Visual Input Enhancement, Attention, Grammar Learning, & Reading Comprehension: An Eye Movement Study*

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Two experiments were conducted to examine the effects of visual input enhancement (VIE) of target forms and deliberate attention on grammar learning and reading comprehension of Korean high school students. In Experiment 1, eighty-eight students read one of the three experimental texts: (i) BT (baseline text), (ii) VIE (BT with the target forms visually enhanced), and (iii) VIE-Attention (VIE with explicit instruction asking students to pay deliberate attention to both the target forms and reading comprehension). After reading, the students responded to grammar and reading comprehension tests. The results showed that only VIE-Attention promoted grammar learning, while both the VIE and VIE-Attention significantly impaired reading comprehension. In Experiment 2, an eye tracker was used in order to further probe the effects of VIE and deliberate attention. The results revealed that the VIE and VIE-Attention groups fixated longer and more often than those in the BT group and that the VIE and VIE-Attention groups performed better in the grammar test and poorer on the reading comprehension test than the BT group. The present study makes significant contributions to the VIE literature since it provides the first eye movement data elucidating the effects of VIE.

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** Sungmook Choi: corresponding author
I. INTRODUCTION

Many English textbooks employ diverse techniques to draw those learners’ attention to vital grammatical elements (e.g., passive form, to-infinitives) for the major purpose of augmenting grammatical competence of second or foreign language (L2) learners. The techniques include **boldfacing**, **underlining**, **color coding**, **italicizing**, and **CAPITALIZING** which have been labeled under the umbrella term of visual input enhancement (VIE) (Berne, 2000; Carroll & Swain, 1993; Dekeyser, 1995; Lee, 2007; Schmidt, 2001; Sharwood Smith, 1993; VanPatten & Cadierno, 1993).

This established use of VIE is grounded on the theories that deliberate attention to target forms is a necessary condition for learning target forms (e.g., Lee, 2007; Leow, 1999; Long, 1991; Rosa & O’Neill, 1999; Santis, 2008; Schmidt, 2001; Sharwood Smith, 1993; Simard, 2009; VanPatten, 1990). For instance, the Noticing Hypothesis proposed by Schmidt (1990, 2001) posits that unless language input is consciously registered, that is, noticed, input is not likely to be acquired. In other words, learners acquire new grammatical elements when they pay deliberate attention to them and do not acquire the elements when they pay little attention to the grammatical structure. Given the perceptual salience induced by VIE, it is reasonable to assume that learners pay additional attention to the visually enhanced target linguistic forms and learn better than when the target forms are not visually enhanced.

Interestingly, however, review of previous studies indicated that the findings are mixed: (i) positive effects (e.g., Doughty, 1991; Jourdenais, Ota, Stauffer, Boyson, & Doughty, 1995; Lee, 2007; Leeman, Arteagoitia, Freedman, & Doughty 1995; Santis, 2008; Shook, 1994, 1999) and (ii) no positive effects (e.g., Izumi, 2002; Leow, 1997, 2001; Leow, Egi, Nuevo, & Tsai, 2003; Overstreet, 1998; White, 1998; Wong, 2003) on grammar learning. In addition to the inconsistent findings, review of previous studies also showed that VIE may yield negative effects on reading comprehension (Lee, 2007; Overstreet, 1998). Concerning the detrimental effects of VIE on reading comprehension, Lee (2007) conjectured that learners “could have been distracted by the visual elements while exposed to the enhanced texts” (p. 107). Unfortunately, however, Lee’s (2007) hypothesis has never been investigated systematically.

Therefore, the present study was designed to address such issues in two experiments. Specifically, in Experiment 1, we examined the effects of VIE and deliberate attention in learning target forms (gerund and to-infinitives) and reading comprehension. In Experiment 2, we tested Lee’s (2007) hypothesis by using an eye tracker which can record moment-to-moment cognitive processes (Chaffin, Morris, & Seely, 2001) while the students in the present study read three different types of texts: (i) baseline text (BT), (ii) VIE (baseline text with target grammar visually enhanced with boldface), and (iii) VIE-
Attention (VIE with explicit instruction which demands the students’ deliberate attention on both the grammar and reading comprehension). By using the eye tracker, we could determine how much attention learners pay attention to the enhanced or non-enhanced target forms and how attention allocation patterns were associated with learning of target grammar and reading comprehension. The results of this study have a great bearing on teaching and learning grammar in context (i.e., focus on form: Long, 1991) for L2 learners of English.

II. LITERATURE REVIEW

1. Operationalizing VIE

Visual input enhancement (VIE), also identified as textual enhancement, is one of the pedagogical interventions that have been studied about its effectiveness by a growing number of researchers (for review, see Lee & Huang, 2008). As stated above, VIE embraces various typographical techniques such as **boldfacing**, **underlining**, color coding, **italicizing**, and **CAPITALIZING**. These techniques are intended to make the target grammar more perceptible to L2 learners, which in turn would facilitate grammar acquisition in meaningful contexts (Lee, 2007; Santis, 2008). Among these visual cues, we used boldfacing and underlining because they are the most practical and popular techniques employed by textbook designers and English teachers.

2. VIE and Grammar Learning

As illustrated in Table 1, the effects of VIE on grammar learning is inconclusive. Although several researchers reported that VIE facilitated grammar acquisition (Doughty, 1991; Shook, 1994; Jourdenais et al., 1995; Lee, 2007; Santis, 2008), other researchers found no positive effects of VIE (Izumi, 2002; Leow, 1997, 2001; Leow et al., 2003; Overstreet, 1998; White, 1998; Wong, 2003).

