Causal Explanation in EFL Readers: Memory for Causal Information is Necessary but Not Sufficient

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Abstract
This study explored EFL readers’ ability to produce a causal explanation of the text in light of their memory for causal information (CI), which is necessary for explaining the text. In L1 reading, memory for CI contributes to causal explanation, even in low-skill readers. In contrast, little is known about the relation between memory for CI and EFL readers’ actual ability to causally explain the text. In an experiment, ninety-eight university students with different L2 reading proficiency read an expository text. They took a recall test measuring memory for CI and a causal question eliciting a causal explanation of the text. The amount of the CI recalled was not significantly different between high- and low-proficiency readers. However, performance on the causal question was lower for the low-proficiency readers than for the high-proficiency readers, even when the analysis focused on the participants recalling all CI. The qualitative inspection revealed that the low-proficiency readers failed to understand the CI as a network, as a consequent of which they could not integrate the CI into one explanation. Together, the findings indicate that, in contrast to L1 readers, memory for CI is necessary but not sufficient for EFL readers to be able to produce a causal explanation.

Keywords: EFL reading, causal explanation, causal relations, text memory, expository text

Introduction
To assess how well students understand a text, teachers often instruct them to explain what the text communicates. For example, after students read an English text on how zero gravity environments cause heart shrinkage, teachers may elicit students’ explanation by asking, “Why does ‘staying in zero gravity’ lead to ‘the heart becoming smaller’?” This explanation technique, called causal explanation, is an effective indicator of readers’ deep-level comprehension (Coté, Goldman, & Saul, 1998; Millis, Todaro, & Magliano, 2006). An ability to causally explain situations in the text is closely linked to the understanding of causal relations in the text (called causal comprehension). Causal comprehension is vital for the construction of coherent mental representations, or situation models of the text (e.g., Hosoda, 2017; McCrudden, Schraw, & Lehman, 2009).

Previous research on first-language (L1) reading reported that the first and most important cognitive process for causal explanation is encoding information into memory that is necessary for explaining the text (Hua & Keenan, 2014). Readers must then causally integrate pieces of that information into one coherent idea (Millis et al., 2006; Ozuru, Briner,
In contrast to L1 research, little is known about how students learning English as a foreign language (EFL) formulate a causal explanation, or what factors make it difficult. Accordingly, no empirically valid evidence is available about how to effectively assist or promote EFL students to develop a causal explanation of the text. To fill in this gap, I designed this study to explore the cognitive nature of EFL readers’ ability to produce a causal explanation, with a focus on their memory for the information necessary for explanation. In addition to theoretical contributions, this goal has educational importance because the elicitation of a causal explanation is a frequently-used technique in the classroom, and prompting students to explain the text can facilitate their comprehension (Ozuru et al., 2010).

A Cognitive Account of Reading Comprehension and the Role of Causal Relations

Successful text comprehension involves readers’ understanding of various types of relations between events in the text (e.g., causal, temporal, special, and intentional relations), whereby pieces of the text are linked into a coherent whole (Kintsch, 1998). Among these relations involved in text comprehension, none has received more scrutiny than causal relations (e.g., Hosoda, 2017; McCrudden et al., 2009; Singer, Halldorson, Lear, & Andrusiak, 1992; Ushiro et al., 2015; Varnhagen, 1991). Causal relations are vital for text comprehension, as they constitute a necessary basis on which information can be logically and coherently interrelated. It has been empirically shown that (a) processing of causally related information is facilitated, compared to information linked by other types of relations (Singer et al., 1992), and (b) ideas having stronger causal relations with other ideas are better memorized and thus better retrieved later than other peripheral ideas (Varnhagen, 1991).

The significance of causal relations has motivated researchers to explore the extent to which causal comprehension is related to moment-by-moment (on-line) comprehension processes as well as resulting situation models in long-term memory (Hosoda, 2017; Millis et al., 2006). In this line of research, readers’ ability to causally explain the text has been used as an indicator of their causal comprehension (McCrudden et al., 2009; Ushiro et al., 2015). Specifically, a why-type question, called a causal question, is used (e.g., “Why does ‘staying in zero gravity’ lead to ‘the heart becoming smaller’?” for the text shown in Table 1). Based on verbal protocols by L1 readers, Millis et al. (2006) reported that readers who successfully provided a causal explanation to the causal question actively made causal links between the current and the prior text as they proceeded through texts. This indicates that causal explanation (elicited by the causal question) is closely linked to on-line processes pertaining to causal relations.

In relation to EFL readers, Hosoda (2017) used a causal question with Japanese university students. He first showed that students with high L2 reading proficiency (as indexed by scores on the reading subsection of the EIKEN test) explained an English text better than students with low L2 reading proficiency, showing that L2 reading proficiency impacts EFL readers’ ability to produce a causal explanation. Further, multiple regression analyses showed that the performance of causal explanation predicted the richness of situation models (measured by the problem-solving test) better than the EIKEN test scores. Together, these findings confirm the notion that readers’ causal explanation is a good indicator of causal
comprehension, which is in turn related to final situation models.

