International Journal of Education & Literacy Studies
ISSN: 2202-9478
www.ijels.aiac.org.au

The Science of Reading: The Eyes Cannot Lie

Yueh-Nu Hung*

Department of English, National Taichung University of Education, Taiwan

Corresponding author: Yueh-Nu Hung*, E-mail: yuehnuhung@gm.ntcu.edu.tw

ARTICLE INFO

Article history
Received: May 30, 2021
Accepted: September 04, 2021
Published: October 31, 2021
Volume: 9 Issue: 4

Conflicts of interest: None
Funding: The research is financed by The Ministry of Science and Technology, Taiwan (MOST 106-2918-I-142-001)

ABSTRACT

The eyes cannot lie. Eye movements are biological data that reveal information about the reader's attention and cognitive processes. This article summarizes the century-old eye movement research to elucidate reading comprehension performances and more importantly, their implications for reading instruction. This review paper addresses three research questions: (1) What do we know about eye movements? (2) What do we know about reading based on eye movements? (3) What reading instruction suggestions can be made based on eye movement research? Eye movement research show that reading is a selective, dynamic, sampling, integrating, and more than a perceiving process. Implications for reading instruction include: teach beyond phonics, teach beyond text, every element counts, make text natural, and evaluate the result and the process. This study contributes to the timely conversations about the science of reading and reading instruction and presents directions by which more effective reading instruction and policies can be established to address the needs of children and teachers.

Key words: Eye Movement, Reading Comprehension, Reading Instruction

INTRODUCTION

Studies on eye movements started at around the same time when scholars began to take a scholarly look at reading processes and reading comprehension more than a century ago. In psychology, most studies on eye movement have focused on reading (Radach et al., 2002), and eye movement is the most important indicator in studies on cognitive processes (Sanders & McCormick, 1993). Conklin et al. (2018) stated that "…tracking eye-movements provides a window into a largely unconscious behavior" (p. 2). Several studies on reading eye movement have revealed the biological, behavioral, and cognitive aspects of reading. This robust research literature should be considered in the discussions on the science of reading and reading practice among researchers, classroom practitioners, the general public, and education policy makers.

Reading and reading methods have been extensively studied, debated on, and politicized (Goodman et al., 2016). This review article aims to contribute to the ongoing discussion by presenting the perspective of eye movements in reading. This study, therefore, addresses three questions:

1. What do we know about eye movements?
2. What do we know about reading based on eye movements?
3. What reading instruction suggestions can be made based on eye movement research?

Instead of criticizing or endorsing any reading programs or movements, this paper explicitly presents what reading is, how we read, and what teachers can do to support students' reading comprehension and performance.

Notably, this paper focuses on the reading and comprehension of complete texts, not merely words or parts of words. Comprehension, rather than word recognition, is the focus of discussion. Furthermore, when reading, eye movements are influenced by linguistic and cognitive processes, not the other way around. Eye movements are the results of or the indication of the reader's cognitive processes. A glimpse of how the brain works can be achieved based on eye movements. Therefore, it is not recommended to train students to move their eyes in order to better understand what they read. Instead, the understanding processes of the students determine their eye movements.

WHAT WE KNOW ABOUT EYE MOVEMENTS

Studies on eye movements can be traced back to more than 2000 years ago when Aristotle noted the binocular feature of the eyes (Wade, 2010). Early eye movement studies have focused on the physiology and anatomy of the eyes and vision, and it was only in the nineteenth century that eye movements were studied more systematically (Wade, 2010). Edmund Huey, an American psychologist, presented a study on eye movements when reading in his seminal book, *The Psychology and Pedagogy of Reading* (1908), and cited French ophthalmologist, Emile Javal, who coined the term "saccade" to refer to the rapid movements of the eyes from one fixation point to the next.

