

Selective attention of L2 learners in task-based reading online

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Abstract

Selective attention to task-relevant content is an essential strategy for readers. There is evidence that proficient readers more often consider their purpose and focus attention selectively. However, eye tracking research has revealed several limitations with survey data on reading strategies, and few second language (L2) reading studies have explicitly examined selective attention. This study includes two experiments utilizing eye tracking to determine how Japanese university-aged learners read an online text to research specific information. The first experiment evaluates the reading strategies of the participants and examines the effect on task performance. The second experiment investigates the effect of strategy training. The eye tracking results in experiment one suggested that many participants did not display strategic competence. Selective attention and the number of reading strategies identified in the data correlated with task-performance. The second experiment revealed that strategy training increased the use of selective attention and improved task performance.

Keywords: second language reading, reading strategies, eye tracking, selective attention, strategy training

Selective attention involves focusing on task-relevant content for deeper processing while skimming or ignoring irrelevant content (Stevens & Bavelier, 2012). Like other related global reading strategies, it is imperative for reading success, especially when researching a particular topic (Peshkam, Mensink, Putnam, & Rapp, 2011). Selective attention helps readers process texts more effectively by optimizing cognitive efficiency (McCrudden, Magliano, & Schraw, 2011), and studies have suggested that it may even predict second language (L2) reading proficiency (Zhang & Wu, 2009). However, it has been argued that L2 readers often lack the ability to strategically focus attention on task-relevant passages (Grabe, 2009).

Nevertheless, there has been little L2 research explicitly examining selective attention (Grabe, 2009). While L2 research into metacognitive strategies does include selective attention, these studies have tended to rely on survey responses, which have limitations (Denscombe, 2014).

Therefore, eye tracking and screencast recording are gaining momentum to examine online reading strategies in a more valid and reliable way (Kang, 2014; Hahnel, Goldhammer, Naumann, & Kröhne, 2016). However, while L2 eye tracking research has greatly increased recently (e.g., Godfroid, 2012), the selective attention of L2 learners when researching specific content has not yet been empirically examined.

To fill the aforementioned gap, this study analyzes the eye movements and webpage navigation of Japanese learners of English to examine how they read to research specific information online. Second, this study investigates the effect of reading strategy instruction on learners' reading and task performance.

Literature Review

Selective attention fits into the theoretical reading framework in varying and dynamic ways; it is a metacognitive reading strategy, yet it also reflects one's cognitive capacity to focus on task-relevant content (Sinatra, Brown, & Reynolds, 2002). As a metacognitive strategy, selective attention can involve both planning and monitoring (Smallwood, Fishman, & Schooler, 2007). These mechanisms can be executed in different ways depending on the task, the difficulty of the text, one's reading style, and so on (Weir & Khalifa, 2008). In some cases, readers have clear goals and plans before reading. They may preview or scan to identify relevant sentences, sections, or texts, and then carefully read selected passages. This style of reading has been labelled *search reading* (Urquhart & Weir, 1998). In other cases, readers may begin reading the entire text linearly, but they may more carefully read or re-read relevant content. Readers utilizing selective attention maintain goal awareness, monitor task-based comprehension, and remediate when needed (Weir & Khalifa, 2008).

Especially considering the growth of online reading and the mass of information on the internet, navigating effectively and reading selectively to find and comprehend relevant and reliable information are essential for both general and academic purposes (Anderson, 2003; Kang, 2014). First language (L1) research utilizing think-aloud protocols revealed that readers who more successfully identified relevant texts performed better on essay assignments (Anmarkrud, McCrudden, Bråten, & Strømsø, 2013). Research of tenth-grade readers showed that effective readers "learned and recalled more important information... because they were more metacognitively aware of how and when" to utilize selective attention (Reynolds, Shepard, Lapan, Kreek, & Goetz, 1990, p. 749).

While selective attention is a metacognitive strategy, it also concerns one's cognitive capacity to focus on goal-relevant information while ignoring irrelevant content (Tipper & Baylis, 1987). Readers often struggle to suppress attention to irrelevant text. Distractibility and mind-wandering affects certain people more than others (Smallwood et al., 2007). *Seductive details*, amusing but irrelevant information, are particularly hard to ignore (Peshkam et al., 2011). However, since processing information in a text exhausts working memory, focusing attention on goal-relevant content can help readers achieve optimal cognitive efficiency (McCrudden et al., 2011).

L2 Studies on Selective Attention

Grabe (2009) argued that many L2 readers lack the ability to devote “attentional processes selectively to ensure... an appropriate standard of coherence that is required to achieve reading goals” (p. 55). However, few L2 studies have focused explicitly on selective attention, and Grabe suggested it was a key aspect of reading in which there was much to learn.

Survey-based research into L2 metacognitive and global reading strategies has touched upon selective attention. In the Survey of Reading Strategies (SORS; Sheorey & Mokhtari, 2001), it is measured directly and indirectly in the global strategies construct. Most directly measuring selective attention are items about considering whether the text is relevant to one’s purpose and deciding what to read closely and what to ignore. Both strategies are dependent on having a purpose in mind when reading, the first item on the survey. Other items in the global construct involve previewing, which can reflect or enable selective attention (Prichard & Atkins, 2016).

Studies utilizing SORS have shown that items related to selective attention correlate with reading proficiency. Zhang and Wu (2009) compared SORS results and exam scores of 249 Chinese high school readers of English to measure the relationship between reading strategies and achievement. The results showed that having a purpose when reading and deciding what to read closely both had a significant correlation with comprehension scores. In an analysis of the reading strategies of 447 Japanese university learners of English (Prichard, 2014), high proficiency readers reported significantly more use of two strategies related to selection attention: having a purpose when reading and thinking about whether the content fits their purpose.