Potential Components of Causal Explanation: Memorization and Integration

As reviewed above, causal relations constitute a vital component of text comprehension, and readers’ causal comprehension is construed as their performance of causal explanation. Then, what is necessary for causal explanation? As noted in the introduction, valid empirical evidence is scarce about this question in the context of EFL. Nevertheless, past L1 research suggests that two potential cognitive components are involved (e.g., Graesser & Clark, 1985; Hua & Keenan, 2014).

The first component is the memorization of relevant information from the text; readers first have to understand and encode information into memory that is necessary for explaining the text. To illustrate, consider the causal question, “Why does ‘staying in zero gravity’ lead to ‘the heart becoming smaller’?”, about the text on effects of zero gravity environments on the human body (see Table 1). To answer this question, readers must have a series of information that is causally related to the heart shrinkage available in memory (e.g., blood and water go to the upper body, the body feels a flood of fluids, organs try to reduce the body water, the body water level decreases, and the heart does not work strongly). In this article, these pieces of information necessary for formulating a causal explanation are termed causal information (CI).

Table 1

Experimental Text in This Study

When people first considered space travel they did not know how the zero gravity of space would affect humans. The human body is a complex system that automatically responds to the lack of gravity

While in space, the body is not affected by gravity. Therefore, blood and water do not travel to the lower parts of the body, especially the legs. Instead, the blood and water within the body move to the upper body. Because the blood and water travel to the upper parts of the body, the body feels like the chest and head are filled with blood and water. The heart and lungs send messages that the amount of blood and water in the upper part of the body must be reduced. As a result, space travelers do not feel thirsty, and therefore, space travelers drink less water. Body water is eliminated, and the body water levels become lower than normal. When the amounts of blood and water decrease, it becomes more difficult for the human body to work normally. The heart pumps less blood than normal. Therefore, the heart does not need to work as hard as it does on Earth. As a result, the heart becomes smaller.

Studying the effects of space travel on humans can help us better understand many illnesses such as high blood pressure and other heart problems.

It has been shown that memory for CI is indeed a key for producing a causal explanation in L1 readers. In Hua and Keenan’s (2014) experiment, L1 skilled and less-skilled readers read expository texts and took a recall test (assessing memory for CI), followed by causal questions. Overall, performance of explanation was higher for skilled than for less-skilled
readers. However, when the analysis focused on the readers recalling all the CI, the less-skilled readers were found to produce explanation that was as well developed as the skilled readers’. This result means that memory for the CI allowed the less-skilled readers to achieve equal explanation performance to the skilled readers.

The second component of causal explanation is integration; causal explanation involves integrating the memorized CI into one coherent idea (Millis et al., 2006; Ozuru et al., 2010). More specifically, this integration process cognitively requires that readers possess relevant information in such a way that pieces of the information are meaningfully and coherently interrelated, not separately stored, in memory. Such an organization of memory, consisting of links shared by multiple pieces of information, are called memory networks (Graesser & Clark, 1985). The necessity of memory networks in the integration process can be understood with reference to the fan effect (Anderson & Reder, 1999). The fan effect is a phenomenon where a large amount of information is haphazardly activated when a stimulus (e.g., a question) is given, reducing the availability of each information for the subsequent use (e.g., using the information to answer the question). To avoid the fan effect, one must have relevant information in a networked way so that activation can converge on the most relevant information to the question.

Importantly, building such memory networks may be constrained by readers’ L2 reading proficiency. This is mainly because low-proficiency L2 readers tend to understand each word or sentence separately, due to their under-developing basic reading skills (e.g., word decoding and syntactic processing; Horiba, 2000; Hosoda, 2014). For example, Ushiro et al. (2015) reported that low-proficiency EFL students recalled text ideas in a more separate manner than did high-proficiency students. This finding was interpreted to indicate that the low-proficiency students failed to make coherent links between pieces of text information. Based on this observation, it is necessary to examine whether and how L2 reading proficiency affects EFL readers’ memory networks, which are necessary for integrating the CI into one explanation.

**The Present Study**

The goal of this study is to reveal the cognitive nature of EFL readers’ ability to produce a causal explanation of the text in light of readers’ memory for CI. The following research question (RQ) was addressed.

**RQ:** Does the relation between memory for CI and causal explanation in EFL readers differ by readers’ L2 reading proficiency?

As mentioned in the previous section, L2 reading proficiency may influence how well readers build memory networks of text information (Ushiro et al., 2015), as well as their performance of causal explanation itself (Hosoda, 2017). Given the view that the possession of memory networks of relevant information is necessary for the integration of that information into an explanation (Anderson & Reder, 1999), it is possible that low-proficiency L2 readers with inefficient memory networks may struggle to use memorized CI to develop a causal explanation. The present RQ addressed this possibility.

Regarding the methodologies, I used a causal question to elicit participants’ causal
explanation. I also used a recall test to assess participants’ memory for CI. Additionally, to gain a more detailed view of the nature of EFL readers’ text memory and a causal explanation, I examined participants’ recall and explanation protocols using both qualitative and quantitative approaches (see the Analysis section).

Method

Participants

Ninety-eight Japanese EFL students at a national university in Japan participated in this study. Their majors were humanities, education, international studies, phycology, and physics. According to their self-reports, they had a mean TOEIC test score of 692 (SD = 70.88, Min/Max = 420/925). Their overall English proficiency was estimated to be beginner-intermediate to advanced, or CEFR A2 to B2 levels (Council of Europe, 2001; Tannenbaum & Wylie, 2013).

