Automatization Process of Grammatical Encoding in Second Language Production of Japanese EFL Learners: Evidence from the Occurrence of Syntactic Priming as Interactive Alignment

Hamada, Mayu

(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7236号

(URL)
https://hdl.handle.net/20.500.14094/D1007236

2017 年 12 月 22 日提出

博士論文

Automatization Process of Grammatical Encoding in Second Language Production of Japanese EFL Learners: Evidence from the Occurrence of Syntactic Priming as Interactive Alignment

（日本人英語学習者の第二言語産出時における文法符号化の自動化プロセスの解明：相互的同調機能としての統語的プライミング現象による検討）

指 導 教 員：横川 博一 教授

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
121c128c　濱田 真由
HAMADA Mayu

CONTENTS

TABLES

FIGURES

ACKNOWLEDGEMENTS

I owe my deepest gratitude to my academic advisor Professor Hirokazu Yokokawa whose continuing support and constant encouragement helped me very much throughout the production of this study.

I would also like to express my appreciation to Professor Masayuki Kato and Professor Atsuhisa Shimazu for valuable advice and assistance.

I would like to give heartfelt thanks to Professor Gregory Sholdt for the helpful comments and suggestions.

I am deeply grateful to Professor Kazuhito Yamato whose enormous support and insightful comments were invaluable.

I wish to offer my special thanks to my family for their moral support and warm encouragements.

Finally, I would like to thank JSPS Grant-in-Aid for Scientific Research (A) "An investigation of the automatization process in second language processing with respect to noticing, attention and interactive alignment" (PI: Hirokazu Yokokawa, No. 26244031) for a grant that made it possible to complete the study.

1. INTRODUCTION

1.1 Background

It is essential to acquire productive language skills, such as speaking and writing skills, to express your opinions and get the message across to others efficiently in communication using foreign languages. Particularly, acquisition of speech communicational skills is receiving increasing attention, and the automatization of lexical and syntactic processing is one of the significant factors. However, Japanese EFL learners often face difficulties in producing the language smoothly, and their production processes also lack automaticity. It is pointed out that this lack of automaticity is caused because of difficulties with syntactic processing.

1.2 The Purpose of the Study

The present study attempted to explore some of the mechanisms of Japanese EFL learners' language production focusing on syntactic processing in terms of the learners' input and output. The previous studies showed that the occurrence of *alignment* at each linguistic level (e.g., sound, syntactic, semantic, etc.) plays an important role to achieve goals of communication (Pickering & Garrod, 2004), and the same structure tends to be repetitively used between interlocutors in the dialogue (*syntactic priming*). In order to accomplish a purpose, I devised four experiments, Experiments 1a, 1b, 2 and 3. The current study, first, specifically focused on the occurrence of a syntactic priming caused by an interactive alignment by hearing spoken output, and investigated the Japanese EFL learners' magnitude of automatization of syntactic processing in language production. Next, the study also attempted to investigate how repeated exposure to specific syntactic structures promotes the occurrence of a syntactic priming effect to ease syntactic processing of Japanese EFL learners.

The aim of Experiments 1a and 1b is to consider how Japanese EFL learners operate syntactic representations in language production by investigating the occurrence of syntactic priming effect, and to investigate whether syntactic representations are shared between spoken and written production. A picture description task with spoken primes was conducted to investigate whether the differences of output modality (i.e., spoken or written) and verb (i.e., same or different between primes and targets) affect Japanese EFL learners' syntactic priming. Two experiments were conducted to investigate whether the syntactic priming effect is observed after hearing the spoken primes. The participants

described pictures in either forms after listening to the primes with a Prepositional-Object (PO), Double-Object (DO), or filler. Experiment 1a was conducted with spoken targets, and Experiment 1b was conducted with written targets. Moreover, the present study researched whether the differences of primes' presentation conditions affect participants' syntactic priming rate. Thus, in Experiments 1a and 1b, participants were randomly allocated to three conditions (i.e., presentation of primes: once, twice, and once with a question) to determine whether focus on contents or repetition of a prime would enforce syntactic structures.

The aim of Experiment 2 is to examine how Japanese EFL learners' production of syntactic structures automatize by investigating the effects of learners' proficiency differences on the occurrence of syntactic priming effect, and to investigate the effects of output modality on the automatization process. A picture description task with spoken primes was conducted to investigate whether the differences of learners' proficiency levels (i.e., upper or lower) and output modality affect Japanese EFL learners' syntactic priming in three different conditions.

The aim of Experiment 3 is to investigate how Japanese EFL learners' production skills of syntactic structures are learned by investigating the mechanism of syntactic priming effects and the effects of repeated exposure of the syntactic structures. A picture description task with spoken primes and targets was conducted to examine whether Japanese EFL learners' syntactic priming effect persists with filler sentences (lag) intervened between primes and targets. The study clarified whether observed syntactic priming effect was caused by the temporary occurrence of the residual activation or by acquisition of target structures by implicit learning. Therefore, a learning experiment was conducted using syntactic priming to observe the persistence of syntactic priming to observe whether the knowledge of target structures is changing from declarative to procedural knowledge. In the pretest, learning sessions, immediate posttest and delayed posttest, the participants describe pictures in either forms after listening to the primes with a PO, DO, or filler, and repeating it.

1.3 Organization of the Dissertation

This dissertation is organized as follows.

Chapter 1 mentions about the purpose and the background of the study, and Chapter 2 describes the processes of spoken language and written language and previous studies about interactive alignment and priming mechanism. The chapter also describes about studies which investigated the

effects of verb, modality and learners' proficiency levels differences on syntactic priming, conducted on English native speakers and EFL learners. The previous studies which argued about persistence of a syntactic priming and spacing effect are also mentioned. Chapter 3 refers to Experiments 1a and 1b which investigated the effects of modality differences on syntactic priming in the language production of Japanese EFL learners in terms of the syntactic priming effect observed after hearing the spoken primes. Directions for Experiments 1a and 1b are described in Chapter 3.1, and Chapter 3.2 presents hypotheses relating to the research questions of Experiments 1a and 1b. Methods including participants, materials and the procedure of experiments are described in Chapter 3.3. Chapter 3.4 cites results and analysis according to the results of proficiency tests, spoken, and written data by the participants. Chapter 4 mentions about Experiment 2 which investigated the effects of proficiency differences on syntactic priming in language production of Japanese EFL learners. In Chapter 4.1, research questions for Experiment 2 are presented, and in Chapter 4.2, hypotheses according to research questions are described. Methods including participants, material and the procedure are also mentioned in Chapter 4.3. Chapter 4.4 cites results and analysis according to the results of proficiency tests, spoken, and written data based on proficiency differences. Chapter 5 describes about Experiment 3 which investigated the effects of syntactic priming training on the occurrence of interactive alignment in language production of Japanese EFL learners. In Chapter 5.1, research questions for Experiment 3 are mentioned, and in Chapter 5.2, hypotheses are described. Methods and the study's procedure are also mentioned in Chapter 5.3. Chapter 5.4 cites results and analysis according to the results of proficiency tests, spoken data by the participants. Chapter 6 summarizes the results and offers pedagogical implications from results of experiments. Chapter 7 concludes the study and suggests further avenues of research drawn from the experiments.

2. LITERATURE REVIEW

In this chapter, the processes of spoken language and written language are reviewed using the models. Previous studies about the occurrence of an interactive alignment and a syntactic priming effect are mentioned in terms of differences in verb, input and output modality, and learners' proficiency levels. Besides, previous studies about the persistence of a syntactic priming and effects of spacing effect on language acquisition are also cited.

2.1 Spoken Language Processing

One of the psycholinguistic accounts of listening and speaking processes is Levelt's (1989) account shown in Figure 1.

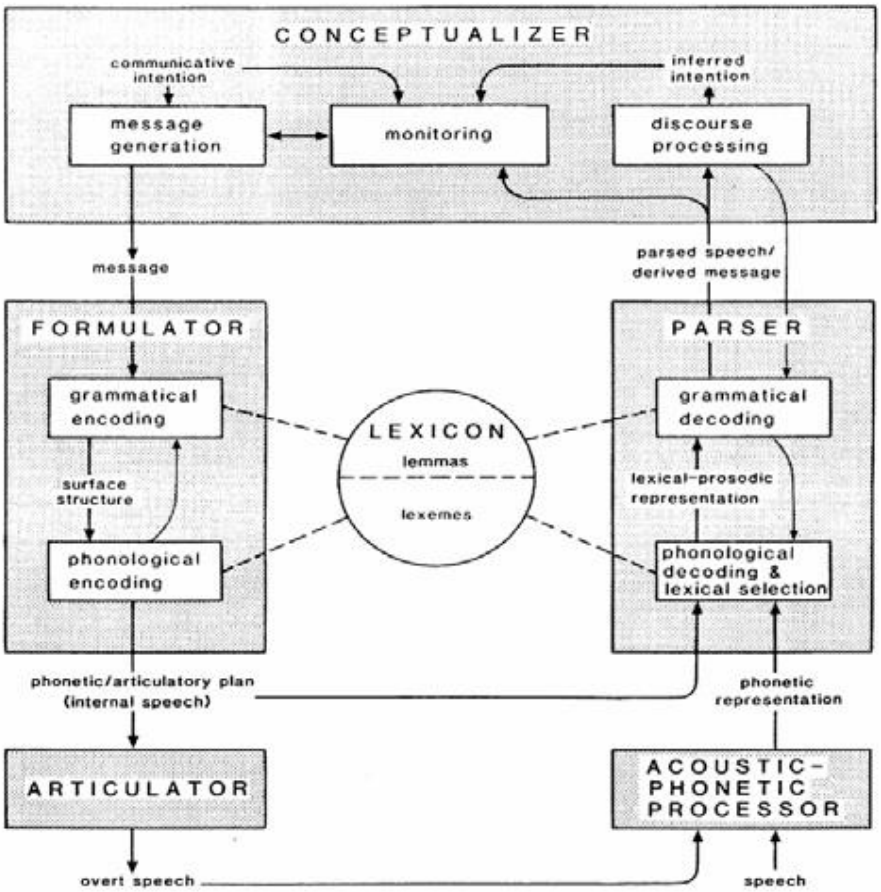

Figure 1. Speaking and listening processes: A blueprint for the speaker (Levelt, 1989, p. 9).

