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The Research of Eye-Tracking (ET) Technology in English Reading of University Students: A Systematic Literature Review

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ABSTRACT

Eye-tracking (ET) technology has become an important tool in second language (L2) reading research, yet a lack of comprehensive review studies highlights the need to systematically examine its applications and future directions in this emerging field. This study systematically analysed 32 ET papers, including ScienceDirect, Scopus, Wiley Online Library, SpringerLink, Google Scholar, and the ACM Digital Library, over the last decade to investigate the use of ET technologies in reading research. The study's findings identified seven domains for the use of ET technology in reading research, with strategy research and comparison research emerging as the predominant research paths. The trends in eye tracking (ET) research in English reading reveal a growing number of studies utilising eye tracking equipment to examine reading strategies among university students, especially in China. Moreover, the predominant number of researchers depend mostly on textual materials as their reading source. The methodologies used in ET study on reading were also recognised. Among them, fixation duration, reading time, saccades, regressions, and gaze duration were the most frequently used metrics. This review deepens our understanding of how ET technology is applied in English reading research at university, informs the design of more targeted and methodologically sound experimental studies, and promotes the adoption of broader, more diverse, and multimodal research approaches in future investigations.

Keywords: Eye-Tracking; Reading; University Students; Systematic Literature Review; Second Language Acquisition

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1. Introduction

Eye-tracking (ET) is a technique for studying and analysing visual attention, cognitive processes, and behavioural responses by monitoring and recording eye movements[1]. It is a relatively undisturbed and instantaneous measurement method that acquires eye movement data from both the temporal and spatial dimensions[2]. The principle of ET technology is to track the position and track of the eyes using specialised devices (ET devices), which usually detect eye movements by means of infrared light or other sensing technologies[3]. These devices can provide very precise data to help researchers understand how an individual's eyes move, stay, and shift focus when observing a scene or target[4].

In recent years, ET technology has been increasingly integrated into second language acquisition (SLA) research, particularly in the domain of reading, where it supports interdisciplinary exploration of the underlying mechanisms of language processing[5, 6]. Specifically, ET has emerged as an essential tool for examining English reading behaviours among second language (L2) learners, allowing researchers to track how readers allocate attention, employ comprehension strategies, and respond to textual complexity[7]. This method provides empirical access to the cognitive processes that underlie reading performance, enabling detailed analysis of gaze patterns and linguistic processing across different proficiency levels and text types[7–10].

Despite the growing body of research using ET in L2 reading contexts, there remains a lack of systematic reviews focusing specifically on university EFL learners. Most existing studies are scattered across various subtopics and do not provide an integrated view of how ET contributes to understanding reading behaviors in higher education contexts. This research gap underscores the need for comprehensive syntheses to map out existing findings, clarify methodological trends, and identify directions for future investigation.

2. Eye-Tracking and Reading

In eye-tracking research, understanding the basic types of eye movements is fundamental to analyzing reading behavior and cognitive processes. These movements provide valuable insights into how readers allocate visual attention, process linguistic information, and navigate through text. Among the key metrics used in eye-tracking studies, two primary categories are particularly noteworthy: fixation and saccade. Fixation denotes the duration in which the central fovea of the eye is aligned with an object for over 100 milliseconds, allowing the object to be imaged on the fovea, which is subsequently processed to create a clear image[11]. The fovea possesses the highest visual acuity and is the sole region of the visual field utilised for reading, whereas peripheral areas exhibit diminished visual clarity[12]. Visual information can be processed during the fixation interval. A saccade is an ocular movement transitioning from one location to another or a rapid alteration in gaze direction. Saccade ranges from 2 to 20 degrees[11]. Saccades result in minimal imaging of objects, serving the function of rapidly scanning the visual field and selecting fresh visual information for cognitive processing. Generally, saccades are orientated forward; however, 10–15 percent are directed backward, a phenomenon known as regression[12]. The objective of regression is to analyse items at a more profound level.

Eye-tracking technology has become a vital tool in reading research, offering insights into various cognitive and behavioral processes involved in reading. The application of eye-tracking in this field generally focuses on five primary objectives. First, it examines visual attention allocation, capturing where readers focus their gaze and for how long, which reveals their attention distribution across text[13]. Second, it explores linguistic processing strategies, analyzing how readers decode vocabulary, syntax, and semantics, including skipping, regression, and rereading behaviors[14]. Third, it assesses reading fluency and efficiency, using metrics such as fixation duration, reading speed, and saccade amplitude to identify factors affecting reading performance[15]. Fourth, it investigates comprehension monitoring and repair, identifying how readers detect and correct misunderstandings, often through regression and re-reading[16]. Finally, it examines the effects of text characteristics on reading, analyzing how elements like font size, line spacing, and text complexity influence reading behavior and comprehension[17]. These objectives together provide a comprehensive understanding of how readers engage with text, process language, and overcome comprehension challenges.

Beyond the foundational understanding of eye movements and their classification into fixation and saccade, it

is crucial to examine how these movements reflect the underlying cognitive processes involved in reading. Reading is a complex, multifaceted cognitive activity that engages a range of mental functions, including perception, attention, memory, comprehension, and reasoning[18]. These cognitive processes operate in concert as readers acquire, process, store, and apply information. Within this framework, fixation behavior—a primary metric in eye-tracking research—serves as a reliable indicator of cognitive engagement[19]. The well-established "eye-mind hypothesis" in applied linguistics posits a direct correspondence between cognitive processing and eye movement patterns[20, 21]. According to this hypothesis, the duration and location of fixations provide critical insights into readers' real-time cognitive activities, including lexical decoding, semantic integration, and syntactic parsing. Moreover, word recognition, a fundamental aspect of reading, is significantly influenced by word frequency, which has been shown to produce measurable variations in eye movement patterns, such as fixation duration and saccade amplitude[22]. These insights underscore the value of eye-tracking technology in capturing the dynamic and nuanced cognitive processes that underpin reading.

