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博 士 論 文

Processing mechanisms in the comprehension of ambiguous
sentences by Japanese learners of English: Does implicit learning
occur through repeated exposure?

(日本人英語学習者の曖昧文理解における処理メカニズムの解
明—繰り返し接触による潜在学習は起こるのか—)

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Processing Mechanisms in the Comprehension of Ambiguous Sentences by Japanese Learners of English: Does Implicit Learning Occur Through Repeated Exposure?

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ABSTRACT

This study aims to explore the causes of individual differences in sentence comprehension among Japanese EFL learners and to examine whether repeated exposure to specific syntactic structures promotes syntactic processing ability. For these, two experiments were conducted. The participants in the experiment were Japanese EFL learners and native English speakers, a group that has not been tested in previous studies (Experiment 1). It was also examined the data for Japanese EFL learners only in detail (Experiment 2). For Japanese EFL learners, their proficiency was also measured, and experiments were performed. This paper shows the effect of promoting comprehension of reduced relative clause sentences by repeated exposure visually, presenting reduced relative clauses and unreduced relative clauses for each phrase and comparing and analyzing reading times and correct answer rates. The reduced relative clause is a representative sentence in which a verb appears twice in one sentence and is likely to cause temporary ambiguity for readers.

It is possible to suggest learning from the step-by-step reading time data and the percentage of correct responses to content comprehension questions presented in the native language from these results. It was also set two critical regions for the experimental sentences, analyzed the two staged reading times, and randomly presented content comprehension questions in Japanese in a multiple-choice format for the experimental sentences, and analyzed the trends in the percentage of correct answers to verify the learning effect. In Experiment 1, the percentage of correct answers was recorded in Yes or No questions. However, since the percentage of correct answers tended to be relatively high and it was unclear whether the learners were reliably understanding the content in their native language, it was expected that Experiment 2 would be able to measure the learners' learning effects in more

detail. The results of the step-by-step reading time showed that there was a significant difference in the first order of item presentation in both regions at session 1. Therefore, it is possible that the experimental group learned the reduced relative clause within the session, since the reading time of the experimental group became shorter step-by-step. The results of the correct response rate show that both groups had a correct response rate above the chance level in session 1, but in session 2, the content comprehension questions for the reduced relative clause in the B1 control group (questions for the ambiguous sentence structure first exposed in session 2) had a correct response rate below the chance level. The fact that the questions presented in the native language were appropriate indicated that the results were appropriate for each proficiency level and for each group. Then it was tested whether an implicit learning effect could be observed in a shorter time by increasing the amount of exposure to about twice the number of exposures in Experiment 1. As in Experiment 1, word-level processing was tested by comparing reduced relative clause and non-contracted clauses that shared structural information and differed only in structural ambiguity. It was predicted that increasing the amount of exposure would induce implicit learning, even for short periods. The number of exposures in session 1 was significantly increased from Experiment 1, which increased the burden on participants to perform the task, while unconscious learning of syntactic knowledge resulted in a significant increase in the percentage of correct responses to content comprehension questions, as suggested by the correct response rate results. Implicit learning with a high number of exposures is effective in learning syntactic knowledge.

In the previous study, the processing cost reflecting prediction error was largest at the beginning of the session and became progressively smaller with experience with reduced relative clauses, i.e., the reading time became progressively shorter, indicating a learning effect based on prediction error. In this experiment, the reading time became progressively longer with each experience of reading ambiguous sentences, but the higher percentage of correct responses to content comprehension questions suggests that syntactic processing is occurring. The latency of reading and the high percentage of correct responses from session 1 to session 2 also suggest that implicit learning occurred. Native English speakers also showed progressively longer reading times suggests that the reading time regions in this study were regions where participants had to reanalyze and where processing costs were high, and that implicit learning occurred, and syntactic processing was activated in these regions with each trial, resulting in longer reading times.

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1. INTRODUCTION

1.1 Background

Clahsen and Felser (2006) indicated that it is difficult for foreign language learners to perform tasks based on complex syntactic knowledge in manners similar to native speakers. From this, it can be said that non-native speakers lack L2 syntactic knowledge. It can therefore be critical for foreign language learners to acquire syntactic processing ability. In addition, it would be necessary to elucidate the processing mechanism in their sentence comprehension. For this purpose, examination of sentence comprehension research in elucidating this processing mechanism will be indispensable for Japanese EFL (English as a Foreign Language) learners.

It would be possible to elucidate the human language processing mechanism by conducting sentence comprehension research. This paper focuses on the language processing mechanism used by Japanese EFL learners. In particular, (1) when people first comprehend a sentence, the process involves not only lexicon but also phonological information, semantic information, context information, and syntactic information, (2) sentence comprehension involves syntactic, semantic, phonological, and morphological processing, and sentence structures that contain syntactic ambiguity.

In the case of native language (L1) acquisition, it is believed that the knowledge to produce sentences (linguistic competence) and the knowledge to use the language (performance) can be acquired naturally (Chomsky, 1965). On the other hand, it has often been pointed out that second language (L2) learners have difficulties in performance, even if they are able to acquire linguistic competence in the target language (Sorace, 2005). In L2 acquisition research, there have been many studies on the acquisition of linguistic knowledge (Hawkins, 2001; White, 2003), but there has been a growing body of research on learners' sentence processing as an aspect of their performance (Clahsen & Felser, 2006; Dussias & Piñar, 2009). In these sentence processing studies, different responses to different linguistic structures, such as ambiguity in sentence interpretation, the influence of morphology, and the dependency between filled words (fillers) and gaps, as well as the influence of learners' abilities, such as proficiency, L1, and even memory capacity, have been investigated and numerous experiments have been conducted. When listening to another person's speech or reading a book or newspaper, people are able to process it rapidly and understand its content without any special effort (Ferreira, et al., 2002). Linguistic information processing consists of several levels of processing: speech (text) processing, word processing,

syntactic processing (syntactic analysis), semantic processing, and context processing. At the text processing level, auditory processing of speech or visual processing of text is performed. Word processing involves word recognition and retrieval of information stored in a mental dictionary. In syntactic processing, the relationship between words is calculated and the structure of the sentence (syntactic structure) is created. In the subsequent semantic processing stage, the semantic interpretation corresponding to this syntactic structure is given, and in the context processing stage, the most appropriate interpretation is selected using pragmatic knowledge and premise knowledge, and the speaker's intention is inferred (Sakamoto, 2005). In this way, the human linguistic information processing mechanism is divided into several stages, and each stage consists of many sub-mechanisms.

Lexical information plays a central role in the language comprehension and production process. The lexical hypothesis model of language processing of Levelt (1993) indicates that language comprehension and production are performed by referring to linguistic information described as declarative knowledge in the mental lexicon. Linguistic information registered in the mental lexicon acts as an intermediary for each stage of language processing. In the process from conceptualization to grammatical encoding, lemma information (semantic / syntactic information), and from phonological encoding to articulation, lexeme information (morphological / phonological information) is used (Levelt, 1989). For example, at the stage of phonological encoding, the phonological representation stored in the mental lexicon corresponding to the word to be uttered is activated and accessed or retrieved (Levelt, 1992).

Previous studies have stated that the resolution of temporary structural ambiguity in sentences in human language processing has not been successful and attempts to find ways to resolve this ambiguity have been made in sentences (Inoue, 2006). Inoue states that it is a major theme in the research field of comprehension research. According to this article, when humans comprehend sentences, temporal ambiguity in processing them is an important step in human comprehension of sentences, and it plays an important role in elucidating human language processing mechanisms.

1.2 The Purpose of the Study

Learners lack knowledge of foreign language syntax, and it is therefore difficult to use foreign languages. The initial lack of language syntax knowledge when studying a new language can make usage difficult. Clahsen and Felser (2006) described manners in which learners were unable to perform tasks requiring complex syntactic knowledge on the same levels as native speakers. The purpose of this study was to investigate the processing mechanisms in sentence comprehension and whether repeated exposure facilitates implicit learning for Japanese EFL learners and native English speakers.

The input for sentence processing comes from various modalities, such as auditory, visual, and tactile. For example, in spoken communication, information is input from the auditory sense; in written communication, it is input from the visual sense; and in Braille and tactile sign language, it is input from the tactile sense. It is not clear whether there are differences in sentence processing, especially in syntactic analysis and semantic processing, depending on the input modality. However, it is known that there are some sentence processing processes that are common to at least some input modalities. Ferreira et al. (1996) showed that when sentences were presented aurally in small parts, the participants misinterpreted the same parts (words, phrases) as when the sentences were presented visually in small parts. Thus, it has been shown that sentence processing occurs in the same way whether the sentence is presented visually or aurally, and regardless of the input modality, i.e., via visual or audio input, a common language processing process may be involved (Ferreira et al., 1996; Waters & Caplan, 2004, 2005). In the present study, it will be focused on language processing via visual input.

In the experiment, participants were exposed to either reduced or unreduced relative clause sentences in the first session, and then randomly exposed to both reduced and unreduced relative clause sentences in the second session. The results showed that the Japanese learners' reading time slowed as they were exposed to reduced relative clause sentences, but the percentage of correct answers increased. Native English speakers showed a similar tendency to Japanese EFL learners in the first session, but there was no gradual change in the second session. Although these results are not consistent with the prediction error-based implicit learning hypothesis, they indicate that repeated exposure enhanced the comprehension of relative clause sentences.

2. LITERATURE REVIEW

2.1 Characteristics of Sentence Comprehension

When people comprehend languages, whether by speech or textual information, they are processing the information “incrementally”. Incremental processing is an information processing strategy where an individual does not wait until complete information is obtained until the end of the sentence and performs analysis that can be performed at any time without retaining judgment in comprehending the sentence (Altmann & Steedman, 1988). In the process of receiving language information sequentially, incremental processing leads to misinterpretations because languages have ambiguities at various levels, such as lexical meaning, speech, and information about sentence structure. A typical example can be found in a sentence called a “garden path sentence,” as seen below;

(1) The defendant examined by the lawyer turned out to be unreliable.

This example of a garden path sentence is often introduced as a sentence that causes temporary ambiguity. Since the noun phrase that appears first is an animated noun phrase proceeded by the word, defendant, it is predicted that this is probably the subject and plays the role of agent. Examined, appears next as the expected verb. At this point, the reader recognizes it as being in the past tense and interprets it as “the defendant has examined something.” Finally, the reader expects the “examined object” to appear, but contrary to this, the preposition phrase “by the lawyer” appears. The interpretation of the reader so far, however, is actually incorrect. At this point, although examined is still a verb, it is a past participle, and [examined by the lawyer] has been interpreted as a modifier of the defendant, making it necessary for the reader to change the structure and interpretation. The verb, turned, corresponding to the subject [The defendant] appears, and finally leads to the correct interpretation “The defendant examined by the lawyer turned out to be unreliable.”

When reading or listening to this sentence, people perform linguistic processing, a property of which is incremental processing (Altmann & Steedman, 1988). This means that linguistic information is processed little by little from the beginning. In this incremental processing, the moment the reader encounters turned, they will find it difficult to process the sentence due to temporary structural ambiguity as to whether the main verb was, examined.

2.2 Lexicalization Associated with Syntactic Knowledge

2.2.1 Lexicalization in General

Word recognition is indispensable for language comprehension and production, and vocabulary acquisition is said to be a central element of successful foreign language acquisition (Beglar & Hunt, 2005). For this reason, issues surrounding vocabulary acquisition pose problems that have been addressed for many years not only in English but in language education as a whole. Clarifying the word recognition process, therefore, is an important topic in language processing research (Davis, 2010). It is important to acquire vocabulary and language proficiency, in both native languages and foreign languages. It is also widely recognized that lexical information plays an important role in language comprehension and production.

In psycholinguistics, the establishment of lexical information is a state in which a novel word is registered in a mental lexicon; this is called lexicalization (Gaskell & Dumay, 2003). When a novel word (*colleju*) settles in a mental lexicon, the ability to search for an existing word (*college*) is suppressed, and in the lexical decision task (to determine whether it is a word or non-word) it can be seen from the phenomenon that the judgment time of existing words is delayed. This phenomenon is called the lexical competition effect, and the lexicalization state can be judged by the occurrence of the lexical competition effect.

Lexical information plays a central role in the language comprehension and production process. The lexical hypothesis model of language processing of Levelt (1993) indicates that language comprehension and production are performed by referring to linguistic information described as declarative knowledge in the mental lexicon. Linguistic information registered in the mental lexicon acts as an intermediary for each stage of language processing. Lemma information (semantic/syntactic information) is used in the processes of conceptualization and grammatical encoding, whereas lexeme information (morphological/phonological information) is used from the stages of phonological encoding to articulation (Levelt, 1989). For example, at the stage of phonological encoding, the phonological representation stored in the mental lexicon corresponding to the word to be uttered is activated and accessed or retrieved (Levelt, 1992).

2.2.2 L2 Learner Lexicalization

Research on second language vocabulary acquisition has shown that retrieval practice promotes long term memory retention of vocabulary (Barcroft, 2007; Karpicke & Roediger, 2008; Nakata, 2017). Retrieval here

means to retrieve content learned before from the memory (mental lexicon). Although retrieval practice is an effective vocabulary learning activity, memory decays with time, and words are eventually forgotten. Therefore, in order to fix a word in the memory, it is indispensable to perform retrieval practice more than once regularly. Whether or not retrieval practice regularly promotes long term memory retention of vocabulary is an important research subject in L2 learning acquisition study.

In second language vocabulary acquisition research so far, the method of studying how newly acquired words are represented by the mental lexicon and how they combine with existing lexical representations has not been well established. The lexical competition effect may provide a new methodology for vocabulary acquisition research. For lexical competition to occur, competing lexical representations must be stored in the mental lexicon. After learning a novel word, if lexical competition between the word and the existing word is confirmed, it can be said that a representation of the word has been formed with the mental lexicon.

2.2.3 Insights of Lexical Boost with Comprehension

The lexical boost is a priming phenomenon at the lexical level in the production process, which can be seen as causing the syntactic priming phenomenon, indicating that priming that occurs at one language level also affects priming at another language level (Yokokawa, 2016). Several studies have also shown that lexical boosts occur in comprehension priming, as the priming effect can be larger when the critical verb is repeated between prime and target. For example, Tooley et al. (2009) reported that both the eye-tracking and event-related potential (ERP) effects are larger when the first verb of reduced relative clause sentence appears in both the prime and target sentences than when it does not. On the other hand, no lexical effect has been shown for modifier-object ambiguity (Traxler, 2008). several studies on double-object and prepositional-object datives (e.g., The pirate gave the princess the necklace; The pirate gave the necklace to the princess) have shown evidence for lexical boosts (Arai et al., 2007; Carminati et al, 2008). The characteristic of syntactic priming in comprehension, especially the presence of a lexical boost, may have important implications for syntactic representation and processing theory. In addition, it is important to know whether the lexical boost is a general phenomenon that occurs when syntactic priming occurs, or whether it is restricted to a few sentence types.

When verbs are repeated across primes and targets, the priming effect is larger. It has been suggested that part of the priming effect is due to semantic repetition rather than syntactic repetition. However, a number of

findings suggest that syntactic, rather than semantic, processes are responsible for the previously observed facilitation effects (in production; Bock, 1986; Bock & Loebell, 1990). If semantic redundancy facilitates the processing of target sentences, then sentences in which the prime and target verbs are synonymous should lead to priming, but this does not appear to result (Tooley et al., 2009), and semantic redundancy should lead to priming with repeated verbs, but this does not. It has been said that this is often the case (e.g., Traxler, 2008). Semantic redundancy should also lead to a reduction of N400 (this is a type of component in the EEG known as ERP. It is named a negative directional oscillation with a peak at about 400 milliseconds after the onset of stimulus presentation, but it can extend to 250-500 milliseconds. The maximum amplitude is usually observed at the electrode located around the center of the parietal. N400 is thought to be the brain's response to verbal and other meaningful (or implicit meaningful) stimuli, such as visual and auditory words, sign language signs, pictures, faces, environmental sounds, and smells; Kutas & Federmeier, 2000) during target sentence processing. This effect can be observed with repeated verbs, but the late positive reduction is typically seen after syntactic disambiguation of the target sentence (Ledoux et al., 2007; Tooley et al., 2009, Tooley et al., 2014). As priming effects are easily observed when verbs are repeated between priming and target, participants may notice the repeated verbs and consider ways to deal with syntactically difficult target sentences. In the Tooley et al. (2009) experiment, even the first one or two trials showed similar priming effects (larger effects) to those obtained throughout the experiment. Some reports have also shown that the presence or absence of cues on how to cope is decoupled from the presence or absence of priming effects (Traxler & Tooley, 2008). This suggests that the syntactic priming effect is likely to be independent of the participant's strategy. Although previous studies of syntactic priming in comprehension have reliably observed the facilitation of target sentence processing, a number of questions remain. One of these is the extent to which the priming effect during online interpretation depends on lexical repetition between the prime and target sentences.

Language production studies have shown that lexical boosts rarely persist across unrelated intervening sentences (Branigan & McLean, 2016; Hartsuiker et al., 2008). It has been argued by some that lexical boosts are more likely to be generated by short-term (i.e., non-learning-based) mechanisms (Bernolet et al., 2016; Branigan & McLean, 2016; Hartsuiker et al., 2008; Tooley & Traxler, 2012). This could be a residual activation mechanism (similar to that proposed by Pickering & Branigan, 1998), in which links between structural and verbal nodes activated during prime processing retain their activation, facilitating the processing of targets of the same verb-

structure pair (Tooley & Traxler, 2012). Another mechanistic hypothesis suggests that structural information from the prime sentence (stored in long-term memory) is temporarily linked to individual words in the prime sentence (stored in working memory) (e.g., Reitter, Keller, & Moore, 2011; Chang et al., 2006; Chang, Janciauskas, & Fitz, 2012). According to this hypothesis, when content words from the prime are redetected during target processing, relevant structural information is activated, and this information influences the structural formalization/interpretation of the target, leading to target facilitation. Results from comprehension studies have shown that the syntactic priming effect of lexical mediation can persist over one to three filler sentences (Pickering et al., 2013; Tooley et al., 2014). This may indicate that the lexical boost and the abstract syntactic priming effect share a common mechanism.

The abstract syntactic priming effect is due to an error-based learning mechanism, and the degree of priming at a target can be predicted by the degree of error that occurs during the processing of the prime (Fine & Jaeger, 2013; Fine et al., 2013; Jaeger & Snider, 2013). If the lexically-mediated priming effect varies with the error signal during the reanalyzing processing of the prime, then the lexically-mediated priming effect will only appear if the prime sentence itself requires syntactic reanalysis (or will be particularly large in these cases). Structural representations can be activated via working memory mechanisms (Chang et al., 2006). In this type of hypothesis, words from the prime are stored in working memory and are temporarily adjacent to a specific structural representation in long-term memory. When the verb is encountered again in the target sentence, this serves as a cue for retrieval of structural information from long-term memory (although this hypothesis challenges recent evidence that individuals with severe short-term memory impairment still exhibit lexically-mediated syntactic priming effects in the production environment (Yan et al., 2018)). Thus, it can be said that structural representations are more likely to be prepared via residual activation of links between specific verb nodes and structural nodes in the lexical framework of long-term memory (Tooley & Traxler, 2012). This is similar to the residual activation mechanism proposed by Pickering and Branigan (1998), but without the shared structural nodes of different verbs, and without assuming that residual activation of the structural nodes themselves is the source of abstract syntactic priming effects. The dual-mechanism assumes that error-based learning produces abstract syntactic priming effects, while residual activation mechanisms produce lexical-mediated priming effects. This hypothesis most easily accounts for the abstract syntactic priming effect (Fine & Jaeger, 2013; Tooley & Traxler, 2018), which includes the lexical-mediated priming effect observed in the present study and the

cumulative priming effect observed in previous comprehension studies. Conceptually, there are two types of processing that prime sentences may affect. Prime sentence processing can weaken the tendency of readers to adopt simpler and more frequent (main clause) interpretations of temporarily ambiguous reduced relative clause sentences and can affect the ease with which participants recover the alternate syntactic and semantic analysis of garden-path sentences. This effect could appear at the beginning of the syntactic analysis of the target sentence, or the effect could appear during syntactic reanalysis (i.e., during garden-path recovery). For example, many priming effects are said to appear relatively early during target sentence processing (Tooley et al., 2019).

One thing about lexical boost is the nature of the syntactic representations that are promoted. It is unclear whether the promoted syntactic representations are highly abstract and reflect global constituent structures (not lexical features within constituent phrases) or whether they are based on specific lexical content within constituent phrases. For example, the reduced relative clause sentence (The boy pushed by the girl cried) and the relative clause sentence (The boy who was pushed by the girl cried) have the same global abstract structure (noun phrase - relative clause - verb phrase). Nevertheless, the relative clause differs from the constituent relative clause phrase in that it contains a “who was”, but not a reduced relative clause sentence. It is also important to note that all major mechanistic hypotheses of syntactic priming assume that priming effects reflect the promotion of abstract structural representations (Chang et al., 2006; Pickering & Branigan, 1998). This assumption is in line with the results of Bock (1989), who found that the priming of the prepositional case object is not affected by the preposition (to vs. for) used in the prepositional phrase of this structure. This is also consistent with findings from a study (Hsieh, 2017) that found evidence of interlingual syntactic priming across Chinese and English sentences with the same abstract structure but different word order (and content words). However, this assumption may not be consistent with findings that participants may be prepared to produce (or not produce) the word as part of an intrinsic complement clause in a sentence (Ferreira, 2003). A lexical boost triggered by word-level information may be sensitive to changes in the exact lexical/syntactic matching within a constituent.

2.3 Variability of Linguistic Knowledge: Implicit Learning through Experience

People are said to change their gradual processing based on statistical and other information about linguistic information from previous experiences (Mitchell et al., 1995). This is constantly changing with experience, even in adults (Norris et al., 2003; Wells et al., 2009; Kaschak & Glenberg, 2004). This change due to

experience is also referred to as implicit learning, which refers to the updating of knowledge based on experience since this change due to experience is implicit and usually unconscious. Priming is a visible phenomenon that can be seen to cause implicit learning where information given earlier unconsciously affects later information processing. The phenomenon of priming by syntactic knowledge, which is knowledge of sentence structure, is called “syntactic priming”. Syntactic priming refers to the habit of using sentences with the same sentence structure as sentences previously exposure. This is thought to occur as a result of repeated exposure to a particular sentence structure which potentially results in learning and updating of syntactic knowledge. Although syntactic priming has been observed in comprehension as well as language production and has been found in foreign languages as well as native languages (e.g., Arai, 2016), syntactic priming has not yet been fully as it relates to foreign language learners and many challenges remain.

As a mechanism for syntactic priming, Chang et al. (2006) believe that a prediction error occurs, which is caused by an increase in the probability that the structure encountered will be predicted again the next time. This prediction error is a difference in the comprehension of a language or a sentence that contradicts people’s original knowledge, or when the predicted output differs from the actual output received. This prediction error-based learning takes place to update existing syntactic knowledge. This suggests that learners’ exposure to sentences with temporary ambiguity and making changes to existing syntactic knowledge affects language processing and facilitates sentence comprehension.

One mechanism that contributes to syntactic priming, especially relatively persistent priming effects, is implicit learning. One of the models was developed to explain long-term priming patterns in production studies (Chang et al., 2000, 2003, 2006; Chang et al., 2012; Fitz et al., 2011). Prediction and error-based learning are the core features of this model, which has since been extended to account for patterns of syntactic structure learning in children and adults (Rowland et al., 2012). In the case of comprehension, the model predicts the next constituent each time a new word is encountered. If the actual input differs from the predicted input, e.g., a relative clause appears instead of the direct object NP, the model changes the connection weighting between the input, hidden, and output units (Traxler et al., 2014). In this way, the model’s predictions may change with exposure, increasing or decreasing the preference for different types of sentences. In this type of hypothesis, the strength of the underlying syntactic structure representation has been shown to increase with exposure to the appropriate type of sentence. Implicit learning occurs outside of the conscious mind, without conscious effort on the part of the

readers, and has been shown in studies of exposure to specific types of sentences (Long & Prat, 2008; Wells et al., 2009) and may explain the facilitative effects seen in changes in preference for unusual syntactic forms (Luka & Barsalou, 2005; Luka & Choi, 2012; Kaschak & Glenberg, 2004; Kaschak et al., 2011). Also, the implicit learning hypothesis expresses effects based on input features beyond the structural organization and category order. Implicit learning can also be applied to simple word sequences (Arnon & Snider, 2010).

2.4 Changes in the Processing of Syntactic Knowledge

Priming is a visual phenomenon in which implicit learning is triggered. Priming is the process of experiencing one piece of information, which in turn affects the process of processing the same piece of information. Syntactic priming is the priming phenomenon based on knowledge of sentence structure and syntactic knowledge. Syntactic priming has been observed in language production and comprehension and has a certain temporal persistence, it has been shown that the less frequent the structure, the greater the priming effect. Syntactic priming refers to the phenomenon of producing sentences using the same structure as sentences the reader has previously come into exposure.

Syntactic priming occurs when the sentence structure elements of the prime sentence influence the comprehension of subsequently encountered target sentences (Bock, 1986; Pickering & Ferreira, 2008). For example, when a speaker makes or hears a passive sentence, the speaker is more likely than usual to make subsequent sentences in the passive form. On the other hand, the effects of syntactic repetition can be distinguished from other types of repetition, and syntactic priming effects in production do not depend on the repetition of functional words. The priming effect of a given construction is the same if the prime sentence contains the preposition “to” and the target sentence contains the preposition “for”, and vice versa. In addition, the priming effect in production does not depend on the repetition of meaning between the prime and target sentences. Bock and Loebell (1990) show similar priming for prepositional datives (e.g., *The woman gave the Mercedes to the church*) and for locative expressions (e.g., *The woman drove the Mercedes to the church*). This is thought to be due to the syntactic structure-building process that mediates between conceptual expressions and spoken and written output. In comprehension, the processing time is often shorter than usual when syntactically similar sentences precede syntactically difficult sentences (Tooley et al., 2009; Traxler, 2008). The effect of syntactic form has also been observed in visual-world experiments (Arai et al., 2007; Carminati et al., 2008;

Thothathiri & Snedeker, 2008). In ERP experiments, syntactic repetition between sentences is associated with a decrease in positivity after syntactic disambiguation (Ledoux et al., 2007; Boudewyn et al., 2014). Similar effects have also been observed with syntactic repetition within sentences (Frazier et al., 2000; Sturt et al., 2010; Trueswell & Kim, 1998).

