Analogical Transfer in EFL Reading Comprehension: 
The Roles of Similarity Types and Causality Between Texts

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Abstract

The present study investigated how the similarity features between texts (i.e., similarity types, causality) and L2 reading proficiency affect EFL learners’ reading comprehension through analogical transfer. To clarify the process of analogical transfer as well as the quantity and quality of information comprehension facilitated by this process, a recognition test and recall task were administered. The results showed that analogical transfer occurred in EFL reading comprehension. However, each process in the series was influenced by different factors. Accessing and mapping processes were driven by the causality between texts. Meanwhile, the process of encoding the analogical information to the EFL learners’ text representations was mainly driven by the surface similarity between texts. Moreover, it was revealed that the transfer of causal structure from the source analog to the target representation effectively enhances text comprehension, but it requires a certain level of L2 reading proficiency.

1. Introduction

1.1 Background

In order to understand new information when reading, we often utilize similar concepts or situations derived from our prior knowledge. The cognitive process in which a well-known domain (i.e., source analog) is applied to a new domain (i.e., target information) is called analogical transfer. Many studies have established that analogical transfer works as a powerful mechanism for promoting the learning of new information through reading, conceptual change and problem solving (Blanchette & Dunbar, 2002; Gentner & Markman, 1997; Holyoak & Koh, 1987). Thus, reading to learn new information requires one to understand the relevant concepts in a similar domain, as well as to interpret the relations between those concepts. Previous research has demonstrated the knowledge effect in learning from text: readers who have more knowledge of the text topic tend to show better comprehension and learning from texts (Braasch & Goldman, 2010). However, it often happens that learners who are reading to learn do not have sufficient prior knowledge, and have difficulty making the relevant connections between the target and analogous domains. To begin with, it has been pointed out that it is difficult for EFL learners to
activate their prior knowledge, since it is higher-level text processing that requires cognitive resources such as attention and working memory (Nassaji, 2003).

One solution to this difficulty is to provide an analogical text as an advance organizer. The effects of giving an analogy prior to reading the target text could be explained in terms of two major points: (a) the activation of relevant knowledge and (b) the analogy as a basis for constructing a text representation, which assists learners in higher-level text processing. As for point (a), learners are able to compensate for the lack of prior knowledge by using analogical text information. Since information from the analogy activates the relevant schema at the same time, it is easier for them to construct a text representation. Taniguchi (1988) suggested that showing an analogy activates the readers’ schema related to sentence information, and understanding is then promoted by assimilating new information into the schema.

Point (b) is that analogical information serves as a basis for constructing a text representation and helps with reading comprehension. The target text and source analog share a similar propositional structure within the text, so if learners construct a basis for a text representation from a source analog in advance, it helps them construct the target text representation, because they have only to map the propositions and their relations to the target text onto the representation base of the source analog. According to the structure-mapping theory (Gentner, Loewenstein, & Thompson, 2003; Gentner & Markman, 1997), the comparison processes act to achieve a structurally consistent alignment between two representations. Structural consistency requires that the correspondences between the surface features and structural relations in two representations must satisfy one-to-one correspondence. Once a structural alignment has been established, readers can generate inferences about what is connected to the base structure but is not explicitly presented in the target (Day & Gentner, 2007).

Let us look at specific examples of how analogies facilitate the understanding of text. Consider first a story: A hunter who shoots an arrow at a hawk, but misses because the arrow does not have any feathers on it to help stabilize its flight. The hawk then gives the hunter some of its own feathers, and the hunter is so pleased that he promises not to hunt hawks anymore. Consider a second story: An aggressive country attacks its neighbor with missiles. The missiles fail to do any damage because they were poorly guided and missed their targets. The neighbor, which makes supercomputers, offers to sell some to the aggressive country. The aggressive country is appreciative and promises never to attack its neighbor again. These two stories differ in terms of surface features (e.g., hawk and arrow vs. countries and missiles) but share a similar structure. If learners had read the first story before reading the second story, information on the relations between propositions (e.g., A hunter shoots at a hawk with an arrow vs. An aggressive country attacks its neighbor with missiles) is activated and facilitates the structure mapping of the two stories. That is to say, readers can easily build connections between propositions by applying the propositional structure of the source analog from the first story, thus promoting the understanding of the target of the second story.
Concerning both points stated above, reading is a complicated process that is achieved through lower-level text processing such as word recognition, lexical access and syntactic parsing, and through high-level processing, which includes grasping sentence structure, constructing a propositional text representation, and the global understanding of discourse. Hence, for unskilled readers such as EFL learners, it is very difficult to reach a comprehensive understanding of the text. However, through the presentation of analogies, the activation of their schema and text structure construction should become easier, thus decreasing the cognitive burden on higher-level processing and making the process of reading easier for less proficient EFL readers. The author believes that it is very instructive for English teaching to clarify the facilitative effects of analogical transfer in EFL reading comprehension.