3. Methodology

3.1. Research Design

This study review seeks to analyze the application areas and methodology of ET in reading research, along with potential advancements in this field. Following is a list of the research questions (RQs) that will be asked throughout this investigation:

RQ1: What are the primary domains of English literature pertaining to ET among university students?

RQ2: What are the trends for ET research in English reading of university students?

RQ3: Which ET measures have been utilized across various research domains?

3.2. Data Collection

Data for this study was systematically collected to ensure comprehensive and unbiased inclusion of relevant research. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines were followed in the generation of the dataset for this study[23]. To retrieve research papers in the selected journals that use eye tracking methods, we selected Science Direct, Scopus, Wiley, Springer Link, Google Scholar, and AMC Digital Library databases and used the 'title of source' method to search for electronic documents. Search terms included: ET (OR eye-tracking OR eye movements OR eye) AND reading (OR decoding OR word recognition OR literacy OR visual word OR sight vocabulary) AND university students OR college students OR undergraduates). The search resulted in a collection of 368 publications. As we focused on recent publications, we used a timeframe (2013–2024) to search for studies; the last search was conducted in December 2024.

3.3. Data Analysis

To ensure the quality and relevance of the studies included in this systematic review, a rigorous selection process was applied. This involved reviewing the abstracts and titles to determine whether each study met predefined inclusion and exclusion criteria. After the abstracts and titles were looked over, they had to meet the following requirements: (1) the study had to measure at least one eye movement; (2) the study used healthy college students with no history of brain injury or neurological disorders; (3) the participants involved could see well or with corrective lenses; (4) Words, sentences, paragraphs, or even the whole book were required of them; and (5) the article had to be written in English. If a study (1) used people who weren't healthy or compared healthy people to dyslexic people, (2) used EEG but not ET, (3) performed speech production or phonological processing, or (4) only used people who spoke one language, we didn't include it. Although our original exclusion criterion was intended to filter out studies in which 'participants exhibited multilingualism,' this criterion became implausible due to the insufficient detail provided by these studies. PRISMA Flow Diagram of Selection Strategy can be seen in **Figure 1**. Therefore, studies were initially included if they included bilingual participants or participants who read in both L1 and L2. **Table 1** provides a more intuitive view of the information in the articles[2, 4, 6, 8–10, 17, 24–48].

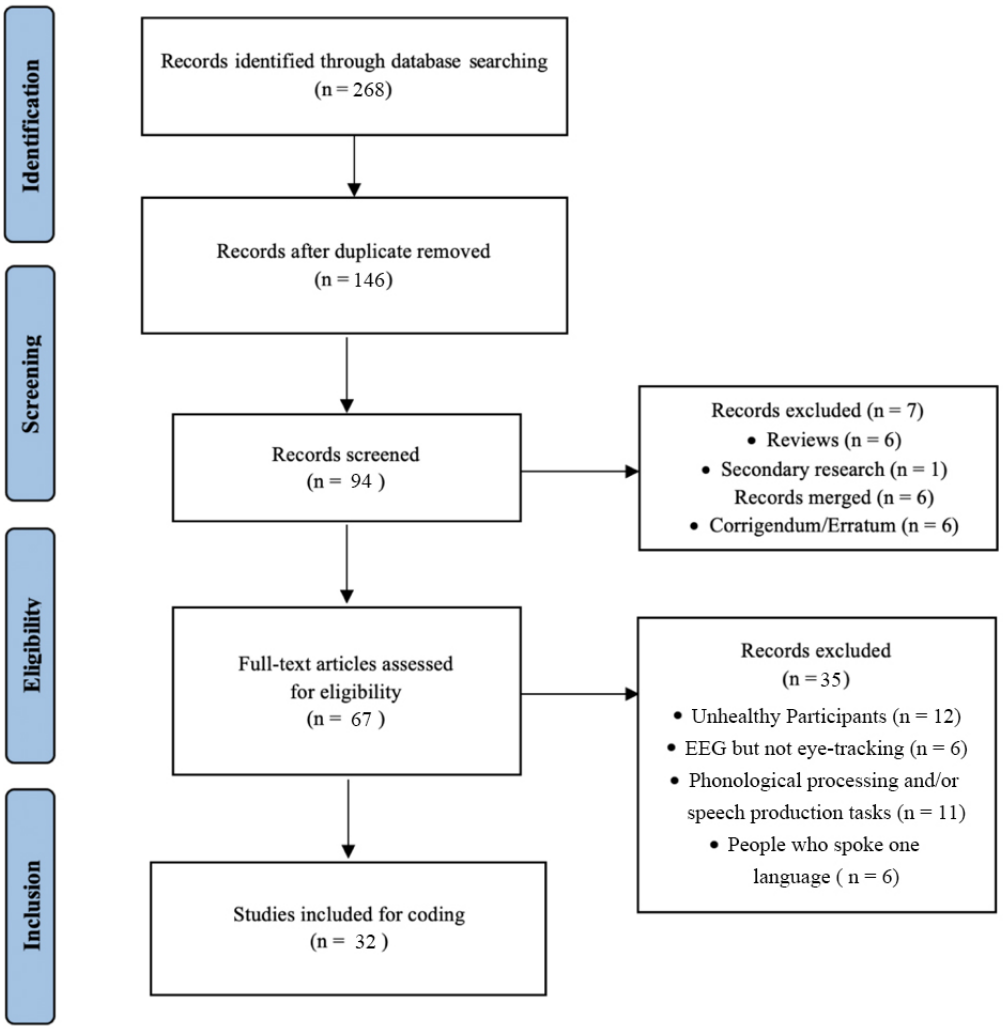

Figure 1. The PRISMA Flow Diagram for the Selection Process.

Table 1. Literature Analysis [2, 4, 6, 8–10, 17, 24–48].

