Lexical Inference Specificity and its Activation Level: Effects of Contextual Constraint and L2 Reading Proficiency

Akira HAMADA
Graduate School, University of Tsukuba

Abstract

When L2 learners encounter unknown words in a text, they must narrow down the possible inferable meaning of those words based on contextual information. However, it remains uncertain how specific meaning is strongly inferred according to a context during reading. This study examined how the strength of contextual constraint affected the specificity of activated lexical inference and its activation level in a semantic relatedness judgment task with 52 Japanese undergraduates. Two kinds of contextual constraint were distinguished: those that strongly constrained the inferable meaning of unknown words and those that did not. The results showed the complicated effects of contextual constraint and L2 reading proficiency on lexical inference specificity and its activation level. Specifically, in the strong constraint context, high L2 proficiency learners strongly activated the specific meaning of target words, while low L2 proficiency learners could not narrow the possible meanings down to the specific ones during reading. In the weak constraint context, the general meaning of target words was strongly activated regardless of the learners’ L2 reading proficiency. Together, these results suggest that teachers should understand the benefits of contextual constraint to the specificity of lexical inferences activated in reading comprehension for practical reading instructions.

1. Introduction

L2 learners are more likely to encounter unknown words in a text because of their small vocabulary knowledge. These words can create gaps in learners’ comprehension of the text’s meaning and prevent them from understanding explicit text contents. To close the gaps of text comprehension created by unknown words, various researchers have examined how learners make lexical inferences to identify the meaning of unknown words from a given context (de Bot, Paribakht, & Wesche, 1997; Haastrup, 1991; Hamada, 2012; Huckin & Bloch, 1993; Nassaji, 2006; Wesche & Paribakht, 2009). These studies have focused on how accurately learners can infer the intended meaning of unknown words and revealed the effects of various mediating factors on the accuracy of lexical inferences.
However, Ushiro (2010) suggested the importance of specificity in interpreting the meaning of unknown words during reading. In other words, learners have to control the extent to which they narrow down the possible inferable meanings of unknown words as they process the individual words in context. For example, let us consider the following sentence pairs with a pseudoword *sind* (van Assche, Drieghe, Duyck, Welvaert, & Hartsuiker, 2011, pp. 104–105).

a. The surfers were attacked by a dangerous *sind* in the sea.
b. The group was surprised by a large *sind* in the sea.

In sentence (a), learners should infer from the contextual information that the meaning of *sind* is “a shark.” If they can identify specific meanings of unknown words through such inferences, they can successfully comprehend the remainder of the text, including passages where the words appear again. In contrast, making a vague lexical inference from sentence (b), by which the learners broadly interpret the meaning of *sind* (e.g., something large in the sea), seems to be preferable rather than avoiding guessing the unknown word. This is because unknown words are cumulatively interpreted by the learner comprehending enough contextual information to identify the meanings (Huckin & Bloch, 1993). Thus, vague lexical inferences gradually change into specific ones as the learner receives additional contextual information about the unknown words.

These context-based lexical inferences to narrow down the possible meanings of unknown words are essential for successful reading comprehension. Given the clear importance of reading instruction based on learners’ on-line reading process (Ushiro, 2010), it is meaningful to reveal the on-line process of context-based lexical inferences from the viewpoint of specificity. The purpose of this study is to address this issue by expanding previous research on the effects of context on lexical inferences during reading.

1.1 Lexical Inferences in Reading

The process of making lexical inferences during reading has been examined by various research methods. Through the use of an eye-movement method, Chaffin, Morris, and Seely (2001) revealed that native (L1) readers make good use of contextual information in on-line lexical inferences. In their study, L1 readers initially spent a longer time processing an unknown word because they made more regressions out of the relevant contextual information back to an unknown word than to a known word. Based on these results, the researchers concluded that L1 readers use the informative contexts to infer the meaning of unknown words during reading comprehension.

In L2 research, many studies used a think-aloud method to verbalize the learners’ thinking while attempting to infer the meaning of unknown words from contexts (de Bot et al., 1997; Haastrup, 1991; Huckin & Bloch, 1993; Nassaji, 2006; Wesche & Paribakht, 2009). The protocols elicited by think-aloud clearly demonstrated that when learners encounter an unfamiliar word in a
text and recognize it as totally unknown, they often attempt to infer the meaning of the word from contextual information (de Bot et al., 1997; Huckin & Bloch, 1993). As in L1 research, the good use of contextual information is necessary for the success of lexical inferences (Huckin & Bloch, 1993; Nassaji, 2006; Wesche & Paribakht, 2009). However, some researchers have also indicated that higher L2 proficiency learners can integrate relevant contextual information into the meaning of unknown words based on their robust text comprehension (Haastrup, 1991; Wesche & Paribakht, 2009). In short, context-based lexical inferences require high L2 reading proficiency to comprehend contexts surrounding an unknown word.