Published by Australian International Academic Centre PTY.LTD.

http://dx.doi.org/10.7575/aiac.ijels.v.9n.4p.26

Early eye movement studies have focused on the physiological and perceptual features of the eyes, partly because the understanding of cognition and learning was still nascent until the 1950s and 1960s, when the connection between eye movements and attention began to be understood (O'Regan, 1990; Wade, 2010). The emerging research interest in psychology and cognitive science contributed to the increasing application of eye-tracking technology in reading research. According to the eye–mind assumption, the eyes are a window into the mind, and what is looked at is what is being processed (Just & Carpenter, 1980). Over the past few decades, scholars have agreed that fixations and saccades are influenced by the linguistic and cognitive processing of words and text (Rayner, 1979, 1998, 2009; Liversedge & Findley, 2000). In recent decades, with the advent of user friendly and affordable eye trackers, an exponential number of eye movement studies have been conducted in various disciplines.

Eyes fixate on a point to collect visual information, and in order to gain more information, they move from one fixation point to another. A very small portion (approximately 2 visual degrees) of what humans see is reflected in the fovea region where the image is clear (Rayner, 1998); therefore, the eyes must constantly move to send more visual information to the fovea region to obtain better acuity for the brain to build a more complete picture of what is seen. Movements from one fixation to another, called saccades, are rapid, with an average length of 20–35 ms; moreover, little or no information is collected during saccades (Rayner, 2009). Although studies with different research purposes and designs use different measures, the eye movement measures most often used in reading research include fixation count (the number of fixations), fixation duration (the duration of each fixation), fixation position (where the fixations are located), saccade size (the size of the movements), and scan path (the direction of the movements). This paper presents a brief interpretation of these measures below in relation to the cognitive processes in reading.

Based on the robust eye movement research in the past century, a higher number of fixations and longer fixations indicate a higher degree of attention and cognitive activities (Just & Carpenter, 1980; Paulson & Freeman, 2003; Rayner et al., 2006; Rayner, 2009; Rayner & Liversedge, 2011; Samuels et al., 2011; Conklin et al., 2018). Interesting or difficult texts usually require a higher number of and longer fixations. Children with developing reading abilities and people reading texts in their nonnative languages also exhibit more and longer fixations (Kowler & Martins, 1982). Small saccade sizes (small movements) suggest increased cognitive load and careful inspection scans (Holmqvist et al., 2011). Scan paths indicate the point at which the eyes are focused and provide useful information about the reader's interest, attention, and reading processes (Rayner et al., 2006). Based on a review by Rayner (2009), the mean fixation duration during silent reading is in the range of 225–250 ms and the mean saccade size is 2 visual degrees. In oral reading, the mean fixation duration is in the range of 275–325 ms and the mean saccade size is 1.5 deg.

WHAT WE KNOW ABOUT READING BASED ON EYE MOVEMENTS

In the field of reading and reading instruction, eye movement studies have been conducted to understand a wide range of topics, including letter and word recognition; the effects of word frequency, predictability, and number of letters; syntactic processing; comprehension; and dyslexia. This paper reports findings of eye movement studies that have focused on whole texts instead of single and isolated words and phrases or controlled language. The act of reading involves complex visual, perceptual, psycholinguistic, cognitive, and sociocultural processes, but debates on reading often focus on decoding and phonics. The aim of the present study was to direct the concern of the debates to a broader and more comprehensive view of reading. Eye movement studies that have examined the reading of different languages and genres and with different reading tasks and purposes are reviewed and cited to elucidate the various textual, contextual, and sociocultural factors that influence the reading processes and performance. What is already known about reading based on studies on eye movements is summarized as follows.

Reading is a Selective Process

Not all letters and words are treated equally. Readers do not fixate on every letter in every word when they read. Huey (1908) demonstrated that while reading, a reader fixates on only 20%–70% of words and that the first fixation on a line is not necessarily on the first word but may be on the second or even third word. Likewise, the final fixation on a line may not be on the last word. Ko et al. (2005) reported that, in the reading of a traditional Chinese text, 52% of words in expository text and 67% in stories are not fixated. When the word length is controlled, readers more often fixated on words with low frequency and low predictability (Inhoff & Rayner, 1986; Rayner & Duffy, 1986; Yan et al., 2006). Numerous studies on eye movement have reported that readers fixate on content words more often than on function words. Because word information can also be obtained in the parafoveal region, the area outside the fovea that renders blurry vision, a common argument is that all the words are "seen." However, eye movement research evidence that not all words are treated equally, and the reader can decide on the fixation point and the eye movement.