References	Participants	Nationality	Reading Materials	Research Method	Measures
ET and Reading Strategies					
Liu (2014) [24]	86 non-English major	Chinese	6 articles	Quantitative	Fixation time, Fixation path, and Regressions
Godfroid & Spino (2015) [25]	116 second- or third-year university students	Belgium	20 paragraphs	Quantitative	Not Mention
Prichard & Atkins (2016) [26]	38 university students	Japanese	A text	Mixed	The total pre-reading time, The number of fixations, and Total fixation duration
Dolgunsöz (2016) [27]	72 participants	Not Mention	12 words	Quantitative	Saccadic data, Dwell time, and Regressive
Catrysse et al. (2018) [28]	20 first year students	Not Mention	A text	Quantitative	The first pass, Second pass, and Total fixation duration
Prichard & Atkins (2021) [29]	64 second-year university students	Japanese	A text	Mixed	Total fixation duration, Review duration, and Regression
Roncevic (2021) [30]	43 third year students	Republic of Croatia	2 texts	Quantitative	Forward fixations, Re-inspective fixations, Look-backs and Look-froms

Table 1. *Cont.*

References	Participants	Nationality	Reading Materials	Research Method	Measures
Tsai et al. (2022)[31]	48 undergraduate and graduate students	Chinese	Conflicting texts	Quantitative	Fixations and Saccades
Paulson et al. (2024)[10]	11first-year university students	Hispanic non-Hispanic	two-page unaltered excerpts	Mixed	Not Mention
Comparative Studies of Reading via ET					
Ho et al. (2014)[32]	13 university and graduate students	Chinese	A text and graphics	Mixed	The total reading time, Total fixation duration, and Total regression number
Leung et al. (2014)[33]	42 EFL and 14 L1 undergraduate or graduate students	Japanese	96 sentences	Quantitative	Forward saccade length, Forward fixation duration, and Number of forward fixations
Demareva & Edeleva (2020)[34]	30 university students	Russian	8 texts	Quantitative	Fixation duration time, Saccade duration time, Saccade amplitude, Saccade acceleration average, and Saccade velocity average
Johnston & Ferguson (2020)[35]	40 undergraduate and postgraduate students	Australian, Japanese, Iranian, Indian, Brazilian, and the UK.	15 pages	Mixed	Scan paths, Fixations, and Heat maps
Conklin et al. (2020)[36]	28 L2 participants	Arabic, Chinese, Turkish, Hindi, Dutch, and German	2 stories	Quantitative	First fixation duration, First-pass reading time, and Total reading time
Nahatame (2021)[9]	48 undergraduate and graduate students	Japanese	21 passages	Quantitative	Fixation duration, Saccade length, Skipping rate, and Regression rate
Delgado & Salmerón (2022)[37]	116 undergraduates	Not Mention	6 texts		Saccades and Regressions
ET and Lexical Studies					
Pellicer-Sánchez (2016)[6]	25 undergraduate students	English	A short story	Quantitative	First fixation duration, Gaze duration, number of fixations, and Total reading time
Godfroid et al. (2018)[38]	19 primarily undergraduate students	American	The first five chapters of *A Thousand Splendid Suns*	Quantitative	Fixation duration, and Gaze duration
Warren et al. (2018)[39]	52 ESL learners	American	A text	Quantitative	First fixation duration, Total fixation counts, and Total reading time
Ouyang et al. (2020)[40]	45 college English learners	Chinese	A passage	Quantitative	Fixation and Fixation durations
Schmidtke & Moro (2021)[41]	70 University students	Chinese	7 stories	Quantitative	First fixation duration, Gaze duration, Go-past time, Total reading time, Probability of refixation, and Regression
Correlation Studies of Reading via ET					
Dolgunsöz (2015)[42]	75 university students	Not Mention	15 words	Quantitative	Fixation values and Fixation duration
Bax & Chan (2019)[43]	24 Master's-level students	Chinese	6 reading items	Mixed	Fixation duration, Fixation count, Visit duration, and Visit count
Huang et al. (2022)[8]	48 first-year university students	Chinese	A text	Quantitative	First fixation duration, Gaze duration, Fixation count, and Total reading time

Table 1. *Cont.*

References	Participants	Nationality	Reading Materials	Research Method	Measures
ET and Electroencephalogram					
Gwizdka et al. (2017)[44]	24 undergraduate and graduate students	Native English speakers	Short texts	Quantitative	RPD moving-average, Fixation duration, Fixation count, and Saccade distance
Cheng et al. (2020)[45]	A teacher	Chinese	A paper	Quantitative	Reading speed, Reading time, and Switching frequency
Impact Factors of Reading Studies via ET					
Kruger & Steyn (2014)[4]	36 first-year university students	South African	6 recordings	Quantitative	Number of fixations, Number of refixations, Number of regressions, Number of return sweeps, Saccade direction, and Saccade length
Dirix & Beken (2020)[17]	80 first-year university students	Dutch	4 texts	mixed	First pass reading time, Saccadic amplitude, The total reading time, The fixation count, Regression count, Average word frequency, and Average word length
Other Studies					
Yang et al. (2016)[46]	25 university students	Chinese	An article	Mixed	Total reading time, Percentage of total fixation duration, and The average fixation duration
Augereau et al. (2016)[47]	9 Japanese male university students	Japanese	10 documents	Quantitative	Fixations and Saccades
Sulaiman et al. (2020)[48]	20 first year ESL undergraduates	Malaysian	3 texts	Mixed	Total fixation duration, Total fixation count, Fixation duration, and Scan path
Mézière et al. (2023)[2]	79 undergraduate students	Australian	YARC: 2 passages GORT-5: passages of text WRAT-4: 55 words	Quantitative	Average fixation duration, Average forward saccade, First-pass skipping rate, First-fixation duration, Regression rate, Go-past time, and Total-reading time

4. Results

4.1. Research Question 1: What Are the Primary Domains of English Literature Pertaining to ET among University Students?

Based on **Figure 2**, the reviewed literature on eye-tracking (ET) in university English reading is categorized into seven major themes: reading strategies, comparative studies of reading, lexical studies, correlation studies, ET combined with EEG, impact factors of reading studies, and other studies. This classification reflects the diverse directions of ET applications in second language reading research. Among the 32 selected articles, reading strategies are the most frequently explored topic, with 9 studies (28.13%). Comparative studies follow with 7 articles (21.88%), and lexical studies account for 5 articles (15.63%). Correlation studies include 3 (9.38%), while ET and EEG as well as impact factor studies each have 2 (6.25%). Finally, 4 articles (12.5%) fall into the "other" category.

