulary, faster RAN, and faster processing speed. The measure of time to first whole fixation is the most predictive of vocabulary and processing speed, while gaze duration is the most predictive of RAN. Vocabulary data are in line with Verhoeven et al. (2011), who found faster eye movements in students with a larger vocabulary. The finding on RAN is consistent with the study by Gordon et al., (2020), which also associates it with shorter gaze durations. These findings are novel, leading to a lack of scientific literature for discussion. Nevertheless, it seems coherent to reflect that a larger vocabulary implies faster word recognition during reading, as well as speed in both analyzed types of speeds.

4.1 Educational implications

Several educational implications can be drawn from this research. Theoretically, the results empirically support the theoretical models (Duke & Cartwright, 2021; Kintsch, 1998; Reichle, 2003) that underpin this study, providing further scientific support. Practically, in the classroom, vocabulary can be increased and timed exercises can be conducted across all subjects. Additionally, dialogic readings of the syllabus can be implemented. In this regard, a study (Okkinga et al., 2018) found improvements in reading comprehension through collaborative readings such as peer dialogic reading. Specifically, when studying the mother tongue, initial three-minute daily sessions of naming and vocabulary related to the syllabus can be conducted. Furthermore, all teachers can develop strategies to consolidate information implicitly and playfully, using digital resources. For example, experiences indicate an increase in reading comprehension through the use of digital tools (Lorusso et al., 2021) or use social media platforms (SMP) (Martín-Gutiérrez et al., 2024).

From an orientation perspective, workshops on implicit reading comprehension can be conducted during tutorial hours by the group's tutors. In these workshops, which can be conducted every term or year, strategies for individual and paired (peer mediation) implicit reading comprehension can be worked. A personalised digital game with vocabulary, RAN, processing speed, and reading comprehension tasks could also be designed for students to interact with their classmates; this would be highly beneficial for those with greater difficulties in reading comprehension.

At the educational centre level, progress can be made in two directions: creating a transversal project on reading comprehension and providing teachers with materials designed for all grades with playful activities that integrate vocabulary, RAN, and processing speed with attractive and interesting texts. Eye-tracking data can complement individual educational programs in both assessment and intervention.

4.2 Limitations and future studies

Sample size always constitutes a limitation as the number of participants could be improved; however, this study has evaluated a considerable number of eye movements in second-grade primary school students. Additionally, the type of open-ended questions in the implicit reading comprehension task may introduce biases in the results since different question formats can lead to different outcomes in eye movements and reading comprehension (Méziére et al., 2023). There is no consensus among education professionals on this matter, with reading comprehension assessments including multiple-choice, cloze, yes/no closed response, and open response formats. These limitations should be considered to improve the generalization of the research results.

Future research could relate eye-tracking data with evoked potentials and functional magnetic resonance imaging to expand the empirical evidence on the subject. Additionally, the involvement of other intervening variables in implicit reading comprehension could be evaluated, following Duke and Cartwright's framework (2021) or another theoretical approach. Of course, increasing the sample size, including both second-grade children and older students up to university level, and designing a future cross-sectional study are also recommended. As a future prospect, if possible, comparing eye-tracking results of students with lower and higher performance in any intervening variable in reading comprehension would be valuable; in this study, the children were distributed in a middle range, and this comparison could not be made.

5 Conclusion

The need to improve a basic competency such as reading comprehension (OECD, 2021) compels researchers to seek, update, and use all necessary tools for its optimization, including eye-tracking. This research determines that better performance in implicit reading comprehension is related to and explained by shorter eye movement times in word recognition and meaning access, larger vocabulary, and faster RAN and processing speed. Furthermore, eye-tracking measures predict implicit reading comprehension better than vocabulary, RAN, and processing speed tests. This study can be used as a starting point to provide data on implicit reading comprehension (not indicating that questions will follow a reading) with data interpreted in a research context.

The study's findings contribute to the scientific literature in several ways. Firstly, by providing data on implicit reading comprehension in its general, literal, and inferential dimensions. This type of reading comprehension is frequently employed in classrooms. Secondly, by providing evidence on the predictive relationship between eye movements and implicit reading comprehension. The results are consistent with theoretical frameworks on eye movements and reading comprehension. Thirdly, by supplying information on the predictive relationship between implicit reading comprehension and intervening skills such as vocabulary (size of known lexicon), RAN (speed of naming stimuli), and processing speed (speed of completing a cognitive task). Information on predictions or predictive relationships can be used to complement standardised assessments and plan educational interventions. Therefore, the contribution of eye-tracking to optimizing the level of implicit reading comprehension is promising.

Acknowledgements
Not aplicable.

