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PDF issue: 2024-12-20

Japanese EFL learners' meaning-syntax mapping mechanism for English sentence comprehension: Evidence from Psycholinguistic Investigation

Hirano, Ayako

(Degree)
博士（学術）

(Date of Degree)
2018-03-25

(Date of Publication)
2020-03-25

(Resource Type)
doctoral thesis

(Report Number)
甲第7237号

(URL)
https://hdl.handle.net/20.500.14094/D1007237

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博士論文

Japanese EFL learners' meaning-syntax mapping mechanism for English sentence comprehension: Evidence from Psycholinguistic Investigation

（日本人英語学習者の英文理解における意味と統語とのマッピング処理
―心理言語学実験による検討―）

平成 29 年 12 月 28 日

神戸大学大学院国際文化学研究科
グローバル文化専攻　外国語教育システム論コース
学籍番号：136c301c　　氏名：平野　亜也子/HIRANO Ayako

Contents

Figures and Tables v

Acknowledgement vi

1. Introduction 1

1.1 Background 1

1.2 Purposes of the Dissertation 3

1.3 Organization of the Dissertation 3

2. Literature Review 5

2.1 Models of Spoken Language Use 5

2.1.1 Speech Comprehension 6

2.2 Relationship between Listening and Reading Comprehension 7

2.3 Relative Clause Processing 7

2.4 Effects of Animacy Information on Sentence Comprehension 9

2.4.1 Animacy Information and L2 Relative Clause Comprehension 9

2.4.2 Animacy Information and L2 Passive Voice Comprehension 10

2.5 Effects of Context and Topicality on Relative Clause Processing 11

2.6 Effects of Experience on Relative Clause Processing 13

2.7 Priming Effects on Sentence Comprehension 15

2.8 Repeated Exposure on Subject/Object Relative Clauses and Inverse Frequency Effects .. 18

2.9 Research Questions 20

2.9.1 Research Questions for the Effects of Modality and Proficiency on Syntax-Meaning Mapping in L2 Online Sentence Comprehension 20

2.9.2 Research Questions for the Effects of Experience-based Learning on L2 Relative Clause On-line Processing 21

3. Experiment 1 22

3.1 Purpose and Research Questions 22

3.2 Participants 22

3.2.1 Auditory Presentation 22
3.2.2 Visual Presentation 22
3.3 Materials 23
3.3.1 Auditory Stimuli 24
3.3.2 Visual Stimuli 24
3.4 Procedures 24
3.4.1 Auditory Presentation 24
3.4.2 Visual Presentation 25
3.5 Results and Discussion 25
4. Experiment 2 27
4.1 Purpose and Research Questions 27
4.2 Participants 27
4.2.1 Auditory Presentation 27
4.2.2 Visual Presentation 27
4.3 Materials 27
4.4 Procedures 28
4.5 Results and Discussion 28
5. Experiment 3 30
5.1 Purpose and Research Questions 30
5.2 Participants 30
5.3 Materials 30
5.3.1 Task 30
5.3.2 Critical Pictures, Lists, and Critical Sentences 31
5.4 Procedures 32
5.5 Results and Discussion 34
5.5.1 Accuracy Rate 35
5.5.2 Response Latency 36
5.6 Discussion of Experiments 1, 2, and 3 38

6. Experiment 4 40
6.1 Purpose and Research Questions 40
6.2 Participants 41
6.3 Materials 42
6.3.1 Materials for Pre-test, Post-test and Delayed-post-test 42
6.3.2 Materials for Experience Session 44
6.4 Procedures 46
6.4.1 Schedule of Sessions 46
6.4.2 Pre-test 46
6.4.3 Experience Session 48
6.4.4 Post-test and Delayed-post-test Sessions 49
6.5 Results 49
6.5.1 Accuracy 49
6.5.2 Self-paced Reading Times 50
6.6 Discussion 54
6.6.1 Does Repeated Exposure Facilitate Relative Clause Processing Immediately After the Exposure? 55
6.6.2 Do the Repeated Exposure Effects on Relative Clause Processing Persist for One Day After the Exposure? 56
6.6.3 Do Immediate and Delayed Repeated Exposure Effects Distribute Equally Between Subject Relative and Object Relative Clauses? 57
7. General Discussion 59
7.1 Summary of the Study 59
7.2 Intermediate-level and Elementary-level JEFLLs' Sentence Processing 61
7.3 Pedagogical Implication 61
8. Conclusion and Further Research 63
References 64
Appendices 69
Appendix 1. Critical Sentences and Questions for Experiments 1 and 2 69

Appendix 2. Answer Sheet for Listening Experiments 1 and 2 : Original Version (Excerpt) ... 72
Appendix 3. Answer Sheet for Listening Experiments 1 and 2 : Translated Version in English (Excerpt) ... 73
Appendix 4. Answer Sheet for Experimenter-paced Reading Experiments 1 and 2 : Original Version (Excerpt) ... 74
Appendix 5. Answer Sheet for Experimenter-paced Reading Experiments 1 and 2 : Translated Version in English (Excerpt) ... 75
Appendix 6. Critical Sentences for Experiment 3 ... 76
Appendix 7. Word Lists Used in Experiment 3 : Original Version ... 80
Appendix 8. Word Lists Used in Experiment 3 : Translated Version in English ... 81
Appendix 9. Critical Sentences Used in Experiment 4 ... 82
Appendix 10. Critical Sentences Used for Relative Clause Sentence Experience Group in Experiment 4 ... 94
Appendix 11. Critical Sentences Used for Control Sentence Experience Group in Experiment 4 ... 102
Appendix 12. Word Lists Used in Experiment 4: Original Version ... 110
Appendix 13. Word Lists Used in Experiment 4: Translated Version in English ... 113

Figures and Tables

Figures

1. This figure shows the schematic representation of the processing components involved in spoken language use. 5
2. This figure indicates the schematic diagram of the set up for a trial used for experiments 1, 2, & 3 in Thothathiri and Snedeker 16
3. This figure compares the intermediate-level JEFLLs' mean scores between the auditory group and the visual group for animate ORCs and inanimate ORCs. 25
4. This figure compares the elementary-group JEFLLs' mean scores between the auditory group and the visual group for animate ORCs and inanimate ORCs. 28
5. This figure shows the flow of one auditory presentation trial on a PC screen. 33
6. This figure shows the flow of one visual presentation trial on a PC screen. 34
7. This figure shows the flow of one test session trail on a PC screen. 47
8. This figure shows the flow of one experience session trail on a PC screen. 48
9. This figure shows the Relative Clause group's mean reading times for SRC and ORC. 52
10. This figure shows the Control group's mean reading times for SRC and ORC. 52

Tables

1. Critical Sentence Types and Their Examples 31
2. Descriptive Statistics for the Mean Accuracy Rates for the Proficiency, Modality, and Sentence-Type Conditions 35
3. Descriptive Statistics for the Mean Response Latency for the Proficiency, Modality, and Sentence-Type Conditions 36
4. The Examples of Critical Sentences and Comprehension Sentences 43
5. Mean proportion of correct answers (standard deviations) on comprehension questions for SRC and ORC 50
6. Accuracy and Reading Time at Region 5 Between Tests 54
7. Accuracy and Reading Time at Region 5 Between Clause Types 54

Acknowledgement

In this acknowledgement, I would like to express my sincere gratitude to the people who have contributed to this dissertation in one way or another. First, my greatest gratitude goes to Professor Hirokazu Yokokawa, my supervisor I respect the most. I am deeply indebted for his professional comments, thoughtful feedback, and tremendous encouragement, which guided me to completion of this dissertation. Secondly, I am much indebted to Professor Masayuki Kato, who gave me valuable comments on my dissertation. I am also grateful to Professor Kenichi Hashimoto whose previous research motivated me to conduct this study, and he provided expert advice.

My special thanks also go to the students at Ritsumeikan University who participated in the experiments. Without their participation or cooperation, I could not finish the dissertation. I would also like to thank my colleagues and friends who always helped me intellectually and emotionally.

Last, but by no means least, I would like to express my thanks to my family, who have supported me mentally and emotionally throughout my graduate education.

1. Introduction

1.1 Background

Against the backdrop of rapid spread of globalization, communication is one of the most important skills to understand each other with many different cultural backgrounds. The definition of "communication" in Oxford Dictionary of English is "the imparting or exchanging of information by speaking, writing, or using some other medium" and "the successful conveying or sharing of ideas and feelings." For an effective communication, we need to understand written or spoken sentences accurately. In sentence comprehension, it is acknowledged that we construct structures unconsciously, and this processing is called "syntactic processing." When performing syntactic processing, we use several types of information, such as semantic information, syntactic information, and world knowledge. If the sentences are presented in our native language, we instantly understand them without any effort. This ability of performing a task without conscious effort is called automatic processing.

Unlike comprehending our own native language, when we try to comprehend L2 sentences, our attempts would sometimes result in failure. What hampers our correct understanding? What is the difference between L1 and L2 sentence comprehension? Clahsen and Felser (2006) claim that the syntactic representations L2 learners process during comprehension are shallower and less detailed than those of native speakers (Shallow Structure Hypothesis). Based on the hypothesis, automatization of L2 learners' syntactic processing seems to play a pivotal role in correct sentence comprehension. However, correct comprehension requires comprehenders to construct semantic and syntactic structures and meaning-syntax mapping. So far extensive effort has been dedicated to clarify L1 sentence processing mechanism, however, relatively little is known about the mechanism of Japanese English as Foreign Language Learners' (JEFLLs) sentence processing. Therefore, it is essential to pin down the underlying mechanism of their L2 sentence comprehension.

To reveal the mechanism of sentence comprehension, a psycholinguistic research method is one of the best ways. This is because the psycholinguistic method can detect on-line processing by monitoring comprehenders' behavior such as reading time or response latency. In this field, previous studies have commonly manipulated and controlled several information necessary to understand a sentence, such as semantic, syntactic, context information. There is consistent evidence that L1 and

L2 readers use semantic information, specifically animacy of nouns, to facilitate sentence comprehension (Ferreira & Clifton, 1986; Trueswell, Tanenhaus, & Garnsey, 1994). For example, Traxler, Morris and Seely (2002) examined relative clause sentence processing by manipulating semantic information of the noun phrases. They showed that native speakers of English use the animacy information, one of the semantic information, of a noun phrase when reading relative clauses. Hashimoto (2011, 2012) compared the results of his two experiments and reported that JEFLLs use the animacy information as well when reading relative clause sentences. Actually, comprehending relative clauses requires comprehenders to conduct several processing, such as gap-filling, θ-role assignments, meaning-syntax mapping. It also requires processing some information such as semantic, syntactic and context information. However, to the best of my knowledge, no research thus far has investigated which processing is difficult to conduct nor which information is difficult to process. Therefore, pinpointing the problems that JEFLLs have with their sentence comprehension must be addressed urgently.

Additionally, no study has examined the effects of different modalities, reading or listening, on JEFLLs' sentence comprehension. Regarding the difference between listening and reading comprehension, previous studies have shown that the comprehension processing routes between spoken and written languages share similarities (Bradley & Forster, 1987; Hirai, 1999; O'Malley & Chamot, 1990). In contrast, other studies have claimed that listeners utilize spoken-language-specific information, such as prosody (Snedeker & Trueswell, 2003; Speer, Kjigarrd, & Dobroth, 1996). In fact, little is known about interaction effects of different input modalities and proficiencies on L2 sentence comprehension. Therefore, it is the first step to examine whether different modalities and proficiencies differentiate JEFLLs' sentence processing.

The second step should be finding an effective learning method to deal with problems experienced by JEFLLs. Moreover, the learning method should ensure the long-lasting effectiveness. Previous studies have indicated that repeated exposure to certain constructions promotes on-line sentence processing. For example, Wells, Christiansen, Race, Acheson and MacDonald (2009) conducted a study aiming to examine the effects of repeated exposure on relative clause processing. They manipulated readers' experience with relative clause constructions in four sessions spaced over three to four weeks. The results, great effects on relative clause processing, support their account that experience-based learning facilitates sentence processing. More importantly, the study showed that

the experience-based learning effects persisted despite several days' interval between the last exposure to relative clauses and the post-test. They provided useful findings: however, the participants in their study were native speakers of English, not JEFLLs. Sakakibara and Yokokawa (2015) conducted a study for JEFLLs to examine the effects of experience-based learning on relative clause processing. They reported encouraging results that JEFLLs benefit from repeated exposure. However, they didn't confirm the persistence of the repeated exposure effects.

1.2 Purposes of the Dissertation

The current study aims to reveal the mechanisms of JEFLLs' English sentence comprehension, and find factors that hamper the correct understanding. Unlike L1 sentence processing, L2 sentence processing takes time and is not always easy. Therefore, investigating those factors with a psycholinguistic approach is pedagogically significant in finding a way to facilitate JEFLLs' automatization on L2 sentence comprehension.

The study also intends to examine the effects of experience-based learning on JEFLLs' L2 sentence comprehension and on-line processing. The comparison data consists of reading time and accuracy rates for comprehension questions on relative clause sentences because comprehenders' on-line processing can be monitored by analyzing those data. After confirming the effectiveness of experience-based learning, ultimately, I would like to suggest one reliable method for developing JEFLLs' sentence comprehension skill.

1.3 Organization of the Dissertation

Chapter 2 examines previous studies, regarding psycholinguistic model of spoken language use, and relationship between listening and reading comprehension. It refers to several information that affect sentence processing, especially animacy information. How the animacy information is utilized while readers process a sentence, such as relative clauses and passive voices, is explained. Following other information affecting sentence comprehension is mentioned, past studies on syntactic priming and repeated exposure to specific syntactic construction are displayed. Based on past studies and theoretical background, research questions in this study are then described.

Chapter 3 states details of Experiment 1 which investigates how much intermediate-level JEFLLs can comprehend visually and auditorily presented object relative clauses (ORCs). By

manipulating the animacy information of the noun phrase of the relative clause, Experiment 1 reveals to what extent Japanese readers and listeners can successfully conduct meaning-syntax mapping during ORC comprehension. The effects of different input modalities on their comprehension are also illustrated.

Chapter 4 presents details of Experiment 2 which examines whether elementary-level JEFLLs can comprehend visually and auditorily presented ORCs. Utilizing the same material as Experiment 1 enables Experiment 2 to reveal the effects of proficiency on JEFLLs' object relative clause comprehension. The effects of different input modalities on elementary-level JEFLLs' comprehension are also indicated. After discussing how the different English proficiency levels affect the use of animacy information on ORC sentence processing, the questions are indicated which aren't clarified in Experiments 1 and 2. Then, it explains why Experiment 3 is necessary.

Chapter 5 reports details of Experiment 3 which examines whether JEFLLs successfully construct semantic and syntactic structures, namely meaning-syntax mapping, when reading and listening to active/passive voices. After stating the effects of interaction, between the different proficiency levels and different input modalities, on meaning-syntax mapping, this chapter discusses the results gathered through Experiments 1, 2 and 3.

Chapter 6 explains Experiment 4 in detail which clarifies the effects of experience-based learning on JEFLLs sentence comprehension, involving subject relative and object relative clauses. It refers to how self-paced reading experiment and repeated experience session are conducted. The compared data were reading time and accuracy rates for comprehension questions between pre-, post- and delayed-post-tests. After indicating results, I will argue how JEFLLs can improve their on-line meaning-syntax mapping during sentence comprehension.

Chapter 7 states general discussion and conclusion of this dissertation and the direction of a further study is mentioned.

2. Literature Review

This chapter first illustrate a psycholinguistic model of spoken language use which depicts the connection between comprehension and production. After reviewing previous studies of sentence processing, especially sentence comprehension, studies on the effects of topicality and context on relative clause sentence processing are mentioned. After that, past studies on priming effects on sentence comprehension and experience-based learning are reported. Lastly, ten research questions of this study are indicated.

2.1 Models of Spoken Language Use

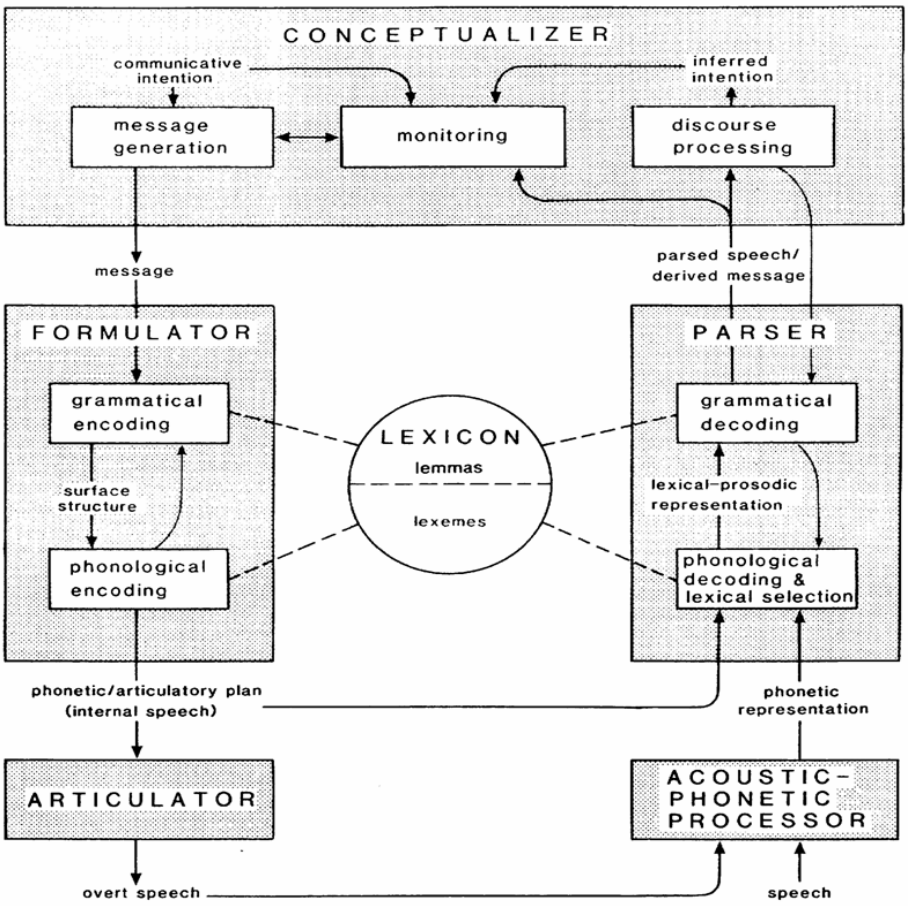

Figure 1. This figure shows the schematic representation of the processing components involved in spoken language use (Reprinted from Levelt, 1993, p. 2).

To date, a considerable number of language learning studies have drawn upon Levelt's (1993) model of speech production, that is, the schematic representation of the processing components in spoken language. Figure 1 illustrates the model, depicting the main processing components and their connections to spoken language use. According to this model, the comprehension process is shown on the right side of the figure, production on the left, and the circle in the center of the figure represents the mental lexicon, which is assumed to store lexical information, such as phonology, morphology, syntax, and semantics (Levelt, 1989).

2.1.1 Speech Comprehension

Within the Levelt's (1993) psycholinguistic model, Figure 1, several speech comprehension mechanisms exist. Under normal understanding, the first mechanism performs an acoustic-phonetic analysis of the speech signal, and then produces a phonetic representation of the signal. The signal is the code for accessing the mental lexicon and for deriving the metrical structure of the utterance. This process is performed at the Acoustic-phonetic processor stage. Next, the recognized words and the prosodic information are used to perform syntactic and semantic processing. This process is performed presumably at the Parser stage. Finally, the listener interprets this linguistic structure in terms of the ongoing discourse in order to derive the speaker's communicative intentions. The right side of Figure 1 illustrates these bottom-top processes.

Among the three parts, namely, the Acoustic-phonetic processor, the Parser, and the Conceptualizer, foreign language learners have the most difficulty with processing at the Parser stage because of the limited information in their lexicon, and some errors in the information may be represented. For example, listeners can retrieve the lexical information only if the lexical information is correctly registered. Furthermore, they need to process incoming information on-line as it is. If the retrieving process lags behind, listeners would encounter difficulty to comprehend the message.

Given the complications at the Parser and the Formulator, reducing processing load at these mechanisms can facilitate a smooth flow from listening to speaking. Furthermore, fine-tune adjustment of processing load can determine the fluency of the language user.

2.2 Relationship between Listening and Reading Comprehension

In order to understand spoken language, we need to process the incoming information on-line as it is. Oyama (2007, 2011) claimed that this process requires information serial processing skill. He concluded that the information serial processing skill highly correlates with listening skill. On the other hand, spoken sentences involve prosodic information that directly connects with the syntax. It is well known that listeners use the prosodic cue to solve syntactic ambiguity derived from a certain syntactic structure (Snedeker & Trueswell, 2003; Snedeker & Casserly, 2010; Speer, Kjelgaard, & Dobroth, 1996).

Even though there are unique characteristics of listening comprehension, there have been studies that claimed listening and reading comprehension are quite similar (O'Malley & Chamot, 1990). Bradley and Forster (1987) highlighted the similarities between reading and listening, in particular with respect to visual and auditory word recognition. Based on this claim of the similarities between reading and listening comprehension, Hirai (1999) conducted an experiment with JEFLLs to examine the relationship between the optimal listening rate and the optimal reading rate. She concluded that cognitive processes utilized in listening and reading comprehension, exclusively for intermediate JEFLLs, share the same route, at some point, or that the two processes are highly interactive with each other, or both.

In order to ascertain effective instructions for JEFLLs according to their proficiency levels and/or the different input modalities, the effects of the interactions of these factors must be explored. However, to date, the number of studies investigating the effects of interactions of proficiencies and the different modalities on JEFLLs' sentence comprehension is limited.

2.3 Relative Clause Processing

A number of reading studies have asserted that comprehension of complex syntactic sentences reduces the processing speed and accuracy in native speakers (Gibson, Desmet, Grodner, Watson, & Ko, 2005; King & Just, 1991). One of the complex structures includes relative clauses, and the processing load of object-relative clause is higher than that of subject-relative clause. This asymmetry has been attributed to several accounts such as limited working memory capacity (Gibson, 1998) and syntactic factors (Sheldon, 1974). The following sentence (1a) is a subject-relative clause (SRC), whereas (1b) is an object-relative clause (ORC).

(1) a. The boy who ____ helped the girl passed the test last week. (SRC)

b. The boy who the girl helped ____ passed the test last week. (ORC)

According to the explanation of the limited working memory capacity, the filler phrase, "the boy," must be carried unattached until the comprehender encounters the gap indicated by "___" in both (1a) and (1b). As for the distance between the filler phrase "the boy" and the gap position "___", ORC is longer than SRC. Therefore, the memory load required for ORC is heavier.

Another account, namely, syntactic factors, is claimed by Sheldon (1974) as a parallel function account. In the SRC sentence (1a), the sentential subject phrase "the boy" is also the syntactic subject phrase of the relative clause. On the other hand, in the ORC sentence (1b), the sentential subject phrase "the boy" is the direct-object phrase of the verb in the relative clause "helped." Thus, the comprehenders must simultaneously treat "the boy" as a syntactic subject phrase and a syntactic object phrase. As a result, such complexity in the processing of the structure accounts for the increased difficulty of ORCs.

From the standpoint of a θ-role assignment, also, the processing load for ORCs is heavier than that for SRCs. The θ-roles or thematic roles are conceptual notions and determined by an argument structure of a sentence. For example, the semantic content of the following sentence (2a) consists of a predicate "hit," an external argument "Mary," and an internal argument "Ken." Although different linguists use different terms for θ-roles, Agent, Patient and Theme are widely accepted. This study employs a simple definition of the terms, and defines "Agent" and "Theme" based on Aarts (1997) as follows: "Agent" as the "doer" or instigator of the action denoted by the predicate and "Theme" as the entity that is moved by the action or event denoted by the predicate. Therefore, in both (2a) and (2b), "Mary" is agent and "Ken" is theme. Similarly, in (2c) and (2d), "Mary" is agent and "the table" is theme.

(2) a. Mary hit Ken.

b. Ken was hit by Mary.

c. Mary pushed the table.

d. The table was pushed by Mary.