According to Tooley et al. (2014), the priming effects observed in comprehension of syntactically disambiguated sentences (especially in reduced relative clause sentences, which have received the most attention) are driven by syntactic representations and processes, as opposed to purely semantic or lexical ones. This does not mean that semantic processes do not facilitate the by-phrase processing of such sentences, but rather that syntactic processes are the most likely source of the priming effect. However, the exact mechanisms and processes that cause such effects are still under debate and identifying mechanisms and processes that enhance comprehension will help people better understand how lexical and syntactic representations are organized, and how the process of comprehension compares to the process of production. It also helps to understand how the process of comprehension compares to the process of production.

Research by Bock and Loebell (1990) indicates that changes in syntactic knowledge occur. For example, after reading the sentence, *Susan brought Stella a book*, in the case of performing a picture description task, if a child is showing a photo to a man when they were given *the children*, they produced *shown a man a picture* instead of *shown a picture to a man*. This is thought to be due to the idea that exposing a sentence structure repeatedly potentially leads to learning and changes in syntactic knowledge. It has also been suggested that syntactic priming is caused by a prediction error, which increases the probability of predicting the structure encounters again (Chang et al., 2006). This prediction error is the difference between the predicted output and the actual output received in comprehending the language or sentence. Learning based on this prediction error will change existing syntactic knowledge. From this, considering this research theme, exposure to sentences that create temporary ambiguity and change existing syntactic knowledge can affect human language processing and promote sentence comprehension.

While there is a large body of literature on syntactic priming in sentence production (Pickering & Ferreira, 2008), the literature on comprehension is scarce (Branigan et al., 2005; Tooley & Traxler, 2010, 2012). The syntactic priming effect that occurs in the process of sentence comprehension is most relevant to the problem addressed in the current experiment. Studies that have been reported so far include reduced relative clause

sentences (Ledoux et al., 2007; Tooley et al., 2009; Traxler, 2008; Traxler & Tooley, 2008), prepositional object and double-object datives (Arai et al., 2007; Carminati & van Gompel, 2008; Thothathiri & Snedeker, 2008).

Previous research on reduced relative clause sentences has shown that exposed the prime sentence influences the online processing of the target sentence immediately after the prime sentence (Tooley et al., 2009; Traxler, 2008) and that the priming effect is greater when the first verb of the prime sentence appears in the target sentence. It has been suggested that the priming effect is greater when the first verb of the prime sentence appears in the target sentence. Comprehension studies have reported the effect of prime sentences on the process outcome of comprehension.

Picture matching experiments have shown that interpreting ambiguous prime sentences in a particular way biases subsequent picture matching responses to the target sentence (Branigan et al., 2005). If participants read “The girl poked the policeman with the umbrella” and interpreted it to mean “the policeman has an umbrella” (the girl does not have an umbrella), they were just as likely to interpret “The clown poked the nurse with the pencil” in the same way. (i.e., the nurse has the pencil; Raffray & Pickering, 2010). Experiments in which the prime was given as a formula and the target was a syntactically ambiguous sentence showed that comparable effects occurred and vice versa (Scheepers et al., 2011). These results show that processing prime stimuli can influence the assignment of syntactic structure to a target at an abstract level, but they do not assess whether a process of structure building is unfolding.

Studies of preference judgments have shown that exposure to large numbers of syntactically marginal sentences increases ratings of acceptability (the grammaticality of a sentence as judged by native speakers through intuition) (Kaschak & Glenberg, 2004; Luka & Barsalou, 2005). This effect has been shown to occur for as much as a week between exposure and testing sessions (Luka & Choi, 2012; Kaschak et al., 2011). The increase in acceptability may reflect the ease of online processing (i.e., increased ease of processing increases acceptability), but this cannot be determined by acceptability alone.

Comprehension research aimed to prove that syntactic priming exists (Carey et al., 1970). The other studies relied on the mass repetition of specific syntactic structures and did not necessarily show the effects of syntactic repetition. Such studies were weak against alternative explanations such as participant strategies and prosodic repetition (Noppeney & Price, 2004). However, recent studies have also demonstrated the effects of syntactic repetition across online comprehension and have not relied on large amounts of repetition (Arai et al.,

2007; Ledoux et al., 2007; Traxler, 2008; Trueswell & Kim, 1998). In this type of research, participants are usually exposed to a single prime sentence before responding to the target sentence, indicating that semantic repetition alone is not sufficient to facilitate processing some semantically difficult sentences (Tooley et al., 2009). Participant strategies likewise show that they are not sufficient to facilitate the processing of syntactically difficult sentences (Traxler & Tooley, 2008; Traxler et al., 2014).

2.5 Research on Native English Speaker Reading Comprehension

Looking at what has been revealed and what has not been done in previous research first, there are many comprehension studies involving L1 English speakers, especially in reading comprehension experiments, in which speakers take time to process unexpected words or structures (Jurafsky, 1996). Other authors have shown difficulty of processing words and phrases (Fine & Jaeger, 2013). Fine and Jaeger (2013) re-analyzed an eye-movement experiment on syntactic priming in comprehension performed by experiment three of Thothathiri and Snedeker (2008). Thothathiri and Snedeker (2008) showed that syntactic structure is easier to comprehend after exposure to the structure. They focus on ditransitive alternation, which allows English speakers to encode the same meaning using a double object (DO) syntax or a prepositional object (PO) structure:

DO: John gave his daughter a book.

PO: John gave a book to his daughter.

In their experiment, during each trial, participants listened to the story, followed by two primes related to that story (both the story and the prime were spoken by the same speaker). Both primes were PO or DO syntax. Immediately after the prime, the participant's eye movements relative to the visually presented object were recorded (irrelevant to the story and prime, spoken by another speaker; the transitive verb was included). As a result, they showed that syntactic priming in comprehension was due to implicit learning. Specifically, they found that the surprisal prime structure leads to a strong prediction / expectation that the same structure will be used in later sentences. This suggests that implicit learning underlying syntactic priming is error-based (Chang et al., 2000, 2006) and emphasizes the importance of error-based implicit learning beyond language acquisition (Chang et al., 2006). They also showed how this effect could be part of an adaptive response that promotes efficient communication, as suggested by studies from perceptual adaptation.

However, comparing different types of sentences, for example reduced relative clause sentences and main clause sentences, only the results for the entire sentence have been observed. Also, since the research is intended for L1 English speakers, it is a change in syntactic knowledge that has already been acquired, so it is not learning in the sense that previously unknown or incomplete knowledge is acquired. Therefore, it has been suggested from previous studies on L1 English speakers that it is difficult to verify whether learning based on prediction errors is effective in learning syntactic knowledge from data of L1 English speakers only.

According to Spivey-Knowlton et al. (1993) reduced relative clause sentences are ambiguous because the same verb form (usually with verb +ed) is used for both past tense and most verb participles in English. Thus, a fragment that starts with a noun followed by the verb + ed is ambiguous between the start in the main clause and the start of the relative clause sentence. In the main clause, the noun phrase is the subject of the verb, but in the relative clause sentence, the noun phrase is the logical object of the verb. Simplified relative clause sentences are a convenient structure for examining the role of context in ambiguity resolution for several reasons. First, as this paper demonstrates, there is a clear and definitive baseline condition, a complete (non-minified) relative clause sentence. Second, ambiguities are local, as sentence ambiguities. Third, in the absence of context, there is a strong preference for one of the syntactic alternatives. This makes evidence of context effects very convincing. Finally, relative clause sentences allow the readers to explore different kinds of contexts using the same structure, and possibly the same statement. This allows the readers to compare time courses where different types of information are used in processing a sentence while keeping the local factor constant.

The model of Chang et al. (2006) was originally proposed as a mechanism to explain the priming phenomenon in language production, but there have been many recent reports showing that the same mechanism causes the priming of language comprehension (Arai, 2016). Regardless of the mode of usage (production/comprehension), it is now considered a phenomenon that reflects implicit learning. Therefore, several attempts have been made to explain this syntactic priming with the more general model of implicit learning based on prediction errors, as well as syntactic knowledge. A widely used theoretical basis for such research is the probability-based predictive sentence processing theory called surprise theory (Hale, 2001; Levy, 2008). The theory states that once a person comprehends a sentence, the next information in each phrase is based on the information received so far (including not only the sentence currently being processed but also previously processed information). Based on assumptions, probabilities are calculated, and ambiguities are assumed to be

resolved predictively. This defines the inverse relationship between the predicted probability and the processing load when the information is displayed and allows quantification of the cost of linguistic information processing. In recent years, much research has been done on such predictive information processing in language comprehension (Altmann & Kamide, 1999), which has given this amazing theory a great deal of attention. When the magnitude of the prediction error reflects the degree of learning, Chang et al. (2006) argue that the lower probability of predicting a piece of linguistic information when an error occurs. It can be considered that the effect on learning information is great. The surprise is calculated as the negative logarithm of the probability (p) that a structure is predicted based on the preceding context ($-\log p(\text{structure} | \text{preceding context})$). The higher the surprise in the treatment, the greater the priming indicated effects (Fine & Jaeger, 2013). Recent studies have shown that syntactic priming reflects implicit learning based on prediction errors, but these studies have targeted L1 English speakers. Therefore, the results of these studies show a change in syntactic knowledge already acquired, rather than learning in the sense that previously unknown or incomplete knowledge is acquired. Currently, few studies have found that learning models based on prediction errors are effective for learning in this more general sense.

2.6 Research on Japanese EFL Learner Reading Comprehension

There are only a few studies that verify learning based on prediction errors for Japanese EFL learners. Among them, Arai (2016) verified that Japanese EFL learners were not able to attain complete or stable knowledge, so it could be effective for them to understand the mechanism of the process of learning through experience by comparing the reading time of reduced relative clause sentences and unreduced relative clause sentences. The reason for choosing these structures is that they differ only in the presence or absence of temporary structural ambiguities that have the same meaning, with the same vocabulary. The results show that exposure to structurally ambiguous sentences affects implicit learning of structural information, and that prediction error-based learning is also effective when incomplete or unstable knowledge is learned through experience. However, native English speakers were not included in the experiments, and the proficiency level of the learners was not considered.

If past experience with a particular structure affects the lexically specific representation of that structure, one would expect to see a priming effect when the comprehender experiences the same verb as the preceding

sentence, but not when they experience a different verb. In fact, the majority of previous studies on syntactic priming during comprehension have observed the effect only when the verb is repeated between the prime and target sentences (Arai et al., 2007).

Arai, M., Nakamura, C., & Mazuka R. (2015) used temporally ambiguous relational clause sentences in Japanese to examine whether the immediately preceding syntactic context leads comprehenders to expect structures not normally preferred before disambiguating information. The results revealed a priming effect prior to disambiguation, as those who predicted the relational clause structure when they heard the verb were more likely than those who predicted the main clause structure to have experienced the same structure before. In addition, the sentence completion task and reading time of the prime sentences suggested a strong initial preference for analyzing the main clause, which became more difficult to process when the disambiguating relational clause head was encountered. These results indicate that experience with relational clause structure strongly activates structures that are not normally preferred, and that comprehenders predict the same structures in subsequent processing. However, the priming effect was observed only when the comprehenders heard the same verb as the one in the prime sentence. This suggests that in Japanese, the representation of the relational clause structure is directly related to the individual verbs. This contradicts several previous studies that observed lexically independent priming in comprehension. To address this issue, it was proposed that priming occurs independently of the verb when the relevant structure is accessed before the verb, but priming is strongly bounded lexically when the structure is accessed after the verb.

2.7 Residual Problems

This experiment, therefore, verifies whether implicit learning by the role of exposure is effective in learning syntactic knowledge and especially whether it can be seen from word-level processing. In addition, the purpose is to determine whether the learning was done from the correct answer rate of the questions on the experimental sentences, which was not verified in the research on Japanese EFL learners, and whether the degree of learning differs depending on proficiency levels. This study examines whether repeated exposure produces implicit learning and changes in syntactic knowledge for Japanese EFL learners and native English speakers, based on Arai's (2016) experimental text and design. The degree of learner proficiency is also considered, and the effect of proficiency on implicit learning and its degree is examined.

3. EXPERIMENT 1: A comparison of the effects of syntactic processing on reduced and unreduced relative clause comprehension between Japanese EFL learners and English native speakers

3.1 Research Question

Three points have been revealed in previous studies. (1) Differences in Japanese EFL learners' proficiency and learning by L1 English speakers. (2) Suggestion of learning based on reading time and correct answer rate in sentence comprehension experiment. (3) Learning effect with a small number of exposures. To confirm these findings, three research questions arise in the experiment: (1) Does the degree of learning vary with proficiency? (2) Is it possible to suggest learning from the correct answer rate of questions for experimental sentences? (3) Is implicit learning with few repeated exposures effective in learning syntactic knowledge?

3.2 Hypothesis

In this experiment, reduced and unreduced relative clause sentences were presented to participants under the following two conditions (2a, 2b).

(2a) The professor assisted in the difficult experiment enjoyed the task.

(2b) The professor who was assisted in the difficult experiment enjoyed the task.

In (2a), the relative pronoun and the connecting verb (*was*) in the embedded relative clause sentences are omitted. More specifically, the verb (*assisted*) following the subject noun phrase is structurally ambiguous because its past and completed forms are isomorphic. However, because the main clause structure is much more frequent than the relative clause sentence structure, the reader usually selects the main clause structure as a progressive analysis at this point. The preposition phrase “*in the difficult experiment*” that comes next does not prove that the main clause analysis is disproved (because it may be an intransitive structure with implicit term information), so the main clause structure interpretation is retained. Therefore, it is hypothesized that the prediction probability of the main clause structure at the time when the normal preposition phrase is processed highly. This is disproved for the next main verb (*enjoyed*), which leads to a prediction error. This process is thought to cause learning.

The important point is that the prediction error of the relative clause sentence structure increases as the relative clause sentence is experienced, so the prediction error gradually decreases. In other words, the

processing cost reflecting the prediction error is expected to be the largest at the beginning of the session and gradually decreases as reduced relative clause experience sentences. On the other hand, (2b) does not omit the relative pronoun and the connecting verb, and there is no ambiguity in the verb. This means that at the time when the relative pronoun comes after the subject noun phrase, the appearance probability of the main clause structure becomes zero, and incorrect prediction itself is not considered to occur. Therefore, it is believed that implicit learning of this relative structure does not occur by processing the sentence (2b).

In this experiment, the learning effect is verified by using unreduced relative clause sentences as control sentences and observing differences in the reading time from reduced relative clause sentences. The important factor is that the two conditional sentences have the same meaning with the same vocabulary and differ only in the presence or absence of temporary structural ambiguities. In previous studies on syntactic information learning for L1 English speakers, the predicted occurrence probability of syntactic structure was calculated based on sentence-based experience (Fine & Jaeger, 2013). Therefore, it was unclear from these results whether the structural ambiguity contained in the sentence plays a decisive role in implicit learning. If the prediction error is calculated for the group of syntactic information of relative clause sentence structure, it should not affect whether the structure contains temporary ambiguity or not. Only relative probabilities with the syntax of should have an effect.

For the first research question, Japanese EFL learners are asked to conduct a survey of their proficiency and to analyze the level of learning based on their proficiency in analysis. In these studies, the results were analyzed without regard to proficiency. Differences in learning may be seen depending on the level of proficiency. As a prediction, if the number of exposures is small based on the results of previous research, it is believed that a learner with a higher level of proficiency has a higher learning effect.

Next, regarding the second research question, questions are set in all experimental sentences and the transition of the correct answer rate is analyzed to verify the learning effect together with the reading time. In previous studies, the correct answer rate was recorded, but no indication of learning effect was made. It is predicted that the learning effect of the participant can be measured in more detail by using the correct answer rate as an analysis target.

Finally, with respect to the third research question, word-level processing is verified by comparing reduced and unreduced relative clause sentences that share structural information but differ only in structural

ambiguity. In addition, even though a small number of exposures, the learning effect can be seen for each sentence.

This experiment verifies whether implicit learning by repeated exposure is effective in learning syntactic knowledge and especially whether this can be shown by word-level processing. In addition, it was decided that whether learning was achieved from the correct answer rate of the questions on the experimental sentences, which was not verified in the research on Japanese EFL learners, and whether the degree of learning differs depending on proficiency levels. The number of sentence exposures was verified using the same number of exposures as in Arai's (2006) study on Japanese EFL learners.

Referring to the experimental text and design of Arai's (2016) experiment, it was tested whether repeated exposure in sentence comprehension can cause implicit learning and changes in syntactic knowledge in Japanese EFL learners and native English speakers. Specifically, if the reading time of a sentence is gradually short, it was predicted that prediction errors should occur and cause implicit learning. It also considered the proficiency of the learners and tested whether proficiency had different effects on implicit learning and its degree.

In this experiment, the learning effect is verified by using two conditional sentences, unreduced and reduced relative clause sentences. The unreduced relative clause sentences were used as control sentences and any differences in the reading time compared with reduced relative clause sentences were observed. It was important that the two conditional sentences have the same meaning with the same vocabulary and differed only in the presence or absence of temporary structural ambiguities. In previous studies on syntactic information learning for L1 English speakers, the predicted occurrence probability of syntactic structure was calculated based on sentence-based experience (Fine & Jaeger, 2013). Therefore, it was unclear from these results whether the structural ambiguity contained in the sentence plays a decisive role in implicit learning. If the prediction error is calculated for the group of syntactic information of relative clause sentence structure, it should not affect whether the structure contains temporary ambiguity or not. Only relative probabilities of the syntax should have an effect.

3.3 Methods

3.3.1 Participants

Fourteen Japanese EFL learners (experimental groups: A2:3, B1:2, and B2:2; control groups: A2:2, B1:2, and B2:3) from the Kansai area and ten L1 English speakers from the countries of the United States of America,

Canada, United Kingdom of Great Britain and Northern Ireland and Australia where English is the native tongue were tested. Prior to the experiment all Japanese EFL learners had studied English for at least six years. The experiment was conducted from November 21st to December 19th, 2019.

3.3.2 Apparatus

The presentation of trial events was controlled by a laptop PC, using SuperLab 5 Stimulus Presentation Software (Cedrus Corporation, San Pedro, CA, USA).

3.3.3 Materials and Design

The participants were randomly assigned to one of two groups (experimental or control groups) and participated in a reading experiment consisting of two sessions. In the first session, in the experimental group, the experiment was performed under the condition that all 16 experimental sentences (32 sentences were filler sentences) out of a total of 48 English sentences were reduced relative clause sentences. In the control group, the experiment was performed under the condition that all the experimental sentences were unreduced relative clause sentences. In the second session after a short break, half were randomly presented with reduced relative clause sentences and half with unreduced relative clause sentences, regardless of group. The ratio of experiment sentences to filler sentences was the same as in the first session. In both sessions, in order to measure the effect of learning on the comprehension of reduced relative clause sentences, question sentences were presented for all sentences including filler sentences, and the answers were recorded. The stimulus sentence (both the experimental sentence and the filler sentence) was randomized with the restriction that the test items were not continuous, and each test list was created so that each test subject was presented only once for each subject under each condition.

3.3.4 Procedure

The stimulus was presented using a method called self-paced reading, and each time the subject pressed the space bar, the stimulus sentences separated phrase by phrase were sequentially presented on the display (Just et al., 1982). Jegerski (2014) said that “self-paced reading is still the most fundamental experimental measure employed by psycholinguists interested in processing at or above the level of the sentence. Self-paced reading was also the first on-line (i.e., real-time) method to be applied in non-native sentence processing research.” This

experiment method allows the experiment participants to read the sentence at the speed of their comprehension and quantifies the processing cost of each phrase using the reaction time in each region as an index. Therefore, it is widely used as an effective method for seeing the real-time information processing in sentence comprehension (Arai, 2016). In the self-paced reading task, participants can read at their own pace, which allows us to capture the reading in a more natural way. In addition, the reading time obtained by this method includes the motor programming for key presses and the motor latency, which can lead to a trade-off between processing speed and accuracy (McElree & Griffith, 1995), and it is also difficult to capture the time limit of processing. Although the self-paced reading task is different from natural situations such as reading a newspaper or a book at one's own pace, it is possible to capture the temporal limits of sentence processing as well as the increase in processing time. In addition, since it does not require a response while reading a sentence, it can measure the processing time excluding the time for exercise, and thus has high power to detect the processing load.

A self-paced reading experiment consisting of two sessions was conducted. In the first session, the experimental group read only reduced relative clause sentences, and the control group read only unreduced relative clause sentences. Participants were randomly assigned to the experimental and control groups. In the second session, both groups read eight sentences from both reduced and unreduced relative clause sentences at random and answered a comprehension question. For the content comprehension question, the participants were asked to complete a questionnaire to ascertain whether they had correctly dismissed an incorrect interpretation of the initial analysis in both first and second sessions. Filler sentences were also included in both sessions.

3.4 Results

3.4.1 Data Analysis

In this section, to report the reading time data and the analysis results of the correct answer rate to the question. After the results of the first session, the results of the analysis of the second session are reported. For the analysis, a linear mixed-effects model was mainly used. The reason for setting the question was to confirm that the participants comprehended the sentence correctly, so only the sentences which the participants answered the question correctly were analyzed this time.

The analysis results of the correct answer rate for the reading time data and the content comprehension questions are reported below. In order to test the role of prediction errors from word- level processing, two regions of interest were set in the reading time data. One was in the main clause verb region where structural ambiguity is expected to be resolved and the typical garden-path effect often occurs. The other was in the post-main clause verb region, where the garden-path effect may also appear. For example, in the sentence “the professor / (who was) / assisted / in the difficult experiment / enjoyed / the task / recently”, “enjoyed” is the main clause verb region and “the task” is the post-main clause verb region. For the analysis, a linear mixed model was used. Significant differences were seen when the absolute value of the calculated t-value for each effect was equal to or greater than 2, for Gelman & Hill (2007), more than 2SEs away from the mean. The order of item presentation included both first-order covariates centered on numbers one to sixteen assuming linear change, and second-order covariates assuming a curve. Both the first and second order covariates included interactions with the group factors in the model.

3.4.2 Results and Discussion

3.4.2.1 First Session: Reading Time

There are two target phrase ranges (hereinafter “regions”). One is the main clause region (hereafter “main clause verb region”) where structural ambiguity is resolved, and a typical garden path effect is expected to occur. The other is the next region in which the garden path effect is expected to appear later (called spillover) (hereinafter “post-main clause verb region”). The analysis results for the reading time in these two regions are reported below. Figures 1 and 2 show the subjects’ average reading time by group in these two regions.

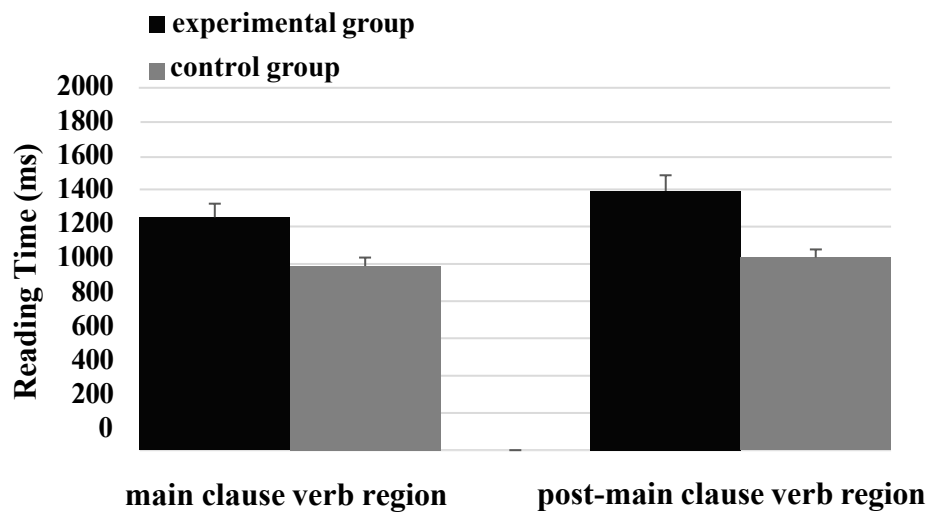


Figure 1. The Average Reading Time of Japanese EFL Learners

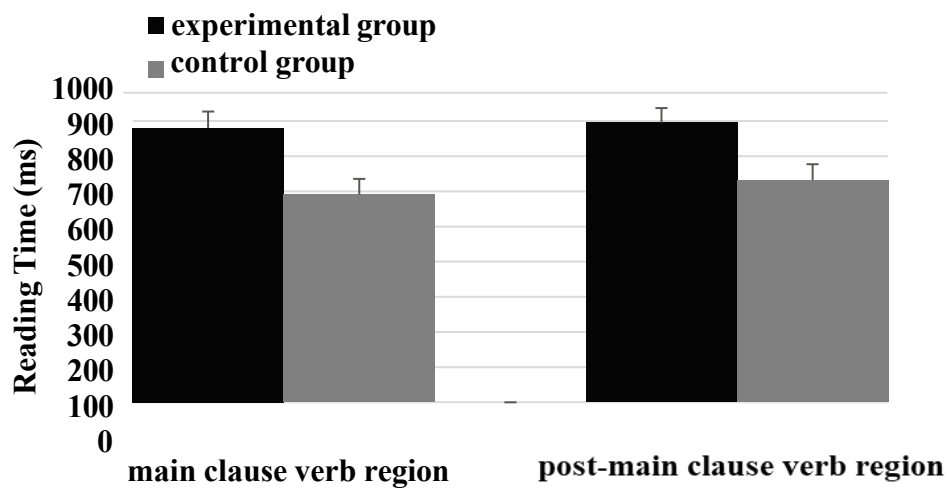


Figure 2. The Average Reading Time of L1 English Speakers

The average reading time of Japanese EFL learners and L1 English speakers are almost the same, but L1 English speakers' reading time is faster than Japanese EFL learners.

Overall, the average reading time of native English speakers was 1.5 times that of Japanese EFL learners in both the main clause and post-main clause verb regions (Table 1). In addition, the average reading time was significantly longer in the experimental group that was exposed to reduced relative clause sentences than in the control group that was exposed to unreduced relative clause sentences. These results indicate that both native English speakers and Japanese EFL learners had more difficulty comprehending reduced relative clause sentences which contain temporary structural ambiguities than relative clause sentences, and that they were much more difficult for Japanese EFL learners to comprehend than for native English speakers.