Author's information
Cristina de-la-Peña is specialized in linguistic competence, early literacy and neuropsychopedagogical processes that affect academic skills and their difficulties. She has more than 15 years of experience in this field and has participated in a wide range of projects and more than fifty publications of scientific articles on linguistic competence and its difficulties. She collaborates with other universities and research groups and counsels educational centers and national and international associations. email: cristina.delapena@unir.net https://orcid.org/0000-0003-1176-4981.

Author's contributions
C d-l-P wrote the entire article.

Funding
This work is linked and has been funded by the Research Project "Early literacy: intervening variables in plurilingual educational contexts" with reference (PP-2023–05) granted in the call for Own Research Projects UNIR 2023 of the International University of La Rioja (UNIR).

Availability of data and materials
The data of this research are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate
All procedures and instruments used in this research were approved by the Research Ethics Committee of the International University of La Rioja (Spain) with the code PI: 019/2023.

Consent for publication
Parents gave informed consent to publish anonymous data.

Competing interests
The authors no conflicts of interest to disclose. Author have no relevant financial or non-financial interests to disclose. Author confirm that this research is original.

Received: 27 June 2024 Accepted: 11 July 2024
Published online: 19 August 2024

References

Andrianatos, K. (2019). Barriers to reading in higher education: Rethinking reading support. *Reading & Writing: Journal of the Reading Association of South Africa, 10*(1), a241. https://doi.org/10.4102/rw.v10i1.241

De-la-Peña, C., & Luque-Rojas, M. J. (2021). Levels of reading comprehension in higher education: Systematic review and meta-analysis. *Frontiers in Psychology, 12*, 712901. https://doi.org/10.3389/fpsyg.2021.712901

Cartwright, K., Timothy, R., & Nathan, A. (2020). Concurrent and longitudinal contributions of a brief assessment of reading specific executive function to reading comprehension in first and second grade students. *Mind, Brain, and Education, 14*(2), 114–123. https://doi.org/10.1111/mbe.12236

Christopher, M. E., Miyake, A., Keenan, J. M., Pennington, B., DeFries, J. C., Wadsworth, S. J., Willcutt, E., & Olson, R. K. (2012). Predicting word reading and comprehension with executive function and speed measures across development: A latent variable analysis. *Journal of Experimental Psychology: General, 141*(3), 470–488. https://doi.org/10.1037/a0027375

Cox, S., Friesner, D., & Khayum, M. (2014). Do reading skills courses help underprepared readers achieve academic success in college? *Journal of College Reading and Learning, 33*, 170–196. https://doi.org/10.1080/10790195.2003.10850147

Cuetos, F., Rodríguez, B., Ruano, E., & Arribas, D. (2014). *Prolec-r. Batería de evaluación de los procesos lectores - Revisada* (5ª edición). TEA ediciones.

D'Mello, S. K., Southwell, R., & Gregg, J. (2020). Machine-learned computational models can enhance the study of text and discourse: A case study using eye tracking to model Reading comprehension. *Discourse Processes, 57*(5–6), 420–440. https://doi.org/10.1080/0163853X.2020.1739600

den Broek, V., Paul, M. J., & Kraal, A. (2016). Individual differences in reading comprehension. In P. Afflerbach (Ed.), *Handbook of individual differences in reading: Reader, text, and context* (pp. 138–150). Routledge.

Dewi, R. S., Fahrurrozi, U. H., & Wahyudi, A. (2020). Reading interest and reading comprehension. A correlational study in Syarif Hidayatullah State Islamic University, Jakarta. *Talent Development & Excellence, 12*(1), 241–250. http://repository.uinjkt.ac.id/dspace/handle/123456789/50885.

Diningrat, S. W. M., Setyosari, P., Ulfa, S., & Widiati, U. (2023). The effect of an extended flipped classroom model for fully online learning and its interaction with working memory capacity on students' reading comprehension. *Journal of New Approaches in Educational Research, 12*(1), 77–99. https://doi.org/10.7821/naer.2023.1.1073

Duke, N., & Cartwright, K. (2021). The science of reading progresses: Communicating advances beyond the simpe view of Reading. *Reading Research Quarterly, 56*(S1), S25–S44. https://doi.org/10.1002/rrq.411

Dunn, Ll. M., Dunn, L.M., & Arribas Águila, D. (2010). *PPVT-III Peabody*. Tea ediciones.

Eilers, S., Tiffin-Richards, S., & Schroeder, S. (2018). Individual differences in children's pronoun processing during reading: Detection of incongruence is associated with higher reading fluency and more regressions. *Journal of Experimental Child Psychology, 173*, 250–267. https://doi.org/10.1016/j.jecp.2018.04.005

Fawcett, A. J., & Nicolson, R. I. (2016). *Dst-j. Test para la detección de la dislexia en niños*. Tea ediciones.