In the SRC sentence (1a), “the boy” is agent in both the main clause and the relative clause. On the other hand, in the ORC sentence (1b), “the boy” is not only agent in the main clause, but also theme in the relative clause, which means comprehenders must assign an agent role and a theme-role to “the boy.” Therefore, the processing load for ORCs is heavier than that of SRCs.

2.4 Effects of Animacy Information on Sentence Comprehension

2.4.1 Animacy Information and L2 Relative Clause Comprehension

Previous studies have shown a way to reduce the difficulty of ORC processing. Up to this point, manipulating semantic information for a noun phrase in a relative clause, specifically an animacy status, has enabled researchers to investigate the effects of semantic information on sentence processing. Traxler et al. (2002) revealed that L1 readers mitigate the difficulty of comprehending ORC by using animacy information. The following sentences (3a) and (3b) are both ORCs, and the difference is the animacy of the matrix noun phrase (NP1) and the relative clause subject noun phrase (NP2). In (3a), the NP1, “the scientist,” is animate, and the NP2, “the machine,” is inanimate. On the other hand, in (3b), the NP1, “the machine,” is inanimate, and the NP2, “the scientist,” is animate.

(3) a. The **scientist** who the machine aided solved the problems easily. (ORC)

b. The **machine** which the scientist arranged solved the problems easily. (ORC)

Generally, an animate noun is a good agent and frequently functions as a subject in the subject position. Conversely, an inanimate noun is a poor agent and is frequently assigned a theme role in the object position. Traxler et al. (2002) highlighted that readers prefer to treat a sentential subject as the subject of the relative clause. In (3a), because the NP1 “the scientist” is a good agent, readers can easily assign an agent role. However, “the scientist” is the direct object of the relative clause verb “aided.” Therefore, readers need to reanalyze the θ-role of the NP1 after encountering the relative clause verb. In contrast, in (3b), the NP1 “the machine,” is inanimate and a poor agent, which therefore reduces the processing difficulty.

Similarly, Mak, Vonk & Schriefers (2002) explored the effects of animacy on relative clause processing for native speakers of Dutch. Before performing two behavioral experiments, they conducted a corpus study and scrutinized German and Dutch newspaper texts. The corpus study

results, representing written production, showed animacy is an important determinant of the distribution of the SRCs and ORCs. Then, they conducted self-paced reading and eye-tracking experiments both of which illustrate reading comprehension. The results displayed that when the two noun phrases are animate, there were difference in processing difficulty between the SRCs and ORCs. However, when the object of the relative clause is an inanimate, the processing difference completely disappeared. Therefore, they concluded that semantic factor of animacy affects the relative clause processing for both production and comprehension.

Hashimoto (2011, 2012) conducted experiments with JEFLLs using a self-paced moving window paradigm. He compared the results obtained from his two experiments and showed that JEFLLs use animacy information when processing relative clause sentences. These studies mentioned above indicate that native speakers and foreign language learners use animacy information when reading relative clause sentences. To date, however, no study has examined whether JEFLLs construct both semantic and syntactic structure successfully, essential for correct comprehension. Moreover, even though the use of the animacy information has been identified in the reading studies, no study has examined whether JEFLLs use animacy information during listening comprehension.

2.4.2 Animacy Information and L2 Passive Voice Comprehension

Like relative clauses, active/passive voices are also useful structures to investigate the comprehenders' use of animacy information (Ferreira & Stacey, 2000; Ferreira, Baily, & Ferraro, 2002). Both structures require double θ-role assignments. For example, sentences (4a) and (4b) are actives, and the subject noun phrase (NP1) and the object noun phrase (NP2) are animate–animate for (4a), and animate–inanimate for (4b). In both (4a) and (4b), the NP1's θ-role is agent, and NP2's θ-role is theme, respectively. Because inanimate referents are likely to function as theme and animate referents as agent, (4b) can be easier to process than (4a).

(4) a. The boy was pushing the boy. [active–animate–animate]
b. The boy was pushing the table. [active–animate–inanimate]
c. The boy was pushed by the girl. [passive–animate–animate]
d. The table was pushed by the boy. [passive–inanimate–animate]

Similarly, sentences (4c) and (4d) are passives, and the NP1 and the prepositional noun phrase (NP2) are animate–animate for (4c), and inanimate–animate for (4d). In (4c) and (4d), the NP1's θ-role is theme, and NP2's role is Agent. When processing (4c), comprehenders are likely to assign an agent role to the NP1, "the boy" because of its animacy and its subject position, but when they encounter the verb, "was pushed," they need to reassign a theme role to the NP1 and then assign an agent role to the NP2, "the girl." On the other hand, in (4d), NP1, "the table" is a poor agent, so comprehenders can reduce the processing difficulty. As a result, (4d) is supposed to be easier to process than (4c).

The difference between relative clauses and passives is the complexity of their syntactic constructions. Relative clauses are complex but passives are simple sentences. In addition, relative clauses demand gap-filling, but passives don't. Passives need morphosyntactic processing, instead. Therefore, employing two syntactic forms allows to examine what processing is possible and what is not for JEFLLs in the process of meaning-syntax mapping. So far to my knowledge, however, there has been no research addressing these issues by employing the two structures together. In addition, no study has examined whether the interaction of proficiency and modality affects JEFLLs' sentence processing. Therefore, Experiments 1, 2 and 3 examine these issues by using two syntactic structures: relative clauses and passives.

2.5 Effects of Context and Topicality on Relative Clause Processing

In addition to animacy information that affects difficulty of processing relative clauses, Yang, Mo and Louwerse (2013) revealed that discourse information differentiates the level of processing difficulty. They designed an eye-tracking experiment and compared the processing differences between SRCs and ORCs when they were presented with a preceding context. For each clause type, they constructed two conditions, discourse context locally (within the sentence) and globally (extra-sententially).

For example, (5a) and (5b) have null discourse context condition and appear in isolation, without prior information being given. Next, (5c) and (5d) are examples of local discourse context, and the lexical information of the verb in the relative clause region, "look after," is biased towards only one of the two noun phrases, "the babysitter"; only the noun phrase in the (5d) ORC is plausible for the action described by the verb. The sentences in (5e) and (5f) are examples of subject-favored

discourse context, and preceding discourse information highlights the subject, “the child,” of the SRC. Last, (5g) and (5h) demonstrate object-favored discourse context, and preceding discourse material emphasizes the subject, “the babysitter,” of the ORC.

(5) a. The child that chased the babysitter squealed with delight at the game.

b. The child that the babysitter chased squealed with delight at the game.

c. The child that looked after the babysitter squealed with delight at the game.

d. The child that the babysitter looked after squealed with delight at the game.

e. The child with a pony tail was playing on the playground with the babysitter. She looked pretty good in the pink sweater, and her white sport shoes were very cute. When the child laughed, her voice sounded sweet. On this sunny spring day, the breeze gently blew her brown hair. The child was busy picking up wildflowers, chasing the birds, and playing a game of tag. The child that chased the babysitter squealed with delight at the game. Their laughter could be heard a few miles away.

f. The child with a pony tail was playing on the playground with the babysitter. She looked pretty good in the pink sweater, and her white sport shoes were very cute. When the child laughed, her voice sounded sweet. On this sunny spring day, the breeze gently blew her brown hair. The child was busy picking up wildflowers, chasing the birds, and playing a game of tag. The child that the babysitter chased squealed with delight at the game. Their laughter could be heard a few miles away.

g. The babysitter with a pony tail was playing on the playground with the child. She looked pretty good in the pink sweater, and her white sport shoes were very cute. When the babysitter laughed, her voice sounded sweet. On this sunny spring day, the breeze gently blew the brown hair. The babysitter was busy picking up wildflowers, chasing the birds, and playing a game of tag. The child that chased the babysitter squealed with delight at the game. Their laughter could be heard a few miles away.

h. The babysitter with a pony tail was playing on the playground with the child. She looked pretty good in the pink sweater, and her white sport shoes were very cute. When the babysitter laughed, her voice sounded sweet. On this sunny spring day, the breeze gently blew the brown hair. The babysitter was busy picking up wildflowers, chasing the birds,

and playing a game of tag. The child that the babysitter chased squealed with delight at the game. Their laughter could be heard a few miles away.

(Yang, Mo & Louwerse, 2013)

By comparing reading performance with two clause types' in two areas, the relative clause and the matrix verb, Yang et al. (2013) showed that when the sentence emphasizes the object-favored discourse context (5d) (5h), ORC becomes easier to read than SRC. Their study revealed that discourse significantly affects the processing difficulty between SRC and ORC.

Similarly, Mak, Vonk, and Schriefers (2006) illustrated how discourse information affects relative clause processing. They proposed the topichood hypothesis to account for the default preference for SRCs. According to the hypothesis, the choice of one entity as the subject of the relative clause is determined by the topicworthiness of the entities. In general, the antecedent of the relative clause is more topicworthy than the noun phrase in the relative clause because the antecedent is the topic of the relative clause.

Based on the topichood hypothesis, Mak, Vonk, and Schriefers (2008) conducted two self-paced reading experiments with native speakers of Dutch. In Experiment 1, they compared the processing of SRCs and ORCs with a personal pronoun in the relative clauses. They predicted that comprehenders would prefer ORCs because personal pronouns refer to a discourse topic and are thus topicworthy. Their results were expected, and thus Experiment 1 supported the topichood hypothesis. In Experiment 2, they manipulated the discourse status of the noun phrase in SRCs and ORCs, presenting or not presenting the noun phrase in the preceding context. The results revealed that when the noun phrase in the relative clause refers to the discourse topic, the difficulty of ORCs is reduced. They concluded that discourse factors facilitate relative clause processing at the sentence level.

2.6 Effects of Experience on Relative Clause Processing

In addition to syntactic and discourse information, previous studies have reported that statistical information, namely "experience," differentiates reading performance on relative clauses. Reali and Christiansen (2007) conducted a corpus study and four self-paced reading experiments to examine the role of experience in SRC/ORC sentence processing. In the corpus study, they scrutinized the American National Corpus, comprising written and spoken language of native speakers of English.

In general, corpus data present how frequently speakers or writers use certain expressions. In other words, the data show how frequently comprehenders experience a certain expression. Their corpus analysis demonstrated that when the noun phrase in the relative clause is a personal pronoun, (6), (7), and (8), ORC was preferred over SRC. In contrast, when the noun phrase in the relative clause is an impersonal pronoun (9), SRC was preferred. From the stand point of the working-memory-based account, ORC should be more difficult to read than SRC, irrespective of types of pronouns. However, if experience or statistical learning plays a significant role in relative clause processing, the asymmetry of processing difficulty is expected to disappear. The following stimuli were used to investigate which of the two accounts, experience-based or working-memory-based, has more effect on relative clause processing.

(Experiment 1)

(6) a. The consultant that you called *emphasized* the need for additional funding.

b. The consultant that called you *emphasized* the need for additional funding.

(Reali & Christiansen, 2007, p. 9)

(Experiment 2)

(7) a. The lady that I visited *enjoyed* the meal.

b. The lady that visited me *enjoyed* the meal.

(ibid. p. 11)

(Experiment 3)

(8) a. According to the Taylors, the landlord that they telephoned *offered* a nice apartment.

b. According to the Taylors, the landlord that telephoned them *offered* a nice apartment.

(ibid. p. 13)

(Experiment 4)

(9) a. The research was very illuminating. The studies that it motivated *converged* to similar results.

b.The research was very illuminating. The studies that motivated it *converged* to similar results.

(ibid. p. 9)

Reali and Christiansen analyzed reading times in two critical regions: the matrix verb of the sentence, *emphasized* in (6); and two words following the relativizer *that*, ORC *you called* in (6a) vs. SRC *called you* in (6b). The juxtaposition of the two clauses' reading times indicated that the asymmetry of processing difficulty disappeared at the matrix verb in (6), (7), and (8). Furthermore, at the second critical region, participants read ORC more quickly than SRC in (6), (7), and (8). On the other hand, in (9), with an impersonal pronoun in the relative clause, they obtained opposite results. Participants read the ORC region more slowly than that of SRC. All results from the self-paced reading experiments matched the distribution of the corpus study. Based on these findings, they concluded that experience determines the difference in processing difficulty between SRC and ORC.

2.7 Priming Effects on Sentence Comprehension

Priming is another phenomenon in which experience affects subsequent processing. Priming effect has been identified in several levels, such as lexical meaning, phonology, prosody and syntax (Pickering & Ferreira, 2008). There are two accounts of the syntactic priming effect (Bock & Griffin, 2000). Pickering and Branigan (1998) explain this phenomenon as a transient activation of specific structures' nodes such as NP NP for double object and NP PP for prepositional object constructions. In contrast, Ferreira and Bock (2006) claim that syntactic priming is implicit learning. They argue that comprehending or producing a message causes language users to link certain syntactic configurations in certain orders to relational structures in their message. By doing so, the grammatical-encoding process is tuned to compute such linkages of message structures and syntactic configurations.

Previous studies have reported that the phenomenon exists both in production and comprehension. Syntactic priming effect in production refers to the tendency of speakers to reuse the syntactic structure which they recently encountered (e.g., Bock, 1986; Bock & Griffin, 2000; Morishita, Satoi, & Yokokawa, 2010; Morishita, 2011). Morishita and Yokokawa (2012) examined cumulative effects of syntactic priming in production of JEFLLs. They reported that the more the speakers were exposed to a certain sentence structure, the stronger syntactic priming became. Their results indicate the possibility that repeated exposure accelerates learning during language production.

Syntactic priming during comprehension is characterized by the facilitated comprehension of a syntactic structure after comprehenders have recently encountered the same structure (e.g., Ledoux, Traxler, & Swaab, 2007; Thothathiri & Snedeker, 2008a, 2008b; Tooley & Traxler, 2010; Fine, Jaeger, Farmer, & Qian, 2013). Thothathiri and Snedeker (2008a) examined syntactic priming during spoken language comprehension by employing a visual world paradigm. In their three experiments, native speakers of English sat in front of a podium with four shelves. A camera was set at a hole in the center of the podium and it recorded the participants' eye movement. In each trial, four toys (2 animals and 2 inanimate objects) were put on the shelves of the podium (Figure 2).

(10) a. Show the horse the book.

b. Show the horn to the dog.

(Thothathiri & Snedeker, 2008a, p. 54)

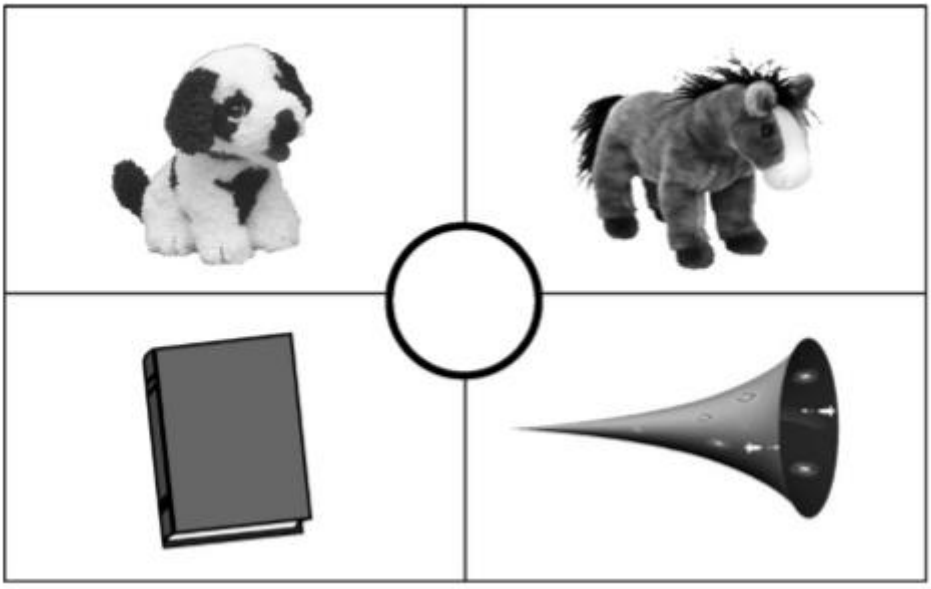

Figure 2. This figure indicates the schematic diagram of the set up for a trial used for experiments 1, 2, & 3 in Thothathiri and Snedeker (Reprinted from Thothathiri & Snedeker, 2008a, p.54).

In Experiment 1, participants were told to listen to the instruction before acting. In Experiments 2 and 3, participants were told to listen to a conversation between two people, a speaker and an actor, but were not required to act. Thothathiri and Snedeker used direct-object (DO) and prepositional-

object (PO) sentences as stimuli. In the trial, participants listened to a DO (e.g. *Send the frog the gift*) or PO (e.g. *Send the gift to the frog*) prime sentence and then listened to a target DO (10a) or PO (10b) sentence. The target sentences contained a temporary ambiguity in terms of phonology (DO: *Show the **hor**se the book*; PO: *Show the **hor**n to the dog*). For instance, the initial part is shared by the first nouns, ***hor**se* and ***hor**n*, a possible animate recipient and a possible inanimate theme, respectively. The visual world paradigm enabled them to identify which sentence type participants expected, DO or PO, after listening to a prime sentence. Participants' gazing at an animate recipient (horse), before listening to a target sentence, indicates their expectation of a DO sentence. Their gaze at an inanimate theme (horn), on the other hand, explains their anticipation of a PO sentence.

The results provide the evidence that participants' eye movements during the period of ambiguity were affected by the prime. Importantly, even though different verbs were used between the primes and target sentences, syntactic priming effects were found. Based on these results, Thothathiri and Snedeker (2008a) concluded that syntactic priming occurs during sentence comprehension and that this phenomenon is a form of implicit learning.

Noppeney and Price (2004) demonstrated the neural behavior of syntactic priming by conducting self-paced reading and fMRI experiments with the same stimuli. The stimuli involved four different syntactic forms and two types of syntactic ambiguity: clause boundary ambiguity and reduced relative / main clause ambiguity. For example, in sentences with clause boundary ambiguity (11a) (11b), the noun after the verb can either be interpreted as the direct object of the proposed clause (late closure) or as the subject of the subsequent main clause (early closure). In general, late closure (11a) is the preferred and early closure (11b), the nonpreferred interpretation. In sentences with reduced relative / main clause ambiguity, the verb can be interpreted as the main verb of the sentence (11c) or as a reduced relative (11d). Generally, main verb (11c) is the preferred and reduced relative (11d), the nonpreferred interpretation. Thus, the design can be described in a way as 2 x 2 x 2 x 2 design with the factors (1) syntactic priming (dissimilar vs. similar sentence structures) (2) syntactic ambiguity (presence vs. absence of a comma) (3) interpretation (preferred vs. nonpreferred) and (4) structure (clause boundary vs. reduced relative / main clause ambiguity).

(11) a. Before the director left the stage(,) the play began.

b. After the headmaster had left(,) the school deteriorated rapidly.

c. The artist left his sculptures to the British Museum.

d. The child(,) left by his parents(,) played table football.

The underlined words indicate when the reader encounters the temporary syntactic ambiguity where the "preferred" as well as the "nonpreferred" syntactic forms can be assigned.

(Noppeney & Price, 2004, p.703)

The results indicated that reading time and left anterior temporal activation were decreased when participants read sentences of which syntactic form were similar to the one they recently encountered. The left anterior has previously been considered to conduct lexical semantic and sentence processing. Thus, their findings showed that syntactic priming effects during sentence comprehension occurs behaviorally and physiologically. Noppeney and Price (2004) concluded that if successive sentences follow the same syntactic structure, it is less demanding for the readers to assign θ-roles to the sentence argument. They also explained that it becomes easier for the readers to determine "who does what to whom" in the sentence. Their claims indicate that exposure to the same syntactic structure could facilitate meaning-syntax mapping.

2.8 Repeated Exposure on Subject/Object Relative Clauses and Inverse Frequency Effects

Wells et al. (2009) examined the effects of repeated exposure to relative clauses on sentence processing with a self-paced reading paradigm. The participants in their study were native speakers of English, and the experiment was conducted over several weeks, from session 1 to session 4, each of which was spaced four to eight days apart. The participants consisted of two groups, relative clause sentence experience and control sentence experience groups. The relative clause group read both SRC and ORC during the experiment sessions, while the control group read sentences other than relative clauses. The relative clause group's better results clearly indicated that reading experience improved reading performance for relative clauses. What is noteworthy in their study is that they confirmed that reading experience has long-lasting effects.

Wells et al. (2009) also presented an interesting finding in which the degree of reading speed improvement for ORC was more conspicuous than that for SRC. This phenomenon, so-called

"inverse frequency effect," has been explained by the idea that infrequent syntactic structure is more primed than frequent structure, meaning that prediction error leads to more learning. This phenomenon is observed in some studies (MacDonald & Christiansen, 2002; Wei, Dong, Boland, & Yuan, 2016). MacDonald and Christiansen (2002) pointed out that only implicit learning caused by the priming effect can account for this Frequency × Regularity interaction. Also, Jaeger and Snider (2007) argued that each structure can be seen as a piece of evidence that affects the overall probabilistic distribution. Therefore, less expected prime structures are predicted to prime more than more expected prime structures. Jaeger and Snider referred to this hypothesis as surprisal-sensitive persistence. The idea of this hypothesis, as reported by them, came from Bock's (1986) syntactic priming study of passives and actives. Bock demonstrated syntactic persistence for passives, which are relatively infrequent in her production experiments. On the other hand, the much more frequent active structure was not found to prime. Following the results, Jaeger and Snider (2007) concluded that syntactic priming is not just a transient phenomenon but a kind of implicit learning.

Fine and Jaeger (2013) confirmed this tendency by reanalyzing a previous study's data, Thothathiri & Snedeker's (2008a) syntactic priming experiment which is referred to in section 2.7 of this study. Fine and Jaeger found that the surprising effect, in which comprehenders encounter unexpected syntactic form, leads to error signal. Then, the signal associated with a syntactic prime influences comprehenders' subsequent syntactic expectation. Moreover, they concluded that the more surprising prime structures lead to stronger expectations that the same structure will be used in later sentences. Their findings support inverse frequency effect.

Sakakibara and Yokokawa (2015) reported the immediate effects of repeated exposure on JEFLLs' sentence processing. Following Wells et al. (2009), they divided participants into two groups, a relative clause group and a control group. They set SRC and ORC as stimuli and utilized self-paced reading for pre- and post-tests. The results showed that after repeated exposure to 80 sentences, the relative clause group's sentence processing was significantly facilitated. They also found an inverse frequency effect on JEFLLs' relative clause sentence processing. However, they did not confirm whether the effects persist or not.

Additionally, the material used in Sakakibara and Yokokawa (2015) requires some modification. For example, even though they compared SRC and ORC in the pre- and post-test sessions, the number of noun phrases used in SRC and ORC varied, meaning that different structures were mixed.

As indicated below, the number of the noun phrase in some SRCs (12a) was three (*the nurse*, *the doctor*, *the car*), while, in ORCs (12b), two (*the solder*, *the enemy*). Moreover, the number of yes-or-no answers for SRC and ORC confirmation sentences differed, even though they were employed during the test sessions. The different distribution of correct yes-or-no answers could have influenced the accuracy rates, because people usually hesitate to answer "No." Furthermore, the interrogating points of the confirmation sentences were not controlled between SRCs and ORCs. Any of them could have affected the accuracy rates and experimental results. More controlled stimuli should be used to provided firm evidence.

(12) a. The nurse that followed the doctor got in the car.
Q: The doctor followed the nurse. Answer : No
b. The solder that the enemy attacked was wounded.
Q: The enemy was wounded. Answer : No

(Sakakibara, 2016)

2.9 Research Questions

2.9.1 Research Questions for the Effects of Modality and Proficiency on Syntax-Meaning Mapping in L2 Online Sentence Comprehension

On the basis of theoretical background and evidence from previous studies, Experiment 1 and Experiment 2 manipulated animacy information of the matrix noun phrase, animate or inanimate, and investigated whether listeners and readers comprehend object relative clauses (ORCs) correctly. Experiment 1 targeted intermediate-level JEFLLs, and Experiment 2, elementary. For that purpose, research questions were set as follows:

RQ 1: Do intermediate-level JEFLLs score higher on inanimate ORCs than animate ORCs when comprehending spoken and written ORCs?

RQ 2: Does the input modality affect the intermediate-level JEFLLs' accuracy rates of inanimate ORCs and animate ORCs?