According to Chaffin (1997), the inferred meaning of unknown words typically includes information about either synonyms or hypernyms of those words. For example, the lexical inferences activated from sentence (a) might be “a shark” as a synonym of *shark* or “fish” as a hypernym of *shark*. Following a hierarchical lexical network between hyponyms (e.g., *shark*) and hypernyms (e.g., *fish*), the former has more semantically specific characteristic than the latter (Miller, Beckwith, Fellbaum, Gross, & Miller, 1990; Rosch, Mervis, Gray, Johnson, & Boyes-Braem, 1976). Therefore, the present study considers the activation of synonymous meanings as a specific lexical inference, while a hypernymic inference can be defined as a general one.

Such specificity of activated lexical inferences is also affected by readers’ proficiency; Fukkink, Blok, and de Glopper (2001) demonstrated that L1 children with lower language proficiency than adults could not narrow inferable meanings down to specific ones. In particular, the children’s lexical inferences typically produced the widely interpreted meaning of unknown words, which easily matched contextual information in meaning. Additionally, their general lexical inferences developed into specific ones as their language proficiency improved. Thus, a strong relationship has been established between language proficiency and the specificity of meanings as activated by lexical inferences.

However, Fukkink et al. (2001) analyzed only the lexical inferences reproduced by retrospective questioning about the meaning of target words. Tapiero (2007) emphasized the importance of the activation level of inferences; namely, how strongly readers activate some inferences while reading. Moreover, her study showed that if readers activated inferences at a higher level, the activated inferences were fixed in their memory, leading to better reading comprehension. Even in the case of lexical inferences, it can be argued that activation level plays an important role in reading comprehension. Thus, in order to approach the on-line process of context-based lexical inferences, it is necessary to examine the effects of L2 reading proficiency on the specificity of activated meanings and its activation level during reading.

1.2 Effects of Contextual Constraint

In reading, words seldom appear in isolation, so readers have to interpret the words based on contextual information. Each word meaning in a text is woven into a context to construct a coherent message; this means that contexts have great effects on the interpretation of individual
words (Camblin, Gordon, & Swaab, 2007). Several studies have demonstrated that the interpretation of a word can be facilitated if a context is highly congruent with the word in meaning (Camblin et al., 2007; Chaffin et al., 2001; Griffin & Bock, 1998; van Assche et al., 2011). Again, let us consider sentences (a) and (b) from the viewpoint of the semantic congruity between the contextual information and pseudoword. If sind in sentence (a) represents its meaning as “a shark,” the meaning seems highly related to the contextual information. Compared to this, “a shark” as the meaning of sind has lower congruity with the message represented in sentence (b), because “something large in the sea” is not necessarily “a shark.”

This congruity between contextual information and word meanings is often defined as contextual constraint (e.g., Otten & van Berkum, 2008; van Assche et al., 2011). In sentence (a), the contextual information strongly constrains the inferable meaning of sind to “a shark.” In contrast, various interpretations remain of sind in sentence (b), because the context has a relatively weak constraint on its possible meaning. The effects of contextual constraint on the lexical inference processes have been also studied in Chaffin et al. (2001), whose Experiment 2 manipulated the strength of contextual constraint. Using eye-movement measures, Chaffin et al. showed that when contextual information strongly constrains the meaning of unknown words, the processing time of those words did not differ from that of high-frequency words. On the other hand, the L1 readers more frequently made regressive eye-movements when encountering unknown words in weak contextual constraint. These results demonstrate that the readers were so sensitive to the strength of contextual constraint that they could associate the contextual information with the unknown word meanings for reading comprehension. According to Otten and van Berkum’s (2008) further investigation, strongly constraining contextual information (e.g., The surfers were attacked by a dangerous…) allowed readers to anticipate the meaning of an upcoming word like sind; thus, the word was rapidly processed in the same way as high-frequency words are.

In research on Japanese EFL learners, Hamada (2012) conducted a semantic priming study that examined whether or not the learners were sensitive to contextual constraint for the on-line lexical inferences. After reading the contextual sentences whose constraint was manipulated, for example sentences (a) or (b), the semantically related probe word of the target word (e.g., sind → shark) was flashed. As a result, the EFL learners made on-line lexical inferences when the meaning of the target words was strongly constrained. However, as in past studies, it remains unclear how specific meanings are strongly activated according to the strength of contextual constraint.

1.3 Overview of the Current Study

As was reviewed before, several studies have demonstrated that (a) the learners can use contextual information to infer the meaning of unknown words during reading, and (b) the process and outcomes of context-based lexical inferences depend on both L2 reading proficiency and contextual constraint. However, most think-aloud studies have focused on only how accurately learners infer unknown word meanings from a given context. For example, some studies used a
3-point scale for rating lexical inference attempts, such as success, partial success, and failure (Fukkink et al., 2011; Nassaji, 2006; Wesche & Paribakht, 2009) and did not focus on the relationship between contextual constraint and the specificity of meanings inferred from contexts. Furthermore, it is most important to note that these studies did not demonstrate how strongly the learners activate the meaning of unknown words based on context-based lexical inferences.

