

Effects of forward and backward contextual elaboration on lexical inferences: Evidence from a semantic relatedness judgment task

Akira Hamada
University of Tsukuba
Japan

Abstract

Three experiments examined whether the process of lexical inferences differs according to the direction of contextual elaboration using a semantic relatedness judgment task. In Experiment 1, Japanese university students read English sentences where target unknown words were semantically elaborated by prior contextual information (forward lexical inferences) and by subsequent contextual information (backward lexical inferences). Accuracy of semantic relatedness judgments, and reaction times to target-probe words demonstrated that participants could activate lexical inferences in either case. These findings were replicated in Experiments 2 and 3, where sentence chunks were presented one at a time to prevent the use of a rereading strategy. Taken together, the results suggest that whereas the processes of forward lexical inferences are involved in context-word integration by anticipating upcoming word meanings, those of backward lexical inferences are operating an unknown word in working memory, finding highly elaborative contexts, and then integrating the contextual message with the possible meaning.

Keywords: reading, lexical inference, contextual elaboration, semantic relatedness judgment task, reaction time research

Unknown words in a text are a critical problem that inhibits the second language (L2) reading comprehension. When L2 learners encounter unknown words while reading, it is preferable to infer appropriate word meanings from context (Wesche & Paribakht, 2010). As shown in Common European Framework of Reference for Languages' (CEFR) descriptors, lexical inference is a necessary reading skill. For example, A2-level (basic user) learners “can use an idea of the overall meaning of short texts and utterances on everyday topics of a concrete type to derive the probable meaning of unknown words from the context” (Council of Europe, 2001, p. 72). Although lexical knowledge must be at least 95% before learners successfully guess unknown words (Nation, 2013) and the lexical inference strategy does not fully compensate for a lack of vocabulary knowledge, making lexical inferences is still essential in reading comprehension because learners always encounter unknown words, even in texts at an appropriate level of difficulty.

Some teachers and researchers, however, have doubted the effectiveness of lexical inferences for two reasons. First, Bensoussan and Laufer (1984) pointed out that making lexical inferences is too difficult because it often requires high linguistic and meta-linguistic proficiency that is beyond learners' knowledge. In fact, some think-aloud studies showed that L2 learners have to control the processes involved in decision making while finding contextual information, generating the possible meanings of unknown words, and evaluating outcomes (e.g., de Bot, Paribakht, & Wesche, 1997; Huckin & Bloch, 1993). Second, L2 learners often ignore unknown words in the absence of a specific goal, such as performing a think-aloud task, even though their text comprehension will be disrupted (Huckin & Bloch, 1993; Nassaji, 2006; Paribakht & Wesche, 1999). Although strategy instructions can change learners' lexical inference behavior (Fraser, 1999), it is reasonable to claim that learners should not depend heavily on a guessing strategy.

In contrast, the idea that contextual information derives specific concepts from background knowledge as a sentence unfolds is not popular, even in the first language (L1) reading research (Szewczyk & Schriefers, 2013). For example, when we read or hear that "the brave knight saw that the dragon threatened the benevolent sorcerer. Quickly he reached for his..." a specific word like "sword" might be retrieved from our prior experiences of (non)verbal inputs (Otten & van Berkum, 2008). Given that readers activate highly probable concepts from such elaborative information during reading, even when unfamiliar word form hides a specific concept, it is possible that elaborative contextual information enables L2 learners to integrate the word form with its likely meaning. In line with this background, the current study focuses on the effects of contextual elaboration, and aims to expand the prior findings of think-aloud studies that have demonstrated that L2 learners can infer the meaning of unknown words.

Processing Unknown Words in L2 Reading

A think-aloud protocol has been the primary measure used to examine the process of lexical inferences, in which learners are asked to verbalize the processes of thoughts while trying to derive the meaning of unknown words (e.g., de Bot et al., 1997; Haastrup, 1991; Huckin & Bloch, 1993; Nassaji, 2006; Paribakht & Wesche, 1999). Evidence from think-aloud protocols suggests that when readers notice that they do not know the syntactic and semantic properties of unfamiliar words, they try to find and use various sources, such as contextual information and background knowledge to fill the gaps in their knowledge concerning the word (e.g., Wesche & Paribakht, 2010). Therefore, Haastrup (1991) defined that the process of lexical inferences involves informed guessing. However, some studies have shown that L2 learners are likely to ignore unknown words in the absence of specific reading tasks (Bensoussan & Laufer, 1984; Huckin & Bloch, 1993; Paribakht & Wesche, 1999). This implies that learners' lexical inference behavior may be specific to think-aloud tasks, because cognitive style in reading can vary according to a given situation (Horiba, 2013). In addition, it should be noted that an explicit goal of making lexical inferences does not necessarily contribute to the accuracy of word meaning guessing (e.g., Nassaji, 2006).

Although these findings suggest that there are some weaknesses in a lexical inference strategy, two critical deficiencies in past experimental designs prevent accurate examination of successful

processes of lexical inferences. For example, Bensoussan and Laufer (1984) used text in which the percentage of known words was only 88%; however, to make successful lexical inferences, this percentage is required to be 95%–98% (Nation, 2013). Even when an experimental passage satisfied this criterion (e.g., Nassaji, 2006; Paribakht & Wesche, 1999; Wesche & Paribakht, 2010), Webb (2008) claimed that most studies did not consider context quality. That is, the meaning of unknown words is clear in some contexts, but is so obscure in others that even high-proficiency learners cannot identify them (Huckin & Bloch, 1993; Webb, 2008). To examine how L2 learners process unknown words by lexical inferences, this study focuses on the interaction between contextual information and the language comprehension system.

Contextual Elaboration in Lexical Inferences

The language comprehension system does not exclusively involve passive processes of waiting for upcoming words that are integrated into the mental representations of a text (Szewczyk & Schriefers, 2013). An example of contrary is that many L1 reading studies demonstrated a highly contextual elaboration for readers to anticipate a specific upcoming word (DeLong, Urbach, & Kutas, 2005; Otten & van Berkum, 2008; Szewczyk & Schriefers, 2013). In Otten and van Berkum (2008), after reading a prior context, such as “Sylvie and Joanna really feel like dancing and flirting tonight,” participants were implicitly tested on anomalous word detection in a subsequent sentence (e.g., “Therefore they go to a *stove* [*disco*]...”). In this case, the prior context semantically elaborated the possible meaning of upcoming words (i.e., *disco*); therefore, participants quickly detected anomalies through context-based word anticipation. Although some researchers have regarded anomaly detection as a sign of the difficulty of integrating words into mental representations, most psychophysiological studies have suggested that readers are using context to generate predictive inferences for an upcoming word meaning (see DeLong et al., 2005).