RQ 3: Do elementary-level JEFLLs score higher on inanimate ORCs than animate ORCs when comprehending spoken and written ORCs like intermediate-level JEFLLs do?

RQ 4: Does the input modality affect the elementary-level JEFLLs' accuracy rates of inanimate ORCs and animate ORCs?

Some points remained unclear after analyzing data obtained from Experiment 1 and Experiment 2. In specific, a question arose whether JEFLLs succeeded in meaning-syntax mapping during sentence processing. To clarify the question, Experiment 3 utilized active/passive voices with manipulation of animacy for noun phrases and set research questions as follows:

RQ 5: Do English proficiency and input modality affect JEFLLs' accuracy when comprehending animacy-manipulated passive/active sentences?

RQ 6: Do English proficiency and input modality affect JEFLLs' response latency when comprehending animacy-manipulated passive/active sentences?

2.9.2 Research Questions for the Effects of Experience-based Learning on L2 Relative Clause On-line Processing

Based on findings from Experiments 1, 2 and 3, theoretical framework and evidence from previous studies, Experiment 4 was designed to scrutinize the effects of experience-based learning on JEFLLs' relative clause processing by utilizing stimuli controlled between two groups and between two clause types. Experiment 4 also examined whether the repeated exposure effects persist one day after the exposure. As such, the following research questions were posed:

RQ 7: Does repeated exposure to relative clauses facilitate JEFLLs' relative clause sentence processing immediate after the exposure?

RQ 8: Do the repeated exposure effects on JEFLLs' relative clause processing persist one day after the exposure?

RQ 9: Does the same number of exposure to SRCs and ORCs equally affect JEFLLs' SRC and ORC reading performance?

RQ 10: Does the distribution of facilitated exposure effects between SRCs and ORCs remain the same one day after the exposure?

3. Experiment 1

3.1 Purpose and Research Questions

The purpose of Experiment 1 was to examine whether or not intermediate-level JEFLLs utilize animacy information when comprehending spoken and written ORCs. In lieu of that, the following research questions for Experiment 1 were posed:

RQ 1: Do intermediate-level JEFLLs score higher on inanimate ORCs than animate ORCs when comprehending spoken and written ORCs?

RQ 2: Does the input modality affect the accuracy rates of inanimate ORCs and animate ORCs?

3.2 Participants

3.2.1 Auditory Presentation

For the auditory presentation experiment, the participants comprised 57 JEFLLs who were undergraduate and graduate students. They took the listening section of the Tactics for TOEIC® (Test of English for International Communication) Listening and Reading Test 2 (Oxford University Press, 2007) as the proficiency test just before Experiment 1. The score was calculated for TOEIC® score based on the corresponding value, set by Tactics for TOEIC® Listening and Reading Test 2. The participants with scores ranging from 330–475 out of 495 were examined. As a result, the final number of the participants was 25 (score range: 310–415, *SD*: 31.3).

3.2.2 Visual Presentation

For the visual presentation experiment, the participants comprised 50 JEFLLs who were undergraduate students. They took the listening section of the TOEIC® IP test as the proficiency test about three months before Experiment 1. The participants with scores ranging from 310–475 out of 495 were examined. As a result, the final number of the participants was 25 (score range: 330-475, *SD*: 33.1).

No difference was identified between the auditory presentation and the visual presentation groups' proficiency with a *t*-test (t (48) = 1.229, p = .225, *ns*). The TOEIC® Test corresponds to the levels of the Common European Framework of Reference for Languages (CEFR) that divides

language learners' proficiency into 6 levels, A2, A1, B2, B1, C2, and C1 with C2 being ranked the highest. Judging from the participants' listening scores, that ranged from 310–475 in the TOEIC® Test, they were in the B1 and B2 levels. Therefore, the participants in Experiment 1 were considered intermediate-level learners.

3.3 Materials

Two types of critical ORC sentences were prepared by manipulating the animacy of a matrix noun phrase (NP1), animate and inanimate for (13a) and (13b), respectively. The subject noun phrase of the relative clause (NP2) was always animate. Each sentence is coupled with a question that enquired about the relationship between the NP1 and the NP2. The correct answer for the experimental questions was always "Yes." Questions with the "No" correct answer were excluded in the critical sets because those questions required asking about relationships other than the NP1 and NP2 or using words that were not in the sentences.

(13) a. The **boy** that the girl helped passed the examination. (animate ORC)
Question: Did the girl help the boy?
b. The **accident** that the manager watched appeared in a newspaper. (inanimate ORC)
Question: Did the manager watch the accident?

For each condition, animate ORC and inanimate ORC, 10 sets were prepared, with 20 sets in total. The critical sentences were prepared in the following conditions: (a) 8–11 words (mean 9.2) for an animate ORC, (b) 6–7 (mean 6.1) for an animate ORC question, (c) 9–10 (mean 9.6) for an inanimate ORC, and (d) 6–7 (mean 6.4) for an inanimate ORC question. In addition, the grammatical items in the 67 filler sentences involved datives (15 sets), passives (15), conjunctions (15), animate ORCs with the "NO" correct answer (10), and inanimate ORCs with the "NO" correct answer (10). Those ORC questions asked about relationships other than the NP1 and the NP2.

All the words used in the sentences, except for one word "have" which was used in a filler sentence, had more than a 5.0 familiarity rate on a 7-point scale: The familiarity rate of a word is determined by the perceived frequency of encountering the word in speech or written texts and a 7-point rate means highly familiar (Yokokawa, 2009). The sentences were checked by an English native

speaker. The critical sentences are in Appendix 1.

3.3.1 Auditory Stimuli

The 85 sets of sentences were read by an English native speaker. Between one to nine filler sets were randomly inserted between the critical sets so that the critical sets were not presented in a row. The 85 sets were stored into seven files.

The stimuli were recorded as follows: (1) a sentence was read, (2) a two-second pause was inserted, (3) the set question was read, and (4) a four-second response time was inserted.

3.3.2 Visual Stimuli

The presentation time of the visual stimuli was determined based on the auditory stimuli. First, the presented time for each spoken sentence and question sentence was checked with Praat (Boersma & Weenink, 2012). Then, the presentation time for the visual stimuli was calculated by adding 50 ms for each word to the presented time in the auditory stimuli. In order to make the visual stimuli similar to the auditory stimuli, which were stored into 7 files, a 6-second pause divided the 85 sets into 7 parts. The stimuli were created using PowerPoint in 32-size font, and the sentences, that were one or two lines, were center-aligned.

The stimuli were presented as follows: (1) a sentence was presented on a PC, (2) a two-second pause was inserted, (3) the set question was presented on a PC, and (4) a four-second response time was inserted.

3.4 Procedures

3.4.1 Auditory Presentation

A B4 size answer sheet was provided to each participant. The participants were instructed to check either “Yes” or “No” quickly with a pencil. The participants completed three practice questions. Upon confirmation that the participants understood clearly the sequence of the procedure, the experiment started and took approximately 25 minutes to completion (See Appendices 2 and 3). Before beginning the experiment, participants were informed that their responses were confidential and would not be related to their grades. Then each participant signed a consent form.

3.4.2 Visual Presentation

It was an experimenter-paced reading task conducted in a Computer-Assisted Language Learning room; therefore, each participant used their own PC. The procedure of the task implementation was the same as that of the auditory presentation. The reading task took approximately 25 minutes to completion as well (See Appendices 4 and 5).

3.5 Results and Discussion

A correct answer was given a score of 1. Figure 3 illustrates the comparison of mean scores between the auditory group and the visual group. As for the auditory group, the mean score was 5.88 (*SD*: 1.590) for animate ORCs and 7.40 (*SD*: 1.756) for inanimate ORCs. For the visual group, the score was 5.32 (*SD*: 1.958) for animate ORCs and 6.82 (*SD*: 1.313) for inanimate ORCs. The differences between the two groups were analyzed by a two-way Analysis of Variance (ANOVA). No significant interactions were observed between the effects of modality and animacy ($F(1,48) = 2.946$, $p = .093$, *ns*). The main effect of animacy was significant ($F(1,48) = 54.576$, $p<.001$, $\eta p^2 = .532$). The paired *t*-test revealed a significant difference between the animate ORCs and the inanimate ORCs for the auditory ($t(24) = -3.91(p<.001)$) as well as the visual ($t(24) = 6.59(p<.001)$) groups, reflecting poorer performance for animate ORCs.

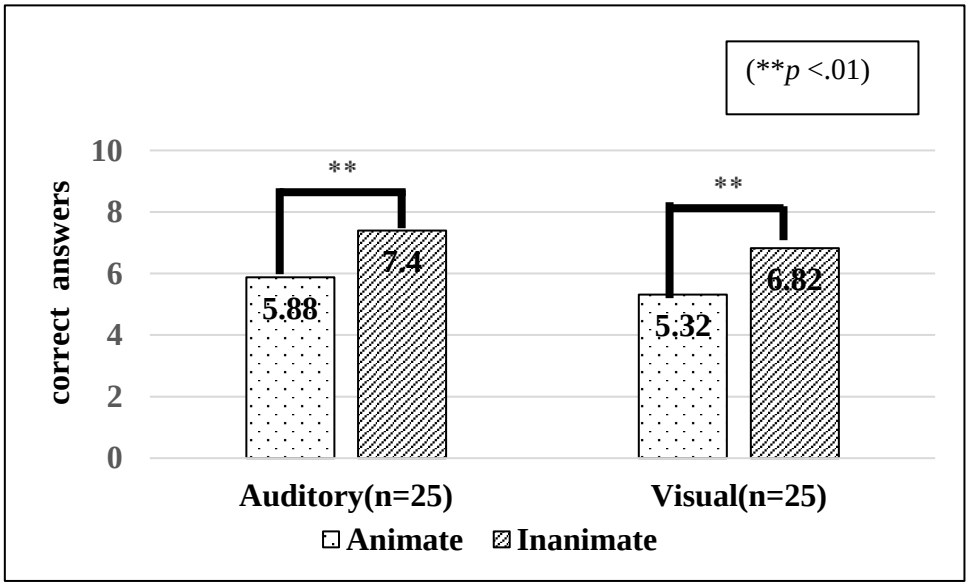

Figure 3. This figure compares the intermediate-level JEFLLs' mean scores between the auditory group and the visual group for animate ORCs and inanimate ORCs.

To answer RQ1, the results reveal that intermediate-level JEFLLs scored higher on inanimate ORCs, reflecting their use of animacy information when reading and listening to ORC sentences. To answer RQ2, the input modality did not affect their comprehension because no significant interactions were observed between listening or reading.

Previous reading studies (Traxler, Morris, & Seely, 2002; Hashimoto, 2011, 2012) have shown that readers perform the θ-role assignments in parallel with syntactic processing when reading relative clause sentences. Therefore, the results imply that the participants performed the same processes when listening to ORC sentences. This may possibly be derived from the visual experiment condition, that is, the experimenter-paced reading method. However, the low accuracy rate for the animate ORC question, almost the chance level, suggests that the processing load for the reassignment of θ-roles was too high to be completed in real time because of the JEFLLS' less automatized syntactic processing.

Experiment 1 examined the intermediate-level JEFLLs' processing of ORC sentences. Considering a high number of the Japanese university students were at the elementary level of L2 proficiency, investigating their processing pattern is also necessary. Furthermore, proficiency could affect the processing behavior due to the differences of the syntactic processing automaticity. Therefore, Experiment 2 examined the effects of proficiency on the use of animacy information when comprehending spoken and written ORC sentences.

4. Experiment 2

4.1 Purpose and Research Questions

The purpose of Experiment 2 was to investigate whether elementary-level JEFLLs process spoken and written ORC sentences in the same way as the intermediate-level JEFLLs do. As such, the following research questions for Experiment 2 were posed:

RQ 3: Do elementary-level JEFLLs score higher on inanimate ORCs than animate ORCs when comprehending spoken and written ORCs like intermediate-level JEFLLs do?

RQ 4: Does the input modality affect the accuracy rates of inanimate ORCs and animate ORCs?

4.2 Participants

4.2.1 Auditory Presentation

For the auditory presentation experiment, the participants comprised 48 JEFLLs who were undergraduate students. The listening section of the TOEIC® IP test was the proficiency test taken about one month before Experiment 2. The participants with scores ranging from 140–250 out of 495 were examined. As a result, the final number of the participants was 36 (score range: 155-250, *SD*: 28.7).

4.2.2 Visual Presentation

For the visual presentation experiment, the participants comprised 48 JEFLLs who were undergraduate students. The proficiency test was the same as the auditory version employed. The participants with scores ranging from 140–250 out of 495 were examined. As a result, the final number of the participants was 34 (score range: 140-240, *SD*: 26.2).

No difference was identified between the two groups' proficiency with a *t*-test ($t(68) = -1.17$, $p = .25$, *ns*). The TOEIC® Test scores correspond to the 6 levels of CEFR; therefore, for scores ranging from 140-250, the participants were at the A2 elementary level.

4.3 Materials

The same materials used in Experiment 1 were used in Experiment 2.

4.4 Procedures

The procedures in Experiment 1 were also followed for Experiment 2.

4.5 Results and Discussion

A correct answer was given a score of 1. Figure 4 illustrates the comparison of the mean scores between the auditory group and the visual group. As for the auditory group, the mean score was 4.17 (*SD*: 1.7) for animate ORCs and 5.17 (*SD*: 1.86) for inanimate ORCs. For the visual group, the score was 4.88 (*SD*: 2.1) for animate ORCs and 6.47 (*SD*: 1.8) for inanimate ORCs. The ANOVA results with the factors of modality and animacy conditions revealed the main effects for animacy ($F(1,68) = 14.97$, $\eta\rho^2 = .18$, $p<.001$), and for modality ($F(1,68) = 11.45$, $\eta\rho^2 = .14$, $p<.001$). No significant interactions were observed between the effects of modality and animacy ($F(1,48) = 2.946$, $p = .093$, *ns*). The paired *t*-test revealed a significant difference between the animate ORCs and the inanimate ORCs for the visual group ($t(70) = 3.04$ ($p<.001$)) and the auditory group ($t(35) = 1.98$ ($p<.056$)), thus reflecting poorer performance for animate ORCs, although the auditory group's difference was marginal.

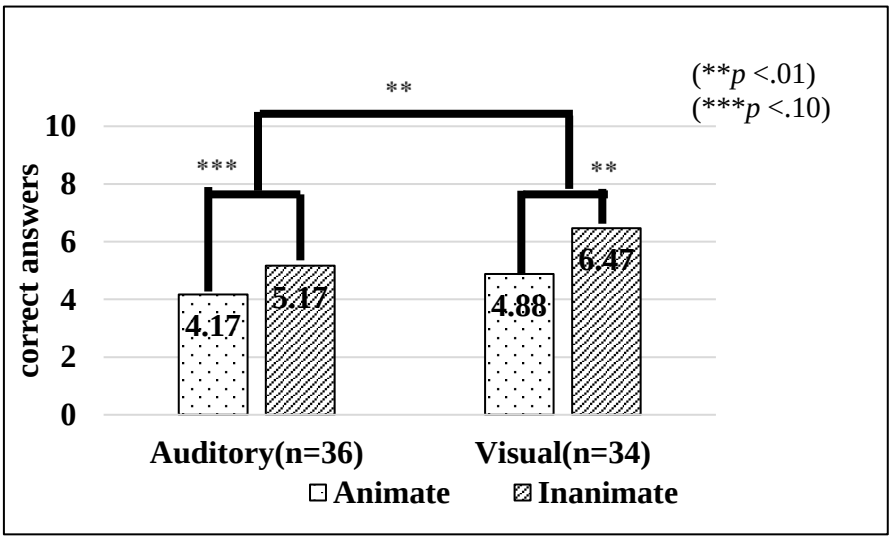

Figure 4. This figure compares the elementary-group JEFLLs' mean scores between the auditory group and the visual group for animate ORCs and inanimate ORCs.

To answer RQ3, the results demonstrate a high accuracy rate of inanimate ORCs. In addition, their pattern is similar to that of the intermediate-level participants. To answer RQ4, the results illustrate the effect of input modality, poorer at listening, but the mean scores of animate ORCs for both auditory and visual groups were below chance level.

Therefore, the results must be carefully interpreted. In addition, the accuracy rate for ORC questions that can be possibly guided by the meanings of two nouns and a verb or their world knowledge, was relatively high. For example, the question "Did the assistant support the cameraman?" is easily answered with a "Yes," by utilizing their world knowledge without comprehending the coupled animate ORC sentence, "The cameraman that the assistant supported gave him a present."

Taken together, the results obtained from Experiment 1 and Experiment 2 showed that elementary- and intermediate-level participants facilitated their sentence comprehension by utilizing animacy information. However, it is still unclear whether they were able to construct syntactic structures by employing animacy information. The results of Experiment 1 and Experiment 2 may guide two interpretations: (1) by applying animacy information, intermediate- and elementary-level participants could construct a syntactic structure and facilitated sentence comprehension even though the processing performance was not good enough, or (2) intermediate- and elementary-level participants facilitated sentence comprehension by utilizing the meanings of a matrix noun phrase, a relative clause subject's noun phrase and a verb, or their world knowledge. However, they failed to construct a syntactic structure and failed to conduct meaning-syntactic mapping while comprehending written and spoken ORC sentences.

To clarify the results of Experiments 1 and 2, Experiment 3 employed a passive structure, simpler than ORC, and examined whether the elementary and intermediate-level JEFLLs could successfully construct semantic-syntactic structure when comprehending active/passive voice structures. In addition, Experiment 3 was designed for each participant to take both auditory and visual experiments to contrast more sharply the results from the differences in modality.

5. Experiment 3

5.1 Purpose and Research Questions

The purpose of Experiment 3 was to investigate if JEFLLs' levels of English proficiency and/or input modality affect the pattern of constructing semantic-syntactic structures when comprehending passive/active sentences with the following research questions:

RQ 5: Do English proficiency and input modality affect JEFLLs' accuracy when comprehending animacy-manipulated passive/active sentences?

RQ 6: Do English proficiency and input modality affect JEFLLs' response latency when comprehending animacy-manipulated passive/active sentences?

5.2 Participants

In Experiment 3, the participants comprised 48 JEFLLs who were undergraduate students. Based on their total scores of TOEIC® IP test or TOEIC® Bridge scores converted to TOEIC® test equivalents, the participants were divided into two groups: intermediate-level (n=24, mean score: 581.9, score range: 470-750, SD: 76.5) and elementary-level (n=24, mean score: 379.0, score range: 320-440, SD: 37.8) groups. A significant difference was identified between the two groups' proficiency with a t-test ($t(46) = 11.64$, $p<.001$).

5.3 Materials

5.3.1 Task

Experiment 3 employed a sentence-picture verification task, for which critical sentences and pictures were prepared. In this task, participants sat in front of a computer, and a written or spoken sentence was presented followed by a picture on the screen. Participants pressed the "○" key (for a matching sentence) or the "×" key (for a non-matching sentence) after judging whether the picture on the screen matched with the sentence that was presented just before the picture. For critical and filler sentences, half of the correct answers were "○" (matching sentence).

5.3.2 Critical Pictures, Lists, and Critical Sentences

Each critical picture was a snapshot in which both a girl and a boy or one of them would appear. Either the pictures matched the event of the sentence, or they showed the event with the agent and patient/theme reversed. Table 1 shows an example of eight critical sentence types, voice (passive/active) (2) × animacy (animate/inanimate) (2) × match (matching/non-matching). In the critical sentences, either "a boy and a girl" or "one of them" appeared. For animacy manipulation, two different pictures were prepared; one for 4 sentence types in (14a), (14b), (14c), and (14d); and the other for 4 sentence types in (14e), (14f), (14g), and (14h). In this example, (14a), (14b), (14c), and (14d) were followed by the same picture, in which a girl is pushing a boy. Therefore, (14a) and (14c) are matching, but (14b) and (14d) are non-matching. Sentences (14e), (14f), (14g) and (14h) were followed by the same picture, in which a boy is pushing a table. Therefore, in this case, (14e) and (14g) are matching, but (14f) and (14h) are non-matching.

Table 1

Critical Sentence Types and Their Examples

(14) a. the girl was pushing the boy.	Active /Animate	[AA] / Match
b. the boy was pushing the girl.	Active/ Animate	[AA] / Non-match
c. the boy was pushed by the girl.	Passive/ Animate	[PA] / Match
d. the girl was pushed by the boy.	Passive/ Animate	[PA] / Non-match
e. the boy was pushing the table.	Active/ Inanimate	[AI] / Match
f. the table was pushing the boy.	Active/ Inanimate	[AI] / Non-match
g. the table was pushed by the boy.	Passive/ Inanimate	[PI] / Match
h. the boy was pushed by the table.	Passive/ Inanimate	[PI] / Non-match

Each participant performed the sentence-picture verification task twice, once in the auditory and visual presentation sessions, respectively. In addition, 4 different lists were created with one list consisting of 60 sentences, which comprised 24 critical and 36 filler sentences. Each list contained one type of the critical sentences to counterbalance the design. Each participant encountered 3 sentences for 8 sentence types and was presented with only one picture of the four conditions, from animate sentence types— (14a), (14b), (14c), (14d)—and from inanimate sentence types—(14e),

(14f), (14g), (14h).

The verb forms of the critical sentences of active and passive voices consisted of "was + present participle" and "was + past participle." For each sentence type, 12 sentences were prepared, in total 96 stimuli by utilizing 16 verbs with regular participle forms. At the beginning of the critical and filler sentences, the adverb phrase, "In my opinion," was inserted to secure the comprehension of the first noun phrase, namely, the critical region. The critical sentences are in Appendix 6.

In total, 72 filler sentences involved existential (24), intransitive (20), transitive (20), passive voice without animate nouns (4), and causative psych verb (4) constructions, and 72 snapshots for the filler sentences were also prepared. Half of the fillers were assigned to List 1 and 3, and half to List 2 and 4. Each participant was presented with an odd-numbered list and an even-numbered list so that the filler sentences were always different.

All the words used in the sentences except for five verbs, namely, *lift, hug, pull, pick and carry,* had more than a 5.0 familiarity rate on a 7-point scale (Yokokawa, 2006; 2009). For the participants to be familiarized with the words used in the experiment, a 15-word list (e.g., lift, pick, pull, hug, pack, pleased, shout, magazine, dish, plate, picture, hand, smartphone, carry, and turn) with their Japanese translations was prepared (Appendices 7 and 8). All the Japanese translations in the list were printed in red and a red polypropylene sheet was provided with the list. Participants were asked to use the sheet to check whether they were familiar with the words. The sentences were checked by an English native speaker.

The experimental sentences were read by an English native speaker. Each list was stored into two files. The recording time was checked with Praat (Boersma & Weenink, 2012). The visual presentation time was the same as that of the auditory one.

5.4 Procedures

Each participant took the test individually. Before beginning the experiment, participants were informed that their responses were confidential and would not be related to their grades. Then each participant signed a consent form. The stimuli were randomly presented on a PC with the psychological experiment software SuperLab Pro Version 5 (Cedrus). The order in which the modality came first was counterbalanced between the participants within a group. To illustrate, the visual-first experiment was performed by the participants in the following order:

1) Familiarized themselves with the words in the given 15-word list. A red clear sheet made out of polypropylene was provided so that participants can check whether they know the meaning by covering the word list with the sheet;
2) Sat in front of a PC and a fixed set of instructions about the procedure was given;
3) Familiarized themselves with the visual version task by performing eight practice trials with a headphone on;
4) Performed the first half of the trials of 30 sentences for the visual version;
5) Rested briefly, and performed the second half of the trials of 30 sentences for the visual version;
6) Rested briefly, and familiarized themselves for the auditory version task by performing 8 practice trials with a headphone on;
7) Performed the first half of the trials of 30 sentences for the auditory version; and
8) Rested briefly, and performed the second half of the trials of 30 sentences for the auditory version.