The experiment presented here used a semantic priming method to examine how strongly Japanese EFL learners activate specific or general meanings while they are processing unknown words. The analysis focused specifically on the strength of the contextual constraint. In addition, since the learners’ L2 reading proficiency is a significant factor in context-based lexical inferences, the present study was designed to address the interaction between contextual constraint and L2 reading proficiency during the lexical inferences in terms of their specificity and activation level. The hypothesis (H) and two research questions (RQs) are as follows:

H: A strong contextual constraint facilitates the processing of unknown words by on-line lexical inferences.

RQ1: How does the strength of a contextual constraint affect lexical inference specificity and its activation level?

RQ2: Are higher L2 reading proficiency levels required in order for the learners to receive benefits from contextual constraint in the on-line lexical inferences?

2. Method

2.1 Materials

2.1.1 Probe words

Prior to the experiment, two pilot studies were conducted to confirm the validity of probe words used for a semantic relatedness judgment task. Because the meanings of unknown words inferred from contexts will be synonyms or hypernyms (Chaffin, 1997), two levels of the specificity of probe words (hereafter $P_{\text{specific}}$ and $P_{\text{general}}$) were created (see Table 1).

A total of 39 high-frequency target words as $P_{\text{specific}}$ were selected from past studies (Griffin & Bock, 1998; van Assche et al., 2011). The hypernyms corresponding to each target word (e.g., shark $\rightarrow$ fish) were created as $P_{\text{general}}$ on the basis of WordNet’s (Miller et al., 1990, p. 8) definition, “hyponym is a kind of hypernym.” The task in the first pilot study asked 28 Japanese university students to give Yes/No judgments about the hyponymy-hypernymy relationship between probe words, for example, “Is a shark a kind of fish?” The result showed that more than 80% of the respondents regarded 29 out of all the target words as having the hyponymy-hypernymy relationship ($M = 94\%$, range: 82%–100%). However, the other target words were judged not to have such a connotational relationship ($M = 48\%$, range: 14%–79%) and were excluded from the stimuli.
In the second pilot study, 29 Japanese university students took part in a lexical decision task to confirm no significant differences of word recognition speed between \( P_{\text{specific}} \) and \( P_{\text{general}} \). Each probe pair was translated into Japanese katakana or hiragana to avoid the effects of English word familiarity on word recognition (average word length = 3.04, range: 2–4 letters). A total of 116 lexical decision items were paired with each of the 58 experimental sets and the same number of pronounceable Japanese nonwords. The participants had to determine if a probe presented on a computer screen was an existing word or a nonword as quickly as possible. A paired \( t \) test demonstrated no significant differences in word recognition between the probe pairs (\( P_{\text{specific}}: M = 530.25, SD = 80.69; P_{\text{general}}: M = 540.50, SD = 80.30 \), \( t(27) = 1.22, p = .234, r = .23 \).

Table 1

<table>
<thead>
<tr>
<th>Conditions / ( P )</th>
<th>Contextual sentences</th>
<th>Probe words</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strong / ( P_{\text{specific}} )</td>
<td>The surfers were attacked by a dangerous ( \text{sind} ) in the sea.</td>
<td>サメ [same]</td>
</tr>
<tr>
<td>Strong / ( P_{\text{general}} )</td>
<td>The surfers were attacked by a dangerous ( \text{sind} ) in the sea.</td>
<td>さかな [sakana]</td>
</tr>
<tr>
<td>Weak / ( P_{\text{specific}} )</td>
<td>The group was surprised by a large ( \text{sind} ) in the sea.</td>
<td>サメ [same]</td>
</tr>
<tr>
<td>Weak / ( P_{\text{general}} )</td>
<td>The group was surprised by a large ( \text{sind} ) in the sea.</td>
<td>さかな [sakana]</td>
</tr>
<tr>
<td>Filler</td>
<td>His coat was open because it was missing a ( \text{button} ).</td>
<td>ライト [light]</td>
</tr>
</tbody>
</table>

Note. Target words are italicized.

### 2.1.2 Contextual sentences

The reading materials were 29 contextual sentence pairs used in previous research (Griffin & Bock, 1998; van Assche et al., 2011), corresponding to the selected target words. Each contextual constraint was confirmed in their studies by a cloze completion task. The task showed that each \( P_{\text{specific}} \) had a high cloze probability in the strongly constraining sentence (e.g., in "The surfers were attacked by a dangerous ____ in the sea," the blank line was typically filled with shark) but a low cloze probability in the weakly constraining sentences. However, nine out of 29 sentence pairs were removed because they included many low-frequency words (level 5 and over) according to JACET 8000 (JACET, 2003). Finally, 20 strongly and weakly constraining sentence pairs were used in the experiment. As shown in Table 1, the syntactic properties of these sentence pairs were almost parallel, and the target word forms were replaced by one of 20 pseudowords.

