English Teaching, Vol. 78, No. 2, Summer 2023, pp. 29-54
DOI: https://doi.org/10.15858/engtea.78.2.202206.29
http://journal.kate.or.kr

Effects of Visual Input Enhancement and Working Memory on Grammar Learning by Korean EFL Learners

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Cho, Juhyung, & Song, Mi Jeong. (2023). Effects of visual input enhancement and working memory on grammar learning by Korean EFL learners. *English Teaching, 78*(2), 29-54.

This study aimed to investigate the effect of visual input enhancement (VIE) on the comprehension of reading texts and the learning of two grammatical forms: English relative clauses and articles. Individual learners' working memory (WM) capacity was also tested to explore its impact on the effectiveness of VIE. A total of 48 Korean college learners of English were assigned into three groups: (a) relative group receiving VIE on relative clauses (b) article group receiving VIE on articles, and (c) a control group receiving no VIE. Results showed that VIE did not have any negative effect on the learners' reading comprehension. Rather, it had positive effects on the learning of the two grammatical forms. According to the findings, VIE on relative clauses enhanced the learners' receptive knowledge of the grammatical form, whereas VIE on articles enhanced the learners' productive knowledge of the form. There was a potential link between the effectiveness of VIE and the learners' working memory processing ability. Pedagogical implications are also discussed based on these findings.

Key words: attention, noticing, visual input enhancement, working memory, L2 grammar learning, reading comprehension

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Received 31 March 2023; Reviewed 17 April 2023; Accepted 30 May 2023

1. INTRODUCTION

In second language acquisition (SLA) research, the role of noticing in L2 learning has drawn a lot of interest and attention from SLA researchers and practitioners. Since the noticing hypothesis was proposed by Schmidt (1990), it has been suggested that attention is essential to learning, and input is likely to be acquired when learners notice it. According to this hypothesis, noticing does not in itself result in acquisition, but it is considered an essential starting point.

Based on research findings that showed a positive role of noticing (e.g., Robinson, 2003; Schmidt, 1990, 1993), drawing learners' attention to language forms was important in EFL classroom settings, and various techniques have been applied. These range from explicit techniques such as rule explanation and prompts to implicit techniques such as input flooding and recasts. Visual input enhancement (VIE) is in the middle of the range, making grammatical features salient for learners to notice. It involves **boldfacing**, underlining, or *italicizing* features that need to be emphasized, and it has been extensively used in EFL reading textbooks. Due to the perceptual saliency of VIE, learners would pay additional attention to the enhanced target forms. As noticing is considered as a crucial starting point for language learning, VIE on grammar forms is expected to facilitate learners' grammar accuracy.

The efficacy of VIE has been investigated in many studies (Alanen, 1992; Doughty, 1991; Ha, 2009; Izumi, 2002; Jahan & Kormos, 2015; Jourdenais, 1998; LaBrozzi, 2016; Lee, 2021; Lee, 2007; Leow, 2001; Overstreet, 1998; Park & Nassif, 2014; Shook, 1994; White, 1998; Wong, 2003); however, the findings showed mixed results. In addition to these inconsistent findings on the efficacy of VIE on grammar learning, there has been controversy as to the impact of VIE on the comprehension of a reading text. Some researchers argued that VIE interferes with the comprehension of a text (Lee, 2007; Overstreet, 1998; Park & Nassif, 2014), while others claim that VIE does not affect reading comprehension (LaBrozzi, 2016; Leow, 2001; Leow, Egi, Nuevo, & Tsai, 2003; Meguro, 2019). Regarding such mixed findings, the variations in methodologies such as typological formats of VIE, pedagogical procedure, and types of target grammar features have been suggested as one of the major reasons (Lee & Huang, 2008).

Among the methodological differences, many researchers focused on the nature and characteristic of a selected target form. They argue that it may influence the perceived effectiveness of instructional interventions such as VIE (Goldschneider & DeKeyser, 2001; Spada & Tomita, 2010). According to a previous study (Mackey, Philp, Egi, Fuji, & Tatsumi, 2002), grammatical forms differ in complexity, communicative value, and perceptual salience. Empirical evidence tends to support that forms with higher communicative value are likely to be learned better from VIE, while forms with lower communicative value seem

to be more challenging to be acquired from VIE (Doughty, 1991; Jourdenais, Ota, Stauffer, Boyson, & Doughty, 1995; Park & Nassif, 2014; Shook, 1994). However, the evidence is insufficient and still inconclusive; therefore, it is essential to investigate the issue with various targeted structures to better understand how VIE affects the acquisition of grammatical features with different characteristics. Selecting two grammatical structures with different characteristics, this study investigates the impact of VIE on the learning of the forms.

In addition to the type of target grammar feature, another important factor that might affect the effectiveness of VIE is learners' working memory (WM) capacity. When grammar forms are visually enhanced in reading texts, learners must process two tasks simultaneously; on the one hand, they should construct meaning of a text, and on the other, they should process the enhanced grammar forms. The simultaneous tasks caused by the VIE may overburden learners, especially those with a lower level of working memory capacity. Previous studies suggest that there are individual differences in processing given input with limited working memory, and only a certain amount of information can be processed within this limited WM capacity (Daneman & Carpenter, 1980; Harrington & Sawyer, 1992; Juffs & Harrington, 2011). Thus, it can be assumed that learners with a higher level of WM capacity are likely to notice and process VIE more effectively while comprehending a reading text. Given the critical role that noticing plays in the effectiveness of VIE, more research needs to be conducted to explore the relationship between working memory capacity and the efficacy of VIE.

Therefore, the major goal of this study is to investigate whether VIE affects reading comprehension and whether VIE is effective for Korean EFL college learners in improving their accuracy on two different grammatical features. Another goal of this study is to investigate whether learners' individual WM capacity mediates the impact of VIE on both reading comprehension and the acquisition of grammatical features.