Table 1

Number of Subjects, Mean Reading Time (in milliseconds), and Standard Deviation for Each Region for Native Speakers and Japanese EFL Learners in the first session

control group				experimental group			
	<i>n</i>	main clause verb region	post-main clause verb region		<i>n</i>	main clause verb region	post-main clause verb region
L1	5	591(397)	631(411)	5		780(421)	796(368)
L2	7	988(485)	1034(461)	7		1250(777)	1391(896)

Since the reading time data of the two regions was unequal on the left and right and a long-tailed distortion was seen on the right (skewness > 0), logarithmic conversion was performed so that the extreme value did not unduly affect the estimation of the average value. Figures 3 and 4 show a Q-Q plot (normal quantile-quantile plot) of the original reading time and the reading time after logarithmic conversion in the main clause verb region. The post-main clause verb region was performed in the same way (Figures 5 and 6).

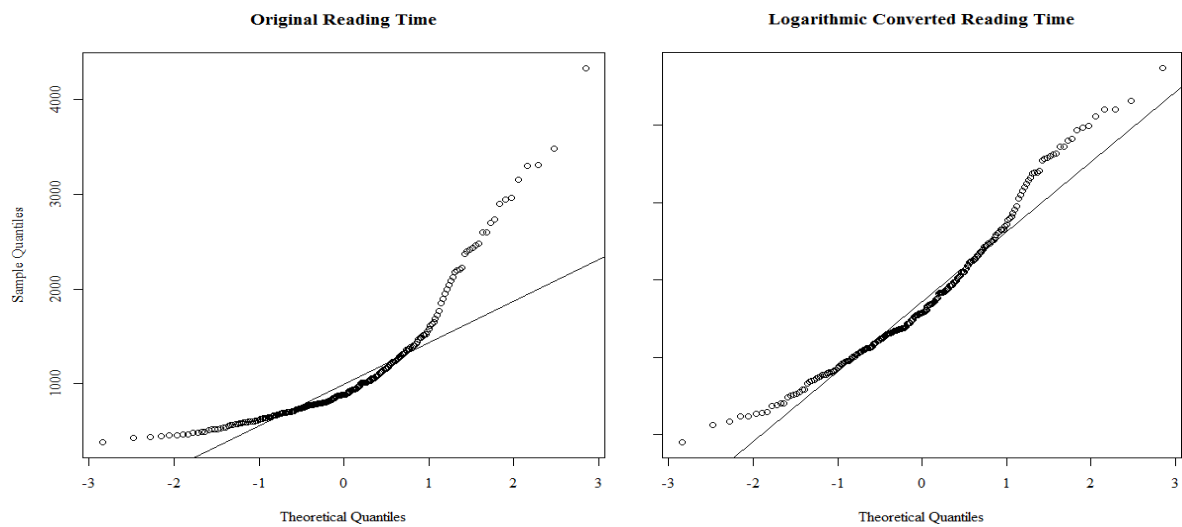


Figure 3. Japanese EFL Learners' Q-Q Plots of Reading Time Without Conversion (left) and Logarithmic Converted Reading Time (right) in Main Clause Verb Regions

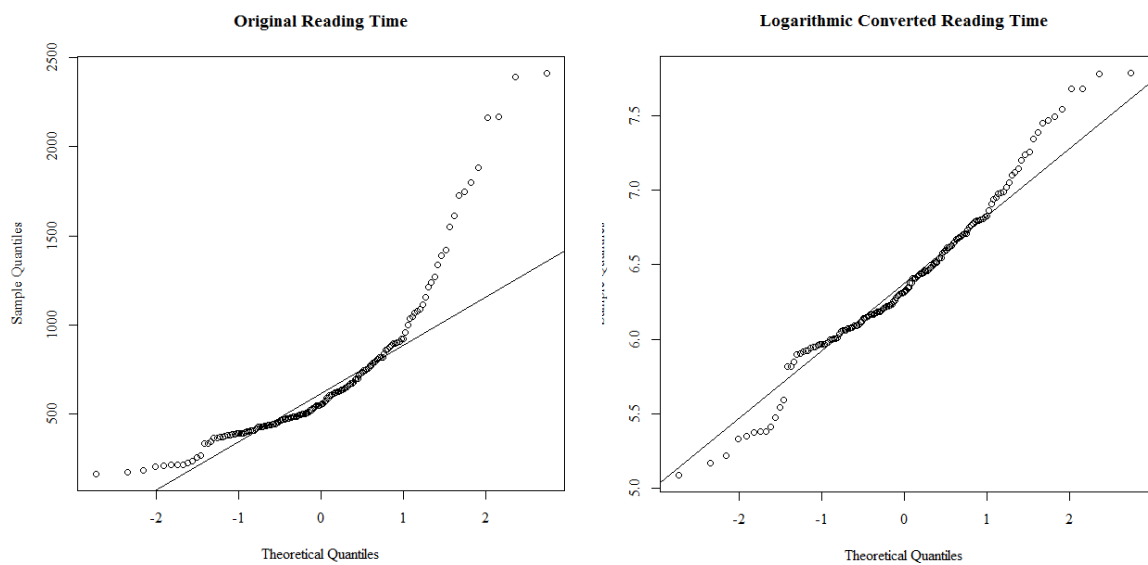


Figure 4. L1 English Speakers' Q-Q Plots of Reading Time Without Conversion (left) and Logarithmic Converted Reading Time (right) in Main Clause Verb Regions

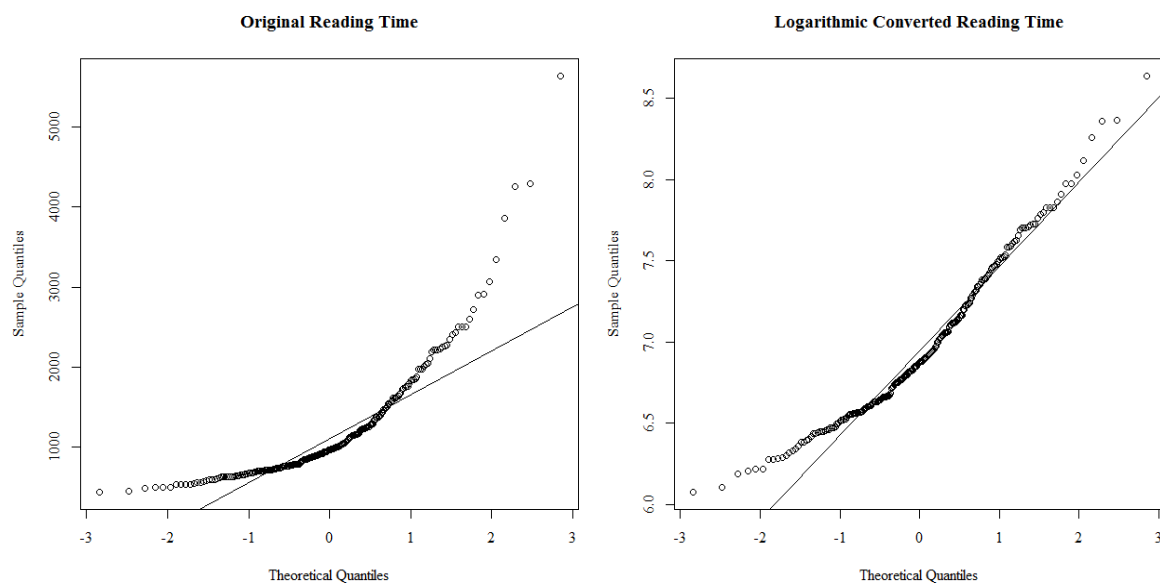


Figure 5. Japanese EFL Learners' Q-Q Plots of Reading Time Without Conversion (left) and Logarithmic Converted Reading Time (right) in Post-Main Clause Verb Regions

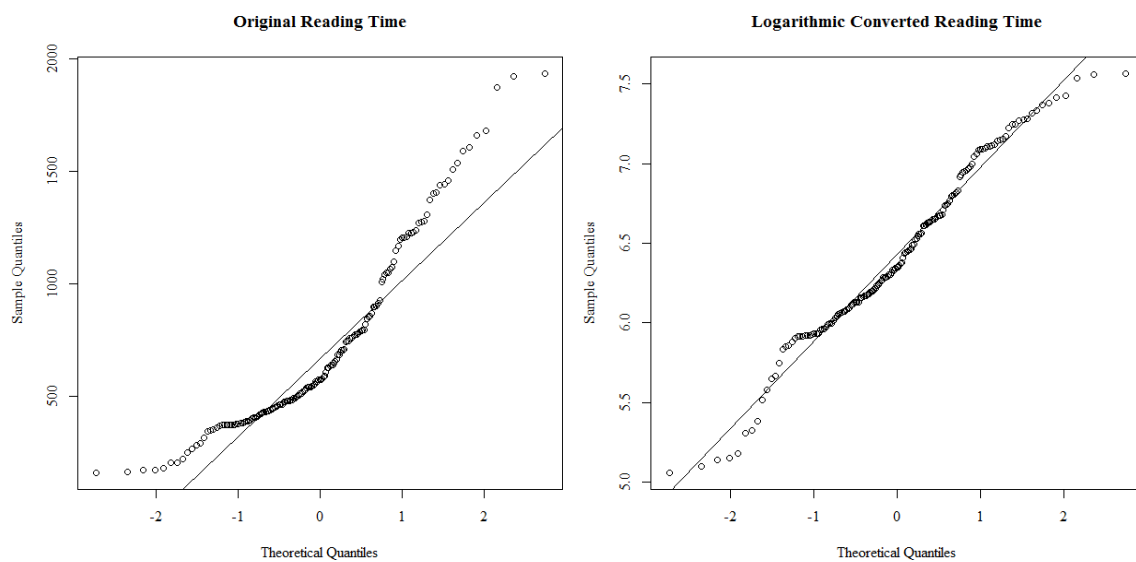


Figure 6. L1 English Speakers' Q-Q Plots of Reading Time Without Conversion (left) and Logarithmic Converted Reading Time (right) in Post-Main Clause Verb Regions

If the reading time data completely follows the normal distribution, the data is placed on a straight line 45 ° diagonally right on the graph. As can be seen from the graph, the original reading time has a large distortion, but the logarithmic transformation approximates the normal distribution. Statistical analysis was performed using the linear mixed model with the reading time in these two regions as the dependent variable. The linear mixed model is an extension of the linear regression model, in which multiple random factors can be included in the equation together with the explanatory factors, and the effects of the explanatory factors can be verified by exploratory model selection (Arai, 2016). In studies dealing with languages, since the data is obtained from a certain number of subjects and a certain number of experimental stimuli, the merit is very considerable in that the random factors of these two different sources can be simultaneously included in one model (Baayen, 2008; Baayen et al., 2008).

The following two explanatory factors were included in the linear mixed model: the group in the first session (experimental / control group) as the inter-subject factors, and the order in which the sixteen experimental items were presented in each group (“order of item presentation”). The order of item presentation was to include both the covariate of the first-order term centered on the numbers from one to sixteen and assuming a linear change, and the covariate of the second-order term assuming a curve and included interaction with the group factor. For the random effect, the model with the largest structure including the random slope of all explanatory factors (the group is a between-subject design and not included in the subject random factor) was first tested. In the linear mixed model, it is difficult to determine the degree of freedom, and therefore the degree of freedom is not considered in the *t* value calculated for each coefficient. For this reason, *p*-values are not calculated for lme4, a typical R package for linear mixed model analysis (Bates, 2005). Therefore, this paper does not report *p*-values (some parts are reported), assumes normal distribution for the data, and there is a significant difference if the absolute value of the *t*-value calculated for each effect is equal to or greater than two (Gelman & Hill, 2007). In other words, if the distance from the average is two or more SE, it is determined that there is a significant difference. Table 2 shows the results of the optimal model for the reading time data of the main clause verb region. Table 3 shows the results of the optimal model for the reading time data of the post- main clause verb region. Also, L1 English speakers’ data was performed in the same way (Tables 4 and 5). This paper looks at how the experimental group is decreasing compared to the control group.

Table 2

Japanese EFL Learners' Optimal Model Results for Reading Time Data in Main Clause Verb Regions

	<i>Coeff.</i>	<i>SE</i>	<i>t</i>
intercept	6.724348	0.109713	61.29
group	0.422196	0.164103	2.573
order of item presentation (first-order)	0.010866	0.012028	0.903
order of item presentation (second-order)	0.003961	0.003146	1.259
group×order of item presentation (first-order)	0.012376	0.024298	0.509
group×order of item presentation (second-order)	-0.011155	0.00585	-1.907

Table 3

Japanese EFL Learners' Optimal Model Results for Reading Time Data in Post-Main Clause Verb Regions

	<i>Coeff.</i>	<i>SE</i>	<i>t</i>
intercept	6.801579	0.103542	65.689
group	0.07127	0.153328	0.465
order of item presentation (first-order)	0.029077	0.01016	2.862
order of item presentation (second-order)	0.002584	0.002659	0.972
group×order of item presentation (first-order)	0.029645	0.020598	1.439
group×order of item presentation (second-order)	0.007481	0.004959	1.509

Table 4

L1 English Speakers' Optimal Model Results for Reading Time Data in Main Clause Verb Regions

	<i>Coeff.</i>	<i>SE</i>	<i>t</i>
intercept	5.837269	0.263817	22.126
group	1.194016	0.416208	2.869
order of item presentation (first-order)	-0.117236	0.036285	-3.231
order of item presentation (second-order)	0.004235	0.002083	2.033
group×order of item presentation (first-order)	0.183614	0.069125	2.656
group×order of item presentation (second-order)	-0.00871	0.003759	-2.317

Table 5

L1 English Speakers' Optimal Model Results for Reading Time Data in Post-Main Clause Verb Regions

	<i>Coeff.</i>	<i>SE</i>	<i>t</i>
intercept	5.68489	0.281917	20.165
group	0.934227	0.445358	2.098
order of item presentation (first-order)	-0.141923	0.039039	-3.635
order of item presentation (second-order)	0.006284	0.002241	2.804
group×order of item presentation (first-order)	0.159423	0.074371	2.144
group×order of item presentation (second-order)	-0.006915	0.004044	-1.71

In the case of Japanese EFL learners' optimal model results for reading time data in main clause verb regions, the category of group has significant difference, which means that experimental group has significantly slower reading time than the control group. This result suggests when the readers are exposed to reduced relative clause sentences, the second verb was appeared, so it may be possible that the reading time has become longer due to the surprisal effect. In the case of post-main clause verb regions, the category of order of item presentation(first-order) has significant difference, which means the reading time was significantly slower in both the experimental and control groups. This experiment has the question was appearing in each sentence, so the participants may have read the phrase carefully.

In the case of L1 English speakers' optimal model results for reading time data in main clause verb regions, all categories have significant differences. Particularly, the categories of order of item presentation(first-order) and group×order of item presentation(second-order) show significantly faster reading time. The category of order of item presentation (first-order) has significant difference, which means the reading time was significantly faster in both experimental and control groups. The category of group×order of item presentation(second-order) has significant difference, which means the reading time became faster as the item presentation order advanced in the experimental group. The more they were exposed to reduced relative clause sentences, the more they became used to reading them unlike Japanese EFL learners.

This paper focus on the reading time of Japanese EFL learners' proficiency (based on CEFR). Tables 6, 7, 8 and 9 summarizes the average reading time according to their proficiency. The effect of proficiency on Japanese EFL learners was examined (Table 6). In all proficiency levels, the experimental group tended to read significantly longer than the control group in both main clause and post-main clause verb regions, but the difference between the groups became smaller as proficiency levels increased.

Table 6

Reading Time (in milliseconds) and Standard Deviation of Native Speakers and Japanese EFL learners by Proficiency Level in Main Clause Verb Region in the first session

	experimental group	control group		experimental group	control group
B2	1066(841)	879(478)	upper	1264(818)	879(487)
B1	1463(755)	1192(563)	lower	1230(727)	1070(471)
A2	1230(727)	948(322)			
L1	780(421)	591(397)			

Table 7

Reading Time of Main Clause Verb Regions (Proficiency Levels)

proficiency	<i>n</i>	<i>M</i>	<i>SD</i>	Min.	Max.
A2	5	1117	612.1	466	3154
B1	4	1328	674.6	493	3483
B2	5	954	653.6	383	4330

Table 8

Analysis of The Reading Time of Main Clause Verb Regions (Proficiency Levels)

	<i>Coeff.</i>	<i>SE</i>	<i>t</i>
intercept	6.742051	0.212016	31.8
group	0.371052	0.276749	1.341
order of item presentation (first-order)	0.008682	0.021453	0.405
order of item presentation (second-order)	0.005542	0.005764	0.962
B1	0.17702	0.296804	0.596
B2	-0.161411	0.272817	-0.592
group×order of item presentation (first-order)	0.010024	0.025804	0.388
group×order of item presentation (second-order)	-0.011928	0.006121	-1.949
group×B1	-0.030234	0.393621	-0.077
order of item presentation (first-order) ×B1	-0.010065	0.02982	-0.338
order of item presentation (second-order) ×B1	-0.002059	0.007352	-0.28
group×B2	0.130289	0.380861	0.342
order of item presentation (first-order) ×B2	0.013136	0.026257	0.5
order of item presentation (second-order) ×B2	-0.002786	0.006852	-0.407

Table 9

Reading Time of Post-Main Clause Verb Regions (Proficiency Levels)

proficiency	<i>n</i>	<i>M</i>	<i>SD</i>	Min.	Max.
A2	5	1255	687.3	503	4254
B1	4	1438	807.4	648	5643
B2	5	991	657.6	435	4292

Table 10

Analysis of the Reading Time of Post-Main Clause Verb Regions (Proficiency Levels)

	<i>Coeff.</i>	<i>SE</i>	<i>t</i>
intercept	6.693826	0.439388	15.234
group	-0.50133	0.45722	-1.096
order of item presentation (first-order)	-0.002782	0.081236	-0.034
order of item presentation (second-order)	0.002301	0.004834	0.476
B1	0.574889	0.570613	1.007
B2	-0.473384	0.529291	-0.894
group×order of item presentation (first-order)	-0.108653	0.079202	-1.372
group×order of item presentation (second-order)	0.008003	0.00512	1.563
group×B1	-0.073934	0.281952	-0.262
order of item presentation (first-order) ×B1	0.053956	0.097544	0.553
order of item presentation (second-order) ×B1	-0.004788	0.006167	-0.776
group×B2	-0.120837	0.273975	-0.441
order of item presentation (first-order) ×B2	-0.046001	0.094976	-0.484
order of item presentation (second-order) ×B2	0.002706	0.005742	0.471

Japanese EFL learners in both the experimental and control groups tended to show the shortest reading time in the main clause verb region for B2, followed by A2 and then B1 in the main clause verb region. On the other hand, when comparing the two groups, the reading time of the upper control group was shorter than that of

the lower group, but there was little difference between the upper and lower groups in the experimental group. These tendencies were also observed in the post-main clause verb region.

Arai (2016) found that in the first session, the experimental group tended to show a gradual decrease in reading time according to the order of item presentation, while the control group was not affected by the order of item presentation. It was suggested that the gradual decrease in reading time in the experimental group was not an effect of habituation, because there was an interaction between the experimental and control groups. In this study, however, exactly the opposite was seen, there was a gradual increase in reading time for both the control and the experimental groups depending on the order in which the items were presented. This result is consistent with the prediction error-based implicit learning hypothesis.

This may be attributed to the fact that the present study also attached a content comprehension question in the first session, in order to ensure that the participants processed the input sentences, which was not the case in Arai (2016). In other words, by attaching the content comprehension questions, it may have forced syntactic and semantic processing, and made sentence processing rather time-consuming. This can be seen from the fact that the same tendency was observed in the experiment group of native English speakers. Japanese EFL learners did not show a gradual increase in reading time in either the experimental group or the control group. In addition, a similar tendency was found in the unreduced relative clause sentences, suggesting that prediction error-based implicit learning cannot be completely ruled out, but it is unlikely that implicit learning occurred based on the reading time data.

3.4.2.2 First Session: Answering Rate

In order to see the learning effect on correct comprehension of relative clause sentences, questions were presented after the experimental sentences (not only in the experimental sentences but also in all sentences including filler sentences). The question asks, “did the professor assist somebody in the difficult experiment?” to confirm that the correct interpretation was made. Table 11 summarizes answering rate of Japanese EFL learners and L1 English speakers.

Table 11

The Answering Rate (%)

<i>participants</i>	<i>experimental</i>	<i>control</i>
Japanese EFL Learners	38.4	65.2
L1 English Speakers	63.8	76.3

In the cases of both groups of participants (Japanese EFL learners and L1 English speakers), the control group had a higher correct answer rate than the experimental group. This means reduced relative clause sentences have a lower correct answer rate than unreduced relative clause sentences, and interpretation based on erroneous initial analysis is retained due to structural ambiguity (Arai, 2016).

In the case of Japanese EFL learners, this section shows the proficiency levels of answering rate and analysis. Tables 12 and 13 summarize the answering rate by proficiency level.

Table 12

Answering Rate of Japanese EFL Learners' Proficiency Levels

<i>proficiency</i>	<i>n</i>	<i>Rates (%)</i>
A2	5	46.3
B1	4	56.3
B2	5	53.8

Table 13

Analysis of Answering Rate (Japanese EFL Learners' Proficiency Levels)

	<i>Coeff.</i>	<i>SE</i>	<i>z</i>	<i>p</i>
intercept	0.50466	0.31603	1.597	0.110292
group	-1.1052	-0.31196	3.543	0.000396
B1	0.32297	0.3859	0.837	0.40263
B2	0.09484	0.36608	0.259	0.795586

B1 and B2 are compared with A2 in analyzing the answering rate by proficiency level. Table 13 shows no statistical difference between levels. The category of group shows significantly lower correct answer rate for reduced relative clause sentences. This also means that statistically, interpretation based on erroneous initial analysis is retained due to structural ambiguity (Arai, 2016). The percentage of correct answers was higher in the control group than in the experimental group for both native speakers and Japanese EFL learners (Table 14). This indicates that the interpretation based on the wrong initial analysis was retained. Although native English speakers had a higher percentage of correct responses than Japanese EFL learners, the percentage of correct responses in the experimental group of Japanese EFL learners was below the chance level, indicating that they had considerable difficulty in comprehending reduced relative clause sentences.

Table 14

Percentage of Correct Answers in the first session (%)

experimental group (reduced relative clause sentences)				control group (unreduced relative clause sentences)			
L1	overall	upper	lower	L1	overall	upper	lower
63.8	35.0	40.6	31.3	76.3	62.0	56.3	68.8

A comparison of the three groups of Japanese EFL learners by proficiency level (Table 15) showed that B1 the middle level proficiency had the highest percentage of correct answers 56.3%, B2 the highest level of proficiency had 53.8%, and A2 the lowest level of proficiency had 46.3%, however, this difference was not significant. While B1, which had a longer reading time, had a higher percentage of correct answers, B2, which had a shorter reading time, also had a higher percentage of correct answers than the chance level, so it cannot be said that the longer the reading time, the higher the correct answer rate.

Table 15

Results of Analysis of Japanese EFL Learners by Proficiency Level

	<i>Coeff.</i>	<i>SE</i>	<i>z</i>	<i>P</i>
intercept	0.50466	0.31603	1.597	0.110292
group	-1.1052	-0.31196	3.543	0.000396***
B1	0.32297	0.3859	0.837	0.40263
B2	0.09484	0.36608	0.259	0.795586

Second session shows how the correct answer rate changed in the experimental group and the control group and reports the analysis results.

3.4.2.3 Second Session: Reading Time

In the second session, both groups performed experiments under the same conditions. As for the experimental sentences, half of the eight sentences were presented with reduced relative clause sentences, and the other half were unreduced relative clause sentences, for a total of sixteen experimental sentences, together with 32 filler sentences. Figures 7, 8, 9 and 10 show the participants' average reading time for each group and relative clause sentence type in each region. Also, Figures 11 and 12 show a Q-Q plot (Normal Quantile-Quantile Plot) of the original reading time and the reading time after logarithmic conversion in the main clause verb region. The post-main clause verb region was performed in the same way (Figures 13 and 14).

Overall, the average reading time of Japanese English learners was significantly longer than that of native English speakers in both the main clause verb region and the post-main clause verb region but was slightly shorter than in the first session. The reading time for reduced relative clause sentences was longer than for unreduced relative clause sentences, showing a typical garden-path effect. Japanese EFL learners are significantly different only in the post-main clause verb region group (*Coeff.* = 0.556185, *SE* = 0.217207, *t* = 2.561). This suggests that the experimental group had significantly longer reading times than the control group, suggesting that the surprisal effect may have appeared later. Native English speakers are significantly different only in the main clause verb region group $\times$ relative clause sentence type (*Coeff.* = 0.64065, *SE* = 0.25876, *t* = 2.476), and the experimental group had significantly longer reading times when exposed to reduced relative clause sentences in the second

session. Interestingly, however, unlike the first session, there were no statistically significant changes in gradual reading times in the experimental and control groups, and in the upper and lower groups, respectively.