On the basis of the two pilot studies, each set of pseudowords (e.g., "sind") had two types of probe words (i.e., \( P_{\text{specific}} = \text{サメ} [\text{same}], P_{\text{general}} = \text{さかな} [\text{sakana}] \)) in the semantic relatedness judgment task to examine the activation level of specific or general meanings inferred from the contextual sentences. Every set of 20 fillers also had similar probe words, but the target-probe pairs of the fillers were unrelated to each other (e.g., "button → ライト [light]") in order to counterbalance the number of “related” and “unrelated” responses. The materials are all presented in the Appendix.
2.2 Participants

The participants in the experiment were 52 Japanese undergraduates majoring in Education, Social Studies, Comparative Cultures, International Relations, Engineering, Chemistry, Medicine, or Nursing. None of them had participated in the pilot studies. All the participants had studied English for more than six years. Their L2 reading proficiency was estimated with the reading subsection of the pre-first (6 items) and second grade (20 items) STEP test conducted in 2007 (Obunsha, 2010a, 2010b). A total of 27 participants were determined to have higher L2 reading proficiency based on a median split for their performance on the test. These 27 participants, regarded as the Upper group, showed substantially better performance on the test ($M = 17.41$, $SD = 2.34$, $Min = 14$, $Max = 23$) than the other 25 participants categorized as the Lower group ($M = 8.76$, $SD = 2.95$, $Min = 3$, $Max = 13$), $t(50) = 11.76$, $p < .001$, $r = .86$.

2.3 Procedure

The participants worked individually in a single session that lasted about 50 minutes. First, the participants were notified of the general purpose of the study. After 30 minutes were given to take the STEP test, they were instructed on how to do the semantic relatedness judgment task.

In the semantic relatedness judgment task, the 10 strongly and 10 weakly constraining sentences and the 20 fillers were presented in a random order to each participant. The participants read each contextual sentence in the center of a computer screen at their own pace by pressing a button on a response pad (RB730). When they finished each contextual sentence, a row of central fixation crosses appeared in the center of the screen for 500 ms; then, the crosses were replaced by the target word for 500 ms. After a 300-ms presentation of a blank sheet, a corresponding probe word was displayed. The participants were asked to judge whether the two words were semantically related or not by pressing the appropriate keys. Figure 1 shows the sequence of each trial.

Prior to the semantic relatedness judgment task, the participants were presented with six practice sets to familiarize them with the procedure. SuperLab 4.5 for Windows was used to record the responses and their latencies of the semantic relatedness judgment task.

![Figure 1](image-url)  
*Figure 1.* The sequence of each trial of the semantic relatedness judgment task.
2.4 Data Analysis

To examine the lexical inference specificity and its activation level, analyses of variance (ANOVAs) were used to analyze the following three types of data: reading time of the contextual sentences, success rates, and response latencies of the semantic relatedness judgment task. An alpha level of .05 was consistently used, and the effects of marginal significance were regarded as insignificant. In all subsequent analyses of any interactions, Bonferroni adjustment was applied.

Reading time: To examine the study hypothesis, the reading time of each contextual sentence was recorded, which tested the effects of contextual constraint on the processing time of unknown words on the basis of Chaffin et al. (2001). The reading time for each sentence was converted into time per syllable. The between-participant variable was Proficiency (Upper, Lower), and the within-participant variable was Constraint (Strong, Weak, Filler).

Success rates and response latencies: To answer the RQs, the success rates and response latencies of the semantic relatedness judgment task were analyzed. Before the analysis of the response latencies, error trials and the response latencies that were ±2.5 standard deviations beyond the mean for a participant were excluded. In addition, the data of seven participants were excluded due to lack of the response latency data because their success rates were 0.00% in any of the trials. The between-participant variable was Proficiency (Upper, Lower), and the within-participant variables were Constraint (Strong, Weak) and Specificity (Pspecific, Pgeneral).

3. Results and Discussion

3.1 Reading Time

The descriptive statistics of the reading time are presented in Table 2. A 2 × 3 ANOVA showed a significant main effect of Constraint, \( F(2, 100) = 127.05, p < .001, \eta^2 = .290 \). However, there was no significant main effect of Proficiency, \( F(1, 50) = 3.00, p = .090, \eta^2 = .034 \) or interaction, \( F(2, 100) = 0.94, p = .395, \eta^2 = .002 \). A post hoc comparison with Bonferroni adjustment revealed that reading time for the weak constraint context was longer than the other two types of the contextual sentences \( (p < .001, \text{respectively}) \), while there were no significant differences between the strong constraint context and fillers \( (p = 1.000) \). Therefore, the effects of contextual constraint on reading time can be presented as follows: Strong = Filler < Weak.