In this account, speakers first think about what they want to say in the *conceptualizer*; then, *grammatical encoding* and *phonological encoding* occur in the *formulator*. In the grammatical encoding, information of the lemmas and lexemes stored in a speaker's mental lexicon becomes activated after which the syntactic and phonological representations are constructed. Finally, in the *articulator*, successive chunks of internal speech are retrieved and unfolded for execution.

According to Levelt's account, it is significant for speakers to automate the process of grammatical encoding, especially in accessing and building syntax for spoken language comprehension and production to accomplish smooth and efficient communication. In Indefrey, Hellwig, Herzog, Seitz, and Hagoort (2004) neuropsychological research, the Broca's area (the area in the frontal cortex of the brain responsible for speech production) that is sensitive to the complexity of syntactic encoding is strongly activated only with phrase and sentence production, but not with phrase and sentence comprehension. Therefore, syntactic processing seems to be an essential processing within language production. However, non-native speakers, such as Japanese EFL learners, often encounter difficulties with this grammatical encoding, and these difficulties intervene with a smooth output production (Morishita & Yokokawa, 2014). In the present study, we attempted to elucidate on this syntactic processing.

2.2 Written Language Processing

Figure 2 shows Flower and Hayes' writing model (Flower & Hayes, 1981, p. 370). This model mentions that writing activity is involved with task environment, long-term memory, and writing processes such as planning, translating, and reviewing. In the process of writing, a writer generates abstract and inner representative of information, translates ideas linguistically with word and syntactic information, and reviews the text for confirmation and modification. Monitoring function plays the role for watching the process and determines which stage the writer goes next to.

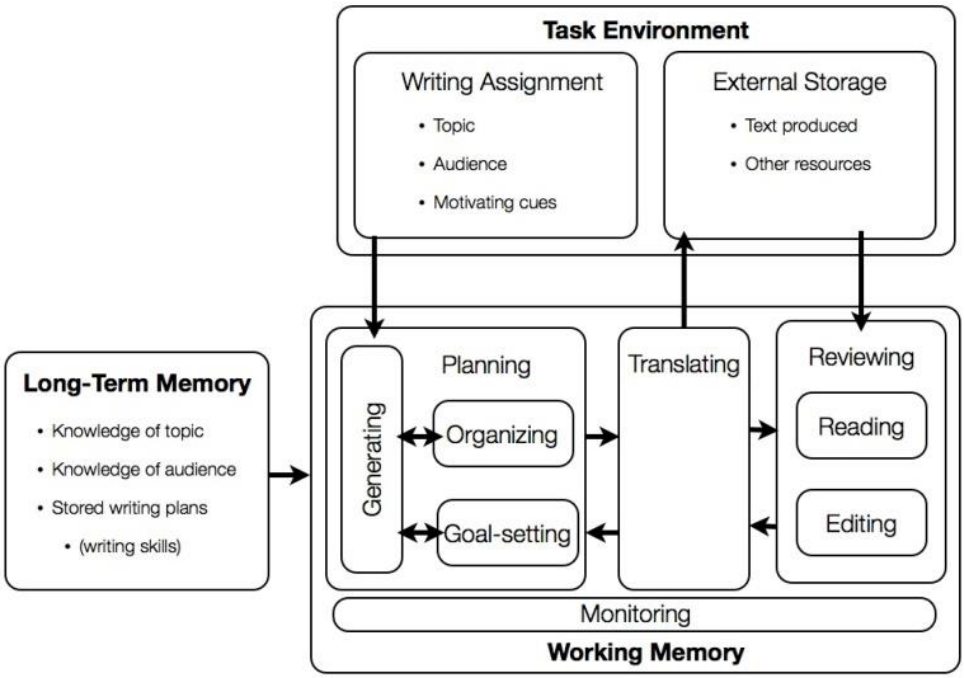

Figure 2. Structure of the writing model (Flower & Hayes, 1981, p. 370).

Figure 3 shows Hayes' writing model (Hayes, 1996, p. 4). This model which revised Flower and Hayes' model, put emphasis on writer's working memory (WM). The task environment and the individual are involved with writing activity, and WM including phonological memory and visual sketchpad are added.

The differences between writing and speaking activities are time and permanence. Writing has enduring record and slower pace compared to speaking, so the writer can stop, think and review the text to correct the linguistic feature.

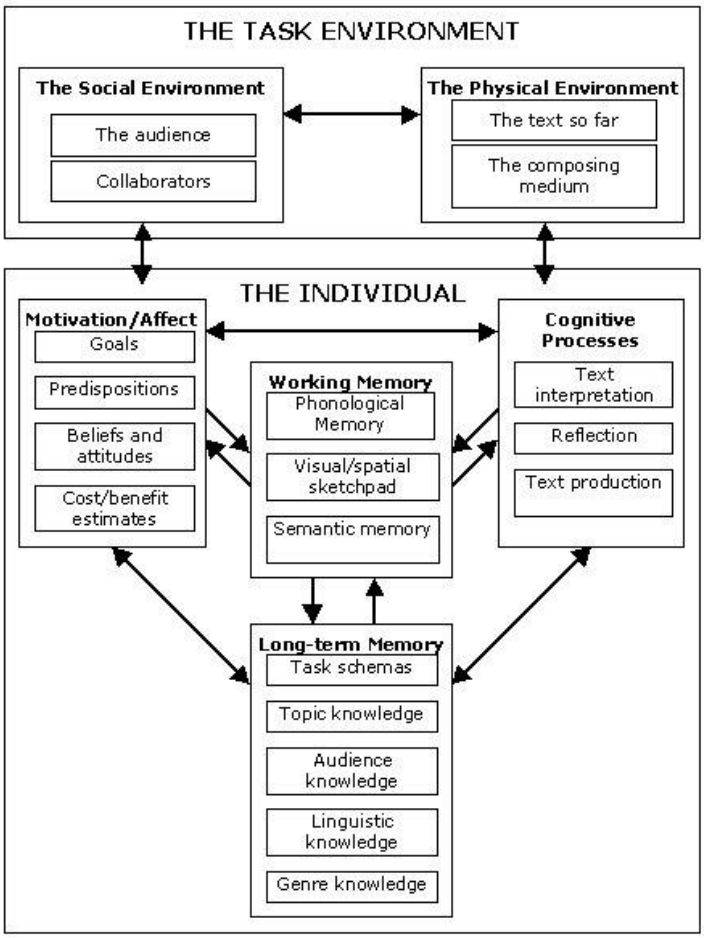

Figure 3. Writing model (Hayes, 1996, p. 4).

2.3 Interactive Alignment

It is important for interlocutors to align their linguistic representations at each linguistic level within a dialogue and to lead them to mutual understanding to achieve effective communication. Figure 4 illustrates the schematic representation of the stages of comprehension and production processes (Pickering & Garrod, 2004, p. 176). This repetitive use of linguistic elements and structures by interlocutors is said to be caused by the occurrence of the *interactive alignment* (*co-ordination*), and repetitions occur at all linguistic levels. Garrod and Anderson (1987) found that participants who played the cooperative maze game tended to repeat their lexical contents each other in order to identify their current places in the maze. Furthermore, Levelt and Kelter (1982) showed that speakers tended to answer to "*What time do you close?*" or "*At what time do you close?*" by using a congruent answer

(e.g., "*Five o'clock*" or "*At five o'clock*"). These repetitions may be caused by a lexical or syntactic alignment. In Branigan, Pickering, and Cleland's (2000) study, participants repeated the confederate's syntactic structure in a picture description task. The study states that co-ordination occurs when interlocutors share the same representation at some level. Trofimovich, McDonough, and Foote (2014) explored the occurrence of stress pattern alignment in a dialogue in an L2 classroom. The L2 learners participated in information exchange quizzes. Transcribed texts were analyzed for alignment. The occurrence of alignment was regarded as higher accuracy rates in contexts where an interlocutor previously produced an accurate target stress. The results showed that alignment had occurred in terms of pronunciation when participants conducted all the collaborative tasks.

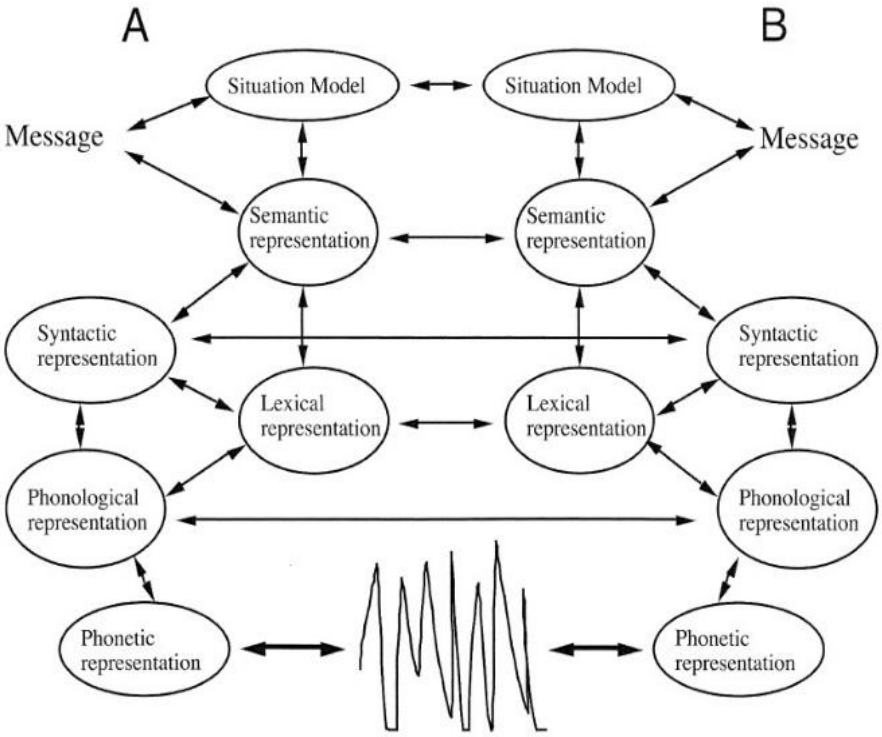

Figure 4. Schematic representation of the stages of comprehension and production processes according to the interactive alignment model (Pickering & Garrod, 2004, p. 176).