Georgiou, G. K., & Das, J. P. (2014). Reading comprehension in university students: Relevance of PASS theory of intelligence. *Journal of Research in Reading, 37*, S101–S115. https://doi.org/10.1111/j.1467-9817.2012.01542.x

Gerth, S., & Festman, J. (2021). Reading development, Word length and frequency effects: an eye-tracking study with slow and fast readers. *Frontiers in Communication, 6*, 743113. https://doi.org/10.3389/fcomm.2021.743113

Gordon, P., Moore, M., Choi, W., Hoedemaker, R., & Lowder, M. (2020). Individual differences in reading: Separable effects of reading experience and processing skill. *Memory & Cognition 48*(4), 553–565. https://doi.org/10.3758/s13421-019-00989-3

Grabe, W., & Stoller, F. (2019). *Teaching and researching reading* (3rd ed.). Routledge. https://doi.org/10.4324/9781315726274

IBM (2016). *IBM SPSS Statistics para Windows, versión 24.0*. IBM Corp.

Inhoff, A., Gregg, J., & Radach, R. (2018). Eye movement programming and reading accuracy. *Quarterly Journal of Experimental Psychology, 71*(1), 3–10. https://doi.org/10.1080/17470218.2016.1226907

Jian, Y. (2021). Reading in print versus digital media uses different cognitive strategies: Evidence from eye movements during science-text reading. *Reading and Writing, 35*(7), 1–20. https://doi.org/10.1007/s11145-021-10246-2

Kaakinen, J., & Hyönä, J. (2007). Perspective effects in repeated Reading: An eye movement study. *Memory & Cognition, 35*, 1323–1336. https://doi.org/10.3758/BF03193604

Kaakinen, J., Lehtola, A., & Paattilammi, S. (2015). The influence of a reading task on children's eye movements during reading. *Journal of Cognitive Psychology*, *27*(5), 640–656. https://doi.org/10.1080/20445911.2015.1005623

Kintsch, W. (1998). *Comprehension: A paradigm for cognition*. Cambridge University Press.

Korkman, M., Kirk, U., & Kemp, S. (2014). *Batería neuropsicológica infantil NEPSY-II*. Pearson Clinical Assessment.

Krstić, K., Soskic, A., Kovic, V., & Holmqvist, K. (2018). All good readers are the same, but every low-skilled reader is different: An eye-tracking study using PISA data. *European Journal Psychology Educational, 33*, 521–541. https://doi.org/10.1007/s10212-018-0382-0

Kucer, S. (2016). Accuracy, miscues, and the comprehension of complex literary and scientific texts. *Reading Psychology, 37*(7), 1076–1095. https://doi.org/10.1080/02702711.2016.1159632

Kuperman, V., Matsuki, K., & Van Dyke, J. (2018). Contributions of reader-and text-level characteristics to eye-movement patterns during passage reading. *Journal of Experimental Psychology: Learning, Memory, and Cognition., 44*(11), 1687–1713. https://doi.org/10.1037/xlm0000547

Laubrock, J., & Kliegl, R. (2015). The Eye-Voice span during reading aloud. *Frontiers in Psychology, 6*(1432), 1432. https://doi.org/10.3389/fpsyg.2015.01432

Lorusso, M., Borasio, F., Rold, M., & Martinuzzi, A. (2021). Towards consensus on good practices for the use of new technologies for intervention and support in developmental dyslexia: A Delphi study conducted among Italian specialized professionals. *Children, 8*, 1126. https://doi.org/10.3390/children8121126

Martín-Gutiérrez, A., Said-Hung, E., & Conde-Jiménez, K. (2024). Social media and non-university teachers from a gender perspective in Spain. *Journal of New Approaches in Educational Research, 13*(10). https://doi.org/10.1007/s44322-024-00010-z

McCarthy, K., & McNamara, D. (2021). The multidimensional knowledge in text comprehension framework. *Educational Psychology, 56*, 196–214. https://doi.org/10.1080/00461520.2021.1872379

Méziére, D., Yu, L., Reichle, E., Malsburg, T., & McArthur, G. (2023). Using eye-tracking measures to predict Reading comprehension. *Reading Research Quarterly, 58*(3), 425–449. https://doi.org/10.10002/rrq.498

Mullis, I., & Martin, M.O. (2021). *PIRLS 2021. Assessment Frameworks*. TIMSS & PIRLS International Study Center and International Association for the Evaluation of Educational Achievement (IEA). https://pirls2021.org/wp-content/uploads/sites/2/2019/04/P21_Frameworks.pdf

National Assessment of Educational Progress. (2022). *Reading assessments*. Institute of Education Sciences. https://www.nationsreportcard.gov/highlights/reading/2022/

Oakhill, J., Cain, K., & McCarthy, D. (2015). Inference processing in children: The contributions of depth and breadth of vocabulary knowledge. In E. J. O'Brien, A. E. Cook, & R. F. Lorch (Eds.), *Inferences during reading* (pp. 140–159). Cambridge University Press.