The participants were classified into high- and low-proficiency groups (hereafter, high and low groups, respectively, for the sake of simplicity), according to their performance on the L2 reading proficiency test (see below; M = 13.23, SD = 4.74, Min/Max = 4/26). A median split technique was used to form these groups (Mdn = 13). Forty-eight participants, who scored the median or higher, constituted the high group (M = 17.31, SD = 2.98, Min/Max = 13/26). The other 50 participants, who scored below the median, formed the low group (M = 9.32, SD = 2.03, Min/Max = 4/12). An independent t-test proved that the high group scored significantly better than the low group, t(96) = 15.57, p < .001, d = 3.15.

Materials

L2 reading proficiency test. Twenty-six items from the reading section of the second (k = 20) and pre-first grads (k = 6) of the EIKEN test constituted the L2 reading proficiency test. This study was interested in the participants’ comprehension ability at a discourse level, not at a lower level (i.e., word and syntax). Therefore, this test consisted of items assessing how appropriately and adequately participants understood English written discourse, not specific knowledge of vocabulary or grammar. The EIKEN test was adopted because this is widely used by Japanese English teachers as well as past EFL reading studies to test EFL readers’ discourse-level comprehension, and its reliability is generally confirmed (e.g., Hosoda, 2017; Ushiro et al., 2015). The reliability of the present test was acceptable, Cronbach’s α = .81.

Text. An expository text, discussing how the human body is affected by lack of gravity, was employed from past expository text comprehension studies (Hosoda, 2017; McCrudden et al., 2009). Table 1 shows the text. This text was selected because its content is assumed not to be too difficult or unfamiliar to the present participants, given the fact that several past studies used it with similar populations of Japanese EFL students (Hosoda, 2017; Ushiro et al., 2015).

Low-frequency words corresponding to level 5 or over in the JACET (the Japan Association of College English Teachers) 8000 List (Ishikawa et al., 2003) were replaced with words of higher-frequency (level 4 or less) so that the participants would not experience much trouble with lexical-level processes. In addition, following criteria in Ushiro et al. (2015), the text was divided into 29 statements, each consisting of one predicate and one argument, for a scoring
purpose (see Appendix and the scoring section). Characteristics of the text are as follows: the number of words = 226, the number of sentences = 14, the mean number of words per sentence = 16.14, the Flesch-Kincaid grade level = 7.78.

**Causal question.** The causal question elicited the participants’ causal explanation with the instruction: “According to the text, why does ‘staying in zero gravity’ lead to ‘the heart becoming smaller’? Explain this by writing down relevant information as detailed as possible in a causally correct order.” This instruction was communicated both orally and visually in Japanese (the participants’ L1).

Note that the emphasis on explaining the text in as detailed a manner as possible was communicated to the participants. This was intended to avoid confounding caused by the omission of understood ideas from explanation. In a reproductive measure including the causal question, all that was understood was not necessarily produced. When a certain idea was omitted, it would be difficult to discern whether the absence of it was due to the participants’ intention or lack of understanding. Thus, I decided to ask the participants to provide detailed explanation by producing as many of the relevant ideas as possible.

**Procedure**

The experiment was individually conducted. First, the participants were informed of the purpose of the study, and informed consent was obtained. They were then asked to read the text for understanding (no specific information about post-reading tasks was given). After reading, a recall test was administered, followed by the causal question. Finally, the participants took the L2 reading proficiency test for 30 mins. The average time to complete the experiment was 70 mins.

**Scoring**

**Identifying causal information.** I identified CI that was necessary for explaining the text with reference to the causal diagram created by McCrudden et al. (2009) and Ushiro et al. (2015). As Figure 1 shows, the causal diagram lists eight pieces of CI (CI 1 “Lack of gravity” to 8 “Heart shrinks”), in a cause-effect order. This series of CI was confirmed by a pilot study of Ushiro et al. (2015) as necessary for explaining why zero gravity environments cause the heart to shrink. CI 1 and 8 were provided in the instruction (see the material section). Thus, the other six (CI 2–7) were considered. To specify where these six pieces of CI are located in the text, two raters identified 12 statements, presented in Table 2, that include information corresponding to each of CI 2 to 7 (inter-rater agreement = 92.3%). Disagreements were resolved through discussion.
Recall. Quantitative and qualitative approaches were used to assess the participants’ recall. First, we quantitatively examined how many of the six pieces of the CI in Figure 1 was recalled. Each of the CI gained a point, when a participant correctly produced the gist of at least one of the corresponding statements (Hua & Keenan, 2014). Taking CI 2 (“Body fluids shift headward”) for example, one point was equally given when a participant correctly produced the gist of Statement 8, Statement 9, or both. The data were scored by two trained raters (inter-rater agreement = 91.0%). Disagreements were resolved through discussion.