Because fixating on all the letters in each word and sentence is not necessary, the reader must determine their eye movements in order to collect more useful information. They predict what they might see next and determine whether to fixate or not. For example, when moving to the end of a line, they predict what word or words they might see on the next line based on the syntactic structure and meaning of the sentence. Therefore, the first fixation on a line is not necessarily on the first word but may be on the second or even third word. Another example is the scarcity of eye movements on punctuation marks, which are usually predicted based on the syntactic and semantic information. Figure 1 presents a fixation-time-based heat map constructed to depict the fixation time of fifth-grade children in Taiwan who read

a short folktale written in traditional Chinese; it is evident that very little fixation time is spent on punctuation marks. Punctuation marks are such an integral part of sentences that they can be predicted in the reading process and thus skipped by the eyes.

Reading is a Dynamic Process

Readers use all available resources in order to understand what they read. They rely on their background knowledge and seek information from the print to decipher the meaning of the text. Their eye movements reveal that they read the verbal text and text features, pause to think, reread, go back to earlier parts of the text, check visuals, and go back and forth between the text and visuals. Regressive eye movements are evidence of such dynamic reading processes. In studies on reading eye movement, the percentage of regressive eye movements is often used to indicate how challenging the text is for the reader or how actively the reader is integrating information to reach comprehension. On average, the regression rate in reading has been reported to be 10%–15% (Conklin et al., 2018) and 10%–20% (Rayner & Pollatsek, 1989). In another study, the reported regression rate was 21% in adult readers and 34% in first-grade children (McConkie et al., 1991). A higher regression rate means that the reader goes back to earlier parts of the text to confirm or reconfirm information more often. Notably, regression is the result of a challenge in reading or the need to integrate information from different parts of the text, not the cause of poor reading performance. Eye movement research has also found that, compared with adult readers, younger readers are less proficient in making bidirectional scan paths across text and illustrations (Jian, 2015).

Reading is a Sampling Process

Reading is a process involving sampling and making use of all types of textual and visual information including verbal, nonverbal, and multimodal information to construct meaning.

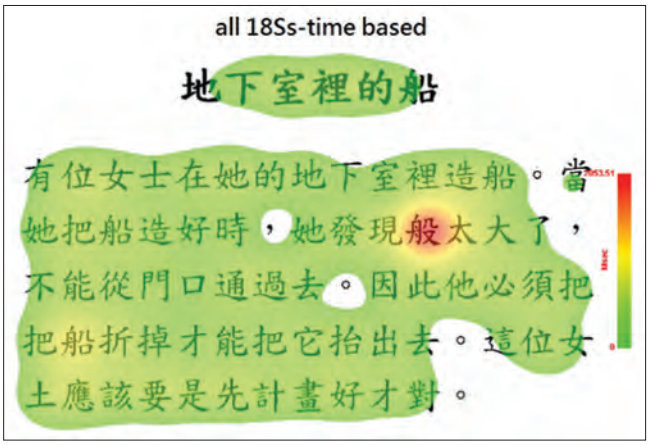

Figure 1. A heat map of reading eye movements
Fixation-time-based heat map of 18 fifth-grade Taiwanese children reading a short folktale intentionally embedded with errors (Hung, 2019, p. 414). Very little fixation time was observed for the four periods (。) and the two commas (,).

This means that the reader moves within and across various text and image components of the reading material to gather useful information in order to understand the text. Some readers, however, especially the inexperienced ones, dwell on difficult words in an attempt to sound out letters or letter combinations. Most readers sample the next few words and letters within these words, examine titles and headings, and view illustrations and captions, as shown by their eye movements. Figure 2 shows the eye movements of a Taiwanese adult during the first 5 s of reading a visual poem. Before she started focusing on the main text in the middle right section of the page, she sampled the poem by reading the title and glancing at the words and images on the left side.