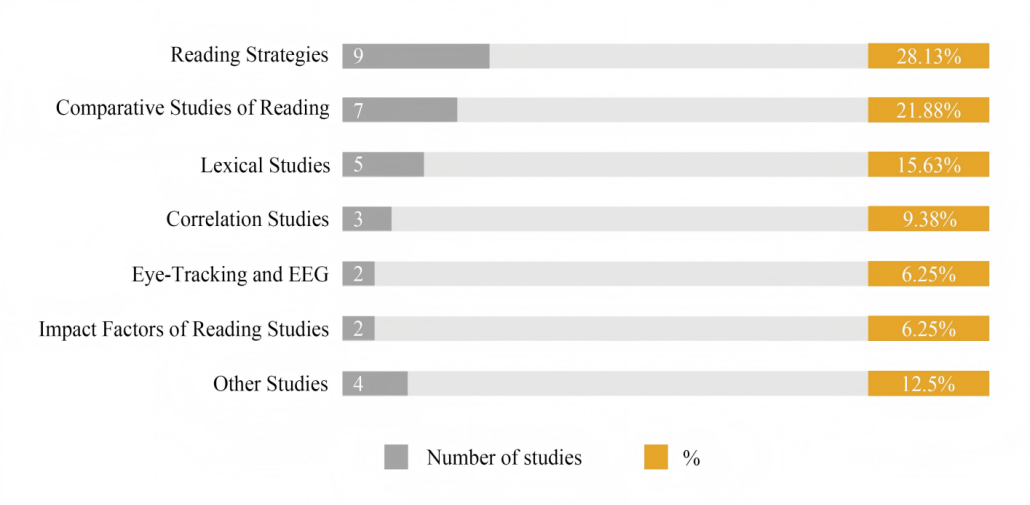

Figure 2. Distribution of Empirical ET Studies by Research Area.

4.1.1. Eye-Tracking and Reading Strategies

ET helps researchers observe how structured strategies affect university students' English reading. Concept-mapping and think-alouds are commonly examined. Liu used ET to show that concept-mapping helped L2 readers improve comprehension and identify main ideas [24]. Godfroid & Spino explored think-alouds under different reading conditions and found a small positive effect on vocabulary recognition, though comprehension remained unchanged [25]. Paulson et al. examined how students used textbook reading strategies in think-aloud sessions, offering insights into metacognitive engagement [10]. These studies demonstrate that ET not only captures surface behavior but also uncovers how strategic interventions shape reading outcomes. By tracking gaze patterns, ET reveals how such strategies support information processing, from decoding to meaning construction. Collectively, this body of research underscores the value of combining behavioral data with cognitive strategy instruction to improve reading performance in second language contexts. It also highlights how structured strategies can be evaluated more objectively through eye movement patterns.

Beyond structured strategies, ET studies have explored various tactical approaches. Prichard & Atkins found that most Japanese L2 students rarely used previewing strategies [26]. Dolgunsöz showed that lexical inference, or guessing word meaning from context, often reduced reading speed, especially among EFL learners [27]. Prichard & Atkins revealed that many students relied on dictionaries unnecessarily, even when context made meaning clear [29]. Roncevic identified four reading styles: selective fast linear, selective slow linear, selective structural, and nonselective [30]. The results showed that L2 reading generally takes longer than L1, suggesting a greater need for targeted strategy training. These findings indicate that while learners use a range of techniques, not all are effective or efficient. ET helps pinpoint where time and cognitive effort are allocated, revealing strategy use or its absence. Overall, the evidence calls for more explicit instruction in strategy development to foster faster, more structured, and goal-oriented reading behavior in second language contexts.

ET research also addresses higher-order strategies, such as critical reading and deep processing. Tsai et al. studied students reading conflicting socio-scientific texts and found that those with stronger strategies showed more fixations on reasoning-related information and made more evaluative judgments [31]. Catrysse et al. used both online and offline data to compare deep versus surface reading approaches [28]. Results showed that ET could clearly differentiate students who actively used cognitive and regulatory strategies from those who did not. Less strategic readers demonstrated lower attention to key content and weaker self-regulation. These findings suggest that ET is valuable for identifying not just what readers look at, but how they process and engage with texts. By tracking fixations, regressions, and reading flow, ET provides a real-time window into students' thinking. This line of research highlights the importance of fostering strategic awareness and metacognition to support advanced reading comprehension in academic and multilingual learning environments.

4.1.2. Comparative Studies of Reading via Eye-Tracking

Comparative studies using eye-tracking (ET) offer valuable insights into how different learner characteristics and reading conditions affect university students' English reading. These studies aim to identify variation in gaze behavior, attention allocation, and comprehension outcomes by comparing participants, reading modes, media formats, and text readability. ET provides a precise, real-time method to detect subtle differences in visual processing across individuals and contexts. This section organizes existing comparative ET research into four main dimensions: participant-based differences, differences in reading modes, differences in reading media, and the predictive validity of readability formulas. Together, these studies enhance our understanding of second language reading and provide evidence for improving instructional methods, material design, and assessment strategies.

This dimension focuses on how learners' individual differences impact reading behavior. Ho et al. examined how students with different levels of prior knowledge processed scientific texts and diagrams[32]. Leung et al. conducted a cross-cultural study comparing perceptual span in native and non-native English readers[33], especially Japanese L2 learners. Demareva & Edeleva used ET to distinguish reading patterns between L1 and L2 readers and detect non-nativeness[34]. Yang et al. explored how gender and epistemic beliefs influenced comprehension and eye movement during science text reading[46]. These studies show that ET is effective in identifying how cognitive, cultural, and demographic factors influence reading strategies and processing depth, offering important insights into personalized language instruction.