Interactive alignment is achieved by a *priming* mechanism, and this mechanism produces alignment at other levels of representation, such as *syntactic priming*. It occurs when the interlocutor repeatedly uses the same particular syntactic structure because of a recent prior experience with the structure. Recurrent findings have shown that priming at one level can lead to more enhanced priming

at other levels (Pickering & Garrod, 2004). According to the Usage-based approaches, this repetition priming is caused by recency effects of prior exposure to stimulus, and it occurs unconsciously when interlocutors use implicit memory (Ellis, Romer, & O'Donnell, 2016).

Branigan, Pickering, and Cleland (2000) conducted an experiment with English native speakers by using an oral picture description task, in which the participants described the pictures freely after they were given stimulus sentences (prime sentences, e.g., *the nun giving the book to the clown*). As a result, the priming rate was higher when the verbs in the prime and target sentences were shared (e.g., *the cowboy giving the banana to the burglar*) compared to when the verbs were not shared (e.g., *the cowboy handing the banana to the burglar*). The participants produced target sentences by using the same syntactic structures as the prime sentences. Thus, the study revealed that syntactic priming is enhanced when more lexical items are shared between interlocutors. This enhancement is not limited to different linguistic levels independently, and interlocutors align their representations at each linguistic level mutually.

Experiments 1 and 2 focus on the occurrence of syntactic priming effect to clarify the magnitude of automatization of syntactic processing of Japanese EFL learners.

2.4 Effects of Verb Differences on Syntactic Priming

Bock and Loebell (1990) investigated the syntactic priming effects of English native speakers. The participants in the study were given prime sentences with a PO or DO, and they read the prime sentences aloud and they were instructed to complete the target fragments with each fragment containing a subject followed by a dative-alternating verb. The primes were the PO and DO in the sentences. In the result, participants tended to produce more PO sentences after the PO primes and more DO sentences after the DO primes; thus, a syntactic priming effect was observed. The result showed that English native speakers tended to replicate the syntactic structures of the primes within sentence targets.

The previous study discussed above have shed light on the mechanism of syntactic processing of English native speakers and attempted to explain how speakers retained their syntactic representations. Figure 5 shows a partial model of the representation of syntactic information associated with verbs in the production lexicon (Pickering & Branigan, 1998, p. 635).

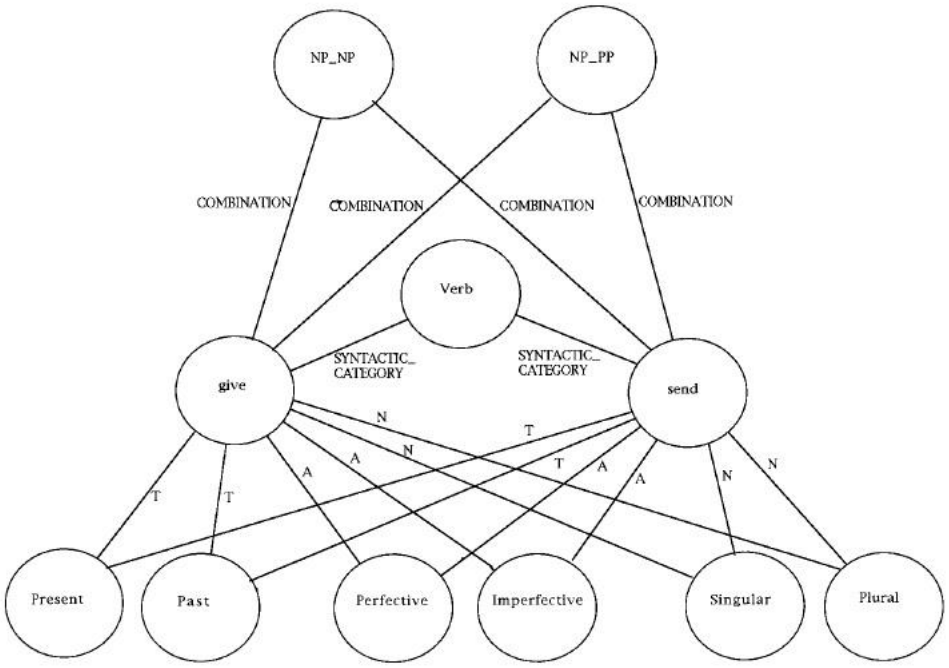

Figure 5. A partial model of the representation of syntactic information associated with verbs in the production lexicon. The labels T, A, and N refer to tense, aspect, and number, respectively (Pickering & Branigan, 1998, p. 635).

In this model, Pickering and Branigan mentioned that syntactic information is consisted of three types of information: *category* information, *featural* information, and *combinatorial* information. Category information encodes the syntactic category of a word such as noun, verb and adjective. Featural information deals with the number, person, tense, and aspect of an instantiation of a verb and so on. Combinatorial information designates the way for a word to combine with other linguistic units in order to from possible expressions.

According to the Figure 5, combinatorial nodes *NP (noun phrase), NP* and *NP, PP (prepositional phrase)* are directly linked to the lemma *give*. This lemma is unspecified for features such as tense, aspect and number. Moreover, these nodes are also directly linked to the lemma *send*. Therefore, these combinatorial nodes are shared between two different lemmas. When a speaker is exposed to a PO sentence with a lemma *give*, a combinatorial node of *NP, PP* gets activated, and the activation does not disappear immediately. Thus, if a speaker tries to produce a subsequent sentence with different lemma *send*, the combinatorial node *NP, PP* will be more higher activated than normal to produce a

PO sentence.

McDonough (2006) examined the occurrence of syntactic priming of L2 English speakers. The study used confederate scripting to elicit PO or DO structures when participants began describing the pictures orally after they were exposed to the structures as prime sentences. Results showed that syntactic priming was observed with only PO sentences, and not DO sentences. Therefore, McDonough found that the production percentage of L2 English speakers' PO and DO sentence structures is biased compared to English native speakers who produced both sentence structures equally with evidence of syntactic priming with both structures. The result revealed that the degree of how speakers retain their syntactic representations in their mental lexicon differs with English native speakers and L2 English speakers. McDonough and Chaikitmongkol (2010) investigated the influence of syntactic priming effects on second language acquisition by using wh-questions as the target structure. The study used an information exchange task to EFL learners, and participants who completed a priming activity produced more wh-questions than participants who did not complete the activity.

Pickering and Branigan (1998) investigated syntactic priming using a written completion task. English native speakers were told to complete the prime sentences such as fragments (1a) to (1d) with either PO or DO sentences, and after that, they were instructed to complete the target sentences, such as the incomplete clause in (2). The result showed that syntactic priming occurred with both PO and DO sentence structures. The experiments also showed that syntactic priming was observed when the verbs remained the same and when the verbs varied between the prime and target sentences. However, syntactic priming was stronger if the verbs remained the same as illustrated in (1a), (1b), and (2) compared to when the verbs varied in (1c), (1d), and (2).

(1) a. The racing driver *showed* the torn overall...

b. The racing driver *showed* the helpful mechanic...

c. The racing driver *gave* the torn overall...

d. The racing driver *gave* the helpful mechanic...

(2) The patient *showed*...

(Pickering & Branigan, 1998, p. 637)

Morishita, Satoi, and Yokokawa (2010) applied the experimental method of Pickering and Branigan (1998) to Japanese EFL learners and conducted a written completion task. The study found similar results to the results of the study using English native speakers obtained by Pickering and Branigan (1998) but with stronger syntactic priming when the verbs remained the same between prime and target sentences.

Syntactic structure is said to be consisted of a combination of lexical representations, and the node between a word and syntax is activated when the same word is repeated (*lexical boost effect*). This activation also reaches other words which shares the same syntax. In Hartsuiker, Bernolet, Schoonbaert, Speybroeck, and Vanderelst (2008), syntactic priming effect and lexical boost effect were observed in experiments using a picture description task to Dutch native speakers. By controlling the number of fillers between the prime and the target, this study found that a lexical boost effect sustained in a speaker's short-term memory; on the other hand, a syntactic priming effect sustained in the long-term memory. Thus, the study implied that the syntactic priming is one of the forms of implicit learning. If syntactic priming is observed when the verbs remain the same, it is likely that only a short-term lexical boost effect occurred. On the other hand, if syntactic priming is observed when the verbs vary, it is likely that a long-term generalization of syntactic information by learners occurred.

2.5 Effects of Modality on Syntactic Priming

Cleland and Pickering (2006) reported the effects of the differences of output modality (i.e., spoken or written) on syntactic priming effect. English native speakers were instructed to complete spoken or written target sentences after hearing or seeing the prime sentences. The result shows the evidence of syntactic priming with both spoken and written primes. Therefore, the result indicates that English native speakers' syntactic representations are shared between spoken and written production, and the differences of output modality do not affect the operation of a speaker's or writer's knowledge of sentence structures. Morishita (2011a) used the experimental method of Cleland and Pickering (2006) to Japanese EFL learners, and conducted sentence completion task. As a result, the Japanese EFL learners' priming rate was stronger with PO prime sentences compared to the priming rate with DO prime sentences; however, it was the lowest with spoken primes and targets. The results suggest that the differences of output modality affect the operation of Japanese EFL learners' knowledge of sentence structures, and the magnitude of the operation differs with spoken and written production.

However, the study highlighted the learners' lack of listening ability, and the results cannot be concluded since learners might not be able to hear and understand the spoken primes. Thus, in the current experiments, we controlled the primes in terms of their syllable, familiarity and speed to ensure that the participants of the study could hear the spoken primes. Moreover, there is a possibility that presentation of prime once was not enough to cause syntactic priming with spoken primes and targets. Therefore, the present study researched whether the differences of primes' presentation conditions affect participants' syntactic priming rate. In Experiments 1a and 1b, we set conditions which focus participants' attention more to meanings or forms, and participants were randomly allocated to three conditions: (a) presentation of a prime once, (b) presentation of a prime once with a question, and (c) presentation of primes twice.

Morishita (2011b) conducted the experiments using a sentence completion task, which produced spoken or written targets with spoken and written primes in a simultaneous presentation to English native speakers and Japanese EFL learners. As a result, the syntactic priming effect was observed with both English native speakers and Japanese EFL learners. The English native speakers' priming rate was stronger with spoken targets, but the differences of output modality were not observed with the Japanese EFL learners' priming rate. However, Morishita's (2011b) participants received spoken and written primes simultaneously, so the study did not intend to clarify how Japanese EFL learners are operating their syntactic representations during spoken and written production. Morishita (2011b) has not explored the effect of modality, and the studies conducting on EFL learners are still scarce. Thus, the current study needs to clarify the evidence of syntactic priming by presenting only spoken primes.