\begin{table}[h]
\centering
\begin{tabular}{|l|l|l|l|l|l|l|}
\hline
 & \multicolumn{2}{c}{Strong constraint} & \multicolumn{2}{c}{Weak constraint} & \multicolumn{2}{c}{Filler} \\
\hline
Proficiency & \( n \) & \( M \) & \( SD \) & \( M \) & \( SD \) & \( M \) & \( SD \) \\
\hline
Upper & 27 & 495.67 & 173.77 & 798.07 & 310.69 & 495.43 & 151.99 \\
Lower & 25 & 569.98 & 202.04 & 937.23 & 355.96 & 597.35 & 175.26 \\
Total & 52 & 531.40 & 189.76 & 864.98 & 337.29 & 544.43 & 169.93 \\
\hline
\end{tabular}
\caption{Means (inMilliseconds) With Standard Deviations of Reading Time for Each Contextual Sentence}
\end{table}
The reading time data demonstrated the effects of contextual constraint on the processing of unknown words, corresponding to the study hypothesis. Although the strong and weak constraining sentences used in this study shared a common unknown word, the learners spent a longer time processing the unknown words in the weak constraint context. On the other hand, the faster processing time of the unknown words in the strong constraint context is consistent with the results of L1 reading studies (Chaffin et al., 2001; Otten & van Berkum, 2008). The results of this study fully support the hypothesis, suggesting that L2 learners are so sensitive to the strength of contextual constraint that they can predict and narrow the possible meanings of upcoming words at the point of understanding such contexts.

However, the reading time data did not provide evidence of the lexical inference specificity or its activation level. For example, there is no guarantee that in the weak constraint context, the learners did not infer the meaning of the target words while reading. Therefore, to reveal that how specific meaning was strongly activated during the lexical inferences, the results of the semantic relatedness judgment task will be discussed in Section 3.2.

### 3.2 The Semantic Relatedness Judgment Task

The overall results of the semantic relatedness judgment task are presented in Table 3. To examine the interaction of contextual constraint × L2 reading proficiency on lexical inference specificity and its activation level, this study analyzed the success rates and response latencies when $P_{\text{specific}}$ and $P_{\text{general}}$ were presented. Two three-factor mixed ANOVAs on the mean success rates and response latencies were conducted.

<table>
<thead>
<tr>
<th>Proficiency</th>
<th>n</th>
<th>Specific</th>
<th>General</th>
<th>Specific</th>
<th>General</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strong constraint</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upper</td>
<td>27</td>
<td>74.07 (23.41)</td>
<td>72.59 (19.33)</td>
<td>47.41 (20.87)</td>
<td>71.85 (23.70)</td>
</tr>
<tr>
<td>Lower</td>
<td>25</td>
<td>52.80 (25.74)</td>
<td>64.00 (26.46)</td>
<td>40.00 (30.00)</td>
<td>59.20 (28.57)</td>
</tr>
<tr>
<td>Total</td>
<td>52</td>
<td>63.85 (26.58)</td>
<td>68.46 (23.21)</td>
<td>43.85 (25.68)</td>
<td>65.77 (26.67)</td>
</tr>
<tr>
<td>Weak constraint</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 3**

**Means With Standard Deviations of the Semantic Relatedness Judgment Task**

**Note.** Standard deviations are in parentheses. As was mentioned in Section 2.4, the response latency data of seven participants were excluded (Upper: $n = 1$, Lower: $n = 6$).
3.2.1 The specificity of activated lexical inferences

The ANOVA of success rates showed the significant main effects of Constraint, $F(1, 50) = 19.23, p < .001$, $\eta^2 = .043$, Specificity, $F(1, 50) = 41.39, p < .001$, $\eta^2 = .060$, and Proficiency, $F(1, 50) = 5.88, p = .019$, $\eta^2 = .053$. More importantly, the interaction of Constraint $\times$ Specificity was significant, $F(1, 50) = 6.98, p = .011$, $\eta^2 = .024$. Figure 2 displays the success rates of participants' performances in the semantic relatedness judgment task by proficiency group.

![Figure 2](image)

*Figure 2.* The mean success rates of the semantic relatedness judgment task by Upper and Lower group.

The first concern was to investigate the specificity of the meanings activated from the contextual sentences. Post hoc analyses of the interaction between Constraint and Specificity revealed a significant simple main effect of Specificity in the weak constraint context, $F(1, 50) = 31.66, p < .001$, $\eta^2 = .386$ ($P_{specific}: 43.85\% < P_{general}: 65.77\%$). This indicated that although the participants had relative difficulty inferring the specific meanings from the weakly constraining sentences, they could activate at least the general lexical inferences for reading comprehension.

Next, the strong constraint context elicited more correct responses than the weak constraint context did in the presentation of $P_{specific}$, $F(1, 50) = 24.36, p < .001$, $\eta^2 = .315$ (Strong: 63.85% > Weak: 43.85%). In addition, the simple main effect of Specificity was not significant in the strong constraint context, $F(1, 50) = 1.67, p = .203$, $\eta^2 = .030$ ($P_{specific}: 63.85\% \div P_{general}: 68.46\%$). These results showed that in the strong constraint context, the participants responded to the given $P_{specific}$ more correctly than in the weak constraint context. Additionally, the success rates between $P_{specific}$ and $P_{general}$ did not differ significantly in the strong constraint context.