2. BACKGROUND

2.1. Visual Input Enhancement

The importance of input has been greatly addressed by many researchers in the second language acquisition (SLA) studies. Given that not all of the input learners are exposed to is utilized as an intake for learning, previous research has focused on the function of attention in facilitating input and learning (Robinson, 2003; Schmidt, 1990, 1993). The attention system is considered a low-capacity mechanism (Just & Carpenter, 1980). Learners with limited attentional resources and processing capacity can only attend to a limited amount of

incoming information (Robinson, Mackey, Gass, & Schmidt, 2012). Due to the limited attentional resources, different strategies have been utilized to direct learners' attention to language forms without interrupting meaning. One of the mechanisms for increasing the perceptual saliency of target forms is input enhancement, which can be constructed in various ways by instructors (Smith, 1991).

Visual input enhancement (VIE), one of the input enhancements, has been widely used in second language learning environments. VIE has been proposed as a useful technique of bringing language learners' attention to certain linguistic features while keeping the overall focus on the meaning of a reading text (Smith, 1991, 1993). This technique aims to make a target grammar feature more noticeable to L2 learners, thereby facilitating the acquisition of the form in meaningful contexts (Lee, 2007).

Many studies indicated that VIE aided grammar acquisition (Alanen, 1992; Doughty, 1991; Ha, 2009; Jourdenais et al., 1995; LaBrozzi, 2016; Lee, 2007; Shook, 1994). Doughty (1991), for example, examined the effects of VIE on English relative clauses and found positive effects on the grammar learning. In Jourdenais et al.'s (1995) experiment, VIE had a beneficial effect on learning Spanish preterit and imperfect verbs. Ha (2009) also examined how VIE could be used to help Korean learners become more aware of the use of phrasal verbs. The results of this study also suggested that VIE had a positive effect on the acquisition of the grammar form. Jahan and Kormos (2015) investigated how input enhancement affects the acquisition of "be going to" construction and found a positive effect of enhancement on grammar learning of the feature. In the study by Lee (2021), input enhancement was slightly effective in improving the learning of third-person singular forms for Japanese learners. Overall, previous studies have shown that participants whose attention was brought to target features obtained more linguistic knowledge about the items than those whose attention was not drawn to the forms.

Other studies, however, found that enhancement does not affect grammar learning (Izumi, 2002; Jourdenais, 1998; Leow, 2001; Leow et al., 2003; Overstreet, 1998; Park & Nassif, 2014; White 1998; Wong, 2003). White (1998) investigated the relative effect of VIE and input flood instruction on the acquisition of English possessive determiners. The groups were divided into three groups: input enhancement group, enhancement plus input flood group, and input unenhanced group. All three groups showed significant improvement, and there was no significant difference between the three groups. In Izumi's (2002) study, VIE had a positive effect on noticing the target form of English relative clauses, but there was no effect on the learning of the grammar. Wong (2003) studied the effects of VIE on the acquisition of past participle agreements in French relative clauses by adult English speakers. The results also indicated that the acquisition of the target form was found to be unaffected by VIE.

These inconsistent findings on the effect of enhancement in grammar acquisition can be attributed to methodological differences. Some researchers have investigated whether the

degree of effectiveness of VIE on learning a target structure varies depending on the nature of the target form (Alanen, 1992; Park & Nassif, 2014; Shook, 1994). In Shook's (1994) study, the effects of VIE on the acquisition of Spanish present perfect tense and relative pronouns were investigated. The present perfect was a more meaning-bearing and aspectual option than relative pronouns, which were less meaning-bearing and governed by syntactic choice. The participants in the VIE condition outperformed the control group, exhibiting a significant advantage in the present perfect but not in relative pronouns. Alanen (1992) investigated the efficacy of VIE with semi-artificial language as the target feature. The target linguistic constructions were locative suffixes (semantically definable content) and consonant alternation (semantically empty feature) of semi-artificial Finnish. Similar to Shook's (1994) finding, this study showed that semantically abundant features are better acquired through VIE than semantically empty forms. Park and Nassif (2014) also investigated a possible connection between the efficiency of VIE and the characteristics of target forms. The research examined how VIE affected comprehension and production of Arabic comparative forms (more meaning-bearing structure) and Arabic dual pronouns (less meaning-bearing structure). The findings demonstrated that VIE had no effect on noticing both target forms, but VIE on the less meaningful forms had a negative effect on learners' reading comprehension.

Taken together, previous studies on the effectiveness of VIE on the acquisition of different target forms showed mixed results. Therefore, this study aims to examine whether the effectiveness of VIE differs depending on the type of grammatical features that differ in their grammatical complexity.

2.2. Grammatical Features

Previous studies have tested the efficacy of VIE on grammatical features such as English relative clauses (Doughty, 1991; Izumi, 2002), Spanish preterit and imperfect (Jourdenais et al., 1995), English possessive determiners (White, 1998), and Spanish imperatives (Leow, 2001). Few studies, however, compared the effectiveness of VIE between two different grammatical features in one study. Research on VIE that has investigated the type of the target forms showed that semantically meaningful features are better acquired through VIE than semantically empty forms (Alanen, 1992; Park & Nassif, 2014; Shook, 1994). However, the empirical evidence remains inconclusive (Jourdenais, 1998; Leow, 2001; Leow et al., 2003).

In second language research, a variety of definitions have been suggested for grammatical difficulty or complexity. Different studies utilized different criteria to distinguish between simple and complex features. For example, Spada and Tomita (2010) distinguished the complexity of grammatical features in terms of the number of transformation rules. From

this perspective, simple features include tense, articles, plurals, and prepositions, while dative alternation, passives, and relativization are categorized as complex features, which include more than two transformations. However, grammatical complexity is not simple. As Table 1 shows, it can be differentially defined according to different criteria. The nature of these different complexity criteria and the target forms may influence the perceived effectiveness of instructional intervention (Goldschneider & DeKeyser, 2001; Spada & Tomita, 2010).

The target grammatical features chosen for the study were relative clauses and articles. Table 1 illustrates the different characteristics in complexity between relative clauses and articles.