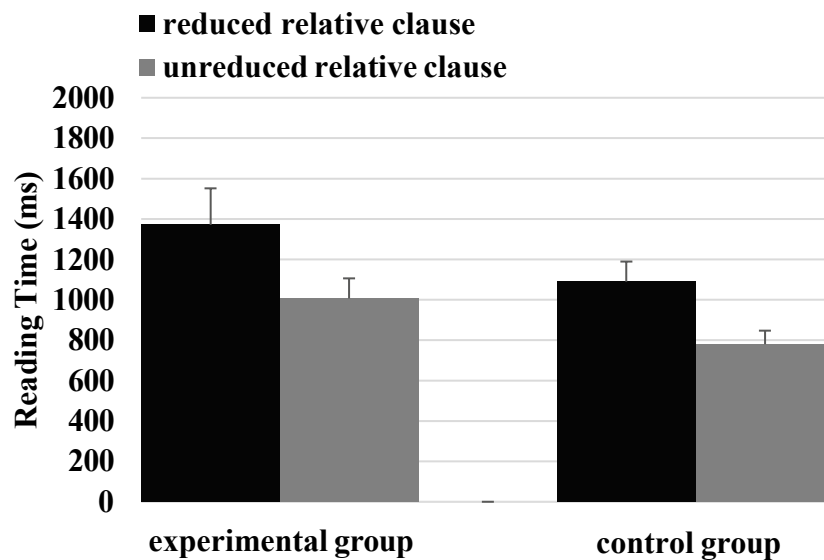


Figure 7. Japanese English Learners' Average Reading Time in Experimental and Control Groups / Relative Clause Sentence Type in Main Clause Verb Region

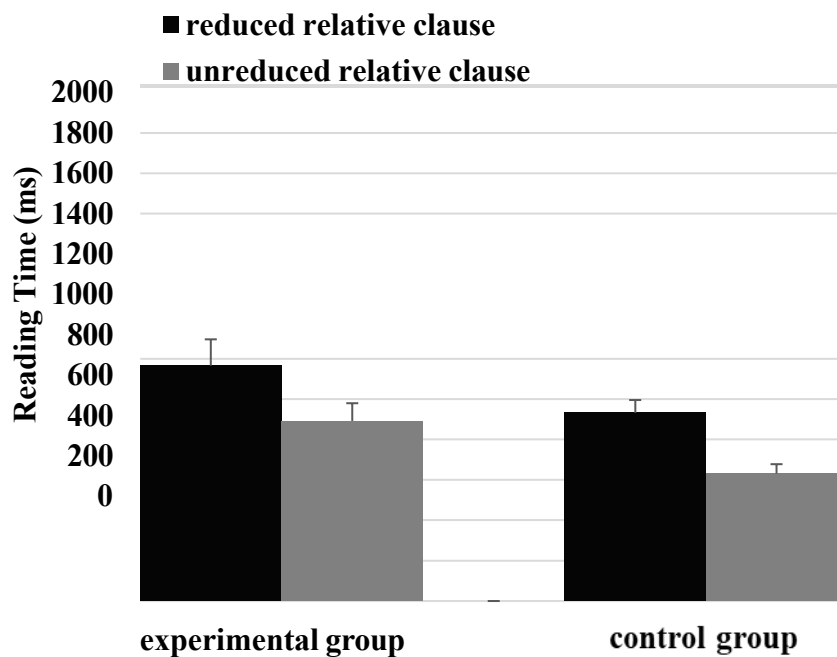


Figure 8. Japanese English Learners' Average Reading Time in Experimental and Control Groups / Relative Clause Sentence Type in Post-Main Clause Verb Region

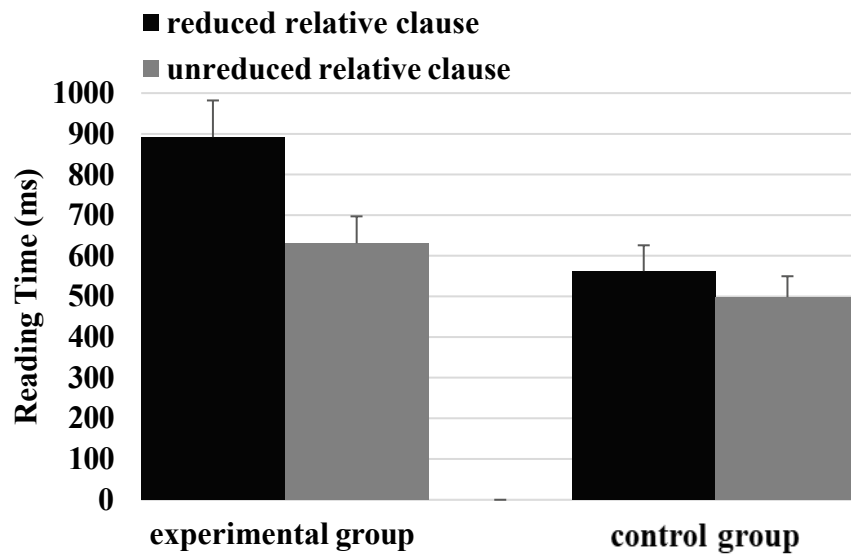


Figure 9. L1 English Speakers' Average Reading Time in Experimental and Control Groups / Relative Clause Sentence Type in Main Clause Verb Region

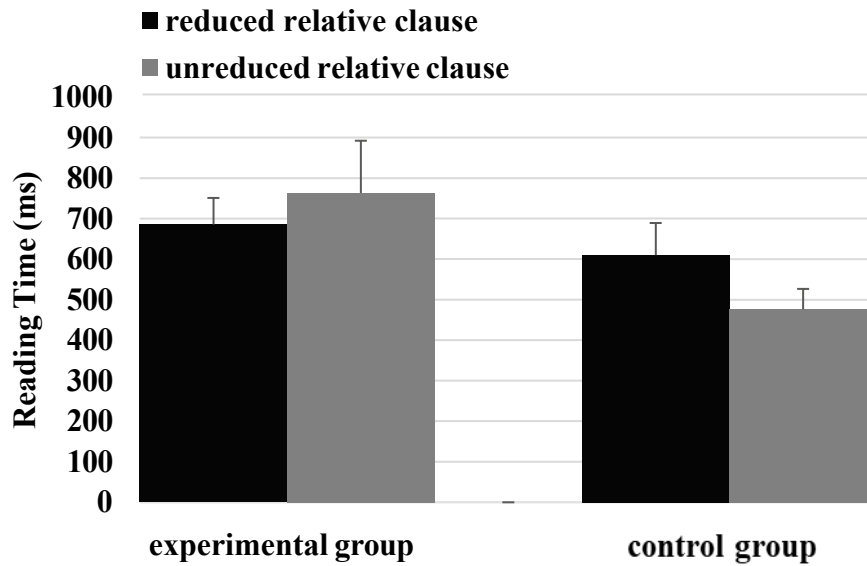


Figure 10. L1 English Speakers' Average Reading Time in Experimental and Control Groups / Relative Clause Sentence Type in Post-Main Clause Verb Region

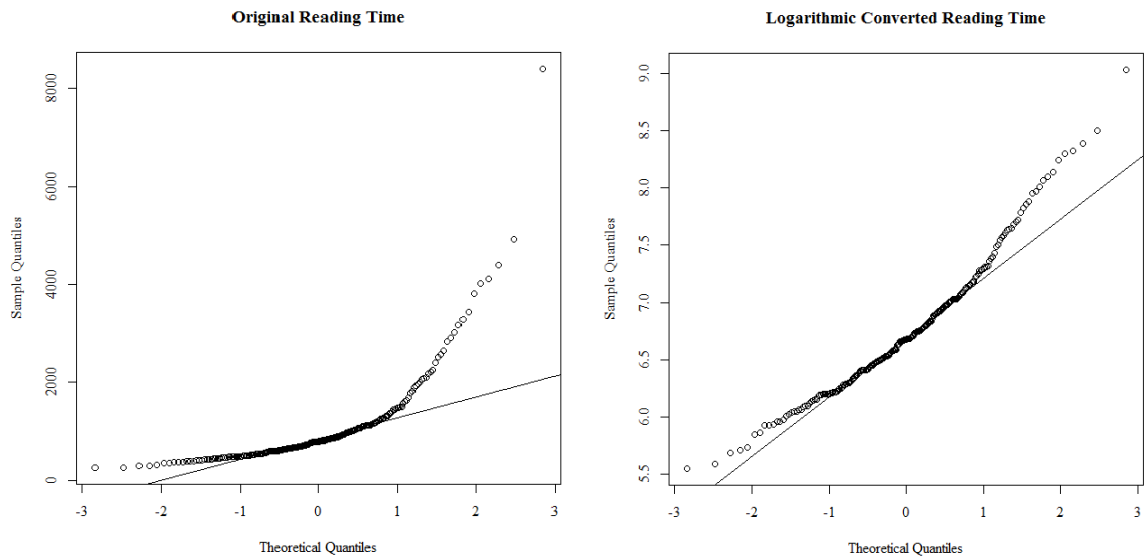


Figure 11. Japanese EFL Learners' Q-Q Plots of Reading Time Without Conversion (left) and Logarithmic Converted Reading Time (right) in Main Clause Verb Regions

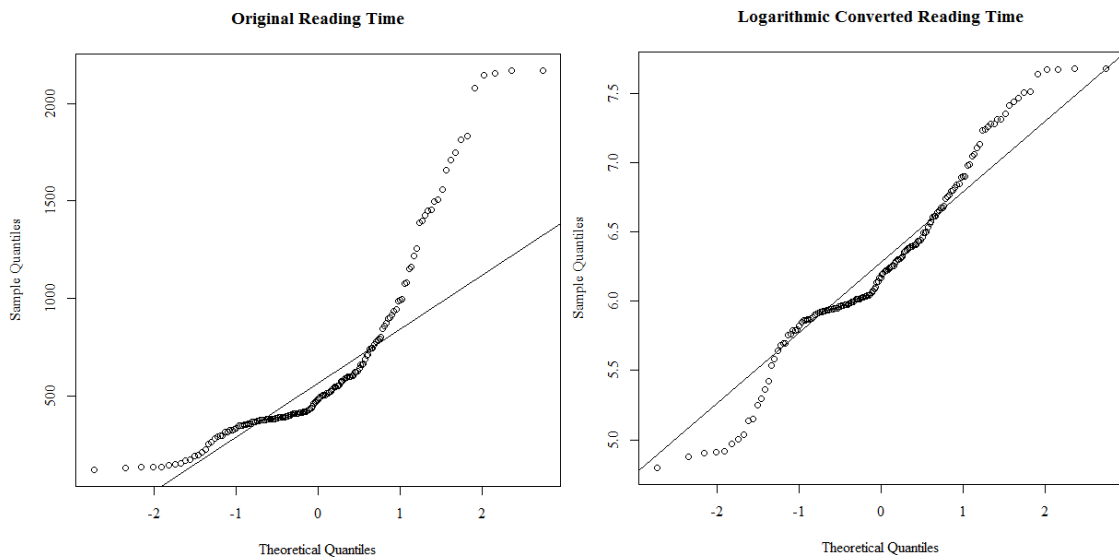


Figure 12. L1 English Speakers' Q-Q Plots of Reading Time Without Conversion (left) and Logarithmic Converted Reading Time (right) in Main Clause Verb Regions

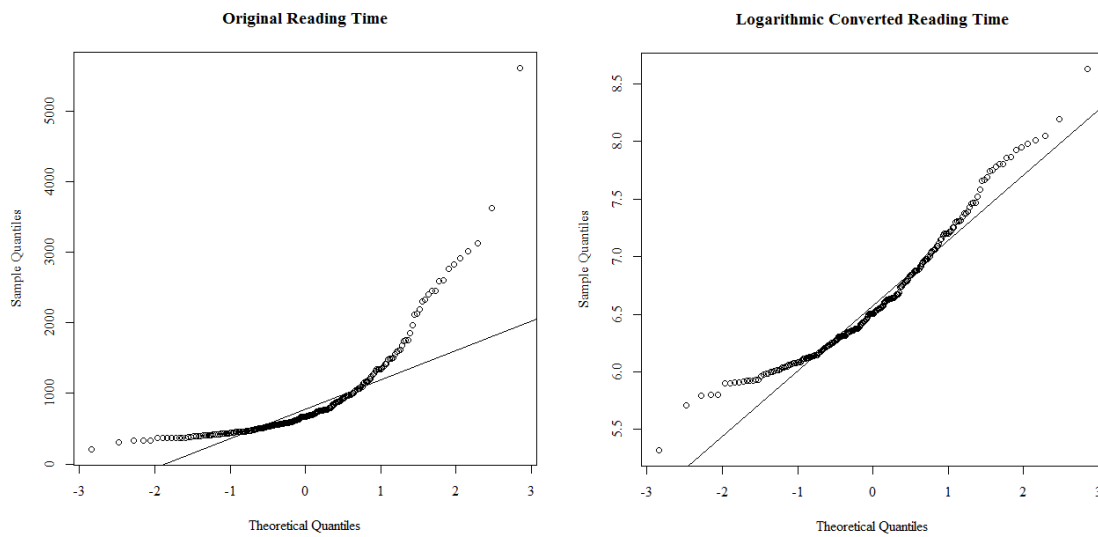


Figure 13. Japanese EFL Learners' Q-Q Plots of Reading Time Without Conversion (left) and Logarithmic Converted Reading Time (right) in Post-Main Clause Verb Regions

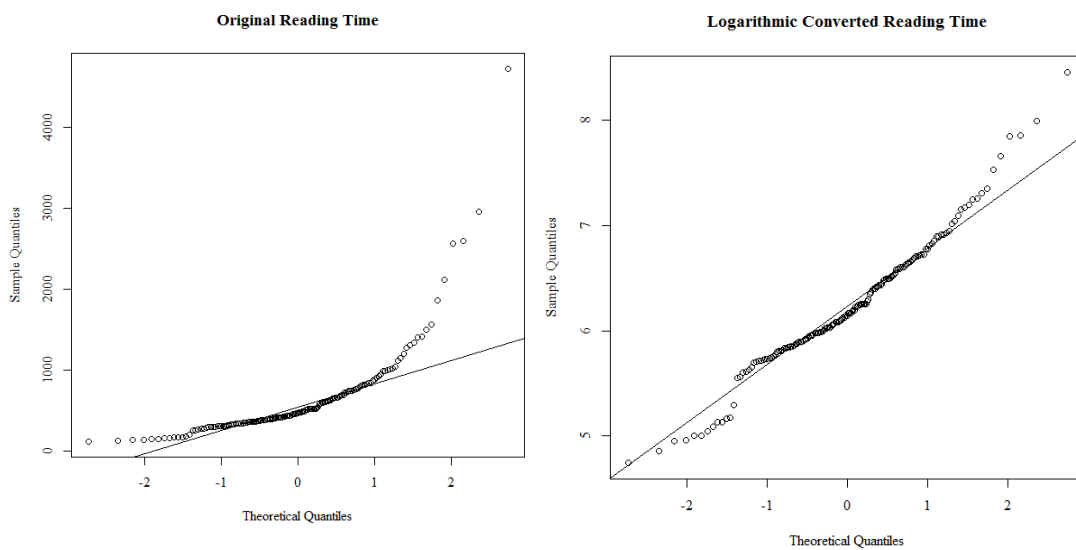


Figure 14. L1 English Speakers' Q-Q Plots of Reading Time Without Conversion (left) and Logarithmic Converted Reading Time (right) in Post-Main Clause Verb Regions

There was different tendency by region, and although the experimental group had a longer reading time than the control group, in the post-main clause verb region, the experimental group had a shorter reading time for reduced relative clause sentences than for unreduced relative clause sentences (Tables 16 and 17). This suggests that they may have become accustomed to reading reduced relative clause sentences.

Table 16

Average Reading Time (in milliseconds) of Japanese EFL Learners in the Main Clause Verb Region by Overall and Proficiency Level in the second session

	experimental group			control group		
	overall	upper	lower	overall	upper	lower
reduced	1371	1569	1107	1089	869	1254
unreduced	1006	999	1016	780	639	886

Table 17

Average Reading Time (in milliseconds) of Japanese EFL Learners in the Post-main Clause Verb Region by Overall and Proficiency Level in the second session

	experimental group			control group		
	overall	upper	lower	overall	upper	lower
reduced	1165	1126	1217	931	805	1026
unreduced	891	929	839	631	618	640

Table 18 shows the results of the optimal model for the reading time data of the main clause verb region. Table 19 shows the results of the optimal model for the reading time data of the post- main clause verb region. Also, L1 English speakers' data was performed in the same way (Tables 20 and 21). This paper looks at how the experimental group is decreasing compared to the control group. There were three explanation factors: group (experimental / control), relative clause sentence type (reduced / unreduced), and item presentation order (one to sixteen). In the first model, the item presentation order included both primary and quadratic parameters, but the covariates of the quadratic terms were not affected and were excluded from the model (AIC, one of the model

selection criteria). The value dropped from 642 to 638, indicating that the simpler model is better.

Table 18

Japanese EFL Learners' Optimal Model Results for Reading Time Data in Main Clause Verb Regions

	<i>Coeff.</i>	<i>SE</i>	<i>t</i>
intercept	6.475119	0.197171	32.84
group	0.296518	0.211367	1.403
type of relative clause sentences	0.36105	0.286777	1.259
order of item presentation	0.006555	0.029488	0.222
group×type of relative clause sentences	0.140373	0.305002	0.46
group×order of item presentation	-0.037964	0.044547	-0.852
type of relative clause sentences×order of item presentation	-0.012643	0.043523	-0.29
group×type of relative clause sentences×order of item presentation	0.112622	0.064683	1.741

Table 19

Japanese EFL Learners' Optimal Model Results for Reading Time Data in Post-Main Clause Verb Regions

	<i>Coeff.</i>	<i>SE</i>	<i>t</i>
intercept	6.261026	0.167931	37.283
group	0.556185	0.217207	2.561
type of relative clause sentences	0.022224	0.030328	0.733
order of item presentation	0.396568	0.24695	1.606
group×type of relative clause sentences	-0.465901	0.313242	-1.487
group×order of item presentation	0.003692	0.045789	0.081
type of relative clause sentences×order of item presentation	-0.026587	0.044697	-0.595
group×type of relative clause sentences×order of item presentation	-0.042957	0.066362	-0.647

Table 20

L1 English Speakers' Optimal Model Results for Reading Time Data in Main Clause Verb Regions

	<i>Coeff.</i>	<i>SE</i>	<i>t</i>
intercept	6.10676	0.2509	24.339
group	0.10025	0.17769	0.564
type of relative clause sentences	0.07674	0.35428	0.217
order of item presentation	-0.01862	0.02526	-0.737
group×type of relative clause sentences	0.64065	0.25876	2.476
group×order of item presentation	0.025	0.03722	0.672
type of relative clause sentences×order of item presentation	0.03493	0.03573	0.978
group×type of relative clause sentences×order of item presentation	0.04229	0.05361	0.789

Table 21

L1 English Speakers' Optimal Model Results for Reading Time Data in Post-Main Clause Verb Regions

	<i>Coeff.</i>	<i>SE</i>	<i>t</i>
intercept	5.9316	0.25003	23.724
group	0.0977	0.214	0.457
type of relative clause sentences	0.01495	0.03044	0.491
order of item presentation	0.56173	0.35279	1.592
group×type of relative clause sentences	-0.17337	0.31167	-0.556
group×order of item presentation	-0.03016	0.04483	-0.673
type of relative clause sentences×order of item presentation	-0.04247	0.04305	-0.987
group×type of relative clause sentences×order of item presentation	0.05205	0.06458	0.806

In the case of Japanese EFL learners' optimal model results for reading time data in post-main clause verb regions, the category of group has significant difference, which means that the experimental group has significantly slower reading time than control group. This result suggests that the surprisal effect was delayed in the experimental group.

In the case of L1 English speakers' optimal model results for reading time data in main clause verb regions, the category of group×type of relative clause sentences has significant difference which means the reading time of experimental groups' readers is statistically slow when they are exposed to reduced relative clause sentences in the second session. This result suggests that the garden-path effect appears.

The second session also focuses on the reading time of Japanese EFL learners' proficiency (based on CEFR). Tables 22, 23, 24 and 25 summarize an average of reading time according to their proficiency.

Table 22

Reading Time of Main Clause Verb Regions (Proficiency Levels)

proficiency	<i>n</i>	<i>M</i>	<i>SD</i>	Min.	Max.
A2	5	979	644.3	294	3292
B1	4	1509	1382	444	8410
B2	5	786	404.7	256	2095

Table 23

Analysis of The Reading Time of Main Clause Verb Regions (Proficiency Levels)

	<i>Coeff.</i>	<i>SE</i>	<i>t</i>
intercept	6.8567292	0.2443977	28.056
group	-0.1518572	0.3030032	-0.501
order of item presentation (first-order)	-0.0434821	0.0911968	-0.477
order of item presentation (second-order)	0.0003073	0.0112101	0.027
B1	-0.1252234	0.3225529	-0.388
B2	-0.4680242	0.3098743	-1.51
group×order of item presentation (first-order)	0.056671	0.1344317	0.422
group×order of item presentation (second-order)	0.0050238	0.0162295	0.31
group×B1	1.1838743	0.372345	3.18
order of item presentation (first-order) ×B1	0.0946654	0.0398486	2.376
order of item presentation (second-order) ×B1	-0.0040513	0.0048549	-0.834
group×B2	0.5197126	0.3722646	1.396
order of item presentation (first-order) ×B2	0.039143	0.0383984	1.019
order of item presentation (second-order) ×B2	0.0036699	0.00465	0.789

Table 24

Reading Time of Post-Main Clause Verb Regions (Proficiency Levels)

proficiency	<i>n</i>	<i>M</i>	<i>SD</i>	Min.	Max.
A2	5	916	657.5	301	3620
B1	4	984	744.4	330	5612
B2	5	829	650.7	204	2914

Table 25

Analysis of the Reading Time of Post-Main Clause Verb Regions (Proficiency Levels)

	<i>Coeff.</i>	<i>SE</i>	<i>t</i>
intercept	4.166033	0.677372	6.15
group	-0.045686	0.943385	-0.048
order of item presentation (first-order)	-0.861729	0.24801	-3.475
order of item presentation (second-order)	0.035407	0.010034	3.529
B1	0.225978	0.481912	0.469
B2	-0.470122	0.459526	-1.023
group×order of item presentation (first-order)	0.495206	0.262287	1.888
group×order of item presentation (second-order)	0.012308	0.014526	0.847
group×B1	-0.837817	0.333226	-2.514
order of item presentation (first-order) ×B1	-0.160298	0.082563	-1.942
order of item presentation (second-order) ×B1	0.003053	0.004345	0.703
group×B2	-0.281142	0.333164	-0.844
order of item presentation (first-order) ×B2	-0.111889	0.082571	-1.355
order of item presentation (second-order) ×B2	0.005842	0.004161	1.404

In the case of the reading time of main clause verb regions, the category of order of item presentation (first-order) $\times$ B1 has significant difference, which means the reading time of participants of B1 level is slow when they are exposed to the sentences many times in the second session. This result suggests the participants were able to learn the structure of the reduced relative clause sentences. In the case of the reading time of post-main clause verb regions, the categories of order of item presentation (first-order), order of item presentation (second-order) and group $\times$ B1 have significant differences. In the case of the category of order of item presentation (first-order) suggests that when all participants were exposed to all sentences repeatedly, the reading time became faster in all conditions. In addition, the case of the category of order of item presentation (second-order) suggests that the reading time of all participants become faster, but gradually shortening speed decreases. The case of the category of group $\times$ B1 suggests that the reading time of the experimental group participants of B1 level became significantly faster. These results also suggest that the Japanese EFL learners learned the structure of reduced relative clause sentences and how to read these sentences. They perceived that they also must comprehend the sentence at the point of the main clause verb region.

The results of the three groups of Japanese EFL learners by proficiency level showed that in the main clause verb region, as in the first session, there was no significant difference between proficiency levels, but there was a significant difference in the item presentation order first order term $\times$ B1, indicating that B1 had a progressively significantly longer reading time ($Coeff.= 0.0946654$, $SE= 0.0398486$, $t=2.376$). As in the first session, this suggests that the difficulty in comprehension of relative clause sentences continues to be the same as in the first session. On the other hand, the reading time in the post-main clause verb region was longer than in the main clause verb region in the first session, but in the second session the reading time in the post-main clause verb region was shorter than in the main clause verb region.

This suggests that the participants' reading of sentences changed and their comprehension of sentence structure was enhanced. And the comparison between the three groups showed significant differences in item presentation order (first and second order terms) and group $\times$ B1, with significantly shorter reading times for all sentences at all levels and shorter reading times for the experimental group in B1, suggesting that the facilitate of sentence structure comprehension occurred (item presentation order (first order term): $Coeff.= -0.861729$, $SE=0.24801$, $t=-3.475$, item presentation order (second order): $Coeff.=0.035407$, $SE=0.010034$, $t=3.529$, Group

× B1: *Coeff.* = - 0.837817, *SE* = 0.333226, *t* = -2.514).

Overall, these results are not consistent with the prediction error-based implicit learning hypothesis. However, Japanese EFL learners had considerable difficulty in comprehension of the relative clause sentence structure embedded in the subject position, whether it was a reduced or unreduced relative clause sentence. Although only at the hypothesized stage, it is also possible that at a proficiency level of B1, syntactic processing was relatively more automated than in group A1, and that exposure to ambiguous relative clause sentences (reduced relative clause sentences) may have resulted in the prediction error-based implicit learning hypothesis.

3.4.2.4 Second Session: Answering Rate

This section focuses on how the correct answer rate changed in the experimental group and the control group from the first session. Tables 26, 27 and 28 show the correct answer rate in the second session, which is shown for each relative clause sentence type and each group. Also, Tables 29 and 30 summarize the relation of answering rates between the first session and second session. Analysis was performed using a generalized linear mixed model with the answer data to this question as binary variables of correct / incorrect. There were two explanatory factors: relative clause sentence type (reduced / unreduced relative clause sentences) and group (experimental / control group). The interaction was included in the model together. Significant differences were found between the groups for both Japanese EFL learners and native English speakers, with the experimental group having a significantly lower percentage of correct answers. As in the first session, the results suggest that interpretations based on incorrect initial analysis were retained. It is possible that the control group had a higher rate of correct responses, and that repeated exposure to unambiguous sentences (unreduced relative clause sentences) in the first session may have resulted in a higher rate of correct responses when participants were exposed to ambiguous sentences (reduced relative clause sentences) in the second session. As they realized that the relative clause sentence had been omitted and comprehended the structure of the sentence.

Table 26

Japanese EFL Learners' Relative Clause Sentence Type of Question for Experimental Sentences, Correct Answer Rate for Each Group (%)

<i>type</i>	<i>experimental</i>	<i>control</i>
reduced relative clause sentences	62.5	64.3
unreduced relative clause sentences	75	85.7

Table 27

L1 English Speakers' Relative Clause Sentence Type of Question for Experimental Sentences, Correct Answer Rate for Each Group (%)

<i>type</i>	<i>experimental</i>	<i>control</i>
reduced relative clause sentences	70	72.5
unreduced relative clause sentences	85	92.5

Table 28

Percentage of Correct Responses by Group of Japanese EFL Learners and by Relative Clause Sentence Type in the second session (%)

	<i>experimental group</i>			<i>control group</i>		
	<i>overall</i>	<i>upper</i>	<i>lower</i>	<i>overall</i>	<i>upper</i>	<i>lower</i>
reduced	62.5	65.6	50.0	64.3	70.8	59.4
unreduced	75.0	81.3	66.6	85.7	87.5	81.3

Table 29

Answering Rate of Japanese EFL Learners

	<i>Coeff.</i>	<i>SE</i>	<i>z</i>	<i>p</i>
intercept	1.8492	0.4196	4.407	0.0000105
group	-1.2384	0.4795	-2.582	0.00981
type of relative clauses	-0.7083	0.5431	-1.304	0.19216
type of relative clauses × group	0.6295	0.6371	0.988	0.3231

Table 30

Answering Rate of L1 English Speakers

	<i>Coeff.</i>	<i>SE</i>	<i>z</i>	<i>p</i>
intercept	2.5123	0.6003	4.185	0.0000285
group	-1.5429	0.697	-2.214	0.0268
type of relative clauses	-0.7777	0.7459	-1.043	0.2971
type of relative clauses ×group	0.6556	0.8949	0.733	0.4638

The category of group shows a significantly lower correct answer rate, which means the experimental group's answering rate is significantly low. This also means that statistically, interpretation based on erroneous initial analysis is retained due to structural ambiguity (Arai, 2016).