Subsequently, we qualitatively assessed recall by those participants who recalled all the six pieces of the CI (hereafter, All-CI participants),\(^1\) in order to examine their memory networks of the CI. In scoring, the three criteria were constructed based on literature on memory networks (Coté et al., 1998; Ushiro et al., 2015): (a) ideas leading to the direct cause of the heart shrinkage were provided, (b) information was sequenced in a causally and logically correct order, and (c) statements were cohesively and meaningfully interrelated. When all of these were satisfied, the participants’ recall was deemed as +Network (NT), meaning that they meaningfully and coherently interrelated the six pieces of CI in memory. When the participants failed at least one of these, their recall was deemed as -NT, meaning that they memorized the CI in a separate manner. Two trained raters scored the data (inter-rater agreement = 91.2%) with disagreements resolved through discussion.

Causal question. Performance on the causal question was also quantitatively and qualitatively assessed. For quantitative scoring, one point was given for each of the six pieces of CI that was produced in a causally correct order (Min/Max = 0/6; McCrudden et al., 2009). As long as the order was correct, a pair of CI was credited even when the intermediate CI between them was absent. However, CI that was scientifically incorrect, inconsistent with the
text, or provided in an incorrect order was not credited. To illustrate, consider the answer, “In space, people sense a lot of water in their body (CI 3), and the blood goes up (CI 2). So, the body tries to reduce the body water (CI 4), and the heart pumps less blood (CI 7).” This answer gains two points (CI 4 + CI 7); CI 2 and 3 are not credited as they are produced in a reversed order. The data were scored by two trained raters (inter-rater agreement = 92.7%) with disagreements resolved through discussion.

In addition, we qualitatively assessed the internal coherence of explanation protocols by the All-CI participants, in order to explore the relation between memory for the CI and the actual contents of explanations. In scoring, the three criteria were constructed based on Coté et al. (1998): (a) an explanation showed overall coherence without internal contradiction, (b) statements were consistent with the text and scientifically correct, and (c) a series of CI was cohesively produced. Explanations satisfying all of these were deemed as coherent, whereas explanations failing at least one of these were deemed as incoherent.

Analysis

Relation between memory for CI and causal explanation. Figure 2 gives an overview of the present study’s quantitative analysis. To answer the RQ (Does the relation between memory for CI and causal explanation in EFL readers differ by readers’ L2 reading proficiency?), I first focused on the moderation effect of L2 reading proficiency (hereafter Proficiency for simplicity) on the relation between recall rates of CI (CI Memory) and causal question performance.

**Figure 2.** An overview of the quantitative analysis.
A moderation effect is a certain variable’s effect on the relation(s) between other variables. For example, consider the situation in Figure 3 where CI Memory contributes to causal question performance when Proficiency is high, but not when Proficiency is low.

![Diagram](image)

*Figure 3. An example of Proficiency’s moderation effect on CI Memory’s contributions to causal question performance. The solid line shows the significant contribution, whereas the broken line shows the non-significant contribution.*

In this case, Proficiency moderates the relation between CI Memory and causal question performance; CI Memory’s effect on causal question performance differs by Proficiency. Thus, Proficiency’s moderation effect means Proficiency-related difference in the relation between CI Memory and causal explanation, which is central to the RQ.

This moderation effect is statistically operationalized by the interaction term created by multiplying a predictor (CI Memory, in this case) by a moderator (Proficiency; Jaccard & Turrisi, 2003). I tested this interaction term with a hierarchical regression analysis on causal question performance (Hosoda, 2017; Ozuru et al., 2010). In Steps 1 and 2, I entered L2 reading proficiency scores (Proficiency) and recall rates of CI (CI Memory), respectively, in order to examine their main effects. In Step 3, I entered the interaction term of CI Memory × Proficiency, created by multiplying recall rates of CI by L2 reading proficiency test scores. If the entry of this interaction term increases the model’s predictive power above and beyond the main effects of Proficiency and CI Memory, Proficiency moderates the relation between CI memory and causal question performance (Jaccard & Turrisi, 2003; Ozuru et al., 2010). All variables were centered to avoid the multicollinearity.

**Proficiency effect on the All-CI participants’ causal explanation.** Note that the regression analysis cannot directly clarify how well readers who sufficiently memorized the CI actually explained the text; what the analysis indicates is the strength of the relation between CI Memory and a causal explanation. To address this point, I focused on the All-CI participants and compared their causal question performance between the two proficiency groups (Hua & Keenan, 2014).

It must be noted that this analysis was limited to the All-CI participants. Therefore, the focus was not on the relation between recall rates of CI (always 100%) and causal question performance, but on the proficiency effect on causal question performance; that is, whether the high- and low-proficiency participants differed in causal question performance even when...
they had all the CI in memory (see Figure 2).

**Memory networks and the internal coherence of explanation.** Regarding memory networks, I compared proportions of All-CI participants who produced +NT recall between the high and low groups with a chi-square test. To help elucidate the intergroup difference, I report examples of recall protocols along with the statistical results.

Likewise, for explanation protocols, I compared proportions of All-CI participants who produced a coherent explanation between the two proficiency groups. As with memory networks, I report examples of explanation protocols along with the statistical results.

## Results

### Descriptive Statistics of Measures

Table 3 shows descriptive statistics of causal question performance and recall rates of the CI. For recall rates, there was no significant difference between the high and low groups, $t(96) = 1.70, p = .091, d = 0.34$.

