Reading is arguably the most utilized method for acquiring knowledge. Accordingly, reading is a point of emphasis in someone's education since an early age. Yet, it is often taken for granted that readers will absorb what they read. Relative to the mechanics of reading, there is little focus on instructing young readers how to understand the information provided in written form. It seems to be ubiquitously assumed that as children grow and their domain knowledge increases, so does their comprehension. However, if they are unable to fully comprehend what they read, then their domain knowledge may not be increasing at a satisfactory rate.

In other words, students are expected to know the text material without specific guidance on how to learn it, and, hence, are left to discover their own methods to comprehending written text. Highlighting is commonly a part of their solution to improving comprehension, due to its convenience and apparent ease. Trouble arises, however, because students use highlighting as a study aid without any clear instructions or training on how to do so effectively. For example, Dunlosky, Rawson, Marsh, Nathan, and Willingham (2013) suggested that highlighting effectiveness can improve as one's knowledge in a particular domain increases. Therefore, before a subject matter becomes familiar, it could be more difficult to pinpoint the pertinent information that should be highlighted. Proper training on how to identify important ideas within novel content areas could help make highlighting more efficient.

Identifying important information is a skill needed for minimizing the amount of information one is trying to retain and, thus, for optimal learning and understanding to occur. Those individuals who cannot identify the important details that should be highlighted, tend to “over-highlight”, which hinders comprehension (Dunlosky, Rawson, Marsh, Nathan, and Willingham, 2013). Ozcelik, Karakus, Kursun, and Kursat (2009) conducted a study that showed color coding a picture to match relevant material in a text helped to improve comprehension of the material (2009). This is accomplished by making meaningful connections of the visual and written information. Reisberg (2013) further bolstered this argument when he showed that making meaningful connections helps to enhance memory and understanding through relational rehearsal. Thus, making meaningful connections with a particular manner of highlighting should reduce a persons need to over-highlight.

The goal of this study was to find a way that could make highlighting more useful, even in the absence of extensive training. Previous research has supported that active reading can help to improve the use of appropriate highlighting (Gier, Herring, Hudnell, Montoya, & Kreiner, 2010). Therefore, implementing a method of
highlighting that promotes active reading could prove to be beneficial to comprehension. It is feasible to believe that when students take enough time to think about and judge the information as they read it, in order to color code the relevant text, they should then be simultaneously enhancing their comprehension of the material by making meaningful connections through active reading. Furthermore, the highlighted text would then be color-coordinated and organized for a quick and meaningful review of material. Comprehension would be aided by the need to understand to which main topic the text is referring, so that they may assign the correct color. Comprehension would then further be aided through the rehearsal and review of the understood material as it is meaningfully connected to gether. Peterson conducted a study where 65% of participants reported that highlighting serves as a way to improve their encoding and review of material (1991). This would make this method a popular choice among students as it allows for encoding while reading and also organizes material for a meaningful review. Another study showed improved comprehension of color coded material (Oczelik et al., 2009). With these things in mind, it was hypothesized that using a dual color highlighting technique would enhance comprehension more than what occurs with the use of the traditional single color highlighting method. The organization and thought processes used to highlight with dual colors are likely to enhance encoding and review processes, which should lead to better comprehension of the material.

A second hypothesis is that training people to highlight with a dual color method would be more beneficial than training people to highlight with the traditional single color method. Regardless of whether or not dual color highlighting enhances comprehension through enhanced encoding processes, previous research has still shown that the most pertinent information needs to be physically highlighted in order to improve comprehension (Peterson, 1991; Dunlosky, Rawson, Marsh, Nathan, and Willingham., 2013). Therefore, the use of a dual color method, for which a critical analysis of what is read occurs, could lead to a better discrimination method for determining relevance and the need for specific ideas to be highlighted.

**Methods**

**Participants**

The sample consisted of 217 undergraduate students (with 31 excluded from analyses: 28 for not following instructions, four for ineligibility) ages 18 – 47 (M=19, SD=4.23) recruited from introductory psychology and social work courses over the span of three semesters at the Lima campus of the Ohio State University.

**Design and Materials**

We used a 2 x 2 within-subjects design. The independent variables were highlighting condition (with one or two highlighter colors) and article topic (Contribution and Selection).

We used two one-page passages, excerpts from mid-level psychology courses’ textbooks, titling them “Emotional Contributions of the Left and Right Hemispheres” (excerpted from Kalat, 2013, and herein referred to as the “Contribution article”) and “Early and Late Selection” (excerpted from Reisberg, 2013, and herein referred to as the “Selection article”). Yellow and pink highlighters were chosen for participants to highlight the articles. Yellow and pink highlighters were selected because the two colors are unlikely to be confused due to color blindness.