TABLE 1

Complexity Differences Between Relative Clauses and Articles

	Relative Clauses	Articles
1) Comparison to Korean	different	absent in Korean
2) Acquisition order	late	late
3) Form-meaning mapping	difficult	difficult
4) Communication value of a form	low	low
5) Saliency of a form	yes	no
6) Reliability of the rule	concrete	abstract
7) Item-learning	no	yes
8) Transformation	complex	simple
9) Meaning expressed through a form	no	abstract

Note. The criteria in this table were taken from DeKeyser (2005), Goldschneider and DeKeyser (2001), and Spada and Tomita (2010)

The two features show similarities in some criteria, while they also show differences in other criteria. Both forms are considered challenging by many Korean EFL learners in that there are no equivalent forms in Korean, and these two features are found to be acquired relatively late by Korean learners. In addition, both forms have low communicative value, and previous studies (Alanen, 1992; Park & Nassif, 2014; Shook, 1994) showed that VIE on lower communicative value hinders the processing of form and meaning. Thus, in this study it was hypothesized that enhancement on these features in the reading text would be challenging for learners to process both form and meaning simultaneously.

The two features, however, differ in other criteria. Relative clauses have concrete rules and are generally acquired through more rule-based learning, whereas articles are more abstract and generally acquired by more item-learning. Compared to articles, relative clauses are less complex in terms of meaning and do not express meaning through a form. Moreover, relative clause is perceptually more salient than articles, and thus relative clauses are more likely to be noticed when it is enhanced. Given the difference in nature, it was hypothesized that the two features would have different impacts on reading comprehension and grammar

learning when visually enhanced.

2.3. Working Memory Capacity

Working memory has been emphasized in L2 learning as an important individual factor mediating the effects of diverse instructional techniques (Goo, 2012; Harrington & Sawyer, 1992; Juffs & Harrington, 2011; Mackey et al., 2002). Researchers in the field of SLA paid close attention to the role of working memory capacity. It has been investigated as individual differences to account for varying outcomes in acquiring different types of L2 knowledge and abilities. Working memory (WM) is defined as a brain system that stores and manipulates information required for complex cognitive functions, and it consists of subcomponents for information storage and processing (Baddeley, 1992, 2000).

A variety of working memory span measures have been developed to assess an individual's working memory capacity. Working memory span tasks are categorized into two types depending on the component of working memory: simple span tasks and complex span tasks. A simple span task measures the simple storage functions (Linck, Osthus, Koeth, & Bunting, 2014). Complex span tasks, on the other hand, incorporate an additional task to simple tasks and measure the processing function as well as the storage function of working memory (Daneman & Carpenter, 1980). In a complex span task, participants are asked to store information while simultaneously performing other types of cognitive activity. The reading span task (RSPAN) is regarded as a well-established and influential method of evaluating working memory capacity (Wen, 2012). The RSPAN demands participants to switch between two tasks of processing and storage, and it has been empirically utilized in L2 settings.

One of the key properties of working memory is that it has a limited capacity and individuals differ in terms of the amount of input they can process at once (Just & Carpenter, 1980). Working memory has been claimed as one of the most plausible elements accounting for individual variables in L2 performance and acquisition within the cognitive SLA paradigm. Previous studies showed the extent to which individual differences in working memory can predict abilities in various aspects of L2, such as reading comprehension (Harrington & Sawyer, 1992) and recasts (Goo, 2012; Mackey et al., 2002). However, the relationship between VIE and WM capacity has not been dealt with in many studies; thus, it needs further examination. In order to acquire a target form visually enhanced, learners need to hold both the form and meaning simultaneously while comprehending a text. The ability to perform such a dual task is closely related to one's WM capacity, which consists of processing and temporarily storing incoming information. This hypothesis leads to the prediction that learners with a higher WM capacity may benefit more from VIE than otherwise. Based on the rationales above, the current study attempts to investigate whether

individual differences in working memory capacity can explain the efficacy of visual input enhancement on grammar learning and reading comprehension.

In order to explore the issue, the following research questions are addressed:

1) Does VIE on grammar forms affect reading comprehension and the learning of English relative clauses and articles?
2) Does the effect of VIE differ depending on the type of the two grammatical features?
3) Does working memory capacity affect the efficacy of VIE?

3. METHODOLOGY

3.1. Participants

A total of forty-eight undergraduate students participated in this study. Participants were recruited from mandatory general English courses at a university in Seoul, South Korea. Those enrolled in the courses have a TEPS (Test of English Proficiency by Seoul National University) score of 298 to 386, which is regarded as an intermediate level in English proficiency. Fliers to gather participants were distributed and students voluntarily participated in this experiment. At the beginning of the study, the participants were given a general guideline and provided with an information sheet explaining (i) the main purpose of the study, (ii) the overall procedures and length of the study, and (iii) the participant's right to withdraw from the study at any time. In addition, the participants were given 10,000 won worth of a coffee coupon as a compensation for their participation.

3.2. Procedure

The experiment was carried out individually, and the participants' responses were collected through Google Forms. All of the sessions were conducted online, so students were able to participate in the experiment at their convenient time and environmental setting with their laptop or PC. They were given guidelines on the procedure for each session in Korean, and they performed reading comprehension tests, grammar tests, and working memory task.

For each participant, the experiments were performed on three separate days over three weeks. In the first session, pretests were administered for reading comprehension ability and grammar knowledge. The reading text in the pretest was not enhanced, and all the participants were given the same text. The grammar pretests included a grammaticality judgment test (GJT) and a fill-in-the-blank (FIB) test. After the pretests, the participants were randomly assigned to one of the three experimental groups: (a) relative group (VIE on

relative clauses, n=16), (b) article group (VIE on articles, n=16), and (c) control group (no VIE, n=16).