Planning is a construct closely related to selective attention in the Metacognitive Online Reading Strategies Questionnaire (MORS-Q; Romly, Badusah, & Maarof, 2017). Four of the eight planning strategy items directly concern selective attention and the others involve previewing. In studies using the MORS-Q, the planning construct has been a significant predictor of proficiency among 361 Malaysian university students (Romly et al., 2017), 33 Chinese university students (Zhang & Seepho, 2013), 384 Thai university students (Phakiti, 2003), and 506 Iranian post-graduate students (Ghafournia & Afghari, 2013). Lower proficiency learners may less often utilize metacognitive reading strategies related to selective attention, but they could theoretically benefit even more from selective attention as reading challenging but irrelevant texts exhausts working memory that could be better used to tackle relevant passages.

There are several reasons why certain L2 readers lack metacognitive competence, including selective attention. First, learners from some cultures may utilize specific strategies more often (e.g., Taki, 2015). One’s strategy use may be related to the role of reading and education in one’s culture, and metacognitive skills may not be developed in educational systems that focus more on rote learning (Novak, 1990). Moreover, learners heavily exposed to grammar-translation, still a prominent L2 pedagogy in many contexts including Japan, may not acquire strong metacognitive strategies (Sakurai, 2015). In such classrooms, special attention is not paid to any particular section, and the text is read linearly, word for word. Moreover, in teacher-centered classes, students are assigned reading materials so they do not need to consider relevance. In contrast, learners with plentiful chances to read for authentic purposes, such as researching

information and reading to discuss ideas, may be more likely to develop strategic reading habits (Zhang, 2010).

Media literacy and navigation strategies are other related factors affecting one's ability to strategically focus on relevant information. When users revisit websites, they acquire schemas which help them orient pages effectively (Stenfors, Morén, & Balkenius, 2003). While most Japanese college students use the web daily, few frequently read English sites (Hirata & Hirata, 2010). Moreover, among this population, much web searching is done on smartphones not personal computers; only 16% have desktop computers at home while over 98% have smartphones (Cabinet Office, Government of Japan, 2014). Because of these factors, many Japanese university students may have difficulty accessing English media strategically, especially on personal computers. Indeed, some report not knowing what to look for in a website and lacking the ability to preview pages, and these participants tend to navigate English sites non-strategically (Hirata & Hirata, 2010).

Strategy training. While not focusing on selective attention specifically, research suggests that strategy training can improve both reading strategy use and comprehension (e.g., Salataci & Akyel, 2002). Wang's (2009) research used a pre- posttest control group design to examine the effect of ten weeks of metacognitive strategy training involving 110 Taiwanese high school learners of English. The intervention raised learners' reported metacognitive strategy use and comprehension scores. However, not all L2 metacognitive strategy training has been successful (e.g., Pei, 2014). Based on the CALLA model (O'Malley & Chamot, 1990), strategy training should be extensive and focus on developing strategy awareness, practice, reflection, and expansion.

Limitations of Surveys and the Role of Eye Tracking and Screencasts

Although prior L2 research suggests the value of metacognitive skills and selective attention, the studies have tended to rely on surveys. In self-report instruments, respondents may answer based on what they consider is the ideal response, or they may not be cognizant of strategies that have become automated (Denscombe, 2014). It has been argued that selective attention is one aspect in which readers are not always conscious (Sinatra et al., 2002). Perhaps because of these reasons, research has shown L2 participants, in the context of testing, misreported their reading behavior almost one in three times (Bax & Weir, 2012).

Moreover, strategy surveys reveal general tendencies, not how readers read given a specific text or task (Mokhtari, Dimitrov, & Reichard, 2018). Less proficient learners may report less selective attention simply because they lack experience in reading in the target language for authentic purposes; these learners may read selectively when necessary, but they simply may not regularly do so in the L2 given their needs. Therefore, research correlating reading proficiency with survey responses does not demonstrate causation.

Eye tracking. Considering the limitations of self-report protocols, several L1 studies have used eye tracking to evaluate global reading strategies. Eye tracking research assumes that the position of the eyes on a page is indicative of where attention is focused, and research shows there is indeed an extremely strong correlation between eye movements and attention (Deubel &

Schneider, 1996). Eye movements reveal “a window into language and cognition” (Spivey, Richardson, & Dale, 2009, p. 225), showing how readers approach an actual text on a moment-to-moment basis.

Most L1 studies utilizing eye tracking to research global reading strategies have shown that learners tend to display selective attention. For example, Lewis and Mensink (2012) found that L1 readers tended to focus on sentences that were related to pre-reading questions. Research by Hyönä, Lorch, and Kaakinen (2002) was an exception in showing that L1 readers do not always pay selective attention; most Finnish university students reading an expository text to write a summary did not give increased attention to sentences that contained the main points. Nevertheless, the readers displaying the most selective attention performed better on the summary.

While more L2 reading researchers are utilizing eye tracking (e.g., Godfroid, 2012), relatively few have focused on global reading strategies. Prichard and Atkins (2016, 2018) used eye tracking to analyze how Japanese high-intermediate and advanced learners of English read texts in order to write a summary. The first study (2016) revealed that the participants did very little if any previewing, though they responded on the SORS that they tended to do so. In the second study (2018; replicating Hyönä et al., 2002), participants instructed to write a summary tended to give no selective attention to the introduction and topic sentences, which contained all the main points. Considering this along with other research described above, the researchers concluded that this population may benefit from authentic reading tasks and explicit strategy training.

Tracking online navigation. Screencast recording and tracking links accessed are other frequently used tools to validly and reliably examine L1 reading strategies online. Scrolling and clicking on hyperlinks demonstrates attentive processing and online research strategies, with studies showing that navigation strategies are closely related to reading success (e.g., Hahnel et al., 2016). While online navigation has long been recognized as an essential L2 skill (Anderson, 2003), screencasts have not been frequently utilized in L2 research of online reading strategies.