In the case of Japanese EFL learners, this section shows the proficiency levels of answering rate and analysis. Table 31 and Figure 15 summarize the answering rate by proficiency level. Comparisons of the three groups of Japanese EFL learners by proficiency level showed significant differences between the groups and B1 (Figure 15), indicating that the experimental group had a significantly lower percentage of correct responses and a significantly higher percentage of correct responses in B1 compared to A2. This suggests that a learning effect was found for participants in B1, while the interpretation based on the incorrect initial analysis was retained. These results may indicate that A2 remained difficult to comprehend due to difficulties in syntactic analysis, while B2 may have been relatively more automated in its syntactic processing to some extent and did not facilitate further comprehending.

Table 31

Analyzes of Answering Rate (Japanese EFL Learners' Proficiency Levels)

	<i>Coeff.</i>	<i>SE</i>	<i>z</i>	<i>p</i>
intercept	1.4153	0.4562	3.103	0.00192
group	-1.2343	0.4792	-2.576	0.01
type of relative clauses	-0.6294	0.5175	-1.216	0.22387
B1	0.816	0.4343	1.879	0.06026
B2	0.4499	0.3951	1.139	0.2548
type of relative clauses ×group	0.6232	0.6378	0.977	0.32848

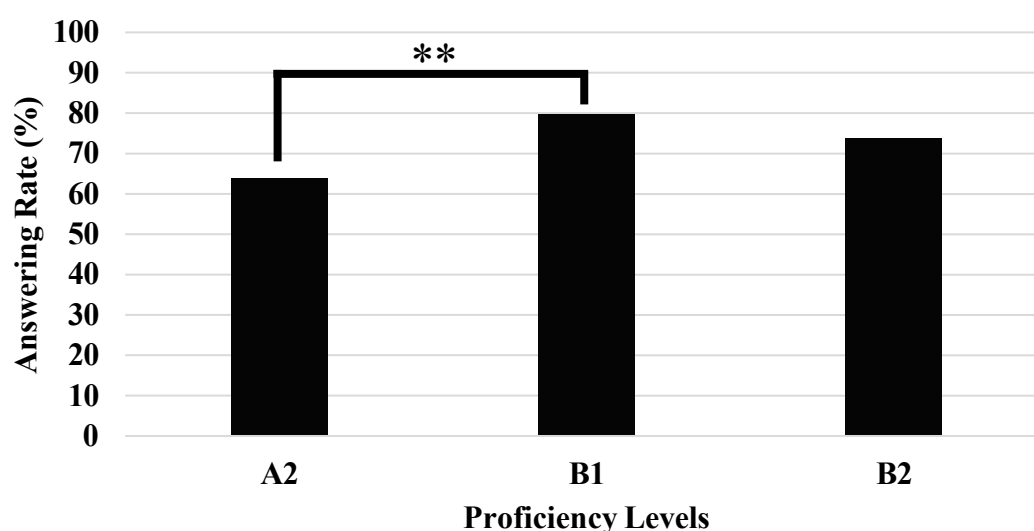


Figure 15

Average Answering Rate (Japanese EFL Learners' Proficiency Levels)

The category of group and B1 are significantly different. In the case of category of group, all Japanese EFL learners' answering rates of reduced relative clause sentences were lower than unreduced relative clause sentences. However, since the correct answer rate increased from the first to second session, it is possible that the readers became accustomed to reading reduced relative clause sentences. In the case of category of B1, participants at the B1 level have a high correct answer rate at 10% significance level. This suggests that intermediate learners have a better comprehension of reduced relative clause sentences. This is only a prediction, but learners with low proficiency may not have learned, and learners with high proficiency may not have learned

due to the knowledge they already have; however, further research is needed in this regard.

The results of the second session show that, overall, the garden-path effect occurred in the main clause verb region and there was no longer a delay to the next region, the post-main clause verb region, which facilitated the comprehension of relative clause sentences. Although the percentage of correct responses in the experimental group was significantly lower than in the control group, the percentage of correct responses was considerably higher than in the first session, suggesting that a learning effect was observed.

3.5 Hypothesis Verification

This section provides results and discussions with regard to each research question. No statistical comparison was made, but it is possible that participants in the first and second session became used to reading the reduced relative clause sentence structure little by little from the results of answering rate.

For the first research question, of whether the degree of learning varies with proficiency, for Japanese EFL learners, the overall correct answer rate increased from the first to second session. However, there was no change in the ratio, and the correct answer rate was high in the order of B1, B2, and A2. As for the reading time, B1 level participants who have a highly correct answer rate look longer, and the reading time of the reduced relative clause sentence was longer. In previous studies, it was thought that the shorter the reading time became, learning progressed (Arai, 2016). However, their study did not ask questions in the first session, only in the second session. Since there was no load on the first session, it seems natural that the reading time became shorter. However, this time it is not reliable data due to the small number of samples, and further research is needed in the future. As for L1 English speakers, the tendency of reading time was almost the same as that of Japanese EFL learners. Despite having knowledge, reading time gradually increased. Regarding the correct answer rate, the experimental group was significantly lower than the control group, which means that interpretation based on incorrect first analysis was retained due to structural ambiguity.

Even if L1 English speakers have reduced relative clause sentence structure information, it can be said that the garden path effect continues to occur, which is a normal reading. From this, the hypothesis that the degree of learning differs depending on the level of proficiency is verified, and by comparing L1 English speakers and Japanese EFL learners, it is also clear that L1 English speakers read faster than Japanese EFL learners. The fact that the percentage of correct answers is high suggests that the exposure volume may be small for Japanese EFL

learners. By changing the degree of exposure and the task, there is a possibility that more learning effects can be seen.

For the second research question of whether it possible to suggest learning from the correct answer rate of questions for experimental sentences, it is believed that the effect of learning can be suggested from the result of the correct answer rate. By measuring from the first session to second session, the effect of learning was seen, and the gradual length of the reading time and the correct answer rate increased, suggesting a learning effect on the reduced relative clause sentence. However, since the number of exposures is small, a statistical archive has not been obtained, so it is thought that more detailed analysis should be conducted.

For the third research question of whether implicit learning with few repeated exposures is effective in learning syntactic knowledge, although the reading time is significantly longer, the correct answer rate is higher, so it is possible that the learning effect can be seen even with a small amount of exposure. Previous studies have suggested that the shorter the reading time, the learning effect becomes more effective. However, since the correct answer rate is not considered and only the reading time is analyzed, it cannot be said that the learning effect has been generally obtained. In this experiment, considering the correct answer rate and comparing data with L1 English speakers, Japanese EFL learners' reading time is long, they learned the reduced relative clause sentence structure information, and better reading tips.

The experimental group read the reduced relative clause sentences that temporarily contained structural ambiguity experienced a large processing load due to ambiguity immediately after the start of the session, and contrary to expectations, the reading time increased as they experienced the reduced relative clause sentences. In addition, sentence comprehension was greatly accelerated in the second session compared to the first session, but this tendency was observed not only for the reduced relative clause sentences containing ambiguity, but also for unreduced relative clause sentences that did not contain ambiguity. This is a different result from previous studies and is not consistent with the implicit learning by prediction error hypothesis. However, in the analysis by proficiency level, moderately proficient learners showed an acceleration of sentence comprehension and a gradual decrease in reading time, which is partially consistent with the implicit learning by prediction error hypothesis. On the other hand, native English speakers also showed a gradual increase in reading time in the first session, which may indicate the influence of content comprehension questions that were not present in previous studies.

4. EXPERIMENT 2: Repeated exposure effects on Japanese EFL learners' reduced and unreduced relative clause sentence processing: Evidence from self-paced reading experiment

4.1 Research Questions

In previous studies, the following three points have been identified. (1) Implicit learning effects of intermediate level Japanese EFL learners. (2) Implications for learning based on gradual reading time and correct answer rate in sentence comprehension experiment. (3) Learning effects at a greater number of exposures than in Experiment 1. To confirm these findings, three research questions arise in the experiment: (1) Do intermediate level Japanese EFL learners comprehend reduced relative clause sentences based on syntactic knowledge across trials? (2) Is it possible to suggest learning from the step-by-step reading time of the experimental sentences and the percentage of correct answers to the content comprehension questions presented in the native language? (3) Is implicit learning with a high number of repeated exposures in a short time effective in learning syntactic knowledge?

4.2 Hypothesis

In this experiment, based on the results of Experiment 1, testing whether increasing the amount of sentence exposures and changing the question presentation method from foreign language Yes or No questions to Japanese multiple-choice questions triggers implicit learning based on syntactic knowledge by narrowing the target group to intermediate level Japanese EFL learners.

In the first research question, based on the results of Experiment 1, Experiment 2 was conducted and analyzed an experiment focusing on intermediate proficiency level Japanese EFL learners. Since the results of Experiment 1 were partially consistent with the implicit learning hypothesis based on prediction error for Japanese EFL learners at the intermediate proficiency level, it was predicted that intermediate learners in Experiment 2 would also understand reduced relative clauses based on syntactic knowledge with each successive trial.

Next, for the second research question, Experiment 2 set two critical regions for the experimental sentences, analyzed the reading time for the two phases, randomly presented content comprehension questions in Japanese in a multiple-choice format for the experimental sentences, and analyzed the trends in the percentage of correct answers in order to examine the learning effect. In Experiment 1, the percentage of correct answers was

recorded in Yes or No questions. However, since the percentage of correct answers tends to be relatively high and it is not clear whether the learners are reliably understanding the content in their native language, it is expected that Experiment 2 will be able to measure the learners' learning effects in more detail.

Finally, regarding the third research question, Experiment 2 tested whether implicit learning effect could be observed in a shorter time by increasing the amount of exposure to approximately double the number of exposures in Experiment 1. As in Experiment 1, word-level processing was tested by comparing reduced and unreduced relative clause sentences that shared structural information and differed only in structural ambiguity. The third research question predicted that increased exposure would induce implicit learning even for short periods of time.

As in Experiment 1, Experiment 2 tested whether implicit learning by repeated exposure is effective in learning syntactic knowledge, and whether this is demonstrated especially in word-level processing. The number of sentence exposure was verified by increasing the number of exposures about twice as much, using the same exposure frequency ratio as in Experiment 1. As in Experiment 1, the experimental sentences were created at the same intimacy level as in Experiment 1, and as for the implementation of the experiment, it was conducted remotely rather than in person. Experiment 2 tested whether repeated exposure in sentence comprehension can induce implicit learning and changes in syntactic knowledge in intermediate Japanese EFL learners. Specifically, Experiment 2 predicted that a gradual decrease in sentence reading time should cause prediction errors, which in turn should induce tacit learning. By focusing on the proficiency level of intermediate learners, the study also examined the impact of intermediate learners on implicit learning and whether there are differences among intermediate learners who are closer to the basic level and those who are closer to the advanced level.

Experiment 2 was similar to Experiment 1, using two conditioned sentences: reduced and unreduced relative clause sentences. The reduced relative clause sentences served as experimental sentences and were compared to the unreduced relative clause sentences to control sentences whether there was a difference in reading time; it was important to note that the two conditional sentences had the same vocabulary and the same meaning, differing only in the presence or absence of temporal structural ambiguity.

4.3 Methods

4.3.1 Participants

Ten Japanese EFL learners (experimental groups: B2:3 and B1:5; control groups: B2:3 and B1:3) from the Kansai area. Prior to the experiment all Japanese EFL learners had studied English for at least six years. The experiment was conducted from August 24th to November 22th, 2022.

4.3.2 Apparatus

Regarding the proficiency test before starting the experiment, the participants were instructed to solve the Oxford Quick Placement Test created by Google Form in 30 minutes. The time limit was controlled using an add-on (Form Timer). Experiments created in SuperLab 6 Stimulus Presentation Software (Cedrus Corporation, San Pedro, CA, USA) were dropped into SuperLab Remote Package, and the created experimental application was provided to the participants.

4.3.3 Materials and Design

Participants were randomly assigned to one of two groups (experimental and control) and participated in a reading experiment consisting of two sessions: in the first session, the experimental group was conducted under the condition that all 32 experimental sentences (64 were filler sentences) out of a total of 96 sentences were reduced relative clause sentences. In the control group, the experiment was conducted under the condition that all experimental sentences were unreduced relative clause sentences. In the second session after the break, regardless of group, half of the 12 experimental sentences (16 were filler sentences) out of a total of 28 sentences were randomly presented as reduced relative clause sentences and half as unreduced relative clause sentences.

In both sessions, to measure the effect of learning on comprehension of the reduced relative clause sentences, content comprehension questions were randomly presented to the sentences containing filler sentences, and the responses were recorded. All experimental sentences were accompanied by a content comprehension question. Stimulus sentences (both experimental and filler sentences) were randomized with the constraint that items were not contiguous, and each list was created so that each participant was presented only once in each condition.

4.3.4 Procedure

Before conducting the experiment, participants accessed Google Form and took the online Oxford Quick Placement Test. This was a 30-minute proficiency test. It took 15 to 20 minutes for some participants to complete. To conduct the experiment, participants prepared their own personal computers, accessed the Dropbox address sent to them in advance, and downloaded the file containing the SuperLab Remote application. After extracting (unzipping) the file and setting the desktop to save the file generated after the experiment, the experiment began. After the experiment was completed, the application was automatically terminated and the text data file of the reading time and correct answers generated was saved on the desktop that was specified earlier. The entire experiment was completed by sharing the saved data file via email to the implementer.

Stimulus presentation was similar to Experiment 1, using a technique called the self-paced reading method, in which participants themselves sequentially presented word-separated stimulus sentences on the display each time they pressed the space bar (Just et al., 1982). This experimental method allows experimental participants to read through the sentences at their own rate of comprehension, and quantifies the cost of processing each word as indexed by the reading time in each region. Therefore, it is widely used as an effective method for looking at the real-time information processing process in sentence comprehension (Arai, 2013). Experiment 2 was conducted remotely. In addition to the fact that the self-paced reading method was automatically controlled by SuperLab Remote, participants were controlled so that once they opened the application, they could not exit it midway through and could not start over. This allowed Experiment 2 to follow the same procedure as the face-to-face experiment in Experiment 1.

4.4 Results

4.4.1 Data Analysis

This section reports the results of the analysis of reading time data and the percentage of correct answers to the content comprehension questions. After the results of the first session, the results of the analysis of the second session were reported. The analysis was conducted primarily using a linear mixed model. This is the same analysis method used in Experiment 1.

Below this section reports the results of the analysis of the reading time data and the percentage of correct

responses to the content comprehension questions. In order to examine the role of prediction error due to word-level processing, two regions of interest were established in the reading time data. One is the main clause verb region, where structural disambiguation is expected to occur and where the typical garden-path effect often occurs. The other is the post-main clause verb region where the garden-path effect may appear. For example, in the sentence “the professor / (who was) / assisted / in the difficult experiment / enjoyed / the task / recently,” “enjoyed” is the main clause verb region and “the task” is the post main clause verb region. The analysis was conducted using a linear mixed model. A linear mixed model was used in the analysis. Significant differences were found when the absolute value of the t-value calculated for each effect was more than 2, or more than 2 SE away from the mean in Gelman & Hill (2007). The order of item presentation included both first-order covariates centered on items 1-32 in session one and 1-12 in the second session, assuming linear change, and second-order covariates assuming a curve; both first-order and second-order covariates included interactions with the group factor in the model.

In Experiment 2, outliers were treated and data containing reading times greater than the mean $\pm 3 \times \text{SD}$ were removed. Therefore, 434 (row data were 448) and 158 (row data were 168) reading time and correct response rate data were included in the analysis for the first and second session.

4.4.2 Results and Discussion

4.4.2.1 First Session: Reading Time

There are two target phrase ranges (hereinafter “regions”). One is the main clause region (hereafter “main clause verb region”) where structural ambiguity is resolved, and a typical garden path effect is expected to occur. The other is the next region in which the garden path effect is expected to appear later (called spillover) (hereinafter “post-main clause verb region”). The analysis results for the reading time in these two regions are reported below. Figures 16 shows the subjects’ average reading time by group in these two regions.

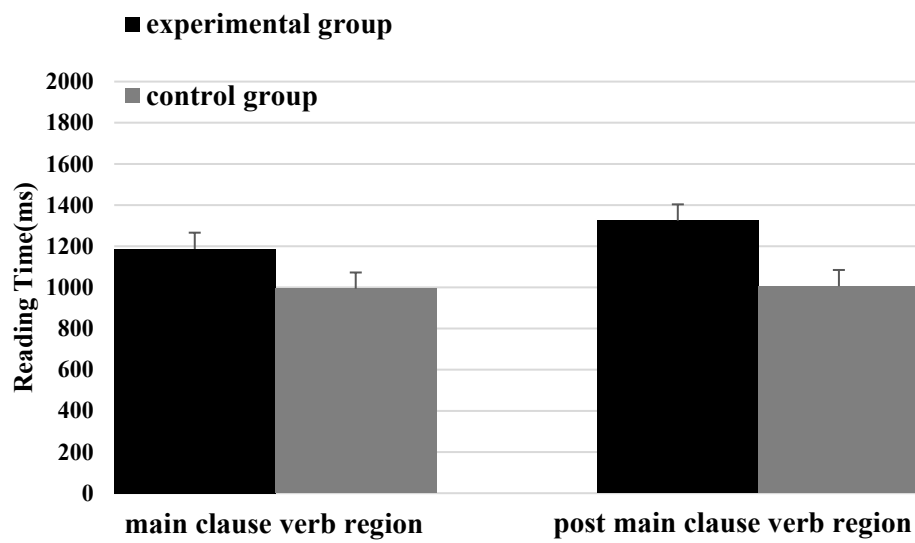


Figure 16. The Average Reading Time

Table 32

Number of Subjects, Mean Reading Time (in milliseconds), and Standard Deviation for Each Region for Japanese EFL Learners in the first session

control group			experimental group		
<i>n</i>	main clause verb region	post-main clause verb region	<i>n</i>	main clause verb region	post-main clause verb region
6	993(503)	1006(638)	8	1187(707)	1324(815)

In both regions, the experimental group tended to have longer reading times than the control group. The reading time of the experimental group was slightly longer in the post main clause verb region than in the main clause verb region, suggesting that the garden-path effect may have appeared later (spillover effect). On the other hand, the control group had the same reading time in both regions, suggesting that they were able to read the sentences without any delay.

Since the reading time data of the two regions was unequal on the left and right and a long-tailed distortion was seen on the right (skewness > 0), logarithmic conversion was performed so that the extreme value did not unduly affect the estimation of the average value. Figures 3 and 4 show a Q-Q plot (normal quantile-quantile plot) of the original reading time and the reading time after logarithmic conversion in the main clause verb region. The post-main clause verb region was performed in the same way (Figures 17 and 18).

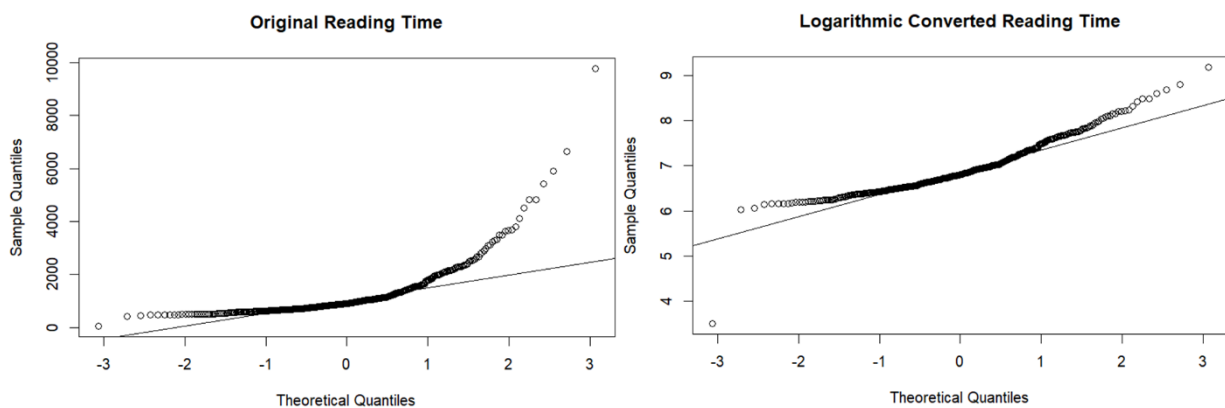


Figure 17. Q-Q Plots of Reading Time Without Conversion (left) and Logarithmic Converted Reading Time (right) in Main Clause Verb Regions

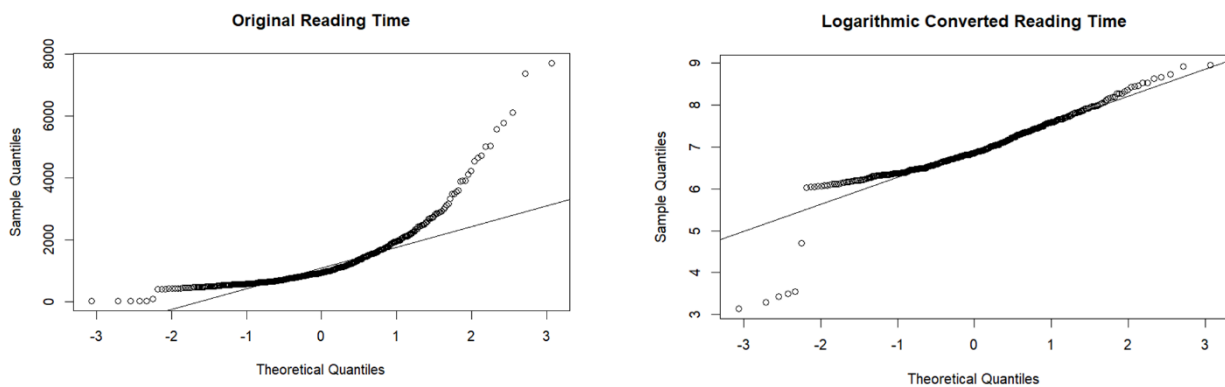


Figure 18. Q-Q Plots of Reading Time Without Conversion (left) and Logarithmic Converted Reading Time (right) in Post-Main Clause Verb Regions

If the reading time data completely follows the normal distribution, the data is placed on a straight line 45° diagonally right on the graph. As can be seen from the graph, the original reading time has a large distortion, but the logarithmic transformation approximates the normal distribution. Statistical analysis was performed using the linear mixed model with the reading time in these two regions as the dependent variable. The linear mixed model is an extension of the linear regression model, in which multiple random factors can be included in the equation together with the explanatory factors, and the effects of the explanatory factors can be verified by exploratory model selection (Arai, 2016). In studies dealing with languages, since the data is obtained from a certain number of subjects and a certain number of experimental stimuli, the merit is very considerable in that the random factors of these two different sources can be simultaneously included in one model (Baayen, 2008; Baayen et al., 2008).

The following two explanatory factors were included in the linear mixed model: the group in the first session (experimental / control group) as the inter-subject factors, and the order in which the 32 experimental items were presented in each group (“order of item presentation”). The order of item presentation was to include both the covariate of the first-order term centered on the numbers from 1 to 32 and assuming a linear change, and the covariate of the second-order term assuming a curve and included interaction with the group factor. For the random effect, the model with the largest structure including the random slope of all explanatory factors (the group is a between-subject design and not included in the subject random factor) was first tested. In

the linear mixed model, it is difficult to determine the degree of freedom, and therefore the degree of freedom is not considered in the t value calculated for each coefficient. For this reason, p-values are not calculated for lme4, a typical R package for linear mixed model analysis (Bates, 2005). Therefore, this paper does not report p-values (some parts are reported), assumes normal distribution for the data, and there is a significant difference if the absolute value of the t-value calculated for each effect is equal to or greater than two (Gelman & Hill, 2007). In other words, if the distance from the average is two or more SE, it is determined that there is a significant difference.

Table 33 shows the results of the analysis of the same items as the optimal model of the previous study (Arai, 2016) for the reading time data of the main clause verb region. Table 34 shows the results of the analysis of the same items as the optimal model of the previous study (Arai, 2016) for the reading time data of the post-main clause verb region.

Table 33

Analysis of the Optimal Model of the Previous Study (Arai, 2016) for the Reading Time Data in Main Clause Verb Regions

	<i>Coeff.</i>	<i>SE</i>	<i>t</i>
intercept	6.941	0.1145	60.616
group	0.02236	0.1547	0.145
order of item presentation (first-order)	-0.01542	0.01595	-0.967
order of item presentation (second-order)	0.0002962	0.0004688	0.632
group×order of item presentation (first-order)	0.01755	0.02136	0.821
group×order of item presentation (second-order)	-0.000458	0.0006266	-0.731

Table 34

Analysis of the Optimal Model of the Previous Study (Arai, 2016) for the Reading Time Data in Post-Main Clause Verb Regions

	<i>Coeff.</i>	<i>SE</i>	<i>t</i>
intercept	6.991	0.147	47.564
group	0.6123	0.199	3.076
order of item presentation (first-order)	-0.03407	0.01999	-1.704
order of item presentation (second-order)	0.0007815	0.0005877	1.33
group×order of item presentation (first-order)	-0.01841	0.02678	-0.688
group×order of item presentation (second-order)	0.00006033	0.0007855	0.077

In the case of optimal model of the previous study (Arai, 2016) results for reading time data in main clause verb regions, no main effects were found in all categories. In the case of optimal model of the previous study (Arai, 2016) results for reading time data in post-main clause verb regions, group category has main effect. This indicates that the reading time of the experimental group in the post-main clause verb region was significantly longer than that of the control group. Since neither the difference in reading time per region nor the difference in gradual reading time per group was significant, it is not possible to determine whether a learning effect can be seen at the first session in the overall participant data. In Arai (2016), proficiency is not included as a variable. This led to a discrepancy with the optimal model for this experiment. The next section presents the results of the analysis including proficiency in this experiment.