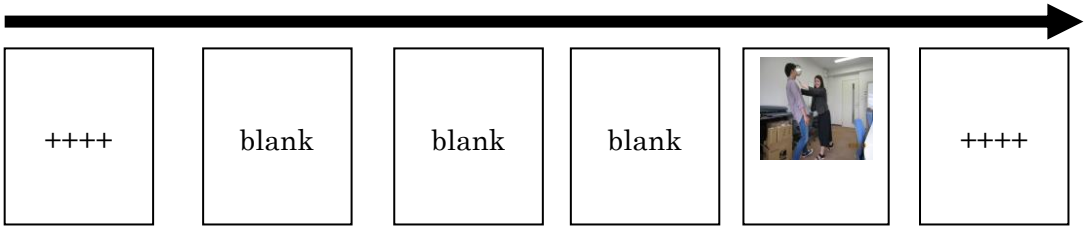

Figure 5. This figure shows the flow of one auditory presentation trial on a PC screen.

An example of the auditory presentation trial flow is illustrated in Figure 5. Each trial began with the mark "++++" on the screen. When the participants pressed the space key, a 200 ms blank screen appeared, and then, a spoken sentence was presented with the screen blank. Subsequently, another 200 ms blank screen was replaced by a picture, and the participants judged whether the stimuli was "matching" or "non-matching" by pressing the respective designated key, either " ○" or " ×" as quickly as possible. Subsequently, the mark "++++" appeared to signal the beginning of

the next round.

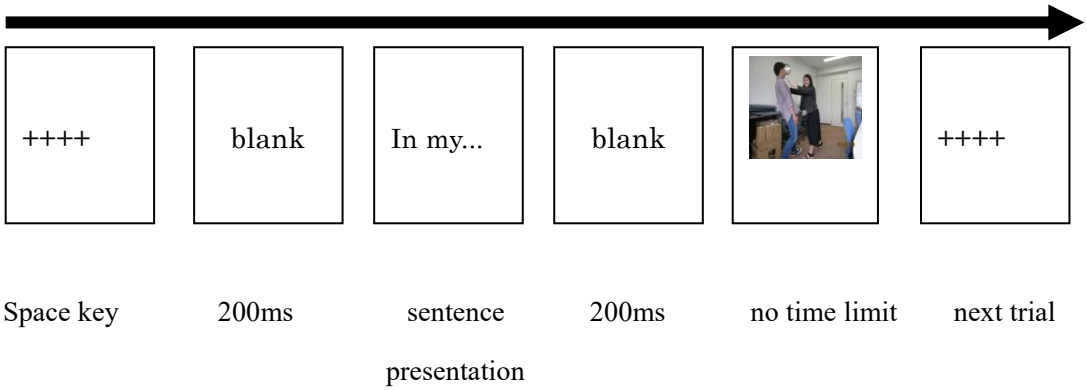

Figure 6. This figure shows the flow of one visual presentation trial on a PC screen.

An example of the visual presentation trial flow is illustrated in Figure 6. Each trial began with the mark "++++" on the screen. When the participants pressed the space key and after a 200 ms blank screen, a one-lined center-aligned written sentence with font size 28 appeared. Subsequently, after another 200 ms blank screen, a picture appeared on screen, and the participants judged whether it matches with the sentences by pressing the designated key, either " ○" (matching) or " ×" (non-matching), as quickly as possible. Subsequently, the beginning mark of the next trial "++++" appeared.

The accuracy rate and the response latency were obtained from 4 sentence-picture matching conditions, (14a) [AA], (14c) [PA], (14e) [AI], and (14g) [PI]. The response latency was measured from the onset of the picture presentation to the onset of the participant's pressing the key, so there was no time limit. The experiment was carried out in a quiet room and lasted approximately 45 minutes.

5.5 Results and Discussion

Prior to the analysis, any response latency longer than 7,000 ms was considered as outliers and was interpreted as an inaccurate response. As a result, four data for the auditory version were considered inaccurate and were eliminated prior to the response latency analyses. Then, among the accurate responses, the response latency that was not within the average response latency ± 2.5 *SD* was replaced with the boundary value (*M*± 2.5 *SD*).

5.5.1 Accuracy Rate

A correct answer was given a score of 1, so the full score for each sentence type was 3. Table 2 shows the intermediate and elementary-level participants' accuracy rates on the sentence-picture verification task for the four sentence types for the auditory and visual versions.

Table 2

Descriptive Statistics for the Mean Accuracy Rates for the Proficiency, Modality, and Sentence-Type Conditions

	Intermediate (*n*=24)		**Elementary (*n*=24)**	
	Auditory	Visual	Auditory	Visual
	Mean (rate%)	Mean (rate%)	Mean (rate%)	Mean (rate%)
Sentence type	*SD*	*SD*	*SD*	*SD*
[AA]	2.8(92)	2.9(97)	2.5(85)	2.7(90)
Active/Animate	.442	.282	.779	.690
[PA]	2.9(96)	2.9(97)	2.1(71)	2.5(85)
Passive/Animate	.338	.282	1.076	.721
[AI]	2.8(94)	2.9(96)	2.7(90)	2.8(94)
Active/Inanimate	.381	.338	.690	.381
[PI]	2.9(97)	2.9(97)	2.6(86)	2.8(94)
Passive/Inanimate	.282	.282	.654	.482

These scores were analyzed with a 2×4×2 mixed ANOVA, with modality and sentence type as the within-participants factors and proficiency as the between-participants factor. The interaction of modality, sentence type, and proficiency was not observed ($F(2.684,123.458) = .722$, $p = .526$, *ns*). There was a significant interaction between sentence type and proficiency ($F(2.389, 109.915) = 6.412$, $p<.01$), and main effects for proficiency ($F(1,46) = 6.989$, $\eta\rho^2 = .132$, $p<.05$), reflecting less accuracy for the elementary-level group, and modality ($F(1,46) = 6.981$, $p<.05$) reflecting less accuracy for the auditory presentation, and sentence type ($F(2.389, 109.915) = 5.281$, $p<.01$). Post hoc comparisons for sentence type by proficiency groups using a Bonferroni correction indicated

that [PA] was significantly less accurate than [AI] and [PI] in the elementary-level group (p<.05), but no difference was identified in the intermediate-level group. Post hoc comparisons for modality by proficiency groups revealed that auditory presentation was less accurate for the elementary-level group (F(1,23) = 5.699, $\eta\rho^2$ = .256, p<.05), but no difference was identified for the intermediate-level group (F(1,23) = 1.302, p=.266, *ns*).

5.5.2 Response Latency

Table 3 shows the intermediate and elementary level participants' mean response latency for the four sentence types for the auditory and visual versions.

Table 3

Descriptive Statistics for the Mean Response Latency for the Proficiency, Modality, and Sentence-Type Conditions

	Intermediate (*n*=24)		**Elementary (*n*=24)**	
	Auditory	Visual	Auditory	Visual
	Mean (ms)	Mean	Mean	Mean
Sentence type	*SD*	*SD*	*SD*	*SD*
[AA]	1632	1382	1452	1557
Active/Animate	653.71	529.60	427.12	633.73
[PA]	1736	1413	2210	1617
Passive/Animate	625.10	422.79	671.68	797.32
[AI]	1498	1299	1335	1270
Active/Inanimate	581.11	644.73	591.88	434.67
[PI]	1679	1419	1831	1520
Passive/Inanimate	641.99	740.53	1016.48	867.48

The data were analyzed with a 2×4×2 mixed ANOVA, with modality and sentence type as the within-participants factors and proficiency as the between-participants factor. The interaction of modality, sentence type, and proficiency was not observed (F(2.408, 110.787) = 2.189, p=.107, *ns*).

There was a significant interaction between modality and sentence type (F(2.408, 110.787) = 3.687, p<.05), and main effects for modality (F(1,46) = 8.275, p<.01) reflecting longer response latency for auditory presentation, and sentence type (F(2.363, 108.704) = 8.728, p<.01). There was no main effect for proficiency (F(1,46) = .559, p=.44, *ns*). Post hoc comparisons for sentence type by proficiency groups using a Bonferroni correction indicated that [PA] was significantly longer than [AA] and [AI] for the elementary-level group (p<.01), but no difference was identified for the intermediate-level group. Post hoc comparisons for modality by proficiency groups revealed that auditory presentation was longer for the intermediate-level group (F(1,23) = 5.878, $\eta\rho^2$ =.204, p<.05), but no difference was identified for the elementary-level group (F(1,23) = 2.946, p=.10, *ns*).

For RQ5, the results indicate that English proficiency and the different input modality affect the accuracy when comprehending animacy-manipulated passive/active sentences. For RQ6, the results illustrate that English proficiency and the different input modality affect the response latency when comprehending animacy-manipulated passive/active sentences.

These results, derived from the accuracy rate and response latency results, show clear effects of these factors, namely, modality and proficiency, in constructing semantic-syntactic structures for passive/active sentences.

First, the simulation of the processing model, necessary to understand correctly a [PA] sentence (e.g., the boy was pushed by the girl), is explained as follows. On encountering the NP1, “the boy,” comprehenders assigned an agent role because, being animate, it is a good agent. After they encountered the passive verb phrase, “was pushed,” they needed to access their mental lexicon to retrieve the semantic and argument structure information, and almost simultaneously, they reassigned a theme (or patient) role to the NP1 within a limited amount of time. After they have assigned an agent role to NP2, that is, the prepositional object “the girl,” they could then finalize the construction of the semantic-syntactic structure.

Considering the intermediate-level participants’ results of a high accuracy rate for all sentence types and no different response latency among four sentence types, they processed the [PA] sentence as described previously. On the other hand, the elementary-level participants ended up with a lower accuracy rate for the [PA] sentence (auditory: 71%, visual: 85%) compared with [AI] (90, 94) and [PI] (86, 94), and slower response latency for [PA] (auditory: 2210, visual: 1617) compared with [AA] (1451, 1557) and [AI] (1335, 1270). This indicates that they have failed to perform multi-

processing when they encountered the passive verb phrase "was pushed," and they could not reassign the NP1 or assign the NP2 accurately. Consequently, they missed a correct comprehension of the sentence.

The intermediate-level group yielded mixed results: Auditory was slower than visual for response latency but with no difference for accuracy rates. On the other hand, the results of the elementary-level group showed no modality effect for response latency. The interpretation of these results is discussed in section 5.6.

5.6 Discussion of Experiments 1, 2, and 3

Experiments 1, 2 and 3 examined how elementary and intermediate-level JEFLLs construct semantic-syntactic structures, namely meaning-syntax mapping, and how the interaction of proficiency and input modality affects JEFLLs' L2 sentence processing of relative clauses and passives.

The findings from Experiments 1, 2 and 3 revealed the elementary-level JEFLLs' following (in)abilities: (1) They could not construct semantic-syntactic structures, and failed meaning-syntax mapping, when comprehending spoken and written ORCs and animate/animate passives; (2) they are poorer at comprehending spoken sentences than written ones; and (3) their response latency is not affected by modalities when accurately comprehending passives. In contrast, intermediate-level JEFLLs demonstrated the following: (4) They could conduct meaning-syntax mapping when comprehending spoken and written passives, and as for ORCs, their comprehension does not always end up succeeding, especially when the animacy information is not available; (5) their accurate sentence processing is not affected by modalities; and (6) their response latency is affected by modalities, with slower response latency in spoken sentences.

First, I discuss these findings in light of Levelt's (1993) model of speech, namely, the schematic representation of the processing components involved in spoken language use. According to his model, parsers comprehend languages by accessing their mental lexicon and retrieving phonological, morphological, syntactic, and semantic information. The ORC sentences in Experiment 1 and Experiment 2 required participants to perform simultaneously syntactic and semantic processing and θ-role assignments to each noun phrase after retrieving phonological information. Moreover, understanding animate ORC sentences required parsers to perform reassignment of θ-roles in

addition to the complicated syntactic processing. The use of passives with two animate noun phrases in Experiment 3 demanded participants to perform multi-processing, reassignment of θ-role, and accessing the mental lexicon and retrieving information.

The intermediate-level group demonstrated mixed results. In Experiment 1 and Experiment 3, no modality effect was identified for the accuracy rates, but a modality effect was confirmed for response latency, although slower in auditory presentation. These results indicate that the intermediate JEFLLs could process passives accurately even though their processing speed to phonological representation lagged behind. According to Hirai (1999), intermediate-level JEFLLs' optimal reading speed was faster than their optimal listening speed. The current study shows similar results, reflecting the possibility of a shared route or interactive relationship between listening and reading comprehension. However, their low accuracy rates for animate ORCs show that their syntactic processing is not automatized enough to understand the complicated structure correctly, when semantic information, specifically animacy information, is not available.

The results from the elementary-level participants with their low accuracy rates demonstrate their inability to construct semantic-syntactic structures even for passives. This means that they depended on semantic information and world knowledge to understand ORCs in Experiment 2. Unlike the intermediate-level participants, the elementary-level group was clearly affected by the mode of input for correct understanding, but not affected for the response speed. Given that Experiment 2 and Experiment 3 employed high-familiarity words and the participants had familiarized the target words beforehand with a word list in Experiment 3, the elementary-level JEFLLs' phonological representation in their mental lexicon may store some inaccurate information (Yokokawa, 2009). In addition, considering that inaccurate answers were eliminated from the data in Experiment 3, their delayed access of the mental lexicon and/or phonological representation could have directly led to their failure of both written and spoken sentence comprehension.

6. Experiment 4

Findings from Experiments 1, 2 and 3 indicate (1) elementary and intermediate-level JEFLLs don't always succeed in meaning-syntax mapping especially when animacy information aren't available, (2) the factor hampering JEFLLs' successful sentence comprehension was their nonautomatic syntactic processing. In other words, facilitated meaning-syntax mapping plays a vital role in the improvement of their L2 sentence comprehension. Previous studies have obviously demonstrated that repeated exposure facilitates sentence processing. Also, structural priming in comprehension research showed the evidence that exposure to the same syntactic structure accelerates the subsequent sentence processing with the same structure.

Although a previous study examining the repeated exposure effects on JEFLLs' sentence processing provided positive results, the stimuli used in the study were partly insufficient. To date, also, the lasting effects of the exposure toward JEFLLs on sentence comprehension have not been investigated. Therefore, strictly controlled stimuli were created for Experiment 4, the same number of noun phrase and the same number of Yes / No answers between SRCs and ORCs. Furthermore, verifying points of the confirmation sentence between the two clause types are controlled in a careful manner so as to prevent readers from using reading strategy. Also, to control the conditions between the two groups regarding words and the level of complexity of structures, the current study applies the same confirmation sentences for the two groups. As a result, during the exposure session both groups read sentences that are constructed with the same words.

As for facilitation of sentence processing, recent studies have revealed that context and topicality affect the relative clause processing. Especially for ORCs, the topicality of the noun phrase in the relative clause determines the difficulty of the sentence processing. During the exposure session, sentences with high topicality for the noun phrase in the relative clause are utilized so that participants could improve their ORC reading performance.

6.1 Purpose and Research Questions

As mentioned above, Experiment 4 aimed to investigate the effects of repeated exposure to relative clauses on JEFLLs' relative clause processing. This experiment also examined whether the repeated exposure effects persist one day after the exposure. As such, the following research

questions were posed:

RQ7: Does repeated exposure to relative clauses facilitate JEFLLs' relative clause processing immediately after the exposure?

RQ8: Do the repeated exposure effects on JEFLLs' relative clause processing persist one day after the exposure?

RQ 9: Does the same number of exposure to SRCs and ORCs equally affect JEFLLs' SRC and ORC reading performance?

RQ 10: Does the distribution of facilitated exposure effects between SRCs and ORCs remain the same one day after the exposure?

6.2 Participants

The participants in Experiment 4 consisted of 60 undergraduates who belonged to intermediate- or elementary-level English classes at a university. All were native speakers of Japanese. The data obtained from the participants whose TOEIC® IP Test scores were between 400 and 600 out of 990 were analyzed. Five participants were excluded from the analysis due to their out-of-range scores. In addition, one participant was excluded from analysis because of absence in his second-day session. Another eight participants were excluded because their mean comprehension accuracy in either of the pre-, post- or delayed-post-test was less than 33%. Wells et al. (2009), conducting a similar experiment, excluded those participants whose mean comprehension accuracy across all items was 75% or below on either the pre- or the post-test. They reported that some participants rushed through the test sentences without reading carefully and answered "yes" to every comprehension question without regard to actual sentence content. Following their exclusion criteria, the current study, targeting non-native speakers of English, retained only those participants who had comprehension accuracy above 42% on pre-, post- and delayed-post-tests, because those participants appeared to have conscientiously performed all tasks in the test sessions.

As a result, data from 46 participants, 25 in the relative clause sentence experience group (mean TOEIC® IP Test score: 502.8, score range: 435-600, *SD*: 47.11) and 21 in the contrast sentence experience group (mean TOEIC® IP Test score: 490.7, score range: 400-580, *SD*: 50.78), were analyzed. No difference was identified between the two groups' TOEIC® IP Test scores, with a *t*-test

($t(44)=.837$, $p=.407$, *ns*).

6.3 Materials

6.3.1 Materials for Pre-test, Post-test and Delayed-post-test

Seventy-two pairs of SRC/ORC sentences, totaling 144, were created for the self-paced reading pre-, post-, and delayed-post tests. All of them were split into six different lists, A, B, C, D, E, and F, resulting in 24 sentences in each list. Relative clause sentences in lists A and B used the same words, but the subject/object clause type was inversed. Lists C and D, and E and F, similarly, consisted of the same words, but the clause type, inverse. Either list A or B, C, or D and E or F were presented once to each participant across the three test sessions. For example, one participant read lists B, F, and D, and another, E, B, and C, during their pre-, post-, and delayed-post tests in order to minimize their familiarity with the words during the test sessions. Table 4 shows examples of SRC sentences, (15a), and ORC sentences, (15f), as well as comprehension sentences for SRC, (15b), (15c), (15d), and (15e), and for ORC, (15g), (15h), (15i), and (15j).

All SRC (15a) and ORC (15f) experimental sentences consisted of nine words. The head noun phrase of the SRC always comprised six words and had the form *The noun that verbed the noun* (15a: *The boy that visited the woman*), while the ORC always had the form *The noun that the noun verbed* (15f: *The boy that the woman visited*). The main verb (e.g. *showed*) was always transitive and immediately following the relative clause, such that it was always the seventh word in the sentence. Material after the main verb maintained plausibility and contained a noun phrase, *the noun* (e.g. *the photos)*.

All experimental sentences had minimal plausibility in noun-verb relationships, as the absence of plausibility increases the difficulty of sentence comprehension. The two noun phrases and two verbs, in the main clause and the relative clause, however, were replaceable. By employing replaceable noun phrases between the main clause and the relative clause, participants had to conduct syntactic processing and meaning-syntax mapping for correct understanding. Processing meaning alone could result in wrong comprehension.

Table 4

The Examples of Critical Sentences and Comprehension Sentences

sentence	clause type	*comprehension sentences	yes no
(15) a. The boy that visited the woman showed the photos.	SRC		
b. The boy showed the photos.		[NP_1 V_2 NP_3] **	yes
c. The boy visited the woman.		[NP_1 V_1 NP_2]	yes
d. The woman visited the boy.		[NP_2 V_1 NP_1]	no
e. The woman showed the photos.		[NP_2 V_2 NP_3]	no
f. The boy that the woman visited showed the photos.	ORC		
g. The boy showed the photos.		[NP_1 V_2 NP_3]	yes
h. The woman visited the boy.		[NP_2 V_1 NP_1]	yes
i. The woman showed the photos.		[NP_2 V_2 NP_3]	no
j. The boy visited the woman.		[NP_1 V_1 NP_2]	no

Note. * Comprehension sentences were used to verify readers' comprehension of the relative clauses. **NP_1 means the matrix noun phrase, NP_2, the noun phrase in the relative clause, and NP_3, the object of the main clause. V_1 equals the verb in the relative clause and V_2, the matrix verb

Beyond plausibility, the lexical and other properties of the experimental sentences were controlled in several respects. First, both the head noun and the noun in the relative clause were either *boy, girl, man*, or *woman*. By utilizing such nouns that can serve as either an agent or a theme, comprehenders were required to conduct meaning-syntax mapping accurately. Second, the third noun phrase, namely the direct object of the matrix verb, was always an inanimate noun phrase. By employing a transitive verb and an inanimate noun phrase for the SR and OR main clauses, syntactic structures other than relative clauses were shared between the two clause types. As a result, the level of processing difficulty regarding the main clause can be controlled between the two clause types. Third, no pronouns were used, though they are common in relative clauses, particularly in ORC. Fourth, the relative pronoun was always *that*, though other choices such as *who* or the omission of the relative clause pronoun entirely are also common in natural language. Fifth, most of the words

used in the sentences had more than a 5.0 familiarity rate on a 7-point scale (Yokokawa, 2006; 2009). There were some words whose familiarity rate was lower than 5.0. For those words, word lists with their Japanese translations were prepared for the participants to be familiar with the words before the pre-, post-, and delayed-post-tests. Each list (A, B, C, D, E, and F) was accompanied by a word list. All Japanese translations in the list were printed in red so that they could be concealed when covered with a red polypropylene sheet.

In addition, yes-or-no comprehension sentences were constructed for each experimental sentence in a controlled manner. Each clause type was investigated by four kinds of comprehension sentences, as in (15b), (15c), (15d), and (15e) for SRC and (15g), (15h), (15i), and (15j) for ORC. For example, (15b) consisted of a matrix noun phrase, the matrix verb, and the main clause object noun phrase [NP_1 V_2 NP_3]; (15c), the matrix noun, the relative clause verb, and the relative clause noun [NP_1 V_1 NP_2]; (15d), the relative clause noun, the relative clause verb, and the matrix noun [NP_2 V_1 NP_1]; and (15e), the relative clause noun, the matrix verb, and the main clause object noun [NP_2 V_2 NP_3]. Therefore, the correct answers for the comprehension sentences (15b), (15c), (15d), and (15e) were *yes*, *yes*, *no*, and *no*, respectively.

As for the comprehension sentences for ORC (15f), (15g) consisted of the matrix noun phrase, the matrix verb, and the main clause object noun phrase [NP_1 V_2 NP_3]; (15h), the relative clause noun, the relative clause verb, and the matrix noun [NP_2 V_1 NP_1]; (15i), the relative clause noun, the matrix verb, and the main clause object [NP_2 V_2 NP_3]; and (15j), the matrix noun, the relative clause verb, and the relative clause noun [NP_1 V_1 NP_2]. The correct answers for comprehension sentences (15g), (15h), (15i), and (15j) were, therefore, *yes*, *yes*, *no*, and *no*, respectively. The critical and comprehension sentences are shown in Appendix 9.

6.3.2 Materials for Experience Session

Two sets of stimuli were created to manipulate participants' reading experience, one set each for the relative clause group and the contrast sentence group. During the session for both groups, two sentences were presented simultaneously. According to the topichood hypothesis, the topicality of the relative clause's noun phrase determines the difficulty of relative-clause sentence comprehension. Therefore, the preceding sentence emphasized the noun phrase of the relative clause for the relative clause group's materials, because the study was aiming to facilitate JEFLLs' relative clause

processing.

The materials for the relative clause group consisted of 40 SRCs (16a) and 40 ORCs (17a). Those for the contrast group, such as (16b) and (17b), consisted of 80 texts involving subordinate clauses and complement or conjoined structures but excluding relative clauses. All contrast sentences were made by modifying materials used for the relative clause group. For example, a conjoined structure sentence (16b) was changed from SRC (16a), and a subordinate clause sentence (17b) from ORC (17a). As a result, there was a substantial overlap in the topics and content words across the two sets of materials, although the relative clause and contrast experience materials differed in sentence structure.

Compared to the pre-, post-, and delayed-post-test stimuli, the materials for the experience session were longer and more variable, with many noun and verb phrase modifiers, as well as other pragmatic cues.

(16) a. A president wanted a beautiful garden. The president that hired the gardener ordered a Japanese garden. (Relative Clause group)

b. A president wanted a beautiful garden. Therefore, the president hired the gardener and ordered a Japanese garden. (Contrast group)

c. The president wanted a Japanese garden.

d. The gardener wanted a Japanese garden.

(17) a. The princess was allergic to eggs. The cook that the princess knew made a meal without eggs for her. (Relative Clause group)

b. The princess was allergic to eggs. Because she knew the cook, she asked him to make a meal without eggs. (Contrast group)

c. The princess knew the cook.

d. The princess made a meal.