General Method

This study examined how Japanese university-aged learners of English read an online article for the purpose of researching specific content. Only one in three body sections of the text were relevant to the task, and participants’ eye movements and page navigation were analyzed to determine if they paid selective attention to the task-relevant section and if they utilized other global strategies. The study included two experiments. The first was designed to answer the following research questions:

1. To what degree do participants utilize selective attention and global reading strategies when researching specific content on a webpage?
2. Does selective attention and global reading strategies use predict the participants’ ability to recall task-relevant content?

The second study aimed to answer the following using a pre- and posttest:

3. Does strategy training increase participants' selective attention and global reading strategies?
4. Does strategy training improve participants' ability to recall task-relevant content?

Equipment

A Gazepoint GP3 Eye Tracker and Gazepoint Analysis Software were utilized. The tracker is designed for analyzing users' web use, and page navigation posed no discernable issues for the eye tracker in previous research on global reading strategies (Prichard & Atkins, 2018). The tracker has a 60Hz refresh rate, and its accuracy is within 0.5 to 1.0 degrees. While not suitable for measuring reading fluency, the refresh rate and accuracy of the tracker were suitable for this study as the experiments examined global reading strategies by comparing fixations within large sections of the text (two paragraphs each, which took up the whole screen).

The tracker was placed on a small tripod under the 24-inch high-definition monitor. The eyes of the participants were about 60 centimeters from the screen.

Materials

Two expository texts were involved. One concerned mosquitoes (used in both experiments) and the second concerned the hand game *rock, paper, scissors* (used only in experiment two). The articles, adapted from various sources, were displayed as Wikipedia webpages. Most Japanese are accustomed to the Wikipedia layout; the Japanese-language version is the country's 13th-most accessed page (SimilarWeb, 2018). Each article had a short introduction and a table of contents, which included page jump links to each body section. Users could also scroll to view different parts of the text using the scroll bar, the mouse's scroll wheel, or the keyboard.

Each article included three subsections. The first article included sections on mosquito feeding habits, mosquito killing contests, and control methods. The second had the following sections: variations of rock, paper, scissors; skills and strategies; and worldwide competitions. As is described below, the task required the participants to research one aspect of the article (mosquito killing contests in text one; skills and strategies in text two), so only the second of three sections in each text was relevant to the task. The second section was designated in both studies as the task relevant section to analyze if participants would skip over the first irrelevant section and stop reading after the relevant section.

Vocabulary, sentence length, and content were carefully controlled since these are known to affect eye movements, reading strategies, and comprehension. Each of the three sections in both articles had exactly two paragraphs, ten sentences, and 150 words. All sections were edited so that they all had very similar readability scores (61-66) on the Flesch-Kincaid test (Kincaid, Fishburne, Rogers & Chissom, 1975). As for the vocabulary difficulty, excluding loan words and pronouns, 95-96% of the running words in each section were within the top 3,000 words, based on the British National Corpus (2007). Finally, content was chosen after piloting among a similar

population suggested that participants would be very familiar with the general topic, but not familiar with the specific content of the articles.

In sum, because the language and content were carefully controlled, any large disparities in eye movements, particularly total fixation times between the relevant and irrelevant sections (and between the two texts), could likely be attributed to participants' global reading strategies, not to text difficulty or saliency. Data collected previously from 30 participants from the same institution when reading the same materials for general comprehension revealed little difference in fixation duration on the various sections in both texts.

Procedures

Students in the lead author's English reading and writing courses were asked to visit his office individually for an out-of-class reading assignment. Those who consented to the study were seated at a computer. (Other students completed an identical task on paper and were not included in the study.) Participants reading the first text were asked to read the following instructions:

Imagine you are researching about mosquito killing contests. You will be shown a website on the screen to research this. The time you have to view the site is up to ten minutes. (If you finish early, please tell the teacher.) Afterwards, you need to write on paper as many details about mosquito killing contests as you can in English.

The researcher then re-read the instructions aloud to each participant and asked if they could imagine what a mosquito killing contest was like. For the second text, the same procedures were carried out, except "mosquito killing contests" was replaced with "skills and strategies for rock, paper, scissors." After the participants confirmed they understood the task, their eyes were calibrated using 9-point calibration, and the reading task began if there were no further questions.

When the participants indicated they had finished reading or if ten minutes had passed, they moved to a nearby desk to complete the recall task. The recall form indicated that participants should write as many relevant details as they could. There was no time limit on the recall task.

Analyses

In most reading studies utilizing eye-tracking, researchers have been interested in reading accuracy, fluency, and general comprehension, so they have looked at a variety of measures, such as fixation duration and saccade length. However, because the focus of this study is on global reading strategies and metacognitive strategy use online, the methodology focuses more on fixation duration within areas of interest (as in Hyönä et al., 2002) and page navigation (as in Hahnel et al., 2016).

Fixation duration on the relevant and irrelevant sections. To determine the participants' level of selective attention to the relevant section, areas of interest measuring fixations within a fixed space were formed with the eye tracking software on each of the three subsections of the article. The total fixation duration was noted for the relevant and irrelevant sections, and the ratio was calculated to reveal the overall degree of selective attention.

Global reading strategies displayed. Moment-to-moment eye movements (fixation maps) and page navigation were also recorded in the software, and these data were analyzed and coded to identify specific global reading strategies utilized by each participant.

Two previewing behaviors were identified *before* the participants started to linearly read a body paragraph:

- Previewing the table of contents (determined by multiple fixations on it)
- Scrolling to preview the body (scrolling down to fixate on two or more sections of the text)

The following behaviors were identified to demonstrate other global strategies after previewing:

- Clicking the link in the table of contents to the relevant section (indicated by a yellow box in the analysis software)
- Scrolling directly to the relevant section (not linearly reading section one, but scrolling down to linearly read section two)
- Stopping reading the first irrelevant section
- Re-reading the relevant section two before linear reading section three
- Not linearly reading irrelevant section three
- Stopping reading irrelevant section three
- Scrolling to re-read section two after linear reading of section three

In the above coding, linear reading was determined by three or more fixations on at least three lines of a paragraph going down from the first line. Stopping reading a section was judged if the participant began to linearly read the first paragraph in a section but fixated on just four or fewer lines and scrolled to read another section. Re-reading a section was determined in cases in which there was linear reading of both paragraphs of the section twice. These strategies were coded independently by two researchers. Inter-rater reliability was over 95%, reaching 100% after discussion.