<table>
<thead>
<tr>
<th>Proficiency</th>
<th>Causal question</th>
<th>Recall rates of the CI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$M$</td>
<td>95%CI</td>
</tr>
<tr>
<td>High ($n = 48$)</td>
<td>3.56</td>
<td>[3.18, 3.94]</td>
</tr>
<tr>
<td>Low ($n = 50$)</td>
<td>2.68</td>
<td>[2.39, 2.97]</td>
</tr>
</tbody>
</table>

*Note. Causal question performance ranges from 0 to 6."

Similarly, proportions of All-CI participants were not different between the two proficiency groups: the high group at 38% [18 out of 48 participants] and the low group at 26% [13 out of 50], $\chi^2(1) = 1.50, p = .221, \varphi = .12$. On the other hand, the high group significantly outperformed the low group in terms of causal question performance, $t(96) = 3.63, p < .001, d = 0.73$.

### Relation Between Memory for CI and Causal Explanation

**Regression analysis.** Table 4 shows correlations between measures. L2 reading test scores were moderately correlated with causal question performance, whereas the correlation between proficiency test scores and recall rates of CI was relatively weak.

<table>
<thead>
<tr>
<th>Measure</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Proficiency</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. CI Memory</td>
<td>.21*</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>3. CQ Performance</td>
<td>.41**</td>
<td>.49**</td>
<td>-</td>
</tr>
</tbody>
</table>

*Note. Proficiency = L2 reading proficiency test scores; CI Memory = Recall rates of CI; CQ Performance = Causal question performance. *$p < .05$. **$p < .01$."
Table 5 shows the results of the regression analysis. The Proficiency × CI Memory interaction was not significant. Conversely, CI Memory explained 14% of the variance of causal question performance, above and beyond a main effect of Proficiency. It was thus revealed that (a) Proficiency did not moderate the relation between CI Memory and causal explanation, and (b) CI Memory contributed to explanation performance irrespective of L2 reading proficiency.

Table 5
Hierarchical Regression Analysis on Causal Question Performance

<table>
<thead>
<tr>
<th>Step (Predictor)</th>
<th>β</th>
<th>R²</th>
<th>ΔR²</th>
<th>F for ΔR²</th>
<th>p for ΔR²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1 (Proficiency)</td>
<td>.30**</td>
<td>.17</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Step 2 (CI Memory)</td>
<td>.45**</td>
<td>.34</td>
<td>.17</td>
<td>25.07</td>
<td>.001</td>
</tr>
<tr>
<td>Step 3 (Proficiency × CI Memory)</td>
<td>.08</td>
<td>.35</td>
<td>.01</td>
<td>.92</td>
<td>.340</td>
</tr>
</tbody>
</table>

Note. **p < .01.

**Proficiency effect on the All-CI participants’ causal explanation.** Table 6 shows descriptive statistics of causal question performance in the All-CI participants. Causal question performance was still significantly higher for the high group than for the low group with a large effect size, t(29) = 2.90, p = .007, d = 1.05. This result indicates that even when all the CI was recalled, the low group’s causal explanation was still less developed, compared to the high group’s. To further explore this finding, the following sections report the qualitative results from recall and the causal question.

Table 6
Descriptive Statistics of Causal Question Performance in the ALL-CI Participants

<table>
<thead>
<tr>
<th>Proficiency</th>
<th>M</th>
<th>95%CI</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>High (n = 18)</td>
<td>4.33</td>
<td>[3.68, 4.99]</td>
<td>1.41</td>
</tr>
<tr>
<td>Low (n = 12)</td>
<td>2.85</td>
<td>[2.08, 3.61]</td>
<td>1.45</td>
</tr>
</tbody>
</table>

Note. Causal question performance ranges from 0 to 6.

Qualitative Analyses Results From the All-CI Participants

Memory networks. The results from the qualitative analysis revealed that 78% (14 out of 18) of the All-CI high group produced +NT recall. In contrast, 62% (8 out of 13) of the All-CI low group produced −NT recall. This intergroup difference was statistically significant, χ²(1) = 4.92, p = .027, φ = .40, indicating that the low group’s recall was significantly less networked than the high group’s.

Specifically, the analysis revealed two characteristic patterns for the low group’s recall. First, 46% (6 out of 13) of the All-CI low group produced a series of CI in a causally incorrect order. For example, one participant exhibited, “In zero gravity, the body sends a message that the heart does not have to work hard. Because of this, water and blood do not travel to the lower body, especially legs.” As to the underlined part, the weakening of heart functioning in
space is in reality an outcome of the body water not going to the lower body, not a cause. 
Second, 38% (5 out of 13) of the All-CI low group recalled CI in a list like manner without 
interrelating them. An example is “There is no gravity in space. One does not drink water in 
space. Water and blood goes up. The heart circulates less blood.” Here, ideas are just 
individually listed with no connectives among them.

**Coherence of explanation protocols.** The scrutiny into the internal coherence of 
explanation protocols revealed that 78% (14 out of 18) of the All-CI high group produced 
coherent explanations. Oppositely, 69% (9 out of 13) of the All-CI low group produced 
explanations lacking the internal coherence. This intergroup difference was significant, \( \chi^2(1) = 6.85, p = .009, \phi = .47 \), indicating that the low group was behind the high group in terms of the 
coherence of explanations.