1.2 Review of Related Literature

Many previous studies have claimed that analogical transfer between the representations of the source analog and target is caused by two types of similarity: surface similarity, which refers to the semantic resemblance between the elements in the source analog and target, and structural similarity, which refers to the resemblance in the underlying system of relations between the source and the target elements (Blanchette & Dunbar, 2002).

These two types of similarity are defined based on three different levels of matches: entity match; first order relation (FOR) match; and higher-order relation (HOR) match (Gentner, Ratterman, & Forbus, 1993). The features of each match are explained as follows. An entity match refers to the minimal surface feature overlap of the entities involved in relations. Each entity shares the same categorical or semantic attributes in terms of the characters, physical objects, and locations (e.g., hawk vs. eagle; arrow vs. crossbow). A FOR match, the second level of match, involves events or other relations between entities. Its relations take two or more objects and a similar predicate (e.g., A hunter shoots at an eagle with an arrow vs. An aggressive country fires on a neighboring country with missiles). A HOR match, the third level, points to causal relations or other kinds of plot structure. It shares information such as characters’ actions and outcomes relevant to the causality between two storylines (e.g., an attack is made but fails; this causes the one being attacked to offer to provide an item to the attacker to help the attacker; this offer causes the attacker to be grateful and to promise not to attack again).

The similarity features of the analogical text are determined according to how these matches are shared between source analog and target text. Surface and structure similarities are separated by the presence or absence of entity matches. Also, FOR is basically part of either similarity type if these texts are analogous, whereas the causality of the two texts grows as the number of FOR and HOR matches increase. Table 1 briefly shows the combination of matches comprising each similarity feature.
Table 1 Components of Common Matches in Each Similarity Feature

<table>
<thead>
<tr>
<th>Causality</th>
<th>Surface similarity</th>
<th>Structural similarity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strong</td>
<td>Entity, FOR, HOR match</td>
<td>FOR, HOR match</td>
</tr>
<tr>
<td>Weak</td>
<td>Entity, FOR match</td>
<td>FOR match</td>
</tr>
</tbody>
</table>

Over the past 20 years, the role of surface and structural similarities in analogical transfer has been investigated through empirical research. Some of these studies have shown that analogical transfer is driven mainly by surface similarity (Gentner et al., 1993; Keane, 1987). For example, Gentner et al. (1993), using the recall paradigm, found that a source analog that shares many entity matches with the target text (as in the case of surface similarity) is more likely to lead participants to recall target text information compared with conditions in which only FOR is shared. In addition, they showed that a source analog that shares a HOR but had no entity matches (as in the case of structural similarity) is more likely to lead to reminding than conditions in which only FOR is shared. However, the effect of structural similarity was much smaller than that of surface similarity. In short, the results suggested that surface similarity plays a large role in analogical transfer, while the effect of structural similarity is relatively small.

On the other hand, subsequent studies have argued that structural similarity is also crucial for analogical transfer (Blanchette & Dunbar, 2002; Catrambone, 2002; Gentner & Markman, 1997). Catrambone (2002), for example, systematically manipulated the number of surface and structural similarities. His results involving reminding in recall tasks and reading time data indicated that surface and structural similarities affected the transfer process about as equally when a HOR match was shared in both conditions. When a HOR was not shared, though the effect of surface similarity continued, the effect of structural similarity decreased. This is a particularly insightful finding in terms of showing that the degree of causality (i.e., the presence of HOR) is the key factor in the use of structural similarity.

However, these past studies have only focused on whether text information could be retrieved, because they were conducted in psycholinguistic contexts. Thus, they have not clarified the issue of what kind of text information was left by analogical transfer in readers’ text representations after reading. Successful reading involves constructing a coherent representation of text. This is accomplished by actively integrating the important main ideas from text rather than detailed ideas of lesser importance (Graesser, Singer, & Trabasso, 1994). Therefore, it is useful in this study to examine the extent to which the important information remained with different similarity features. As stated above, the effect of enhancing information understanding and promoting text representation construction by analogical transfer has been addressed mainly in first language (L1) research. Few studies concerning this issue have been conducted in second language (L2) contexts. Furthermore, the L2 studies that do exist report that analogies did not aid in the L2 reading comprehension process because the addition of analogies to the target text
appeared to make the reading process even more multifarious (Brantmeier, 2005; Hammadou 2000). However, one limitation in these L2 studies was that surface and structural similarities between the target and source analog were not manipulated with any degree of precision. Also, as L2 reading proficiency was not given much consideration, it was not made sufficiently clear whether the effect of analogical transfer on EFL learners' reading varies with proficiency level.