In relation to RQ1, the success rates of the semantic relatedness judgment task provided evidence that the lexical inference specificity changed according to the strength of the contextual constraint. Firstly, in the weak constraint context, the success rates for the presentation of $P_{general}$ were significantly higher. This means that the weakly constraining sentences drew out a general lexical inference, which can broadly match a given contextual sentence in meaning. Some previous studies have showed that poor readers make such general or vague lexical inferences (e.g., Fukkink et al., 2001), and the present study further demonstrated that the weak constraint context also activated the general meanings of unknown words in on-line lexical inferences.
Secondly, the presentation of $P_{\text{specific}}$ elicited higher success rates in the strong constraint context than in the weak constraint context. This result indicates that the strongly constraining sentences contributed to the activation of specific meanings of the target words. However, the success rates for the presented $P_{\text{general}}$ in the strong constraint context were also high to the same degree of those for $P_{\text{specific}}$. Therefore, it is necessary to take the response latency data into account, because a possible interpretation still remains as follows: The participants initially activated a general inference (e.g., *fish*) in their mind, but when $P_{\text{specific}}$ (e.g., *shark*) was flashed on the screen, they changed their general inferences for specific ones by checking the meaning of $P_{\text{specific}}$ with their activated general inference based on the contextual information. If so, the response latencies for the presentation of $P_{\text{specific}}$ will be longer compared with the case that the learners initially activate a specific lexical inference. This issue is discussed further in the analysis of the response latencies.

These findings on lexical inference specificity, on the other hand, have another interpretation. Because the contextual sentences used in this study contained more or less words semantically related to the target words (e.g., *dangerous, sea → shark* as a shark), it is possible that the participants responded to the presented probe words only based on the co-occurrence of the words, not on the context-based lexical inferences during reading. However, Otten and van Berkum's (2008) experiments contradicted this possibility and showed that the coherent message of the contexts up to the target word activates context-based lexical inferences.

The other finding of the ANOVA was the effects of L2 reading proficiency on lexical inference specificity (a partial answer to RQ2; see Section 3.2.2 for further discussion). The results indicated that the high L2 proficiency learners responded to either probe type more accurately than the low L2 proficiency learners did. That is, the strongly constraining sentences can promote the activation of specific meanings of unknown words; nevertheless, poor L2 reading proficiency may inhibit this benefit for lexical inferences. In the weak constraint context, the limitations of the learners' L2 reading proficiency also decrease the success rates for the presentation of $P_{\text{general}}$. These findings are supported by many previous conclusions that learners' L2 proficiency affects lexical inference success (Haastrup, 1991; Nassaji, 2006; Wesche & Paribakht, 2009) and its specificity (Fukkink et al., 2001). The present study also suggests that L2 reading proficiency affects the specificity of the meanings activated through on-line lexical inferences.

### 3.2.2 The activation level of lexical inferences

The ANOVA for the response latencies revealed significant main effects of Constraint, $F(1, 43) = 22.27, p < .001, \eta^2 = .444$, and Specificity, $F(1, 43) = 15.80, p < .001, \eta^2 = .041$. Although the main effect of Proficiency was not significant, $F(1, 43) = 1.17, p = .285, \eta^2 = .015$, the outcomes showed that the three-way interaction of Constraint $\times$ Specificity $\times$ Proficiency was significant, $F(1, 43) = 4.49, p = .040, \eta^2 = .012$. Figure 3 graphically presents the differences of the response latencies in each proficiency group.
A first post hoc analysis examined the activation level of lexical inferences in the strong constraint context with a focus on each level of L2 reading proficiency. In the Upper group, there was no difference in the response latencies between $P_{\text{specific}}$ (1008.00 ms) and $P_{\text{general}}$ (1103.12 ms) in the strong constraint context, $F(1, 43) = 0.00, p = .975, \eta^2 < .001$. However, the response latencies of the Lower group were longer in the presentation of $P_{\text{specific}}$ (1463.19 ms) than in that of $P_{\text{general}}$ (1095.70 ms), $F(1, 43) = 12.86, p = .001, \eta^2 = .230$.

In reading the weakly constraining sentences, the response latencies for the given $P_{\text{general}}$ were significantly shorter than those for $P_{\text{specific}}$ regardless of the participants’ L2 reading proficiency, Upper: $F(1, 43) = 6.15, p = .017, \eta^2 = .115$, Lower: $F(1, 43) = 4.10, p = .049, \eta^2 = .077$. These results demonstrated that in the weak constraint context, the activation level of the general meanings was stronger than that of the specific meanings.

As a further discussion of RQ1 and RQ2, the response latencies in the semantic relatedness judgment task indicated that the activation level of the inferred meaning was affected by the interaction between contextual constraint and L2 reading proficiency. First, the higher L2 proficiency learners could respond to both $P_{\text{specific}}$ and $P_{\text{general}}$ at almost the same speed when the meaning of the target words was strongly constrained by the contextual sentences. As stated in Section 3.2.1, it would take a longer time to respond to the presented $P_{\text{specific}}$ after the learners strongly activated the general meaning of the target words; therefore, the possibility that the high L2 proficiency learners changed their general inferences for more specific ones by checking the given $P_{\text{specific}}$ can be ruled out. Additionally, the insignificance of the difference in response latencies between the probe types suggests that the learners simultaneously activated the general inferences as a possible meaning of the target words. That is, good learners initially activate the specific meaning of unknown words, keeping the general inferences in their mind, while they are reading the strongly constraining sentences.