As the coding procedures were created by the researchers based on the literature, seven participants were interviewed in Japanese after the data collection to validate the procedures. While viewing the screencast of their eye fixations and page navigation, the participants were asked to state their strategies. If they did not mention a perceived strategy unprompted, the recording was stopped and replayed and the participants were prompted to explain what was shown. They were also asked to explain the purpose of the strategies. In each case, the participants verified the coding and the rationale by the researchers (e.g., “I scrolled down to view this section because the directions said I should search this topic.”).

Post-reading task. The number of idea units recalled in the post-reading task were counted to determine the participants’ success on the task, as in Peshkam et al. (2011). An idea unit is a piece of information from the relevant section. For example, the sentence “the winner was a pig farmer” was divided into the following two idea units: a farmer won and there were pigs (on the farm). A recalled idea unit was given a point regardless of whether it was verbatim or paraphrased. Spelling and grammatical accuracy were not scored, so the following would be

given two points despite the errors: “Farmer winned. She was pigs farmer.” The relevant section contained 36 idea units in both texts. The post-reading task was scored by the two researchers with an initial 93% inter-rater reliability rate and 100% agreement after discussion. Equality of variance and normal distribution on the recall protocol was confirmed (skewness = .37; kurtosis = -.51).

Experiment 1

The first experiment aims to determine the selective attention and related global reading strategies of Japanese university-aged learners of English when given a task to research a specific topic. Another main objective is to examine the relationship, if any, between reading strategy use and task performance.

Methods

Participants. Forty-two Japanese university students consented to participate. They were second-year students from medical and natural science faculties. Thirty were male and 12 were female. The mean score on the Test of English for International Communication (TOEIC) was 571.81 ($SD = 50.47$), suggesting the participants had intermediate to upper-intermediate proficiency. The participants had learned English for over seven years, but as mentioned above, reading instruction in Japan is often based on grammar-translation.

Analyses. Selective attention and task performance were evaluated based on the analyses described above. To determine any relationship between selective attention and task performance, the ratio of total fixation durations on the relevant section and the irrelevant sections (the independent variable) was calculated for each participant and compared with his or her recall protocol score (the dependent variable) using Pearson's correlation coefficient. The number of global strategies identified in the coding of the screencast was also used as a separate dependent variable.

Results

Reading behavior. As Table 1 shows, overall the participants paid more attention to the relevant section of the text. The total fixation duration on section two was significantly higher than on section one, $t(41) = 4.12, p < .01, d = .95$, and on section three, $t(41) = 6.40, p < .001, d = 1.40$. While the group as a whole did fixate more on the relative section, seven of the 42 participants did not fixate on the relevant section any longer than irrelevant sections.

Table 1. *Eye fixation duration (in seconds) on each section*

	Section 1 (irrelevant)	Section 2 (relevant)	Section 3 (irrelevant)
<i>M</i>	73.55	128.80	36.58
<i>SD</i>	25.93	77.72	26.97

The screencast of the participants' fixation map and page navigation suggested that the participants did not utilize many global reading strategies (see Table 2). Half of the participants fixated on the table of contents, yet they tended not to do anything strategic after this; none clicked on the link in the contents to jump to the relevant section and just one scrolled directly to it.

Table 2. *The number of global strategies identified in the screencast*

Previewed table of contents	Scrolled down to preview	Clicked link to section 2	Scrolled to section 2	Stopped reading section 1	Re-read section 2 before 3	Did not read section 3	Stopped reading section 3	Re-read section 2 after 3
21	2	0	1	0	5	1	4	15

Twenty-seven participants (64%) read the entire article linearly once without utilizing any of the global strategies other than previewing. Of these participants, five did return to re-read the relevant section. Therefore, 22 of the participants (52%) failed to display any of the coded global reading strategies after previewing.

The relationship between reading behavior and task performance. The participants recalled a mean of 7.65 idea units on the post-reading task ($SD = 5.19$). Those who paid relatively more attention to the relevant section performed better. There was a significant correlation between the number of task-relevant idea units recalled (dependent variable) and the ratio of eye fixation durations on the relevant versus irrelevant sections (independent variable), $r(40) = .43, p < .0001$. The recall score had a positive correlation with the total fixation duration on the relevant section, $r(40) = .55, p < .0001$, and a negative correlation with the irrelevant sections, $r(40) = -.32, p = .02$. The number of idea units recalled also correlated with the number of global reading strategies displayed by participants (independent variable), $r(40) = .63, p < .0001$.

Discussion

To what degree do participants utilize selective attention and global reading strategies when researching specific content? Overall, the participants paid more attention to the relevant section than the irrelevant sections. This is similar to L1 studies (e.g., Lewis & Mensink, 2012) which showed closer reading of task-relevant segments, but it differs from L1 (Hyönä et al., 2002) and L2 (Prichard & Atkins, 2018) studies in which most participants did not pay selective attention to the main points mentioned in topic sentences for a summary task. The obvious organization of the text in the current study, where task-relevant and irrelevant information was provided in totally different sections signaled by section headings, seemingly made it much easier for participants to distinguish relevant and irrelevant information.

While most participants focused more on the relevant section, the results revealed that most initially read the entire text even though it should have been clear that most of it was irrelevant to the task. Many participants did read the table of contents, but they did not do anything strategic immediately afterwards; only one navigated to read the relevant middle section first. The other participants began to read the first irrelevant section. In other words, they tended not to use the search reading strategy (Urquhart & Weir, 1998). However, most did focus on the relevant section and re-read it, suggesting that they were able to maintain goal awareness.