Further, consideration should be given to the sequence processing by which the two types of similarity affect analogical transfer. Analogical transfer progresses through three basic steps: (a) accessing the source analog information relevant to the target; (b) mapping the components of the source and target; and (c) encoding the mapped information to the text representation (Holyoak & Koh, 1987). Figure 1 depicts the serial processes of analogical transfer. Blanchette and Dunbar (2002) have raised the possibility that the two types of similarity involve analogical transfer in different ways. They suggested that surface similarity mainly promotes the accessing and mapping processes while structural similarity influences mostly the encoding process. This issue has yet to be sufficiently studied, though it is crucial to understand the processes by which readers activate relevant information.

3 Overview of the Present Research

The purpose of the present research was twofold. The primary purpose was to investigate how much information (i.e., quantity) and what kind of information (i.e., quality) is facilitated through analogical transfer in EFL learners' reading comprehension. The secondary purpose was to reveal how similarity features such as the similarity types and causality of texts influence the process of analogical transfer (i.e., accessing, mapping, and encoding). The present study makes use of material in which the number of surface and structural similarities has been systematically manipulated, and incorporates participants' L2 reading proficiency into the experiment design as a between-subject factor. Furthermore, following the methodology of past research (Blanchette & Dunbar, 2002; Gentner et al., 1993), the processes of accessing and mapping in analogical transfer are explored using an immediate recognition task, and the encoding to text representation process is examined using a recall task. The following two research questions (RQs) were posed:

RQ1: Do the quantity and quality of information facilitated by analogical transfer differ according to EFL learners' L2 reading proficiency and similarity features between texts?

RQ2: Do the serial processes of analogical transfer differ according to EFL learners' L2 reading proficiency and similarity features between texts?
2. Method

2.1 Participants

A total of 46 Japanese university EFL students participated in this study. They were students from a national university with diverse majors: international studies, science and engineering, and education. All participants were divided into two proficiency groups based on their scores on an L2 reading proficiency test. Two students were excluded from the data analysis because their experimental scores were outliers, resulting in 44 students in the analysis (see 2.4 Scoring and Data Analysis for details).

2.2 Materials

(1) L2 Reading Proficiency Test: With regard to testing the participants’ English reading proficiency, all of the test items were adopted from the Society for Testing English Proficiency (STEP) pre-2nd, 2nd, and pre-1st Grade test (2007). The item numbers were 35, and only the reading section was used. When two items were deleted, Cronback’s alpha reliability was \( a = .82 \).

(2) Reading materials: Four sets of paired analogical texts were used. Each set consisted of a target text and four paired source analogs. The four source analogs were assigned four conditions, namely similarity type (surface vs. structural) x causality (strong vs. weak) based on the components of common matches in each similarity feature (the number of entity matches, FOR matches, and HOR matches; see Appendix A). In other words, a total of 20 narrative texts were used. Ten of the narrative texts used were modified versions of those found in Gentner et al. (1993), while six were modified from Catrambone (2002). The remaining four were by the author, written to conform to the same standards as the other texts.

<table>
<thead>
<tr>
<th>Target</th>
<th>Source analog</th>
</tr>
</thead>
<tbody>
<tr>
<td>Karla, an old hawk, lived at the top of a tall oak tree. One afternoon, she saw a hunter on the ground with a bow and some crude arrows that had no feathers...</td>
<td>Once there was an eagle named Salam who nested on a rocky cliff. One day she saw a sportsman coming with a crossbow and some arrows that had no feathers...</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Entity</th>
<th>FOR</th>
<th>HOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>hawk vs. eagle; bow vs. crossbow; feathers vs. tail-feathers...</td>
<td>Karla saw a hunter coming with a bow vs. Salam saw a sportsman coming with a crossbow...</td>
<td>An attack is made but fails; this causes the one being attacked to offer to provide an item to the attacker...</td>
</tr>
</tbody>
</table>

Note. The above represents one of the Text A pairs.
To manipulate the level of similarities in the texts, two raters identified the matches between the target and source analog. Following the methodology used by Catrambone (2002), entity matches were identified at the individual word level, FOR matches at the sentence level, and HOR matches at the text level, as shown in Table 2. The two raters scored the texts independently, and the resulting inter-rater agreement rate was 84.82%. All the disagreements were resolved through discussion. As for the results, surface similarity conditions \((M = 4.38)\) shared more entity matches than structural similarity conditions \((M = 1.25)\). The number of FOR matches by condition was, in descending order, surface-strong \((M = 5.75)\), structural-strong \((M = 4.75)\), surface-weak \((M = 4.5)\), and structural-weak \((M = 2.25)\). HOR matches were shared only in strong causality conditions. Accordingly, it is reasonable to conclude that the materials used in the experiment accurately reflect the similarity features shown in Table 1 in Section 1.2 above.