In Experiment 2, as in Experiment 1, this section focused on the reading times of Japanese EFL learners by proficiency level (CEFR-based). In particular, the analysis was conducted on intermediate learners. Tables 35 and 36 summarize the average reading time and basic statistics in the main clause verb region by proficiency level. Table 37 shows the results of the analysis of the optimal model for the reading time data of the main clause verb region.

Table 35

Reading Time (in milliseconds) and Standard Deviation of Japanese EFL learners by Proficiency Level in Main Clause Verb Region in the first session

	experimental group	control group
B2	1134(673)	922(434)
B1	1241(754)	1064(555)

Table 36

Reading Time of Main Clause Verb Regions (Proficiency Levels)

proficiency	<i>n</i>	<i>M</i>	<i>SD</i>	Min.	Max.
B2	5	962	444.7	416	2387
B1	9	1183	709	33	4108

Table 37

Analysis of the Optimal Model for the Reading Time Data in Main Clause Verb Regions (Proficiency Levels)

	<i>Coeff.</i>	<i>SE</i>	<i>t</i>
intercept	6.923	0.09807	70.596
group	0.1248	0.1204	1.037
order of item presentation (first-order)	-0.004383	0.002567	-1.708
B2	-0.1167	0.07087	-1.647
group×B2	-0.0136	0.1007	-0.135

The analysis showed no main effects for all categories. However, the significant trend in the order of item presentation (first-order) indicates that the experimental group tended to have progressively shorter reading times.

Table 38

Reading Time (in milliseconds) and Standard Deviation of Japanese EFL learners by Proficiency Level in Post-Main Clause Verb Region in the first session

	experimental group	control group
B2	1309(853)	1031(674)
B1	1301(812)	980(600)

Table 39

Reading Time of Post-Main Clause Verb Regions (Proficiency Levels)

proficiency	<i>n</i>	<i>M</i>	<i>SD</i>	Min.	Max.
B2	5	1158	739.4	416	4649
B1	9	1198	771.8	23	4550

Table 40

Analysis of the Optimal Model for the Reading Time Data in Post-Main Clause Verb Regions (Proficiency Levels)

	<i>Coeff.</i>	<i>SE</i>	<i>t</i>
intercept	6.946295	0.226636	30.65
group	0.348425	0.307581	1.133
order of item presentation (first-order)	-0.017238	0.003265	-5.279***
B2	0.093422	0.064068	1.458

Tables 38 and 39 summarize the average reading time and basic statistics in the main clause verb region by proficiency level. Table 40 shows the results of the analysis of the optimal model for the reading time data of the post-main clause verb region. The results of the analysis showed the category of order of item presentation (first-order) has significant difference in the post-main clause verb regions. This indicates that in the post-main clause region, the experimental group had significantly shorter reading times in a stepwise manner.

In both regions, there were significant differences in the order of item presentation (first-order terms), indicating that the experimental group progressively shortened their reading time. This is the same trend as in the

previous study, indicating that the experimental group learned the reduced relative clause within the session.

Since there was no significant difference in group categories, there was no statistical difference in reading time between the experimental and control groups, but the fact that the experimental group had a longer overall reading time than the control group suggests that reduced relative clauses are syntactically ambiguous sentences and tend to increase reading time, i.e., they function as sentences in which temporary ambiguity occurs. It can be said that they functioned as sentences in which temporal ambiguity occurred.

Taken together with the results of Experiment 1, the results of Experiment 2 suggest a trend toward a garden-path effect and an increase in implicit learning to read reduced relative clauses when the amount of exposure doubled, while no gradual change in reading time or differences by proficiency level were observed in the low-exposure condition of Experiment 1. This suggests that the amount of exposure and the method of presentation of the randomly presented content comprehension questions had an effect.

4.4.2.2 First Session: Answering Rate

This section presents an analysis of the percentage of correct responses to content comprehension questions in the first session. Percentages of correct responses by group and proficiency level (Tables 41 and 42) are presented, and the results of the analysis are shown in Table 42.

Table 41

The Answering Rate (%)

<i>experimental</i>	<i>control</i>
57.9	68.8

For both groups of participants, the control group had a higher percentage of correct responses than the experimental group. This is a result of the fact that the reduced relative clauses had lower percentages of correct responses than the unreduced relative clauses. However, compared to Experiment 1, both groups in Experiment 2 answered correctly at or above the chance level from the first session, suggesting that content comprehension occurred at an earlier stage. This suggests that the number of exposures and the manner in which content comprehension questions are presented may have facilitated comprehension in the native language from the first session.

Table 42

Answering Rate of Japanese EFL Learners' Proficiency Levels

proficiency	<i>n</i>	<i>Rates (%)</i>
B2	5	76.9
B1	9	54.4

Table 43

Analysis of Answering Rate (Japanese EFL Learners' Proficiency Levels)

	<i>Coeff.</i>	<i>SE</i>	<i>z</i>	<i>p</i>
intercept	0.33647	0.20702	1.625	0.1041
group	-0.24652	0.25568	-0.964	0.33496
B2	0.99853	0.3256	3.067	0.00216**
group×B2	-0.07154	0.45677	-0.157	0.87554

* $p < .01$ ** $p < .001$

The response data for the content comprehension questions were analyzed using a generalized linear mixed model with correct/incorrect as the binomial variable. Table 43 shows the results from the optimal model. In the generalized linear mixed model, z-values are reported because the maximum likelihood method is used. Therefore, a normal distribution is assumed here, and a z value of 1.96 or higher is considered significant.

In the results of the optimal model, significant difference was found in the B2 category, indicating that B2 is significantly more correct than B1. It is suggested that learners closer to the advanced level within the intermediate level are more likely to promote sentence comprehension. As expected, the results suggest that reduced relative clause sentences are affected by gradual processing, which tends to lead to incorrect interpretations. Although the results of the percentage of correct responses by proficiency level showed no statistically significant differences, the higher percentage of correct responses at the B2 level, which has less data, than at the B1 level, which has more data, suggests the validity of the way the questions are presented.

The second session shows how the correct answer rate changed in the experimental group and the control

group and reports the analysis results.

4.4.2.3 Second Session: Reading Time

In the second session, both groups performed experiments under the same conditions. As for the experimental sentences, half of the six sentences were presented with reduced relative clause sentences, and the other half were unreduced relative clause sentences, for a total of twelve experimental sentences, together with 16 filler sentences. Figures 19 and 20 show the participants' average reading time for each group and relative clause sentence type in each region. Also, Figures 21 and 22 show a Q-Q plot (Normal Quantile-Quantile Plot) of the original reading time and the reading time after logarithmic conversion in the main clause verb region. The post-main clause verb region was performed in the same way (Figures 23 and 24).

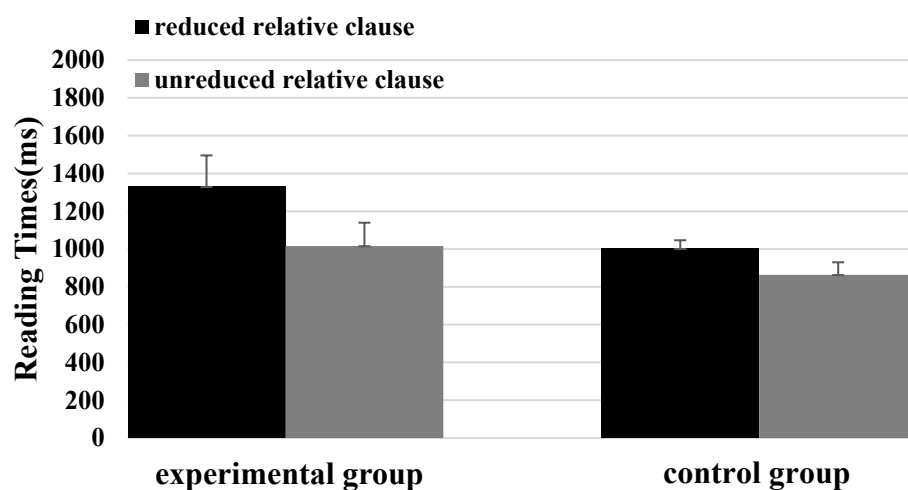


Figure 19. Average Reading Time in Experimental and Control Groups / Relative Clause Sentence Type in Main Clause Verb Region

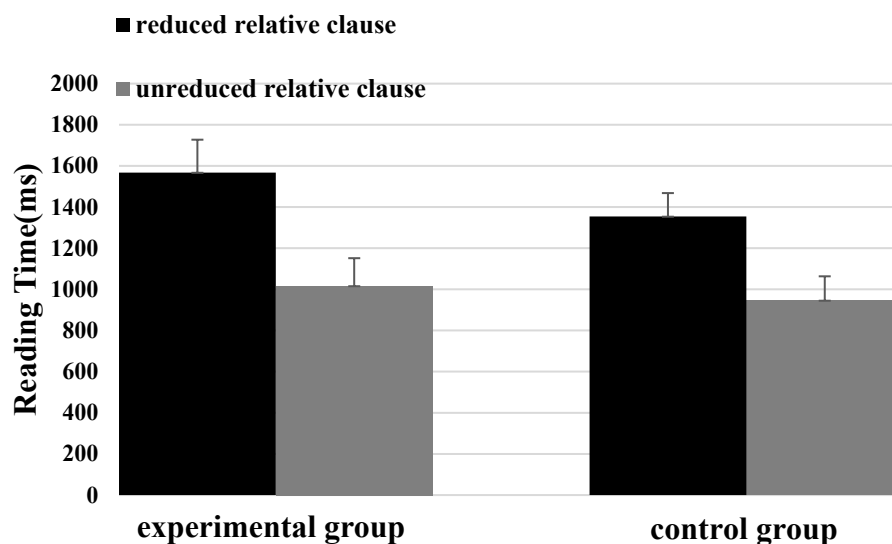


Figure 20. Average Reading Time in Experimental and Control Groups / Relative Clause Sentence Type in Post-Main Clause Verb Region

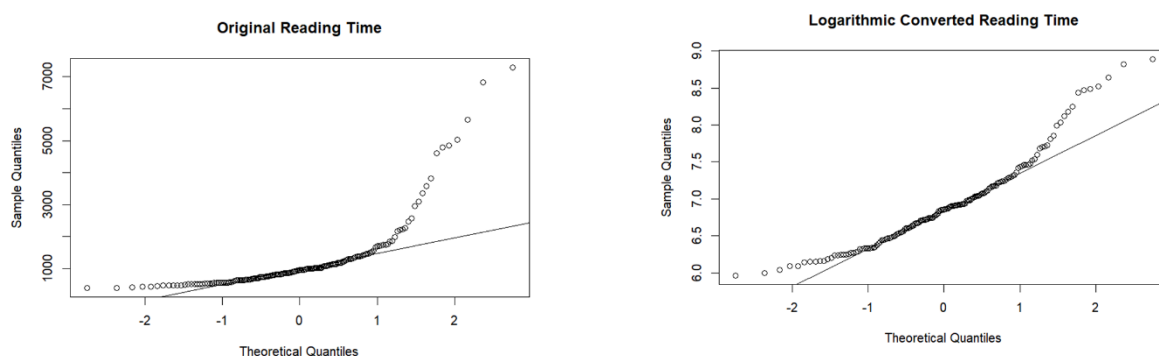


Figure 21. Q-Q Plots of Reading Time Without Conversion (left) and Logarithmic Converted Reading Time (right) in Main Clause Verb Regions

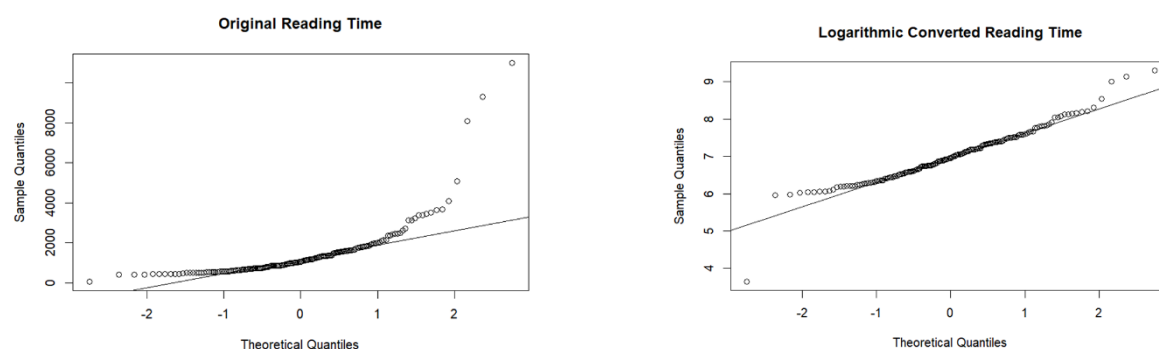


Figure 22. Q-Q Plots of Reading Time Without Conversion (left) and Logarithmic Converted Reading Time (right) in Post-Main Clause Verb Region

In both regions, the experimental group had a longer overall reading time and a longer reading time for the reduced relative clause than the control group. On the other hand, in Arai (2016), the experimental group had shorter reading times than the control group. Since no main effect was observed, no statistical difference was found, but the trend suggests that the experimental group may have read more carefully based on their experience in the first session.

There was different tendency by region, and although the experimental group had a longer reading time than the control group, in the post-main clause verb region, the experimental group had a longer reading time for reduced relative clause sentences than for unreduced relative clause sentences (Tables 44 and 45). In both regions, the experimental group had longer reading times than the control group (Tables 44 and 45). B2 learners also had longer reading times than B1 learners (except for the control group in the main clause verb region). This suggests that learning to read reduced relative clause sentences may have taken place in the first session, resulting in adaptation to the reading style in the second session.

Table 44

Average Reading Time (in milliseconds) in the Main Clause Verb Region by Overall and Proficiency Level in the second session

	experimental group			control group		
	overall	B2	B1	overall	B2	B1
reduced	1329	1098	1428	1002	1071	932
unreduced	1016	733	1116	863	875	852

Table 45

Average Reading Time (in milliseconds) in the Post-Main Clause Verb Region by Overall and Proficiency Level in the second session

	experimental group			control group		
	overall	B2	B1	overall	B2	B1
reduced	1568	1827	1457	1354	1601	1107

unreduced	1016	1035	1009	946	1060	831
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In the main clause verb region, the experimental group had longer reading times than the control group, with the B1 experimental group averaging the longest reading time with contracted relative clauses. This may be the emergence of a typical garden-path effect, but it is not statistically significant. Since there is no significant difference in group categories in the post-main clause verb region, it cannot be said that the reading time of reduced relative clause sentences in the B2 experimental group is statistically longer. However, since it took nearly two seconds, a garden-path effect delay is possible.

Table 46 shows the results of the analysis of the same items as the optimal model of the previous study (Arai, 2016) for the reading time data of the main clause verb region. Table 47 shows the results of the analysis of the same items as the optimal model of the previous study (Arai, 2016) for the reading time data of the post-main clause verb region. As in the previous analysis, a linear mixed model was applied to the reading time per region. Three explanatory factors were included in the model: group (experimental/control), and relation clause type (reduced/unreduced), and item presentation order (1-12), including all centralized interactions.

Table 46

Analysis of the Optimal Model of the Previous Study (Arai, 2016) for the Reading Time Data in Main Clause Verb Regions

	<i>Coeff.</i>	<i>SE</i>	<i>t</i>
intercept	6.725028	0.166436	40.406
group	0.077189	0.230297	0.335
type of relative clause sentences	0.113371	0.245414	0.462
order of item presentation	-0.00728	0.022654	-0.321
group×type of relative clause sentences	-0.190294	0.324478	-0.586
group×order of item presentation	0.007233	0.030303	0.239
type of relative clause sentences×order of item presentation	0.005967	0.033131	0.18
group×type of relative clause sentences×order of item presentation	0.038055	0.04385	0.868

Table 47

Analysis of the Optimal Model of the Previous Study (Arai, 2016) for the Reading Time Data in Post-Main Clause Verb Regions

	<i>Coeff.</i>	<i>SE</i>	<i>t</i>
intercept	6.998	0.2317	30.209
group	0.0506	0.3221	0.157
type of relative clause sentences	-0.1459	0.3011	-0.485
order of item presentation	-0.05442	0.02779	-1.958
group×type of relative clause sentences	0.2069	0.3981	0.52
group×order of item presentation	0.009145	0.03717	0.246
type of relative clause sentences×order of item presentation	0.07562	0.04064	1.86
group×type of relative clause sentences×order of item presentation	-0.01014	0.05379	-0.188

In the case of optimal model of the previous study (Arai, 2016) results for reading time data in main clause verb regions, no main effects were found in all categories. In the case of optimal model of the previous study (Arai, 2016) results for reading time data in post-main clause verb regions, also no main effects were found in all categories. In Arai (2016), proficiency is not included as a variable. This led to a discrepancy with the optimal model for this experiment. The next section presents the results of the analysis including proficiency in this experiment.

The second session also focuses on the reading time of learners' proficiency (based on CEFR). Tables 48, 49, 50 and 51 summarize an average of reading time according to their proficiency.

Table 48

Reading Time of Main Clause Verb Regions (Proficiency Levels)

proficiency	<i>n</i>	<i>M</i>	<i>SD</i>	Min.	Max.
B2	5	950	501.5	440	3368
B1	9	1123	664.1	387	3830

Table 49

Analysis of the Optimal Model for the Reading Time Data in Main Clause Verb Regions (Proficiency Levels)

	<i>Coeff.</i>	<i>SE</i>	<i>t</i>
intercept	6.68	0.1469	45.485
group	0.1622	0.1852	0.876
order of item presentation (second-order)	-0.0004477	0.00118	-0.379
type of relative clause sentences	0.05565	0.1153	0.483
type of relative clause sentences × order of item presentation (second-order)	0.00224	0.00162	1.383

Table 50

Reading Time of Post-Main Clause Verb Regions (Proficiency Levels)

proficiency	<i>n</i>	<i>M</i>	<i>SD</i>	Min.	Max.
B2	5	1371	928	390	4085
B1	9	1123	610.4	38	3394

Table 51

Analysis of the Optimal Model for the Reading Time Data in Post-Main Clause Verb Regions (Proficiency Levels)

	<i>Coeff.</i>	<i>SE</i>	<i>t</i>
intercept	6.48	0.4121	15.722
group	0.9214	0.5384	1.711
order of item presentation (first-order)	0.09028	0.1774	0.509
order of item presentation (second-order)	-0.008404	0.01544	-0.544
type of relative clause sentences	0.6592	1.062	0.621
B2	1.158	0.6007	1.927
group×order of item presentation (first-order)	-0.2941	0.2158	-1.363
group×order of item presentation (second-order)	0.02086	0.01798	1.16
group×type of relative clause sentences	-1.037	1.177	-0.881
order of item presentation (first-order) ×type of relative clause sentences	-0.2388	0.3259	-0.733
order of item presentation (second-order) ×type of relative clause sentences	0.02059	0.02329	0.884
group×B2	-1.456	0.9139	-1.593
order of item presentation (first-order) ×B2	-0.2959	0.2456	-1.205
order of item presentation (second-order) ×B2	0.01643	0.02042	0.804
type of relative clause sentences×B2	-1.003	1.28	-0.784
group×order of item presentation (first-order) ×type of relative clause sentences	0.4862	0.3739	1.3
group×order of item presentation (second-order) ×type of relative clause sentences	-0.03522	0.02703	-1.303
group×order of item presentation (first-order) ×B2	0.4449	0.3691	1.205
group×order of item presentation (second-order) ×B2	-0.02927	0.03097	-0.945
group×type of relative clause sentences×B2	0.887	1.643	0.54
order of item presentation (first-order) ×type of relative clause sentences×B2	0.3462	0.4117	0.841
order of item presentation (second-order) ×type of relative clause sentences×B2	-0.01892	0.02992	-0.632
group×order of item presentation (first-order) ×B2×type of relative clause sentences	-0.2692	0.558	-0.482
group×order of item presentation (second-order) ×B2×type of relative clause sentences	0.01593	0.04215	0.378

The analysis showed no main effects for all categories in both reading regions. There were 24 categories of optimal models in the post-main clause verb region, but none of the categories showed significant differences. However, the significant trend in B2 at the post-main clause verb region indicates that B2 shows a significant trend toward longer reading times than B1.

The findings from previous studies have suggested that the long reading time in the main clause verb region is a manifestation of the garden-path effect and a characteristic of reduced relative clause sentences, but when the appropriate cue word appears, the reading time in the post-main clause verb region becomes longer because the reader realizes the error in the previous interpretation and corrects his/her interpretation. The result is considered as the region where the garden-path effect is occurring, or where the effect appears as the position where syntactic processing is performed. Therefore, it should be redefined as a region where the effect appears as the position where syntactic processing is performed.

4.4.2.4 Second Session: Answering Rate

This section focuses on how the correct answer rate changed in the experimental group and the control group from the first session. Table 52 shows the correct answer rate in the second session, which is shown for each relative clause sentence type and each group. Also, Table 53 summarizes the relation of answering rates between the first and second session. Analysis was performed using a generalized linear mixed model with the answer data to this question as binary variables of correct / incorrect. There were two explanatory factors: relative clause sentence type (reduced / unreduced relative clause sentences) and group (experimental / control group). The interaction was included in the model together.

Table 52

Percentage of Correct Responses by Group of Japanese EFL Learners' Proficiency Levels and by Relative Clause Sentence Type in the second session (%)

	experimental group			control group		
	overall	B2	B1	overall	B2	B1
reduced	82.5	91.7	78.6	52.8	83.3	22.2
unreduced	80.4	83.3	79.4	77.8	88.9	66.7

Table 53

Analyzes of Answering Rate

	<i>Coeff.</i>	<i>SE</i>	<i>z</i>	<i>p</i>
intercept	0.6148	0.4422	1.39	0.164437
group	0.5149	0.5741	0.897	0.369756
type of relative clauses	-1.312	0.5651	-2.322	0.020253*
B2	1.6572	0.4916	3.371	0.000749***
type of relative clauses ×group	1.4062	0.8021	1.753	0.079574

*p<.01 **p<.001 ***p< 0

The main effect of the type of relative clauses category was significant. This indicates that the experimental group had a higher percentage of correct responses to reduced relative clauses than to unreduced relative clauses, while the control group had a lower percentage of correct responses to reduced relative clauses than to unreduced relative clauses. Significant differences were also observed in the B2 category, indicating that the percentage of correct responses was significantly higher for B2 than B1. These results indicate that the learning effect in the first session directly leads to an improvement in the comprehension of the relative clause sentences. In addition, the reading time data for the second session showed that both the experimental and control groups were already reading in the first session, reflecting the learning effect.

4.5 Hypothesis Verification

This section provides results and discussions with regard to each research question.

For the first research question, do intermediate level Japanese EFL learners comprehend contracted relative clauses based on syntactic knowledge with each successive trial? The results of the analysis of the second session also showed that the learning effect of the first session was directly related to the improvement in the understanding of the relative clauses. The reading time data showed that reading time was longer in the second session than in the first session, and statistically, reading time was progressively longer in the second session, suggesting that syntactic processing may have been activated. The data on the percentage of correct responses

showed that the percentage of correct responses increased in the second session compared to the first session, and the results of the analysis in the second session also showed that the learning effect in the first session was directly related to the improvement in the comprehension of the reduced relative clause sentences. Therefore, it can be said that the implicit learning effect was observed in the intermediate level Japanese EFL learners, who understood the reduced relative clauses based on the syntactic knowledge they experienced in the first session with each successive trial.

For the second research question, is it possible to suggest learning from the step-by-step reading time of the experimental sentences and the percentage of correct answers to questions presented in the native language? The results of the stepwise reading time showed a significant difference in order of item presentation (first-order) in the post-main clause verb region at the first session (a trend was observed in the main clause verb region). Therefore, it is possible that the experimental group learned the reduced relative clause sentences within the session, since the reading time of the experimental group was progressively shorter. The correct response rate results show that both groups had correct response rates above the chance level in the first session, but in the second session, the B1 control group's comprehension of the content of the reduced relative clause (the first exposure to the ambiguous sentence structure in the second session) was below the chance level, and the B2 control group's comprehension of the content of the reduced relative clause was below the chance level. The results indicate that the questions presented in the native language were appropriate, by proficiency level and by group.

For the third research question, is tacit learning with a large number of repeated exposures in a short period of time effective in learning syntactic knowledge? While the number of exposures in the first session was significantly increased from Experiment 1, which increased the burden on the participants to perform the task, the learning of syntactic knowledge unconsciously resulted in a significant increase in the percentage of correct responses to content comprehension questions, as suggested by the correct response rate results. Therefore, implicit learning with a high number of exposures is effective in the learning of syntactic knowledge.

5. GENERAL DISCUSSION

5.1 Summary of the Results

In the first session of the Experiment 1, the experimental group that reads a structurally ambiguous reduced relative clause sentence had a large processing load due to ambiguity immediately after the start of the session. Reading time became longer with experience. It is not known whether prediction error in the processing of relative clause sentences containing ambiguity indicates that the subjects in this group had learned the relative clause structure. In Chang et al., 2006, it was said that the less the reading time, the more learning occurred. In this experiment, the result was the opposite, and the conditions were different (a question sentence was provided from the first session), so it cannot be said that learning had not taken place.

In the second session of the Experiment 2, in which subjects from both groups were tested under the same conditions, the difference between the groups was evident from the reading time of reduced / unreduced clauses. In the main group verb region of the experimental group, the reading time was gradually increased as in the first session, but since no significant difference was seen, it is believed that the length of reading time has no effect. The reading time was significantly longer in the post- main clause verb region. This is thought to be due to learning the structural information of the reduced relative clause sentences and changing the reading technique.

Regarding the results for each proficiency level, it is conceivable that learning progressed from the result of the correct answering rate for intermediate learners. Regarding the results of L1 English speakers, the reading time gradually increases, so the change in the syntactic knowledge already acquired is not seen by the shortened reading time. In the research of Arai (2016), the shortening of the reading time with the experience of reduced relative clause sentences indicates that the participants in this group learned the relative clause structure due to a prediction error in the processing of relative clause sentences containing ambiguity. However, L1 English speakers already comprehend reduced relative clause sentences, but their reading time is going to be slow when they are exposed to reduced relative clause sentences many times.