This dimension explores how different sensory input formats influence reading. Conklin et al. examined reading-only and reading-while-listening conditions to understand how auditory support affects reading behavior[36]. Their results suggested that readers often look slightly ahead of the audio, highlighting a potential benefit of combining visual and auditory input. The dual-modality format may help reinforce word recognition, regulate pacing, and improve comprehension. Eye-tracking data reveal how gaze patterns shift in response to audio, indicating changes in cognitive load and processing strategy. This comparison contributes to understanding how multimodal reading can support second language learners and guide the development of integrated reading practices in digital or classroom environments.

This dimension investigates how reading tools such as print and digital platforms influence eye movement behavior. Johnston & Ferguson used ET and questionnaires to analyze how students interact with e-books versus printed textbooks[35]. Results showed that digital readers employed different navigation paths and made greater use of features like hyperlinks and search tools. Delgado & Salmerón examined the effects of reading medium and duration on metacognitive monitoring and comprehension outcomes[37]. They found that screen-based reading influenced both processing patterns and learning effectiveness. As educational reading increasingly shifts to digital formats, understanding these differences is crucial for designing materials that align with students' visual attention patterns and support deeper comprehension.

This dimension evaluates how well different readability tools predict actual reading difficulty based on eye movement data. Nahatame tested the construct validity of traditional and modern readability formulas using ET[9]. The study showed that while older formulas could forecast some aspects of eye movement, newer models more accurately reflected cognitive processing demands. By linking metrics such as fixation duration, saccade length, and regression count with text difficulty, researchers demonstrated how ET can validate or improve readability assessments. These findings are useful for educators and material designers aiming to match reading content with learners' abilities and to enhance the precision of reading tasks in both instructional and evaluative contexts.

4.1.3. Eye-Tracking and Lexical Studies

Vocabulary learning plays a crucial role in language acquisition, encompassing the understanding, acquisition, and practical use of vocabulary. Research utilising eye-tracking methodologies has examined the impact of reading strategies about vocabulary enhancement[6], the influence of repeated exposure to new words on vocabulary acquisition[38], the effects of different vocabulary types on reading and the acquisition of vocabulary by second language learners[39], as well as the significance of annotation in incidental vocabulary learning[40].

Building upon these findings, further evidence suggests that online reading environments can markedly improve vocabulary acquisition. Online reading markedly improves vo-

cabulary acquisition, as demonstrated by a study integrating offline vocabulary assessments and online ET techniques[6]. Godfroid et al. investigated the effects of frequent exposure to foreign vocabulary on the acquisition of words[38]. The frequency of exposures was the most significant predictor of vocabulary acquisition, although overall reading duration independently influenced word comprehension.The impact of gloss types on second language learners' reading habits and lexical acquisition was investigated by Warren et al.[39]. The impact of glosses on reading behaviour and incidental vocabulary acquisition in second language (L2) situations was studied by Ouyang et al.[40].

Eye tracking and word studies also focus on how individuals process words during reading and use eye tracking to reveal how the brain processes linguistic information. Schmidtke & Moro found that students with stronger phonological awareness and more vocabulary during a university-level English bridging program offered at a Canadian university showed the most significant advancements in sublexical processing[41].

4.1.4. Correlation Studies of Reading via Eye-tracking

The research focuses on revealing the various factors that influence reading behaviour and comprehension and to explore how these factors interact with each other so as to provide a theoretical basis and practical guidance. Dolgunsöz[42] employed Schmidt's noticing hypothesis to assess attention and learning improvements in second language (L2) reading using ET techniques. The findings indicated a favourable association. Bax & Chan investigated the correlation between reading item types and students' reading processes under test settings[43]. Huang et al. employed both online and offline metrics to investigate the correlation among word processing, working memory, and second language (L2) reading comprehension skills[8].

4.1.5. Eye-Tracking and Electroencephalogram

A growing body of research has employed a combination of eye tracking (ET) and electroencephalography (EEG) to explore the intricate, real-time cognitive mechanisms underlying reading comprehension and decision-making[49]. Gwizdka et al. investigated the dynamics of text relevance decisions in a question-answering task by ET and electroencephalography (EEG)[44]. The findings suggested that the processing of germane words during specific epochs could be distinguished from those during other epochs. This was indicative of an increasing divergence in the processing of relevant versus irrelevant materials after the initial epoch, which suggests that cognitive processes may vary. Cheng et al. introduced a methodology for beginner readers that involves capturing ET and EEG data from educators and transforming it into visualised metrics[45]. This aids kids in modifying reading habits and enhances understanding.

4.1.6. Impact Factors of Reading Studies via ET

Research on reading behavior has increasingly focused on how specific reading conditions—such as the presence of subtitles or varying reading purposes—affect comprehension and learning outcomes. Kruger & Steyn examined the impact of subtitle reading on academic achievement and identified a substantial positive correlation[4], supporting the use of subtitles as an effective tool in reading pedagogy and language acquisition. Similarly, Dirix & Beken explored how different reading objectives influence eye movement patterns in both first (L1) and second (L2) languages[17]. Their findings revealed that participants allocated more time to studying texts than to informative reading, which in turn led to improved test performance

4.1.7. Other Studies

An increasing number of studies have focused on the use of eye tracking (ET) technology as a tool for assessing reading comprehension and related cognitive behaviours in diverse learner populations. These studies explore how ET can be employed not only to monitor reading patterns but also to evaluate language proficiency, problem-solving strategies, and comprehension accuracy. By capturing real-time eye movement data, researchers are able to infer deeper cognitive processes and develop more nuanced measures of reading performance. For example, Augereau et al. introduced a mobile ET system that maps gaze data onto document spaces to assess English reading competence and infer problem-solving behaviours[47]. Sulaiman et al. used eye movement analysis to explore the cognitive strategies of ESL university students while reading academic texts[48]. Mézière et al. further validated the utility of ET by comparing it with standardized reading comprehension tests (YARC, GORT-5, and

WRAT-4)[2], showing that ET explained more variance in performance than traditional speed-based metrics, although no single gaze metric served as a consistent predictor across all assessments.