<table>
<thead>
<tr>
<th>Text pair</th>
<th>Target text</th>
<th>Source analog</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(A)</td>
<td>(B)</td>
</tr>
<tr>
<td>Words</td>
<td>79</td>
<td>79</td>
</tr>
<tr>
<td>Sentences</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>FKG level</td>
<td>5.1</td>
<td>5.5</td>
</tr>
</tbody>
</table>

*Note.* The FKG Level (Flesch-Kincaid Grade) Level was calculated with Microsoft Word 2007. The source analog values are the averages of the four texts that were paired with the target texts.

Also, some difficult words in the texts which were higher than Level 6 on *JACET 8000* (JACET, 2003) were replaced with plainer words. If there was no appropriate substitute word, an explanatory note was added. The number of words and the levels of readability were controlled in each target and source analog. After modification, all passages were between 79 and 95 words in length, contained five to six sentences, and ranged in readability from Level 5.1 to 8.3 on the Flesch-Kincaid Grade (see Table 3). The text conditions and the order of given texts were counterbalanced across the participants.

(3) Recognition Test Items: A recognition test was designed to examine the activation of analogical information by accessing and mapping in the participants’ memory. In the methodology used, the target and source analog were presented in series, but the participants were not directly informed of the link between the two stories. In the experiment, the participants read a source analog which included a statement which was not written in the target text. Immediately after reading the target and source analog (in that order) to their respective ends, three types of probe statements were provided, and participants were asked to judge whether each was in the target text or not. The three types of probe statements were as follows: (a) a *text statement* that was actually in the target text; (b) an *analogical statement* that was not in the target text but was information that drew upon
the source analog; and (c) a control statement that was not in the text and that was not related to the analogy (see Appendix B).

The most important type is (b) the analogical statement because the reactions to this statement represent the degree of activation by accessing and mapping between the two stories. For example, the analogical statement for Text A, “The hunter promised never to shoot at the hawk again,” was not written explicitly in the target text, although the source analog contained the sentence, “He (the sportsman) promised never to attack eagles again.” If the source information was activated when they read the target text, “yes” answer rates to the analogical statement would increase compared with the reaction to the control statements. Also, the text statements were set for the purpose of examining the sensitivity to the target text information compared with the information that was not present in the text.

2.3 Procedures

All tasks were administered to participants individually over the course of about 80 minutes. First, the participants took an L2 reading proficiency test, which took 30 minutes. Second, the reading of analogical texts was conducted on computer screens. Before reading the materials, participants read a practice text to make sure they knew how to operate the device. Each participant read the four sets of analogical texts, which were paired with one source analog and one target text. Texts appeared on the screen sentence by sentence using Super Lab Pro 4.0 for Windows and the successive sentences were displayed whenever the participants pressed the “advance” key in the Response Box, RB730. Third, a recognition test was conducted. After reading each source analog and target text pair to the end, the reading stimulus “***” was presented for 500 milliseconds (ms), and then the probe statement was displayed. Participants were required to answer whether the probe sentence was in the text or not as quickly as possible by pushing the “yes” or “no” key. The precise instructions were as follows: “You will read statements after reading two passages in succession, and you will have to answer whether each statement was or was not in the text that you read by pressing either the YES or NO key.” All analogical text pairs and probe statements were presented in random order. Afterwards, Yes-No comprehension questions were presented in order to verify that they understood these texts.

Finally, the recall task was administered. Participants were given four pieces of paper inscribed with the first story (source analog). Using it as a cue, they were instructed to write down the second story (target text), which they were reminded of in Japanese. There was no time limit set, but almost all participants took 20 minutes to complete this task.

2.4 Scoring and Data Analysis

Two participants were excluded from data since their mean score on the Yes-No comprehension questions was under 50%. Based on the L2 reading proficiency test scores, the rest of the 44 participants were divided into two proficiency groups by t test: an upper group (n = 21,
\[ M = 24.79, SD = 1.68 \] and lower group \((n = 23, M = 18.04, SD = 2.07)\), \(t(42) = 8.71, p < .001\).