In the second week, the two VIE groups were given a text with VIE on each target grammatical feature, and the control group was given a baseline text with no VIE. After reading the enhanced text, VIE groups completed a survey on VIE noticing: (i) whether they've noticed the VIE and (ii) what they thought about the VIE. Then, an immediate posttest on reading comprehension and grammar tests were followed. After a week, the participants took a delayed posttest on grammar and a working memory test. As the experiment lasted for three weeks, some of the students withdrew in the delayed posttest, resulting in 13 participants for relative group, 15 for article group, and 16 for control group. The working memory test was performed in the last session, and some participants withdrew from the working memory procedure, resulting in 12 students for relative group, 15 for article group, and 13 for control group.

3.3. Materials

3.3.1. Reading comprehension

Reading materials were extracted and modified from online articles: one was an article about the Statue of Liberty, and the other was an online news report on a burial found in England. The original text did not have sufficient relative clauses; thus, the materials were modified to include more relative clauses. The two texts were similar in their vocabulary level and length with word count of 512 for the pretest text and 529 for the main text. Both texts were expository texts and different types of comprehension questions, such as true or false questions, multiple-choice questions, and short answer questions were used to assess students' comprehension of the text content. A total of 10 questions were included on each reading comprehension test, and 1 point was given for each correct answer, resulting in a total of 10 points for each test.

In the treatment session, the enhanced texts were used in the immediate posttest for VIE groups, where target forms were enhanced. For the relative group, relative pronouns were enhanced by bolding and color-coding in red. The following verb or preceding preposition was also enhanced depending on the feature of relative clauses. A total of 21 relative clauses were enhanced in the text. The article group received a text with articles enhanced. Articles were also enhanced with bolding and color-coding in red. Of all articles, 42 articles were enhanced when they are used as the function of "first mention" or "definite article". Compared to relative clauses, articles are shorter in length and it was difficult to distinguish whether the form had been enhanced or not. To ensure that articles were noticeable to the participants, the number of enhanced articles was more than the relative clause tokens. The

sample sentences in (1) are identical with different enhancement on features depending on the group: (1a) shows the enhancement for the relative group, (1b) shows the enhancement for the article group, and (1c) shows a baseline sentence for the control group.

(1) a. The chief was buried at the center of a circular pit on the top **of which** soil would have been piled.
b. **The** chief was buried at the center of **a** circular pit on the top of which soil would have been piled.
c. The chief was buried at the center of a circular pit on the top of which soil would have been piled.

3.3.2. Grammar tests

Participants were given both the grammaticality judgment test (GJT) and the fill-in-the-blank (FIB) test to measure their receptive and productive knowledge of each target form, respectively. In earlier studies, the receptive knowledge was frequently evaluated using the GJT. This test is helpful for determining a student's proficiency in a second language since they represent the language competence rather than performance (Gass, 1994). On the other hand, the FIB test, which is a constrained construction type test, is utilized to force participants to produce the target form.

The grammatical features chosen for the study were relative clauses and articles. The GJT for this study contained 26 questions: ten items on relative clauses, ten on articles, and six items on distractors such as prepositions, passive forms, and others. All three groups were given the same GJT, but only the target form for each group was scored. In the GJT, five items were grammatical and five were ungrammatical. Students were asked to point out the incorrect usage and provide the correct form. One point was given only when the participants correctly judged the sentence and changed the error. The total score for the GJT was 10 for both relative clauses and article forms.

After taking the GJT, the participants took fill-in-the-blank (FIB) tests. They were given 20 questions on relative clauses and other distractors. For FIB tests on articles, a short passage was given, and the blanks were provided only for articles. Participants had to write “a/an”, “the,” or “null” articles in 15 blanks. Correct answers on the target articles were given one point. The total score for the FIB test was 10 for relative clauses and 15 for articles. The items used in both the GJT and the FIB test were different in pretests and posttests, though sentences used in the tests were similar in terms of length and vocabulary level.

3.3.3. Working memory capacity

The participants' WM capacity was measured with a web-based reading span task (RSPAN) in English language (Klaus & Schriefers, 2016). The RSPAN involves a dual-task paradigm, which assesses the component of processing and storage. The task consists of a total of 17 sets, and each set contained WM processing and WM storage tasks. In WM processing task, participants first determined whether a given English sentence is semantically meaningful or not. The decision had to be made in less than 10 seconds, and when participants did not answer the question in time, it was automatically calculated as an incorrect answer. After one WM processing task, a single English word appeared for one second. For WM storage tasks, participants had to memorize all the words that appeared in each set, and they had to write as many words as they could remember at the end of each session. Only the correct judgments on WM processing were calculated, and there was a total of 66 sentences. The correct words for each set were counted for WM storage scores, and the total score was 66. The WM composite score was calculated by combining both WM processing and WM storage scores, and the total score was 132.

3.4. Data Analysis

Each VIE group and control group were compared using an independent *t*-test to determine the significant difference in their performance. In order to assure that the treatment group and control group were homogenous in terms of reading and grammatical ability prior to the treatment, independent *t*-tests were performed for the reading comprehension and grammar pretest scores. Posttest scores of the reading comprehension and grammar test between each VIE group and control group were compared using an independent *t*-test. In order to determine the effect of working memory capacity on VIE, a non-parametric test was performed since the sample size (n=5 for each group) was too small. All analyses of the obtained data were performed using IBM Statistical Package for the Social Sciences (SPSS) Version 26.0.

4. RESULTS

4.1. The Effects of Visual Input Enhancement

4.1.1. Reading comprehension

The first research question addresses whether visual input enhancement would have an

impact on reading comprehension. Table 2 shows the descriptive statistics for reading comprehension scores of each group.

TABLE 2
Descriptive Statistics for Reading Comprehension Scores

	Pretest			Posttest		
	N	*M*	*SD*	*N*	*M*	*SD*
Relative Group	16	8.50	1.37	16	8.69	1.19
Article Group	16	7.94	1.12	16	7.56	2,63
Control Group	16	8.25	0.94	16	8.44	1.75

Note. The total score for the pretest is 10.