Focusing on the processing of unknown words in L1 sentence comprehension, Borovsky, Kutas, and Elman (2010) examined contextual elaboration effects. They compared the comprehensibility of a nonword (e.g., *marf*) after presenting two types of prior contexts (“He tried to put the pieces of the broken plate back together with *marf*” vs. “She walked across the large room to Mike’s messy desk and returned his *marf*”). Processing the word *marf* was facilitated by the former compared with the latter sentence, providing evidence that the prior context promoted lexical inferences that the word *marf* referred to *glue*. This result suggests that elaborative contexts activate the meaning of the upcoming words, and the activated meaning is quickly integrated into the word form. In fact, L2 reading research also has demonstrated that meaning-oriented cues in the same sentence as the target unknown word are of primary importance (e.g., de Bot et al., 1997; Nassaji, 2006; Paribakht & Wesche, 1999; Wesche & Paribakht, 2010). Taken together, it is hypothesized that lexical inferences using highly elaborative information are readily available to L2 learners in reading comprehension.

Evidence suggests that the contextual elaboration of a prior context (hereafter, *forward contextual elaboration*) facilitates lexical processing by anticipation. However, in the context of lexical inferences, unknown words are not always elaborated by a prior context. That is, readers often encounter an unknown word that is semantically elaborated by a subsequent context

(hereafter, *backward contextual elaboration*). Let us consider the sentence “Joe picked up the *asdor* and began to strum a tune” (Chaffin, Morris, & Seely, 2001, p. 226). In this example, the likely meaning of nonword *asdor* (i.e., *guitar*) is semantically elaborated by the contextual information, *began to strum a tune*, but not the prior context *Joe picked up*. To successfully comprehend this sentence, readers have to activate the meaning of *asdor* by integrating the subsequent information with the under-constructed mental representation that includes the unknown word. Using eye-tracking measures, Chaffin et al. (2001) found that L1 adult readers frequently made regressive eye-movements when an elaborative context was a primary cue for the meaning of target words. This suggests that the readers were so sensitive to the contextual elaboration that they were able to integrate the contextual message, *began to strum a tune* with the inferable meaning of the word. In other words, the meaning of *asdor* could be represented in the mind after backward elaborative contexts were added to readers’ text memory.

However, backward lexical inferences may be difficult in even L1 reading, especially when language skills (Cain, Oakhill, & Lemmon, 2004) and cognitive resources (Daneman & Green, 1986) are constrained. In particular, these studies suggest that the limited capacity of working memory affects backward lexical inferences because readers must keep an encountered unknown word in working memory until highly elaborative contexts appear. Huckin and Bloch (1993) also demonstrated that if L2 learners had not yet collected enough contextual information to infer the meaning of an encountered unknown word, they often skipped over it. In this case, Hulstijn (1993) showed that learners are very afraid of poor text comprehension, and wonder as to what kind of thing the words refer. Thus, we can infer that the effect of contexts on lexical inferences may vary, but it is possible that a think-aloud task overestimates learners’ good use of contextual information.

The Use of a Semantic Relatedness Judgment Task

The three experiments presented in the current study used a semantic relatedness judgment task instead of a think-aloud task to examine the effects of forward and backward contextual elaboration on lexical inferences. According to Jiang (2012), the semantic relatedness judgment task has been used to examine how target words are semantically represented in mind. In the task, “two words are presented to a participant who has to decide if they are synonyms or related in meaning” (Jiang, 2012, p. 140). Then, the task assumes that the reaction times to a pair of words with the same meaning would be faster than those to semantically different word pairs. Applying this research paradigm, the current study aims to reveal whether or not the meanings of unknown words are generated and represented while participants are trying to comprehend sentences.

Two levels of contextual elaboration (inference vs. control), as in the example below, were compared in the current study:

- (1a) *He tried to put the pieces of the broken plate back together with **marf**.* (inference)
- (1b) *She walked across the large room to Mike’s messy desk and returned his **marf**.* (control)

Sentences (1a) and (1b) both contain a nonword (in bold; *glue*). This target word follows elaborative or non-elaborative contexts (italics) that determine whether inferences about what

kind of thing the target word refers to are represented in the participants' mind. In the experiments, participants read contextual sentences and then made yes-no judgments regarding the semantic relatedness between targets (e.g., *marf*) and probes (e.g., *glue*). Given that forward contextual elaboration may facilitate making lexical inferences, even if an explicit word-meaning guessing task is not given to learners, we hypothesize that the two-word relatedness judgments will be faster and more accurate after reading Sentence (1a) than Sentence (1b). It should be noted that the judgments for Sentence (1b) indicate lucky guesses to some extent, because the control contexts were designed to not constrain the possible meaning of target words, so participants could not identify and represent their specific concepts. Even if participants made a correct judgment, it would indicate that they changed their prior answer (e.g., *something on the desk*) to be more specific (i.e., *glue*), by checking the meaning of a given probe with their understanding of the sentence. In this case, reaction times should be longer compared with a case in which a specific meaning is initially represented in memory.

Experiments were also conducted to examine backward contextual elaboration effects. Similar to the forward condition, Sentences (2a) and (2b) both have the same nonword (in bold; *instrument*), but this target word may or may not be elaborated by subsequent contextual information (italics):

(2a) Joe picked up the **asdor** and *began to play a melody*. (inference)

(2b) Joe picked up the **asdor** and *walked home*. (control)

When participants encounter the target word, a specific meaning cannot be represented because they have not met elaborative contextual information yet. If, as a sentence unfolds, they integrate the elaborative context with an unknown word's meaning, the results of the semantic relatedness judgment task can be explained in the same manner as forward contextual elaboration does. However, insignificant differences in accuracy and reaction times between the inference and control conditions would suggest that the L2 learners were not sensitive to backward contextual elaboration and did not make lexical inferences. Thus, the hypothesis (H) and research question (RQ) addressed in this study are summarized as follows:

H: Forward contextual elaboration facilitates processing of unknown words by lexical inferences.

RQ: Does backward contextual elaboration facilitate the processing of unknown words by lexical inferences?