As for the “yes” answer rates for the recognition test, a 3 (statement: text, analogical, control) \(\times\) 2 (similarity types: surface, structural) \(\times\) 2 (causality: strong, weak) \(\times\) 2 (proficiency: upper, lower) four-way mixed analysis of variance (ANOVA) was performed. The factor of proficiency was the between-subject factor, and the remaining three factors (statement, similarity types, causality) were within-subject factors.

For the scoring of the recall data, the target texts were divided into idea units (IUs) by two raters in accordance with Ikeno’s (1996) criteria. The inter-rater agreement was 96% and all disagreements were resolved through discussion. One point was given when each IU was correctly recalled. The two raters scored 30% of the recall protocols independently. Since the inter-rater reliability was sufficiently high \((r = .95)\), the remaining 70% of the protocols were scored by the author. Production rate data was calculated according to how many IUs out of the total were recalled. This data was analysed by a 2 (similarity types: surface, structural) \(\times\) 2 (causality: strong, weak) \(\times\) 2 (proficiency: upper, lower) three-way mixed ANOVA.

Additionally, in order to examine what kind of information remained in participants’ text representations relative to RQ1, all text information had to be divided into more important IUs (e.g., main ideas) and less important IUs (e.g., detailed information). A total of 10 graduate students who majored in English education helped with the task of importance rating. The degree of importance per IU for understanding text content was rated on a five-point scale. The mean of rated points was analyzed by cluster analysis using Ward’s method. All IUs were classified as more important IUs [range: 3.44-4.89] or less important IUs [range: 1.67-2.89]. Afterwards, the proportions of more and less important IUs in each reading relative to the participants’ recall data were compared with a four-way ANOVA that added information types (more important vs. less important) as a within-subject factor.

3. Results and Discussion

3.1 “Yes” Answer Rates for the Recognition Test

Table 4 shows the descriptive statistics for the “yes” answer rates. As a whole, the “yes” answer rate for analogical information was relatively high. To clarify how similarity features and L2 reading proficiency affect the processes of accessing and mapping, the responses to each probe statement were analyzed. A 3 (statements: text, analogical, control) \(\times\) 2 (similarity types: surface, structural) \(\times\) 2 (causality: strong, weak) \(\times\) 2 (proficiency: upper, lower) four-way mixed ANOVA revealed the significant main effect of probe types, \(F(2, 84) = 136.61, p = .001, \eta^2 = .765\). Moreover, it was shown that there was a significant three-way interaction among the statements, causality and proficiency, \(F(1, 42) = 5.27, p = .007, \eta^2 = .112\). The “yes” answer rates of each statement by proficiency and the degree of causality are presented in Figure 2. Multiple comparisons with the Bonferroni post-hoc test showed that, in strong causality conditions, the
upper group answered “yes” to the text statements ($p < .001$) and analogical statements ($p = .005$) more frequently than to the control statements. Also, the text statements yielded “yes” answers more frequently than the analogical statements ($p = .003$). In weak causality conditions, the same results were obtained: the answer rates to the text statements ($p < .001$) and analogical statements ($p = .023$) by the upper group were higher than those to the control statement. There was also a significant difference between the text and analogical statements ($p = .003$). These results indicate that the proficient learners were significantly more likely to respond that the text and analogical statements had been stated in the target texts when the relevant information could be accessed and mapped from the source analog regardless of causality between the two texts. The sensitivity of access to the information explicitly written in the target text was especially high.

Table 4  *Descriptive Statistics for the “Yes” Answer Rates*

<table>
<thead>
<tr>
<th>Similarity type</th>
<th>Causality</th>
<th>Proficiency</th>
<th>Text $M$</th>
<th>SD</th>
<th>Analogical $M$</th>
<th>SD</th>
<th>Control $M$</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface</td>
<td>Strong</td>
<td>Upper</td>
<td>.90</td>
<td>.30</td>
<td>.57</td>
<td>.50</td>
<td>.00</td>
<td>.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lower</td>
<td>.74</td>
<td>.49</td>
<td>.52</td>
<td>.51</td>
<td>.09</td>
<td>.28</td>
</tr>
<tr>
<td></td>
<td>Weak</td>
<td>Upper</td>
<td>.86</td>
<td>.36</td>
<td>.48</td>
<td>.50</td>
<td>.10</td>
<td>.31</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lower</td>
<td>.76</td>
<td>.21</td>
<td>.38</td>
<td>.51</td>
<td>.00</td>
<td>.00</td>
</tr>
<tr>
<td>Structural</td>
<td>Strong</td>
<td>Upper</td>
<td>.95</td>
<td>.21</td>
<td>.43</td>
<td>.43</td>
<td>.00</td>
<td>.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lower</td>
<td>.78</td>
<td>.42</td>
<td>.48</td>
<td>.58</td>
<td>.09</td>
<td>.28</td>
</tr>
<tr>
<td></td>
<td>Weak</td>
<td>Upper</td>
<td>.81</td>
<td>.30</td>
<td>.24</td>
<td>.49</td>
<td>.00</td>
<td>.39</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lower</td>
<td>.66</td>
<td>.38</td>
<td>.35</td>
<td>.48</td>
<td>.17</td>
<td>.29</td>
</tr>
</tbody>
</table>