Therefore, Experiments 1a and 1b put the focus on observing Japanese EFL learners' syntactic priming after hearing the spoken primes, effects of verb, and primes' presentation conditions differences on the syntactic priming. Moreover, since the previous studies have not demonstrated the effect of output modality on Japanese EFL learners' syntactic priming, we conducted two experiments in order to investigate whether the differences of output modality affect Japanese EFL learners' syntactic priming in language production. Experiment 1a was conducted with spoken targets, and Experiment 1b was conducted with written targets.

2.6 Effects of Proficiency Differences on Syntactic Priming

Rowland, Chang, Ambridge, Pine, and Lieven (2012) conducted oral video description task to

children (3-4 years olds, 5-6 years olds) and adults to clarify English native speakers' development of abstract syntax in a cognitive mechanism of language processing. The results showed that children's magnitude of syntactic priming effect was larger than that of adults', and adults' magnitude of lexical boost effect was larger than that of children's. Thus, children with few knowledge of syntactic structures are more susceptible to the effects of syntactic priming with less competition of structures; however, the lexical boost effect increases with development. Therefore, the results supported the idea that abstract syntactic knowledge develops separately with verb-specific frames.

Hartsuiker and Bernolet (2017) proposed the processing model of L2 syntax acquisition based on the lexically-based model. Figure 6 shows the different steps of development in lexico-syntactic network in L1 (top) or L2 (bottom) (Hartsuiker & Bernolet, 2017, p. 229). The left-hand side panel is that obtained after successful L1 acquisition, and right-hand side panel is that of a second language learner reaching considerable proficiency in their L2.

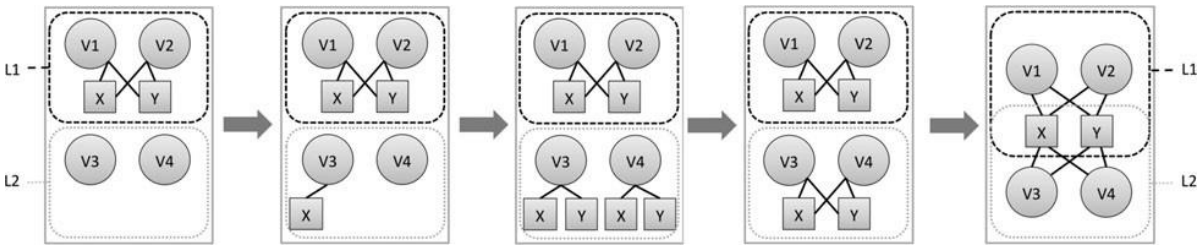

Figure 6. Developmental model. V1 and V2 are verbs in L1 and V3 and V4 are verbs in L2; X and Y are combinatorial nodes that eventually become shared between the different verbs of both languages (Hartsuiker & Bernolet, 2017, p. 229).

Learning occurs in a network of representations that achieves a balance between two principles, namely representational specificity and economy. L2 language acquisition begins with learning of lexical representations without strong connections to syntactic information, and then, syntactic representations emerge with exposure with the syntactic structures. At this stage, combinatorial nodes for both frequent and infrequent structures are added to situations with sufficient exposure to L2 syntactic structures. In the last stage, item-specific syntactic representations become more abstract, and they show both item-specific and abstract priming in L2. Hartsuiker and Bernolet (2017) also proposed that the magnitude of maintaining and retrieving lexico-syntactic representations in a

language processing depends on L2 learners' language proficiency levels. Lower level learners tend to rely on lexical items and transfer from their L1 and imitation when they produce complex structures. After sufficient exposure to L2, language- and item-specific syntactic representations are gradually added for medium level learners. Adding combinatorial nodes in this stage leads to the situation depicted next. For upper level learners, their syntactic representations become more abstract. They are less likely to rely on specific lexical items. Thus, they tend not to be influenced by priming effect.

Previous studies investigating L2 learners' syntactic priming shed light on how learners are operating syntactic information. Kim and McDonough (2008) conducted an oral picture description task to Korean EFL learners to investigate whether L2 speakers produce more target structures when same verb is repeated between the primes and targets, similar to English native speakers (Branigan, Pickering, & Cleland, 2000; Pickering & Branigan, 1998). Results showed that Korean EFL learners produced more passives when they were prompted by verbs which occurred in researchers' passives. Moreover, the lexical boost effect was particularly strong with low level learners. The study found that low level learners are more inclined to rely on the particular lexical items such as verbs compared to higher level learners. Morishita et al. (2010), Morishita (2011b) and Morishita (2013) investigated the effects of the learners' language proficiency differences on syntactic priming effect, and conducted the experiments to Japanese EFL learners. In Morishita et al. (2010), Japanese EFL learners were instructed to complete written target sentences after seeing the written prime sentences. The result showed the syntactic priming rates of medium and upper level learners were higher than the priming rates of lower level learners. The priming rates of medium and upper level learners did not differ significantly. Thus, the results revealed that medium level learners tended to imitate syntactic structures of primes. Upper level learners tended not to care about syntactic structures of primes and constructed sentences freely or they tended to rely on their existing knowledge. On the other hand, lower level learners tended to produce other structures, and the result suggested that their lexical representations have not been well formulated. However, the study was conducted using only written primes, so the results did not show the effect of the differences of learners' proficiency levels on syntactic priming effect with spoken primes. Morishita (2011b) conducted a sentence completion task, which produced spoken or written targets with spoken and written primes in a simultaneous presentation. According to the scores of the Oxford Quick Placement Test (Oxford University Press, 2001), participants were divided into three levels of English proficiency (i.e., upper, medium or lower).

Participants in A1 and A2 levels of the Common European Framework of Reference for Languages (CEFR) were regarded as lower level learners (Council of Europe, 2001). Participants in B1 level were regarded as medium level, and participants in B2, C1, and C2 levels were regarded as upper level learners. As a result, the magnitude of syntactic priming effect increased as learners' proficiency got higher. Morishita (2013) used the experimental method of Branigan, Pickering and Cleland (2000) to English native speakers and Japanese EFL learners, and conducted an oral picture description task. According to the scores of the Versant Speaking Test, participants were divided into three levels of English proficiency (i.e., upper, medium or lower). Participants in A1 level were regarded as lower level learners. Participants in A2 level were regarded as medium level, and participants in B1 or above levels were regarded as upper level learners. The results showed that English native speakers' priming rate was higher than Japanese EFL learners' priming rate in overall, however, the interaction task in this study required participants to exchange information and syntactic structures at the same time. Therefore, the cognitive load of the task might be heavier for Japanese EFL learners who lack automaticity in language processing. The results of Japanese EFL learners replicated the finding of Morishita (2011b) with exception that the difference between the priming rates of upper and medium level learners was not significant.

These studies investigating effects of proficiency differences on syntactic priming showed contradicting results. Syntactic priming is said to be more effective for children with little syntactic experiences (Rowland et al., 2012). However, priming studies with EFL learners revealed that upper level learners' priming rates were higher than lower level learners' (Morishita et al., 2010, Morishita, 2011b, 2013). Compared to English native speakers, EFL learners severely lack the amount of input including syntactic experiences. Thus, EFL learners gradually formulate their lexical representations as the amount of input increases, and syntactic priming effect occurs when they internalize the representations in the mental lexicon.

Previous studies of EFL learners' syntactic priming effect demonstrated that the learners' proficiency differences affect the magnitude of priming. Therefore, the magnitude of operating syntactic information might also differ by learners' developmental stages. However, these study have not controlled the primes in terms of their syllable, familiarity and speed to ensure that the participants could hear the spoken primes. Experiment 2 used the controlled primes to ensure participants can hear and understand the primes. Moreover, the experiment put the focus on observing the effect of Japanese

EFL learners' proficiency differences on the magnitude of syntactic priming in different primes' presentation conditions to investigate the part of L2 learners' language acquisition process. Thus, Experiment 2 divided the participants into two levels of English proficiency (i.e., upper or lower) to observe how Japanese EFL learners' syntactic production become automatic.

2.7 Effects of Repetition of Primes on Syntactic Priming

A number of studies which investigated the syntactic priming effects with English native speakers and EFL learners often presented primes once. However, Huttenlocher, Vasilyeva, and Shimpi (2004) conducted experiments using a picture description task with repetition of primes to show the syntactic priming effect with children. Repetition of primes by participants was said to be indispensable for the syntactic priming effect to occur. Bock and Griffin (2000) also mentioned that speakers implicitly learn somehow better how to express the message with the given structure when they repeat and process a given syntax structure.

On the contrary, according to Branigan, Pickering, Stewart, and McLean's (2000) study, repetition of primes is not necessary for the syntactic priming effect to occur. The syntactic priming occurs not only when people produce a particular syntactic form, but also it occurs when they only hear the form. The study investigated whether priming effects are stronger when the primes are repeated compared to when they are not repeated. In this study, participants were shown pictures and heard a description as a prime given by researchers. Then, they were instructed to repeat the primes and describe a picture after that. The results showed that the participants tended to use the structure of primes. Thus, the result confirmed that children's syntactic form is represented independently of particular lexical items like adults. In addition, comparing the results with or without repetition of primes, the magnitude of syntactic priming effect did not differ. Therefore, by only hearing primes, the participants tended to produce target syntactic structures. However, in the study, experiments were conducted on English native speakers, and they have not investigated whether the repetition of primes promotes syntactic priming effect to EFL learners. Japanese EFL learners' syntactic priming rate with spoken primes and targets is said to be lowest (Morishita, 2011a). Thus, in Experiments 1a and 1b, we set three primes presentation conditions to promote the occurrence of the syntactic priming, and in Experiment 3, the participants listened and repeated the primes to promote them to focus more attention to target syntactic structures.

2.8 Persistence of Syntactic Priming

As mentioned above, the occurrence of the syntactic priming effect in language production is a tendency to reuse the syntactic structure used in the prior context with different vocabulary, and this tendency is independent with specific lexical items or word orders (Bock & Loebell, 1990). Recent interactional studies focus on the positive correlation between interaction and L2 language acquisition. These studies are affected by L1 production and acquisition studies, and recognize the syntactic priming effect as one of interactional features which promote L2 language processing (McDonough & Kim, 2009).