Doughty (1991) was among the first researchers who examined the role of VIE in grammar learning. Participants were twenty ESL learners who were exposed to the enhanced target grammar (relative clause). The results revealed positive effects of VIE on the acquisition of English relativization. However, the findings of Doughty (1991) should be interpreted with caution and taken as indirect evidence of VIE because the treatment included more than simple provision of VIE by including detailed analysis of the target structures, as noted by Cho (2002).

Unlike Doughty (1991), Shook (1994) provided direct evidence on the positive effects
of VIE. Participants were one hundred twenty-five English-speaking Spanish learners, while the target forms were present perfect and relative pronouns enhanced with bold and enlarged letters. The results showed that learners in the VIE condition outperformed the control group in all measures (i.e., written production and recognition tasks). Likewise, Jourdenais et al. (1995) found a positive effect of VIE (bold, shadowed, underlined, enlarged fonts) on learning of Spanish preterit and imperfect verbs. The subjects were ten English-speaking Spanish adult learners, and the assessment data were collected through think-aloud protocols and picture-based written narration. The findings revealed that students exposed to VIE significantly reported more episodes containing the target features than their counterparts.

Lee (2007) also found positive effects of VIE on Korean EFL students’ learning of passive form. Unlike previous studies, Lee provided the learners with lengthy exposure time to assist them to learn the target forms. Two hundred fifty-nine high school students were randomly assigned into one of the four treatment conditions: (i) enhanced/familiar text, (ii) unenhanced/familiar text, (iii) enhanced/unfamiliar text, and (iv) unenhanced/unfamiliar text. Form correction test scores were calculated to investigate the effects of treatment. The results revealed that VIE facilitated the students’ target form learning. Recently, Santis (2008) explored the effects of VIE with Haitian Creole speakers of English learners, who had limited or no formal education. Fifteen subjects were randomly assigned one of three learning conditions: enlargement and red fonts; enlargement and boldfacing; and control conditions. The target form was verbal inflection -s. The participants were instructed to read a passage out loud and complete grammar judgment and picture description tasks to assess the effects of VIE. The results revealed that VIE facilitated the learners’ awareness of the target form in reading.

In contrast, several researchers reported no positive effects of VIE (e.g., Izumi, 2002; White, 1998). For instance, White (1998) explored the effects of VIE on learning possessive determiners in English over a course of five months. The participants were French-speaking L2 English learners in a junior high school. The assessment data were collected through passage-correction, multiple-choice, and oral picture-description tasks. The results reported that the students appeared to show more frequent use of the target form, but they failed to demonstrate the ability to use the target form correctly. Similarly, Izumi (2002) also reported that VIE did yield positive effects on learning relative clause in English. The participants were in adult ESL classes from diverse language backgrounds. Various assessment measures, including sentence combination, picture-cued sentence completion, interpretation, and grammaticality judgment tasks, were used. The findings showed that the students in the VIE condition demonstrated noticing of the target form, but failed to acquire the target form correctly. Overstreet’s (1998) study with fifty adults also found no positive effects of VIE on learning preterit and imperfect in Spanish. Wong (2003)
also examined how VIE affects the acquisition of past participle agreement in relative clause in French. The subjects were English-speaking French adult learners. Wong reported that the students in the VIE condition exhibited no effects on error correction task.

Leow’s (1997, 2001, 2003) three studies did not show positive effects of VIE on grammar learning. In the first study, Leow (1997) examined the effects of VIE on acquisition of Spanish impersonal imperative by manipulating text length (short/long) and VIE (bolded and bolded, underlined, italic, and enlarged fonts). The researcher used a multiple-choice grammar test to measure the students’ grammar learning. The findings revealed no significant effects of VIE by using different assessment measures, such as think-aloud protocols in order to measure noticing and awareness of the target form, but failed to find positive effects on grammar acquisition. In the third study, Leow et al. (2003) examined the role of VIE (underlined bold, enlarged fonts) on learning present perfect and subjective in Spanish. The assessment data was collected from a multiple-choice recognition task and think-aloud protocols and found no effects of VIE on noticing or learning.

3. VIE and Reading Comprehension

Although a growing body of SLA research has investigated the role of VIE in grammar learning (e.g., Lee, 2007; Santis, 2008), relatively few studies have examined the effects of VIE on reading comprehension (e.g., Lee, 2007; Leow, 1997, 2001; Leow et al., 2003; Overstreet, 1998; Wong, 2003). In addition, review of previous studies indicated that the effects of VIE on reading comprehension were mixed: negative effects (Lee, 2007; Overstreet, 1998) and no negative effects (Leow, 1997, 2001; Leow et al., 2003; Wong, 2003) on reading comprehension.