*Note.* The numbers in each proficiency group: upper group ($n = 21$); lower group ($n = 23$).

Much like the upper group, the lower group, in strong causality conditions, answered “yes” to the text statements ($p < .001$) and the analogical statements ($p = .008$) more frequently than to the control statements. However, there was no significant difference between the text and analogical statements. Furthermore, in weak causality conditions, the “yes” answer rates to the text statements were higher than those to the analogical ($p = .002$) and
control statements \((p < .001)\). One particularly noteworthy point is that there was no significant difference between the analogical and control statements \((p = .562)\). These results indicate that the sensitivity of access to the explicit text information had decreased. Also, the accessing and mapping process did not occur in lower group reading when causality was weak, because the analogical information was not activated in their minds.

In sum, the difference of similarity types did not influence the accessing and mapping process at all. More proficient learners were able to access analogical information and map the information from the source analog to the target regardless of the degree of causality. However, it was difficult for less proficient learners to perform accessing and mapping processes when the cue was not sufficient because the causality was weak.

### 3.2 Recall Rates

Table 5 shows the overall results of the recall rates produced in each condition. First, it was confirmed that there were no significant differences among the four texts A-D as the prerequisite for the following results did not lie in the differences in text difficulty. A one-way ANOVA with the text difference as a within-subject factor was conducted. It was confirmed that the four texts were equal in ease of reading comprehension, \(F(3, 129) = 1.15, p = .333, \eta^2 = .026\).

<table>
<thead>
<tr>
<th>Similarity type</th>
<th>Causality</th>
<th>Upper ((n = 21))</th>
<th>Lower ((n = 23))</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>M (\quad SD)</td>
<td>M (\quad SD)</td>
</tr>
<tr>
<td>Surface</td>
<td>Strong</td>
<td>.55 (\quad .15)</td>
<td>.52 (\quad .14)</td>
</tr>
<tr>
<td></td>
<td>Weak</td>
<td>.56 (\quad .16)</td>
<td>.49 (\quad .15)</td>
</tr>
<tr>
<td>Structural</td>
<td>Strong</td>
<td>.58 (\quad .19)</td>
<td>.36 (\quad .24)</td>
</tr>
<tr>
<td></td>
<td>Weak</td>
<td>.41 (\quad .23)</td>
<td>.39 (\quad .23)</td>
</tr>
</tbody>
</table>

Afterwards, to examine the quantity of remaining information in learners’ representations, learners’ recall performances were analyzed. A 2 (similarity types: surface, structural) x 2 (causality: strong, weak) x 2 (proficiency: upper, lower) three-way mixed ANOVA was performed. It revealed a significant main effect of similarity type, \(F(1, 42) = 12.6, p = .001, \eta^2 = .231\), and proficiency, \(F(1, 42) = \)

![Figure 3. The recall rates for each condition.](image-url)
4.58, \( p = .038, \eta^2 = .098 \). Also, there was a significant three-way interaction among similarity type, causality and proficiency, \( F(1, 42) = 6.47, p = .015, \eta^2 = .133 \). The recall rates for each condition are shown in Figure 3. Multiple comparisons of interactions with the Bonferroni test revealed that both the upper (\( p = .012 \)) and the lower (\( p = .048 \)) groups produced more target information based on surface similarity than structural similarity when causality was weak. Also, there was neither a significant difference between the upper and lower group nor strong causality and weak causality in surface similarity conditions. This indicates that the upper and lower groups produced the same amount of information regardless of the causality level in surface similarity conditions.