Also, as mentioned in the introduction, in the comparison of reduced relative clause sentences and main clause sentences, different types of sentences are compared, and the surprisal effect is calculated based on the predicted occurrence probability for the entire sentence, and the role of prediction error has been verified (Fine & Jaeger, 2013) in studies of syntactic priming. Therefore, it was unclear what role temporary structural ambiguity

in relative clauses played in the error-based learning hypothesis. The results of this study show that prediction errors caused by temporary ambiguity play a decisive role in the implicit learning of structural information. The effect of implicit learning on prediction errors observed in second language learners, and the results of research on implicit learning so far, that was also applicable to learning, and also applicable to learning. In other words, error-based learning models are not only effective as a mechanism for changing and adapting the already acquired syntactic knowledge of native speakers.

Also, the results of this study revealed that learning in a more general sense, the mechanism of the process by which incomplete or unstable knowledge is learned through experience, is also effective. It is believed that the theme of this research, implicit learning by repeated exposure, was promoted from the results of reading time and correct answer rate. However, the analysis of reading time has not been statistically analyzed with an appropriate model of the generalized linear mixed model but is reported as data of one model.

In the first session, the experimental group that temporarily exposed reduced relative clause sentences containing structural ambiguity had a large processing load due to the ambiguity immediately after the start of that session. Against all expectations, the reading time was increased with the experience of reduced relative clause sentences. In the second session, sentence comprehension was greatly accelerated compared to the first session. However, this tendency was observed not only in the reduced relative clause sentences but also in the unreduced relative clause sentences. This is a different result from previous studies and is not consistent with the prediction error-based implicit learning hypothesis. However, the results of the proficiency-based analysis showed that learners with moderate proficiency accelerated their sentence comprehension and progressively decreased their reading time, which was partially consistent with the prediction error-based implicit learning hypothesis. On the other hand, native English speakers also showed progressively longer reading times in the first session, which may have been influenced by the content comprehension questions that were not present in previous studies. Various factors have also been found to affect Japanese EFL learners' sentence comprehension, for example, unreduced relative clause sentences do not contain syntactic ambiguity, but they tend to have more words than reduced relative clause sentences, and processing tends to be more difficult when the number of words increases, independent of ambiguity.

Experiment 1 also obtained data on L1 English speakers, but the learning effects may differ between Japanese EFL learners and L1 English speakers. In that case, there are two possible patterns, each of which has

significant differences. When such results are obtained, one pattern observed is that the learning effect is smaller for L1 English speakers than for second language learners. In this case, the native language speaker has already gained enough input through deep language experience and has a stable knowledge of syntactic information, so second language learning from local statistical information in one experiment can be performed. It is suggested that they are not as affected as those in the past. When these results are obtained, L1 English speakers may be more responsive to local distribution information, as they have become accustomed to differences in linguistic information distribution in various contexts through a great deal of linguistic experience. This means that L1 English speakers have a higher ability to adapt to the environment, and this is important in that their ability to adapt improves as language experience accumulates. As a first step, this study has demonstrated the effect of predictive error-based learning on structural knowledge in second language learners comprehend of English reduced relative clause sentences.

In the proficiency-by-proficiency analysis of Experiment 1, the results were partially consistent with the implicit learning hypothesis due to prediction error, as learners with moderate proficiency showed progressively shorter reading times as well as accelerated sentence comprehension. On the other hand, native English speakers also showed progressively longer reading times in Session 1, suggesting that content comprehension problems, which were not present in the previous study, may have influenced the results. Therefore, in Experiment 2, it was limited the number of participants to intermediate Japanese learners of English, increased the number of exposures to reduced relative clauses, and changed the format of the content comprehension questions to one that required more accuracy than in Experiment 1, to see whether the shorter reading time would promote implicit learning, or whether the results for native speakers of English, similar to the results for native speakers of English shown in Experiment 1, would be more accurate. The gradual increase in reading time may be due to the same structural processing as for native English speakers.

The reading time data from Experiment 2 showed that there were differences within the intermediate level, with B2 learners having progressively shorter reading times than B1 learners in the main verb region of the first session. The results by proficiency level show that the percentage of correct responses for B2 is significantly higher than that for B1 in both groups, suggesting that the promotion of sentence comprehension is more pronounced among learners closer to the advanced level than among those at the intermediate level. It is possible that B2 learners may have the same structural processing as native English speakers. However, since the

experiment could not be conducted with native English speakers under the same conditions of Experiment 2, it cannot be said that they are generally the same. There is no doubt that the learning effects of increasing the number of exposures is the same as those observed for native English speakers. Regarding the number of participants, analysis was performed because the number of samples was extremely small. However, the reliability was low, so it was necessary to increase the number of subjects and repeat the experiment. As for the learners' proficiency level, it was somewhat consolidated. In more detail, the learner's proficiency level should be analyzed, and a wide range of learner levels should be collected, and the experiment repeated to confirm the difference.

Clahsen and Felser (2006) stated that second language learners cannot perform processing like native speakers based on syntactic knowledge, but instead rely strongly on the semantic information of the lexicon. Thus, this tendency is especially strong in the case of foreign language learners, who try to comprehend sentences based only on the semantic information of the lexicon, but do not activate the syntactic processing mechanism unless there is a need to do so. Therefore, it is possible that the learners were forced to activate the syntactic processing mechanism by the content comprehension questions, and gradually adapted to it.

In the future, it is necessary to examine the possibility of proficiency in syntactic processing and the prediction error-based implicit learning, considering the frequency of exposure and the characteristics of foreign language learners as described above. It is thought that the method of presenting the experiment should be compared not only with visual presentation but also with auditory presentation. The language processing model shown by Levelt (1993) is divided into a concept level, a lemma level, and a lexeme level, each of which plays a central role in language operation and comprehension. The mental lexicon in this model mediates between concept, grammar, and phonology. Access to the mental lexicon involves syntactic, morphological, and phonological information in addition to semantic information. In the mental lexicon, separate representations contain semantic and syntactic content and representations containing phonological content, each of which are processed (Levelt, 1989; MacKay, 1987; Stemmer, 1985). For a representation including phonological content, a process called phonological encoding is performed, and here, it refers to a series of operations in which a lemma is converted into a general form of a word. The results are different between auditory presentation and visual presentation, and the number of exposures may be affected. At the same time, by changing the number of exposures and the task content and comparing them, it is possible to expect further improvement in the syntactic processing ability, and the promotion of implicit learning by repeated exposure is expected.

The results obtained in this study can be described as a kind of syntactic priming effect. For this reason, various theoretical frameworks have been developed to explain patterns of syntactic priming (Tooley & Traxler, 2010, 2012), which will be reviewed here. Some of the hypotheses point to short-term activation of stored representations (Branigan et al., 2005).

The first is the residual activation hypothesis. This relates to a process involving the lemma of lexical representations in both production and comprehension effects, where syntactic choices have been shown to be encoded as part of the lexical representation of a word (MacDonald et al., 1994; Vosse & Kempen, 2000). According to this hypothesis, when a person produces or understands a sentence, the lexical items (e.g., *examine*) are encoded as lexical items that encode information about how they should be combined with other items (e.g., *defendant*, *lawyer*), in what order they should be expressed, and what endings should be changed. It is said to activate the connection between the lemma node and the syntactic structure representation. Processing of prime sentences has been shown to temporarily increase the activation of structural representations needed to form dependencies between words in a sentence, and to accelerate processing when structural representations are needed. Importantly, the association of syntactic structural representations with word-level (lexical) representations provides a means of generating lexical reinforcement (a greater priming effect occurs when the prime and target share a lexical item). That is, priming can occur when both the prime and target require the same structural representation, but if the words in the target send back to the same lemma as the prime, priming will increase because the connection between the lemma and the required syntactic structural representation will undergo some residual activation. The results of Cleland & Pickering (2003) show that having the same verb in the first place facilitates object processing, either because the syntactic representation associated with the verb remains activated across sentence boundaries, or because the connection is more easily retrieved when object disambiguation information is encountered. This may indicate that they are more easily retrieved or reactivated when disambiguation information is encountered. From the results of this experiment, these have not yet found evidence that verb repetition or noun repetition is important when sentence structure is repeated in reduced relative clause sentences. In the future, it will be focused more on words and improve the stimulus sentences.

The second is the implicit learning hypothesis, which was the focus of this study. In the present experiment, it is difficult to say that a relatively sustained priming effect was observed, so long-term observation is needed. In addition, implicit learning is said to be applicable to simple word sequences (Arnon & Snider, 2010), so the

priming effect may be due to a specific bigram (a string of arbitrary words followed by only two letters). In other words, the prime sentence '*The defendant examined by*' increases the bigram probability of '*examined by*', and '*The engineer examined by the board*'.

Repetition of the bigram is not necessary for priming, and other priming experiments in which the prime and target have different forms of reduced relative clause sentences have also shown that processing of the target was facilitated (Traxler, 2008). In the present experiment, it was not seeing this trend because it was prepared a completely different bigram, but there is a need to test it, and it should be considered in conjunction with the residual activation hypothesis.

The third is the prediction and error-correction model. Although it can explain many phenomena related to syntactic priming, the model of Chang et al. (2006) does not have a mechanism that can easily generate lexical reinforcement. The fundamental problem with this is that if the model can adjust the strength of the connections to produce a trial lexical reinforcement effect, then it will forget previously learned patterns. Since priming in comprehension is affected by lexical reinforcement, this may support the hypothesis of residual activation of syntactic priming in comprehension. However, the patterns of priming effects observed in comprehension and production studies do not necessarily justify this conclusion. For example, lexical reinforcement has been shown to occur only when the prime and target representations are immediately adjacent (Hartsuiker et al., 2008). Furthermore, despite the absence of lexical reinforcement, priming effects in production and comprehension can persist when unrelated sentences are interposed between the prime and target representations (Bock & Griffin, 2000; Tooley et al., 2014).

Residual activation is not considered necessary for the priming effect to persist for a relatively long time, and syntactic priming should ideally cover both production and comprehension phenomena. However, the results of this experiment suggest that neither the residual activation hypothesis nor implicit learning with error correction correspond to the full range of observed effects, and that multiple mechanisms may contribute to the observed results. Indeed, a number of researchers have proposed dual-mechanism accounts (Traxler & Tooley, 2007; Hartsuiker et al. 2008; Chang et al. 2012, Fitz et al. 2011).

In this study, it was used the reading time as a behavioral index, but the findings of electrophysiological indices also show a similar trend to the results obtained in this study. In particular, compared to the self-paced reading task, ERPs allow it to examine not only the quantity of processing load, but also the

quality and when the processing started. In ERP studies, syntactic priming effects, as indicated by modulation of the amplitude of P600, were observed when comprehension questions intervened between the prime and target sentences (Ledoux et al., 2007; Tooley et al., 2009). P600 reflects the load associated with the reanalysis of the syntactic structure of a sentence and is an indicator for determining under which conditions the reanalysis of the syntactic structure of a sentence was performed. The reduction in the rate of correctness in sentence processing studies is commonly referred to as the P600 effect; P600 modulation was first observed in experiments that assessed syntactic manipulations only (e.g., agreement and word order violations, syntactic ambiguity, complexity, etc.). P600 effects have also been observed when syntactic information competes with semantic information in sentences (e.g., semantic violations in syntactically unambiguous sentences; Kim & Osterhout, 2005; Kuperberg, et al., 2006; Nakano, et al., 2010). Importantly, a number of ERP studies have shown the P600 effect, which indicates that syntactic processing is difficult in syntactically ambiguous sentences (Tooley et al., 2014). In priming experiments of comprehension, the increased processing speed and ERP modulation of target sentences may reflect different types of processing, such as lexical, semantic, referential, and syntactic. For this reason, previous studies have attempted to identify the source of the observed priming effects. In Traxler and Tooley's (2008) study, repetition priming of the subject occurred when the subject was repeated to establish a semantic relationship between the prime and target sentences, but no priming effect occurred during processing of syntactically disambiguating by-phrases (e.g., The defendant examined *by the lawyer* turned out to be unreliable). Often, the syntactic priming hypothesis in comprehension must also accommodate broader findings from production, such as the "rapid disappearance of lexical boosts" (Hartsuiker et al., 2008). In addition, the processing process of comprehension is often compared to the production process, and the details of processing during comprehension can always be different from production due to differences in inputs and outputs, the types of goals pursued by the comprehension and production systems, and the time courses over which they operate (Tooley et al., 2014). Considering the above findings together with the present results and considering that the processes of comprehension and production are often compared, and that each system processes differently depending on the type of goal it pursues. Comparing the results of the present sentence comprehension with the results of production when performed under the same conditions will help to promote implicit learning and enforcement of the activation of the syntactic processing mechanism, and to clarify the difference between the processing of comprehension and production.

The presence of one residual activation mechanism and the implicit learning mechanism does not necessarily preclude the possibility of the other mechanism. Indeed, some syntactic priming hypotheses explicitly incorporate separate mechanisms to address different experimental phenomena (Chang et al., 2006; Hartsuiker et al., 2008). Tooley incorporated this assumption into their dual- mechanism account of syntactic priming in comprehension (Tooley & Traxler, 2010; Traxler & Tooley, 2008). As well as the hypothesis of Hartsuiker et al. (2008), the dual-mechanism account incorporates aspects of both combinatorial nodes and implicit learning. According to this hypothesis, exposure to a prime sentence temporarily facilitates the activation of the relevant combinatorial nodes. The combinatorial nodes that encode the actual syntactic relations underlying the final interpretation of the sentence will have the highest degree of activation. In production, this means that structures are more likely to be selected, or that the latency for production is reduced. In comprehension, it means that the relevant structures will be activated or built more quickly.

The distinction between short-term residual activation and long-term implicit learning mechanisms may be rooted in different memory systems, as proposed by some language learning hypotheses (Ullman, 2001). Another possibility is that implicit learning and residual activation apply to different elements of the memory system that encode knowledge of lexical and syntactic structures. Thus, word-related knowledge word-related knowledge is assumed to be encoded in a distributed manner, including the possibility of syntactic structure (Tooley et al., 2014).

The extent to which lexically independent priming may occur is thought to be influenced by the relative strength of various syntactic structure representations (Tooley et al., 2014). According to their idea, in the case of contracted relative clauses, other structural possibilities (such as transitive and passive voice) are dominant. A combination of lexical boost and implicit learning may be required before a facilitated response (priming effect) is observed when the prime sentence precedes the target sentence in a single case. Other structures that are potentially more balanced may be better suited for lexically independent priming and may show different patterns of priming across the intervening material. This is a potentially rich basis for future empirical research and modeling.

The evidence obtained in the present study may indicate that the number of exposures with stimulus sentences and the concomitant, and quality of the comprehension question are important. For the number of exposures, it will be considered the proportion of fillers and the proportion of lags to determine whether the

location of the relevant filler sentence affects the magnitude of priming across lags. The next important step in this study is to determine whether visual or auditory presentation makes a difference, and in particular, whether the longer reading and elapsed time, as in this case, is indicative of implicit learning. A previous study suggested that progressively faster reading times facilitated comprehension through implicit learning based on prediction errors (Arai, 2016). However, in the present experiment, even native English speakers had progressively longer reading times. The fact that the reading time did not tend to become progressively faster, but rather longer, even when the native speakers encountered the reduced relative clause sentences, a structure they do not encounter often, makes it impossible to necessarily suggest the promotion of implicit learning based on reading time only. Therefore, considering the percentage of correct answers to the comprehension question, as was done in this study, would expand the possibilities for the effect of promoting implicit learning and increase its persuasiveness.

Although lexically independent priming has been reported in comprehension (Thothathiri & Snedeker, 2008; Traxler, 2008), the priming effect in production priming studies is thought to be more robust. In production studies, priming effects have been reported to be persistent and to last for several days (Bock & Griffin, 2000; Kaschak & Borreggine, 2008). Although evidence for persistent priming effects is more limited in comprehension, priming studies involving extensive exposure to specific sentence types in comprehension have shown evidence for long-term learning effects (Long & Prat, 2008; Wells et al., 2009). A lexical boost, in which the priming effect is enhanced when a particular word is repeated across primes and targets, also occurs in both production and comprehension. Thus, there may be substantial similarities in the way the priming effect manifests between production and comprehension. In production, priming is often measured as a change in the likelihood of binary choice. In understanding, effects are typically measured in steps and may differ in terms of both overall processing time and the onset of effects. While studies of production priming have increasingly focused on the issue of time lapse (latency), the overall focus remains on the consequences of structural selection. The most conservative position at this point is that more research, especially on understanding, is needed before conclusions about the overlap in mechanisms between production and comprehension can be justified.

The priming effect was observed only when the prime and target sentences had the same critical verb (Arai et al., 2007; Tooley et al., 2009). It is suggested that syntactic structure information is very closely tied to individual lexical items (Vosse & Kempen, 2000). However, priming studies in other on-line comprehension studies (Thothathiri & Snedeker, 2008; Traxler, 2008) and production studies (Pickering & Ferreira, 2008) have

shown that priming can be reliably observed when the content words of the prime and target sentences do not overlap. In addition, it is important to note that lexical repetition is not the same as priming. Therefore, although lexical repetition is not essential for priming to occur, repetition tends to have a greater effect. Thus, priming in comprehension indicates lexical strengthening, and further research is needed to determine whether and when priming in comprehension occurs in the absence of lexical redundancy.

The present experiment was conducted without obtaining a third-party evaluation of the stimulus sentences. Therefore, although it is investigating familiarity, it is not formally measuring the validity of the stimulus sentences. In the experiment of McElree et al. (2001), a norming task was conducted before the experiment. They had native English speakers evaluate the validity of the task and adjust the number of words and letters. As for the purpose of their experiment, it was to provide on-line evidence of a kind of enriched lexical processing, based on lexical semantic research. Although the purpose was different from the present experiment, the experimental method was self-paced reading as in the present experiment, which should be a point of reference and could lead to more convincing results.

For comprehension priming, two prominent results that need to be explained are the lag priming effect and the lexical boost effect (Arai et al., 2007). The mere presence of priming across intervening material suggests that some form of implicit learning is taking place during on-line sentence interpretation (Chang, et al., 2000; Chang, et al., 2006; Luka & Barsalou, 2005). In other words, the hypothesis that exposure with the reduced relative clause sentence enhances the structure-building process of its syntactic structure predicts faster processing of subsequent sentences of the same form, whether the target sentence appears immediately or later. This can be hypothesized to be a relatively persistent priming effect. The lag effect may simply reflect a slow decay of activation within the combinatorial node associated with the lemma representation (Pickering et al., 2002).

With regard to the method of conducting the experiments, the self-paced reading task, which has been the mainstream in sentence comprehension experiments in the past, was used in the two experiments. The reason for this is that the participants can read the sentences according to their own comprehension speed, and the processing cost of each word can be quantified by using the reaction time in each region as an index. And since it is widely used as an effective method for looking at the real-time information processing process in sentence comprehension (Arai, 2016), it was planned to conduct this study. However, in another study (Arai, et al., 2015), reading time with ambiguous verbs was not considered to reflect the process at the verb, and thus, even if the

experience with the prime sentence affected the subsequent process of estimating the probability of structural options when the same verb is encountered, reading time measurement may not be sensitive to this effect, the experiment was conducted using the visual world paradigm because it was determined that reading time was not an appropriate measure to examine verb processing. It would be possible to replace the experimental method conducted in this study with this paradigm in order to examine the transition of experience in the experimental sentences in more detail.

If participants immediately reinforced representations of reduced relative clause sentence syntactic structures via expose and implicit learning, it would have expected them to process reduced relative clause sentence syntactic structures faster during experiments with increased exposure. The analysis did not detect a significant reduction in the overall processing time of reduced relative clause sentences during the experiment, so this prediction was not supported.

5.2 Pedagogical Implications

The results of this study suggest that foreign language learners' syntactic processing ability improves with repeated exposure. Therefore, clarification of the syntactic description of reduced relative sentences is necessary. Repeated exposure to reduced relative sentences, as in the present study, can develop the ability to process reduced relative sentences. In addition, each proficiency level requires a different approach, and further improvement of syntactic processing ability can be expected by changing the amount of exposure and modifying or adding tasks.

It is possible that the syntactic processing mechanism was forcibly activated by the content comprehension questions and that they gradually adapted to it. In addition, since the content comprehension questions were changed from a yes-or-no question format in English to a multiple-choice question format in Japanese, the level of comprehension could be accurately measured. Therefore, in actual educational settings, it would be possible to more accurately measure participants' level of comprehension by increasing the number of choices and using interactive or image-explanation tasks.

6. CONCLUDING REMARKS AND FURTHER RESEARCH

Based on the results obtained in this experiment, it is considered necessary of considering the influence of the content comprehension questions. Since the online comprehension process may have broken down and the students may have been trying to understand the sentences in a way different from the normal language comprehension process, it is necessary to examine the results in an offline experiment (data from the results of the process). In the next experiment, it will be designed and validated an experiment to measure the comprehension of the sentences step by step, not the reading time. As for the purpose of the experiment, it will first examine whether the percentage of correct answers to the content comprehension questions can suggest implicit learning based on prediction errors. Previous studies have shown that implicit learning based on prediction errors can only be observed in the gradual speed of reading time, and in the current experiment, reading time was longer even for native English speakers, suggesting that reading time may be affected by content comprehension questions. Therefore, this study will be focused only on the content comprehension question and analyze it. It will also examine whether the degree of learning differs depending on the level of proficiency, whether the weighting of syntactic knowledge changes, and whether it changes even for participants with low proficiency. The current hypothesis is that if the percentage of correct answers increases within a session or from the first session to the second session, the content comprehension questions can suggest implicit learning based on prediction errors. If the percentage of correct responses were high in the first session, it would like to examine the effects of the method of stimulus presentation, the difference in language comprehension processing (online/offline), and the difference between the first and second sessions.

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APPENDICIES

APPENDIX A: Experiment 1 Sentences in the first session

- 1 The professor / assisted / in the difficult experiment / enjoyed / the task / recently.
The professor / who was / assisted / in the difficult experiment / enjoyed / the task / recently.
Q. Did the professor assist somebody in the difficult experiment?
- 2 The man / questioned / with a difficult problem / confused / the issue / at the meeting.
The man / who was / questioned / with a difficult problem / confused / the issue / at the meeting.
Q. Did the man question somebody with a difficult problem?
- 3 The mouse / caught / under the table / ate / some cheese / last night.
The mouse / that was / caught / under the table / ate / some cheese / last night.
Q. Did somebody catch the mouse under the table?
- 4 The boy / seated / on the chair / loved / ice cream / at the department store.
The boy / who was / seated / on the chair / loved / ice cream / at the department store.
Q. Did somebody seat the boy on the chair?
- 5 The man / found / in the valley / carried / his bag / yesterday morning.
The man / who was / found / in the valley / carried / his bag / yesterday morning.
Q. Did the man find somebody in the valley?
- 6 The students / explained / at the city library / read / some books / last summer.
The students / who were / explained / at the city library / read / some books / last summer.
Q. Did somebody explain the students at the city library?
- 7 The girl / raised / in the countryside / realized / her dream / at that time.
The girl / who was / raised / in the countryside / realized / her dream / at that time.
Q. Did somebody raise the girl in the countryside?
- 8 The staff / helped / with the work / appreciated / his colleagues / at the office.
The staff / who was / helped / with the work / appreciated / his colleagues / at the office.
Q. Did somebody helped the staff with the work?

- 9 The man / judged / at the court / lost / his life / a few days later.
The man / who was / judged / at the court / lost / his life / a few days later.
Q. Did somebody judge the man at the court?
- 10 The young man / promised / in the company / prepared / his presentation / yesterday.
The young man / who was / promised / in the company / prepared / his presentation / yesterday.
Q. Did somebody promise the young man in the company?
- 11 The girl / remembered / during an interview / experienced / horse riding / during summer vacation.
The girl / who was / remembered / during an interview / experienced / horse riding / during summer vacation.
Q. Did the girl remember somebody during an interview?
- 12 The students / guided / in their studies / received / the comments / by email.
The students / who were / guided / in their studies / received / the comments / by email.
Q. Did the students guide somebody in their studies?
- 13 The doctor / respected / for his bravery / agreed / to his new contract / last weekend.
The doctor / who was / respected / for his bravery / agreed / to his new contract / last weekend.
Q. Did somebody respect the doctor for his bravery?
- 14 Her son / attacked / at the park / hugged / his mother / immediately.
Her son / who was / attacked / at the park / hugged / his mother / immediately.
Q. Did her son attack somebody at the park?
- 15 The players / surprised / at the number of people / included / one of my classmates / yesterday evening.
The players / who were / surprised / at the number of people / included / one of my classmates / yesterday evening.
Q. Did somebody surprise at the number of people?
- 16 My aunt / welcomed / with open arms / cooked / some sausages / last year.
My aunt / who was / welcomed / with open arms / cooked / some sausages / last year.
Q. Did my aunt welcome somebody with open arms?
-

APPENDIX B: Experiment 1 Sentences in the second session

-
- 1 The young men / arrested / on the spot / included / one of my brothers / last year.
The young men / who were / arrested / on the spot / included / one of my brothers / last year.
Q. Did somebody arrest the young men on the spot?
- 2 The cat / chased / by the dog / climbed / the tree / in my garden.
The cat / that was / chased / by the dog / climbed / the tree / in my garden.
Q. Did the dog chase the cat in my garden?
- 3 The staff / checked / with his schedule / made / a plan / yesterday.
The staff / who was / checked / with his schedule / made / a plan / yesterday.
Q. Did somebody check the staff with his schedule?
- 4 My brother / named / on his uncle's birthday / played / baseball / from now on.
My brother / who was / named / on his uncle's birthday / played / baseball / from now on.
Q. Did my brother name somebody at his house?
- 5 The young boy / imagined / with his red hair / prepared / the table / in his house.
The young boy / who was / imagined / with his red hair / prepared / the table / in his house.
Q. Did the young boy imagine somebody with his red hair?
- 6 His son / taught / in middle school / read / a textbook / yesterday afternoon.
His son / who was / taught / in middle school / read / a textbook / yesterday afternoon.
Q. Did somebody teach his son in middle school?
- 7 The manager / understood / in this situation / solved / the problem / at that time.
The manager / who was / understood / in this situation / solved / the problem / at that time.
Q. Did the manager understand somebody in this situation?
- 8 The man / corrected / in his writing / became / a famous writer / last year.
The man / who was / corrected / in his writing / became / a famous writer / last year.
Q. Did the man correct somebody in his writing?
-

APPENDIX C: Experiment 1 Filler Sentences

- 1 The money / taken / by the students / would be used / in the event of emergency.
Q. Did the students use the money in the event?
- 2 The boat / floating / on the lake / finally / sank.
Q. Did the boat float on the lake?
- 3 Naomi / asked / the man / she was arguing with / to give examples.
Q. Did Naomi give examples?
- 4 The boy / knew / the answer / was wrong / in the classroom.
Q. Did the boy miss the answer?
- 5 The students / repeated / the teacher / was unfair / to the girls.
Q. Did the teacher repeat the students?
- 6 The man / drove / through the gate / to the front door / in the park.
Q. Did the man drive through the gate to the front door?
- 7 Her mother / gave / money /to her daughter / at the party.
Q. Did her mother give money to her daughter?
- 8 The manager / supplied / the wrong information / to the customer / on the phone.
Q. Did the customer supply the wrong information? No.
- 9 The boy / showed / the dance / for the spring performance/ on the stage.
Q. Did the boy show the dance for the spring performance?
- 10 The man / wrote / a birthday card / to the woman / at his house.
Q. Did the woman write a birthday card?
- 11 His mother / cooked / some food / for the party / on weekends.
Q. Did his mother cook dinner for the party?
- 12 The man / advanced / to propose / becoming / the chairman.
Q. Did the chairman advance to propose?
- 13 The woman / apologized / about her mistake / to him / at the meeting.
Q. Did the woman apologize about him?