Inconsistent findings of previous studies appear to have originated from (i) idiosyncratic data collection methods (i.e., free recall, fill-in-the-blank, think-aloud protocols, and multiple-choice questions), (ii) different target forms (i.e., relative clause, passive voice, possessive determiners, and 3rd person present tense verbs), and (iii) different target languages (e.g., Spanish, English). The inconsistent findings and different research methods warrant further studies.
<table>
<thead>
<tr>
<th>Study</th>
<th>TL</th>
<th>TF</th>
<th>Participants</th>
<th>Instruments</th>
<th>Effects on</th>
</tr>
</thead>
<tbody>
<tr>
<td>Doughty (1991)</td>
<td>English</td>
<td>Relative clause</td>
<td>20 Adults</td>
<td>Diverse (ESL)</td>
<td>No</td>
</tr>
<tr>
<td>Shook (1994)</td>
<td>Spanish</td>
<td>PP/RP</td>
<td>125 Adults</td>
<td>-Recognition</td>
<td>No</td>
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<tr>
<td>Jourdenais et al. (1995)</td>
<td>Spanish</td>
<td>Preterit/ imperfect</td>
<td>10 Adults</td>
<td>-Fill-in-the-blank production</td>
<td>No</td>
</tr>
<tr>
<td>Leow (1997)</td>
<td>Spanish</td>
<td>II</td>
<td>84 Adults</td>
<td>-Think-aloud protocols</td>
<td>No</td>
</tr>
<tr>
<td>Overstreet (1998)</td>
<td>Spanish</td>
<td>Preterit/ imperfect</td>
<td>50 Adults</td>
<td>-Picture-based writing</td>
<td>No</td>
</tr>
<tr>
<td>White (1998)</td>
<td>English</td>
<td>PDs</td>
<td>86 Junior-high</td>
<td>-Short-answer RC</td>
<td>No</td>
</tr>
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<td></td>
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<td></td>
<td></td>
<td>-Multi-choice grammar</td>
<td>Negative</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>-T/F RC</td>
<td>No</td>
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<td></td>
<td></td>
<td>-Written narration</td>
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<td>-Passage correction</td>
<td>No</td>
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<td></td>
<td>-Multi-choice</td>
<td>No</td>
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<td></td>
<td>-Oral picture description</td>
<td>No</td>
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<tr>
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<td>Task Description</td>
<td>Group</td>
<td>Assessment Methods</td>
<td>Impersonal Imp.</td>
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<td>Leow (2001)</td>
<td>Spanish</td>
<td>Imperatives</td>
<td>38 Adults</td>
<td>English</td>
<td>No</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>- Short-answer RC</td>
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<td></td>
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<td>- Multi-choice</td>
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<td>- Grammar</td>
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<td>- Fill-in-the-blank</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>- Think-aloud</td>
<td></td>
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<tr>
<td>Izumi (2002)</td>
<td>English</td>
<td>Relative clause</td>
<td>61 Adults</td>
<td>Diverse (ESL)</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- Recall RC</td>
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<td></td>
<td>- Sentence combination</td>
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<td>- Picture-cued sentence completion</td>
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<td>- Interpretation test</td>
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<td></td>
<td></td>
<td></td>
<td>- Grammar test</td>
<td></td>
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<tr>
<td>Wong (2003)</td>
<td>French</td>
<td>Past participle agreement in relative clause</td>
<td>81 Adults</td>
<td>English</td>
<td>No</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- Free-recall RC</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>- Error correction</td>
<td></td>
</tr>
<tr>
<td>Santis (2008)</td>
<td>English</td>
<td>Present tense verbs</td>
<td>15 Adults</td>
<td>Haitian Creole</td>
<td>No</td>
</tr>
<tr>
<td>Lyddon (2011)</td>
<td>French</td>
<td>Preposition before toponyms</td>
<td>136 Adults</td>
<td>Fluent English speakers</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- Cloze tests</td>
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</table>

III. TWO EXPERIMENTS

Figure 1 summarizes the two experiments of this study. Specifically, in Experiment 1, we explored how VIE and deliberate attention affect learning of target forms (gerund and to-infinitives) and reading comprehension of EFL high school students. Specific research questions are as follows:

1. To what degree does VIE affect grammar learning and reading comprehension?
2. How does deliberate attention to the target grammar affect grammar learning and reading comprehension?

Experiment 2 further probed the effects of VIE and deliberate attention by using an eye tracker. We were particularly interested in how VIE and deliberate attention impact eye movements (i.e., eye fixation counts and durations) and also in how such eye movements are associated with grammar learning and reading comprehension. In the present study, more fixations and longer fixation durations are interpreted as evidence of deeper and elaborate processing (i.e., higher intensity), which in turn is closely associated with better learning (Henderson & Ferreira, 2004). The following research questions are addressed in Experiment 2:

3. To what degree does VIE and attention influence eye movements, as measured by eye fixation counts and fixation durations?
4. How are the eye movements associated with grammar learning and reading comprehension?

FIGURE 1
Graphic Summary of the Two Experiments

For research question 1, no predictions were formulated since previous research findings are inconsistent. For research question 2, we predicted that VIE and deliberate attention to the target grammar would significantly impede reading comprehension, based on the
Noticing Hypothesis (Schmidt, 2001) and theories concerning limited processing capacities (e.g., Baddeley, 2003). According to these theories, when learners expend the limited attentional resources processing the visually enhanced grammar features, they may learn grammar better, and yet may not have sufficient cognitive resources available for meaning construction. For research question 3, we predicted that VIE would considerably affect eye movements. Finally, for research question 4, we hypothesized that eye movements would be closely related with how well the students learn grammar and comprehend the experimental text. This hypothesis also drew its rationale from the Noticing Hypothesis (Schmidt, 2001) and the theory of limited processing capacities (Baddeley, 2003).