Reading is an Integrating Process

Readers sample information from various text and image sources and integrate them to construct coherent meaning. Eye movements across different text features can offer evidence of these integration processes. As mentioned above, regressive eye movements are measures of higher-order cognitive processing, wherein readers go back to earlier parts of the text to integrate and construct a coherent representation of what they read (Rayner & Liversedge, 2011). Reading titles and headings is another example of the integrating process. Headings play a crucial role in introducing the topic or labeling the major contents of a text, and one of the common comprehension strategies that students learn at school is using the titles and headings to predict the content in the text, ask questions about the text, and set up reading goals before they start reading (Robb, 2000). Readers can, however, also go back to reread the headings after reading a section to integrate and confirm the meaning. Wiley and Rayner (2000) studied eye movement and revealed that titles help readers to process ambiguous words and integrate meaning.

Duckett (2002) investigated first-grade beginner readers by recording and analyzing their eye movements while reading picture books aloud. The text on a page that shows an

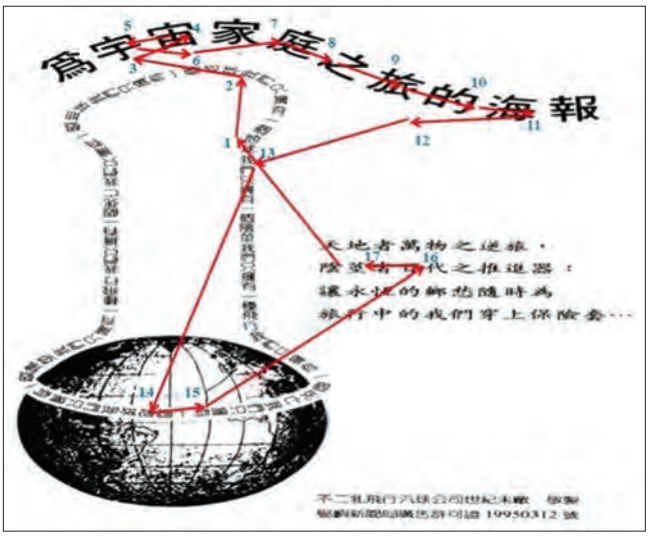

Figure 2. Sampling eye movements
Fixations during the first 5 s in the reading of a visual poem by an adult reader (Hung & Wu, 2015)

alligator holding and looking at a desk calculator says, "I saw an alligator counting on a calculator." Javier, a reader in the study, spent a total of 25.73 s fixating on the word "counting," and read aloud "holding" in the end. The miscue was caused because the phrase "counting on a calculator" is not accurate as per American English conventions and may have also been caused by the pictorial information that depicted the alligator "holding" the calculator.

In an eye movement study on sixth-grade students reading a science text, Hung (2014) found that comprehension performance was positively correlated with the percentage of fixations on visuals. Students who spent more time viewing the visuals performed better in reading comprehension. Mason et al. (2013) found that labeled pictures helped sixth-grade students to read and understand science texts and promoted the integration of verbal and graphical information. Another eye movement study demonstrated that more experienced readers spend more time viewing visual representations (Jarodzka et al., 2010). With the increase in digitalized, nonlinear, and multimodal reading material, reading as an integrating process has important implications for reading instruction.

Reading is More than a Perceiving Process

The eyes cannot lie, but we do not always trust them. The eyes collect visual information and send it to the brain, but the information collected by the eyes can be perceived and understood differently by the brain. Reading is more than a seeing or perceiving process. Smith (1971) stated that reading is only incidentally visual. What we think we see may differ from what we actually see. Our perception is based on the graphic and syntactic information and is influenced by the interpretation of the text and the expectation of what we will see. This process is well demonstrated by the tracking of the eyes combined with the recording and analysis of oral reading miscues. In the example depicted in Figure 3, the text says, "Then I saw two huge eyes. It was the Old Dark Frog." However, a 10-year-old English learner misread it as "The I saw two big eyes on the Old Dark Frog." The eye movement data revealed that this reader made two fixations on the word "huge," indicating that he saw the word "huge," but he read aloud the word "big." "Huge" and "big" have similar meanings, and the substitution does not cause any syntactic alterations. However, "huge" and "big" do not look alike. When the visual information of "huge" was sampled and sent to the brain, the information-processing center, his brain ignored this information and provided the output "big."