Figure 1 highlights the quantitative data. After two minutes of reading, the heatmap shows that the focus was still almost exclusively on the first section and not on the relevant section. This confirms that participants tended to read the text linearly initially, not utilizing search reading strategies. By the end of the reading task, the heatmap confirms relatively more focus on the relevant section, yet much more attention than necessary on the irrelevant sections.

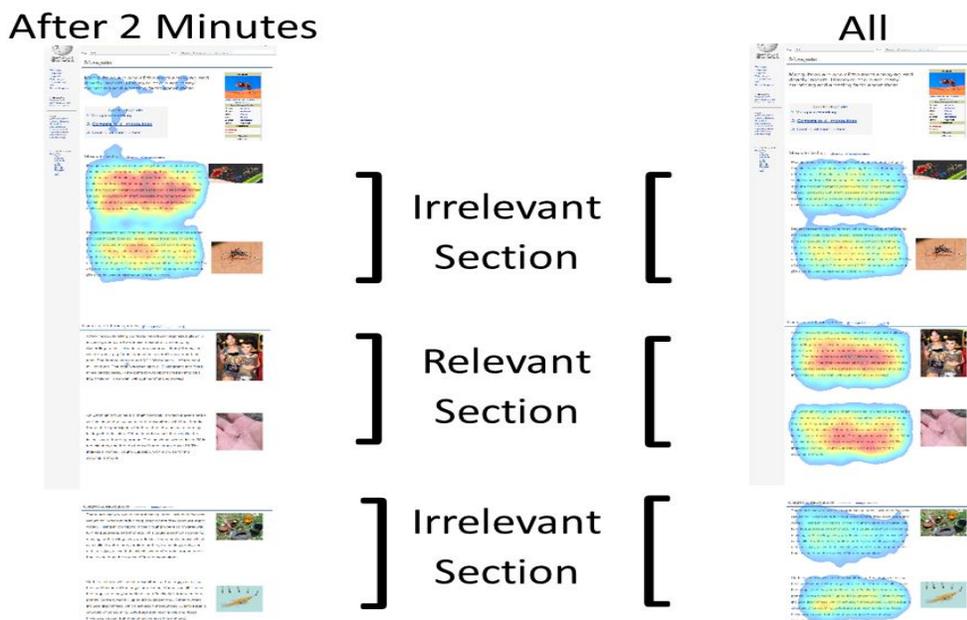


Figure 1. Heatmaps highlighting where participants fixated most, after two minutes and at the end of the task.

In sum, while not without limitations (discussed below), this experiment provided clear data highlighting exactly how learners read given a specific text and task. Considering other research, the results suggested that Japanese university-aged learners of English could benefit from strategy competence training, especially on search reading.

Does selective attention and global reading strategies use predict the participants' ability to recall task-relevant content? The data showed clear evidence that selective attention and related reading strategies led to success on the task. These results provide support for previous survey-based studies, which have suggested that more successful readers tend to more frequently utilize global strategies, including selective attention (e.g., Zhang & Wu, 2009). Higher protocol scores correlated with both the fixation duration data and the number of global strategies observed. This is similar to previous L1 (Hyönä et al., 2002) and L2 (Prichard & Atkins, 2018) eye tracking research, which has shown that learners who pay selective attention to main points performed better on the summary task.

Theoretically, compared to simply re-reading relevant passages after reading the whole text, search reading strategies would be even more effective. This is because readers skipping over irrelevant text would reach optimal cognitive efficiency by not exhausting working memory on irrelevant passages (McCrudden et al., 2011). However, since only one participant in this study used search reading strategies, further research is needed.

Limitations. The experiment had limitations that should be considered. First, while much more authentic than a survey, the task was still somewhat artificial. Note-taking was not allowed because this could have affected the eye tracking. Therefore, the participants needed to store and recall information, which can contribute to cognitive load. Working and short-term memory were potentially influential variables not controlled for in the experiment.

Second, the task-relevant section did not vary among participants. It is possible that there were differences in the saliency or linguistic difficulty between the various sections. However, this was not considered a major limitation because significant efforts were taken to control the content and language of the different sections. Moreover, data collected previously suggested there was little difference in how a similar population read the different sections for general comprehension. Nevertheless, it would have been preferable if the text-relevant section had varied.

Experiment 2

The second study aimed to determine the effect of strategy training on learners' reading strategies and task performance.

Methods

Participants. Twenty-six participants from the same university and faculties as experiment one consented to take both tests. They were taking the lead authors' academic reading and writing course (a two-hour course once a week for 16 weeks), a university requirement. The participants' mean TOEIC score was 568.46 ($SD = 34.38$) suggesting roughly intermediate to high-intermediate proficiency.

Procedures and the intervention. In the first two weeks of the term, the participants signed up to come to the researcher's office. They took the pretest (mosquito text) as described above. During these weeks, reading was not covered in the class. Instruction revolved around preparations for the first essay assignment, a collaborative research paper with five English sources.

Reading strategy training took place in the third through fifth lessons. The students read articles on various social and environmental issues, and the learners needed to identify and underline relevant causes and solutions to practice selective attention. To encourage strategic reading, the students first needed to preview the text to identify which sections contained information relevant to the task. The students compared their findings in small groups after previewing, and then the instructor highlighted the relevant sections on the projector while explaining the importance of subject headings and topic sentences. After reading, the students compared the relevant points they marked in the text with their group and discussed any differences. The instructor then showed his marked text on the projector and asked the learners to compare and reflect. Finally, the learners paraphrased the marked sections in writing and discussed the content in groups.

Lessons six through eight focused on writing skills, and the students researched and wrote their essays outside of class.