- 14 Jane / bought / a dog / with long hair / at the pet shop.
Q. Did Jane buy a dog with long hair at the pet shop?
- 15 The girl / caught / my hand / at the park / yesterday.
Q. Did the girl catch my hand yesterday?
- 16 The teacher / felt / the power / of the students / in the classroom.
Q. Did the students feel the power of the teacher?
- 17 Her father / heard / the news / for the first time / on TV.
Q. Did her father hear the news on TV?
- 18 The author / kept / writing / until shortly / before his death.
Q. Did the author keep writing before his death?
- 19 Keiko / told / the man / she was uncomfortable / with going home with him.
Q. Did Keiko tell the man to go home?
- 20 The woman / enjoyed / listening to music / at the concert hall / last night.
Q. Did the woman listen to music at the concert hall?
- 21 Before the mother / ate / the candies / had disappeared / at the store.
Q. Did the mother eat candies?
- 22 The businessman / worked / at the bank / under her / for 20 years.
Q. Did the businessman work at the bank for 20 years?
- 23 There is a degree of difficulty / experienced / in walking / on a road / in this area.
Q. Is there a degree of difficulty experienced on a road?
- 24 My son / understood / a difficult word / clearly / in the textbook.
Q. Did my son understand the textbook?
- 25 Little Red Riding Hood / left / her lodge / to go / to Little Rock.
Q. Did Little Red Riding Hood leave Little Rock? No.
- 26 The man / lent / his support / to the project / at his office.
Q. Did the man lend his support to the project? Yes.
- 27 The woman / lost / four kilograms / in two months / at the gym.
Q. Did the woman lose four kilograms in three months? No.
- 28 After the teacher / scolded / the kids / in class / they became quiet.
Q. Did the teacher become quiet? No.

29 The girl / thought / of her boyfriend / in her room / last night.

Q. Did her boyfriend think of the girl last night? No.

30 The old man / met / his wife / for the first time / 28 years ago.

Q. Did the old man meet his wife 28 years ago? Yes.

31 Their mother / said / many things / with a smile / on her face.

Q. Did their mother say many things? Yes.

32 The bentos / sold / at train stations / are called / ekiben.

Q. Are bentos sold at train stations? Yes.

APPENDIX D: Experiment 2 Sentences in the first session

Stimulus	Content Comprehension Questions (Japanese)
The students \ accepted \ to the University \ understood \ their situation \ at that time. The students \ who were accepted \ to the University \ understood \ their situation \ at that time.	Q. 学生は何をしていましたか？ 大学に行った 大学を受け入れた 状況を受け入れた 状況を理解した
The artist \ acknowledged \ in his play style \ remembered \ memories of childhood. The artist \ who was acknowledged \ in his play style \ remembered \ memories of childhood.	Q. 芸術家は何をしていましたか？ プレイスタイルを思い出した プレイスタイルを認めた 幼少期の思い出を思い出した 幼少期の思い出を認めた
My daughter \ adapted \ to the new school \ made \ friends with anyone. My daughter \ who was adapted \ to the new school \ made \ friends with anyone.	Q. 娘は何をしていましたか？ 友達に会った 誰とでも友達になった 新しい学校に行った 新しい学校を作った
My mother \ added \ to my worries \ forgot \ to answer the letters \ for a long time. My mother \ who was added \ to my worries \ forgot \ to answer the letters \ for a long time.	Q. 私の母は何をしていましたか？ 悩んでいた 心配していた 忘れていた 返事をした

The ambassadors\addressed\as ‘Your Excellency’ \ left \Japan \last night.
The ambassadors\who were addressed\as ‘Your Excellency’ \ left \Japan \last night.

Q. 大使たちは昨夜何をしていましたか？

日本を発った

日本に来た

住所を書いた

会議を行った

The man \affected \in the eyes\ reserved
\admission \into the hospital.
The man \who was affected \in the eyes
\reserved\ admission \into the hospital.

Q. 男性は何をしていましたか？

眼科を予約した

入院を予約した

傷を負った

傷を治した

The student \agreed \on other’s opinion
\found \new information \at that time.
The student \who was agreed \on other’s
opinion \found \new information \at that
time.

Q. 学生はその時何をしていましたか？

他者の意見を聞いた

他者の意見を否定した

新しい情報に同意した

新しい情報を発見した

My son \allowed \on time deposits
\continued\ saving money\ constantly.
My son \who was allowed \on
time deposits\ continued \saving money
\constantly.

Q. 私の息子は何をしていましたか？

時間を節約した

時間を無駄にした

お金を貯め続けた

お金を浪費し続けた

The woman \answered \with a smile
\accepted \his proposal \yesterday.
The woman \who was answered \with a
smile\ accepted \his proposal \yesterday.

Q. 女性は昨日何をしていましたか？

彼のプロポーズを受け入れた

彼にプロポーズした

彼と笑っていた

彼と受け入れた

The player \approached \by a few teams
\played \an active role \in Tokyo Olympics.
The player\ who was approached \by a few
teams \played \an active role\ in Tokyo
Olympics.

Q. 選手は東京オリンピックで何をしていたか？

チームに所属した

活躍した

他の選手に近づいた

意気投合した

The young men \ arrested \ on the spot
\ included \ one of my brothers \ last year.
The young men \ who were \ arrested \ on
the spot \ included \ one of my brothers
\ last year.

Q. 若い男性たちは私の兄弟と昨年何をして
いましたか？

遊んでいた

逮捕した

仲間になった

逮捕された

The businessman \ asked \ for his signature
\ completed \ the task \ every time.
The businessman \ who was asked \ for his
signature \ completed \ the task \ every time.

Q. ビジネスマンは毎回何をしていました
か？

会社に訪れた

仕事を終わらせた

サインした

人に尋ねていた

The professor \ assisted \ in the difficult
experiment \ enjoyed \ the task \ recently.
The professor \ who was \ assisted \ in the
difficult experiment \ enjoyed \ the task
\ recently.

Q. 教授は何をしていましたか？

難しい実験を手伝った

難しい実験を楽しんだ

課題を手伝った

課題を楽しんだ

Her son \ attacked \ at the park \ injured \ a
shoulder \ immediately.
Her son \ who was \ attacked \ at the park
\ injured \ a shoulder \ immediately.

Q. 彼女の息子は公園で何をしていました
か？

肩を負傷した

肩を負傷させた

友人と遊んでいた

友人を攻撃した

A cabin crew \ attended \ to passengers'
needs \ moved \ their bags \ aside.
A cabin crew \ who was attended \ to
passengers' needs \ moved \ their bags
\ aside.

Q. 客室乗務員は何をしていましたか？

飛行機を降りた

飛行機に乗った

荷物を破損した

荷物をどけた

My father \ based \ at the head office
\ worked \ as a director of bank \ this year.
My father \ who was based \ at the head
office \ worked \ as a director of bank \ this
year.

Q. 私の父は今年何をしていましたか？

銀行のベースを作った

銀行の取締役として働いていた

銀行の取締役を任命した

銀行で働くのを辞めた

The journalist \believed \in the theory
\reported\ a speech\ for a newspaper.
The journalist \who was believed \in the
theory \reported \a speech \for a newspaper.

Q. ジャーナリストは何をしていましたか？

新聞のスピーチを報告した

新聞のスピーチを信じた

理論を提唱した

理論を作った

The deer \begun \to appear in the mountain
\ate \many trees\ recently.
The deer\ that were begun \to appear in the
mountain \ate \many trees \recently.

Q. 鹿たちは最近何をしていましたか？

山にたくさん入っていった山にたくさん出
現した

木をたくさん食べていた

木にたくさん群がった

My parents\ broken \into the shop
\contacted\ a police station \last night.
My parents\ who were broken \into the
shop\ contacted \a police station \last night.

Q. 私の両親は何をしていましたか？

お店に押し入った

お店に連絡した

警察署に押し入った

警察署に連絡した

The suspect \brought \before the judge
\killed \some people \in the city.
The suspect \who was brought \before the
judge \killed\ some people \in the city.

Q. 容疑者は何をしていましたか？

人々に容疑をかけられた

人々を殺害した

街から逃げて行った

街を支配した

The girl \brushed \aside her reservations
\took\ a party \tonight.
The girl \who was brushed \aside her
reservations\ took \a party \tonight.

Q. 少女は今夜何をしていましたか？

パーティに参加した

パーティを予約した

パーティをキャンセルした

パーティを主催した

The mouse \caught \under the table \ate
\ some cheese \ last night.
The mouse \ that was \ caught \ under the
table \ ate \some cheese \ last night.

Q. ネズミは昨夜何をしていましたか？

何かを捕まえていた

チーズを食べていた

仲間を連れてきた

机の上にいた

The cat \ chased \ by the dog \ climbed \ the
tree \ in my garden.
The cat \ that was \ chased \ by the dog
\ climbed \ the tree \ in my garden.

Q. 猫は何をしていましたか？

犬と戯れていた

犬を追っていた

木を削っていた

木に登っていた

The staff \ checked \ with his schedule
\ made \ a plan \ yesterday.
The staff \ who was \ checked \ with his
schedule \ made \ a plan \ yesterday.

Q. スタッフは昨日何をしていましたか？

スケジュールを管理した

スケジュールを確認した

計画を立てた

計画に失敗した

The man \ corrected \ in his writing
\ became \ a famous writer \ last year.
The man \ who was \ corrected \ in his
writing \ became \ a famous writer \ last
year.

Q. 男性は昨年何をしていましたか？

小説家を雇った

小説を書いた

有名な作家に連絡した

有名な作家になっていた

The students \ explained \ at the city library
\ read \ some books \ last summer.
The students \ who were \ explained \ at the
city library \ read \ some books \ last
summer.

Q. 学生たちは昨年の夏何をしていましたか？

何冊かの本を読んだ

本の説明を受けた

市立図書館に行った

市立図書館で勉強した

The lady \ found \ in the valley \ carried
\ her bag \ yesterday morning.
The lady \ who was \ found \ in the valley
\ carried \ her bag \ yesterday morning.

Q. 女性は昨日の朝何をしていましたか？

谷に登った

谷に落ちた

カバンを持っていた

カバンを捨てた

The learners \ guided \ in their studies
\ received \ the comments \ by email.
The learners \ who were \ guided \ in their
studies \ received \ the comments \ by
email.

Q. 学習者たちは何をしていましたか？

メールでコメントを受け取った

メールでコメントを書いた

自分の学習を見直した

自分の学習方法を紹介した

The staff member \ helped \ with the work
\ appreciated \ his colleagues \ at the office.
The staff member \ who was \ helped \ with
the work \ appreciated \ his colleagues \ at
the office.

The young boy \ imagined \ with his red
hair \ prepared \ the table \ in his house.
The young boy \ who was \ imagined \ with
his red hair \ prepared \ the table \ in his
house.

The man \ judged \ at the court \ lost \ his
life \ a few days later.
The man \ who was \ judged \ at the court
\ lost \ his life \ a few days later.

My brother \ named \ on his uncle's
birthday \ played \ baseball \ from now on.
My brother \ who was \ named \ on his
uncle's birthday \ played \ baseball \ from
now on.

Q. スタッフは何をしていましたか？

仕事に感謝した

仕事を頑張った

会社の同僚といた

会社の同僚に感謝した

Q. 少年は家で何をしていましたか？

食事の準備をしていた

食事をイメージしていた

髪を赤に染めた

髪を赤に染める準備をした

Q. 男性は数日後何をしていましたか？

裁かれた

裁いた

命を落とした

命を救った

Q. 私の兄（弟）は何をしていましたか？

誕生日を祝った

野球をした

ゲームをした

命名した

APPENDIX E: Experiment 2 Sentences in the second session

Stimulus	Content Comprehension Questions (Japanese)
The boy \pleased \by his grades \went \out with his friends\ to celebrate.	Q. 青年は友人と何をしていましたか？ 成績をつけた 謝った 遊んだ 出掛けた
The young man \ promised \ in the company \ prepared \ his presentation \ yesterday.	Q. 若い男性は昨日何をしていましたか？ 会社に行く約束をした 会社に行く準備をした プレゼンテーションの発表を行った プレゼンテーションの準備をした
The man \ questioned \ with a difficult problem \ confused \ the issue \ at the meeting.	Q. 男性は会議で何をしていましたか？ 混乱させた 難題を提示した 問題に立ち向かった 問題解決をあきらめた
The girl \ raised \ in the countryside \ realized \ her dream \ at that time.	Q. 女の子は何をしていましたか？ 夢を見た 夢を追いかけた 夢を実現した 夢を決めた
Her daughter \ remembered \ during an interview \ experienced \ horse riding \ during summer vacation.	Q. 彼女の娘は夏休み中に何をしていましたか？ 乗馬体験をした 取材体験をした 馬を飼った 記憶がよみがえった

The doctor \ respected \ for his bravery
\ agreed \ to his new contract \ last
weekend.

Q. 医師は先週末何をしていましたか？

勇敢に立ち向かった

尊敬する人と仕事をした

新しい契約に合意した

新しい契約に納得いかなかった

The boy \ who was \ seated \ on the chair
\ loved \ ice cream \ at the department
store.

Q. 男の子は何をしていましたか？

アイスクリームを食べさせた

アイスクリームを買ってきた

椅子を壊した

椅子に座らされた

The coach \ who was smiled \ at the player
\ led \ a team \ to the championship.

Q. コーチは何をしていましたか？

チームを優勝に導いた

チームを笑顔にさせた

チームを作った

チームを作った

The players \ who were \ surprised \ at the
number of people \ included \ one of my
classmates \ yesterday evening.

Q. 選手たちは何をしていましたか？

クラスメートに驚かされた

クラスメートと遊んだ

人の多さに驚いた

人々とゲームをした

His son \ who was \ taught \ in middle
school \ read \ a textbook \ yesterday
afternoon.

Q. 彼の息子は昨日の午後何をしていましたか？

教科書を使って教えた

教科書を読んでいた

教科書をなくした

教科書を買った

The manager \ who was \ understood \ in
this situation \ solved \ the problem \ at
that time.

Q. マネージャーは何をしていた？

問題解決をした

問題を起こした

問題を理解した

問題を理解できなかった

My aunt \ who was \ welcomed \ with
open arms \ cooked \ some sausages \ last
year.

Q. 叔母は去年何をしました？

出迎えられた

帰って来た
ソーセージを振る舞われた
ソーセージを作った

APPENDIX F: Experiment 2 Filler Sentences

Her father \ heard \ the news \ for the first time \ on TV.

彼女の父は何をした？

① テレビで初めてニュースを聞いた ②初めてテレビを見た

③テレビでニュースを読んでいた ④新聞を読んでいた

The author \ kept \ writing \ until shortly \ before his death.

著者は何をした？

① 死ぬ準備をした ②死の直前まで執筆をつづけた

③死ぬ覚悟をしていた ④本を出版した

Keiko \ told \ the man \ she was uncomfortable \ with going home with him.

ケイコは男性に何を言った？

① 意見を言った ②家に帰るよう言った

③気が引けると言った ④仲良くしたいと言った

The woman \ enjoyed \ listening to music \ at the concert hall \ last night.

女性は昨晚何をした？

① 遊んでいた ② コンサートに行った

③音楽を聴いていた ④音楽を聴くことを楽しんだ

Before the mother \ ate \ the candies \ had disappeared \ at the store.

飴はどうなった？

① 店で消えた ②母親によって食べられた ③店に並んでいた ④売れた

The businessman \ worked \ at the bank \ under her \ for 20 years.

サラリーマンは何をした？

① 銀行を辞めた ②銀行に勤めていた ③彼女を解雇した ④散歩した

There is a degree of difficulty \ experienced \ in walking \ on a road \ in this area.

このエリアは何が困難？

① 道をふさぐこと ②経験すること ③道路を歩くこと ④工事すること

My son \ understood \ a difficult word \ clearly \ in the textbook.

私の息子は何をした？

① 難しい単語がわからなかった ②教科書無くした

③理解できなかった ④教科書の単語を理解した

Little Red Riding Hood \ left \ her lodge \ to go \ to Little Rock.

赤ずきんは何をした？

- ① リトルロックに行った ②下宿した
- ③オオカミに襲われた ④おばあさんと会った

The man \ lent \ his support \ to the project \ at his office.

男性は何をした？

- ① サポートしなかった ②力を貸した ③会社を辞めた ④本を貸した

The woman \ lost \ four kilograms \ in two months \ at the gym.

女性は何をした？

- ① 4キロ太った ②ジムを辞めた ③減量に成功した ④物を無くした

After the teacher \ scolded \ the kids \ in class \ they became quiet.

先生は何をした？

- ① 学校に行った ②学校を辞めた ③授業した ④叱った

The girl \ thought \ of her boyfriend \ in her room \ last night.

少女は何をした？

- ① 彼を思い浮かべた ②彼と別れた ③部屋に入った ④意見を言った

The old man \ met \ his wife \ for the first time \ 28 years ago.

老人は28年前何をした？

- ① 妻と別れた ②妻に会った ③家を買った ④亡くなった

Their mother \ said \ many things \ with a smile \ on her face.

彼らの母は何をした？

- ① たくさん考えた ②叱った ③笑顔でいろいろ話した ④意見を言った

Bill \ had been \ at an interview \ with an actress \ for ten minutes.

ビルは何をした？

- ① 帰った ②10分休憩した
- ③インタビューを受けた ④インタビューをした

Jim \ ran \ across the street \ to play with friends.

ジムは何をした？

- ① 通りの向こう側へ走っていった ②友人と遊んだ
- ③友人と走った ④家に帰った

The construction project \ on the mall \ was about to begin.

プロジェクトはどうなった？

- ① 中止になった ②始まろうとしていた ③計画された ④終了した

A young woman \ was found \ shot dead \ in the park.

若い女性は何をした？

- ① 目撃した ② 逃げた ③ 射殺された ④ 射殺した

John \ advised \ the doctor \ to take a vacation.

ジョンは何をした？

- ① 休んだ ② 医者に休むよう言われた
③ 医者にアドバイスをされた ④ 医者に休暇を勧めた

Paul and Mary \ are planning \ their wedding ceremony.

ポールとメアリーは何をした？

- ① 結婚式を計画した ② 結婚式を中止した
③ 結婚式に出席した ④ 結婚式を欠席した

The novelist \ was invited \ to give a lecture.

小説家は何をした？

- ① 講演を中止した ② 講演に招かれた ③ 招待した ④ 帰宅した

Mr. Smith \ wanted \ to remodel \ his living room.

スミスさんは何をした？

- ① リフォームを中止した ② リビングに入った
③ リフォームを希望した ④ リビングを壊した

Mary \ cooked \ Thanksgiving dinner \ at her house.

メアリーは何をした？

- ① 夕食を食べた ② 感謝祭を行わなかった
③ 家に帰った ④ 感謝祭の夕食を作った

The students \ were studying \ for a major social studies test.

学生は何をした？

- ① 勉強をしていた ② テストを受けた
③ 社会科を選択した ④ 学校に行った

Jill \ went \ to visit \ her mother \ in the hospital.

ジルは何をした？

- ① 母と帰った ② 母の見舞いに行った
③ 入院した ④ 退院した

The army \ was being defeated \ by the enemy.

軍はどうだった？

- ① 勝利した ② 攻撃した ③ 負けていた ④ 帰還した

David \ was looking \ for a traveler's handbook.

デイビッドは何をした？

- ① 旅行者と会った ② 旅行を計画した

③ハンドブックを作った ④ハンドブックを探していた

Susan \ sat in the library \ thinking about \ the examination.

スーザンは何をした？

① 試験について考えていた ②試験を受けていた

③図書館を後にした ④勉強をしていた

Peter \ enjoyed \ going for a walk \ in the morning.

ピーターは何をした？

① 朝起きた ②散歩を楽しんだ ③散歩を辞めた ④遊んでいた

Joanne \ was looking \ into the window \ of a jewelry store.

ジョアンは何をした？

① 宝石店に入った ②宝石店を出た

③宝石店の窓を覗いた ④宝石店の窓を壊した

Jack \ is a science teacher \ at a local high school.

ジャックは何をしている？

① 地元の高校に通っている ②地元の高校で勉強をしている

③教師を辞めようとしている ④理科の教師をしている

The money \ taken \ by the students \ would be used \ in the event of emergency.

学生たちはイベントで何をした？

①お金を使った ②踊った ③買い物をした ④危険を冒した

The boat \ floating \ on the lake \ finally \ sank.

湖の上で船はどうなった？

① ずっと浮かんでいた ②最終的に沈んでいった ③壊れた ④動いていた

Naomi \ asked \ the man \ she was arguing with \ to give examples.

ナオミは男性に(と)何をした？

① 喧嘩をした ②殺害した ③頼みごとをした ④別れた

The boy \ knew \ the answer \ was wrong \ in the classroom.

少年は何を考えていた？

① 答えが間違っていることを知っていた ②答えが正しいことを知っていた

③答えを考えていた ④答えを出すのを悩んでいた

The students \ repeated \ the teacher \ was unfair \ to the girls.

学生たちは何をした？

① 不公平なことをした ②女子生徒と口論になった

③先生と口論になった ④意見を繰り返した

The man \ drove \ through the gate \ to the front door \ in the park.

男性は公園で何をした？

- ① 遊んでいた ② 運転していた ③ ゲートを壊した ④ トイレに行った

Her mother \ gave \ money \ to her daughter \ at the party.

彼女の母は何をした？

- ① パーティに出席した ② パーティを欠席した
③ 娘にお金を渡した ④ 娘を生んだ

The manager \ supplied \ the wrong information \ to the customer \ on the phone.

マネージャーは何をした？

- ① 誤った情報を伝えた ② 正しい情報を伝えた
③ 接客をした ④ 電話を切った

The boy \ showed \ the dance \ for the spring performance \ on the stage.

少年は何をした？

- ① 舞台を見た ② ダンスを見た ③ 講演をした ④ ダンスを披露した

The man \ wrote \ a birthday card \ to the woman \ at his house.

男性は何をした？

- ① 家に帰った ② バースデーカードを書いた
③ バースデーカードを捨てた ④ 家を買った

His mother \ cooked \ some food \ for the party \ on weekends.

彼の母は何をした？

- ① 料理をした ② パーティに出席した
③ パーティを欠席した ④ 食事をした

The man \ advanced \ to propose \ becoming \ the chairman.

男性は何をした？

- ① アドバイスをした ② クレームを言った
③ 前進した ④ プロポーズした

The woman \ apologized \ about her mistake \ to him \ at the meeting.

女性は何をした？

- ① 意見を言った ② ミーティングに出席した ③ 告白した ④ 謝罪した

Jane \ bought \ a dog \ with long hair \ at the pet shop.

ジェーンは何をした？

- ① 犬を買った ② 犬の髪を切った
③ ペットショップに勤務した ④ ペットショップに侵入した

The girl \ caught \ my hand \ at the park \ yesterday.

少女は何をした？

① 手を切った ②手を掴んだ ③捕まえられた ④盗んだ

The teacher \ felt \ the power \ of the students \ in the classroom.

教師は何をした？

① 生徒を叱った ②生徒となじんだ ③生徒のパワーを感じ取った ④教室に入った

The rock concert \ was held \ in an outdoor stadium.

The man \ dragged \ the chair \ over to the girl.

Susan \ was rushing \ because she was running late \ for a party.

Andy \ loved to travel, \ but he was terrified \ of flying.

The fans \ at the rock concert \ were going wild.

Mary \ apologized \ for being late \ and began to explain.

Jane and Tom \ were looking \ for a wedding ring.

The bentos \ sold \ at train stations \ are called \ ekiben.

The traffic jam \ annoyed him \ on his way \ to the office.

Tom \ bought \ the computer \ the day before yesterday.

Richard \ had always wanted \ to be a public accountant.

Mary \ apologized \ for being late \ and began to explain.

The landlady \ collected the rent \ on the first day \ of every month.

The birthday party \ for Jill \ was just getting underway.

The parents \ watched \ all the children \ having a good time.

The movie \ was being filmed \ on location in Siberia.

It was hard \ for him \ to believe \ that it was Monday.

Most people \ in Europe \ speak more than one language.

Jenny \ looked up \ from her computer \ with a smile.

Mark's health problems \ created \ a big challenge \ for the company.

Many presidents \ would prefer \ to keep \ their personal problems private.

Miki \ made her \ a cup of coffee \ and handed her \ the morning newspaper.

The dealer \ took out a small calculator \ from his jacket pocket.

We \ sat back and enjoyed \ a magnificent wine \ and smoked cigars

He \ sat on the sofa \ and read \ a morning newspaper.

The secretary \ picked up \ the phone \ and pushed a button.

There were \ a few men \ hanging around the entrance \ of the school.

The judge \ had spent hours \ buried in law books \ looking for an answer.

He \ was planning a holiday \ in France with his brother.

He \ regretted \ not being a member \ of the gym.

The boy \ kicked the classmate \ and stayed away \ from school.

The murderer \ killed a wealthy man \ living alone.