In previous studies, the mechanism of the syntactic priming effect was described using two accounts: residual activation account and implicit-learning account (Pickering & Branigan, 1998; Bock & Griffin, 2000; Chang, Dell, & Bock, 2006). In residual activation account, a lexical-syntactic node representing a certain syntactic structure gets activated when a speaker processes a prime sentence, and the probability of selecting those structures would increase as long as the node is more active than usual. When a prime sentence is processed with a certain verb and structure, the link between the relevant verb lemma and combinatorial node gets more active which leads to a lexical boost effect. In this account, priming is attributed to an activity in a particular memory location or representation. Therefore, the activation needs to be moved away from a current focus of processing to additional information to process. Thus, the syntactic priming effect decays rapidly, and it sustains for a short period of time (Pickering & Branigan, 1998). In Levelt and Kelter (1982) investigating syntactic priming effect using questions and answers, the repetitions of word and syntax were observed in dialogue in laboratory. However, the repetitions of syntactic structures diminished rapidly in a condition in which one filler was inserted between a question and an answer, and lower magnitude of syntactic priming effect sustained for a longer period. Branigan, Pickering and Cleland (1999) mentioned that syntactic priming effect did not sustain for a longer period of time. The study investigated the persistence of syntactic priming effect using a sentence completion task to English native speakers, which produced written targets with written primes. Verbs between primes and targets were always repeated.

(3) a. The woman sent the insurance claim...

b. The woman sent the insurance company...

(4) The fan sent...

The prime and target fragments each contained a dative verb that could appear with both the PO and DO construction. Prime fragments also contained a post verbal noun phrase to design that participants can either complete with PO constructions for a plausible patient for the action mentioned by the verb as in (3a), and with DO constructions for a plausible beneficiary as in (3b). The results showed that the syntactic priming effect decayed rapidly when 1 lag was inserted between a prime and a target, and there was no priming effect when 4 lags intervened. Thus, the study mentioned that the syntactic priming effect did not sustain for a longer period of time. Reliable priming occurred only when the target immediately followed the prime. However, the rapid decay of priming effect might be observed because written output modality affects amount of time required and pace. Moreover, the sentence completion task might focus attention to processing at conceptual level rather than syntactic encoding, and the task did not require speakers to remember the prime sentences. The study did not clarify that these possibilities affect the rapid decay of syntactic priming effect. Contrary to results of Branigan et al. (1999), Branigan, Pickering, Stewart, et al. (2000) argued that the syntactic priming effect can sustain over intervals. The study used the experimental method and stimuli of Branigan et al. (1999) to English native speakers with exception that it employed spoken primes and targets. It also set the conditions with 0 or 1 lag intervened between primes and targets. If the rapid decay of the syntactic priming effect observed in a previous study was caused because the syntactic priming effect in written production decays rapidly compared to spoken production, the magnitude of syntactic priming effect in each condition does not differ. However, if this rapid decay was caused by characteristic of sentence completion task, syntactic priming effect decays rapidly with a filler intervened. As a result, the study found equivalent priming effects at all conditions. Thus, the study showed that the syntactic priming effect with spoken primes sustains over intervals, and the results contradicted with the results of Branigan et al. (1999). It suggested that the results of Branigan et al.'s (1999) were not accounted for the characteristics of the task employed, but the output modality they used. Therefore, syntactic priming effect with spoken sentence completion task sustains for a longer period of time; however, it might differ by using different modalities, tasks and linguistic materials between primes and targets.

Wheeldon and Smith (2003) examined the persistence of the syntactic priming effect on sentence production latencies using a picture description task with spoken primes. Sentence production latencies were significantly shorter with targets production using same syntactic structures with primes compared to targets using different structures. However, this priming effect decayed rapidly when 1 lag was inserted between a prime and a target. The results showed that speakers could retrieve syntactic structures of primes as an explicit memory when target immediately followed the prime. However, the fact that the priming effect failed to persist over 1 lag suggested that analyses of sentence production latencies instead of syntactic selection investigated the different part of processing from previous studies analyzing speakers' syntactic selection. Moreover, the use of stimuli which did not contrast the mapping from thematic to grammatical roles failed to occur priming during the mapping from conceptual to functional processing, but the current study showed the priming of constituent assembly processes at the positional level.

Branigan, Pickering, Stewart, et al. (2000) showed English native speakers' syntactic priming effect with spoken primes and targets. However, it explored the persistence of the syntactic priming effect with relatively short lags. Thus, Experiment 3 was conducted on Japanese EFL learners with spoken primes and targets with longer lags intervened between primes and targets.

In implicit-learning account, syntactic priming is recognized as learning processes for longer term adjustments in the sentence production system (Levelt, 1989). The changes induced by syntactic priming are seen as procedural or implicit learning (Tulving & Schacter, 1990). Syntactic priming effect can be seen without lexical repetitions, and it can sustain over intervals that are unlike to involve memory maintenance. Chang, Dell, Bock, and Griffin (2000) and Chang et al. (2006) proposed that both immediate and long-term effects of prior syntactic experiences occur from a single error-based implicit learning mechanism. The study mentioned that speakers use the difference (error) between the predicted and actual next word to adjust weights associated with syntactic knowledge in the mechanism to improve their subsequent production. This theory considered about changes in abstract syntactic processes. The account mentioned that lexical repetitions do not influence on the magnitude of priming.

Bock and Griffin (2000) conducted a picture description task to English native speakers with spoken primes and targets. The study set five lag conditions (i.e., the number of lag between primes and targets: 0, 1, 2, 4, and 10) to investigate if learners tend to use more primed syntactic structures

compared to unprimed syntactic structures over longer lags. Figure 7 shows the sequence of the priming trial in the study (Bock & Griffin, 2000, p. 178).

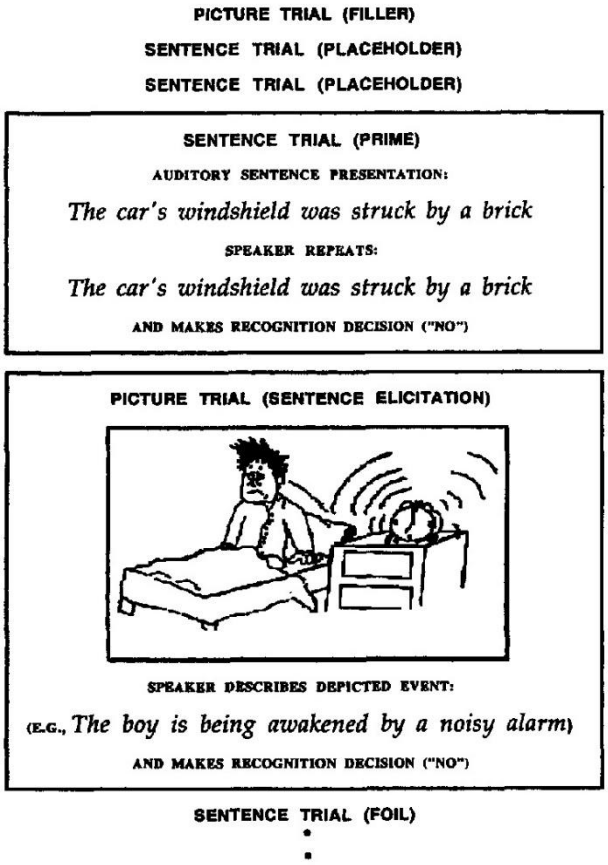

Figure 7. Sequence of events on a sample Lag-0 structural priming trial (Bock & Griffin, 2000, p. 178).

The participants heard the spoken primes, and they were instructed to judge if they heard the same primes in the experiments after they repeated the primes. After they answered the judgement task, they orally described about the target pictures, and answered the judgment task once more. Verbs between primes and targets were always different. As a result, syntactic priming effect did not decline and sustained in all conditions, with lags inserted between primes and targets. The result suggested that the syntactic priming effect can sustain for longer period of time, and speakers adapt their cognitive mechanism as a form of implicit or procedural learning rather than temporary activation of memory representations. The speakers of the study could be able to generalize the target structures and use it with a variety of lexical items. The study implies that the results shown were caused by

experience-dependent adaptation in the mechanisms of language production, and this adaptation was caused by implicit learning. The study also mentioned that syntactic priming can be used to promote learners using known syntactic structures to express new or different ideas. Bock, Dell, Chang, and Onishi (2007) replicated the experimental method of Bock and Griffin (2000) without primes' repetitions by speakers. The syntactic priming effect occurred in all lag conditions without primes' repetitions. The result demonstrated structural persistence from comprehension to production in comparable magnitude to persistence from production to production.

In most studies, it has considered the longevity of priming has shown priming to be long-lived, and it is consistent with the implicit learning account. However, some studies showed contradicting results with a rapid decay of syntactic priming effect. Thus, Hartsuiker et al. (2008) suggested that the best working hypothesis might be a multi-factorial account. According to the theory, syntactic priming is caused by abstract and long-term learning mechanisms as the implicit-learning account proposed (Bock & Griffin, 2000). However, it is also caused by lexically-specific mechanisms as the residual activation account proposed (Pickering & Branigan, 1998). The theory was proposed by Bock and Griffin (2000) and Chang et al. (2006). The multi-factorial account suggests that syntactic priming is partly caused by lexicon-external and implicit-learning mechanisms. However, a further driving force is a mechanism that uses primes' sentence structures as explicit memory. Therefore, according to this account, the syntactic priming effect should be enforced when primes and targets share verbs which would act as a retrieval cue. Lexical boost effect decay faster than the syntactic priming effect, and this decay is caused by a decline in explicit memory of sentence structures. As mentioned in the previous chapter, Hartsuiker et al.'s (2008) showed syntactic priming effect and lexical boost effect conducting a picture description task to Dutch native speakers. Syntactic priming effect sustained in all lag conditions (i.e., lag 0, lag 2, and lag 6). However, priming effect was significantly high at Lag 0 condition with same verb between prime and target, and it decayed rapidly as the number of lags increase (lag 0: 23%, lag 2: 13%, lag 6: 3%). Because the lexical boost effect decays quickly, priming effect in Lag 0 was lexically enhanced as priming effect was shown in Lag 0 condition in Branigan et al. (1999), whereas priming effect at later lags did not benefit from lexical support, leading to the decay of priming. Therefore, the results showed that the lexical boost effect decays quickly, but the priming effect sustains for longer period of time.