The result from the independent *t*-test on reading comprehension pretest scores between the relative group and the control group indicates that the two groups were homogenous in reading ability (t=.605, p=.55). Also, the difference in the pretest between the article group and the control group was not statistically significant (t=-.857, p=.39). The reading comprehension posttest scores of the relative group and the control group were compared to see whether VIE affected the reading comprehension of the relative group. The difference between the relative group and the control group was not statistically significant (t=.472, p=.64), indicating that VIE did not affect the reading comprehension of the relative group. As for the article group, the reading comprehension posttest result did not differ from that of the control group (t=-1.107, p=.28). This result indicates that the VIE did not affect the article group in terms of reading comprehension.

4.1.2. Grammar learning

The first and second research questions ask whether visual input enhancement (VIE) can help improve EFL learners' receptive and productive knowledge of two grammatical features: English relative clauses and articles. First, the relative group and the control group were compared to examine whether the VIE on relative clauses improved participants' grammatical knowledge. The descriptive statistics for the two posttests of grammar tests of the relative group and the control group are presented in Table 3. Table 4 shows the independent *t*-test results on GJT and FIB posttests between the relative group and the control group.

Both independent *t*-test results on GJT and FIB pretest (GJT: t=.457, p=.65, FIB: t=-.445, p=.66) indicate that the two groups were homogenous in this grammar ability prior to the treatment. The immediate posttest GJT scores of the relative group and the control group were statistically different (t=2.14, p=.04), indicating that VIE on relative clauses was effective in improving participants' receptive knowledge on relative clauses. However, the

FIB posttest scores of the two groups were not statistically significant (*t*=.456, *p*=.65). Lastly, in order to examine the long-term effect of visual input enhancement on the target grammar feature, independent *t*-tests were performed on receptive and productive delayed posttest scores. The delayed posttest scores of the relative group and the control group were not statistically different (GJT: *t*=1.45, *p*=.16; FIB: *t*=-.03, *p*=.98).

TABLE 3

Descriptive Statistics for Grammar Posttests for Relative Clauses

		Relative Group			Control Group		
		N	*M*	*SD*	*N*	*M*	*SD*
Pretest	GJT	16	6.38	2.39	16	6.00	2.25
	FIB	16	7.88	1.31	16	8.06	1.06
Immediate Posttest [1]	GJT	16	6.06	1.57	16	5.00	1.21
	FIB	16	7.56	1.31	16	7.25	2.41
Delayed Posttest	GJT	13	7.00	1.08	16	6.31	1.40
	FIB	13	6.92	1.55	16	6.94	1.34

Note. The total score for the posttest is 10.

TABLE 4

Independent *t*-test Summary between Relative Group and Control Group

		t	*df*	*sig.*
Immediate Posttest	GJT	2.14	30	.04*
	FIB	.456	30	.65
Delayed Posttest	GJT	1.45	27	.16
	FIB	-.03	27	.98

* $p < .05$

The effects of VIE on articles were examined by comparing the article and the control group. Table 5 illustrates the descriptive statistics for the posttests of the article and the control group, and Table 6 shows the independent *t*-test results between the article group and the control group. Both GJT and FIB *t*-test results for the pretest indicate that the two groups were homogenous in terms of grammar knowledge before the treatment (GJT: *t*=-.357, *p*=.72; FIB: *t*=.873, *p*=.39). The independent *t*-test results for the immediate posttest of articles indicates that the article group did not show any significant improvement in the immediate posttest for GJT (*t*=-.783, *p*=.44). However, the participants in the article group showed significant difference compared to the control group in the FIB test scores (*t*=.078, *p*=.038), which suggests that the VIE on articles were effective in improving participants' productive knowledge on English articles. However, the long-term effect of VIE on articles was not observed in this study, as the article and control groups were not statistically different in the

[1] Paired *t*-tests were performed to see whether the decrease in immediate posttest scores compared to pretest scores were significant, but the results showed no significant differences among the tests.

delayed posttests (GJT: t=1.193, p=.24; FIB: t=1.029, p=.31).

TABLE 5

Descriptive Statistics for Posttests for Articles

		Article Group			Control Group		
		N	*M*	*SD*	*N*	*M*	*SD*
Pretest	GJT	16	5.56	1.21	16	5.69	0.70
	FIB	16	9.50	2.53	16	8.75	2.32
Immediate Posttest	GJT [2]	16	3.88	0.96	16	4.19	1.27
	FIB [3]	16	12.31	2.18	16	9.88	3.91
Delayed Posttest	GJT	13	5.00	1.31	16	4.44	1.32
	FIB	13	12.00	1.31	16	11.00	3.54

Note. The total score for GJT is 10, and the total score for FIB is 15.

TABLE 6

Independent *t*-test Summary Between Article Group and Control Group

		t	*df*	*sig.*
Immediate Posttest	GJT	-.783	30	.44
	FIB	.078	30	.038*
Delayed Posttest	GJT	1.193	29	.24
	FIB	1.029	29	.31

* p <.05

4.2. The Effects of Working Memory Capacity

The third research question addresses whether participants' working memory capacity can mediate the efficacy of VIE. WM capacity in this study was subdivided into three parts: (a) WM storage, (b) WM processing, and (c) WM composite. The three groups (relative, article, and control group) were subdivided into two sub-groups according to their working memory test results. Those who were in the upper rank of five in each group were classified as the high WM sub-group, while the lower five were categorized as the low WM sub-group. In all of the pretest results, the differences between participants with high working memory and those with low working memory were not significant, indicating that these two groups were homogenous in terms of reading comprehension and grammar ability prior to the treatment.

The descriptive statistics of WM composite scores for the relative group are presented in

[2] Paired *t*-tests were performed to see whether the two groups performed differently in the immediate posttest for GJT compared to pretest, and the results showed a statistical significance in difference: Pretest – Immediate Posttest GJT for Article Group: t(15)=4.81 p <.000, and for Control Group: t(15)=3.77, p =.002. Although the tests were aimed to have similar level in difficulty, both the article and control group showed significant difficulties in the immediate posttest for GJT.

[3] The difference between the pretest and posttest for FIB scores were compared with paired *t*-tests, and the results showed a significant increase in the article group (t(15)=-3.88, p=.001) but no significant differences in the control group (t(15)=-.89, p=.385).