4.2. Research Question 2: What Are the Trends for ET Research in English Reading of University Students?

First of all, this study found that the largest percentage of literature related to ET and reading strategies in college students' English reading. This research trend indicates that traditional methods such as questionnaires, self-reports, or test scores are insufficient to reveal the 'immediate' and 'process-orientated' cognitive mechanisms of learners during the reading process. Therefore, researchers are gradually turning to more dynamic and objective eye-tracking technology for in-depth exploration.

Early research primarily focused on using eye-tracking to validate the use of specific strategies. For example, Liu applied the concept map strategy to reading training and used gaze trajectories to reveal its impact on optimising processing paths[24]. Such research provides direct behavioural evidence for strategic training. Subsequently, Prichard & Atkins focused on the deployment of predictive strategies in the initial stages of reading, using eye movement data to reveal that efficient readers tend to preview more intensively at the beginning of paragraphs[26]. Dolgunsöz explored word meaning inference strategies and found that different strategy choices significantly affect reading speed and comprehension quality, expanding the microanalysis of vocabulary processing[27].

In recent years, eye-tracking research has switched from studying single-strategy behavior to probing multi-strategy integration and higher-order cognitive processes. Catrysse et al.[28], for example, used self-reports and eye-tracking data to rigorously examine whether learners' performance was consistent when utilising diverse reading techniques. By cross-validating data from numerous sources, they improved the reliability and accuracy of their findings. Tsai et al. expanded on this basis by using eye-tracking technology and "lag sequence analysis" to investigate how readers participate in reasoning and analyse evidence during critical reading[31]. This technique shows that the focus of eye-tracking research has switched from assessing 'if strategies are utilised' to more carefully tracking 'how readers employ and coordinate various strategies'.

Additionally, researchers have increasingly acknowledged that strategies are not independent but are shaped by the nature of the reading job, text complexity, and reader characteristics. Paulson et al. tried to elucidate strategies for instructing students with more efficient reading techniques by analyzing the gaze patterns of university students engaged in textbook reading[10]. Roncevic examined the progression of paradigms in L2 reading eye-tracking research and emphasised that further studies should concentrate on the interplay between variations in reading environments and the capacity for strategy transfer[30].

Overall, the application of eye tracking in the study of English reading strategies among university students has evolved from single-strategy validation to multi-dimensional behavioural identification to the tracking of advanced reasoning and processing mechanisms. Current trends exhibit two key characteristics: first, research methods are becoming increasingly integrated, often combined with interviews, think-aloud protocols, or behavioral assessments to enhance the interpretive power of results; second, research themes are deepening, expanding from basic strategy identification to higher-order understanding domains such as cross-textual integration and evaluative judgement. This trend not only enriches the theoretical framework of language processing but also provides more targeted intervention design guidelines for EFL instruction.

Second, the study on eye movement and reading centres on Chinese university students, reflecting a major shift in current reading research: from samples mainly consisting of primary and secondary school students or general adults to a focus on learners at the university level. University students face higher-level cognitive challenges in their studies, such as multi-text integration, conflicting viewpoint analysis, terminology comprehension, and academic writing. Their participation in eye movement research helps reveal the actual reading behaviour and strategy use of learners when dealing with complex academic tasks and exam pressure.

Cheng et al. conducted an experiment in Chinese university classrooms that integrated eye-tracking and electroencephalography (EEG) data[45], further broadening the perspective of reading research. The study broke through traditional behavioural-level analysis and integrated multimodal cognitive neuroscience, focusing not only on 'what students

read' but also on understanding 'why they read that way' and 'what cognitive changes occurred during the reading process'. This change aligns well with the 'process-orientated reading model' in today's psycholinguistics and educational neuroscience, offering a new way to examine how Chinese university students read strategically and manage their cognitive load.

In terms of vocabulary processing and learning, Ouyang et al. and Huang et al. analysed the moderating effects of vocabulary annotations and working memory on vocabulary acquisition among Chinese university English learners[8, 40]. Eye-tracking data revealed significant differences in attention distribution across different words, with short-term reading experiences being influenced by individual cognitive resources and the allocation of visual attention, thereby affecting vocabulary memory outcomes. This study further confirms the complex processing mechanisms involved in language learning among Chinese university students and highlights the plasticity and variability in their use of vocabulary strategies.

Furthermore, Bax & Chan employed Chinese university students as language test subjects to investigate the validity of exam design using eye-tracking[43]. This study not only revealed the actual application potential of eye-tracking technology in language tests (such as the CET-4 and CET-6), but it also gave fresh suggestions for data-driven assessment design in light of current exam changes. Given that Chinese university students are often subjected to substantial language evaluation pressure, this study is very practical and educationally valuable.

In summary, eye-tracking research on Chinese university students has achieved significant breakthroughs in recent years in terms of technical methods, research perspectives, and theoretical depth. From basic processing indicators to multi-strategy dynamic tracking and from static behaviour observation to neuro-cognitive integration modelling, eye movement research has continuously deepened our understanding of the nature of university students' reading behaviour. These studies have not only enriched our understanding of the reading mechanisms of EFL learners but also provided solid empirical support for improving teaching interventions, assessment tool design, and learning strategy training at the university level.

Finally, the majority of investigations in the field of ET and reading implement text as the reading material. Over the past decade, eye tracking and reading research have gradually become more diverse in terms of material types, structural complexity, and real-life task contexts, with an increasing emphasis on research related to reading strategies.

Some studies have begun to incorporate authentic academic materials to enhance the contextual relevance of research. For example, Ho et al. and Huang et al. used scientific academic texts to explore the influence of prior knowledge and lexical processing on comprehension[8, 32], noting that academic texts are more effective in stimulating strategy use and deep information processing, aligning with the real-life learning scenarios of EFL university students. Similarly, Dirix & Beken focused on the reading process of L2 learners when encountering longer informational texts[17], while Sulaiman et al. investigated the eye-tracking characteristics of Malaysian ESL students when processing long sentence structures and materials with a high terminology density[48], emphasising the impact of material length and complexity on cognitive load.