Lessons nine through 11 again involved reading instruction. The classes were similar to the previous reading-focused lessons. However, as their second essays concerned researching the advantages and disadvantages of a controversial topic (with six English sources), the training focused on finding relevant pros and cons to various issues. The texts distributed in class had task-irrelevant content to encourage selective attention.

On the 12th lesson, the class met in the computer lab for a lesson on researching online. The instructor reviewed tips for researching on the internet, including quickly identifying task-relevant passages online. Then the students did a web search activity to find answers to trivia questions as quickly as possible.

Writing skills were the focus of the 13th through 16th lessons. Participants were asked to sign up for the posttest in the last week. The test procedures were identical to those described in the pretest, but the second text was used.

Overall, the intervention included 14 hours of in-class reading instruction (practice, collaboration, instructor guidance, and reflection) and task-based assignments out of class (two research essays with English sources).

Analyses. The participants' pre- and posttest data were analyzed through paired *t* tests. As in Experiment 1, the data compared included:

- the ratio of the total fixation duration on the relevant versus irrelevant sections
- the global reading strategies coded through the screencast
- the post-task recall score

Cohen's *d* was used to measure effect size.

Results

Reading behavior. The total eye fixation duration data on the three sections of each text showed that the participants read much differently on the posttest than on the pretest (see Table 3). Compared to the pretest, the posttest total fixation duration on the irrelevant sections was significantly less, including section one, $t(25) = 5.94$, $p < .001$, $d = 1.74$, and section three, $t(25) = 4.80$, $p < .001$, $d = 1.40$. However, participants did not fixate longer on the relevant section in the posttest than they did on the pretest, $t(25) = .16$, $p = .88$. Overall, they spent less time reading on the posttest ($M = 400.35$ seconds, $SD = 133.44$) than on the pretest ($M = 486.23$ seconds, $SD = 129.68$), a significant difference, $t(25) = 3.02$, $p = .006$, $d = .65$.

Table 3. *Total eye fixation duration (in seconds) on each section*

	Pretest			Posttest		
	Section 1 (irrelevant)	Section 2 (relevant)	Section 3 (irrelevant)	Section 1 (irrelevant)	Section 2 (relevant)	Section 3 (irrelevant)
<i>M</i>	93.75	145.42	82.19	35.73	148.46	33.09
<i>SD</i>	33.31	69.40	40.41	33.35	75.96	28.89

The screencast of the eye movement map further confirmed the fixation duration data. On the posttest, five of the participants (19%) re-read the relevant section and did not read the irrelevant sections at all. This reading behavior was not exhibited in the pretest. On the other hand, in the pretest, 15 participants (58%) first read the whole text linearly without re-reading or skipping over any sections, and in the posttest only seven participants (27%) read in this way. In both tests, three participants who first read linearly did later return to re-read the relevant section. Therefore, 12 of the participants (46%) did not show any strategic behavior in the pretest, compared to just four (15%) in the posttest.

The global reading strategies displayed in the screencast further revealed that the learners were more strategic in the posttest (see Table 4).

Table 4. *The number of global strategies identified in the screencast*

	Previewed table of contents	Scrolled down to preview	Clicked link to section 2	Scrolled to section 2	Stopped reading section 1	Re-read section 2 before 3	Did not read section 3	Stopped reading section 3	Re-read section 2 after 3
Pretest	12	2	0	1	0	4	1	2	11
Posttest	20	3	10	7	2	4	5	3	13

Although nearly half of the participants in the pretest (46%) viewed the table of contents, almost none did anything strategic afterwards; only one participant skipped over the first section in the pretest. In contrast, 20 participants (77%) in the posttest read the table of contents, and 19 (73%) skipped or stopped reading the first section. Ten participants clicked on the link in the contents to jump to the relevant section, and seven scrolled to this section.

Statistical analysis comparing first fixation times on the relevant section further confirmed that participants viewed the relevant section much earlier on the posttest. The first fixation on the relevant section was after a mean of 92.17 seconds ($SD = 52.60$) in the pretest, but in the posttest the mean was 28.04 seconds ($SD = 32.61$), a significant difference, $t(25) = 5.34$, $p < .001$, $d = 1.47$.

Task performance. The participants recalled more task-relevant details on the posttest ($M = 12.27$, $SD = 4.54$) compared to the pretest ($M = 7.35$, $SD = 4.86$), a significant difference, $t(25) = 4.55$, $p < .001$, $d = 1.05$. Especially considering the reading time tended to be shorter on the posttest, the participants' read much more efficiently on the second test. The participants recalled a mean

of 1.46 idea units per 100 seconds reading on the pretest ($SD = .89$), compared to 3.40 on the posttest ($SD = 1.77$), a significant difference, $t(25) = 5.18$, $p < .001$, $d = 1.38$.

Discussion

Does strategy training increase participants' selective attention and global reading strategies?

The results of the second experiment suggested that the intervention was effective. The course, which included guided strategic reading activities and research projects, seemingly led the participants to display more strategic competency. After the intervention, the fixation duration data showed less focus on the irrelevant sections, as is highlighted by Figure 2.