To control for any order effects that might have occurred from article order presentation, half of the participants were presented with the Selection article first and followed by the contribution article. The other half were presented with the Contribution article first and secondly being presented with the Selection article. In addition, we aimed to control for highlighting method order. We manipulated the order of highlighting conditions (either single-color or dual color) for half of the participants used the single-color method to highlight the first article and the dual-color method for the second article. The other half of the participants used the dual-color method for the first article, followed by single-color highlighting the second article. Note that a neutral control group, in which no highlighting was used, although plausible, was not necessary. Previous research has shown that regarding effectiveness, students still choose to highlight (Dunlosky, Rawson, Marsh, Nathan, and Willingham, 2013). If highlighting is ubiquitous, this study intended to contrast two highlighting methods to ascertain if one could enhance comprehension more effectively than the other, such that highlighting training could focus on the most affective method.

Two crossword puzzles were used as filler tasks in the packets. A filler task is to prevent participants from ruminating about what they had just read in order to keep the article’s information within their working or short-term memory storage for quicker retrieval. Participants were informed that their performance would earn them extra credit points and their performance would earn them extra credit points per correct answer for a maximum of four points. The extra credit points were incentives so that participants would perform using their best effort as if they were actually studying for a real exam.

Each packet contained a consent form to be signed before starting the study. The packets would either ask the participants to highlight any important information with the yellow highlighter or highlight any important information involving one topic in yellow and important information involving another topic in pink. For the dual color, where both yellow and pink highlighters were used, the participants were free to choose which two topics they judged to be important. This was to ensure that their judgment on what to highlight in the articles was generalizable to their actual studying method to comprehend the material. Next, the packets contained information that participants were advised to complete as much of a crossword puzzle as they could within the allotted time.

A ten-question quiz followed and participants were instructed to complete the quiz without flipping back and forth between pages to ensure that their performance would be solely based on the highlighting method on the given level. After completing the quiz the participants were advised that their performance would determine the number of extra credit points they would receive. Once finished, the participants began the same process over again with a new article, crossword puzzle, and quiz questions. The packets were randomized among the participants. The two texts and highlighting colors were alternated to identify any order effects that might have occurred. Yellow and pink highlighters were used and two different crossword puzzles were alternated within the packets. The packets were randomized among the participants. The two texts and highlighting conditions were alternated to identify any order effects that might have occurred.

There were four conditions; (1) Selection article with single-color highlighting first and the Contribution article with single-color highlighting second, (2) Selection article with single-color highlighting first and the Contribution article with dual-color highlighting second, (3) Contribution article with single-color highlighting first and the Selection article with dual-color highlighting second, and (4) Contribution article with dual-color highlighting first and the Selection article with single-color highlighting second.

**Procedures**

Each participant was instructed to read the consent form, which informed them that their participation was voluntary and that their performance would determine the amount of extra credit points they would receive, should they agreed to participate. Participants began the study by highlighting one of two one-page passages that were drawn from mid-level psychology course textbooks for 8 minutes. They highlighted either using a dual-color technique or a single-color technique. In the dual-color highlighting condition, participants highlighted relevant information that fell under one main idea in yellow, and then used the pink color to highlight relevant information that related to a separate idea in the text. In the single-color highlighting condition, participants used only the yellow highlighter to identify any important information in the text.

Participants then worked on one of two crossword puzzles for 3 minutes. The allotted time that the participants had to work on the crossword puzzle was chosen so that the participants would not continue to rehearse the information they previously highlighted and reviewed in the articles, which would enhance memory consolidation of the information. After completing the quiz the participants were advised that their performance would determine the number of extra credit points they would receive. Once finished, the participants began the same process over again with a new article, crossword puzzle, and quiz questions. The packets were randomized among the participants. The two texts and highlighting colors were alternated to identify any order effects that might have occurred. Yellow and pink highlighters were used and two different crossword puzzles were alternated within the packets. The packets were randomized among the participants. The two texts and highlighting conditions were alternated to identify any order effects that might have occurred.

Next, participants read a second text highlighting in the opposite manner as they had for the first text and repeated the same procedures of highlighting, crossword puzzle, reviewing, crossword puzzle, and finally completing the quiz. At the end of the study participants were debriefed and completed a short questionnaire pertaining to their experience and
thoughts about the study.

Measures

Comprehension performance was measured by the change between the single-color highlighting condition and the dual-color highlighting condition. The number of questions the participant correctly answered for the single-color highlighting condition were subtracted from the number of questions the participant correctly answered for the dual-color highlighting condition. This new value became the comprehension performance score for each participant.