Okkinga, M., Van Steensel, R., Van Gelderen, A., Van Schooten, E., Sleegers, P., & Arends, L. R. (2018). Effectiveness of reading-strategy interventions in whole classrooms: A meta-analysis. *Educational Psychology Review, 30*(4), 1215–1239. https://doi.org/10.1007/s10648-018-9445-7

Organization for the Economic Cooperation and Development. (2021). OECD skills outlook 2021: Learning for life. *OECD Publishing*. https://doi.org/10.1787/0ae365b4-en

Organization for the Economic Cooperation and Development. (2024). PISA 2022 *Technical report*. *OECD Publishing*. https://doi.org/10.1787/01820d6d-en
Parshina, O., Sekerina, I., Lopukhina, A., & Von der Malsburg, T. (2022). Monolingual and bilingual reading strategies in Russian: An exploratory scanpath analysis. *Reading Research Quarterly, 57*(2), 469–492. https://doi.org/10.1002/rrq.414
Peng, P., Lee, K., Luo, J., Li, S., Joshi, R. M., & Tao, S. (2021). Simple view of reading in chinese: A one-stage meta-analytic structural equation modeling. *Review of Educational Research, 1*, 3–33. https://doi.org/10.3102/0034654320964198
Rau, A. K., Moll, K., Snowling, M., & Landerl, K. (2015). Effects of orthographic consistency on eye movement behavior: German and English children and adults process the same words differently. *Journal of Experimental Child Psychology, 130*, 92–105. https://doi.org/10.1016/j.jecp.2014.09.012
Reichle, E., Rayner, K., & Pollatsek, A. (2003). The E-Z reader model of eye-movement control inreading: Comparisons to other models. *Behavioral and Brain Sciences, 26*, 445–526. https://doi.org/10.1017/s0140525x03000104
Reynolds, C. R., & Kamphaus, R.W. (2009). *Escala de inteligencia de Reynolds (RIAS)*. Tea ediciones.
Santos, B., & Capellini, S. (2020). Remediation program with automatized naming and reading for students with dyslexia: Elaboration and clinical significance. *Codas, 32*(3), e20180127. https://doi.org/10.1590/2317-1782/20202018127
Southwell, R., Gregg, J., Bixler, R., & D'Mello, S. (2020). What eye movements reveal about later comprehension of long connected texts. *Cognitive Science, 44*(10), 1–24. https://doi.org/10.1111/cogs.12905
Sulfa, S., Ernawati, E., & Fatmawati, F. (2023). Investigating literal and inferential comprehension achievement of grade six students. *Technium Social Sciences Journal, 39*, 127–133. https://doi.org/10.47577/tssj.v39i1.8057
Tiffin-Richards, S. P., & Schroeder, S. (2015). Word length and frequency effects on children's eye movements during silent reading. *Vis. Res., 113*, 33–43. https://doi.org/10.1016/j.visres.2015.05.008
Tobii Technology AB. (n.d.). *Tobii Pro Lab*. https://connect.tobii.com/
Van Dyke, J. (2021). Introduction to the special issue: Mechanisms of variation in Reading comprehension: Processes and products. *Scientific Studies of Reading, 25*(2), 93–103. https://doi.org/10.1080/10888438.2021.1873347
Varizo, S., Correa, J., Musinho, R., & Navas, A. (2022). The contribution of rapid automatized naming with reading rate and text comprehension in Brazilian elementary school children. *Audiology Communication Research, 27*, 1–8. https://doi.org/10.1590/2317-6431-2022-2641en
Vela-Candelas, J., Catalá, N., & Demestre, J. (2022). Effects of world knowledge on the prediction of upcoming verbs: An eye-tracking study. *Journal of Psycholinguistic Research, 51*, 1335–1345. https://doi.org/10.1007/s10936-022-09900-9
Verhoeven, L., van Leeuwe, J., & Vermeer, A. (2011). Vocabulary growth and reading development across the elementary school years. *Scientific Studies of Reading, 15*(1), 8–25. https://doi.org/10.1080/10888438.2011.536125
Viramonte, M., Amparán, A., & Núñez, L. (2019). Comprensión lectora y el rendimiento académico en Educación Primaria. *Investigaciones Sobre Lectura, 12*, 65–82. https://doi.org/10.37132/isl.v0i12.264
Wechsler, D. (2015). Wisc-v. *Escala de inteligencia de Wechsler para niños-V*. Pearson Clinical Assessment.

Publisher's Note