Shin and Christianson (2012) compared the cognitive benefits of implicit learning using syntactic

priming to the benefits of explicit instruction in L2 production. Two day picture description task with spoken primes and targets was conducted on Korean EFL learners, and they were randomly allocated to three learning conditions (i.e., no-lag comparison: lag 0, long-lag implicit: lag 4-5, explicitly reinforced: no-lag with additional explicit instruction). Learners repeated the primes before they produce the targets, and the verbs between primes and targets were always different. As a result, the production of target structures was increased after the structural priming session, indicating exposure to syntactic priming promoted the learners to use the target structures in L2 production. In the immediate posttest on the first day, explicitly reinforced condition showed more improvement than other conditions. However, in the delayed posttest on the second day, only the long-lag implicit condition involving implicit learning sustained increased production of the DO sentence structure, whereas the no-lag comparison condition involving explicit memory processes did not sustain the improvement. Therefore, the results demonstrated that the syntactic priming effect in the long-lag condition sustained, and the condition involves purely implicit-learning processes because residual activation in explicit memory cannot persist with more than 4-5 filler sentences between primes and targets. Thus, the syntactic priming effect persists longer with lags intervened compared to the no-lag condition with same number of exposure of primes and the study mentioned that the syntactic priming promotes the development of L2 language processing and acquisition.

Experiments 1 and 2 investigated whether the differences of output modality and learners' proficiency differences affected Japanese EFL learners' syntactic priming. However, the experiments were conducted within a relatively short period of time, and the targets immediately followed the primes in both studies. As such, the syntactic priming effect in Experiments 1 and 2 might be caused by the temporary occurrence of the residual activation or by acquisition of target structures by implicit learning. Therefore, the purpose of Experiment 3 was to investigate whether the knowledge of target structures is changing from declarative to procedural knowledge by promoting the syntactic priming effect with repeated exposure to the specific syntactic structures. Experiment 3 clarified whether the syntactic priming effect, which might be observed in prior experiments, would continue for a longer period with insertion of lags between primes and targets.

2.9 Spacing Effect

Ebbinghaus (1885) introduced the theory that mentions about the effective way for learning. The

theory shows that information is best learned and retained by studying in spaced intervals (spaced distribution) compared to studying in one uninterrupted session (massed distribution) by considering about a total constant time for studying. This effect is called *spacing effect*. For effective learning and acquisition of information, this spacing effect has investigated in various learning domains, such as mathematics and memorizing pictures (Rohrer & Taylor, 2006; Toppino, 1993). The spacing effect is also said to be effective for developing more complex skills beyond rote memorization. Rohrer and Taylor (2006) also found the significant spacing effect over development for complex mathematical skills.

Collins and White (2011) conducted experiments to research the spacing effect on L2 language acquisition by comparing spaced distribution and massed distribution. The study investigated whether different distributions of instructional time have differential effects on the acquisition of English by conducting intensive English as a second language program to French-speaking learners. The results showed that learners in both conditions made significant progress, and learners who participated in the 400 hours program in a 5 month block were superior to learners who participated in the program in a 10 month block in 6 measures out of 20. However, the differences between two conditions were not significant. Thus, the superiority of the spaced distribution was not observed in the study, however, the study suggests that the magnitude of the spacing effect might be lowered by the complex task, or conducting delayed posttest was needed to observe the spacing effect. Previous psychological studies did not show the superiority of the spaced distribution in immediate posttest, but in delayed posttest. Besides, in spaced distribution, specific language items need to be reviewed in well-defined spaced intervals. Systematical recycling of target items is important for the spacing effect to be effective. Therefore, lexical or grammar items introduced in one class need to be recycled in later classes with spaced intervals.

In the field of second language learning, a large amount of studies about the spacing effect on L2 vocabulary acquisition have been conducted, and the effect's possible applications for second language learners have asserted. Schmidtt (2000) argued about the significance of rehearsal in vocabulary acquisition. Forgetting about linguistic items tends to occur after they were studied. Therefore, repetitions of reusing the items within the week they were learned or after a period of time are needed to increase the longevity of keeping the information. Bloom and Shuell (1981) confirmed that spacing effect methodology can have a strong effect on language vocabulary acquisition, and showed that

conducting learning sessions in spaced distribution slows the learners' forgetting process. The study was conducted on English native speakers who enrolled in a French course to investigate whether the spacing effect is effective or not for acquisition of vocabulary words learned in French. The massed distribution group spent 30 min of one studying session for learning the words, and the spaced distribution group spent 10 min a day for three days studying sessions for learning. The results showed that identical gains were observed for both groups in an initial test following the last studying session. However, the spaced distribution group outperformed the mass study group in an unannounced delayed retest given four days later from the initial test. Bahrick (1979) compared more carefully in terms of the length of spacing intervals. The study was conducted on English native speakers learning Spanish to investigate the effects of the spacing effect on acquisition of vocabulary words learned in Spanish. Participants in the study were divided into three learning conditions. The first group was presented with the words in massed distribution by studying the words without interruptions between sessions. The second group had study intervals of 1 day between sessions, and the final group had study intervals of 30 days. Six follow-up test sessions were conducted, and a final test was conducted to all conditions 30 days after the fifth test to investigate the retention of the knowledge. The results showed that the massed distribution group was superior to the spaced distribution groups in the first test, however, the spaced distribution groups especially the group with 30 days study intervals had the best results in later tests. Therefore, these studies confirmed the spacing effect and indicated that conducting study sessions in spaced intervals is effective for L2 vocabulary acquisition. Studying the words in particular intervals slows the learners' forgetting process of the items.

The spacing effect has already been investigated in L2 vocabulary acquisition. However, the importance of spacing effect such as rehearsing target items after a certain period of time has not been proved enough in L2 grammar learning. In the field of L2 grammar learning, Year and Gordon (2009) investigated the spacing effect by comparing the learners who had instruction in 4 days, 4 weeks, and 8 weeks intervals. The study conducted experiments to Korean EFL learners to investigate the extent to which a prototypical ditransitive verb with high frequency facilitates the acquisition of the English ditransitive construction. As the result, the spaced distribution groups (4 weeks and 8 weeks intervals) outperformed the massed distribution group on elicited production and acceptability judgement. Miles (2014) also showed the superiority of the spaced distribution. The study conducted on Korean EFL learners compared learners who had all sessions of instruction of the target grammar items in 1 day

and learners who had sessions in a 6 week block. As a result, learners who had sessions in a 6 week block were superior to learners who had all sessions in 1 day on delayed posttest. Moreover, compared to learners who had sessions in a 6 week blocks, the decline on gains from the posttest to delayed posttest for learners who had all sessions in 1 day was larger. The results showed that learners who had spaced distribution made gains which is more stable than learners who had massed distribution, and the process of forgetting gets slower when the interval gets longer.

The studies which investigated the effects of the spacing effect also argued about the length of spacing gap (intersession interval: ISI) for information to be retained longer. Carpenter, Cepeda, Rohrer, Kang, and Harold (2012) mentioned about the time intervals during spaced study. The study noted that learners in spaced distribution outperformed the learners in massed distribution on delayed posttest, however, there was no difference between two conditions on immediate posttest. Therefore, short ISI tends to benefit for short information retention like cramming for exams just before the exam day. Besides, long ISI is thought to be effective for long information retention. Thus, there are no fixed ISI for longer retention of information. Bird (2010) compared two conditions with different length between last session and posttest (retention interval: RI). The participants of the study were Malay EFL learners, and they were assigned to two conditions (i.e., 5 sessions in 3 days block, 5 sessions in 14 days block). They had posttest either 7 days or 60 days after the last session. As the result, the rapid decline was observed for learners who had 5 sessions in 3 days block, but not learners who had sessions in 14 days block on the posttest which was conducted 60 days after the last session. However, the study did not instruct learners to actually produce, but they were instructed to correct the grammatical errors. Therefore, further studies that require learners to produce the language are needed. The results of the previous studies showed that long period of ISI and RI might be effective for learners' longer information retention.

However, in previous studies investigating the spacing effect on L2 grammar acquisition, the target syntactic structures, tasks employed, length of implementation period and intervals varied, and the results often contradicted between studies. Moreover the number of the studies is scarce. In Experiment 3, we attempted to investigate the persistence of the syntactic priming effect by giving syntactic priming exposure with lags intervened between primes and targets.

3. EXPERIMENTS 1A AND 1B: Effects of Modality Differences on Syntactic Priming in the Language Production of Japanese EFL Learners

In Experiments 1a and 1b, a picture description task with spoken primes was conducted to investigate whether the differences of output modality (i.e., spoken or written) and verb (i.e., same or different between primes and targets) affect Japanese EFL learners' syntactic priming. Two experiments were conducted to investigate whether the syntactic priming effect is observed after hearing the spoken primes. Experiment 1a was conducted with spoken targets, and Experiment 1b was conducted with written targets. The previous study by Morishita (2011a) highlighted that the priming rate of Japanese EFL learners was the lowest with presentation of spoken primes. Therefore, the present study researched whether the differences of primes' presentation conditions affect participants' syntactic priming rate. Thus, in Experiments 1a and 1b, participants were randomly allocated to three conditions (i.e., Condition A, B, C).

3.1 Research Questions

The following research questions were addressed in this study:

Research Question 1: Does syntactic priming effect occur with the presentations of spoken primes?

Research Question 2: Do the differences in the primes' syntactic structure affect syntactic priming? Do verb differences (i.e., same or different between primes and targets) affect syntactic priming?

Research Question 3: Do the presentation conditions of the primes' differences affect syntactic priming?

Research Question 4: Do syntactic priming rates differ by comparing the results of spoken production (Experiment 1a) and written production (Experiment 1b)?

3.2 Hypotheses

The result can be hypothesized that, for research question one, syntactic priming occurs if the participants could hear and understand the controlled spoken primes. For research question two, the

result can be hypothesized that syntactic priming rate with PO primes is higher than that with DO primes, and syntactic priming rate with same verbs between primes and targets is higher than different verbs. For research question three, the presentation conditions of the primes' differences affect syntactic priming. For research question four, syntactic priming rates differ by comparing the results of spoken and written production, and the differences of output modality affect the operation of Japanese EFL learners' knowledge of sentence structures.