In Experiment 1, how contextual elaboration affects processing of unknown words was examined, comparing forward and backward lexical inferences by recording accuracy and reaction times. In Experiment 2, participants read contextual sentences that were segmented into chunk units in order to remove the effects of strategic rereading. Experiment 3 sought to replicate the former results after modifying the experimental design by resolving some defects observed in Experiment 2.

Experiment 1

Participants

Participants in Experiment 1 were 20 Japanese undergraduates majoring in social studies, international relations, engineering, and education (10 males and 10 females; average age = 19.2, range = 18–21). All participants had studied English as a foreign language (EFL) for more than six years in Japan. They gave informed consent before the experiment and gained 1,000 yen for their participation.

The participants' English reading proficiency was estimated using the reading subsection of the pre-first (6 items) and second grade (20 items) Eiken test (Obunsha, 2010a, 2010b), in order to ensure that the proficiency level was homogeneous among Experiments. The test scores were not statistically different among Experiments, $F(2, 66) = 0.11, p = .896, \eta^2 < .01$, Cronbach's $\alpha = .85$ (Experiment 1: $M = 11.80, SD = 4.42$; Experiment 2: $M = 11.19, SD = 4.02$; Experiment 3: $M = 11.43, SD = 4.13$). The CEFR level was assumed to be from A2 to B2 based on their self-report.

Materials

Contextual sentences. Two levels of contextual elaboration (inference vs. control) and two types of elaborated direction (forward vs. backward) were crossed in a factorial design (see Table 1). Whereas inference sentences strongly constrained the possible meaning of target words, control sentences did not. There were two types of elaborative contexts for inference sentences: (a) forward elaboration, in which a prior context constrained the inferable meaning of the target words, and (b) backward elaboration, in which a subsequent context constrained the inferable meaning of the target words.

Table 1. *Sample sets of stimuli used in Experiment 1*

Contextual sentences	Probes
Forward	
Inference: He tried to put the pieces of the broken plate back together with <i>marf</i> .	ボンド
Control: She walked across the large room to Mike's messy desk and returned his <i>marf</i> .	[glue]
Backward	
Inference: Joe picked up the <i>asdor</i> and began to play a melody.	がっき
Control: Joe picked up the <i>asdor</i> and began to walk home.	[instrument]

Note. The probes were translated into Japanese.

For the forward condition, 12 pairs were selected, six from van Assche, Drieghe, Duyck, Welvaert, and Hartsuiker (2011), five from Griffin and Bock (1998), and one from Borovsky et al. (2010). For the backward condition, 12 pairs were adapted from Chaffin et al. (2001). All sentences had a minor modification for Japanese EFL learners: low-frequency words (4,000-word level and over) were replaced by easier synonyms based on the JACET (the Japan Association of College English Teachers) list of 8,000 basic words (JACET, 2003). The mean number of words in each condition was almost the same (see Table 2).

Based on past studies (e.g., Borovsky et al., 2010), the degree of contextual elaboration was validated in a pilot study using a cloze test with 40 Japanese EFL learners at the same university. The results indicated that each target word had a high cloze probability in the inference sentences (see Table 2). For example, in "Joe picked up the _____ and began to play a melody," the blank line was typically filled with *instrument*. In contrast, the same word had a low cloze probability

in the control sentences. A two-way ANOVA ensured that there were no differences in the degree of contextual elaboration between forward and backward conditions because there was a significant main effect of Elaboration (i.e., the relative strength of contextual constraint; inference vs. control), $F(1, 11) = 613.58, p < .001, \eta^2 = .95$, but not Direction, $F(1, 11) = 0.55, p = .473, \eta^2 < .01$, nor their interaction, $F(1, 11) = 0.36, p = .559, \eta^2 < .01$.

Table 2. *Characteristics of experimental and filler sentences and probes*

Condition	<i>k</i>	Contextual sentences		Probes
		Sentence length	Cloze probability	Word length
Inference				
Forward	6	10.7	88%	2.85
Backward	6	11.3	87%	2.85
Control				
Forward	6	11.2	15%	2.83
Backward	6	11.0	12%	2.86
Filler	24	11.2		2.72

In addition, 24 filler sentences were prepared. Twelve of these were adapted from Griffin and Bock (1998), and the rest from Chaffin et al. (2001). There were no linguistic differences from the experimental sentences, except that the target words were high-frequency existing English words. The target words for the forward condition were always at the end of each sentence. Those for the backward condition were the same as in Chaffin et al. (2001).

Probe words. Probe words corresponding to each sentence pair were created for the semantic relatedness judgment task. Basically, the original meanings of the target nonwords were used, but some target words were replaced based on the result of the cloze test. For example, Chaffin et al. (2001) originally used the target word *asdor* as *guitar* in the context “Joe picked up the *asdor* and began to strum a tune.” However, after substituting easier words for low-frequency words (e.g., *strum a tune* → *play a melody*), few participants answered that the meaning of *asdor* was *guitar*. In these cases, the hypernyms were used as the probe words (e.g., *guitar* → *instrument*). Each probe word was translated into Japanese to avoid effects of English word familiarity on reaction times. Every set of 24 fillers also had similar probe words, but the target-probe pairs of the fillers were semantically unrelated to each other. Therefore, the participants had to respond “yes” to the experimental target-probe pairs, and “no” to the filler target-probe pairs, because “if related items generate data for answering a research question, unrelated items are fillers” (Jiang, 2012, p. 141). The word-length of the probes were almost the same among the conditions, $F < 1$.

Procedure

Before the experiment, participants were notified of how the personal data collected would be used. Participants were tested individually in a single session. After a participant completed the English reading proficiency test, within a 30-minute time limit, they were instructed on how to complete the semantic relatedness judgment task.

In the task, 12 forward and 12 backward conditions were presented in random order, on a computer screen. A set of 24 fillers was also randomly inserted. Participants were asked to read

the sentences for comprehension at their own pace, by pressing a button on the response pad (Cedrus, RB-730 model), but were not instructed to infer the meaning of the target words. When they finished each sentence, a row of fixation crosses appeared in the center of the screen for 500 milliseconds (ms) to prepare them for the onset of the target word. Then, crosses were replaced with the prime word (i.e., the target nonword) for 500 ms. After an additional blank screen for 300 ms, a corresponding probe word was flashed in Japanese. The task was to judge as quickly as possible whether the two words presented were semantically related, by pressing the appropriate keys. It took participants approximately 20 minutes to complete all of the trials. To familiarize participants with the task procedure, they completed four practice sets before the main task. SuperLab 4.5 for Windows was used to record responses and reaction times. Figure 1 illustrates the sequence of each trial.