On the other hand, even though the contextual sentences strongly constrained the inferable meaning of the target words, the lower L2 proficiency learners’ response latencies were significantly longer for $P_{\text{specific}}$ than for $P_{\text{general}}$. This finding has two likely interpretations; one is that the poor learners inferred the general meaning of the target words from the strongly
constraining sentences at first, and then, the presented $P_{\text{specific}}$ changed their inferences into specific, leading to high success rates for $P_{\text{specific}}$ (see Section 3.2.1). The other account is that low L2 proficiency learners could activate the specific meanings of the target words but needed more time to derive such meanings from the contextual sentences. However, considering that their processing time of the unknown words did not differ from that of high-frequency words, the low proficiency learners seemed to strongly activate general lexical inferences rather than spending a longer time on the activation of specific meanings of the target words.

In the weak constraint context, the response latencies for $P_{\text{general}}$ were shorter than for $P_{\text{specific}}$ regardless of the learners' L2 reading proficiency. This demonstrates that the learners strongly activated the general meaning of unknown words as they read the weakly constraining sentences. Thus, while most past studies have concentrated on the accuracy of lexical inferences (e.g., de Bot et al., 1997; Fukkink et al., 2001; Huckin & Bloch, 1993; Nassaji, 2006; Wesche & Paribakht, 2009), an important suggestion of this study is that the weak constraint context can draw out some general lexical inferences on-line for reading comprehension.

4. Conclusions

The current study provides a new contribution to the field by demonstrating that L2 learners are sensitive to contextual constraints on word meaning and can activate the meaning of unknown words according to the strength of such constraints. The overall results of this study indicate the significant relationship between contextual constraint and L2 reading proficiency for the process of on-line lexical inferences. First, the reading time and success rate data indicate that when the inferable meaning of unknown words is strongly constrained, learners can process unknown words by anticipating those meanings from the useful contextual information. In this anticipation, the activated meaning differs in the level of L2 reading proficiency. The response latencies data demonstrate that higher L2 proficiency learners already identify the specific or synonymous meanings of unknown words at the point of reading strongly constraining contextual information, whereas lower L2 proficiency learners derive the relatively general or vague meaning from the same contextual sentence. Second, unknown words that are weakly constrained need more processing time, and the general meaning of these words is strongly activated during reading regardless of learners’ L2 reading proficiency.

As a general implication for English education, it is important to apply the learners’ reading processes to practical reading instructions (Ushiro, 2010). According to the current study, it is worthwhile to consider the interaction between contextual constraint and students’ English reading proficiency in the teaching of lexical inference skills in a classroom. In regard to the issue of contextual constraint, teachers should previously evaluate whether the contextual information semantically constrains the inferable meaning of the target words presented for a lexical inference task and understand the strength of contextual constraint effects on lexical inference specificity.
the use of strongly constraining contextual sentences, we want our students to identify the specific meaning of the target words; however, it should be considered that poor learners may have difficulty narrowing the meaning of unknown words by their own efforts, even if the contextual information strongly constrains their possible meanings. Therefore, as the given $P_{\text{specific}}$ promoted the participants’ success rates in the semantic relatedness judgment task, teachers can help learners by providing multiple marginal glosses or questioning (e.g., Breaking and entering into a house is against the ____ in every country. Which of the following goes in the blank: “rule,” “common sense,” or “law”?).

Moreover, weakly constraining sentences are also useful for improving students’ skills of lexical inferences. The students may hardly infer the appropriate meaning of target words from only such contextual information, but they are required to activate at least a general or vague lexical inference for reading comprehension. When they come up with some widely interpreted meaning, then, they have to narrow and verify its specificity with the succeeding contextual information. If the inferred meaning is too vague or unexpected, teachers need to help the students change their inferences into more specific ones by asking for an explanation of their reasoning. Combining these suggestions, this study proposes that English reading instructions aim to develop the students’ autonomous reading skills in terms of context-based lexical inferences.

Acknowledgements

I would like to express my deep gratitude to Professor Yuji Ushiro and his colleagues for their valuable comments and suggestions. I also wish to thank three anonymous reviewers for their useful comments to improve this paper.