To reduce potential effects of practice with the yes-or-no question structure of the pre-, post-, and delayed-post-test stimuli, a different comprehension probe structure was used for the experience session materials, specifically, two choices. After each of the experience texts was presented altogether, two statements appeared on the PC monitor, and participants selected which of the two

statements, A or B, was true according to the information in the sentences. The same answer options were applied for both relative clause and contrast groups. This was possible because the experience stimuli for both groups were almost identical in terms of the topic and content words. The numbers of correct answers for "A" and "B" were the same. All the words used in the materials had more than a 4.5 familiarity rate on a 7-point scale (Yokokawa, 2006). An English native speaker checked the sentences used for tests and exposure. The stimuli used during the exposure session are presented in Appendices 10 and 11.

6.4 Procedures

6.4.1 Schedule of Sessions

Before beginning the experiment, participants were informed that their responses were confidential and would not affect their grades. After each participant signed a consent form, they took tests individually. The stimuli were randomly presented on a PC with the psychological experiment software SuperLab Pro Version 5 (Cedrus). Each participant attended four sessions for two days in a row: 1) pre-test, 2) experience session, and 3) post-test on the first day, followed by 4) delayed-post-test on the second day. The spacing of the sessions was designed to assess the immediate and delayed effects of the experience-based learning. In the pre-test session, participants performed the self-paced reading task. After that, participants were assigned to either the relative clause or contrast sentence group. During the experience session, each group read relative clause or contrast sentences, and then chose which of two statements was true according to the information in the sentences. Then, they took post- and delayed-post-tests. The experiment was carried out in a quiet room and lasted approximately 80 minutes on the first day and 20 minutes on the second day.

6.4.2 Pre-test

Materials were presented on a computer screen using a moving window display. The slashes in (19a) for SRC and (19b) for ORC indicate that each sentence type consisted of six regions.

(19) a. The woman /that /respected /the man /announced /the retirement.

b. The woman /that /the man /respected /announced /the retirement.

Figure 7 illustrates an example of the presentation trial flow. At the beginning of the task, participants received instructions that encouraged them to read quickly while maintaining good comprehension. They did not receive feedback on accuracy. Each trial began with "++++" appearing on the screen, which then changed to a series of dashes to start the first round, each dash representing a non-space character in the sentence. Participants pressed the spacebar to replace the first dash with the first word of the sentence. Each subsequent press caused the next word to appear and the previous word to return to a dash. When participants pressed the spacebar after the sentence-final word, a yes-or-no question about the sentence appeared. Participants pressed keys labeled "Yes" or "No" to answer the question. Subsequently, "++++" reappeared to signal the beginning of the next trial.

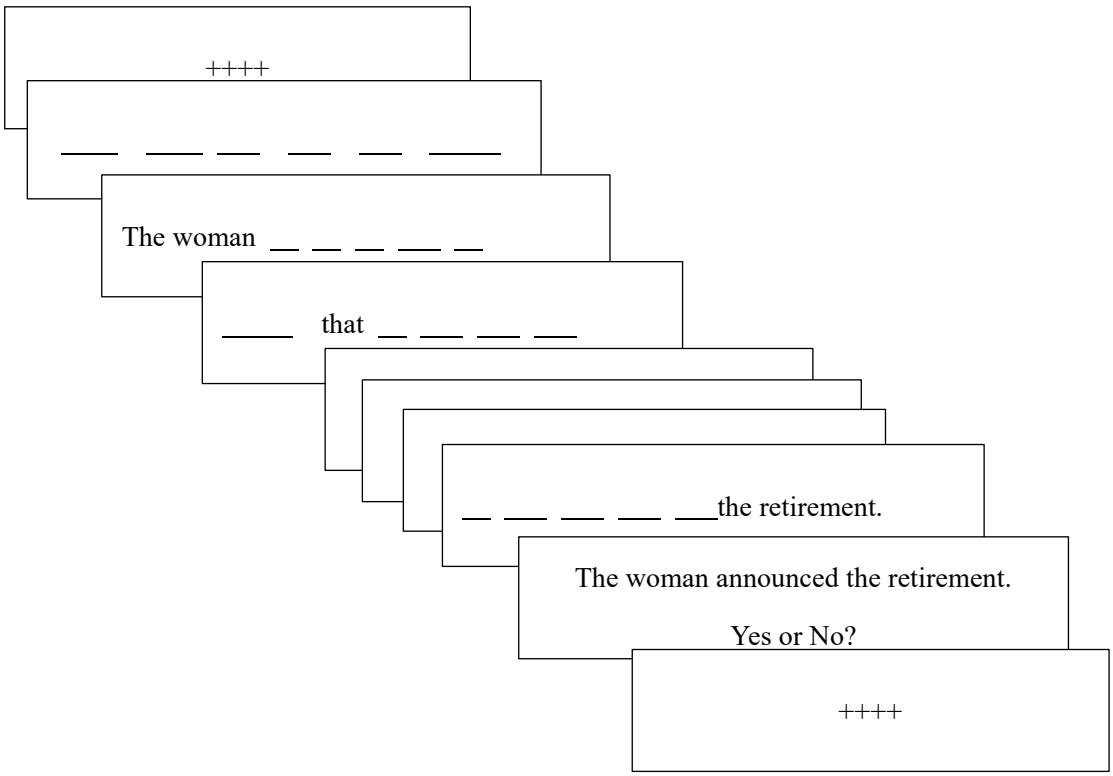

Figure 7. This figure shows the flow of one test session trail on a PC screen.

To illustrate, participants performed the pre-test in the following sequence:

1) Familiarized themselves with the words in the given list. The words' Japanese translations were printed in red, and the English words were in black. A clear red polypropylene sheet was provided so that participants could cover the word list to quiz themselves.

2) Sat in front of a PC and received a fixed set of instructions about the procedure.

3) Familiarized themselves with the self-paced reading task by performing ten practice trials.

4) Each performed 24 trials.

6.4.3 Experience Session

In the experience session, each participant completed 80 trials, which were divided into four blocks of 20 trials. This session presented two whole sentences, in contrast to the single-word presentation of the pre-, post- and delayed-post-test tasks. At the beginning of the task, participants received instructions that encouraged them to read quickly while maintaining good comprehension. After reading the sentences, participants pressed the spacebar, and two statements appeared in two lines. Participants were instructed to select the statement that was true according to the information in the text. Participants pressed a key labeled "A" to choose the A statement or a key labeled "B" to choose the B statement. Participants received feedback about the correct answer. A presentation example of the experience session trial flow is illustrated in Figure 8.

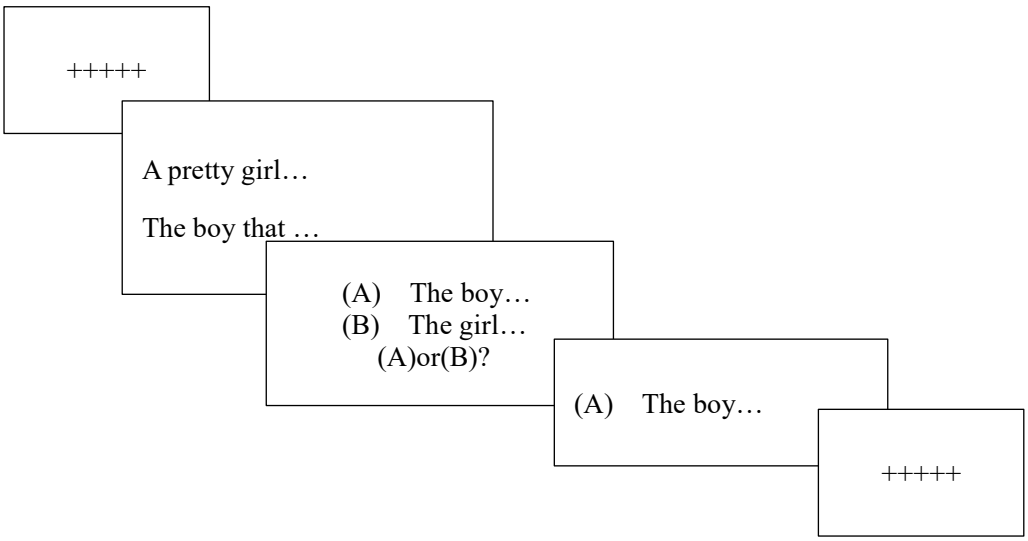

Figure 8. This figure shows the flow of one experience session trail on a PC screen.

To illustrate, the experience session was performed in the following sequence:

1) Sat in front of a PC and received a fixed set of instructions about the procedure.

2) Familiarized themselves with the self-paced reading task by performing five practice trials.

3) Each performed a block of 20 trials, followed by confirmation questions and correct

answers.

4) Rested briefly and recommenced with another block of 20 trials. Repeated this procedure until completing 80 trials.

6.4.4 Post-test and Delayed-post-test Sessions

The procedure of the post- and delayed-post-tests was the same as the pre-test, except for the number of practice trials. No practice trials were given for the post-test, but five practice trials were given for the delayed-post-test.

6.5 Results

6.5.1 Accuracy

Table 5 shows the relative clause and contrast groups' accuracy rates on comprehension questions in the pre-, post-, and delayed-post-tests. First, accuracy rates were analyzed with a Group (2) x Test (3) x Relative Clause Type (2) mixed ANOVA, with Test and Relative Clause Type as the within-participants factors and Group as the between-participants factor. There was no significant interaction of Group, Test, and Clause Type ($F(2,88) = .347$, $p=.708$, *ns*), Clause Type and Test ($F(2,88)=.147$, $p=.864$, *ns*), Test and Group ($F(2,88)=1.471$, $p=.235$, *ns*), nor Clause Type and Group ($F(1,44)=.297$ $p=.589$, *ns*). There was a main effect for Test ($F(2, 88)=22.328$, $p<.000$, partial $\eta^2=.472$). Post hoc comparisons for Test using a Bonferroni correction indicated that the post-test was significantly better than the pre-test ($p<.000$), and that the delayed-post-test was significantly better than the pre-test ($p<.000$).

Second, each group's accuracy rates for each clause type in the pre-, post-, and delayed-post-tests were analyzed with one-way ANOVA. As for the relative clause group, the accuracy rates for SRC on the three tests were significant ($F(2,48)=11.498$, $p<.001$, partial $\eta^2=.324$). Post hoc comparisons with a Bonferroni correction indicated that post-test performance was significantly better than pre-test ($p<.000$), and that the delayed-post-test was significantly better than pre-test ($p<.01$). The accuracy rates for ORC on the three tests were significant ($F(2,48)=8.871$, $p<.001$, partial $\eta^2=.270$). Post hoc comparisons for Test with a Bonferroni correction showed that the post-test was significantly better than pre-test ($p<.01$), and that the delayed-post-test was better than pre-test ($p<.05$).

Table 5

Mean proportion of correct answers (standard deviations) on comprehension questions for SRC and ORC

Group	Pre-test		Post-test		Delayed-post-test	
	SRC	ORC	SRC	ORC	SRC	ORC
Relative	.77 (1.6)	.79 (2.0)	.91 (1.5)	.91 (1.6)	.89 (1.7)	.88 (1.7)
Contrast	.78 (1.8)	.76 (1.8)	.86 (1.8)	.83 (1.9)	.87 (1.5)	.87 (1.4)

The analysis results of the contrast group's SRC performance on the three tests were significant ($F(2,40)=5.276$, $p<.009$, partial $\eta^2=.209$). Post hoc comparisons for Test using a Bonferroni correction demonstrated that the post-test was significantly better than pre-test ($p<.05$), and that the delayed-post-test was better than pre-test ($p<.05$). As for their ORC performance, although accuracy rates on the three tests were significant ($F(2,40)=3.434$, $p<.05$, partial $\eta^2=.147$), post hoc comparisons did not indicate significant difference between the three tests, even though the delayed-post-test was marginally better than pre-test ($p=.08$).

Third, the comparison of accuracy rates at the three tests between the relative clause and contrast groups were made with a *t*-test. In the pre-test, two groups' accuracy rates for both SRC ($t(44)=-.188$, $p=.851$, *ns*) and ORC ($t(44)=.607$, $p=.547$, *ns*) were not significant. In the post-test, neither the SRC ($t(44)=1.308$, $p=.198$, *ns*) nor ORC ($t(44)=1.871$, $p=.068$, *ns*) accuracy rates were significant. The accuracy rates for SRC ($t(44)=.611$, $p=.291$, *ns*) and ORC ($t(44)=.261$, $p=.796$, *ns*) did not indicate significant difference on the delayed-post-test.

Fourth, the comparisons of the accuracy rates between clause types at each test within the groups were made with a *t*-test. No difference was observed on any test, neither the relative clause group's pre-test ($t(24)=-.451$, $p=.656$), post-test ($t(24)=.166$, $p=.870$), and delayed-post-test ($t(24)=.499$, $p=.622$), nor the contrast group's pre-test ($t(20)=.425$, $p=.675$), post-test ($t(20)=.658$, $p=.518$), and delayed-post-test ($t(20)= -.129$, $p=.898$).

6.5.2 Self-paced Reading Times

All analyses of reading times for the pre-, post-, and delayed-post-tests included only those trial rounds in which the comprehension question was answered correctly. Prior to analysis, any

response latency longer than 7,000 millisecond (ms) and shorter than 100 ms were considered outliers and deleted from the analysis. Among accurate responses, for each test session within the group, the cutoff value was calculated by adding the average response latency + 2.5*SD*. Then, the response latency that was not within the boundary value was replaced with the cutoff value (*M*+2.5*SD*).

The sentences consisted of six regions (e.g. SRC: *The woman /that /respected /the man /announced /the retirement*; ORC: *The woman /that /the man /respected /announced /the retirement*). The first region was the head noun phrase, and Region 2 was the relative pronoun *that*. In Region 3, the SRC contained the embedded verb *respected*, whereas the ORC had the embedded subject noun phrase *the man*. Region 4 involved embedded subject noun phrase *the man* for SRC, and embedded verb *respected* for ORC. The fifth and sixth regions were identical for both sentence types. Region 5 contained the main verb *announced*, and Region 6 contained the next two words of the sentence.

To investigate the changes in reading speed from the pre- to the post- and the delayed-post-tests, the reading times in Region 5, the main verb (e.g. *announced*), were compared. Previous studies (Wells et al., 2009; Sakakibara & Yokokawa, 2015) claimed that the differences in reading performance were reflected in the main verb region, because the gap-filling processing of relative clause sentences is supposed to be conducted here. Like previous studies' analyses, this study compared the reading times of the main verb.

Reading times in Region 5 for the relative clause group are shown in Figure 9 and the contrast group, Figure 10. These figures indicate the mean reading times for SRC (dotted line) and ORC (solid line) of the pre-, post- and delayed-post-tests. As for the relative clause group, SRC's reading times at Region 5 (*announced*) in the pre-, post-, and delayed-post-tests were 1396.8 (*SD*:1006), 979.1(*SD*:672), and 1030.9 (*SD*:789), respectively. Their ORC's reading times were 1670.1 (*SD*: 1155), 1310.3 (*SD*: 904), and 1098 *(SD*: 755), respectively. For the contrast group, SRC's reading times at Region 5 in the pre-, post-, and delayed-post-tests were 1422.3 (*SD*: 933), 1372.8 (*SD*: 1063), and 1068.9 (*SD*: 744), and their ORC's were 1861.9 (*SD*: 1192), 1375.3 (*SD*: 1049), and 1395.4 (*SD*: 1059), respectively.

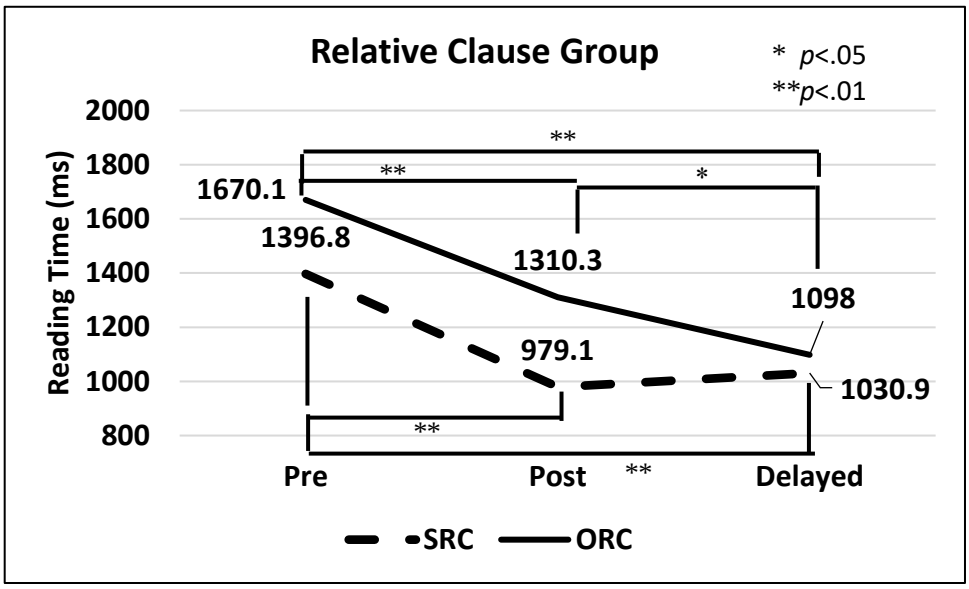

Figure 9. This figure shows the Relative Clause group's mean reading times for SRC and ORC.

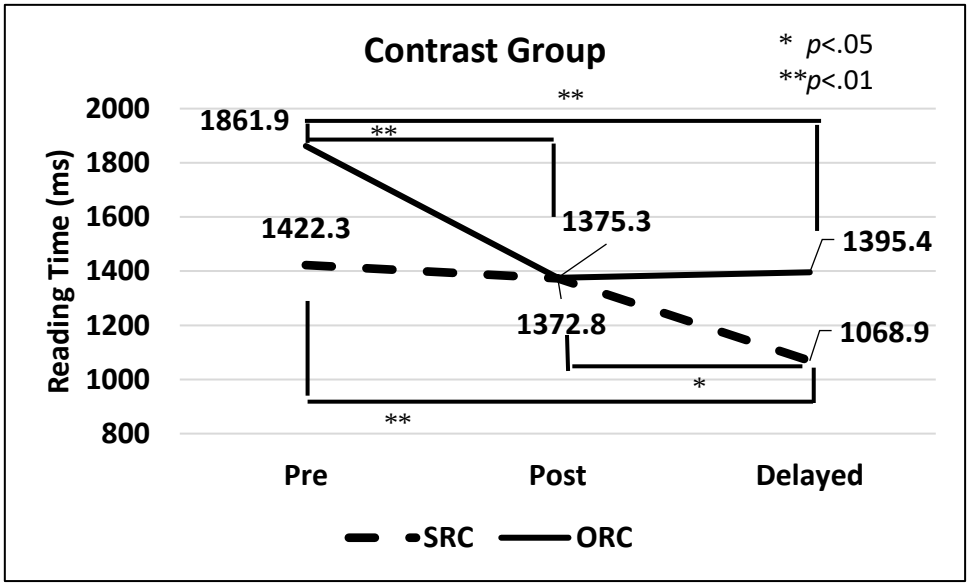

Figure 10. This figure shows the Contrast group's mean reading times for SRC and ORC.

First, Region 5's reading times were analyzed with a Group (2) x Test (3) x Relative Clause Type (2) mixed ANOVA, with Test and Relative Clause Type as the within-participants factors and Group as the between-participants factor. There was significant three-way interaction of Group, Test, and Clause Type ($F(1.976, 689.530) = 5.543$, $p<.01$, partial $\eta^2=.016$). However, no interaction was observed between Clause Type and Test ($F(2,698)=1.934$, $p=.145$, *ns*), Test and Group ($F(1.939, 676.618)=.343$, $p=.703$, *ns*), or Clause Type and Group ($F(1,349)=.466$ $p=.495$, *ns*). There were main

effects for Group (F(1,349)=12.126, p<.01, partial $\eta 2$=.034), reflecting the relative clause group's faster performance, as well as Test (F(1.939, 676.618)=39.209, p<.000, $\eta 2$=.101) and Relative Clause Type (F(1, 349)=42.163, p<.000, $\eta 2$=.108), showing that participants read SRCs faster than ORCs. Post hoc comparisons for Test using a Bonferroni correction indicated that the post-test was significantly better than the pre-test (p<.000), that the delayed-post-test was significantly better than the pre-test (p<.000), and that the delayed-post-test was marginally better than the post-test (p=.08).

Second, each group's reading times in Region 5 for each clause type in the pre-, post-, and delayed-post-tests were analyzed with one-way ANOVA. The relative clause group's reading times for SRC on the three tests were significant (F(1.890, 413.886)= 19.105, p<.000, partial $\eta 2$=.080). Post hoc comparisons for Test with a Bonferroni indicated that the relative clause participants read the main verb in the post-test significantly faster than that in the pre-test (p<.000), and read faster in the delayed-post-test than the pre-test (p<.000). Their reading times for ORC on the three tests were significant (F(1.889, 417.365)= 21.022, p<.000, partial $\eta 2$=.087). Post hoc comparisons for Test with a Bonferroni correction illustrated that the relative clause participants read the main verb faster in the delayed-post-test than the post- (p<.05) and the pre- (p<.000) tests, and read faster in the post-test than the pre-test (p<.001).

The contrast group's reading times for SRC in three tests were significant (F(1.877, 337.839)= 8.047, p<.001, partial $\eta 2$=.043). Post hoc comparisons for Test indicated that the reading time in the delayed-post-test was significantly faster than that in the pre-test (p<.000) and the post-test (p<.005). Their reading times for ORC in the three tests were significant (F(2, 320)= 10.330, p<.000, partial $\eta 2$=.061). Post hoc comparisons showed that the Contrast group's participants read the main verb significantly faster in the delayed-post-test than the pre-test (p<.001) and faster in the post-test than the pre-test (p<.000).

Third, t-test comparisons were made of each groups' reading times for different clause types at Region 5. In the pre-test, Region 5 in SRC was read faster than ORC for the relative clause group (t(210)=- 2.758, p<.01) and contrast group (t(166)= -3.744 p<.000). In the post-test, a difference was observed for the relative clause group (t(260)=-5.100, p<.000), reflecting that they read SRC main verbs faster than ORC, whereas no difference was identified for the contrast group (t(183)=-1.355, p=.177). In the delayed post-test, the difference disappeared for the relative clause group (t(254)= -1.278, p=.203), but a difference was observed for the contrast group (t(205)= -3.507, p<.001),

indicating that the contrast group read SRC main verbs faster than ORC.

Table 6 compares results of each group's accuracy and reading time at Region 5 on the three tests. Table 7 depicts the statistical comparison results of each group's accuracy and reading time at Region 5 between the clause types, SRC and ORC.

Table 6

Accuracy and Reading Time at Region 5 Between Tests

	Accuracy		**Reading time at Region 5**	
Group	**SRC**	**ORC**	**SRC**	**ORC**
Relative	pre<post=delay	pre<post=delay	pre>post=delay	pre>post>delay
Contrast	pre<post=delay	pre=post=delay	pre=post>delay	pre>post=delay

Notes. In the Accuracy column, "< " means "significantly less amount of accuracy < greater amount of accuracy" and "=" means "not different significantly." In the Reading time at Region 5 column, ">" indicates "significantly slower > faster" and "=" means "not different significantly."

Table 7

Accuracy and Reading Time at Region 5 Between Clause Types

	Accuracy		**Reading time at Region 5**	
Test	**Relative**	**Contrast**	**Relative**	**Contrast**
Pre-test	SRC=ORC	SR=OR	SR＜OR	SR＜OR
Post-test	SR=OR	SR=OR	SR＜OR	SR=OR
Delayed-test	SR=OR	SR=OR	SR=OR	SR＜OR

6.6 Discussion

The purpose of Experiment 4 was to investigate the effects of repeated exposure to relative clauses on JEFLLs' relative clause processing. This experiment also examined whether the repeated exposure effects persist one day after the exposure, and whether the experience affects the asymmetry of processing difficulty between SRC and ORC. In order to examine the repeated exposure effects on relative clause sentence processing, exposure sentence was manipulated between Relative Clause group and Control group.

Main findings of the study showed that repeated exposure to relative clauses facilitate JEFLLs' relative clause sentence processing immediate after the exposure and the facilitated effects persisted for one day after the exposure. In this section, I explain the findings by referring to Table 6 and 7.