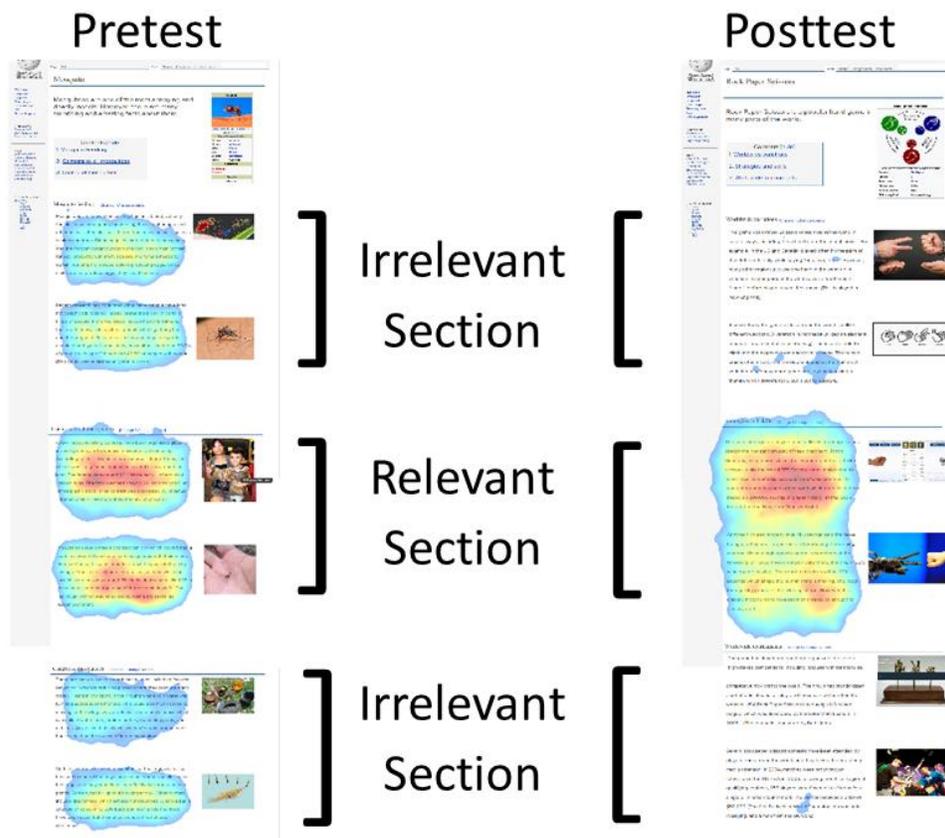


Figure 2. Heatmaps highlighting where participants fixated most in the pre- and posttest.

Compared to the pretest, participants also much more frequently utilized search reading strategies in the posttest by navigating to read the relevant section immediately after previewing. Student A in Figure 3 was an example of a participant who clicked on the link in the contents to jump to the relevant section. Student B was an example of a participant who scrolled to this section. She scrolled down to preview the whole text and then returned to the relevant section.

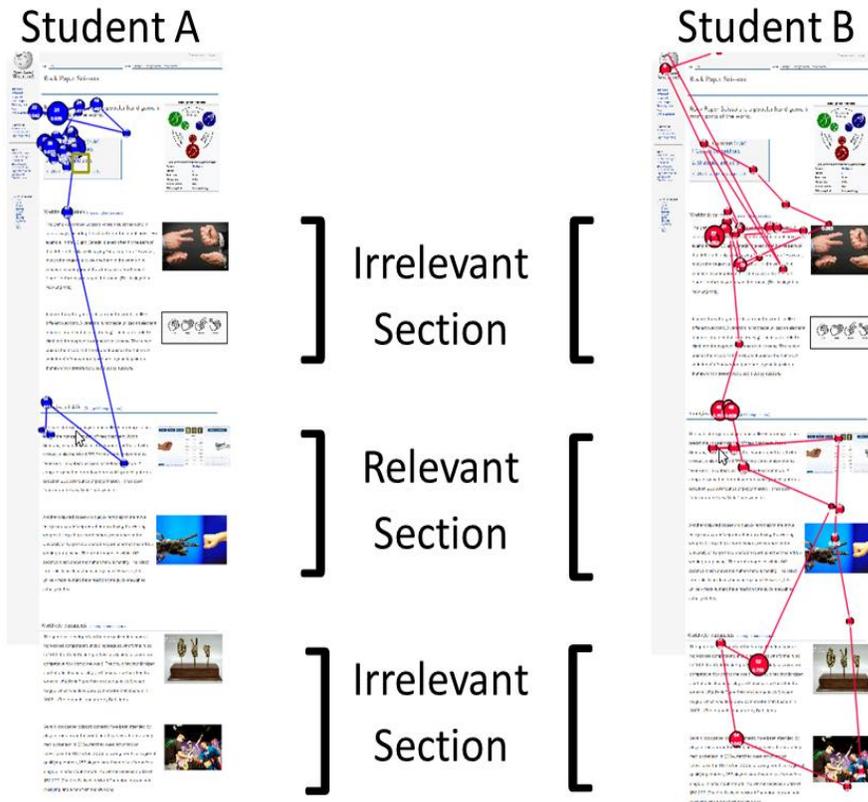


Figure 3. Fixations maps of two students before they began to linearly read a section. The small yellow box of Student A represents a followed link.

The difference in previewing and the reading strategies is highlighted by screenshots of the participants' heatmap after 20 seconds on the task (see Figure 4). The pretest heatmap shows that the focus was on the beginning of the article, as most participants began to read linearly. In contrast, the posttest heatmap reveals more focus on the table of contents and already some focus on the relevant section, as many participants navigated to this section immediately after previewing.