References


### Appendix: Contextual Sentences, Target (Original) Words, and Probe Words Used in the Experiment

<table>
<thead>
<tr>
<th>Contextual sentences</th>
<th>Strong constraint</th>
<th>Weak constraint</th>
<th>Probe words</th>
</tr>
</thead>
<tbody>
<tr>
<td>He is not quite awake yet because he still needs to drink a cup of black <em>windle</em> (coffee) this morning.</td>
<td>He wants to stop for moment because he wants to buy a pack of this <em>windle</em> (coffee) in the shop.</td>
<td>coffee</td>
<td>コーヒー</td>
</tr>
<tr>
<td>Elizabeth II of Great-Britain is the most famous <em>yoot</em> (queen) in Europe.</td>
<td>That proud lady is the most famous <em>yoot</em> (queen) in Europe.</td>
<td>[jyoo]</td>
<td>[jyomomono]</td>
</tr>
<tr>
<td>If Kate wants to free the canary birds, she has to open the iron <em>mend</em> (cage) they are in.</td>
<td>If Kate wants to see those animals, she has to find the special <em>mend</em> (cage) they are in.</td>
<td>[kago]</td>
<td>[kremono]</td>
</tr>
<tr>
<td>If you want to stay in good health, you have to eat 5 pieces of <em>brench</em> (fruit) every day.</td>
<td>If you are able to go to the supermarket, you have to buy a lot of <em>brench</em> (fruit) for me.</td>
<td>kudamono</td>
<td>[kudamono]</td>
</tr>
<tr>
<td>The charming dancer wears a rose in her golden <em>mear</em> (hair) but she will remove it later.</td>
<td>He spilled wine on her <em>mear</em> (hair) but he cleaned it up in a few seconds.</td>
<td>[kami]</td>
<td>[kami]</td>
</tr>
<tr>
<td>When they are on a holiday, they always sleep in a rich <em>mork</em> (hotel) with a beautiful pool.</td>
<td>When they are in Brussels, they always pass by a beautiful <em>mork</em> (hotel) with an impressive pool.</td>
<td>[hotel]</td>
<td>[hotel]</td>
</tr>
<tr>
<td>Breaking and entering into a house is against the <em>cadle</em> (law) in every country.</td>
<td>Politicians of the new party are talking about a <em>cadle</em> (law) for their country.</td>
<td>[houritsu]</td>
<td>[houritsu]</td>
</tr>
<tr>
<td>My husband always watches the seven o'clock <em>jurg</em> (news) in the evening.</td>
<td>My husband always records the <em>jurg</em> (news) in the evening.</td>
<td>[news]</td>
<td>[news]</td>
</tr>
<tr>
<td>The unfaithful man cheated on his <em>nase</em> (wife) and had absolutely no regrets.</td>
<td>Our new friend talked to his <em>nase</em> (wife) and told her the whole story.</td>
<td>[tsuma]</td>
<td>[tsuma]</td>
</tr>
<tr>
<td>When Gary was young, he always confused a goose and a <em>bick</em> (duck) when naming animals.</td>
<td>When Gary was young, he kept a rabbit and a <em>bick</em> (duck) in his room.</td>
<td>[ahiru]</td>
<td>[ahiru]</td>
</tr>
<tr>
<td>The surfers were attacked by a dangerous <em>sind</em> (shark) in the sea.</td>
<td>The group was surprised by a large <em>sind</em> (shark) in the sea.</td>
<td>[same]</td>
<td>[same]</td>
</tr>
<tr>
<td>France is a beautiful <em>tance</em> (country) that attracts many tourists.</td>
<td>Ben visited the beautiful <em>tance</em> (country) which attracts many tourists.</td>
<td>[kuni]</td>
<td>[kuni]</td>
</tr>
<tr>
<td>He tried to put the pieces of the broken plate back together with <em>pakl</em> (glue).</td>
<td>She walked across the large room to Mike’s dirty desk and returned his <em>pakl</em> (glue).</td>
<td>[bondo]</td>
<td>[bondo]</td>
</tr>
<tr>
<td>The little puppy grew up to be a huge <em>parrrow</em> (dog).</td>
<td>At the park she saw a man with a <em>parrrow</em> (dog).</td>
<td>[inu]</td>
<td>[inu]</td>
</tr>
<tr>
<td>The people marched to the beat of a loud <em>bland</em> (drum).</td>
<td>The musician pounded on a <em>bland</em> (drum).</td>
<td>[drum]</td>
<td>[drum]</td>
</tr>
<tr>
<td>The bank robber aimed at the security officer and fired the <em>vack</em> (gun).</td>
<td>The robber had a <em>vack</em> (gun).</td>
<td>[jyu]</td>
<td>[jyu]</td>
</tr>
<tr>
<td>The pitcher was unable to throw the ball because of his broken <em>ring</em> (arm).</td>
<td>He had a scratch on his <em>ring</em> (arm).</td>
<td>[uda]</td>
<td>[uda]</td>
</tr>
<tr>
<td>The bridesmaid wore an ugly <em>prink</em> (dress).</td>
<td>The princess wore a <em>prink</em> (dress).</td>
<td>うし</td>
<td>[ushi]</td>
</tr>
<tr>
<td>The farmer milked the <em>bettle</em> (cow).</td>
<td>The farmer had an old <em>bettle</em> (cow).</td>
<td>[ushi]</td>
<td>[ushi]</td>
</tr>
<tr>
<td>That train always arrives on time at the <em>greel</em> (station) in Tokyo.</td>
<td>My friend sometimes arrives too late at the <em>greel</em> (station) in Tokyo.</td>
<td>[eki]</td>
<td>[eki]</td>
</tr>
</tbody>
</table>