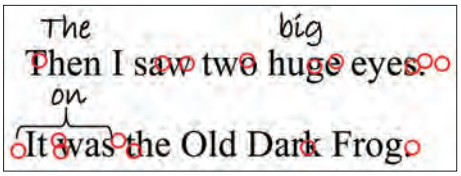

Figure 3. Eye Movements of a young EFL learner
Eye movements of a 10-year-old English learner; the reading material is "Shivers" in "Days with Frog and Toad" (Lobel, 1979)

Similarly, the reader made several fixations on the first two words in the second line "It was" but said aloud "on," resulting in a syntactically acceptable sequence of words. The visual information was overlooked because the prediction of meaning and the next words was quite strong. Seeing is not perceiving. Reading is more than a perceiving process. It is an information-processing and meaning-construction process.

READING INSTRUCTION SUGGESTIONS

Based on research that employed the eye-tracking technology and eye movement analysis, this section presents implications for reading instruction. The main focuses of the paper are on reading and teaching to read whole texts instead of letters or individual words.

Teach Beyond Phonics

Students must be taught to look for linguistic and nonlinguistic cues and all types of information when they encounter reading difficulties. Less-proficient readers tend to depend on low-level linguistic information, such as letters and spelling, whereas more-proficient readers tend to acquire more global information across different words, sentences, and sections of the text to decipher meaning. In classrooms where students are taught to read "carefully" by sounding out each word sequentially, the eye movements of the students reveal that they tend to make sequential and smaller movements. Students should be taught that instead of dwelling on the spelling and sounds of words that they do not know, they can also jump to different parts of the text and gather different types of textual and visual cues to gain useful information. In addition to being taught to rely on background knowledge and past related experiences, students must be made aware of the availability and function of different types of verbal and nonverbal cues that the text provides and how to use them to overcome comprehension difficulties. The implication for the discussions on reading instruction is that successful reading requires more than phonics knowledge.

Teach Beyond Text

Reading is a predicting process. After a few fixations on the first part of a sentence or a line, the reader predicts the words or phrases that might appear later in the sentence or line and the idea presented by the author in the next few sentences. The predictions are based on both the text and the reader. The general and specific background knowledge of the reader is equally, if not more, important than what is physically written on the page or shown on the screen. Text-based reading strategies such as phonics and word recognition techniques are helpful; however, information beyond the text also helps the reader to sample and predict. The implication for reading instruction is that expanding students' background knowledge and enriching their reading experiences across different disciplines and genres should be an integral part of a comprehensive reading curriculum.

Every Element Counts

Students must know that all text features and nonverbal visuals serve a purpose. Every element counts. Learning how to use these elements to understand and improve comprehension should be an important part of reading instruction. This is especially important when students increasingly encounter nonlinear and multimodal texts in which the use and integration of information of different modes and media are key to comprehension. A sound reading curriculum enables children to be competent and efficient in utilizing all types of textual, visual, and multimodal information (e.g., sound, visual, and action) to aid comprehension.

Make Text Natural

Readers construct and predict meaning based on what is written on the page and what they know about the topic already. If the language is natural and the content is close to the reader's life experience, the reading will be more comprehensible. Eye movement studies have demonstrated that words and language conventions that do not sound natural cause reading difficulties among beginner readers. The implication for reading instruction is that reading materials must be natural and authentic. The encountered reading difficulties can be partly attributed to the inauthenticity of the text, not the limitations of the reader. Materials that are linguistically and cognitively natural and authentic are more effective than those that are contrived or controlled.