1. Experiment 1

1) Methodology

(1) Participants
Participants were eighty-eight high school students (ages 16 - 17) residing in a large metropolitan city in Korea. They were recruited from three intact classes in the same school. They were randomly assigned to one of the three experimental groups: (i) BT (baseline text, \( n = 28 \)), (ii) VIE (BT with the target grammar visually enhanced, \( n = 26 \)), and (iii) VIE-Attention (VIE with explicit instruction asking students to pay attention to both the target grammar and reading comprehension, \( n = 31 \)). In order to ensure that the three groups were homogenous, English test scores obtained from a preparatory Korean Scholastic Aptitude Test (KSAT\(^1\)) were compared. An Analysis of Variance (ANOVA) showed that the three groups were homogenous in terms of English language proficiency, \( p = .816 \).

(2) Instrumentation
The instrumental components of Experiment 1 embrace three major tools: (i) three versions (i.e., BT, VIE, VIE-Attention), (ii) a grammar correction test which served as both pre- and post-tests, and finally (iii) a reading comprehension test.

① Three Versions
The three versions (BT, VIE, and VIE-Attention) were identical except for the visual enhancement and an instruction which encourages students’ attention on the target

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\(^1\) The English test in KSAT measures Korean high school students’ receptive English skills with a primary focus on reading skills.
grammar. First, the BT version was adapted from an African folktale, The Spider Who Tried to Steal Wisdom in the World. This text was selected because it was expected that the participants would have little or no prior knowledge of the story. The original text was modified in terms of grammatical structures. Specifically, we modified the original text so that it comprised two types of target forms: gerund (postpone, avoid, keep, resist, quit + -ing) and to-infinitives: (happen to, instruct to, attempt to, determine to, and instruct to). Each target form appeared twice in each text so that the students were exposed to 20 tokens of the target forms in the text. Second, in the VIE version, in order to enhance visual saliency, the target forms were boldfaced and underlined. Finally, in the VIE-Attention version, we added an instruction that asked students to pay attention to both the visually enhanced target grammar and reading comprehension. See excerpts from the three versions below.

i. **BT:** One day, he happened to meet the sky god, and the sky god gave him a big box. Mo walked by and happened to see his father struggling to climb up the tree.

ii. **VIE:** One day, he happened to meet the sky god, and the sky god gave him a big box. Mo walked by and happened to see his father struggling to climb up the tree.

iii. **VIE-Attention:** (With a specific instruction demanding students to focus on both the enhanced grammar and reading comprehension) One day, he happened to meet the sky god, and the sky god gave him a big box. Mo walked by and happened to see his father struggling to climb up the tree.

The total number of words was 415. Readability index using Flesh Kincaid Grade level was 4.87, meaning that the text was easy for the participants to process (416 words, 35 sentences, average number of characters per word = 4.06; average number of words per sentence = 11.89, average number of syllables per word = 1.34).

2 Grammar Correction Test

The Grammar correction test (GCT) was designed to measure the participants’ knowledge of the target grammar (gerund, to-infinitives) before and after treatment, thus serving as pre- and post-tests. In the pre-test, the GCT composed of thirty question items which included 10 to-infinitive, 10 gerund, and 10 distractor (such as prepositions and relative pronouns) items. The distractor items were included in order to prevent participants from being cognizant of target forms of the current study. The distractors were eliminated in the post-test, while the remaining 20 items (gerund, to-infinitives) were rearranged in order to reduce the order effect. During the test, the students were instructed...
to judge the acceptability of the underlined verb form in each sentence. For example, when the sentence was grammatical, they were instructed to put an ‘O’ in the space provided. If the sentence was ungrammatical, they were asked to put an ‘X’ and to correct the error (see APPENDIX A).

③ Comprehension Questions
Eighteen short-answer reading comprehension questions were constructed. All the questions were presented in the native language of the students (i.e., Korean) because previous studies have shown that using students’ native language is more authentic and valid (Shohamy, 1984). Students were also allowed to answer the question in either Korean or English (see APPENDIX B).

(3) Procedures
A week prior to main data collection, the grammar pre-test was administered for fifteen minutes during regular class hours. Main data collection was also conducted during normal class hours. The procedures were as follows. First, students in each condition were told to read their corresponding texts silently. Students in the BT and VIE conditions were told that they would respond to a reading comprehension test (that is, unexpected grammar test for students in the BT and VIE conditions), whereas those in the VIE-Attention condition were told that they would take both grammar and reading comprehension tests. Second, the students responded to the reading comprehension, followed by the grammar test.

(4) Scoring
For the grammar correction test, one point was awarded. For instance, the students were awarded one point when they marked an “O” for the grammatical sentence. To earn one point from the incorrect sentence, the students were required to mark an “X” and correct it. Likewise, one point was awarded for each correct answer for the reading comprehension test.

(5) Statistical Analysis
Text type was the only independent variable with three levels: BT, VIE, VIE-Attention, whereas there were two dependent variables: grammar and reading comprehension test scores. For the first dependent variable (grammar scores), an Analysis of Covariance (ANCOVA) was used in order to minimize within-subject error variance. Specifically, the students’ scores on the pre-grammar test were used as a covariate. By controlling for the covariate differences in the analysis, the three groups were expected to be effectively equal in terms of the mean covariate, pre-existent grammar ability. In this way, any measureable changes in the post-test among the three groups could be attributed only to differences in
the text type. For the second dependent variable (reading comprehension scores), an ANOVA was run to determine the main effect of text type. The magnitude of the main effect of text type (BT, VIE, VIE-Attention) was computed by computing Cohen’s $d$ (Cohen, 1988). Alpha level was set at .05 for all the statistical analyses.