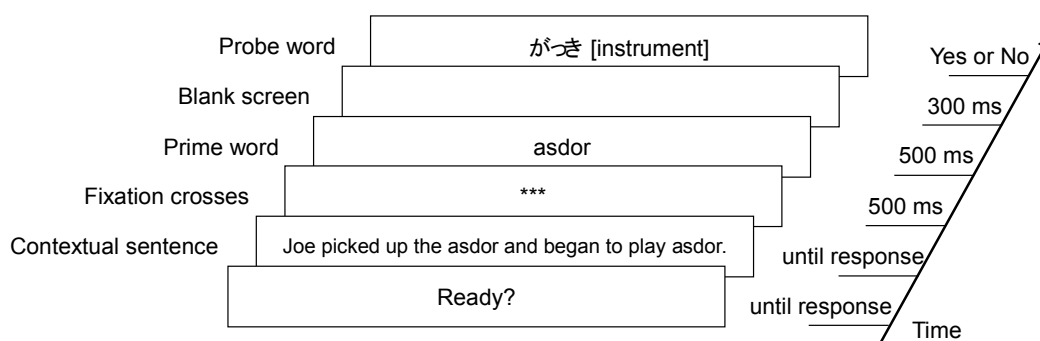


Figure 1. The sequence of events in each trial during the on-line semantic relatedness judgment task in Experiment 1.

Data Analysis

To examine the effects of forward and backward contextual elaboration, two-way analyses of variance (ANOVAs) were conducted on judgment accuracy and reaction times, with Elaboration (Inference vs. Control) and Direction (Forward vs. Backward) as within-participant variables. The procedure for dealing with incorrect responses and outliers was based on Jiang (2012, pp. 68–69). Prior to analyzing the reaction time data, if the participants incorrectly responded to the experimental target-probe pairs in each trial, it was excluded from the data analysis. Then, trials, where reaction times were ± 2.5 SDs beyond the mean of the participant, were eliminated as outliers. This resulted in the removal of 1.31% of all observations.

An alpha level of .05 was used, and effects of marginal significance were not interpreted. ANOVA results with eta squared (η^2) and 95% confidence intervals (CIs) of mean differences (M_{diff}) were reported to assess the degree at which each factor affected the lexical inference processes.

Results

Correct response rates on filler trials reached 97%, supporting the claim that participants performed the semantic relatedness judgment task appropriately. Table 3 presents the means, standard deviations, and mean differences with 95% CIs for task performance.

Table 3. Mean accuracy and reaction times for the semantic relatedness judgment task in Experiment 1

Elaboration	Forward		Backward		M_{diff} (95% CI)
	M	SD	M	SD	
Accuracy (%)					
Inference	81	17	80	15	1 (± 70)
Control	58	22	43	21	15 (± 14)
M_{diff} (95% CI)	23 (± 13)		37 (± 13)		
Reaction times (ms)					
Inference	867	286	863	293	-4 (± 94)
Control	1,141	367	1,149	392	-8 (± 72)
M_{diff} (95% CI)	-274 (± 115)		-285 (± 116)		

Note. $N = 20$.

Accuracy. Figure 2 indicates that judgment accuracy was higher in the inference than in the control condition, regardless of the direction of contextual elaboration. The two-way ANOVA supported this observation; the main effect of Elaboration was significant, $F(1, 19) = 36.38$, $p < .001$, $\eta^2 = .44$. However, there was no significant main effect of Direction, $F(1, 19) = 4.25$, $p = .053$, $\eta^2 = .03$, and these factors did not interact, $F(1, 19) = 3.57$, $p = .074$, $\eta^2 = .02$.

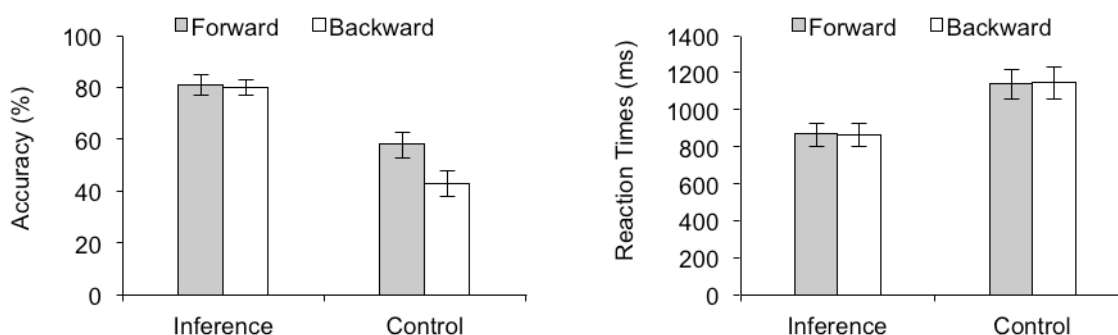


Figure 2. Mean accuracy and reaction times with $\pm SEM$ bars in Experiment 1.

Reaction times. To examine whether the reaction time data was consistent with the accuracy data, a similar two-way ANOVA was performed. As shown in Figure 2, reaction times were shorter in the inference than the control condition, $F(1, 19) = 32.90$, $p < .001$, $\eta^2 = .51$. However, the Direction effect did not appear, $F(1, 19) = 0.01$, $p = .944$, $\eta^2 < .01$, nor interacted with the Elaboration effect, $F(1, 19) = 0.05$, $p = .826$, $\eta^2 < .01$.

Discussion

One of the important findings of Experiment 1 is that highly elaborative contexts lead to more accurate responses and promote faster reaction times. Although both the inference and control sentences shared common target words, participants could respond to the probes more accurately and quickly in the inference condition than the control counterpart. In the control condition, contextual information was not elaborative, and this manipulation ensured that specific lexical inferences were rarely made while reading. Therefore, the difference in elaboration between the inference and control conditions suggests that participants can generate the meaning of unknown words based on highly elaborative information. This result supported the study hypothesis and was consistent with the findings of L1 reading studies (e.g., Borovsky et al., 2010; DeLong et al.,

2005; Otten & van Berkum, 2008; Szewczyk & Schriefers, 2013), indicating that L2 learners might process unknown words by context-based word anticipation (or integration) in the forward condition.