Specifically, this analysis revealed two characteristics for the low group’s explanations. 
First, explanations by 46% (6 out of 13) of the All-CI low group consisted exclusively of two 
ends of the CI, namely, CI 2 (“Body fluids shift headward”) and 7 (“Heart does not work 
normally”). An example by one participant is “Because water goes to the upper body in space 
(CI 2), the heart does not need to circulate the blood (CI 7).” To examine this pattern in more 
detail, proportions of the All-CI participants whose explanations correctly included each of CI 
2 to 7 were computed. Table 7 shows the results. Fisher’s exact tests revealed significant 
tergroup differences in these proportions for CI 3 (“Body senses flood of fluids”) and for CI 
6 (“Decreased body fluid levels”). This means that these two pieces of CI posed specific 
difficulty for the low group to integrate into an explanation.

Table 7

*Proportions of the All-CI Participants Who Correctly Produced Each CI in the Causal Question*

<table>
<thead>
<tr>
<th>CI</th>
<th>High group (n = 18)</th>
<th>Low group (n = 13)</th>
<th>( p ) of Fisher’s exact tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>17 (94)</td>
<td>11 (85)</td>
<td>.558</td>
</tr>
<tr>
<td>3</td>
<td>16 (89)</td>
<td>5 (38)</td>
<td>.006</td>
</tr>
<tr>
<td>4</td>
<td>8 (44)</td>
<td>3 (23)</td>
<td>.275</td>
</tr>
<tr>
<td>5</td>
<td>7 (39)</td>
<td>2 (15)</td>
<td>.237</td>
</tr>
<tr>
<td>6</td>
<td>13 (72)</td>
<td>3 (23)</td>
<td>.011</td>
</tr>
<tr>
<td>7</td>
<td>18 (100)</td>
<td>12 (92)</td>
<td>.419</td>
</tr>
</tbody>
</table>

Second, 38% (5 out of 13) of the All-CI low group’s explanations included information 
irrelevant to what was stated in the text. An example is “In space, water in the body goes up. 
*Because no force is needed to support the body, muscles of the body become weaker.* So, *the 
functioning of the heart is reduced.*” The underlined part regarding the muscle loss associated 
with the lack of supporting force was not inferable, let alone stated, in the text. Further, the 
italicized idea that the body muscle loss impairs heart function does not align with the text; 
actually, the weakening of the heart is caused by a reduction in the body water. Thus, this 
participant included off-text information into an explanation.
Discussion

The regression analysis first showed that memory for the CI contributed to causal explanation (causal question performance). This is consistent with the notion that memory for the CI is a necessary component of formulating a causal explanation (Hua & Keenan, 2014). However, more importantly, even when all the CI was recalled, the low-proficiency readers produced a less-developed causal explanation than the high-proficiency readers; the All-CI low-proficiency readers showed significantly lower causal question performance than the All-CI high-proficiency readers. This finding contrasts with the L1 research that reported that when all the CI was recalled, less-skilled L1 readers exhibited explanation performance that was comparable to skilled L1 readers’ (Hua & Keenan, 2014). It is noteworthy that the All-CI low-proficiency readers scored on average less than half ($M = 2.85$, $SD = 1.45$) out of 6 for the causal question. This means that these readers failed to use the majority of the CI they had memorized to produce the causal explanation.

This result is explained by the qualitative findings in terms of the following two perspectives. First, the low-proficiency readers had difficulty building memory networks of the CI. This explanation comes from the fact that the majority of the low-proficiency readers produced recall lacking network organization. More specifically, the low-proficiency readers tended to recall the CI in a causally incorrect order or a list-like manner. These patterns indicate that those readers had a tendency towards misunderstanding the causal links between pieces of the CI (Coté et al., 1998). This observation partly aligns with the L2 research showing that low-proficiency EFL readers often separately understand pieces of the text (Ushiro et al., 2015).

A second explanation for the low-proficiency readers’ difficulty with causal explanation is that they had a problem with the integration of the memorized CI into one explanation. That is to say, the low-proficiency readers’ explanations often consisted of only two ends of CI (CI 2 and CI 7) or information that was irrelevant to the situation conveyed in the text. These patterns imply that the low-proficiency readers struggled to coherently integrate the six pieces of CI they had memorized into one idea, as a consequence of which they had to rely on only part of the CI or off-text information.

Together, these qualitative findings indicate that the low-proficiency readers had problems with (a) building of memory networks and (b) integration of the memorized CI. Here, it is important to note that readers must first encode relevant text information into memory before they are able to integrate that information into an explanation (Hua & Keenan, 2014; Ozuru et al., 2010). Given this fact, the low-proficiency readers’ difficulty with causal explanation is assumed to be rooted in the building of memory networks. This view is in line with the account provided by the fan effect, which posits that for relevant information to be appropriately activated in response to a given question, readers must store that information as a coherent network in their memory (Anderson & Reder, 1999). In sum, the low-proficiency readers’ difficulties can be broken down into the following three stages. First, they struggled to encode the CI into memory as a network. Second, due to the lack of memory networks, they failed to appropriately activate the memorized CI when the causal question was given. Third and finally, this activation problem led to their failure to integrate the memorized CI into one coherent explanation.
These observations together lead to the conclusion that in the context of EFL, memorizing necessary information after reading does not guarantee one’s actual ability to produce a causal explanation of the text. In other words, remembering causally important information does not mean causal comprehension in EFL readers. This picture of EFL readers again makes a contrast to that of L1 readers whose memory for CI more directly contributes to the ability to produce an explanation, even in less-skilled readers (Hua & Keenan, 2014). It seems that in EFL reading, understanding links between pieces of the text so that one can build networks of information is cognitively demanding, primarily due to the limitation of language proficiency, even when they can understand each piece of the text (Hosoda, 2014). This study has accordingly revealed characteristics of EFL readers’ causal explanation, highlighting the low-proficiency readers’ difficulty with integrative text comprehension.