2) Results

(1) Effects of VIE on Grammar Learning

As summarized in Table 2, the students in the VIE-Attention group ($M = 15.88$) performed the best, followed by VIE ($M = 13.95$) and BT ($M = 13.26$) groups. The mean differences were analyzed by using an ANCOVA with the pretest results serving as the covariate (hence, adjusted mean scores are reported). The results showed that the differences among the three groups were statistically significant, $F(2, 81) = 5.169$, $p = .008$, partial eta squared = .113. Since the overall $F$ test revealed a significant main of VIE, a post-hoc analysis using the Bonferonni adjustment was performed. The analysis indicated that students in the VIE-Attention condition scored significantly higher than those in the BT condition, $p = .009$ with an upper medium effect size ($d = .65$). The analysis also showed that students in the VIE-Attention condition outperformed their counterparts in the VIE condition, but the mean difference between the two groups reached marginal significance, $p = .076$ with small to medium effect size ($d = .41$). In contrast, the difference between the VIE and BT groups did not differ, $p = 1.000$.

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Adjusted Mean</th>
<th>SD</th>
<th>Mean Difference</th>
<th>$p$</th>
<th>Effect Size ($d$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BT (a)</td>
<td>28</td>
<td>13.26</td>
<td>3.75</td>
<td>(a) – (b) = -0.687</td>
<td>1.000</td>
<td>.15</td>
</tr>
<tr>
<td>VIE (b)</td>
<td>26</td>
<td>13.95</td>
<td>5.13</td>
<td>(b) – (c) = -1.93</td>
<td>.076</td>
<td>.41</td>
</tr>
<tr>
<td>VIE-Attention (c)</td>
<td>31</td>
<td>15.88</td>
<td>4.35</td>
<td>(a) – (c) = -2.62</td>
<td>.009</td>
<td>.65</td>
</tr>
</tbody>
</table>

(2) Effects of VIE on Reading Comprehension

On a measure of reading comprehension performance, the BT group ($M = 12.68$) performed the best, followed by VIE-Attention ($M = 9.97$) and VIE-Attention ($M = 9.68$) groups, as shown in Table 3. A one-way ANOVA confirmed that the mean differences among the three groups reached statistical significance, $F(2, 85) = 4.526$, $p = .014$, partial eta squared = .096. In light of the statistically significant results, post-hoc analysis using the Bonferonni was performed. The result showed that the mean difference between the BT and VIE-Attention groups was statistically significant, $p = .021$ with a large effect size.
(\(d = .73\)). Also, the mean difference between the BT and VIE groups showed statistical significance, \(p = .048\) with a large effect size \((d = .74)\). The mean scores of the VIE and VIE-Attention groups rarely differed, \(p = 1.000\).

### TABLE 3

Summary of Reading Comprehension Test Results

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
<th>Mean Difference</th>
<th>Effect Size (d)</th>
<th>p</th>
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</thead>
<tbody>
<tr>
<td>BT (a)</td>
<td>28</td>
<td>12.68</td>
<td>3.02</td>
<td>(a) – (b) = 2.71</td>
<td>.048</td>
<td>.74</td>
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<td>VIE (b)</td>
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<td>9.97</td>
<td>4.18</td>
<td>(b) – (c) = 0.288</td>
<td>1.000</td>
<td>.06</td>
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<td>VIE-Attention (c)</td>
<td>31</td>
<td>9.68</td>
<td>4.98</td>
<td>(a) – (c) = 3.00</td>
<td>.021</td>
<td>.73</td>
</tr>
</tbody>
</table>

(3) Correlation Analysis

To determine the relationship between grammar learning and reading comprehension, the correlation coefficients were computed. As illustrated in Table 4, the BT group students showed relatively strong positive correlation coefficient \((r = .667)\) between grammar and reading comprehension scores. The findings indicate that students who tended to perform better on the grammar test also tended to perform better on the reading comprehension test. Conversely, those who tended to perform poorer in the grammar test also tended to perform poorer on the reading comprehension test. In contrast, the VIE group showed a weak correlation coefficient \((r = .346)\), although the coefficient was not statistically significant. The VIE-Attention group showed the weakest correlation coefficient \((r = .200)\) which was not statistically significant, meaning that grammar and reading comprehension test scores were rarely associated.

### TABLE 4

Correlation between Grammar Learning & Reading Comprehension

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>r</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>BT</td>
<td>28</td>
<td>.667</td>
<td>.000</td>
</tr>
<tr>
<td>VIE</td>
<td>29</td>
<td>.346</td>
<td>.042</td>
</tr>
<tr>
<td>VIE-Attention</td>
<td>31</td>
<td>.200</td>
<td>.250</td>
</tr>
</tbody>
</table>