3.3 Methods

3.3.1 Participants

The participants consisted of 70 Japanese undergraduate learners at a university located in Kansai area (Experiment 1a: 35, Experiment 1b: 35). Participants were all native speakers of Japanese, and their age ranged from 19 to 22 years old. The length of their previous English study ranged from 7 to 10 years. The participants attended one day experiment. The study was conducted from December 2015 to January 2016 with spoken targets, and May to June 2016 with written targets. Informed consent was obtained from all the participants. The participants' English proficiency was measured with the Versant Speaking Test (total score: 20~80) in Experiment 1a and Oxford Quick Placement Test (Oxford University Press, 2001: total score: 60) in Experiment 1b. Two different measurements were used because of the different output modality: the Versant Speaking Test is conducted in spoken modality, whereas the Oxford Quick Placement Test is conducted in written modality.

Table 1 shows the results of the English proficiency tests of the participants in Experiment 1a and 1b. Participants were randomly allocated to three conditions: (a) presentation of a prime once (Condition A), (b) presentation of a prime once with a question (Condition B), and (c) presentation of primes twice (Condition C). The participants' mean scores in the Versant Speaking Test in Experiment 1 (A, B, C) were 42.08, 42.00, and 37.45, respectively: The scores are equivalent to A2 (elementary) level of the CEFR. Their mean scores in the Oxford Quick Placement Test in Experiment 2 (A, B, C) were 41.00, 41.25, and 40.73, respectively: The scores are equivalent to B2 (upper intermediate) level of the CEFR. Their results were compared based on three conditions, namely, A, B, and C, and the differences between the conditions were non-significant in both Experiments 1a and 1b.

Table 1

Mean Scores and SDs of the English Proficiency Tests, and Numbers of Participants across Conditions in Experiments 1a and 1b

	Experiment 1a			Experiment 1b		
	A	B	C	A	B	C
	(*n* = 12)	(*n* = 12)	(*n* = 11)	(*n* = 12)	(*n* = 12)	(*n* = 11)
M	42.08	42.00	37.45	41.00	41.25	40.73
SD	6.76	6.37	8.23	2.95	3.08	4.84

Note. A = presentation of a prime once; B = presentation of a prime once with a question; C = presentation of primes twice.

3.3.2 Materials

The target pictures that are intended to induce PO and DO sentence structures (see Appendix A) and filler pictures were prepared. Each target picture depicts actions involving an agent and a beneficiary. Seven dative verbs (*show, give, tell, send, lend, sell,* and *buy*) were used for the prime sentences and target pictures (Morishita, 2011b, p. 78). Each verb was presented by using PO or DO prime sentences, and using a same or different verb between the primes and targets.

(5) a. The girl *showed* the book to the boy. (*PO sentence structure, same*)
b. The girl *showed* the boy the book. (*DO sentence structure, same*)
c. The girl *gave* the book to the boy. (*PO sentence structure, different*)
d. The girl *gave* the boy the book. (*DO sentence structure, different*).

(6) SHOW

The prime sentences containing a subject followed by a verb were consisted of sentence structure with either a PO or DO (see Appendix B); in addition, filler sentences that were unrelated to both target sentence structures and used intransitive verbs were also prepared (e.g., *The store closed.*).

Sentences (5a) to (5d) are prime sentences, and the verb (6) is presented in a target picture. The verb remains the same between the primes and targets in (5a) and (5b), but it is different in (5c) and (5d). All prime sentences were controlled in terms of their syllable, familiarity, location of agents, and speed. The number of syllables in the prime sentences that were prepared ranged from 7 to 11, and all the prime sentences were constructed by using words that are 5.0 or above, but within 7.0 levels, of its audio familiarity rates based on the audio and word version of the vocabulary familiarity list (Yokokawa, 2006; Yokokawa, 2009). The agents in the target pictures were located on the right side in 10 pictures and on the left side in the other 10 pictures in order to avoid participants being fixated on a specific side of the pictures for smooth production. The speed of all the spoken primes was also controlled at 50 wpm.

In the experiments, 20 sets of experimental items were prepared by using four conditions (PO, DO, same verb, and different verb). The experimental items were then placed into four lists (A, B, C, and D), and each list comprised five experimental sentences from each condition which each condition only appearing in each list once, and ten filler sentences. Therefore, each of the four lists contained 30 sentences, including experimental and filler sentences.

3.3.3 Procedure

The experiments comprised three phases. As described above, Phase 2 was divided into three conditions. In Condition A, the spoken primes were presented only once to the participants, and in Condition B, after hearing the spoken primes once, the participants were instructed to answer a question about the spoken primes. Condition B was set to investigate whether focusing the participants' attention to the sentential meaning would promote an additional syntactic priming effect, or it would inhibit the activation of syntactic structures. In Condition C, the same spoken primes were presented twice. This condition was set to investigate whether hearing the same spoken prime twice would ease participants into "catching" the spoken prime, which they might not have heard for the first time, or repetition would enforce the syntactic structures by hearing the spoken prime twice.

The experimental files were presented on a computer screen. Participants were seated in front of the computer in a quiet booth, and were given instructions from the researcher. They were told that the researcher is interested in what kinds of sentences Japanese EFL learners could produce to divert participants' attention from the actual purpose of the current study after an experimental procedure

was given to them. The total time of the experiment was around 90 minutes. The detailed procedure of the experiment is described below.

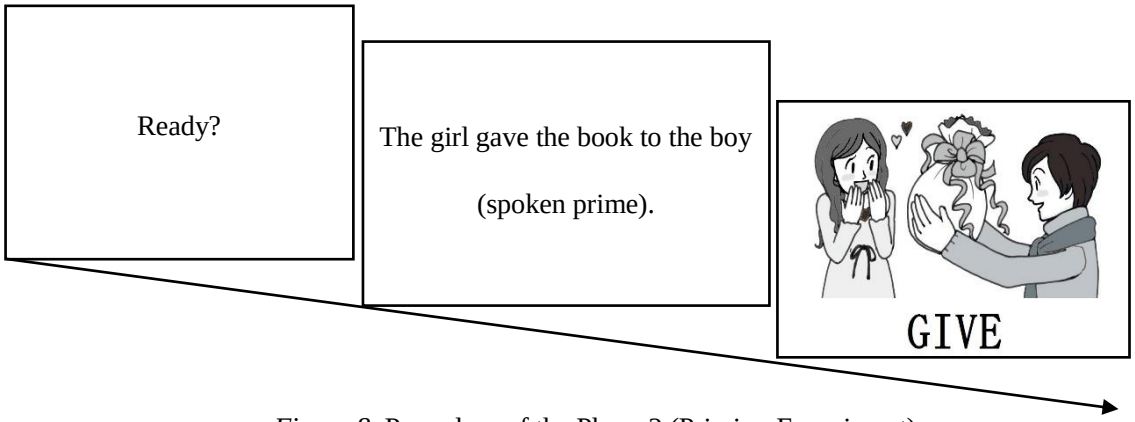

Figure 8. Procedure of the Phase 2 (Priming Experiment).

The Phase 1 (Baseline) of the experiment intended to investigate the participants' original proportional tendency for PO, DO, and other sentence structures. Participants were randomly presented with 30 target pictures to either speak (Experiment 1a) or write (Experiment 1b) about it using the given verbs. The procedure of the Phase 2 is shown in Figure 8. In Phase 2 (Priming Experiment), the participants listened to the spoken primes. They were randomly presented with 30 sentences, including 10 PO sentence structures, 10 DO sentence structures, and 10 fillers, and after they had heard the spoken primes in either forms in either Conditions, A, B or C, then they were told to either speak (Experiment 1a) or write (Experiment 1b) about the target pictures using the given verbs. At the beginning of each trial, the participants would see the message "Ready?" on the computer screen, and press the "Enter" key to start. Then, participants would listen to the primes, repeat it as soon as they heard the primes, and press the "Enter" key. Then, participants would listen to the primes in one condition from the three Conditions A, B, and C, and as soon as they heard the primes, they would press the "Enter" key. After that, a target picture would appear on the computer screen, and the participants would use the verb presented on a target picture to describe the picture in one sentence, either by speaking or writing it down as quickly as they could. Four lists (120 trials) were randomly presented to each participant, and the responses were IC recorded and transcribed. In Phase 3, participants answered a questionnaire their impression of the task after completing the experiment to confirm whether they could listen and understand the primes. The questionnaire also confirmed that

they did not know the purpose of the current study, which was to investigate whether the differences of output modality and verb usage in prime and target sentences affect Japanese EFL learners' syntactic priming.

3.4 Results and Analysis

According to the result of questionnaire, it confirmed that the participants listened and understood the primes without difficulties, and none of them noticed the target structures. In Condition A, the spoken primes were presented only once to the participants, and in Condition B, after hearing the spoken primes once, the participants were instructed to answer a question about the spoken primes. In Condition C, the same spoken primes were presented twice.

3.4.1 Experiment 1a

In Experiment 1a, the participants listened to the spoken primes, and produced the targets in spoken forms.

3.4.1.1 Production of targets' syntactic structures in conditions

Figure 9 shows the overall proportions (%) of participants' responses based on primes' presentation conditions and verb differences in spoken production.

The raw data of the participants' responses was examined. Participants produced more PO targets than DO targets after they were presented with the PO primes (PO: 81.25%, 75.00%, DO: 8.33%, 11.25%); however, they produced more PO targets than DO targets even after they were presented with the DO primes (PO: 72.08%, 76.25%, DO: 10.42%, 10.83%) in Condition A. The proportion of the PO target productions after a PO prime presentation with the same verb between the primes and targets was the largest (81.25%) in all target productions. In Condition B, the participants produced more PO targets than DO targets after they were presented with the PO primes (PO: 59.17%, 55.42%, DO: 14.17%, 15.00%). Nevertheless, they produced more PO targets than DO targets even after they were presented with the DO primes (PO: 53.33%, 55.42%, DO: 17.92%, 17.50%). The proportion of the PO target productions after a PO prime presentation with the same verb between the primes and targets was the largest (59.17%) in all target productions. In Condition C, participants produced more PO targets than DO targets after they were presented with the PO primes (PO: 74.55%, 63.64%, DO:

7.73%, 13.18%); however, they produced more PO targets than DO targets even after they were presented with DO primes (PO: 62.73%, 67.27%, DO: 14.55%, 9.55%). The proportion of the PO target productions after a PO prime presentation with the same verb between the primes and targets was the largest (74.55%) in all target productions.