Meanwhile, in structural similarity conditions, the upper group’s recall performance based on strong causality was significantly higher than that of weak causality (\( p = .006 \)). Furthermore, there was a significant difference between the upper and lower groups (\( p = .002 \)) in structural similarity conditions and strong causality conditions. However, there was no significant difference between the two groups in weak causality conditions. As a result, in surface similarity conditions, both groups were able to recall nearly half of the target text contents (49-56%) regardless of the degree of causality. In contrast, in structural similarity conditions, only the upper group was able to recall a lot of information (58%), compared with the lowers group’s performance (36%), relative to strong causality. These results are quite suggestive because structural similarity refers to the resemblance in the underlying system of relations without semantic resemblance (i.e., shared FOR and HOR matches without entity matches). Therefore, the results show that although more proficient learners were able to encode much of the target information to their text representations with structural similarity as a basis for causal structure within two texts, it was difficult for less proficient learners. This suggests that information encoding based on structural similarity requires a certain level of L2 reading proficiency.

Next, to examine the quality of information which remained in the learners’ representations, their recalled contents were analyzed on the basis of importance-rating classifications (see 2.4 Scoring and Data Analysis for details). In regard to recall rates in each reading condition, a 2 (information types: more important, less important) × 2 (similarity types: surface, structural) × 2 (causality: strong, weak) × 2 (proficiency: upper, lower) three-way mixed ANOVA was performed. The results showed a significant main effect of similarity types, \( F(1, 42) = 13.13, p = .001, \eta^2 = .238 \), and information types, \( F(1, 42) = 116.78, p = .001, \eta^2 = .735 \). Moreover, there was a significant four-way interaction among information types, similarity types, causality and proficiency, \( F(1, 42) = 6.27, p = .016, \eta^2 = .131 \). Multiple comparisons of interactions with the Bonferroni test revealed that the upper group recalled both the more important (\( p = .021 \)) and less important information (\( p = .022 \)) in surface similarity conditions than in structural similarity conditions when causality was weak. However, when causality was strong, the effect was reversed for the upper group, yielding the production of more important information in structural similarity conditions (\( p = .028 \)). That is to say, the upper group recalled more important information based on causal relations (as opposed to less important information) in structural similarity conditions.
The task performance exhibited a significant difference between the upper and lower groups ($p = .011$). In contrast, the lower group produced both types of information in surface similarity conditions than they did in structural similarity conditions. Moreover, causality did not influence any type of information.

To summarize the results of the recall task, when surface similarities with semantic connections (i.e., many entity matches) were common to the target and source analog, the same amount of information was produced in both the upper and the lower groups, regardless of the strength of causality. Meanwhile, in structural similarity conditions, in which there were no entity matches, only the upper group produced the more important information, which was linked to strong causality. According to Langston and Trabasso (1999), it has been shown that it is more important information that has many causal connections with other propositions. In sum, it can be assumed that the understanding of the upper group improved as a consequence of their ability to construct causal relations between propositions and thus transfer them analogically to the target.

4. Conclusion

The goal of this research was to investigate whether analogical transfer occurs in the reading processes of EFL learners, and if so, whether it contributes to improvements in their text comprehension. The investigation was carried out with particular attention to the following two facets: the quantity and quality of information facilitated by analogical transfer (RQ1), and the serial process of analogical transfer (RQ2). As factors which influence these facets, the L2 reading proficiency of EFL learners and similarity features (similarity types and causality) between the target and source analog were examined.

First, with regard to RQ1, the results from the recall task showed the following findings: in surface similarity conditions, both upper and lower proficiency groups were able to recall about half of the text information (49-56%) regardless of causality level. Also, more information was yielded than in structural similarity conditions (39%, 41%) when causality was weak. However, in structural similarity conditions, the performance of the upper group (58%) was higher than that of the lower group (36%) when causality was strong. Meanwhile, the performance of the lower group in structural similarity conditions was consistently low. These results indicate that causal information and a reader’s L2 reading proficiency level are strongly related in the use of structural similarity. Also, the quality of recalled information represented in the upper group tended to include more important information when the causality was stronger under structural similarity conditions. This effect, which did not influence the lower groups’ production, arose because more proficient learners were more aware of the causal relations underlying the story they were reading. This promoted the analogical transfer of causally relevant information to similar text structures. To summarize these points, analogical transfer on the basis of surface similarity occurred easily, irrespective of L2 reading proficiency. On the other hand, analogical transfer based on structural
similarity occurred with a certain level of L2 reading proficiency and causality between the two texts as the key factors. This supports Catrambone’s (2002) suggestion that FOR matches are essential to the use of structural similarity.