3) Discussion

In Experiment 1, we investigated how VIE and attention may affect grammar learning and reading comprehension. Two pedagogically significant findings were observed. First, the VIE group did not benefit from visually enhanced target forms, whereas the VIE-Attention group did show significant gain in grammar scores. The findings are consistent
with the previous study findings (Doughty, 1991; Izumi, 2002; Jourdenais et al., 1995; Lee, 2007; Leeman et al., 1995; Santis, 2008; Shook, 1994, 1999), which suggests that the degree of explicitness of VIE differentially affected the learners’ grammar acquisition. The finding indicates that VIE per se failed to attract sufficient attention of the students on the target forms. It also indicates that focal attention as well as VIE is necessary for target forms to be more perceptually salient to learners. In other words, deliberate attention as well as VIE is necessary for better learning. Second, the BT group outperformed both the VIE and VIE-Attention groups to a statistically significant degree, with large effect size indices detected (\(d = .74\) and \(d = .73\), respectively), replicating the findings of Lee (2007) and Overstreet (1998). From this finding, it can be inferred that there is a potential trade-off between grammar learning and reading comprehension. Finally, analyses of correlation coefficients between grammar and reading comprehension test scores corroborate the above findings. Specifically, the BT group showed a statistically significant positive and strong correlation coefficient \(r = .667\), followed by the VIE and VIE-Attention groups. This finding partially replicates that of Lee (2007), who reported statistically significant positive, yet small correlation coefficient \((p = .35, p = .000)\) for the BT group.

To summarize, the two findings support our prediction and suggest that the degree of attention may be an important variable in accounting the effect of VIE. In addition, the findings support the hypothesis that learners’ reading comprehension may be impeded when they expend their limited attentional resources on processing the target forms (Lee, 2007). This hypothesis was further examined in Experiment 2.

2. Experiment 2

In Experiment 2, we further probed the effects of visually enhanced target forms and attention on grammar learning and reading comprehension by using a novel instrument in VIE literature: the eye tracker. Research to date has shown that there exists a strong positive correlation between attention and moment-to-moment eye movements (Chaffin, Morris, & Seely, 2001). By using the eye tracker, we anticipated that we could determine how much manipulation of salience of the target features (VIE, VIE-Attention) attracts or distracts learners’ attention and also whether levels of attention are associated with learning of target grammar and reading comprehension.

1) Methodology

(1) Participants

In Experiment 2, six high school students (ages 16 -17) voluntarily participated in the experiment. They all had normal or corrected-to-normal vision. Based on their English test
scores in a preparatory KSAT, they were randomly assigned to one of the three conditions: BT, VIE, VIE-Attention (two students in each group). As in Experiment 1, the purpose of Experiment 2 was not disclosed to the students until they terminated all the procedures.

(2) Eye Tracker and Textual Stimuli

In Experiment 2, two additional instruments were used: the eye tracker and the textual stimuli (on-screen versions of BT, VIE, VIE-Attention texts). First, the eye tracking device used in Experiment 2 was Tobii 1750 which appeared as a normal computer monitor (resolution = 1280 x 1024 pixels; gaze estimation frequency = 50 Hz), hence rarely obtrusive and interfering with authentic reading processes. Although the device allowed for some freedom of head movement (44 x 22 x 30), participants were discouraged from moving their head while reading. Second, on-screen versions of BT, VIE and VIE-Attention texts were prepared. Each text version was decomposed into eight slides using TIFF format. The on-screen texts were presented in black on white background on the computer monitor. Due to various text lengths, the reading time for each slide was set differently through a pilot study.

FIGURE 2

Data Collection Using the Eye Tracker

(3) Procedures

Data collection procedures for Experiment 2 are as follows. To begin with, the students completed the grammar correction test which served as the pre-test. Then, after successful calibration values were achieved, the students read specific instructions about the experiments and also a sample story for a warm-up session so that they could be familiar with the experimental procedures. Next, they read the experimental texts corresponding to their condition (see Figure 2). Finally, the students were instructed to complete grammar correction and reading comprehension tests. The whole procedures took about an hour.
(4) Eye Movement Data Analyses

Eye movement data were analyzed in view of eye fixation counts and fixation durations by using Tobii’s Clearview software. A fixation is a pause of eye movement, typically ranging from 200 to 300 milliseconds (ms) in duration. Research has established that it is through the fixation that readers extract information from the text (Vainio, Hyönä, & Pajunen, 2009). Fixation count means the total number that readers fixated on particular areas of interest (AOIs), whereas fixation duration means the total amount of time that readers fixated on particular AOIs. In the present study, the AOIs are the target forms in the three experimental texts, hence 20 AOIs. In our study, more fixations and longer fixation durations will be interpreted as evidence of deeper and elaborate processing, which in turn is closely associated with better learning.

2) Results

Results of Experiment 2 are discussed in light of eye fixation counts and durations, and their relationship with grammar learning and reading comprehension scores. Albeit small in terms of the number of participants in Experiment 2, it should be noted that the findings of Experiment 2 appear to be quite consistent.

Below are results concerning the effects of VIE on eye movements, grammar learning, and reading comprehension. First, analyses of eye movement data revealed that students in the VIE-Attention condition fixated most often \( (M = 9.50) \) on the target forms, followed by those in the VIE \( (M = 7.53) \) and BT \( (M = 5.25) \) conditions. In other words, students in the VIE-Attention condition fixated their eyes on each target grammar 9.50 times on average, while the students in the VIE and BT conditions fixated their eyes on each target grammar 7.53 times and 5.25 times, respectively. Analyses of eye movement data also indicated that students in the VIE-Attention condition made the longest fixation durations \( (M = 224 \text{ ms}) \), followed by the VIE \( (M = 205 \text{ ms}) \) and BT \( (M = 161 \text{ ms}) \) conditions. The results are summarized in Table 5.