First, I discuss accuracy rate results. As shown in Table 6, the relative clause group answered more accurately on the post- and delayed-post-tests than the pre-test for SRC and ORC, but no difference was observed between the post-test and the delayed-post-test. On the other hand, the contrast group's accuracy rates indicate that the post- and delayed-post tests were significantly better than the pre-test for SRC, whereas no difference was detected for ORC. The relative clause group seemed to answer more accurately at first sight but, in fact, the two groups' accuracy rates were not bad, between 77% and 91%. Given the probability of mistakes, this may reflect the ceiling effect for accuracy. As Table 6 summarizes, no difference was observed between the two groups. The results obtained from accuracy rates suggest that the stimuli were easy enough for the participants to understand. However, the four research questions require analyzing reading times and accuracy rates together. By doing so, the effects of repeated exposure on on-line processing can be clarified.

6.6.1 Does Repeated Exposure Facilitate Relative Clause Processing Immediately After the Exposure?

As summarized in Table 6, the relative clause group's reading times and accuracy rates between pre- and post-tests show that participants answered more accurately and read sentences faster on the post-test than the pre-test for both SRC and ORC. On the other hand, the contrast group's reading times and accuracy rates between pre- and post-tests demonstrate the trade-off between accuracy and reading fluency. For example, regarding SRC, the contrast group answered more accurately on the post-test than the pre-test, but the processing speed, reflecting reading fluency, did not show a difference between the pre- and post-tests. Similarly, for ORC, they read the main verb on the post-test faster than in the pre-test, but no difference was observed regarding accuracy. These results clearly demonstrate that repeated exposure to relative clauses facilitates relative clause processing immediately after the exposure (RQ7). The contrast group's facilitated ORC processing is discussed in section 6.6.3.

6.6.2 Do the Repeated Exposure Effects on Relative Clause Processing Persist for One Day After the Exposure?

The reading time comparison between the post- and delayed-post-tests in Table 6 indicates that the relative clause group read the ORC's main verb faster on the delayed-post-test than the post-test, and that the facilitated effect in the post-test continued through the delayed-post-test. As for their reading time and accuracy for SRC, their facilitated effects in the post-test persisted in the delayed-post-test. Therefore, the positive effects on the relative clause groups' SRC processing persisted for one day after the exposure. Effects on ORC further increased one day after the exposure. The results indicate that the repeated exposure caused syntactic priming effects. As previous studies claimed, syntactic priming during comprehension is characterized by the facilitated comprehension of a syntactic structure after comprehenders recently encountered the same structure (Thothathiri & Snedeker, 2008b; Wells et al., 2009; Sakakibara & Yokokawa, 2015).

The contrast group's reading times in Table 6 shows that their SRC processing speed was further increased in the delayed-post-test, compared to the post-test. Additionally, their accuracy on SRCs was the same between the post- and delayed-post-test, meaning that effects persisted for one day after exposure. However, they did not show improved accuracy for ORC, reflecting no exposure effects for ORC.

Even though the contrast group participants were not exposed to SRCs during the experience session, their SRC reading speed at Region 5, the matrix verb, was facilitated. This result may be explained in part by the stimuli's syntactic structure in the experience session. The stimuli contrast group read were sentences reconstructed from the stimuli used for relative clause group. Both groups' stimuli shared content words and the topic. In the process of sentence reconstruction, all the relative clause sentences were rephrased and some were changed into a conjoined structure. For example, some SRCs (e.g. A pretty girl was reading in a park. The boy that watched the girl fell in love.) were changed into a conjoined structure (e.g. A pretty girl was reading in a park. The boy watched the girl and fell in love.). In the center-embedded subject relative clause sentences, the head noun phrase is the subject of the main clause and the subject of the relative clause, and their θ-roles or thematic roles are Agent. Therefore, comprehenders can read the sentence without being bothered by reassigning the syntactic role, nor θ-role to the subject NP. This syntactic feature involved in the contrast stimuli may have enabled contrast group participants to facilitate their SRC processing,

leading to no significant difference between the two groups' SRC processing.

In contrast, in the center-embedded object relative clause sentences, the head noun phrase is both the subject of the main clause and the object of the relative clause, and their θ-roles are Agent and Theme, respectively. As a result, ORC construction requires comprehenders to conduct unique processing. The contrast group did not improve their ORC processing, because they were not given a chance to conduct a double θ-role assignment during the experience session.

One question arises from the result, " why was ORC processing more facilitated one day after the exposure instead of immediately after?." The result may, in part, be explained by Nieuwenhuis, Folia, Forkstam, Jensen, and Petersson's (2013) result examining the effects of sleep on grammar learning. Their study employed Reber Grammar (Reber, 1967), an artificial grammar, and divided participants into a wake group and a sleep group. Based on the result, the sleep group's better performance, they claim that sleep plays a critical role in extracting complex structure from separate but related items during integrative memory processing. Actually, the number of study examining the effects of sleep on grammar learning is not enough, and therefore the relationship between sleep and grammar learning should be examined in the future study. However, in the present study, the sleep could promote ORC processing.

Taken together, the findings suggest that repeated exposure promotes JEFLLs' automatization and implicit learning of L2 sentence processing and that the learning effects persist (RQ8). Additionally, exposure alone to regular English constructions that share θ-role assignments can facilitate JEFLLs' SRC sentence processing.

6.6.3 Do Immediate and Delayed Repeated Exposure Effects Distribute Equally Between Subject Relative and Object Relative Clauses?

As Table 7 summarizes, the relative clause group read SRC's matrix verb faster than the ORC's on both pre- and post-tests. However, the asymmetrical processing difference between the two clause types disappeared on the delayed-post-test. The comparisons of reading time and accuracy between tests within groups (Table 6) show that the relative clause group demonstrated significant exposure effects for SRC and ORC on their post-test. Furthermore, on the delayed-post-test, they displayed a persistent effect for SRC and increased effect for ORC. These findings indicate that the immediate effects distribute equally between SRC and ORC (RQ9). However, delayed repeated exposure effects

does not distribute symmetrically between SRC and ORC, in specific, participants gained the best effects for ORC (RQ10).

This tendency, the so-called "inverse frequency effect," is characterized by less frequent syntactic structure being more primed than the frequent one. Jaeger and Snider (2007) explained that prediction errors based on comprehenders' experience lead to more learning. Similarly, previous studies (e.g. MacDonald & Christiansen, 2002; Wells et al., 2009) claimed that this phenomenon is evidence of implicit learning, because just a transient activation of the syntactic combinatorial nodes cannot explain this tendency. Taken together, repeated exposure enhanced automatization and promoted implicit learning for the relative clause group's meaning-syntax mapping.

The contrast group's reading times between SRC and ORC, on the other hand, showed that participants read SRCs' main verb faster than ORCs' on the pre-test (Table 7). However, the asymmetrical processing difficulty vanished on the post-test. Additionally, as shown in Table 6, their processing speed for ORC got faster on the post-test compared to the pre-test. This result seems confusing because the contrast group did not read ORCs during the experience session. A possible explanation for this is learning effects from the pre-test session because the session was the only chance for the contrast group to read ORCs. However, no difference was illustrated as for their ORC reading time between the post- and the delayed-post-tests (Table 6). Moreover, their SRC and ORC reading times were significantly different on the delayed-post-test (Table 7). The data suggest that if the amount of exposure experience is not enough, the exposure effects do not persist.

The results provide a promising solution to JEFLLs' difficulty with sentence processing, namely meaning-syntax mapping. A 40-minute experience-based learning session, an exposure to just 80 relative clauses, showed positive effects in promotion of elementary- and intermediate-level JEFLLs' on-line relative clause processing. Furthermore, even though the contrast group participants did not read relative clause sentences during the exposure session, they also demonstrated some improvement on their on-line SRC processing. These results clearly indicate that familiarizing themselves with English sentences, such as through extensive reading, should result in remarkable enhancement of JEFLLs L2 sentence processing. In addition, language teachers need to make sure that learning materials contain well-designed discourse information.

7. General Discussion

7.1 Summary of the Study

This psycholinguistic study aimed to examine the JEFLLs' sentence processing mechanism, especially their meaning-syntax mapping. The current study also investigated interaction effects of different modalities and proficiency on JEFLLs' sentence comprehension. Another goal was to determine the effects of experience-based learning on JEFLLs' on-line relative clause processing.

Toward that end, Experiment 1 explored whether intermediate-level JEFLLs successfully conduct syntactic processing and also tested the effects of different modalities, listening and reading, on their comprehension. To determine to what extent they rely on animacy information during their meaning-syntax mapping, the current study employed the center-embedded object relative clause sentences as stimuli and manipulated the animacy of the head noun. The results illustrated that intermediate-level JEFLLs can understand spoken and written ORC sentences to some extent by utilizing animacy information even though the accuracy rates were not good enough. The different modality didn't affect their construction of syntactic-semantic structures.

However, Experiment 1 failed to investigate the effects of English proficiency on their ORC processing. Japanese English classrooms are, however, made up of students whose English proficiencies are different, and therefore, the interaction effects of proficiency and modality on sentence processing need to be examined. Therefore, Experiment 2 targeted elementary-level JEFLLs and explored their ORC sentence processing by employing the same stimuli as Experiment 1. Experiment 2 illustrated that elementary-level JEFLLs were poorer at listening than reading. Moreover, although their use of animacy information was similar to that of intermediate-level ones, the elementary-level JEFLLs showed heavy dependency on world knowledge and word meaning. The results from Experiment 2 raised questions whether they successfully constructed syntactic-semantic structures and understood ORCs. Actually, ORC structure requires comprehenders to conduct multiple processing, such as gap-filling processing, double θ-role assignment and meaning-syntax mapping. To clear the question whether the proficiency and input modalities affect JEFLLs' successful meaning-syntax mapping in sentence comprehension, stimuli with a simpler syntactic structure were necessary.

Experiment 3, therefore, used a passive structure to clarify the question whether the elementary-

level JEFLLs can syntactic processing without heavily depending on semantic information. Comprehending passives requires morphosyntactic processing and meaning-syntax mapping. By introducing picture verification task, Experiment 3 analyzed the accuracy and respond latency. The manipulation of the stimuli was the animacy status of two noun phrases in both passives and actives, namely two animate nouns or an animate and an inanimate nouns. Another purpose of Experiment 3 was to reveal the effects of proficiency and modalities on JEFLLs' meaning-syntax mapping. The results clarified that the intermediate-level JEFLLs can understand passives and can conduct meaning-syntax mapping, and the modality doesn't affect their comprehension. On the other hand, the elementary-level JEFLLs failed to correctly understand passives if they can't utilize animacy information, meaning they can't complete meaning-syntax mapping for passive comprehension. They are also poorer at listening than reading.

The findings from Experiments 1, 2 and 3 revealed that the intermediate-level JEFLLs' have difficulty with meaning-syntax mapping during ORC comprehension and the elementary-level, ORCs and passives. To have JEFLLs acquire good reading and listening skill, improving their meaning-syntax mapping is indispensable. Finding some effective and reliable learning methods can be pedagogically significant. According to previous studies, repeated exposure facilitates comprehenders' sentence processing. Moreover, discourse is a strong factor to promote their comprehension.

Then, Experiment 4 investigated the effects of experience-based learning with relative clauses on elementary- and intermediate-level JEFLLs' relative clause processing. This experiment also examined whether the repeated exposure effects persist one day after the exposure, and whether the experience affects the asymmetry of processing difficulty between SRC and ORC. The stimuli were carefully constructed to provide discourse information. Importantly, this study is the first to examine whether the repeated exposure effects persist one day after the exposure. The results indicated that the repeated exposure, even just 80 sentences, positively improves JEFLLs' relative clause on-line processing. Furthermore, Experiment 4 detected "inverse frequency effects," commonly observed in L1 syntactic priming study and could be the evidence of implicit learning, in JEFLLs relative clause processing.

7.2 Intermediate-level and Elementary-level JEFLLs' Sentence Processing

Experiment 1 shows that the intermediate-level JEFLLs have difficulty with comprehending ORCs if they can't utilize animacy information. The results indicated that they can process semantic information almost automatically, but they are poor at syntactic processing, such as gap-filling, two θ-role assignments in parallel and meaning-syntax mapping. However, as Experiments 1 and 3 illustrate, if the required syntactic processing is just morphosyntactic information, their processing is almost automatic. In addition, they don't have asymmetrical difficulty with processing auditory and visual information.

On the other hand, the elementary-level JEFLLs can't understand ORCs if semantic information is not available as Experiment 2 indicated. The results from Experiment 3 revealed that even though the required processing is simple syntactic information, morphosyntax, they don't always succeed in comprehension. They depend on world knowledge and word meaning too much to conduct meaning-syntax mapping. They are also poorer at processing auditory than visual information. The finding indicates that they are not trained nor exposed to enough spoken languages.

7.3 Pedagogical Implication

What kind of instruction would enable elementary-level JEFLLs to develop into intermediate-level, and intermediate-level JEFLLs to advanced-level? Based on the results from Experiments 1, 2 and 3, modality effects were found in elementary-level, but not in the intermediate-level JEFLLs. The findings suggest that the elementary-level JEFLLs should be exposed to spoken English sentences more than written ones. Furthermore, they must register accurate phonological representation in their mental lexicon. Their poor listening performance could be attributed to their wrong phonological information in their mental lexicon.

Next, they need to be exposed to English sentences as much as possible. Based on Levelt's (1993) speaking model, comprehenders retrieve information, such as morphological, syntactic, and semantic information, by accessing mental lexicon. In Experiment 1, additionally, they conducted several processing, such as gap-filling processing, double θ-role assignment and meaning-syntax mapping. Importantly, when semantic information was not available, they didn't always comprehend ORCs. Their comprehension failure suggests that they should become more familiar with natural speed of English and conduct meaning-syntax mapping in real time. As Experiment 4 presented, a

lot of exposure to English sentences allow them to achieve speedy retrieval and develop automatized syntactic processing skills.

8. Conclusion and Further Research

The results of the present study suggest that both different input modalities and levels of English proficiency interact and affect JEFLLs' accurate comprehension of English sentences. Additionally, the lower their proficiency is, the heavier their dependency on the semantic information is. The results also indicate that repeated exposure to relative clauses promote JEFLLs' automatization in sentence comprehension immediately and one day after the exposure.

Future studies should examine whether repeated exposure has long-lasting and stable effects, for example after one week, one month, or one year. In addition, by confirming the effects of repeated listening to certain constructions, we could find a promising method to boost JEFLLs' listening comprehension, indispensable skill for effective communication.

Also, neurobehavioral tests should be conducted to investigate whether experience-based learning influence neural areas which are linked to semantic and syntactic processing. Noppeney and Price (2004) conducted self-paced reading and fMRI experiments with the same stimuli to investigate the neural behavior of syntactic priming. Following the method of their study, we could explore how JEFLLs' sentence processing is automatized and promoted during the repeated exposure.

In conclude, this research was the first in terms of several points. First, to date, no study has revealed how English proficiency levels and different modalities affect JEFLLs' meaning-syntax mapping. Second, this study provides promising solution to JEFLLs' sentence processing problems. A 40 minutes experience-based learning session, an exposure to just 80 relative clauses, showed positive effects to improve elementary- and intermediate-level JEFLLs' on-line relative clause processing. Furthermore, even though the control group participants didn't read relative clause sentences during the exposure session, they also demonstrated some improvement on their on-line SRC processing. These results clearly indicate that getting familiar with English sentences, like extensive reading should result in remarkable enhancement of JEFLLs L2 sentence processing.

I envisage this study has pedagogical implications for English teachers, as well as benefits for JEFLLs. This study showed that the repeated exposure is one of the reliable learning methods to facilitate their on-line sentence comprehension. In addition, I hope this study can contribute to establishing effective instructional methods in the field of English language education.

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Appendices

Appendix 1. Critical Sentences and Questions for Experiments 1 and 2

Animate object-relative clause sets

The manger that the staff called played tennis.

Q: Did the staff call the manager?

The child that the person called drank a glass of milk.

Q: Did the person call the child?

The visitor that the leader contacted supported the fact.

Q: Did the leader contact the visitor?

The cameraman that the assistant supported gave him a present.

Q: Did the assistant support the cameraman?

The boy that the girl helped passed the examination.

Q: Did the girl help the boy?

The worker that the chief invited attacked her.

Q: Did the chief invite the worker?

The writer that the worker angered wrote the story.

Q: Did the worker anger the writer?

The lady that the scientist looked after ate dinner.

Q: Did the scientist look after the lady?

The guy that the woman called went into the forest.

Q: Did the woman call the guy?

The king that the prince killed carried a cat.

Q: Did the prince kill the king?

Inanimate object-relative clause sets

The carpet that the manager spread satisfied his boss.

Q: Did the manager spread the carpet?

The software that the scientist repaired damaged the train's network.

Q: Did the scientist repair the software?

The performance that the worker worked on enjoyed great success.

Q: Did the worker work on the performance ?

The tickets that the teacher requested included cheap seats.

Q: Did the teacher request the tickets?

The package that the queen expected included an expensive pot.

Q: Did the queen expect the package?

The dream that the prince talked about came true.

Q: Did the prince talk about the dream?

The machine that the worker repaired manufactured excellent cheese.

Q: Did the worker repair the machine?

The orange light that the specialist used damaged the stage.

Q: Did the specialist use the orange light?

The cultural education that the child received influenced his life.

Q: Did the child receive the cultural education?

The newspaper that the woman published covered the western area.

Q: Did the woman publish the newspaper?

Appendix 2. Answer Sheet for Listening Experiments 1 and 2 : Original Version (Excerpt)

内容理解確認テスト　　月　　日　実施

【学籍番号　　】【名前　　】【男　・　女】

短い英語の文が読まれ、続いてその文の内容について英語で質問されます。

あまり考え込まずに、「その通りである」場合は「Yes」、違っていれば「No」を、〇で囲んでください。消しゴムは使用せずに、間違った方に×正しい方を〇で囲んでください。解答用紙の「6 秒」の箇所にはおよそ 6 秒の間があります。計 85 問で、所要時間は約 20 分です。

練習質問に答えてください。	
練 1	Yes　・　No
練 2	Yes　・　No
練 3	Yes　・　No

問題

	質問に答えてください。
1	Yes　・　No
2	Yes　・　No
3	Yes　・　No
4	Yes　・　No
5	Yes　・　No
6	Yes　・　No
7	Yes　・　No
8	Yes　・　No
9	Yes　・　No
10	Yes　・　No
11	Yes　・　No
	6 秒
12	Yes　・　No
13	Yes　・　No
14	Yes　・　No
15	Yes　・　No
16	Yes　・　No
17	Yes　・　No
18	Yes　・　No
19	Yes　・　No
20	Yes　・　No
21	Yes　・　No
22	Yes　・　No
23	Yes　・　No
24	Yes　・　No
	6 秒
25	Yes　・　No
26	Yes　・　No
27	Yes　・　No
28	Yes　・　No
29	Yes　・　No
30	Yes　・　No
31	Yes　・　No
32	Yes　・　No

Appendix 3. Answer Sheet for Listening Experiments 1 and 2 : Translated Version in English (Excerpt)

Comprehension Test　　Date

【student number　　】【name　　】【male ・ female】

First, you listen to an English sentence, and then you are asked about the content of the sentence in English.
If you think " that's right, " circle "Yes." Otherwise, circle "No." Don't use an eraser. If you want to change your answer, cross out the wrong answer, and then circle your new answer. You can see "6seconds" on the answer sheet. At the time, there is a 6- second pause. There are 85 questions in total, and it takes about 20 minutes.

Practice Answer the question	
Pra1	Yes ・ No
Pra2	Yes ・ No
Pra3	Yes ・ No

Questions

	Answer the question
1	Yes ・ No
2	Yes ・ No
3	Yes ・ No
4	Yes ・ No
5	Yes ・ No
6	Yes ・ No
7	Yes ・ No
8	Yes ・ No
9	Yes ・ No
10	Yes ・ No
11	Yes ・ No
	6 seconds

12	Yes ・ No
13	Yes ・ No
14	Yes ・ No
15	Yes ・ No
16	Yes ・ No
17	Yes ・ No
18	Yes ・ No
19	Yes ・ No
20	Yes ・ No
21	Yes ・ No
22	Yes ・ No
23	Yes ・ No
24	Yes ・ No
	6 seconds
25	Yes ・ No
26	Yes ・ No
27	Yes ・ No

Appendix 4. Answer Sheet for Experimenter-paced Reading Experiments 1 and 2 : Original Version (Excerpt)

内容理解確認テスト　　月　　日　実施

【学籍番号　　】【名前　　】【男　・　女】

調査中は全て自動で画面が切り替わりますので、PC 操作は不要です。

まず画面に短い英語の文が表示されますので、素早く読んでください。一定時間後に文字が消えます。続いてその英語の文の内容についての質問が画面に表示されます。画面から質問が消えた後、4 秒以内に回答してください。あまり考え込まずに、「その通りである」場合は「Yes」、違っていれば「No」を、○で囲んでください。消しゴムは使用せずに、間違った方に×正しい方を○で囲んでください。解答用紙の「6 秒」の箇所には 6 秒の間があります。計 85 問で、所要時間は約 20 分です。

練習質問に答えてください。	
練 1	Yes ・ No
練 2	Yes ・ No
練 3	Yes ・ No

問題

	質問に答えてください。
1	Yes ・ No
2	Yes ・ No
3	Yes ・ No
4	Yes ・ No
5	Yes ・ No
6	Yes ・ No
7	Yes ・ No
8	Yes ・ No
9	Yes ・ No
10	Yes ・ No
11	Yes ・ No
	6 秒
12	Yes ・ No
13	Yes ・ No
14	Yes ・ No
15	Yes ・ No
16	Yes ・ No
17	Yes ・ No
18	Yes ・ No
19	Yes ・ No
20	Yes ・ No
21	Yes ・ No
22	Yes ・ No
23	Yes ・ No
24	Yes ・ No
	6 秒
25	Yes ・ No
26	Yes ・ No
27	Yes ・ No
28	Yes ・ No
29	Yes ・ No
30	Yes ・ No
31	Yes ・ No
32	Yes ・ No

Appendix 5. Answer Sheet for Experimenter-paced Reading Experiments 1 and 2 : Translated Version in English (Excerpt)

Comprehension Test　　Date

【student number　　】【name　　】【male ・ female】

During the test, screen changes automatically. You don't need to operate a computer.

First, read an English sentence on the screen as quickly as possible. Then you are asked about the content of the sentence in English. After the question sentence disappear, write your answer on the answer sheet within four seconds. If you think " that's right, " circle "Yes." Otherwise, circle "No." Don't use an eraser. If you want to change your answer, cross out the wrong answer, and then circle your new answer. You can see "6seconds" on the answer sheet. At the time, there is a 6- second pause. There are 85 questions in total, and it takes about 20 minutes.

Practice Answer the question	
Practice1	Yes ・ No
Practice2	Yes ・ No
Practice3	Yes ・ No

Questions

	Answer the question
1	Yes ・ No
2	Yes ・ No
3	Yes ・ No
4	Yes ・ No
5	Yes ・ No
6	Yes ・ No
7	Yes ・ No
8	Yes ・ No
9	Yes ・ No
10	Yes ・ No
11	Yes ・ No

	6 seconds
12	Yes ・ No
13	Yes ・ No
14	Yes ・ No
15	Yes ・ No
16	Yes ・ No
17	Yes ・ No
18	Yes ・ No
19	Yes ・ No
20	Yes ・ No
21	Yes ・ No
22	Yes ・ No
23	Yes ・ No
24	Yes ・ No
	6 seconds
25	Yes ・ No
26	Yes ・ No
27	Yes ・ No

Appendix 6. Critical Sentences for Experiment 3

Each sentence type represents [AA] for active voice and two animate noun phrases, [PA] for passive voice and two animate noun phrases, [AI] for active voice and one inanimate and one animate noun phrases, and [PI] for passive voice and one inanimate and one animate noun phrases.

The beginning of each sentence was “In my opinion.”