In addition to the above findings, I must discuss several results that warrant careful interpretation. First, this study found no difference in quantitative recall rates of the CI between the low- and high-proficiency readers. This result is inconsistent with L2 studies that usually reported high-proficiency readers’ advantage in recall performance (e.g., Ushiro et al., 2015). This difference may be explained through the following two perspectives: (a) the amount of information required for recall and (b) causal connections CI shared with the other part of the text.

First, past L2 research’s recall usually targeted all the information in the text. Conversely, this study focused only on the six pieces of the CI. As such, the amount of information required for recall was smaller in the present study than in past research. This smaller amount of information might reduce the possible proficiency effect on recall rates.

Second, each of the CI had a relatively high number of causal connections to other information in the text. Such an increased number of causal connections are known to attract more of readers’ attention than other peripheral ideas (e.g., Varnhagen, 1991). Hence, simply encoding the respective CI into memory did not pose much demand to the participants as a whole. Indeed, both of the two proficiency groups recalled about 65 to 70% of the CI on average (specifically, the low group at 66% and the high group at 72%), which are generally higher than in past L2 research where recall rates were generally 20 to 40% (e.g., Horiba, 2013; Ushiro et al., 2015).

The second result requiring careful interpretation is that the information integrated into an explanation by participants seems to be constrained by the instruction given in the causal question. As noted in the method section, CI 1 (“Lack of gravity”) and 8 (“Heart shrinks”) were provided in the instruction. It seems that the CI that is immediately related to these two pieces of CI were easier to integrate than the less-related CI, as shown by the qualitative inspection into explanations. Specifically, CI 2 and 7, most immediately related to the instruction, were produced by most participants, regardless of proficiency (see Table 7). This means that the immediate relatedness to the instruction allowed the participants to readily integrate this set of CI into their explanations. On the other hand, CI 4 and 5, most distantly related to the instruction, were produced by less than half of the participants in both proficiency groups. Apparently, the distant relatedness to the instruction posed a difficulty for the participants as a whole. Finally, CI 3 and CI 6 fall in between these two extremes. They have modest relatedness to the instruction and caused different pictures for the different
proficiency groups: High-proficiency readers successfully integrated this set of CI into an explanation, whereas low-proficiency readers failed to do so (see Table 7).

As such, this study found that the integration process of causal explanation was affected by the relatedness to what was given in the instruction, and the modest relatedness caused different integration patterns for readers with different L2 reading proficiency. It is beyond the scope of this study to provide a conclusive explanation with regard to why the modest relatedness leads to specific difficulty for the low-proficiency readers. Successfully addressing this question will give a clearer picture of the integration process of causal explanation in EFL readers.

Conclusion

Summary of Findings

This study explored EFL readers’ ability to produce a causal explanation of the text in light of their memory for CI. The findings can be summarized into the following three statements. First, memory for the CI contributed to EFL readers’ causal explanation performance, irrespective of their L2 reading proficiency. Second, however, even when all the CI was recalled, the low-proficiency readers’ causal explanation was still less developed than the high-proficiency readers’. Third and finally, the low-proficiency readers’ difficulty with causal explanation was attributable to their failure to build memory networks of the CI; as a result, those readers failed to integrate the memorized CI into a coherent explanation.

Taken together, these findings indicate that memory for CI is indeed necessary, but not sufficient by itself for EFL readers to be able to produce a causal explanation of the text. This conclusion highlights important characteristics of causal explanation in EFL readers (as opposed to L1 readers) and thus, is worth translating into EFL reading instructions.

Implications for Reading Instructions

I interpret the findings to suggest a three-step reading instruction that is specifically aimed to promote EFL students’ causal comprehension. First, teachers should assess students’ causal comprehension with causal question(s). To promote causal comprehension, it is first necessary to identify the extent of students’ causal comprehension. Note that this study found that the mere recall of the CI from the text did not mean the ability to causally explain the text. Based on this finding, I recommend that teachers assess students’ causal comprehension by having students actually explain the text, rather than just confirming what they remember about the text. The causal question will usefully serve this purpose; the present findings, along with the cognitive account of causal relations (e.g., Millis et al., 2006), suggest that the causal question is a powerful way of revealing the extent of students’ causal comprehension.

Second, if students cannot explain the text well, teachers can ask students whether they remember causally important information from the text. Considering the present results, it is likely that, even when students cannot produce a coherent causal explanation, they may hold each piece of the CI in their memory. Hence, students should be encouraged to pay attention to the CI in a reflective manner. Factual questions specifically targeting the relevant CI would be useful to this end (e.g., According to the text, what occurs to the human body in zero gravity environments?). These questions can lead students to reflect upon what information is causally
related to the specific event.