Visual representation of the eye movements are displayed in the sample Heat Map (see Figure 3). The colors of the Heat Map represent the fixation patterns and the intensity of visual attention landed on the regions. For instance, red color indicates the most intense and frequent fixations; graduating down to yellow indicates moderate intensity and frequency; and green depicts the least intensity and frequency. Absence of color means the eyes did not land on the spot. The sample Heat Map shows that eye movements of the BT group were evenly distributed throughout the text, while the eye movements of the VIE and VIE-Attention groups were fixated longer on the visually enhanced target forms (AOIs in the Figure 3). As Figure 3 illustrates, AOIs of VIE-Attention are red, which suggests that the eyes fixated longer and more frequently than those of VIE in the text. On the
contrary, BT did not show any significant attention to AOIs.

Second, concerning the effects of VIE on grammar learning, students in the VIE-Attention showed the biggest mean difference between pre- and post-tests ($M = 9.5$), followed by the VIE ($M = 6.5$) and BT ($M = 6.5$) (see Table 5). Finally, in terms of reading comprehension performance, the BT group ($M = 12.5$) performed the best, followed by the VIE ($M = 3.5$) and VIE-Attention ($M = 3.5$) groups.

### TABLE 5

<table>
<thead>
<tr>
<th>Group</th>
<th>Student ID</th>
<th>FC (ms)</th>
<th>FD (ms)</th>
<th>Pretest (A)</th>
<th>Posttest (B)</th>
<th>A - B</th>
<th>Reading comprehension</th>
</tr>
</thead>
<tbody>
<tr>
<td>BT</td>
<td>S1</td>
<td>6.30</td>
<td>146</td>
<td>11.0</td>
<td>15.0</td>
<td>4.0</td>
<td>12.0</td>
</tr>
<tr>
<td></td>
<td>S2</td>
<td>4.20</td>
<td>176</td>
<td>8.0</td>
<td>16.0</td>
<td>9.0</td>
<td>13.0</td>
</tr>
<tr>
<td></td>
<td>M</td>
<td>5.25</td>
<td>161</td>
<td>9.5</td>
<td>15.5</td>
<td>6.5</td>
<td>12.5</td>
</tr>
<tr>
<td>VIE</td>
<td>S3</td>
<td>8.25</td>
<td>222</td>
<td>8.0</td>
<td>12.0</td>
<td>4.0</td>
<td>6.0</td>
</tr>
<tr>
<td></td>
<td>S4</td>
<td>6.80</td>
<td>187</td>
<td>5.0</td>
<td>16.0</td>
<td>9.0</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>M</td>
<td>7.53</td>
<td>205</td>
<td>6.5</td>
<td>14.0</td>
<td>6.5</td>
<td>3.5</td>
</tr>
<tr>
<td>VIE-Attention</td>
<td>S5</td>
<td>12.05</td>
<td>260</td>
<td>6.0</td>
<td>17.0</td>
<td>11.0</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>S6</td>
<td>6.95</td>
<td>187</td>
<td>4.0</td>
<td>12.0</td>
<td>8.0</td>
<td>6.0</td>
</tr>
<tr>
<td></td>
<td>M</td>
<td>9.50</td>
<td>224</td>
<td>5.0</td>
<td>14.5</td>
<td>9.5</td>
<td>3.5</td>
</tr>
</tbody>
</table>

Notes: ID = identification number, FC = fixation counts, FD = fixation durations, ms = millisecond

### FIGURE 3

Sample Heat Map of the Three Groups (BT, VIE, VIE-Attention)

**BT**
3) Discussion

Experiment 2 was designed to probe the effects of visually enhanced target forms and attention on eye movements, and how eye movements are associated with grammar learning and reading comprehension. In general, VIE and deliberate attention appeared to affect eye movements and thus influenced the students’ performance in grammar and reading comprehension tests. Specifically, the results showed that students in the VIE-Attention condition fixated most often and longest on the enhanced target forms and that they performed the best on the grammar test, whereas they scored the lowest on reading comprehension test. Students in the VIE conditions fixated more often and longer than their counterparts in the BT condition. However, their grammar test scores were no higher and comprehension scores were considerably lower than those of the BT students. In stark contrast, students in the BT condition fixated the least often and shortest on the target grammar forms and performed the poorest on the grammar test, whereas they performed the best on the reading comprehension test. Taken together, eye movement patterns appear to be closely related to both grammar learning and reading comprehension.

The findings lend support to a general consensus among many L2 researchers who argued for focal attention to the linguistic input (e.g., Robinson, 2003; Schmidt, 2001). For instance, the VIE-Attention group fixated most often and longest on the enhanced target forms and performed the best on the grammar correction test. It means that enhanced attention is a necessary condition for grammar learning. The findings also support VanPatten (1990) who reported that learners are unable to process both form and meaning simultaneously. In Experiment 2, analyses of movement data showed that learners in the
two VIE groups paid more attention to the enhanced grammar forms and performed very poorly in the reading comprehension test.

IV. DISCUSSION, IMPLICATIONS, AND LIMITATIONS

1. General Discussion

The present study aimed at investigating the role of VIE and deliberate attention in grammar learning and reading comprehension. To achieve that purpose, two experiments were conducted. The results of Experiments 1 and 2 provide converging evidence that VIE alone did not promote grammar learning. In other words, VIE without deliberate attention does not necessarily lead to acquisition of target forms, and therefore, VIE plus deliberate attention is required in grammar learning. This finding is in line with some researchers who proposed that VIE per se is insufficient and also that additional instructional activities are necessary in interlanguage development (Izumi, 2002; White, 1998). The finding is also consistent with those who found that the degree of explicitness of VIE affected the learners’ grammar learning to a varying degree (Doughty, 1991; Izumi, 2002; Jourdenais et al., 1995; Lee, 2007; Leeman et al., 1995; Santis, 2008; Shook, 1994, 1999). However, the finding challenges some previous studies that documented positive effects of VIE on grammar learning (Doughty, 1991; Jourdenais et al., 1995, 1995; Lee, 2007; Santis, 2008; Shook, 1994).