Second, with regard to RQ2, the results from the recognition test showed that the upper group was able to activate analogical information regardless of causality level during reading. However, the lower group needed causal relations by way of shared FOR matches for activation. Thus, the accessing and mapping processes in analogical transfer were affected according to only causality and L2 reading proficiency level. The presence of semantic features via the sharing of many entity matches between texts did not influence the processes. Furthermore, as the recall performance indicated, encoding in analogical transfer was a complex process that involved similarity types, causality, and the L2 reading proficiency of learners. The surface similarity of texts promoted the encoding of a lot of information to their text representations regardless of causality or L2 reading proficiency level, while the structural similarity of texts became available as a cue only if causal relations were recognized effectively. Taken together, we can conclude that analogical transfer did occur in EFL reading comprehension. However, each process in the sequence was influenced by different factors. During reading, it was possible for accessing and mapping to be driven by causal relations between information even in the absence of common surface features. And, after reading, the process of encoding the analogical information to the text representations of EFL learners was mainly driven by the surface features of texts. Moreover, when surface similarity was lost, structural similarity enhanced the understanding of more important information, but its effect was restricted to the skilled learners.

Finally, the findings of the present study may have implications for teaching and future research. It was demonstrated that providing an analogical text with surface similarities as an advance organizer to EFL learners made it easier for them to understand the learning text. Moreover, as L2 proficiency levels increase, it would likely be effective to provide learners with analogical texts with structural similarities. It is educationally valuable to develop analogical transfer skills based on structural similarity, particularly because the process is similar to the way we use schemas in our daily lives. Analogical transfer and schemas have much in common, in that existing knowledge may be used to inform situations that are less well understood, and that both rely on structured representations to do so (Day & Gentner, 2007). Teaching and nurturing the ability to transfer analogically means cultivating strategic ways in which learners can apply their knowledge to new problems, concepts or situations that they need to understand. This study has shed some light on how the reading comprehension of EFL learners can be facilitated through the use of analogical information. As a limitation, this study was only used quantitative analysis and did not directly explore how EFL learners use their relevant knowledge in analogical text reading. In future research, therefore, the author hopes to use qualitative research to examine the relationship between the degree of prior knowledge regarding analogical texts and the EFL learners’ text comprehension.
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**Appendices**

**Appendix A: Materials Used in the Present Research (Text A)**

| Target | Karla, an old hawk, lived at the top of a tall oak tree. One afternoon, she saw a hunter on the ground with a bow and some crude arrows that had no feathers. The hunter took aim and shot at the hawk but missed. Karla knew the hunter wanted her feathers so she glided down to the hunter and offered to give him a few. The hunter was so grateful to Karla. (He promised never to shoot at hawk again.) He went off and shot deer instead. |
| Surface Strong | Once there was an eagle named Salam who nested on a rocky cliff. One day she saw a sportsman coming with a crossbow and some arrows that had no feathers. The sportsman attacked her but the arrow missed. Salam realized that the sportsman wanted her tail-feathers so she flew down and provided a few of her tail-feathers to the sportsman. The sportsman was pleased. (He promised never to attack eagles again.) (No. of matches: Entity 3, FOR 6, HOR 1) |
| Surface Weak | Once there was an eagle named Salam. She provided a few of her tail-feathers to a sportsman. So she promised never to attack eagles. One day Salam was nesting high on a rocky cliff when she saw the sportsman coming with a crossbow. Salam flew down to meet the man, but he aimed and shot her with a single arrow. Falling down to the ground, Salam realized that the arrow had her own tail-feathers on it. (No. of matches: Entity 3, FOR 3, HOR 0) |
| Structural Strong | Once there was a small country called Salam. It developed the world's smartest computer. One day Salam was attacked by its war-like neighbor country, Bolon. But the missiles were badly aimed and the attack failed. The Salam government realized that Bolon wanted smart computers. So they offered to sell some of their computers to the country. The government of Bolon was very pleased. Bolon promised never to attack Salam again. (No. of matches: Entity 0, FOR 5, HOR 1) |
| Structural Weak | Once there was a small country called Salam. It developed the world's smartest computer. Salam sold one of its supercomputers to the neighbor country, Bolon. So Bolon promised never to attack Salam. But one day, Salam was overwhelmed by a surprise attack from Bolon. Upon surrendering, the defeated people of Salam realized that the attackers' missiles had been guided by Salam's supercomputers. (No. of matches: Entity 0, FOR 1, HOR 0) |

*Note.* The underlined sentence in the target was actually omitted in the experiment and presented as probe statements. *Surface/ Structural* refers to the similarity types; *Strong/ Weak* refers to the causality conditions.

**Appendix B: Recognition Test Items**

(a) Text Statement “Karla knew the hunter wanted her feathers.”

(b) Analogical Statement “The hunter promised never to shoot at the hawk again.”

(c) Control Statement “The hunter tried to capture a live brown bear.”