Third and finally, explicit training should be conducted where students causally relate pieces of the CI to one another. The difficulty with causal explanation was found to reside in the building of memory networks of the CI. It is thus recommended that students be trained to consciously interrelate pieces of the CI so that they can understand links between them. For example, teachers can use a causal diagram in a blank format (see Figure 4).

![Figure 4. An example blank causal diagram.](image)

Students are asked to complete the diagram by filling in the blanks with corresponding text events. In this task, the need to visually reconstruct the text’s causal relations could draw students’ focus to links between the individual events. After completing the diagram, students can check networks of the CI visually. The deliberate implementation of this three-step instruction may develop students’ ability to better comprehend causal relations in the text.

**Limitations of This Study**

I conclude this article by discussing this study’s limitations and suggestions for future studies. Above all, this study employed only one simplified expository text. Given the lack of comparison to texts of varying difficulties or topics, it is difficult to generalize the present findings. Additional research is needed using several versions of authentic passages to replicate and advance the present findings.

It is also important to note that this study targeted text memory and causal explanation constructed after reading (*off-line*), without examining cognitive processes implemented during reading (*on-line*). An especially serious limitation is that the present study did not assess integrative on-line processing across multiple pieces of the text (e.g., bridging inferences). The difficulty experienced by the low-proficiency readers with memory networks was presumably related to such integrative processing. It is recommended that future research use on-line measures (e.g., eye tracking) to investigate processes employed during reading, as well as how such on-line processes are related to off-line performance.

Finally, this study did not examine strategies used by readers at the time of answering the causal question. For example, if a participant summarized CI for simplicity, the analyses used here could not assess the performance associated with it. Additional research is needed to directly assess strategies employed in EFL readers’ causal explanation. This can be achieved with a think-aloud method to examine contents of strategies of causal explanation.

Considering these limitations, this study is only a first step in conducting an empirical exploration into the cognitive nature of causal explanation in EFL readers. Future attempts addressing (a) various types of authentic texts, (b) on-line processes pertaining to causal
explanation, and (c) strategy use should constitute additional steps toward a better understanding of EFL readers’ causal explanation, as well as a cognitive account of L2 reading in general.

Notes

1 I also conducted the qualitative analyses on recall and explanation protocols for all the participants. The results found the same trends as for the All-CI participants: the recall and explanation protocols by the low group lacked network organization and internal coherence, respectively, more than those of the high group.

2 The logic underlying the creation of the interaction term is explained with reference to the regression equation below (the interaction term is in the bold face):

\[ Y = \text{CI Memory} \cdot \beta_1 + \text{Proficiency} \cdot \beta_2 + \text{CI Memory} \cdot \text{Proficiency} \cdot \beta_3 + \epsilon \]

This can be summarized in terms of CI Memory:

\[ Y = (\beta_1 + \text{Proficiency} \cdot \beta_3) \cdot \text{CI Memory} + \text{Proficiency} \cdot \beta_2 + \epsilon \]

It is shown in the first argument that the effect of CI Memory depends on Proficiency (CI Memory and Proficiency are in the same argument). The interaction term, created by the multiplication of recall rates of CI by L2 reading proficiency test scores, thus expresses the moderation effect of Proficiency on the relation between CI Memory and causal question performance. I thank the reviewer for commenting on this point.

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References


Appendix: Experimental Text Divided Into Statements

<table>
<thead>
<tr>
<th>No.</th>
<th>Statement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>When people first considered space travel they did not know how the zero gravity of space would affect humans.</td>
</tr>
<tr>
<td>2</td>
<td>The human body is a complex system that automatically responds to the lack of gravity.</td>
</tr>
<tr>
<td>3</td>
<td>While in space, the body is not affected by gravity. Therefore, blood and water do not travel to the lower parts of the body, especially the legs.</td>
</tr>
<tr>
<td>4</td>
<td>Instead, the blood and water within the body move to the upper body.</td>
</tr>
<tr>
<td>5</td>
<td>Because the blood and water travel to the upper parts of the body, the body feels like the chest and head are filled with blood and water.</td>
</tr>
<tr>
<td>6</td>
<td>The heart and lungs send messages that the amount of blood and water in the upper part of the body must be reduced.</td>
</tr>
<tr>
<td>7</td>
<td>As a result, space travelers do not feel thirsty, and therefore, space travelers drink less water.</td>
</tr>
<tr>
<td>8</td>
<td>Body water is eliminated, and the body water levels become lower than normal.</td>
</tr>
<tr>
<td>9</td>
<td>When the amounts of blood and water decrease, it becomes more difficult for the human body to work normally.</td>
</tr>
<tr>
<td>10</td>
<td>The heart pumps less blood than normal.</td>
</tr>
<tr>
<td>11</td>
<td>Therefore, the heart does not need to work as hard as it does on Earth.</td>
</tr>
<tr>
<td>12</td>
<td>As a result, the heart becomes smaller.</td>
</tr>
<tr>
<td>13</td>
<td>Studying the effects of space travel on humans can help us better understand many illnesses such as high blood pressure and other heart problems.</td>
</tr>
</tbody>
</table>