Sentence Type	*Match*	*Verb*	*Sentence*
[AA]	○	push	the girl was pushing the boy
[AA]	×	push	the boy was pushing the girl
[PA]	○	push	the boy was pushed by the girl
[PA]	×	push	the girl was pushed by the boy
[AI]	○	push	the boy was pushing the table
[AI]	×	push	the table was pushing the boy
[PI]	○	push	the table was pushed by the boy
[PI]	×	push	the boy was pushed by the table
[AA]	○	touch	the girl was touching the boy
[AA]	×	touch	the boy was touching the girl
[PA]	○	touch	the girl was touched by the boy
[PA]	×	touch	the boy was touched by the girl
[AI]	○	touch	the girl was touching the flower
[AI]	×	touch	the flower was touching the girl
[PI]	○	touch	the flower was touched by the girl
[PI]	×	touch	the girl was touched by the flower
[AA]	○	kiss	the girl was kissing the boy
[AA]	×	kiss	the boy was kissing the girl
[PA]	○	kiss	the boy was kissed by the girl
[PA]	×	kiss	the girl was kissed by the boy
[AI]	○	kiss	the girl was kissing the apple
[AI]	×	kiss	the apple was kissing the girl
[PI]	○	kiss	the apple was kissed by the girl
[PI]	×	kiss	the girl was kissed by the apple

[AA]	○	watch	the boy was watching the girl
[AA]	×	watch	the girl was watching the boy
[PA]	○	watch	the girl was watched by the boy
[PA]	×	watch	the boy was watched by the girl
[AI]	○	watch	the girl was watching the movie
[AI]	×	watch	the movie was watching the girl
[PI]	○	watch	the movie was watched by the girl
[PI]	×	watch	the girl was watched by the movie
[AA]	○	carry	the boy was carrying the girl
[AA]	×	carry	the girl was carrying the boy
[PA]	○	carry	the girl was carried by the boy
[PA]	×	carry	the boy was carried by the boy
[AI]	○	carry	the girl was carrying the chair
[AI]	×	carry	the chair was carrying the girl
[PI]	○	carry	the chair was carried by the girl
[PI]	×	carry	the girl was carried by the chair
[AA]	○	support	the girl was supporting the boy
[AA]	×	support	the boy was supporting the girl
[PA]	○	support	the boy was supported by the girl
[PA]	×	support	the girl was supported by the boy
[AI]	○	pick	the boy was picking the flower
[AI]	×	pick	the flower was picking the boy
[PI]	○	pick	the flower was picked by the boy
[PI]	×	pick	the boy was picked by the flower
[AA]	○	kick	the girl was kicking the boy
[AA]	×	kick	the boy was kicking the girl
[PA]	○	kick	the boy was kicked by the girl
[PA]	×	kick	the girl was kicked by the boy
[AI]	○	kick	the boy was kicking the ball
[AI]	×	kick	the ball was kicking the boy
[PI]	○	kick	the ball was kicked by the boy

[PI]	×	kick	the boy was kicked by the ball
[AA]	○	pull	the boy was pulling the girl
[AA]	×	pull	the girl was pulling the boy
[PA]	○	pull	the girl was pulled by the boy
[PA]	×	pull	the boy was pulled by the girl
[AI]	○	pull	the boy was pulling the door
[AI]	×	pull	the door was pulling the boy
[PI]	○	pull	the door was pulled by the boy
[PI]	×	pull	the boy was pulled by the door
[AA]	○	hug	the boy was hugging the girl
[AA]	×	hug	the girl was hugging the boy
[PA]	○	hug	the girl was hugged by the boy
[PA]	×	hug	the boy was hugged by the boy
[AI]	○	taste	the girl was tasting the chocolate
[AI]	×	taste	the chocolate was tasting the girl
[PI]	○	taste	the chocolate was tasted by the girl
[PI]	×	taste	the girl was tasted by the chocolate
[AA]	○	lift	the boy was lifting the girl
[AA]	×	lift	the girl was lifting the boy
[PA]	○	lift	the girl was lifted by the boy
[PA]	×	lift	the boy was lifted by the girl
[AI]	○	lift	the boy was lifting the box
[AI]	×	lift	the box was lifting the boy
[PI]	○	lift	the box was lifted by the boy
[PI]	×	lift	the boy was lifted by the box
[AA]	○	call	the boy was calling the girl
[AA]	×	call	the girl was calling the boy
[PA]	○	call	the girl was called by the boy
[PA]	×	call	the boy was called by the girl
[AI]	○	turn	the boy was turning the key
[AI]	×	turn	the key was turning the boy

[PI]	○	turn	the key was turned by the boy
[PI]	×	turn	the boy was turned by the key
[AA]	○	help	the girl was helping the boy
[AA]	×	help	the boy was helping the girl
[PA]	○	help	the boy was helped by the girl
[PA]	×	help	the girl was helped by the girl
[AI]	○	pack	the girl was packing the bag
[AI]	×	pack	the bag was packing the girl
[PI]	○	pack	the bag was packed by the girl
[PI]	×	pack	the girl was packed by the bag

Appendix 7. Word Lists Used in Experiment 3 : Original Version

単語リスト

（お名前　　）

1）暗記用赤シートを使用して、英単語を発音しながら、日本語意味が言えるように学習してください。(2 分)

2）最初から知っていた単語、覚えた単語にチェックを入れてください。

	英単語	日本語意味	覚えた
（例）	apple	リンゴ	✔
1	lift	持ち上げる	
2	pick	摘む	
3	pull	引っ張る　引く	
4	hug	抱きしめる	
5	pack	～に詰め込む	
6	pleased	うれしい	
7	shout	叫ぶ	
8	magazine	雑誌	
9	dish	料理、皿	
10	plate	皿	
11	picture	写真	
12	hand	手渡す	
13	smartphone	スマートフォン	
14	carry	（かついだり、持ち上げたり、引きずったりして）運ぶ	
15	turn	回す	

Appendix 8. Word Lists Used in Experiment 3 : Translated Version in English

Word List

（Name ）

1) Remember the Japanese translation of the English words by reading out them.

Please use the red sheet to check if you have remembered the Japanese translation. (two minutes)

2) After you confirm that you have known or remembered the words, please check OK cells.

	English	Japanese	OK
example	apple	リンゴ	✔
1	lift	持ち上げる	
2	pick	摘む	
3	pull	引っ張る　引く	
4	hug	抱きしめる	
5	pack	～に詰め込む	
6	pleased	うれしい	
7	shout	叫ぶ	
8	magazine	雑誌	
9	dish	料理、皿	
10	plate	皿	
11	picture	写真	
12	hand	手渡す	
13	smartphone	スマートフォン	
14	carry	（かついだり、持ち上げたり、引きずったりして）運ぶ	
15	turn	回す	

Appendix 9. Critical Sentences Used in Experiment 4

"Type" means clause type (e.g., S:SRC, O:ORC), "Part" indicates which phrases of the sentence were checked in the comprehension sentence. "Ans" represents the answer for the comprehension sentence.

List A

Type	Sentence	Comprehension Sentence	Part	Ans
S	The boy that left the girl sent the letter.	The boy sent the letter.	NP1/V2/NP3	yes
S	The woman that suspected the man stole the key.	The woman suspected the man.	NP1/V1/NP2	yes
S	The boy that attracted the girl became a star.	The girl attracted the boy.	NP2/V1/NP1	no
S	The girl that called the boy shared the sweets.	The boy shared the sweets.	NP2/V2/NP3	no
S	The woman that checked the man understood the situation.	The woman understood the situation.	NP1/V2/NP3	yes
S	The boy that visited the woman showed the photos.	The boy visited the woman.	NP1/V1/NP2	yes
S	The boy that monitored the girl overcame the difficulty.	The girl monitored the boy.	NP2/V1/NP1	no
S	The girl that approached the boy spoke French.	The boy spoke French.	NP2/V2/NP3	no
S	The woman that chose the man made a mistake.	The woman made a mistake.	NP1/V2/NP3	yes
S	The girl that noticed the man shook hands.	The girl noticed the man.	NP1/V1/NP2	yes
S	The woman that respected the man announced the retirement.	The man respected the woman.	NP2/V1/NP1	no
S	The boy that shocked the woman wrote the article.	The woman wrote the article.	NP2/V2/NP3	no
O	The boy that the woman invited gave the flower.	The boy gave the flower.	NP1/V2/NP3	yes
O	The man that the woman thanked designed the house.	The woman thanked the man.	NP2/V1/NP1	yes
O	The man that the woman controlled caused the problem.	The woman caused the problem.	NP2/V2/NP3	no
O	The girl that the boy carried began the friendship.	The girl carried the girl.	NP1/V1/NP2	no
O	The woman that the boy knew opened the door.	The woman opened the door.	NP1/V2/NP3	yes

O	The man that the woman employed improved the skill.	The woman employed the man.	NP2/V1/NP1	yes
O	The girl that the boy saved enjoyed the lunch.	The boy enjoyed the lunch.	NP2/V2/NP3	no
O	The man that the woman taught admitted the mistake.	The man taught the woman.	NP1/V1/NP2	no
O	The woman that the man fooled lost the money.	The woman lost the money.	NP1/V2/NP3	yes
O	The man that the woman missed moved to Africa.	The woman missed the man.	NP2/V1/NP1	yes
O	The boy that the woman liked cut the cake.	The woman cut the cake.	NP2/V2/NP3	no
O	The girl that the man phoned lent a camera.	The girl phoned the man.	NP1/V2/NP3	no

List B

Type	Sentence	Comprehension check	Part	Ans
O	The boy that the girl left sent the letter.	The boy sent the letter.	NP1/V2/NP3	yes
O	The woman that the man suspected stole the key.	The man suspected the woman.	NP2/V1/NP1	yes
O	The boy that the girl attracted became a star.	The girl became a star.	NP2/V2/NP3	no
O	The girl that the boy called shared the sweets.	The girl called the boy.	NP1/V1/NP2	no
O	The woman that the man checked understood the situation.	The woman understood the situation.	NP1/V2/NP3	yes
O	The boy that the woman visited showed the photos.	The woman visited the boy.	NP2/V1/NP1	yes
O	The boy that the girl monitored overcame the difficulty.	The girl overcame the difficulty.	NP2/V2/NP3	no
O	The girl that the boy approached spoke French.	The girl approached the boy.	NP1/V1/NP2	no
O	The woman that the man chose made a mistake.	The woman made a mistake.	NP1/V2/NP3	yes
O	The girl that the man noticed shook hands.	The man noticed the girl.	NP2/V1/NP1	yes
O	The woman that the man respected announced the retirement.	The man announced the retirement.	NP2/V2/NP3	no
O	The boy that the woman shocked wrote the article.	The boy shocked the woman.	NP1/V1/NP2	no
S	The boy that invited the woman gave the flower.	The boy gave the flower.	NP1/V2/NP3	yes
S	The man that thanked the woman designed the house.	The man thanked the woman.	NP1/V1/NP2	yes
S	The man that controlled the woman caused the problem.	The woman controlled the man.	NP2/V1/NP1	no
S	The girl that carried the boy began the friendship.	The boy began the friendship.	NP2/V2/NP3	no
S	The woman that knew the boy opened the door.	The woman opened the door.	NP1/V2/NP3	yes
S	The man that employed the woman improved the skill.	The man employed the woman.	NP1/V1/NP2	yes
S	The girl that saved the boy enjoyed the lunch.	The boy saved the girl.	NP2/V1/NP1	no

S	The man that taught the woman admitted the mistake.	The woman admitted the mistake.	NP2 V2 NP3	no
S	The woman that fooled the man lost the money.	The woman lost the money.	NP1/V2/NP3	yes
S	The man that missed the woman moved to Africa.	The man missed the woman.	NP1/V1/NP2	yes
S	The boy that liked the woman cut the cake.	The woman liked the boy.	NP2/V1/NP1	no
S	The girl that phoned the man lent a camera.	The man lent a camera.	NP2/V2/NP3	no

List C

Type	Sentence	Comprehension sentence	Part	Ans
S	The boy that kissed the girl hid the truth.	The boy hid the truth.	NP1/V2/NP3	yes
S	The man that met the woman joined the party.	The man met the woman.	NP1/V1/NP2	yes
S	The man that contracted the woman discussed the matter.	The woman contacted the man.	NP2/V1/NP1	no
S	The man that accepted the woman communicated an idea.	The woman communicated an idea.	NP2/V2/NP3	no
S	The woman that moved the man took a seat.	The woman took a seat.	NP1/V2/NP3	yes
S	The girl that watched the man wanted the camera.	The girl watched the man.	NP1/V1/NP2	yes
S	The girl that chased the boy hit the tree.	The boy chased the girl.	NP2/V1/NP1	no
S	The boy that remembered the girl described the feeling.	The girl described the feeling.	NP2/V2/NP3	no
S	The man that hired the woman built the company.	The man built the company.	NP1/V2/NP3	yes
S	The woman that admired the boy performed a dance.	The woman admired the boy.	NP1/V1/NP2	yes
S	The woman that praised the man showed the talent.	The man praised the woman.	NP2/V1/NP1	no
S	The girl that saw the boy broke the tree.	The boy broke the tree.	NP2/V2/NP3	no
O	The man that the woman hurt entered the office.	The man entered the office.	NP1/V2/NP3	yes
O	The girl that the man avoided closed the window.	The man avoided the girl	NP2/V1/NP1	yes
O	The boy that the woman followed drove a car.	The woman drove a car.	NP2/V2/NP3	no
O	The man that the woman copied realized the dream.	The man copied the woman.	NP1/V1/NP2	no
O	The girl that the man mailed got the job.	The girl got the job.	NP1/V2/NP3	yes
O	The girl that the boy touched dropped the bag.	The boy touched the girl.	NP2/V1/NP1	yes
O	The man that the woman encouraged sang a song.	The woman sang a song.	NP2/V2/NP3	no
O	The man that the woman attacked had a knife.	The man attacked the woman.	NP1/V1/NP2	no
O	The man that the woman protected used the gun.	The man used the gun.	NP1/V2/NP3	yes
O	The girl that the boy pushed began a fight.	The boy pushed the girl.	NP2/V1/NP1	yes

O	The woman that the man supported created a company.	The man created a company.	NP2/V2/NP3	no
O	The man that the woman needed paid the money.	The man needed the woman.	NP1/V2/NP3	no

List D

Type	Sentence	Comprehension check	Part	Ans
O	The boy that the girl kissed hid the truth.	The boy hid the truth.	NP1/V2/NP3	yes
O	The man that the woman met joined the party.	The woman met the man.	NP2/V1/NP1	yes
O	The man that the woman contracted discussed the matter.	The woman discussed the matter.	NP2/V2/NP3	no
O	The man that the woman accepted communicated an idea.	The man accepted the woman.	NP1/V1/NP2	no
O	The woman that the man moved took a seat.	The woman took a seat.	NP1/V2/NP3	yes
O	The girl that the man watched wanted the camera.	The man watched the girl.	NP2/V1/NP1	yes
O	The girl that the boy chased hit the tree.	The boy hit the tree.	NP2/V2/NP3	no
O	The boy that the girl remembered described the feeling.	The boy remembered the girl.	NP1/V1/NP2	no
O	The man that the woman hired built the company.	The man built the company.	NP1/V2/NP3	yes
O	The woman that the boy admired performed a dance.	The boy admired the woman.	NP2/V1/NP1	yes
O	The woman that the man praised showed the talent	The man showed the talent.	NP2/V2/NP3	no
O	The girl that the boy saw broke the tree.	The girl saw the boy.	NP1/V1/NP2	no
S	The man that hurt the woman entered the office.	The man entered the office.	NP1/V2/NP3	yes
S	The girl that avoided the man closed the window.	The girl avoided the man.	NP1/V1/NP2	yes
S	The boy that followed the woman drove a car.	The woman followed the boy.	NP2/V1/NP1	no
S	The man that copied the woman realized the dream.	The woman realized the dream.	NP2/V2/NP3	no
S	The girl that mailed the man got the job.	The girl got the job.	NP1/V2/NP3	yes
S	The girl that touched the boy dropped the bag.	The girl touched the boy.	NP1/V1/NP2	yes
S	The man that encouraged the woman sang a song.	The woman encouraged the man.	NP2/V1/NP1	no
S	The man that attacked the woman had a knife.	The woman had a knife.	NP2 V2 NP3	no
S	The man that protected the woman used the gun.	The man used the gun.	NP1/V2/NP3	yes
S	The girl that pushed the boy began a fight.	The girl pushed the boy.	NP1/V1/NP2	yes

S	The woman that supported the man created a company.	The man supported the woman.	NP2/V1/NP1	no
S	The man that needed the woman paid the money.	The woman paid the money.	NP2/V2/NP3	no

List E

Type	Sentence	Comprehension sentence	Part	Ans
S	The man that married the woman achieved success.	The man achieved success.	NP1/V2/NP3	yes
S	The girl that hated the man locked the door.	The girl hated the man.	NP1/V1/NP2	yes
S	The woman that contacted the boy ordered meat.	The boy contacted the woman	NP2/V1/NP1	no
S	The man that guided the woman rode a bike.	The woman rode a bike.	NP2/V2/NP3	no
S	The woman that criticized the man started crying.	The woman started crying.	NP1/V2/NP3	yes
S	The man that trusted the woman kept a secret.	The man trusted the woman.	NP1/V1/NP2	yes
S	The woman that helped the man found the data.	The man helped the woman.	NP2/V1/NP1	no
S	The boy that caught the girl dropped the phone.	The girl dropped the phone.	NP2/V2/NP3	no
S	The woman that fired the man lost everything.	The woman lost everything.	NP1/V2/NP3	yes
S	The woman that kicked the man told a lie.	The woman kicked the man.	NP1/V1/NP2	yes
S	The girl that advised the boy felt satisfaction.	The boy advised the girl.	NP2/V1/NP1	no
S	The man that impressed the woman offered a job.	The woman offered a job.	NP2/V2/NP3	no
O	The boy that the girl killed became a hero.	The boy became a hero.	NP1/V2/NP3	yes
O	The boy that the girl welcomed brought a present.	The girl welcomed the boy.	NP2/V1/NP1	yes
O	The man that the woman tackled injured his arm.	The woman injured her arm.	NP2/V2/NP3	no
O	The boy that the girl stopped parked the car.	The boy stopped the girl.	NP1/V1/NP2	no
O	The man that the woman loved expressed his joy.	The man expressed his joy.	NP1/V2/NP3	yes
O	The woman that the man influenced developed the weapon.	The man influenced the woman.	NP2/V1/NP1	yes
O	The woman that the man believed signed the document.	The man signed the document.	NP2/V2/NP3	no
O	The boy that the girl assisted made good tools.	The boy assisted the girl.	NP1/V1/NP2	no
O	The man that the woman used repaired the computer.	The man repaired the computer.	NP1/V2/NP3	yes
O	The man that the woman interviewed received the benefit.	The woman interviewed the man.	NP2/V1/NP1	yes
O	The boy that the woman disliked changed the answer.	The woman changed the answer.	NP2/V2/NP3	no

O	The woman that the man managed earned good money.	The woman managed the NP1/V2/NP3 no man.

List F

Type	Sentence	Comprehension check	Part	Ans
O	The man that the woman married achieved success.	The man achieved success.	NP1/V2/NP3	yes
O	The girl that the man hated locked the door.	The man hated the girl.	NP2/V1/NP1	yes
O	The woman that the boy contacted ordered meat.	The boy ordered meat.	NP2/V2/NP3	no
O	The man that the woman guided rode a bike.	The man guided the woman.	NP1/V1/NP2	no
O	The woman that the man criticized started crying.	The woman started crying.	NP1/V2/NP3	yes
O	The man that the woman trusted kept a secret.	The woman trusted the man.	NP2/V1/NP1	yes
O	The woman that the man helped found the data.	The man found the data.	NP2/V2/NP3	no
O	The boy that the girl caught dropped the phone.	The boy caught the girl.	NP1/V1/NP2	no
O	The woman that the man fired lost everything.	The woman lost everything.	NP1/V2/NP3	yes
O	The woman that the man kicked told a lie.	The man kicked the woman.	NP2/V1/NP1	yes
O	The girl that the boy advised felt satisfaction.	The boy felt satisfaction.	NP2/V2/NP3	no
O	The man that the woman impressed offered a job.	The man impressed the woman.	NP1/V1/NP2	no
S	The boy that killed the girl became a hero.	The boy became a hero.	NP1/V2/NP3	yes
S	The boy that welcomed the girl brought a present.	The boy welcomed the girl.	NP1/V1/NP2	yes
S	The man that tackled the woman injured his arm.	The woman tackled the man.	NP2/V1/NP1	no
S	The boy that stopped the girl parked the car.	The girl parked the car.	NP2/V2/NP3	no
S	The man that loved the woman expressed his joy.	The man expressed his joy.	NP1/V2/NP3	yes
S	The woman that influenced the man developed the weapon.	The woman influenced the man.	NP1/V1/NP2	yes
S	The woman that believed the man signed the document.	The man believed the woman.	NP2/V1/NP1	no
S	The boy that assisted the girl made good tools.	The girl made good tools.	NP2 V2 NP3	no
S	The man that used the woman repaired the computer.	The man repaired the computer.	NP1/V2/NP3	yes
S	The man that interviewed the woman received the benefit.	The man interviewed the woman.	NP1/V1/NP2	yes

S	The boy that disliked the woman changed the answer.	The woman disliked the NP2/V1/NP1 no boy.
S	The woman that managed the man earned good money.	The man earned good NP2/V2/NP3 no money.

Appendix 10. Critical Sentences Used for Relative Clause Sentence Experience Group in Experiment 4

"*Type*" means clause type (e.g., S:SRC, O:ORC). "*Correct Comprehension*" indicates the correct choice and "*Wrong Comprehension*," the wrong choice. They are presented either choice A or B, in a counter-balanced manner.

Type	*Sentences*	*"Correct" Comprehension*	*"Wrong" Comprehension*
S	A pretty girl was reading in a park. The boy that watched the girl fell in love.	The boy watched the girl.	The girl watched the boy.
S	A fight started in a supermarket. The customer that hit the shop manager got injured.	The customer hit the shop manager.	The shop manager hit the customer.
S	A scientist wanted money for an experiment. The company president that interviewed the scientist provided money.	The company president interviewed the scientist.	The scientist provided money.
S	The apartment was on fire. The man that rescued his father became a hero.	The man rescued his father.	The father rescued the man.
S	The king controlled his people. The people that disliked the king broke the castle's windows.	The people broke the castle's windows.	The king broke the castle's windows.
S	A university student went to a library. The professor that influenced the student was reading a difficult book.	The professor was reading a difficult book.	The student was reading a difficult book.
S	The boys enjoyed the high school girls' performance. The boys that admired the high school girls bought the CDs.	The boys bought the CDs.	The high school girls bought the CDs.
S	An old man had cancer. The nurse that supported the man understood his feeling.	The nurse understood the feeling.	An old man supported the nurse.
S	The actress stood at the center of the stage. The audience that praised the actress found her crying.	The audience praised the actress.	The actress found the audience crying.
S	Jim was driving a car in Mexico. The police officer that stopped Jim spoke Spanish.	The police officer stopped Jim.	Jim stopped the police officer.

S	Teachers took their students to an art museum. The boy that chased the girl in the museum damaged a painting.	The boy damaged a painting.	A girl damaged a painting.
S	The scientist had a heart attack and was in a hospital. The son that brought the scientist to the hospital worried about him.	The scientist's son brought him to the hospital.	The scientist brought his son to the hospital.
S	The new employee worked hard in a chocolate factory. The manager that thanked the employee gave him a chocolate.	The manager thanked the new employee.	The new employee gave a chocolate to the manager.
S	A president wanted a beautiful garden. The president that hired the gardener ordered a Japanese garden.	The president wanted a Japanese garden.	The gardener wanted a Japanese garden.
S	Alice couldn't go to school because of illness. The friend that phoned Alice took lecture notes for her.	Alice's friend phoned Alice.	Alice phoned her friend.
S	A man had difficulty swimming in a pool. The woman that saved the man called a doctor.	The woman saved the man	The man saved the woman.
S	The apartment owner raised the rent. The man that criticized the owner damaged the building.	The man criticized the apartment owner.	The apartment owner criticized the man.
S	Tom was sharing a big house. The roommate that trusted Tom told a secret to him.	Tom's roommate trusted Tom.	Tom trusted his roommate.
S	A magazine editor always wrote show business news. The comedian that knew the editor asked her to write about his marriage.	The comedian knew the magazine editor.	The comedian wrote about his marriage.
S	Nicole used to be married to a fashion designer. The designer that left Nicole married a fashion model.	The designer left Nicole.	Nicole left the designer.
O	Students were drawing a picture in the art class. The art teacher that the students respected talked about an art exhibition.	The students respected the teacher.	The teacher respected the students.