However, direction did not affect semantic-relatedness judgment performance; accuracy and reaction times in the forward and backward elaboration conditions were not significantly different. Similar to the effects of forward contextual elaboration, the inference sentences in the backward condition promoted higher accuracy and faster reaction times compared to the control contexts. These results suggest that participants could infer the meaning of unknown words based on backward contextual elaboration. This is consistent with the finding that contextual elaboration facilitates backward lexical inferences (Chaffin et al., 2001), and with some think-aloud results showing that L2 learners sometimes wait for additional information to identify unknown word meanings until they meet highly elaborative contexts (Huckin & Bloch, 1993). As many researchers have stated (e.g., Bensoussan & Laufer, 1984; Nassaji, 2006; Nation, 2013; Webb, 2008), semantically strong relationships between unknown words and contextual information is essential for making lexical inferences, and this study especially indicates that the effects of contextual elaboration on EFL learners' lexical inference behavior are not specific to a think-aloud task.

Although the results suggest that participants were sensitive to backward elaborative contexts, Experiment 1 did not reveal why they could make backward lexical inferences when target words were semantically elaborated. Whereas forward contextual elaboration facilitated processing of unknown words by context-based word anticipation, the backward condition might require strategic rereading for context-word integration (Chaffin et al., 2001). Given that the complete sentences appeared in the same manner on the computer screen in Experiment 1, the effects of forward and backward conditions cannot be distinguished. This might hinder any examination of whether lexical inferences using backward contextual elaboration are more complicated. Therefore, Experiment 2 was required to remove the effects of strategic rereading, in which participants read contextual sentences that were segmented into chunk units.

Experiment 2

Participants

The participants in Experiment 2 were 21 Japanese undergraduates majoring in social studies, international relations, engineering, or linguistics (eight males and 13 females; average age = 19.3, range = 18–22). None of them participated in Experiment 1. All have studied English for more than six years in Japan. They gave informed consent before the experiment and gained 1,000 yen for their participation.

Materials, Procedure, and Data Analysis

As shown in Table 4, the contextual sentences used in Experiment 1 were segmented into chunks by two independent raters based on Hijikata's (2012, p. 38) criteria (see Appendix A), and there was high inter-rater agreement (97%). All disagreements were resolved through discussion.

There were no other modifications.

Table 4. *Sample sets of stimuli used in Experiment 2*

Contextual sentences
Forward
Inference: He tried / to put / the pieces of the broken plate back together / with <i>marf.</i> /
Control: She walked across the large room / to Mike's messy desk / and returned / his <i>marf.</i> /
Backward
Inference: Joe picked up / the <i>asdor</i> / and began / to play a melody. /
Control: Joe picked up / the <i>asdor</i> / and began / to walk home. /

Note. Slashes represent pause-chunks. The probes used were the same as in Experiment 1.

The only difference in the procedure compared to Experiment 1 was that the contextual sentences were chunk-parsed, and chunks appeared one at a time on the computer screen. Participants were instructed to read each contextual sentence for comprehension at their own pace, pressing a button on the response pad to indicate they were ready for the next chunk. Figure 3 shows the sequence of each trial.

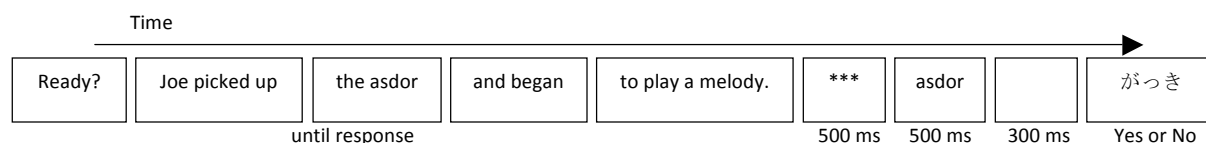


Figure 3. The sequence of events in each trial during the on-line semantic relatedness judgment task in Experiment 2.

The same measures were taken as in Experiment 1 and were analyzed in the same way. The outlier elimination procedure resulted in the removal of 2.93% of all observations.

Results

The correct response rate for the filler items was 94%, indicating that participants completed the semantic relatedness judgment task properly. Table 5 shows the means, standard deviations, and mean differences with 95% CIs for task performance.

Table 5. *Mean accuracy and reaction times for the semantic relatedness judgment task in Experiment 2*

Elaboration	Forward		Backward		M_{diff} (95% CI)
	M	SD	M	SD	
	Accuracy (%)				
Inference	83	16	66	18	17 (± 8)
Control	53	22	46	22	8 (± 9)
M_{diff} (95% CI)	30 (± 9)		20 (± 10)		
	Reaction times (ms)				
Inference	878	272	1,028	302	-149 (± 93)
Control	1,161	355	1,252	377	-92 (± 133)
M_{diff} (95% CI)	-282 (± 92)		-225 (± 156)		

Note. $N = 21$.

Accuracy. Figure 4 shows that accuracy was clearly higher in inference than in control contexts.

This observation was supported by a two-way ANOVA; there was a significant main effect of Elaboration, $F(1, 20) = 50.26, p < .001, \eta^2 = .45$. Although there was no significant main effect of Direction in Experiment 1, this effect was significant with a moderate effect size in Experiment 2, $F(1, 20) = 20.24, p < .001, \eta^2 = .11$; accuracy was higher in the forward compared to backward elaboration condition. The interaction between Elaboration and Direction was not significant, $F(1, 20) = 2.70, p = .116, \eta^2 = .02$.

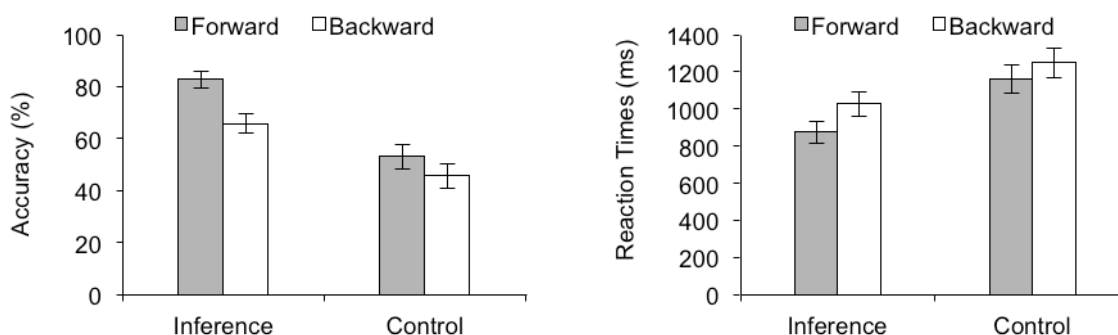


Figure 4. Mean accuracy and reaction times with $\pm SEM$ bars in Experiment 2.