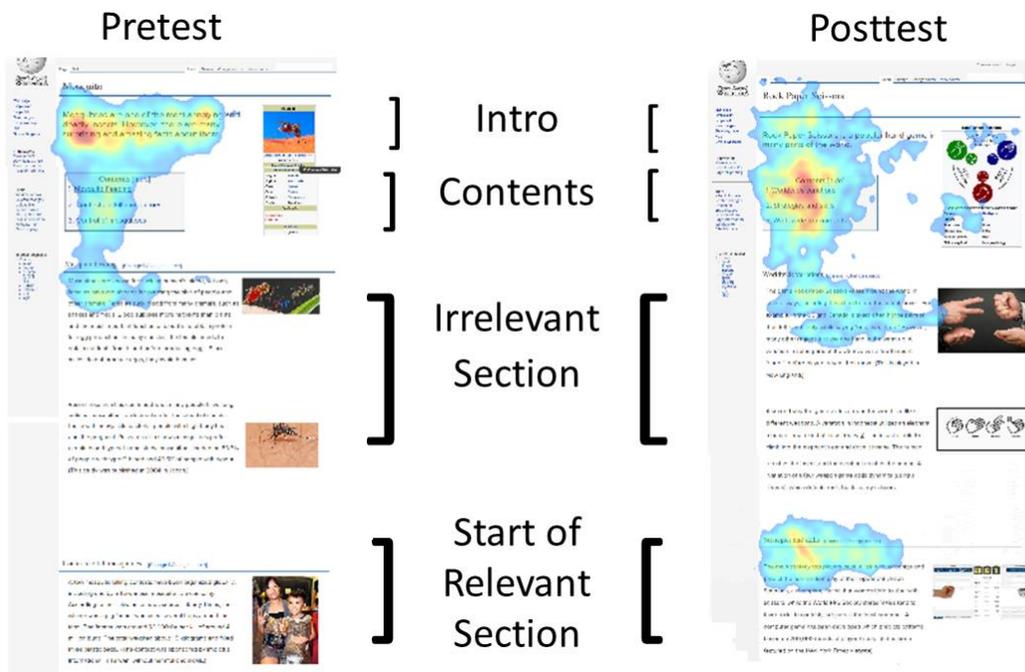


Figure 4. Heatmaps highlighting where participants fixated most after 20 seconds.

Does strategy training improve participants' ability to recall task-relevant content? The participants not only read more strategically in the posttest, they also performed better on the post-reading activity, recalling significantly more task-relevant details despite spending less time reading. Even though the participants spent roughly the same amount of time reading the relevant section on both tests, spending more time reading irrelevant sections on the pretest could have prevented the participants from effectively storing or recalling relevant details. This follows research showing that a lack of selective attention deters cognitive efficiency (McCrudden, et al., 2011).

Pedagogical implications. Along with previous studies (e.g., Wang, 2009), the results offer support for instruction aiming to raise learners' metacognitive skills. This may involve using task-based reading assignments, including irrelevant content in class texts (which should be skimmed or skipped over), and explicit strategy training. Many reading textbooks include pre-reading activities, and this may be enough to encourage strategic reading during the lesson. However, this may not lead readers to develop strategic reading habits as effective strategy training requires plentiful awareness activities, explicit practice, and reflection (e.g., O'Malley & Chamot, 1990). This may be especially the case for L2 learners, like those in this study, who have for years experienced language instruction in which they were expected to read the entire text in a linear fashion. How explicit and extensive the training needs to be to lead to significant results was not examined in this study, warranting further research.

Limitations. Caution is warranted before claiming the intervention was a success. First, the participant size was relatively small, as many potential participants were not available to take the posttest. Second, there was no control group as a suitable comparison group was not available. It could be possible that a control group would also have made posttest gains without explicit

strategy training. Familiarity with the research task and increased proficiency developed over the term could have played a factor. In addition, the texts used in the pretest and posttest did not vary. Although the two texts were carefully piloted and the language and content were tightly controlled, there could have been factors unaccounted for. Finally, though the posttest was two weeks after the in-class training, there was no delayed posttest. Therefore, it is unclear if the gains observed were lasting. Future research should address these concerns.

Summary and Concluding Discussion

This study examined the selective attention and other related global strategies of Japanese English learners who needed to research a specific topic. Given a highly organized webpage containing mostly irrelevant information, the first experiment showed that most participants did tend to pay more attention to the relevant section. However, very few displayed related global strategies, such as skipping over the irrelevant sections. The results showed that global reading strategies correlated with task performance; those who paid little or no selective attention tended to have more difficulty with the task. Overall, the results of the first experiment suggested that the target population may benefit from reading strategy training.

The second experiment examined the efficacy of such instruction; in the intervention, learners were guided through the process of strategic reading and they completed two research projects. The posttest results suggested that the learners paid significantly less attention to task-irrelevant passages and they more frequently displayed global reading strategies, such as search reading. Moreover, despite spending less time reading, the participants improved their score on their post-reading task. Although not without limitations, the results further support the findings in previous studies, suggesting the benefits of building metacognitive awareness.

Suggestions for Follow-up Research

Multiple variables potentially affecting strategy usage, task success, and the impact of the intervention were not examined in this study. Follow-up studies could examine their effect.

First, participant variables could be explored. Certain cultures tend to report different levels of L2 global reading strategies (e.g., Taki, 2015), but eye tracking and page navigation research has not confirmed this. Research is needed among other L2 populations to determine if the results shown here are applicable to them. Since Japanese learners may lack L2 metacognitive reading strategies (Sakurai, 2015), learners from other backgrounds may be more likely to demonstrate selective attention, perhaps meaning strategy training is unnecessary. Moreover, survey research has suggested that higher proficiency readers report more metacognitive strategy usage related to selective attention (Zhang & Seepho, 2013), but the learners' proficiency in this study did not vary enough to examine the effect of proficiency.

Moreover, text variables also likely affect the selective attention (Peshkam et al., 2011) and could be examined in future studies. The texts used in this study were very organized, but texts with less clear organization or passages containing seductive details could lead to very different results. Text length and difficulty could also be examined. Longer texts could theoretically

increase the use and efficacy of search reading strategies. Linguistically challenging texts could make search reading more difficult to achieve since learners may have trouble determining if content is relevant or not. On the other hand, search reading strategies may be even more effective with difficult texts since readers exhaust their working memory by reading challenging, but irrelevant passages (McCrudden et al., 2011).

Finally, task variables could be explored. Shortening the reading time could lead to increased use and efficacy of search reading strategies. In contrast, if participants have plentiful time, they may avoid search reading strategies and read the whole text. Allowing note taking also may affect reading strategies and would likely improve task performance.

In conclusion, as was shown in this study, eye tracking and navigation tracking can greatly add to reading strategy research as it reveals learners' strategy usage on a moment-to-moment basis given a specific text and task. However, this preliminary study is only the beginning; future research examining a number of variables could highlight areas for learner improvement and guide reading strategy training, ultimately leading to effective readers.

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