Table 7. The result from the relative group showed that the participants with low WM composite capacity performed slightly better on both GJT and FIB than high working memory group; however, the non-parametric test results in Table 8 indicate that the differences were not statistically significant.

TABLE 7

Descriptive Statistics of WM Composite Scores for Relative Group

		High (n=5)		Low (n=5)	
		M	*SD*	*M*	*SD*
WM Composite		105.4	11.01	82	2.24
Reading	Posttest	9	1.22	9	1.22
GJT	Immediate Posttest	6.2	1.48	7	1.87
	Delayed Posttest	7	1.41	7.4	0.55
FIB	Immediate Posttest	7.8	0.84	8.6	1.14
	Delayed Posttest	7	1.87	7.4	1.14

Note. The total score for WM Composite is 132. The total score for reading comprehension, GJT and FIB is 10, respectively.

TABLE 8

Non-parametric Test on WM Composite Scores for Relative Group

	Mann-Whitney U	Wilcoxon W	Z	Exact Sig.
Posttest Reading	12.50	27.50	.000	1.000
Immediate Posttest GJT	9.00	24.00	-7.45	.548
Delayed Posttest GJT	12.00	27.00	-.113	1.000
Immediate Posttest FIB	7.00	22.00	-1.193	.233
Delayed Posttest FIB	10.00	25.00	-.537	.690

* $p < .05$

The article group results, presented in Table 9, showed that high WM group performed better than low WM group in the reading posttest and the delayed posttests for both GJT and FIB. However, as outlined in Table 10, non-parametric test results indicate that these differences were not significant.

TABLE 9

Descriptive Statistics of WM Composite Scores for Article Group

		High (n=5)		Low (n=5)	
		M	*SD*	*M*	*SD*
WM Composite		92.6	5.41	68.4	3.58
Reading	Posttest	8.6	1.14	8.2	1.48
GJT	Immediate Posttest	3.8	1.10	4	0.71
	Delayed Posttest	5.4	1.14	5.2	1.64
FIB	Immediate Posttest	12	2.00	13.8	1.64
	Delayed Posttest	13	0.71	12.2	1.10

Note. The total score for WM Composite is 132. The total score for reading comprehension and GJT is 10, respectively. The total for FIB is 15.

TABLE 10

Non-parametric Test on WM Composite Scores for Article Group

	Mann-Whitney U	Wilcoxon W	Z	Exact Sig.
Posttest Reading	10.50	25.50	-.430	.690
Immediate Posttest GJT	10.50	25.50	-.443	.690
Delayed Posttest GJT	10.00	25.00	-.546	.690
Immediate Posttest FIB	4.50	19.50	-1.708	.095
Delayed Posttest FIB	7.50	22.50	-1.181	.310

* $p < .05$

As WM composite ability consists of WM storage and processing ability, the subcomponent of WM composite was separately examined to investigate whether each subcomponent would affect the efficacy of VIE. First, with WM storage, the descriptive statistics for the relative group is illustrated in Table 11. The immediate posttest results for both GJT and FIB are lower in the high WM group, but the delayed posttest results are higher in the high WM group. However, as shown in Table 12, non-parametric tests were performed to determine whether the differences were significant, yet they did not show any significant differences between the two groups.

TABLE 11

Descriptive Statistics of WM Storage Scores for Relative Group

		High (n=5)		Low (n=5)	
		M	*SD*	*M*	*SD*
WM Storage		54.4	1.52	39.8	6.94
Reading	Posttest	8.4	1.34	9.6	0.55
GJT	Immediate Posttest	6	1.58	7.2	1.64
	Delayed Posttest	7.4	0.89	7	1.22
FIB	Immediate Posttest	7.8	0.84	8.6	1.14
	Delayed Posttest	7.4	1.82	7	1.22

Note. The total score for WM Storage is 66. The total score for reading comprehension, GJT and FIB is 10, respectively.

TABLE 12

Non-parametric Test on WM Storage Scores for Relative Group

	Mann-Whitney U	Wilcoxon W	Z	Exact Sig.
Posttest Reading	5.50	20.50	-1.565	.151
Immediate Posttest GJT	7.00	22.00	-1.170	.310
Delayed Posttest GJT	10.00	25.00	-5.65	.690
Immediate Posttest FIB	7.00	22.00	-1.193	.310
Delayed Posttest FIB	11.00	26.00	-.322	.841

* $p < .05$

Table 13 demonstrates the descriptive statistics of WM storage scores for the article group. The findings from the article group showed that the grammar score from the posttests is

higher in high WM group than in low WM group. Non-parametric test results shown in Table 14, however, showed that this difference was not statistically significant.

TABLE 13

Descriptive Statistics of WM Storage Scores for Article Group

		High (n=5)		Low (n=5)	
		M	*SD*	*M*	*SD*
WM Storage		48.2	1.79	26.6	7.92
Reading	Posttest	8.6	1.14	6.8	3.56
GJT	Immediate Posttest	4.4	1.34	4	0.71
	Delayed Posttest	4.8	0.84	4.2	0.84
FIB	Immediate Posttest	10.8	2.59	12.8	2.17
	Delayed Posttest	12.2	1.48	12	1.41

Note. The total score for WM Storage is 66. The total score for reading comprehension and GJT is 10, respectively. The total for FIB is 15.

TABLE 14

Non-parametric Test on WM Storage Scores for Article Group

	Mann-Whitney U	Wilcoxon W	Z	Exact Sig.
Posttest Reading	9.00	24.00	-.745	.548
Immediate Posttest GJT	10.00	25.00	-.542	.690
Delayed Posttest GJT	8.00	23.00	-1.003	.421
Immediate Posttest FIB	5.50	20.50	-1.485	.151
Delayed Posttest FIB	12.00	27.00	-.108	1.000

* $p < .05$

Table 15 illustrates the WM processing score results for the relative group. The results showed that learners with high WM processing ability obtained slightly higher reading comprehension and posttest scores for GJT and FIB than those with low WM processing ability. Non-parametric tests were performed to determine whether the differences were significant. However, no significant differences between high and low WM groups were found, as shown in Table 16.