O	A manager was checking documents with his worker. The worker that the manager trusted found a mistake.	The worker found a mistake.	The manager found a mistake.
O	Tom was a firefighter. The boy that Tom saved was rescuing his dog from the fire.	Tom saved the boy.	Tom rescued a dog.
O	There was a beauty contest. The winner that judges chose danced on stage.	The winner danced on stage.	Judges danced on stage.
O	The lawyer was busy yesterday. The client that the lawyer advised announced her mistake at a news conference.	The client announced the mistake.	The lawyer announced the mistake.
O	Boys were enjoying games in a café restaurant. The café owner that the boys liked was a good gamer.	The café owner was a good gamer.	The boys were good gamers.
O	Mike was seventy years old. The doctor that Mike relied on looked older than him.	The doctor looked older than Mike.	Mike looked older than the doctor.
O	Bob was a dress designer. The fashion model that Bob fired complained about it.	Bob fired a fashion model.	Bob complained about the fashion model.
O	The researcher liked eating at a nice restaurant. The cook that the researcher praised prepared great dishes.	The researcher praised the cook.	The cook praised the researcher.
O	Mary wanted to remodel her living room. The carpenter that Mary phoned accepted the job.	The carpenter accepted the remodeling job.	Mary remodeled her living room herself.
O	Students were studying for a math test. The teacher that the students disliked gave them a difficult test.	The students disliked the teacher.	The teacher disliked the students.
O	A movie director created a good movie. The actress that the movie director used became a star.	The director used the actress.	The director became a star.
O	An actor planned to hold a birthday party. The staff members that the actor depended on arranged a party.	The staff arranged a party.	The actor arranged a party.

O	A man bought a lot of expensive shoes at a store. Two weeks later, the man that the shopkeeper remembered got a good discount.	The shopkeeper remembered the man.	The man remembered the shopkeeper.
O	A woman was running after a bad man. The woman that the man fooled lost her house and money.	The man fooled the woman.	The woman fooled the man.
O	Henry liked rugby. The professional rugby team captain that Henry met invited him to join the team.	Henry met the captain.	Henry invited the captain.
O	A boy was watching a spy movie. The spy that the pilot hurt ran away.	The pilot hurt the spy.	The spy hurt the pilot.
O	The girl's money disappeared from the apartment. The apartment owner that the girl suspected stole the money.	The girl suspected the apartment owner.	The apartment owner suspected the girl.
O	The princess was allergic to eggs. The cook that the princess knew made a meal without eggs for her.	The princess knew the cook.	The princess made a meal.
O	A company president opened the door to his office. The secretary that the president smiled at handed him a newspaper.	The president smiled at the secretary.	The secretary smiled at the president.
S	A bad man with a gun broke into a women's clothing store. The woman that kicked the man was very strong.	The woman kicked the man.	The man kicked the woman.
S	The dancer was practicing for the stage. The stage manager that assisted the dancer expressed her opinion.	The stage manager assisted the dancer.	The dancer expressed her opinion.
S	A novelist appeared in a TV program. The student that mailed the novelist watched the program.	The student mailed the novelist.	The novelist mailed the student.
S	Jack came from a poor family but studied very hard. The man that encouraged Jack presented him with a computer.	The man encouraged Jack.	Jack encouraged the man.

S	Kate went to a movie theater. The man that pushed Kate took her ticket.	The man pushed Kate.	Kate pushed the man.
S	The restaurant was busy. The waiter that served the royal family dropped a napkin by mistake.	The waiter dropped a napkin.	The royal family dropped a napkin.
S	A traveler enjoyed conversations with the local people. The housewife that impressed the traveler took care of 100 animals.	A housewife impressed a traveler.	A traveler impressed a housewife.
S	The journalist always told a lie. The editor that doubted the journalist stopped seeing him.	The editor doubted the journalist.	The journalist doubted the editor.
S	Jane was relaxing at her seaside house. The friend that visited Jane cooked a delicious dinner.	Jane's friend cooked a delicious dinner.	Jane cooked a delicious dinner.
S	The store owner was very handsome. The store owner that attracted the woman opened the door for her.	The store owner opened the door.	A woman opened the door.
S	A secretary apologized for being late and began to explain. The boss that employed the secretary got angry.	The boss got angry.	The secretary got angry.
S	The tennis player didn't want to play tennis that day. The player that feared the tennis coach stayed home.	The player stayed home.	The tennis coach stayed home.
S	George was very shy but went to a party. A woman that noticed George talked about popular comic books.	A woman noticed George.	George talked about popular comic books.
S	The professor was very strict. The student that hated the professor felt uneasy.	The student felt uneasy.	The professor felt uneasy.
S	Helen was a president of an airline company. The pilot that respected Helen proposed a new plan.	The pilot respected Helen.	Helen respected the pilot.
S	The company had a financial problem. The engineer that helped the president worked very hard.	The engineer helped the president.	The president helped the engineer.

S	A couple hired a babysitter. The wife that needed the babysitter cooked dinner for her.	The wife needed the babysitter.	The babysitter needed the wife.
S	Dana worked at a drugstore. The shop owner that fired Dana admitted the mistake.	The shop owner admitted the mistake.	Dana admitted the mistake.
S	Guests attended the wedding party. The wife that welcomed the guests threw the bouquet of flowers.	The wife threw the flowers.	The guests threw the flowers.
S	A girl was crying in a room. The boy that kissed the girl tried to make her smile.	The boy kissed the girl.	The girl kissed the boy.
O	Kate was painting the wall with her children. The children that Kate scolded started crying.	Kate scolded the children.	Kate started crying.
O	Music fans were enjoying a concert in an outdoor stadium. The singer that the fans admired sang a love song sweetly.	The fans admired the singer.	The singer admired fans.
O	The city started the construction project. Some of the workers that the city hired were foreigners.	The city hired some foreigners.	All the workers were foreigners.
O	A school bus was involved in a car accident. The doctor that the driver called came late.	The doctor came late.	The driver came late.
O	A reporter attacked the policy maker. However, the policy maker that the reporter hated requested his support.	The reporter hated the policy maker.	The policy maker hated the reporter.
O	John felt tired lately. The doctor that John consulted advised him to take a vacation.	John consulted the doctor.	John advised the doctor to take a vacation.
O	Baseball players started a fight. The pitcher that the catcher stopped was a troublemaker.	The catcher stopped the pitcher.	The pitcher stopped the catcher.
O	A student applied for a city job. The city official that the student contacted explained the city's system.	The city official explained the city's system.	The student explained the city's system.

O	Sara traveled to England by airplane. The passenger that Sara spoke to didn’t understand English.	Sara spoke to the passenger.	The passenger spoke to Sara.
O	Ann cooked Thanksgiving dinner at her house. The friend that Ann invited enjoyed the food.	Ann invited her friend.	Ann's friend invited Ann.
O	Nancy went to college by bicycle. The student that Nancy saw on her way to college was caught for speeding.	The student was caught for speeding.	Nancy was caught for speeding.
O	The queen had a beautiful garden. The gardener that the queen thanked planted roses.	The queen thanked the gardener.	The gardener thanked the queen.
O	A woman was very popular among men. Actually, the woman that the men approached pretended to be a nice person.	The men approached the woman.	The woman approached the men.
O	A college student conducted a science experiment in a laboratory. The student that the professor monitored developed a new technology.	The professor monitored the student.	The student monitored the professor.
O	The president wasn't comfortable before making a speech. His friend that the president believed advised him to take a deep breath.	The president believed his friend.	The president's friend believed the president.
O	The engineer had trouble with a broken machine. The new worker that the engineer taught repaired it quickly.	The new worker repaired the machine.	The engineer repaired the machine.
O	The hotel owner wanted a relaxing space. The designer that the hotel owner employed showed a gardening plan.	The hotel owner employed the designer.	The hotel owner showed a gardening plan.
O	A train accident happened late at night. The passenger that the reporter interviewed wanted to go home.	The passenger wanted to go home.	The news reporter wanted to go home.
O	The football player always scored in a game. The star player that fans supported earned a lot of money.	The star player was supported by fans.	The fans were supported by the player.

O	The doctor reached his hospital in the morning. The patient that the doctor checked reported a shoulder pain.	The doctor checked a patient.	The doctor reported a pain.

Appendix 11. Critical Sentences Used for Control Sentence Experience Group in Experiment 4

"*Type*" means clause type (e.g., S:SRC, O:ORC). "*Correct Comprehension*" indicates the correct choice and "*Wrong Comprehension*," the wrong choice. They are presented either choice A or B, in a counter-balanced manner.

Type	*Sentences*	*"Correct" Comprehension*	*"Wrong" Comprehension*
S	A pretty girl was reading in a park. The boy watched the girl and fell in love.	The boy watched the girl.	The girl watched the boy.
S	A fight started in a supermarket. The customer hit the shop manager and the shop manager got injured.	The customer hit the shop manager.	The shop manager hit the customer.
S	A scientist wanted money for an experiment. The company president interviewed the scientist and provided money.	The company president interviewed the scientist.	The scientist provided money.
S	The apartment was on fire. The man rescued his father, so he became a hero.	The man rescued his father.	The father rescued the man.
S	The king controlled his people. The people disliked the king, so they broke the castle's windows.	The people broke the castle's windows.	The king broke the castle's windows.
S	A university student went to a library. The student found a professor reading a difficult book.	The professor was reading a difficult book.	The student was reading a difficult book.
S	The boys enjoyed the high school girls' performance. Because the boys admired the high school girls, they bought the CDs.	The boys bought the CDs.	The high school girls bought the CDs.
S	An old man had cancer. The nurse supported the man and understood his feeling.	The nurse understood the feeling.	An old man supported the nurse.
S	The actress stood at the center of the stage. The audience praised her and they found her crying.	The audience praised the actress.	The actress found the audience crying.

S	Jim was driving a car in Mexico. When the police officer stopped Jim, the officer spoke Spanish.	The police officer stopped Jim.	Jim stopped the police officer.
S	Teachers took their students to an art museum. The boy chased the girl in the museum and he damaged a painting.	The boy damaged a painting.	A girl damaged a painting.
S	The scientist had a heart attack and was in a hospital. His son brought the scientist to the hospital and worried about him.	The scientist's son brought him to the hospital.	The scientist brought his son to the hospital.
S	The new employee worked hard in a chocolate factory. The manager thanked the employee and gave him a chocolate.	The manager thanked the new employee.	The new employee gave a chocolate to the manager.
S	A president wanted a beautiful garden. Therefore, the president hired the gardener and ordered a Japanese garden.	The president wanted a Japanese garden.	The gardener wanted a Japanese garden.
S	Alice couldn't go to school because of illness. Her friend phoned Alice and talked about the lecture.	Alice's friend phoned Alice.	Alice phoned her friend.
S	A man had difficulty swimming in a pool. The woman saved the man and called a doctor.	The woman saved the man	The man saved the woman.
S	The apartment owner raised the rent. The man criticized the owner and damaged the building.	The man criticized the apartment owner.	The apartment owner criticized the man.
S	Tom was sharing a big house. The roommate trusted Tom, so she told a secret to him.	Tom's roommate trusted Tom.	Tom trusted his roommate.
S	A magazine editor always wrote show business news. The comedian knew the editor and asked her to write about his marriage.	The comedian knew the magazine editor.	The comedian wrote about his marriage.
S	Nicole used to be married to a fashion designer. The designer left her and then married a fashion model.	The designer left Nicole.	Nicole left the designer.

O	Students respected the art teacher because he was good at painting. The teacher talked about an art exhibition.	The students respected the teacher.	The teacher respected the students.
O	A manager and his worker were checking documents. Then, the worker found a mistake.	The worker found a mistake.	The manager found a mistake.
O	Tom was a firefighter. Tom saved a boy and the boy was rescuing his dog from the fire.	Tom saved the boy.	Tom rescued a dog.
O	There was a beauty contest. After judges chose a winner, she danced on stage.	The winner danced on stage.	Judges danced on stage.
O	The lawyer was busy yesterday. The lawyer advised the client to announce her mistake at a news conference.	The client announced the mistake.	The lawyer announced the mistake.
O	Boys were enjoying games in a café restaurant. The boys liked the owner because he was a good gamer.	The café owner was a good gamer.	The boys were good gamers.
O	Mike was sick. Mike relied on the doctor, but the doctor looked older than Mike.	The doctor looked older than Mike.	Mike looked older than the doctor.
O	Bob was a dress designer and he fired a fashion model. But the fashion model complained about it.	Bob fired a fashion model.	Bob complained about the fashion model.
O	The researcher liked eating at a nice restaurant. Because the cook prepared great dishes, the researcher praised the cook.	The researcher praised the cook.	The cook praised the researcher.
O	Mary wanted to remodel her living room and she phoned a carpenter. He accepted the job.	The carpenter accepted the remodeling job.	Mary remodeled her living room herself.
O	Students were studying for a math test. The students disliked the teacher because he gave them a difficult test.	The students disliked the teacher.	The teacher disliked the students.
O	A movie director used an actress and created a good movie. The actress became a star.	The director used the actress.	The director became a star.

O	An actor planned to hold a birthday party and depended on the staff members. The members arranged a party.	The staff arranged a party.	The actor arranged a party.
O	A man bought a lot of expensive shoes at a store. Therefore, when the man visited the store later, the shopkeeper remembered him.	The shopkeeper remembered the man.	The man remembered the shopkeeper.
O	A bad man fooled a woman and stole her money. She ran after him, but she couldn't catch him.	The man fooled the woman.	The woman fooled the man.
O	Henry liked rugby and he met a professional rugby team captain. Surprisingly, the captain invited him to join the team.	Henry met the captain.	Henry invited the captain.
O	A boy was watching a spy movie. In the movie, a pilot hurt a spy and ran away.	The pilot hurt the spy.	The spy hurt the pilot.
O	The girl's money disappeared from the apartment. The girl suspected the apartment owner.	The girl suspected the apartment owner.	The apartment owner suspected the girl.
O	The princess was allergic to eggs. Because she knew the cook, she asked him to make a meal without eggs.	The princess knew the cook.	The princess made a meal.
O	A company president came to the office early in the morning. When he entered the office, he smiled at the secretary.	The president smiled at the secretary.	The secretary smiled at the president.
S	A bad man with a gun broke into a women's clothing store. The woman was very strong and kicked the man.	The woman kicked the man.	The man kicked the woman.
S	The dancer was practicing for the stage. The stage manager that assisted the dancer expressed her opinion.	The stage manager assisted the dancer.	The dancer expressed her opinion.
S	A novelist appeared in a TV program. After the student mailed the novelist, he watched the program.	The student mailed the novelist.	The novelist mailed the student.

S	Jack came from a poor family but studied very hard. The man encouraged Jack and presented him with a computer.	The man encouraged Jack.	Jack encouraged the man.
S	Kate went to a movie theater. The man pushed Kate and took her ticket.	The man pushed Kate.	Kate pushed the man.
S	The restaurant was busy. The waiter served the royal family, but he dropped a napkin by mistake.	The waiter dropped a napkin.	The royal family dropped a napkin.
S	A traveler enjoyed conversations with the local people. The housewife impressed the traveler because she took care of 100 animals.	A housewife impressed a traveler.	A traveler impressed a housewife.
S	The journalist always told a lie. Because the editor doubted the journalist, she stopped seeing him.	The editor doubted the journalist.	The journalist doubted the editor.
S	Jane was relaxing at her seaside house. Her friend visited her and cooked a delicious dinner.	Jane's friend cooked a delicious dinner.	Jane cooked a delicious dinner.
S	The store owner was very handsome. The store owner attracted the woman and opened the door for her.	The store owner opened the door.	A woman opened the door.
S	A secretary apologized for being late and began to explain. The boss employed the secretary but he got angry.	The boss got angry.	The secretary got angry.
S	The tennis player didn't want to play tennis that day. Because the player feared the tennis coach, she stayed home.	The player stayed home.	The tennis coach stayed home.
S	George was very shy but went to a party. A woman noticed George and talked about popular comic books.	A woman noticed George.	George talked about popular comic books.
S	The professor was very strict. The student hated the professor and she felt uneasy.	The student felt uneasy.	The professor felt uneasy.

S	Helen was a president of an airline company. Because the pilot respected Helen, he proposed a new plan.	The pilot respected Helen.	Helen respected the pilot.
S	The company had a financial problem. The engineer that helped the president worked very hard.	The engineer helped the president.	The president helped the engineer.
S	A couple hired a babysitter. Because the wife needed the babysitter, she cooked dinner for her.	The wife needed the babysitter.	The babysitter needed the wife.
S	Dana worked at a drugstore. The shop owner fired Dana, but he admitted the mistake.	The shop owner admitted the mistake.	Dana admitted the mistake.
S	Guests attended the wedding party. The wife welcomed the guests and threw the bouquet of flowers.	The wife threw the flowers.	The guests threw the flowers.
S	A girl was crying in a room. The boy kissed the girl and tried to make her smile.	The boy kissed the girl.	The girl kissed the boy.
O	Kate was painting the wall with her children. The children were scolded by Kate and started crying.	Kate scolded the children.	Kate started crying.
O	In an outdoor stadium, music fans were enjoying a concert. They admired the singer because he sang a love song sweetly.	The fans admired the singer.	The singer admired fans.
O	The city started the construction project. The city hired a lot of workers, and some of them were foreigners.	The city hired some foreigners.	All the workers were foreigners.
O	A bus had a car accident. The doctor came late even though the driver called him shortly after the accident.	The doctor came late.	The driver came late.
O	A reporter attacked the policy maker because he hated him. But the policy maker requested the reporter's support.	The reporter hated the policy maker.	The policy maker hated the reporter.

O	John felt tired lately. He consulted the doctor and the doctor advised him to take a vacation.	John consulted the doctor.	John advised the doctor to take a vacation.
O	Baseball players started a fight. The catcher stopped the pitcher but the others were troublemakers.	The catcher stopped the pitcher.	The pitcher stopped the catcher.
O	A student applied for a city job and contacted a city official. The official explained the city's system.	The city official explained the city's system.	The student explained the city's system.
O	Sara traveled to England by airplane. She spoke to a passenger but he didn’t understand English.	Sara spoke to the passenger.	The passenger spoke to Sara.
O	Ann cooked Thanksgiving dinner and invited a friend. Her friend enjoyed the food.	Ann invited her friend.	Ann's friend invited Ann.
O	Nancy saw a student on her way to college by bicycle. He was caught for speeding.	The student was caught for speeding.	Nancy was caught for speeding.
O	There were a lot of flowers in the queen's garden. The queen thanked the gardener for planting the flowers.	The queen thanked the gardener.	The gardener thanked the queen.
O	A woman was very popular among men. The men approached the woman, but she pretended to be a nice person.	The men approached the woman.	The woman approached the men.
O	A college student conducted a science experiment in a laboratory. During the experiment, a professor monitored the student.	The professor monitored the student.	The student monitored the professor.
O	The president wasn't comfortable before making a speech. Because the president believed his friend, he listened to the friend's advice.	The president believed his friend.	The president's friend believed the president.
O	An engineer and a new worker had trouble with a broken machine. However, the new worker repaired it.	The new worker repaired the machine.	The engineer repaired the machine.

O	The hotel owner wanted a relaxing space. The designer that the hotel owner employed showed a gardening plan.	The hotel owner employed the designer.	The hotel owner showed a gardening plan.
O	A train accident happened late at night. A reporter interviewed a passenger, and she said that she wanted to go home.	The passenger wanted to go home.	The news reporter wanted to go home.
O	Football fans supported the star player. Because he always scored in a game, he earned a lot of money.	The star player was supported by fans.	The fans were supported by the player.
O	The doctor reached his hospital in the morning. When he checked his patient, she reported a shoulder pain.	The doctor checked a patient.	The doctor reported a pain.

Appendix 12. Word Lists Used in Experiment 4: Original Version

単語リスト（AB）

（お名前　　）

1) 暗記用赤シートを使用して、日本語意味が言えるように学習してください。

2) 最初から知っていた単語、覚えた単語にチェックを入れてください。

	英単語	日本語意味	知ってる・覚えた
（例）	apple	リンゴ	✓
1	suspect	～を疑う	
2	stole	**(steal の過去形)**　～を盗む	
3	attract	～を魅了する	
4	monitor	～を観察する	
5	overcome	（困難など）を乗り越える	
6	shook	**(shake の過去形)**　**shake hands**：握手する	
7	retirement	退職	
8	employ	～を雇う	
9	fool	～をだます	
10	miss	～がいなくて寂しい	
11	lent	**(lend の過去形)**　～を貸す	

単語リスト（CD）

（お名前　　）

1）暗記用赤シートを使用して、日本語意味が言えるように学習してください。

2）最初から知っていた単語、覚えた単語にチェックを入れてください。

	英単語	日本語意味	知ってる・覚えた
（例）	apple	リンゴ	✓
1	hid	**(hide の過去形)　～を隠す**	
2	contract	**～と契約を結ぶ**	
3	accept	**～を受け入れる**	
4	chase	**～を追いかける**	
5	hire	**～を雇う**	
6	admire	**～を素敵だと思う**	
7	praise	**～をほめる**	
8	avoid	**～を避ける**	
9	copy	**～を真似する**	
10	realize	**～を実現する**	
11	encourage	**～を励ます**	
12	satisfaction	**満足**	

単語リスト（EF）

（お名前　　）

1）暗記用赤シートを使用して、日本語意味が言えるように学習してください。

2）最初から知っていた単語、覚えた単語にチェックを入れてください。

	英単語	日本語意味	知ってる・覚えた
（例）	apple	リンゴ	✓
1	achieve	～を達成する	
2	contact	～と連絡を取る	
3	criticize	～を非難する	
4	impress	～に印象付ける	
5	welcome	～を喜んで迎える	
6	weapon	武器	
7	repair	～を修理する	
8	benefit	利益	
9	receive	～を受け取る	
10	earn	（働いてお金など）を稼ぐ	

Appendix 13. Word Lists Used in Experiment 4: Translated Version in English

Word List（AB）

（Name ）

1) Remember the Japanese translation of the English words. Please use the red sheet to check if you have remembered the Japanese translation.

2) After you confirm that you have known or remembered the words, please check OK cells.

	English	Japanese	I know or remembered
e.g.,	apple	リンゴ	✓
1	suspect	～を疑う	
2	stole	**(steal** の過去形) ～を盗む	
3	attract	～を魅了する	
4	monitor	～を観察する	
5	overcome	（困難など）を乗り越える	
6	shook	**(shake** の過去形) **shake hands**：握手する	
7	retirement	退職	
8	employ	～を雇う	
9	fool	～をだます	
10	miss	～がいなくて寂しい	
11	lent	**(lend** の過去形) ～を貸す	

Word List（CD）

（Name　　）

1) Remember the Japanese translation of the English words. Please use the red sheet to check if you have remembered the Japanese translation.

2) After you confirm that you have known or remembered the words, please check OK cells.

	English	Japanese	I know or remembered
e.g.,	apple	リンゴ	✓
1	hid	**(hide の過去形)**　～を隠す	
2	contract	～と契約を結ぶ	
3	accept	～を受け入れる	
4	chase	～を追いかける	
5	hire	～を雇う	
6	admire	～を素敵だと思う	
7	praise	～をほめる	
8	avoid	～を避ける	
9	copy	～を真似する	
10	realize	～を実現する	
11	encourage	～を励ます	
12	satisfaction	満足	

Word List（EF）

（Name ）

1) Remember the Japanese translation of the English words. Please use the red sheet to check if you have remembered the Japanese translation.

2) After you confirm that you have known or remembered the words, please check OK cells.

	English	Japanese	I know or remembered
e.g.,	apple	リンゴ	✓
1	achieve	～を達成する	
2	contact	～と連絡を取る	
3	criticize	～を非難する	
4	impress	～に印象付ける	
5	welcome	～を喜んで迎える	
6	weapon	武器	
7	repair	～を修理する	
8	benefit	利益	
9	receive	～を受け取る	
10	earn	（働いてお金など）を稼ぐ	