In terms of material presentation formats, Delgado & Salmerón compared the effects of paper-based reading and reading on tablet screens on comprehension and cognitive load[37]. Their findings revealed that differences in reading media significantly alter readers' gaze paths and attention allocation patterns, indicating that eye-tracking research is increasingly moving toward multimedia-integrated reading environments. Meanwhile, Warren et al. and Prichard & Atkins studied annotated texts and found that different word prompting methods (such as native language translations, image captions, or word definitions) lead readers to adopt different gaze strategies in word regions, thereby affecting their word processing efficiency and memory outcomes[29, 39].

Some studies have also begun to employ task- and strategy-orientated materials to better monitor the expression of distinct reading techniques in eye movements. Catrysse et al.[28], for example, used self-reports and eye tracking to create reading materials with multiple strategies for studying learners' metacognitive regulation processes, whereas Prichard & Atkins created 'preview task' materials specifically to observe how predictive strategies are activated[26]. Researchers are increasingly highlighting the design function of reading tasks, pushing eye movement research that moves away from static text comprehension and towards

investigating the dynamic process of strategy application.

4.3. Research Question 3: Which ET Measures Have Been Utilised Across Various Research Domains?

Table 2 shows the breakdown of ET measures used in the L2 ET studies[2, 4, 6, 8, 9, 17, 24, 26–29, 31–34, 36–48]. The measure fixation duration was (n = 20; 62.5%); followed by reading time (n = 11; 34.37%), saccade (n = 10; 31.25%), and regression (n = 9; 28.12%), and gaze duration (n = 5; 15.6%). In contrast, other indexes such as fixation count, go-past time, the first pass, the second pass, and dwell were used sparingly in the sample, and pupil dilation and blinking were not used in any of the studies.

ET studies in reading research draw upon a range of measures—including fixation duration, reading time, saccades, regressions, and gaze duration. Across various domains such as strategy use, comparative analysis, lexical processing, correlation studies, and impact evaluation, researchers often employ multiple indicators to provide a more comprehensive picture of readers' cognitive processes.

Table 2. ET Measures Used Across English Reading Research Areas.

Measures	N	P	Domain						
			ETRS	**CSRET**	**ETLS**	**CSRET**	**ETEET**	**IFRSET**	**OS**
Fixation duration	20	62.5%	Prichard & Atkins (2016)[26] Catrysse et al. (2018)[28] Prichard & Atkins (2021)[29]	Ho et al. (2014)[32] Leung et al. (2014)[33] Demareva & Edeleva (2020)[34] Conklin et al. (2020)[36] Nahatame (2021)[9]	Pellicer-Sánchez (2016)[6] Godfroid et al. (2018)[38] Warren et al. (2018)[39] Ouyang et al. (2020)[40] Schmidtke & Moro (2021)[41]	Dolgunsöz (2015)[42] Bax & Chan (2019)[43] Huang et al. (2022)[8]	Gwizdka et al. (2017)[44]	/	Yang et al. (2016)[46] Sulaiman et al. (2020)[48] Mézière et al. (2023)[2]
Reading time	11	34.37%	Prichard & Atkins (2016)[26]	Ho et al. (2014)[32] Conklin et al. (2020)[36]	Pellicer-Sánchez (2016)[6] Warren et al. (2018)[39] Sulaiman et al. (2020)[48]	Huang et al. (2022)[8]	Cheng et al. (2020)[45]	Dirix & Beken (2020)[17]	Yang et al. (2016)[46] Mézière et al. (2023)[2]
Saccade	10	31.25%	Dolgunsöz (2016)[27] Tsai et al. (2022)[31]	Leung et al. (2014)[33] Demareva & Edeleva (2020)[34] Nahatame (2021)[9] Delgado & Salmerón (2022)[37]	/	/	Gwizdka et al. (2017)[44]	Kruger & Steyn (2014)[4]	Augereau et al. (2016)[47] Mézière et al. (2023)[2]
Regression	9	28.12%	Liu (2014)[24] Prichard & Atkins (2021)[29]	Ho et al. (2014)[32] Nahatame (2021)[9] Delgado & Salmerón (2022)[37]	Schmidtke & Moro (2021)[41]	/	/ Dirix & Beken (2020)[17]	Kruger & Steyn (2014)[4]	Mézière et al. (2023)[2]

Table 2. *Cont.*

Measures	N	P	Domain						
			ETRS	CSRET	ETLS	CSRET	ETEET	IFRSET	OS
Gaze duration	5	15.6%	/	/	Pellicer-Sánchez (2016)[6] Godfroid et al. (2018)[38] Schmidtke & Moro (2021)[41]	Huang et al. (2022)[8]	/	/	Mézière et al. (2023)[2]

Note: N = Number, P = Percentage, ETRS = ET and Reading Strategies, CSRET = Comparative Studies of Reading via ET, ETLS = ET and Lexical Studies, CSRET = Correlation Studies of Reading via ET, ETEET = ET and Electroencephalogram, IFRSET = Impact Factors of Reading Studies via ET, OS = Other Studies

Strategy-based ET research focuses on how learners engage with texts using specific cognitive or behavioral approaches, and which eye-movement patterns reveal strategy use or absence. Measures such as fixation duration, reading time, and regressions are often employed to reflect cognitive load, processing depth, and shifts in attention. These indicators help researchers detect whether students engage in predictive reading, rereading, or deep information processing. Studies have shown that many learners either underutilize or inconsistently apply reading strategies. For example, Prichard & Atkins, Catrysse et al., and Prichard & Atkins used these metrics to assess the strategic engagement of university students. Their findings revealed that a significant proportion of readers did not actively employ strategic behaviors while reading, suggesting a need for explicit training in metacognitive regulation and reading awareness[26, 28, 29].

Comparative studies leverage ET to examine reading differences across variables such as language background, reading speed, and processing characteristics. Commonly used metrics include fixation duration, reading time, regressions, and saccades. These measures help to compare L1 and L2 readers, test the impact of different reading conditions, and explore cognitive effort during reading. Ho et al. used reading time to evaluate processing across student groups, while Leung et al. investigated perceptual span using fixation-based analysis[32, 33]. Demareva & Edeleva assessed non-nativeness by comparing fixation duration patterns[34]. Conklin et al. evaluated reading speed and found that L2 readers had longer and more frequent fixations than L1 readers[36]. Furthermore, these studies explored the predictive validity of readability formulas, confirming that newer models outperformed traditional ones in capturing eye movement behavior. Such findings validate the integration of ET measures in cross-group reading research and instructional design.