Evaluate the Result and the Process

Reading is a dynamic, integrating, and perceiving process that should be evaluated carefully. Traditional paper and pencil tests elucidate the *result* of comprehension, but not the underlying comprehension *process*. The complex and active processes of reading and the reader's roles in reading are difficult to measure using the traditional paper and pencil tests (Kaakinen et al., 2003). Therefore, alternative assessments should be used in combination with the more traditional comprehension tests at least in the classroom setting, where assessment is expected to inform instruction and provide individual feedback. Students' use of verbal and visual information, process of information integration, use of text features to aid meaning comprehension, and use of other comprehension strategies can be evaluated using alternatives such as miscue analysis, interviews, read-aloud protocols, teacher observation, and eye movement analysis.

CONCLUDING REMARKS

More than a century ago, Huey stated, "to completely analyze what we do when we read… would be to describe very many of the most intricate workings of the human mind…" (1908, p. 6). The mechanisms underlying how humans read and the teaching of reading remain crucial research topics. Eye-tracking technology has long been used to study the visual attention and cognitive activities involved in reading. Eye movement information reflects what the readers "see" and helps infer their thoughts. Based on over a century of eye movement research in reading, we infer that reading is more than just a perceiving process and is a selective, predictive, dynamic, sampling, and integrating process. Research on eye movement in reading has shown that reading comprehension is optimal if the reading materials are natural and close to the reader's cognitive and life experiences. Moreover, readers should be taught to use the information from different textual, nonverbal visual features, and multiple representations and modes to assist comprehension. Comprehension is also optimal if reading instruction is embedded in a wide cross-disciplinary curriculum through which students build up general and specific background knowledge for reading and learning. In the continuous conversations about reading and reading instruction, let's not forget these very principle understandings about reading and how students read most successfully based on the body of century-old eye movement research.

This review is limited in that most of the eye movement studies reviewed and cited address the reading and comprehending of whole texts, not words or parts of words. Also, these studies involve the reading of English and Chinese, not other languages. For future research, it is suggested that eye movement research review and synthesis method be applied in the investigation of various aspects of reading performance, and eye movement information from readers of different age, proficiency level, and linguistic background be collected and studied to yield an even more comprehensive understanding about reading.

REFERENCES

Conklin, K., Pellicer-Sánchez, A., & Carrol, G. (2018). *Eye-tracking: A guide for applied linguistics research*. Cambridge University Press.

Duckett, P. (2002). New insights: Eye fixations and the reading process. *Talking Points, 13*(2), 16–21.

Goodman, K. S., Fries, P. H., & Strauss, S. L. (2016). *Reading-The grand illusion: How and why people make sense of print*. Routledge.

Holmqvist, K., Nyström, M., Anderson, R., Dewhurst, R., Jarodzka, H., & van de Weijer, J. (2011). *Eye tracking: A comprehensive guide to methods and measures*. Oxford University Press.

Huey, E. B. (1908). *The psychology and pedagogy of reading*. Macmillan.

Hung, Y. H. (2014). What are you looking at? An eye movement exploration in science text reading. *International Journal of Science and Mathematics Education, 12*(2), 241–260.

Hung, Y. H. (2019). Fifth grade students reading a Chinese text with embedded errors: An eye movement miscue analysis study. *Reading Psychology, 40*(4), 397–424.

Hung, Y. H., & Wu, Z. F. (2015). *Reading visual poems*. Paper presented at the 65th Annual Conference of the Literacy Research Association, Carlsbad, CA, USA.

Inhoff, A. W., & Rayner, K. (1986). Parafoveal word processing during eye fixations in reading. *Perception and Psycholinguistics, 40*(6), 431–439.

Jarodzka, H., Scheiter, K., Gerjets, P., & van Gog, T. (2010). In the eyes of the beholder: How experts and novices interpret dynamic stimuli. *Learning and Instruction, 20*(2), 146–154.

Jian, Y. C. (2015). Fourth graders' cognitive processes and learning strategies for reading illustrated biology texts: Eye movement measurements. *Reading Research Quarterly, 51*(1), 93–109.

Just, M. A., & Carpenter, P. A. (1980). A theory of reading: From eye fixations to comprehension. *Psychological Review, 87*(4), 329–354.

Kaakinen, J. K., Hyönä, J., & Keenan, J. M. (2003). How prior knowledge, working memory capacity, and relevance of information affect eye-fixations in expository text. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 29*(3), 447–457.