According to Ozcelik et al. (2009) color-coding illustrations of the nervous system and color-coding information in a text that related specifically to that illustration facilitated memory improvement. Moreover, Peterson (1991) found that comprehension levels improved as long as the information being highlighted directly relates to the comprehension questions being asked. Assuming that using two colors to highlight would facilitate the ease of distinguishing between two separate ideas in a text, comprehension levels should have improved. Highlighting efficiency was measured by the number of words each participant highlighted in either text contrasted to our ideal rubric, assuming that the rubric was useful at all for the participants and found that high-lighters (t(21.892)=-1.357, p=0.906 (M=-0.813)). The two texts, however, were not of the same difficulty to the participants. Text 1, the Contribution article, was found to be the more difficult text of the two, based on the mean difference in quiz scores between dual-color and single-color highlighting. Across participants, we found no evidence to support that the difference between dual-color and single-color highlighting was greater than zero (M=0.043, z=0.254, p=0.600).

We used a z-test to determine whether highlighting in two colors was better than in one color, based on the mean difference in quiz scores between dual-color and single-color highlighting. Participants performed below the average with Text 2, the Contribution article, was found to be the more difficult text. However, both texts are considered more difficult text. Therefore, the level of difficulty of the Contribution article was the main contributor to the mean score differences, rather than the method of highlighting.

The order the articles were presented in the pack-

ets did not show any significant differences in performance among the participants, based on a within-sub-
jects ANOVA (F(1,185)=0.170, p=0.679). Likewise, the highlight order did not do to show any significant differences in performance (F(1,185)=0.635, P=0.426).

We used a t-test to determine whether highlighting was useful at all for the participants and found that highlighting efficiency correlated positively with the quiz scores from both conditions for Text 1 ((t(94) = 1.723, p = 0.044, r single = 0.175); (t(88) = 1.833, p = 0.035, r dual = 0.192)), but not for Text 2. Therefore, highlighting was useful to improve comprehension scores only on the more difficult text. Highlighting efficiency was measured to investigate whether well someone highlights effects their performance. Our analyses show that among good highlighters using two colors is no better than using one color (t(25.097)=-1.885, p=0.965 (M=-1.250)). Similarly, highlighting in two colors is no better than in one color for Text 1 among poor high-

lighters (t(21.892)=-1.357, p=0.906 (M=-0.813)).

Discussion

Highlighting is one of the key tools students use (Dunlosky, Rawson, Marsh, Nathan, and Willingham, 2013). Based on the advantages of processing information beyond a superficial level to retention, we hypothesized that dual-color highlighting would improve comprehension levels beyond that of single-color high-

lighting. We found, however, that highlighting with two colors was no better than highlighting with one color. According to Ozcelik et al. (2009) and Peterson (1991), the rubric, a continuous scale with a 1.0 score indicating perfect performance, emphasized the material that should be highlighted (1) to answer the comprehension questions correctly and (2) to discern between the two main topics of each pas-
sage articles.

This rubric was used as a basis for comparing the number of words highlighted in the article to what should be highlighted in order to answer the compre-

hension questions correctly. The rubric also empha-
sized the material that should be highlighted to discern between the two main topics of the articles. The rubric and the comprehension questions were designed by the first author, who was familiar with the content area, and then revised by the supervising professor, who is an expert in the content area. Therefore, the level of impor-
tance of the highlighted text within the rubric and the corresponding comprehension questions are believed to be relevant items to the understanding of the content, within the article text. Each quiz question correspond-
ed to one or several lines of information in the text. When contrasted against our rubric, words highlight-
ed in the article with the correct color and within what should be highlighted were counted as +1, +2, et cetera. Words that were either highlighted in the wrong color or outside what should be highlighted were counted as -1, -2, and so on until the entire article was analyzed. A participant’s highlighting efficiency performance was based on the sum of correct and incorrect words from the participants’ article divided by the number of words that should be highlighted in our rubric. This produced a score below, at, or above 1.0 on a continuous scale.

Results

According to Dunlosky, Rawson, Marsh, Nathan, and Willingham, (2013) reported students commonly rely on highlighters (t(21.892)=-1.357, p=0.906 (M=-0.813)). The order the articles were presented in the pack-

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lighting. We found, however, that highlighting with two colors was no better than highlighting with one color. According to Peterson (1991) and Dunlosky, Rawson, Marsh, Nathan, and Willingham, (2013), we found that highlighting was useful for improving comprehen-
sion scores, as long as the text was rel-
avely difficult and specific relevant information was highlighted. Each text consisted of the same length and the amount of lines that needed to be highlighted in order to answer the questions on our test quiz cor-
rectly. Text 1 (Contribution article) was found to be the more difficult text. However, both texts are considered to be relatively difficult, as the information presented would have been novel information to the majority of entry level psychology students, as this particular ma-
terial is part of the upper level psychology courses. In either highlighting condition, participants consistent-
ly performed poorly on the quiz questions for Text 1(Contribution article) than they had for Text 2 (Se-
lection article). As a follow-up, we hypothesized that good highlighters would outperform poor highlighters in the dual-color highlighting condition. Regardless of highlighting efficiency, the data showed that dual-color highlighting was no better than single-color highlight-

ing. Considering highlighting efficiency, training to highlight with two colors would be no more beneficial than training to highlight with a single color.