Reaction times. Figure 4 also indicates clear differences in reaction times between Experiments 1 and 2. A two-way ANOVA revealed significant main effects of Elaboration, $F(1, 20) = 28.53, p < .001, \eta^2 = .35$, and Direction, $F(1, 20) = 9.58, p = .006, \eta^2 = .08$. That is, reaction times were shorter in the inference than control condition. More importantly, reaction times were shorter in the forward than backward condition. The interaction of Elaboration \times Direction was not significant, $F(1, 20) = 0.55, p = .468, \eta^2 < .01$. These results were consistent with the accuracy data.

Discussion

Similar to Experiment 1, contextual elaboration had a large effect on making lexical inferences in both the forward and backward conditions. Again, accuracy for the inference sentences was higher and reaction times were faster compared to the control sentences. These results indicate that the meanings of the target words were represented in memory after processing the inference sentences. However, the direction effect also appeared, showing that there were differences in the process between forward and backward lexical inferences. When participants encountered unknown words, whose meanings were elaborated by subsequent contextual information, relatedness judgment accuracy significantly decreased, and accordingly, reaction times increased. This suggests that the meanings generated by backward lexical inferences were activated more weakly than those by forward lexical inferences. Therefore, it is possible that participants found backward lexical inferences more difficult than forward lexical inferences, and this supports the assumption that backward lexical inferences might involve more complicated cognitive processes.

Although Experiment 2 replicated the results of Experiment 1, an uninteresting alternative interpretation still remains. Because the target unknown words always appeared late in the forward sentences, but early in the backward sentences, there was a substantial distance between the target words and probe words. This implies that the participants had to keep the inferred

meanings of the target words in mind longer in the backward condition than in the forward condition. In fact, Experiment 2 could not provide a clear explanation as to why the accuracy for the forward control condition seemed higher than the backward control condition (i.e., insignificant interaction of Elaboration \times Direction) because of no distinction between the Direction and Distance effects. A final experiment addressed this issue.

Experiment 3

Participants

The participants in Experiment 3 were 28 Japanese graduates and undergraduates majoring in psychology, biology, engineering, or medicine (13 males and 15 females; average age = 20.1, range = 18–24). None of them participated in prior the Experiments. All have studied English for more than six years in Japan. They gave informed consent before the experiment and gained 1,000 yen for their participation.

Materials, Procedure, and Data Analysis

There were 12 short story pairs (three-sentence length; see Table 6). The design used was 2 (Elaboration: inference vs. control) \times 2 (Direction: forward vs. backward) factorial, in the same manner as former Experiments. The first sentences of the stories, which were chunk-parsed, shared the same target unknown words as Experiment 2. Each first sentence pair (i.e., inference and control) was followed by a common second and third sentence to leave equal space between the target words and the semantic relatedness judgment task in both conditions (forward: $M = 27.00$ words, $SD = 0.85$; backward: $M = 26.83$ words, $SD = 0.83$), $t(11) = 0.43$, $p = .674$, $d = 0.20$.

Great care was taken to ensure that the second and third sentences did not semantically elaborate the meaning of target words. These sentences were created in cooperation with a native speaker of English, such that the following two criteria were satisfied: (a) coherence, which indicates that the three sentences form a coherent story, and (b) contextual cues, which indicates that the last two sentences do not provide helpful cues for inferring the meaning of target words. Rating data were collected from 23 Japanese EFL learners (none of them had participated in any of the other experiments) to verify the validity of the last two sentences. First, a questionnaire asked them to evaluate the degree of coherence of each story. Participants read both 12 inference and 12 control version stories, and then, answered whether each story was congruent or not based on a seven-point Likert scale ranging from 1 *not at all coherent* to 7 *very coherent* (inference: $M = 5.91$, $SD = 0.52$; control: $M = 5.84$, $SD = 0.42$). The high average rating showed that the stories were coherent and there was no significant difference between the inference and control versions, $t(11) = 0.43$, $p = .673$, $d = 0.15$. Next, participants were presented 12 target words and corresponding second and third sentences, and asked to judge whether or not the sentences allowed identification of the meaning of the presented words based on a seven-point Likert scale ranging from 1 *not at all available* to 7 *very available*. The low average rating indicated that these sentences did not allow lexical inferences to be made and did not differ between the forward condition ($M = 2.17$, $SD = 0.83$) and backward condition ($M = 2.00$, $SD = 0.74$), $t(11) = 0.48$, p

= .638, $d = 0.22$. These results revealed that the last two sentences did not direct participants' attention to target words excessively, because the coherence of each story was homogeneous and the second plus third sentences did not facilitate lexical inference.

Table 6. *A sample set of stimuli used in Experiment 3*

Forward condition	
<i>First sentence</i>	
Inference:	She tried / to put / the pieces of the broken plate back together / with <i>marf.</i> /
Control:	She walked across the large room / to Mike's messy desk / and returned / his <i>marf.</i> /
<i>Second and third sentences</i>	
After that, she ran to school because her school started in twenty minutes. Today, she had an important test so she wanted to get there on time.	
Backward condition	
<i>First sentence</i>	
Inference:	Joe picked up / the <i>asdor</i> / and began to / play a melody. /
Control:	Joe picked up / the <i>asdor</i> / and began to / walk home. /
<i>Second and third sentences</i>	
Then, he noticed that he had just got an email from his boss. The news about his promotion made him very happy.	

Note. Slashes represent pause-chunks. The probes used were the same as in Experiments 1 and 2.

In Experiment 3, the first chunk-parsed sentences appeared one at a time, and the second-third sentences appeared sentence by sentence on the computer screen. Participants were instructed to read each story for comprehension at their own pace, pressing a button on the response pad to indicate that they were ready for the next chunk or sentence.

The same measures were taken as in Experiments 1 and 2, and data were analyzed in the same way. The same procedure of eliminating outliers resulted in a removal of 1.04% of all observations.

Results

Correct response rates of the filler items were 98%, which indicates that participants completed the semantic relatedness judgment task properly. Table 7 shows the means, standard deviations, and mean differences with 95% CIs for task performance.