Other converging evidence from the two experiments is that the BT group significantly outperformed both the VIE and VIE-Attention groups on the reading comprehension test. It means that VIE, regardless of attention level, was detrimental to reading comprehension. From this finding, it can be inferred that when attentional resources are allocated to the peripheral information, such as the target grammar, reduced resources are available to encode central information. In other words, although coherent mental representations of text entails that individual elements (e.g., grammar, vocabulary) should be connected to each other in meaningful relations, VIE may hamper such meaningful connections.

In light of both grammar learning and reading comprehension, it should be noted that VIE did not significantly promote grammar learning, whereas it impaired reading comprehension. In contrast, VIE with deliberate attention (i.e., VIE-Attention text) significantly enhanced grammar scores, while it also impeded reading comprehension. A plausible interpretation of this interesting result is that students in the VIE-Attention condition paid more deliberate attention on the target forms than did those in the VIE condition. Eye movement data provide invaluable evidence for this speculation: VIE-Attention group students fixated more often (mean fixation counts for each target form =
9.50) and longer (mean fixation durations for each target form = 224 ms) than did those in the VIE group (7.53 ms and 205 ms, respectively). The theory of levels of processing (LOP) provides additional rationale for our interpretation. According to LOP, when students are engaged in deeper semantic elaboration (Coomber, Ramstad, & Sheets, 1986), they are more likely to remember the target words. That also appears to be the case with grammar learning: the more elaboration (i.e., the more processing time), the more learning.

2. Implications

Several implications are drawn from the findings of this study. First, given that the students in the VIE-Attention condition outperformed those in the VIE condition on the grammar correction test, it is recommended that VIE should be combined with other instructional techniques. For instance, Izumi (2002) showed that VIE was more effective when it was integrated with output tasks. Alanen (1995) also showed that teaching rules in conjunction with VIE was more effective. In the present study, VIE plus explicit instruction that encouraged students’ attention to the target forms and reading comprehension was more effective than VIE alone.

Second, VIE with or without deliberate attention has the great potential to impair meaning construction of L2 learners whose L2 grammar knowledge is not proceduralized. Therefore, VIE should be practiced with great caution among teachers and textbook authors. The suggestion should not be taken to mean that VIE should be eliminated in meaning-oriented pedagogies. Rather, it means that VIE should be practiced with some caution since integrating language skills (e.g., grammar learning and reading), instead of separately teaching them, is quite essential in second language development (Long, 1991).

The final implication concerns research methods. Specifically, the present study used an eye tracker in order to record how VIE and attention actually affected eye movements, and how eye movements are associated with grammar learning and reading comprehension. As shown in the present study as well as in many previous studies (e.g., Ballard, Hayhoe, Pook & Rao, 1997; Rayner, Chace, & Slattery, 2006), the eye tracker can make a unique contribution to L2 reading research since it can document scientific and observable evidence about L2 readers’ cognitive processes. Nevertheless, very few L2 reading researchers used the eye tracker (no previous studies in VIE literature) in order to monitor and record the cognitive processes while reading.

3. Limitations

Although the present study makes exceptional contributions to the current VIE literature, some limitations of this study merit discussion. First, it remains unclear about the optimal
intervention, as proposed by Lee (2007) who argued that, “excessive intervention might not guarantee learners’ comprehension of meaning, and therefore, suggest that the right amount of obtrusiveness might be crucial to balancing the instructor’s intention to teach form with the learners’ pursuit of meaning comprehension” (p. 88). Our study has consistently shown that VIE alone and VIE with deliberate attention did not constitute an optimal intervention, especially when it comes to reading comprehension. Second, although eye movement data are internally consistent, given the small number of participants, the findings concerning eye movements cannot be generalized. Hence, future eye tracker studies should include a large number of participants. Third, as in all the previous VIE studies, the present study did not document how VIE affects grammar learning on a long-term basis. Future studies should address this matter. Finally, given that processing visually enhanced text involves dual-tasks (i.e., grammar and meaning), reading such text is quite relevant to working memory measures such as the reading span task (for more, see meta-analysis of Daneman & Merikle, 1996). When the visually enhanced forms are competing with meaning construction processes (i.e., reading comprehension) for the limited processing capacities of most learners, some learners who have larger working memory capacity may not be put at a disadvantage. Therefore, the findings of this may not be applicable to those who have greater processing capacities. These limitations should be addressed in future studies.

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**APPENDIX A**

Grammar Correction Test Sample

1. He avoided to show the box.
2. He was instructed sharing wisdom with everyone.
3. He postponed to give out the knowledge.
4. He couldn’t resist to feel stupid.
5. She happened seeing him struggling to climb up the mountain.

**APPENDIX B**

Comprehension Question Sample

1. What is the name of the spider?
2. What did the spider want to be?
3. What was it inside the box?
4. Who gave the box to the spider?
5. What was the spider instructed to do with the box?
Applicable levels: tertiary education
Key words: input enhancement, textual enhancement, eye movement, grammar, attention, reading comprehension, input, noticing

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