Vocabulary-focused ET research investigates how learners recognize, process, and acquire vocabulary while reading. The most relevant metrics in this area are fixation duration, reading time, gaze duration, and regression. These measures indicate how much attention is paid to new or difficult words, the cognitive effort involved in decoding, and whether rereading is required for understanding. Pellicer-Sánchez showed a positive relationship between vocabulary acquisition and online reading behaviors, using ET to track learners' attention to target words[6]. Godfroid et al. found that the frequency of word exposure was the strongest predictor of vocabulary learning outcomes[38], although overall reading time also played a role in word retention. These studies highlight the importance of temporal and spatial attention metrics in understanding how vocabulary knowledge develops during reading and how learners distribute cognitive resources when encountering new lexical items.

Correlation-based ET research explores how eye movement data links with other cognitive or performance variables, such as attention, memory, and comprehension outcomes. Fixation duration is commonly used to assess attentional engagement, while reading time and gaze duration can be tied to task difficulty or item type. Dolgunsöz applied this approach to evaluate Schmidt's noticing hypothesis[42], finding a positive link between attention and learning gains. Bax & Chan studied how different reading item types affected students' eye-movement behavior in test contexts[43], showing that visual patterns could predict comprehension strategies. Huang et al. used both online ET and offline cognitive data to investigate the relationship between working memory and reading comprehension[8]. These studies suggest that ET can serve not only as a descriptive tool but also as a diagnostic measure, helping to explain individual differences in L2

reading ability.

Beyond the major domains, ET has been applied in hybrid studies combining ET with other physiological tools and in evaluating broader reading impact factors. In multimodal research, Gwizdka et al. integrated ET and EEG data to detect shifts in cognitive processing, using fixation duration to map attention over time [44]. Studies on impact factors often utilize saccades, regressions, and reading time to assess how external variables influence comprehension. For instance, Kruger & Steyn found that subtitle reading behavior was shaped more by attention distribution than text density [4], while Dirix & Beken demonstrated that task goals significantly altered time allocation and gaze patterns [17]. In applied contexts, Sulaiman et al. used ET to assess ESL students' proficiency, and Mézière et al. suggested ET could complement standardized reading tests [2, 48]. These applications show that fixation-based and time-based measures are essential in bridging cognitive research and practical assessment tools.

5. Conclusions

This study provides a systematic review of ET research related to English reading among university students, aiming to identify key research domains, emerging trends, and commonly used ET measures. The analysis reveals that ET research in this context is primarily concentrated in five domains: strategy use, comparative reading studies (e.g., L1 vs. L2), vocabulary acquisition, reading comprehension, and cognitive correlation studies, reflecting a growing interest in both the behavioral and cognitive dimensions of second language reading. A notable trend is the increasing focus on Chinese university students, attributed to the significant number of English learners within this demographic and the widespread availability of ET expertise in China. Furthermore, research on eye movements and reading is increasingly focusing on the multidimensional characteristics of the material itself, including text type (such as expository, argumentative, or narrative texts), language difficulty, information density, structural complexity, and other factors, as well as the impact of presentation formats (such as paper, screen, or hypermedia environments) on readers' eye movement patterns and cognitive load. Finally, there is a tendency to integrate ET data with other measures, although comprehensive multimodal approaches remain relatively uncommon. In terms of measurement, a variety of ET metrics have been employed across studies, including fixation duration, reading time, regressions, saccades, and gaze duration. The choice of specific metrics is typically aligned with the research focus: lexical studies often rely on gaze duration, comparative studies emphasize fixation duration and regressions, while strategy research employs multiple indicators to assess cognitive engagement. This review offers a comprehensive overview of how ET has been utilized to investigate reading processes in higher education, providing insights into current research practices and identifying potential directions for future studies.

Despite providing valuable empirical insights into English reading, research on eye movement and reading has several notable limitations. First, the majority of studies predominantly involve Chinese university students, which may limit the generalizability of findings, as learners from diverse cultural and linguistic backgrounds could exhibit distinct reading behaviors and cognitive processes. Consequently, the current findings may not fully capture the global diversity of reading patterns among language learners. Second, there are certain limitations in material design. Especially when simulating digital reading environments, there is a lack of systematic, controllable, and interactive reading materials. Most studies still rely on static, linear, and non-interactive text materials, making it difficult to replicate learners' reading experiences in real digital environments. As tablets, computers, and mobile phones become everyday reading tools, digital reading scenarios have become increasingly complex, involving dynamic interactive forms such as page scrolling, paragraph jumping, link skimming, embedded multimedia, and real-time pop-ups. These factors have significantly altered traditional reading paths, rhythms, and strategy usage patterns. Finally, existing studies largely rely on eye-tracking data without integrating multimodal data, such as electroencephalogram (EEG), heart rate, or facial expressions, which could provide a more comprehensive understanding of cognitive and emotional states during reading.

Addressing these limitations, future research should prioritize three key directions. First, expanding the participant pool to include learners from diverse cultural, linguistic, and age groups, thereby enhancing the generalizability of

the findings. Second, Future research should further develop and validate reading materials that combine experimental controllability with real-world usage scenarios, particularly when considering multimodal information, such as hypervisual charts and audio-visual aids. Precisely measuring learners' gaze paths and strategy usage remains a challenge in such contexts. Additionally, research should more fully consider the influence of variables such as cultural background, professional field, and language proficiency on material comprehension and strategy use, thereby driving eye-tracking research toward more adaptive, widespread, and pedagogically meaningful directions. Third, adopting a multimodal research approach by combining eye-tracking with other physiological measures, such as EEG and facial recognition, to offer a deeper and more nuanced understanding of the cognitive and emotional aspects of reading.

Author Contributions

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Conflicts of Interest

The authors declare no conflict of interest.

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