In order to revise the uncertain highlighting meth-
ods students are acquiring, studies such as this are vital for the improvement of the technique and for the stu-
dents’ enhanced performance. Highlighting is critical beyond the years of education. It is a method that more than students trust, and creating a better understand-
ing of the study method will enhance our knowledge of what may or may not improve comprehension levels. We conclude that dual-color highlighting is not necessary for improved comprehension, but it may be preferred by some individuals. Improved highlighting efficiency would be a valuable interest among students given that Dunlosky, Rawson, Marsh, Nathan, and Willingham (2013) reported students commonly rely on highlight-

ing as a study method. The focus, however, should be on the common single-color method of highlighting.

This study has added to the current evidence sug-
esting that comprehension improves for material that is physically highlighted within a text (Peterson; 1991; Dunlosky, Rawson, Marsh, Nathan, and Willingham, 2013). Therefore, future research should combine the ideas that highlighting specific items is useful for com-
prehension and the preference that students have for highlighting material while learning (Dunlosky, Raw-
son, Marsh, Nathan, and Willingham, 2013) to develop and test a training program that focuses on highlighting efficiency. Such research would be a great contribution to education by increasing the acquisition of knowledge.
In several paradigms, then, it’s clear that people are oblivious to stimuli directly in front of their eyes—whether the stimuli are simple displays on a computer screen, photographs, movies, or real-life events…there are two ways we might think about these results. These studies may reveal genuine limits on perception, so that participants literally don’t see those stimuli; or these studies may reveal limits on attention, so that stimuli but are nevertheless influenced by them [people will make decisions without seeing them; or these studies may look at perception, so that participants literally don’t see these stimuli; or these studies may look at attention, so that only the attended input is remembered. It turns out that these hypotheses capture parts of the truth. On the one hand, [there are many previous cases where] people seem genuinely unaware of the stimuli, so that the selection is done, but then the selection is done, so that only the attended input is remembered. According to the early selection hypothesis, when someone reaches an intersection and increases ________

1. According to the late selection hypothesis, when someone reaches an intersection, she most likely…

A. An inactive right hemisphere in the prefrontal cortex.
B. Processes; ignores other stimuli.
C. Has some damage in her left hemisphere.
D. Right Amygdala

A. Behavioral Inhibition System (BIS)
B. Behavioral Activation System (BAS)
C. Right; Action
D. A relatively hyperactive left hemisphere.

6. According to the late selection hypothesis, when someone reaches an intersection, she most likely…

A. Right;  Attention
B. Unconsciously processing all stimuli before focusing their attention.
C. Unconsciously process all stimuli before focusing attention.
D. A relatively hyperactive left hemisphere.

C. Right; Action

A. Behavioral Inhibition System (BIS)
B. Behavioral Activation System (BAS)
C. Right Amygdala
D. Left Amygdala

8. According to the late selection hypothesis, when someone reaches an intersection, she most likely…

A. Right hemisphere is inactivated, and the left is relatively hyperactive, what is a likely behavior?
B. Fighting
C. Sleeping
D. A relatively hyperactive left hemisphere.

2. According to the information in the article, paying attention can…

A. Unconsciously determine what to pay attention to and what to ignore immediately.
B. Unconsciously processing all stimuli before focusing their attention.
C. Unconsciously process all stimuli before focusing attention.
D. Seen the player get injured but forgotten about it already.

9. Carter is 16 years old. He stays in his room often. At the dinner table, he rarely has…

A. Behavioral Activation System (BAS)
B. Right temporal damage.
C. Left Amygdala
D. Right Amygdala

7. Carter is watching a horror flick when he hears a noise outside. He felt frightened. She most likely has…

A. Right;  Attention
B. Right temporal damage.
C. Unattended; Ignoring
D. A relatively hyperactive left hemisphere.

4. According to the early selection hypothesis, when someone reaches an intersection, she most likely…

A. Right hemisphere appears to be more responsive to emotional stimuli than the left.
B. Right amygdala more than the left (Sander & Scheich, 2001). When people look at faces, directing their attention to the emotional expressions increases the activity in the right temporal parietal cortex (Narumoto, Okada, Sado, Fujii, & Noda, 2001). People with damage to the right temporal cortex have trouble identifying other people’s emotional expressions or even saying whether two people were expressing the same emotion or different ones (H. Q. Rosen & al., 2002).

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