Table 7. *Mean accuracy and reaction times for the semantic relatedness judgment task in Experiment 3*

Elaboration	Forward		Backward		M_{diff} (95% CI)
	M	SD	M	SD	
Accuracy (%)					
Inference	81	12	68	13	13 (± 6)
Control	43	15	47	16	-4 (± 9)
M_{diff} (95% CI)	39 (± 6)		21 (± 9)		
Reaction times (ms)					
Inference	831	185	996	213	-165 (± 110)
Control	1,146	194	1,258	291	-112 (± 138)
M_{diff} (95% CI)	-315 (± 108)		-262 (± 134)		

Note. $N = 28$.

Accuracy. Figure 5 shows that accuracy was clearly higher in the inference than control contexts. This observation was supported by a two-way ANOVA; there was a significant main effect of Elaboration, $F(1, 27) = 118.48, p < .001, \eta^2 = .51$. Although the main effect of Direction did not reach significance, $F(1, 27) = 3.24, p = .083, \eta^2 = .01$, this effect on the accuracy interacted with the Elaboration effect, $F(1, 27) = 9.57, p = .005, \eta^2 = .04$. Post-hoc comparisons showed that whereas the accuracy in the inference contexts was significantly higher in the forward elaboration than in the backward condition ($p < .001, M_{\text{diff}} = 13, 95\% \text{ CI } [7, 19]$), in the control contexts there was no difference between the forward and backward condition ($p = .412, M_{\text{diff}} = -4, 95\% \text{ CI } [-13, 5]$).

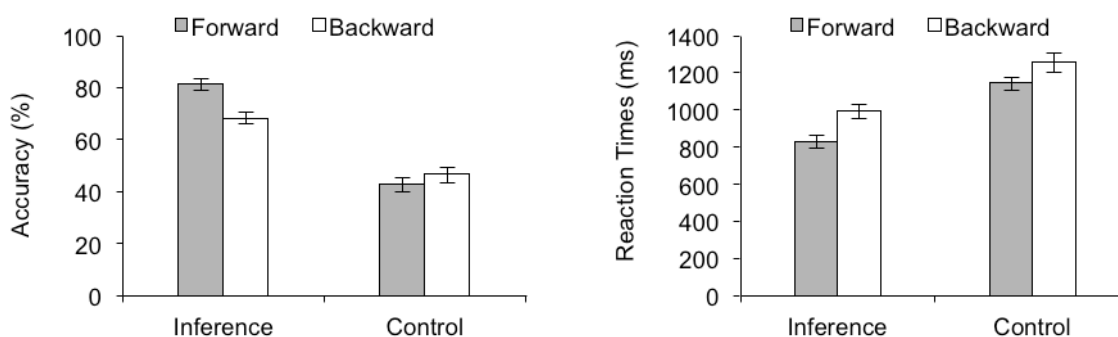


Figure 5. Mean accuracy and reaction times with $\pm SEM$ bars in Experiment 3.

Reaction times. Figure 5 indicates similar trends in reaction times to Experiment 2. A two-way ANOVA revealed significant main effects of Elaboration, $F(1, 27) = 44.43, p < .001, \eta^2 = .28$, and Direction, $F(1, 27) = 9.52, p = .005, \eta^2 = .06$. That is, reaction times were shorter in the inference than in the control condition. More importantly, reaction times were shorter in the forward than backward condition. The interaction of Elaboration \times Direction was not significant, $F(1, 27) = 0.42, p = .523, \eta^2 < .01$.

Discussion

One critical result of Experiment 3 is that, whereas the judgment accuracy for the control sentences did not differ between the forward and backward conditions, the accuracy for the inference sentences was higher in the forward condition than in the backward condition. In Experiment 2, it was possible that the distance between the target-probe words affected the judgment difficulty in the backward condition. This made it difficult to delineate the lexical inference processes from the judgment accuracy and reaction time data. However, Experiment 3 replicated this finding even after controlling for the distance effect. Surprisingly, the judgment accuracy and reaction time did not worsen in spite of the insertion of the second and third sentences. This result can be attributed to the task characteristic of the semantic relatedness judgment. In this task (see Figure 3), regardless of the distance between the target word and probe word in a contextual sentence, the target word was flashed again just before the probe word was presented. As the flashed target word reactivated the meaning of the probe word, inferred from the contextual sentence, it could allow participants to retrieve it from their memory; hence, similar results were obtained in Experiments 2 and 3. More precisely, the meaning of *asdor*—inferred from *Joe picked up the asdor and began to play a melody*—could be reactivated

by the target word (i.e., *asdor*) even if the memory of its meaning would weaken while reading the second and third sentences. Taken together, although the participants could infer the meaning of unknown words in the backward inference condition, the backward lexical inferences were more difficult than the forward lexical inferences.

General Discussion

Three experiments explored the different effects of contextual elaboration (i.e., forward vs. backward) on lexical inferences during L2 sentence comprehension. After participants processed unknown words embedded in sentences, they made semantic-relatedness judgments to target-probe words. Regarding the study hypothesis, in Experiment 1, higher accuracy and faster reaction times in the forward inference condition compared to the control condition, indicate that participants were sensitive to highly elaborative information, and they could retrieve a specific concept for unknown words based on relevant knowledge structures that were evoked by the contextual information. In other words, learners represented upcoming concepts in response to elaborative contexts and integrated them into sentence comprehension. This result was replicated in Experiments 2 and 3, where effects of strategic rereading were excluded. Similar to Experiment 1, forward elaborative contexts promoted higher judgment accuracy and faster reaction times. These findings support the current hypothesis and are consistent with previous L1 reading studies (Borovsky et al., 2010; Otten & van Berkum, 2008; Szewczyk & Schriefers, 2013). Early think-aloud research suggested that lexical inferences are complicated processes that require an informed guess for learners to engage their linguistic and non-linguistic knowledge to derive the meaning of unknown words (e.g., de Bot et al., 1997; Huckin & Bloch, 1993; Nassaji, 2006; Paribakht & Wesche, 1999; Wesche & Paribakht, 2010). Given that the ability to guess word meaning differs according to the quality of contextual information (e.g., Webb, 2008), lexical inferences will sometimes be difficult for L2 learners. However, the current findings demonstrate that when a prior context strongly constrains the possible meaning of upcoming words, learners make dynamic inferences such as anticipation, by representing specific knowledge that is relevant to contextual information.