Ko, H. W., Chen, M. L., & Liao, C. N. (2005). Frequency effect, word class and eye movements: Evidence from the text reading. *Chinese Journal of Psychology, 47*(4), 381–398.

Kowler, E., & Martins, A. J. (1982). Eye movements of preschool children. *Science, 215*(4535), 997–999.

Liversedge, S. P., & Findlay, J. M. (2000). Saccadic eye movements and cognition. *Trends in Cognitive Sciences, 4*(1), 6–14.

Lobel, A. (1979). *Days with Frog and Toad*. HaperTrophy.

Mason, L., Pluchino, P., & Tornatora, M. C. (2013). Effects of picture labeling on science text processing and learning: Evidence from eye movements. *Reading Research Quarterly, 48*(2), 199–214.

McConkie, G. W., Zola, D., Grimes, J., Kerr, P. W., Bryant, N. R., & Wolff, P. M. (1991). Children's eye movement during reading. In J. F. Stein (ed.), *Vision and visual dyslexia* (pp. 251–262). Macmillan Press.

O'Regan, J. K. (1990). Eye movements and reading. In E. Kowler (ed.), *Eye movements and their role in visual and cognitive processes* (pp. 395–453). Elsevier.

Paulson, E., & Freeman, A. E. (2003). *Insight from the eyes: The science of effective reading instruction*. Heinemann.

Radach, R., Inhoff, A. W., & Heller, D. (2002). The role of attention and spatial selection in fluent reading. In E. Witruk, A. Friederici, & T. Lachmann (Eds.), *Basic mechanisms of language and language disorders* (pp. 137–153). Kluwer.

Rayner, K. (1979). Eye guidance in reading: Fixation locations within words. *Perception, 8*(1), 21–30.

Rayner, K. (1998). Eye movements in reading and information processing: 20 years of research. *Psychological Bulletin, 124*(3), 372–422.

Rayner, K. (2009). Eye movements and attention in reading, scene perception, and visual research. *Quarterly Journal of Experimental Psychology, 62*(8), 1457–1506.

Rayner, K., Chace, K. H., Slattery, T. J., & Ashby, J. (2006). Eye movements as reflections of comprehension processes in reading. *Scientific Studies of Reading, 10*(3), 241–55.

Rayner, K., & Duffy, S. A. (1986). Lexical ambiguity and fixation times in reading: Effects of word frequency, verb complexity, and lexical ambiguity. *Memory and Cognition, 14*(3), 191–201.

Rayner, K., & Liversedge, S. P. (2011). Linguistic and cognitive influences on eye movements during reading. In S. P. Liversedge, I. D. Gilchrist, & S. Everling (Eds.), *The Oxford handbook of eye movements* (pp. 751–766). Oxford University Press.

Rayner, K., & Pollatsek, A. (1989). *The psychology of reading*. Prentice Hall.

Robb, L. (2000). *Teaching reading in middle school*. Scholastic.

Samuels, S. J., Rasinski, T. V., & Hiebert, E. H. (2011). Eye movements and reading: What teachers need to know. In S. J. Samuels, & A. E. Farstrup (Eds.), *What research has to say about reading instruction* (4th ed., pp. 25–50). Newark, DE: International Reading Association.

Sanders, M. S., & McCormick, E. J. (1993). *Human factors in engineering and design* (7th ed.). McGraw-Hill.

Smith, F. (1971). *Understanding reading: A psycholinguistic analysis of reading and learning to read*. Holt, Rinehart.

Wade, N. J. (2010). Pioneers of eye movement research. *i-Perception, 1*(2), 33–68.

Wiley, J., & Rayner, K. (2000). Effects of titles on the processing of text and lexically ambiguous words: Evidence from eye movements. *Memory & Cognition, 28*(6), 1011–1021.

Yan, G., Tian, H., Bai, X., & Rayner, K. (2006). The effect of word and character frequency on the eye movements of Chinese readers. *British Journal of Psychology, 97*, 259–268.