TABLE 15

Descriptive Statistics of WM Processing Scores for Relative Group

		High (n=5)		Low (n=5)	
		M	*SD*	*M*	*SD*
WM Processing		54	7.07	36.8	5.59
Reading	Posttest	9	1.22	8.8	1.10
GJT	Immediate Posttest	7	1.73	6	1.73
	Delayed Posttest	7.6	0.89	7.2	0.45
FIB	Immediate Posttest	8.6	1.14	7.8	0.84
	Delayed Posttest	7.8	1.79	6.8	0.84

Note. The total score for WM Processing is 66. The total score for reading comprehension, GJT and FIB is 10, respectively.

TABLE 16

Non-parametric Test on WM Processing Scores for Relative Group

	Mann-Whitney U	Wilcoxon W	Z	Exact Sig.
Posttest Reading	10.50	25.50	-.454	.690
Immediate Posttest GJT	9.00	24.00	-.750	.548
Delayed Posttest GJT	7.00	22.00	-1.270	.310
Immediate Posttest FIB	7.00	22.00	-1.193	.310
Delayed Posttest FIB	7.00	22.00	-1.182	.310

* p <.05

Table 17 shows the descriptive statistics of WM processing scores for the article group. In the article group, high working memory group for WM processing performed better in posttest reading and FIB on both posttests than low WM processing group. Non-parametric tests were performed to determine whether the differences were significant. The result in Table 18 showed that the delayed posttest FIB scores of high working memory group were statistically higher than that of low working memory group.

TABLE 17

Descriptive Statistics of WM Processing Scores for Article Group

		High (n=5)		Low (n=5)	
		M	*SD*	*M*	*SD*
WM Processing		48.8	2.59	30.8	4.76
Reading	Posttest	8.4	0.89	6.8	3.42
GJT	Immediate Posttest	4	1.00	4.2	1.10
	Delayed Posttest	5	0.71	5.2	1.92
FIB	Immediate Posttest	12.6	1.52	11.4	2.97
	Delayed Posttest	12.6	0.89	10.6	0.89

Note. The total score for WM Processing is 66. The total score for reading comprehension and GJT is 10, respectively. The total for FIB is 15.

TABLE 18

Non-parametric Test on WM Processing Scores for Article Group

	Mann-Whitney U	Wilcoxon W	Z	Exact Sig.
Posttest Reading	8.50	23.50	-.859	.421
Immediate Posttest GJT	11.50	26.50	-.219	.841
Delayed Posttest GJT	12.50	27.50	.000	1.000
Immediate Posttest FIB	9.00	24.00	-.745	.548
Delayed Posttest FIB	1.50	16.50	-2.410	.016*

* p <.05

5. DISCUSSION

5.1. The Effectiveness of Visual Input Enhancement

The first and second research questions addressed whether VIE on target forms would affect reading comprehension and grammar learning. The results showed that VIE did not negatively affect reading comprehension and facilitated the participants' grammar learning. As for relative clauses, the receptive knowledge was enhanced by VIE, whereas as for articles, the productive knowledge was enhanced.

Since the participants should engage in dual tasks of processing visually enhanced grammatical forms and comprehending a reading text, it was first hypothesized that reading comprehension would be negatively affected by the enhanced features. However, the results of this study showed no interruption in reading comprehension occurred by VIE. This is in line with findings from previous studies by Wong (2003), Leow (2001), Leow et al. (2003) and LaBrozzi (2016), which found no negative effects of VIE on reading comprehension. No significant differences between the VIE groups and the control group in reading comprehension post-test results indicate that comprehension was not interrupted by the enhancement on either English relative clauses or articles.

The two grammatical features selected for this study share the characteristics of low communicative value. In previous VIE studies (Alanen, 1992; Park & Nassif, 2014), VIE on grammar forms with lower communicative value hinders the processing of both form and meaning. The current result seems to contradict the findings from the previous studies. One possible explanation for the difference can be found in the participants' unfamiliarity of the selected target forms. That is, those studies examined a semi-artificial Finnish consonant alternation (Alanen, 1992) and Arabic forms of dual pronoun (Park & Nassif, 2014), which were not only the features with low communicative value but also the forms that are unfamiliar for the participants. However, unlike the participants in the two studies, the participants in the current study are likely to be very well familiar with the two target forms, since they are university students who have been studying English for more than 10 years. Thus, even though the communicative value of the two forms in this study is low, the participants in this study were probably able to comprehend the text without interference by the enhancement.

As for noticing the forms, most of the participants in the two VIE groups reported that they noticed the forms while reading the text. In the relative group, fifteen out of sixteen participants commented that they noticed the enhancement on relative clauses. In the questionnaire, the participants pointed out a usage that relative clauses modify the noun that comes before them and provide additional information. In the article group, eleven out of sixteen participants commented that they noticed the VIE on articles, and many commented on the usage of articles. They focused on whether the following noun has been first mentioned or has been mentioned before. Such comments in the two VIE groups indicate that VIE effectively drew learners' attention to the target forms and they were aware of the target features.

The impact of VIE on grammar learning was found in this current study, though a different type of knowledge improved depending on a specific target grammar form. The result of the immediate posttest GJT scores shows that VIE on relative clauses was effective in improving receptive knowledge, though it was not effective for productive knowledge. The positive effects of VIE on relative clauses in receptive knowledge may have been attributed to the saliency of the target linguistic form among other characteristics of the form. According to Goldschneider and DeKeyser (2001), the perceptual salience of a linguistic feature plays an important role in acquiring the target form. In the FIB test, however, because participants had to fill in a specific relative clause in the blank, more in depth understanding of the form might have been needed.