In relation to the RQ, Experiment 1 demonstrated that in the backward condition, accuracy was higher and reaction times were faster in the inference than control sentences. These results imply that participants inferred the meaning of unknown words from backward elaborative contexts. The prediction of the present study was that there would be a significant difference in judgment task performance between the forward and backward conditions, which was based on the current proposition that identifying the meaning of unknown words via backward lexical inferences might involve three stages: (a) keeping an encountered unknown word in working memory (Cain et al., 2004; Daneman & Green, 1986), (b) finding a relevant highly elaborative context (Daneman & Green, 1986; Huckin & Bloch, 1993), and (c) integrating the inferred meaning with contextual information (Chaffin et al., 2001). The results of Experiments 2 and 3, whether participants strategically established a connection between an unknown word and contextual messages, are relevant to stages (b) and (c). If participants executed such a time-consuming integration process to infer the well-matched meaning of unknown words, accuracy and reaction times should have suffered when rereading intra-sentence was inhibited. In Experiment 2, the judgment accuracy and reaction time was lower and slower in the backward compared to forward

condition. Controlling the distance effect on the task performances in Experiment 3 refined this result. The findings support the idea that identifying the meaning of unknown words using backward lexical inferences requires effortful processes.

However, it should be noted that the comparison between the inference and control sentences revealed that in the backward condition, the meaning of the target words was also represented in the learners' mental representations in Experiments 2 and 3. Although Huckin and Bloch (1993) demonstrated that L2 learners were able to wait for additional informative contexts to identify the possible meanings of unknown words, it is unclear whether special goals, such as completing a think-aloud task, elicited such a lexical inference behavior. The findings from Experiments 2 and 3 support the early think-aloud studies, suggesting that L2 learners are able to process unknown words by lexical inferences when those meanings are constrained by immediately-following contexts.

Although the current study provides a new perspective by demonstrating that L2 learners make good use of forward and backward elaborative contexts to activate lexical inferences, it has some limitations. Whereas the process of lexical inferences was not specific to completing a think-aloud task, it is possible that the participants in this study inferred the target word meanings intentionally for the semantic relatedness judgment task. In addition, the semantic relatedness judgment task itself may develop strategic processing of unknown words because the required response to experimental target-probe pairs was always "yes." Therefore, future research should replicate the findings by applying different methodologies, such as eye-tracking measures (Chaffin et al., 2001), and event-related potentials (Borovsky et al., 2010). A more practical limitation of the present study is a sparse collection of judgment accuracy and reaction time data. Of course, a longer experiment might make the quality of the behavioral data worse. The results of the initial experiment were replicated by the follow-ups in this study. Nevertheless, this point is critical when conducting an experiment using reaction time data.

The experiments reported in this article were not specifically targeted at means of improving language instruction. However, some implications for foreign language teaching can be drawn from the findings. Because every L2 learner at any proficiency level encounter unknown words in texts, it is important to teach L2 learners how to process unknown words using lexical inferences (Fraser, 1999). Although this study indicates that learners make context-based lexical inferences without specific interventions, concern that their inferred meanings might be wrong will increase until they receive corrective feedback (Hulstijn, 1993). To develop learners' confidence in lexical inference ability, teachers in reading classes could first encourage students to verify the accuracy of their guessing attempts by referring to a dictionary. Before that, the ability to guess unknown words should be taken into account. Many studies recommend using a text with 95%–98% lexical coverage (e.g., Nation, 2013). This study shows that L2 learners are inclined to make lexical inferences from highly elaborative contexts. These perspectives suggest that teachers should remember a fundamental principle of language teaching: A comprehensible input develops learners' language competence in terms of autonomous reading comprehension.

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Appendix A

The Segmentation Rules Into Chunks Adapted From Hijikata (2012, p. 38)

Basic rules

(1) Sentence pattern [Subject + Verb]:

Basically, there are no chunk boundaries.

(2) Sentence pattern [Subject + Verb + Complement]:

Basically, there are no chunk boundaries.

(3) Sentence pattern [Subject + Verb + Object]:

Basically, there is a chunk boundary before Object. When Object consists of only one word or two words, Object is connected with S V; thus, the chunk is “S V O.”

(4) Sentence pattern [Subject + Verb + Indirect Object + Direct Object]:

Basically, there is a chunk boundary before Indirect Object. When Indirect Object consists of only one word or two words, Indirect Object is connected with S V.

(5) Sentence pattern [Subject + Verb + Object + Complement]:

Basically, there is a chunk boundary before Object. When Object consists of only one word or two words, Object is connected with S V.

Exceptions

(6) Big subjects and objects:

Big subjects and objects, which contain three words or over are regarded as one chunk.

(7) Punctuations:

Basically, punctuations such as period (.), comma (,), and colon (:) are signs of chunk boundaries.

However, the comma representing “apposition” is an exception.

(8) Adverbs:

(a) Adverbs consisting of one word are regarded as one chunk if there is a comma after adverb.

Adverbs composed of more than two words are chunks by themselves.

(b) Adverbs consisting of one word are connected to either the former chunk or the latter chunk, if the

(c) adverb is embedded in sentences.

(9) Prepositions:

(a) Prepositional phrases are independent chunks if the phrases are composed of more than two words.

(b) Prepositional phrases that function as a complement follow the basic rules of “S V C.”

(c) Prepositional phrases without content words (e.g., for him) are integrated into the former chunks.

The preposition “of” and “as” are connected with the prior nouns (e.g., A of B). However, if the object of the pronoun “of” consists of more than two words, the preposition “of” and its object are independent chunks.

(d) Relative clauses within prepositional phrases (e.g., about the way they dress) are contained in prepositional phrases.

(10) Conjunctions / Relatives:

(a) Basically, conjunctions and relatives start new chunks.

(b) If there are big Ss or big Os in *that* clauses, the rules of big S and big O are applied.

(c) In the case of the combination of big S and *be* verbs, big S is regarded as one chunk (Big S | (v) that...).

(11) Others:

(a) If an antecedent consists of one word, relative pronouns and their antecedents are integrated as big S and one chunk (e.g., women who say).

(b) To infinitives are basically addressed as one chunk. However, some of them can easily cross chunk boundaries, such as “want + to + do” or “deserve + to + do.”

(c) Present participles with perception verbs (e.g., see + O + doing) are regarded as one chunk because it becomes difficult to interpret the meaning if the participles are independent.

(d) The number of phrases containing content words is two, plus or minus one.

About the Author

Akira Hamada is a PhD student enrolled in the English education program at the University of Tsukuba, Japan. He teaches English as a foreign language to Japanese-speaking university

students. His areas of interest include second language lexical processing, vocabulary learning, and reading comprehension. Corresponding author. E-mail address: a.hamada.0218@gmail.com