VIE on articles showed different results compared to VIE on relative clauses. Articles are considered as one of the most challenging grammatical features for Korean EFL learners, and even advanced Korean learners have difficulties in acquiring the English article system (Park, 2005). On GJT tasks, the distractors may significantly have interfered in detecting the article errors. However, in the FIB task where no distractors were provided, the participants may have utilized the knowledge on articles they obtained during the task. The participants' comments in the article group support such claims. In the questionnaire, they reported that they were aware that the enhancements were on articles and that while reading, they compared the usage of definite and indefinite articles in a given situation. VIE on articles might have led the participants to reinforce the basic characteristics of the article usage; as a consequence, they were able to outperform the control group in the FIB test assessing productive knowledge.

The relative group and the article group did not show any significant difference compared to the control group in any delayed posttests. This result indicates that learners should be provided with multiple VIE exposure for long-term effects. Considering the finding that a single VIE treatment was effective in the immediate improvement of grammar learning, multiple VIE treatments would have a considerably larger impact.

5.2. Working Memory Capacity as Individual Variable

The third research question dealt with the relationship between working memory capacity and the effectiveness of VIE. WM capacity as an individual variable has been widely discussed in instructional settings. Given the theoretical assumption that learners' working memory contributes to their allocation of attention (Robinson et al., 2012), possible associations between working memory capacity and the effects of VIE were examined. In this study, it was assumed that learners with high WM capacity would process visually enhanced grammatical forms more efficiently while they are reading for meaning.

When combining WM storage and processing scores, no discernible pattern was found

between individuals with high and low WM abilities. However, when looking into the two subcomponents, separately certain trend was observed. First, although statistical analyses showed no significant results, the descriptive data of WM storage scores shows a general tendency that in both groups high WM participants outperformed their counterparts in delayed posttests. This implies that students who have a bigger memory storage might benefit more from VIE in the long-term, although this claim should be supported with more data since the number of participants in each WM group was only five.

As for WM processing ability, the high WM processing participants in the relative group showed slightly higher scores in both GJT, indicating that learners with high WM processing ability would process VIE forms more efficiently. With regard to the article group, it showed a significant difference between the participants with high and low WM processing ability in FIB. This finding suggests that working memory plays a facilitative role in grammar learning. The connection between the subcomponent of WM capacity and grammar learning has not been dealt with in previous research. However, due to the small data, further empirical investigation is needed to better understand the connection between VIE and WM processing ability.

The present study provided potential empirical evidence for the theoretical assumption that learners' working memory is related to how effectively they allocate their attentional resources (Robinson et al., 2012). Moreover, this study also showed a potential connection between individual differences in working memory processing ability and grammar learning, and there is a possibility that WM processing and storage ability are linked to VIE.

6. CONCLUSION

This study examined the effect of visual input enhancement and working memory on reading comprehension and grammar learning by Korean EFL learners. The results from this study showed no negative effect on reading comprehension, but an overall positive effect on grammar learning. When VIE was applied to relative clauses, students outperformed the control group in the immediate GJT. VIE on articles helped the participants to produce articles correctly in sentences. Working memory capacity in general did not show a significant impact on the efficacy of VIE. However, the processing component of WM played an important role in effective grammar learning for the article group.

There are several limitations in this study. First, since this study was conducted in real language classrooms, the researchers were able to give only one treatment session for the VIE groups. Further studies need to be conducted to examine the effect of multiple treatments of VIE on grammar learning. Second, the duration of the treatment session was too short to ensure that VIE operated on long-term memory. Participants read the text for

less than ten minutes, which indicates that the time exposed to the VIE was not sufficient. Although the relative and article groups showed some change in their development of the target form, no long-term effect was verified through this study. Thus, research on the appropriate amount and duration of VIE treatment would be warranted. The last limitation to take into account is a small sample size for each working memory group. In both the relative and article groups, only five participants for both high and low working memory groups, respectively, were compared. Nevertheless, this study found some evidence that the higher WM storage and processing ability the participants have, the better they performed in their grammar learning. With more participants in each WM group, the relationship between WM and the efficacy of VIE needs to be retested for a stronger claim.

Despite these limitations, the present research highlights the value and use of VIE in developing L2 grammatical features and expands on the limited existing research about the relationship between VIE and working memory capacity. It demonstrated that VIE may be beneficial in different aspects of grammatical knowledge depending on a target structure. The pedagogical implication is that drawing learners' attention to target grammatical forms through VIE can help them improve L2 grammar. This VIE technique can be applied to real classroom settings, where teachers can use the materials which highlight the important target forms in reading comprehension texts. The findings of this study support the claim that VIE is a practical instructional strategy for language learners. Although composite WM capacity did not show any significant effect, this study demonstrates the potential link between VIE and WM processing ability. Considering that working memory is one of the most important factors affecting learners' performance, more research into the relationship between the VIE and working memory capacity needs to be conducted.

Applicable level: Tertiary

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APPENDIX A

Grammaticality Judgement Test Samples

Relative Clauses

1. Architecture is an academic subject in which many European people have an interest. (O)
2. Hemingway developed a prose style by which influenced an entire generation of authors. (X, by which → which)
3. There are many pictures of famous celebrities in magazines who styles teens want to follow. (X, who → whose)

Articles

1. John's friends had a farewell party for him last Friday. (O)
2. Taking a hot bath is the good way to relax. (X, the → a)
3. They've changed a date of the meeting. It's next Tuesday. (X, a → the)

APPENDIX B

Fill-in-the-blank Test Samples

Relative Clauses

1. The machine _____ broke down a month ago has been repaired now. (which, that)
2. They saw the student _____ they had a higher score than. (whom)

3. That man over there, _____ name I don't remember, is an artist. (whose)

Articles
I just received (1) _____ (a) postcard from the Robinsons, a family I met last year. It made me start thinking: When was (2) _____ (the) last time I actually sent (3) _____ (a) letter or (4) _____ (a) postcard to someone?

APPENDIX C

Working Memory Capacity Samples

Processing Sentences
1. Andy was stopped by the policeman because he crossed the yellow heaven. (X)
2. During winter you can get a room at the beach for a very low rate. (O)
3. People in our town are more giving and cheerful at Christmas time. (O)

Storage Words
1. ring 2. music 3. bag