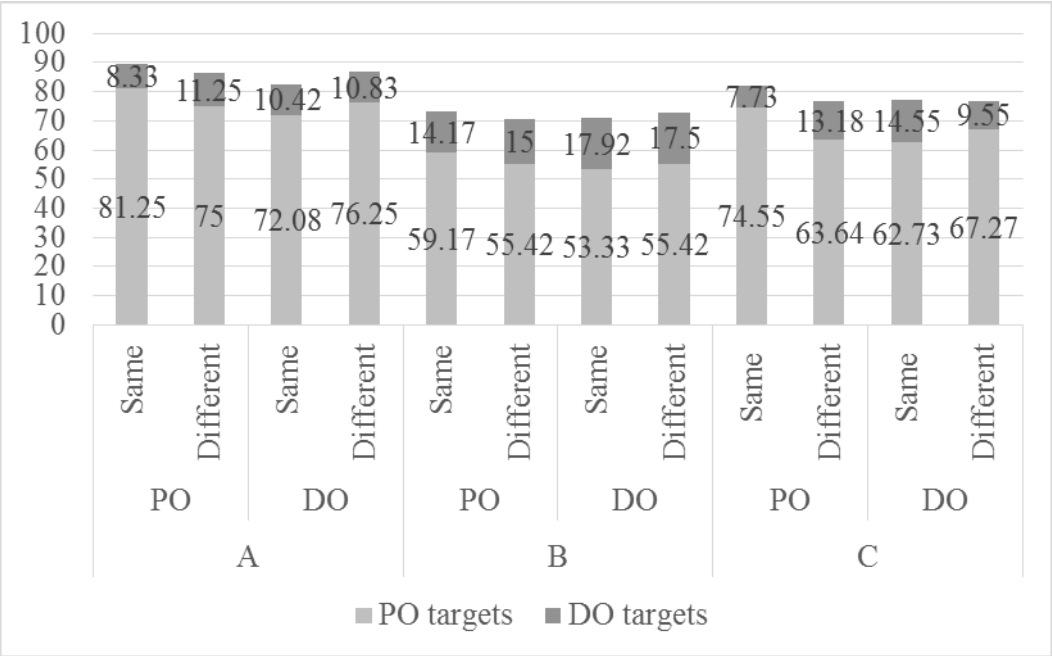

Figure 9. Overall proportions (%) of responses based on primes' presentation conditions and verb differences in spoken production.

3.4.1.2 Primes' presentation conditions and targets' syntactic structures

Transcribed target responses were divided into "Priming" (i.e., Using the same sentence structure between primes and targets), "Alternate" (i.e., DO target production for PO prime sentences or PO target production for DO prime sentences), and "Other" (i.e., Other which is unrelated to Priming and Alternate groups) groups. The primes' presentation conditions (i.e., A, B, or C) as a between-participant factor and sentence structures (i.e., Priming, Alternate, or Other) as a within-participant factor were analyzed in a two-way analysis of variance (ANOVA). Throughout the analyses, *p*-values less than .05 were considered to be statistically significant, and partial eta-squared (η^2) values are reported as effect sizes. Table 2 provides the result of the overall mean numbers of responses, relative

proportions (%), and SDs for Experiment 1a.

Table 2

Experiment 1a: Overall Mean Numbers of Responses, Relative Proportions (%), and SDs

		Priming			Alternate			Other		
Prime		*n*	*%*	*SD*	*n*	*%*	*SD*	*n*	*%*	*SD*
A	PO	31.25	78.13	8.16	3.92	9.79	7.13	4.83	12.08	4.43
	DO	4.25	10.63	6.68	29.67	74.17	10.86	6.08	15.21	3.75
B	PO	22.92	57.29	5.98	5.83	14.58	6.36	11.25	28.13	6.99
	DO	7.08	17.71	8.21	21.75	54.38	8.14	11.17	27.92	8.35
C	PO	27.64	69.09	6.65	4.18	10.45	5.00	8.18	20.45	5.27
	DO	4.82	12.05	6.60	26.00	65.00	7.38	9.18	22.95	5.46

Note. A = presentation of a prime once; B = presentation of a prime once with a question; C = presentation of primes twice.

According to the results of the PO primes, the interaction between the primes' presentation conditions and sentence structures was significant (F (4, 64) = 2.50, $p < .05$, *partial* $\eta^2 = .14$). The simple main effect of sentence structures was significant with all conditions (A: F (2, 64) = 46.64, $p < .01$, *partial* $\eta^2 = .59$; B: F (2, 64) = 16.38, $p < .01$, *partial* $\eta^2 = .34$, C: F (2, 64) = 30.47, $p < .01$, *partial* $\eta^2 = .49$). Thus, the proportion of the Priming was significantly larger than the proportions of the Alternate and Other structures in all conditions (A: *adjusted p* s = .00, .00, B: *adjusted p* s = .00, .00, C: *adjusted p* s = .00, .00). In addition, the simple main effect of the primes' presentation conditions was significant with Priming and Other structures (Priming: F (2, 32) = 3.68, $p < .05$, *partial* $\eta^2 = .19$; Other: F (2, 32) = 3.46, $p < .05$, *partial* $\eta^2 = .18$). The proportion of the Priming structures in Condition A was significantly larger than that in Condition B (*adjusted p* = .03); on the other hand, the proportion of the Other structures in Condition A was smaller than that in Condition B (*adjusted p* = .04). According to the results of the DO primes, the interaction between the primes' presentation conditions

and sentence structures was not significant. However, the main effect of sentence structures was significant (F (2, 64) = 45.98, $p < .01$, *partial* $\eta^2 = .59$). The proportion of the Alternate structures was significantly larger than proportion of the Priming and Other structures in all conditions (Priming: *adjusted* $p = .00$, Other: *adjusted* $p = .00$). Therefore, the results showed that participants had a tendency to produce PO sentence structures even after they were presented with DO primes.

The results demonstrated the evidence of a syntactic priming effect after the presentation of PO primes in all conditions. By comparing Conditions A and B, the proportion of the Priming structures in Condition A was significantly larger. Thus, it is conceivable that focusing participants' attention to semantic processing could have inhibited the activation of target syntactic structures. There was no significant difference between Conditions A and C. The result suggests that participants could catch the spoken prime only once, or hearing the same spoken prime twice was not enough to enforce the target syntactic structures. There was also no significant difference between Conditions B and C, and this suggests that directing participants' attention to semantic processing inhibited the activation of target syntactic structures, or hearing the same spoken prime twice was not enough to enforce the target syntactic structures.

3.4.1.3 Primes' sentence structures and verb differences

The types of sentence structures of the primes (i.e., PO or DO) and the verb differences between the primes and targets (i.e., same or different) as within-participant factors were analyzed using a two-way ANOVA. Table 3 shows the result of the overall mean numbers of responses, relative proportions (%), and SDs based on verb differences for Experiment 1a.

In the case of PO targets in Conditions A and C, the interaction between the sentence structures of the primes and the verb differences was significant (A: F (1, 11) = 7.45, $p < .05$, *partial* $\eta^2 = .40$; C: F (1, 10) = 7.46, $p < .05$, *partial* $\eta^2 = .43$). The simple main effect of sentence structures of the primes was significant, and the syntactic priming rate was significantly higher when the verbs remained the same between the primes and targets (A: F (1, 11) = 7.97, $p < .05$, *partial* $\eta^2 = .42$; C: F (1, 10) = 6.79, $p < .05$, *partial* $\eta^2 = .40$). Therefore, the result shows that using the verb of a prime as a retrieval cue eases the process of retrieving the information from participants' memory, and this enhancement promotes the reutilization of the same syntactic structure for the next output. As mentioned previously, a syntactic priming effect was observed when the verbs remained the same and

when the verbs varied between the written primes and targets in previous studies using English native speakers and Japanese EFL learners as participants. However, the syntactic priming rate was significantly higher when the verbs remained the same, and the present study followed the same tendency with these previous findings (Morishita et al., 2010; Pickering & Branigan, 1998).

Table 3

Experiment 1a: Overall Mean Numbers of Responses, Relative Proportions (%), and SDs Based on Verb Differences

			PO targets			DO targets		
	Prime	Verb	*n*	*%*	*SD*	*n*	*%*	*SD*
A	PO	Same	16.25	81.25	3.79	1.67	8.33	3.52
		Different	15.00	75.00	4.61	2.25	11.25	3.67
	DO	Same	14.42	72.08	3.29	2.08	10.42	3.03
		Different	15.25	76.25	4.07	2.17	10.83	3.74
B	PO	Same	11.83	59.17	3.16	2.83	14.17	3.34
		Different	11.08	55.42	4.01	3.00	15.00	3.46
	DO	Same	10.67	53.33	4.27	3.58	17.92	4.14
		Different	11.08	55.42	4.10	3.50	17.50	4.23
C	PO	Same	14.91	74.55	2.55	1.55	7.73	2.16
		Different	12.73	63.64	4.29	2.64	13.18	3.04
	DO	Same	12.55	62.73	4.16	2.91	14.55	3.81
		Different	13.45	67.27	3.67	1.91	9.55	2.88

Note. A = presentation of a prime once; B = presentation of a prime once with a question; C = presentation of primes twice.

In the case of PO targets in Condition B, the interaction between the primes' sentence structures

and verb differences was not observed, and this result shows that a question after a prime enforced participants to understand the meaning of primes and focused their attention to semantic processing. It inhibited the lexical boost effect that was expected to occur when the verb remained the same. In the case of DO targets in Condition C, the interaction between the sentence structures of the primes and the verb differences was significant (F (1, 10) = 10.71, $p < .01$, *partial* $\eta^2 = .52$). The simple main effect of sentence structures of the primes was significant, and the syntactic priming rate was significantly higher when the verbs remained the same between the primes and targets (F (1, 10) = 5.04, $p < .05$, *partial* $\eta^2 = .34$). This tendency was not observed in the previous study (McDonough, 2006), which had only demonstrated EFL learners' syntactic priming effect with PO sentence structures but not DO sentence structures with spoken primes and targets. Thus, hearing the same prime twice had a possibility of enhancing the activation of syntactic representations of the DO sentence structure with lower preference.

3.4.2 Experiment 1b

In Experiment 1b, the participants listened to the spoken primes, similar to Experiment 1a, and produced the targets in written forms.

3.4.2.1 Production of targets' syntactic structures in conditions

Figure 10 shows the overall proportions (%) of participants' responses based on primes' presentation conditions and verb differences in written production.

The raw data of participants' responses was examined. Participants produced more PO targets than DO targets after they were presented with the PO primes (PO: 62.08%, 53.75%, DO: 16.25%, 22.50%); however, they produced more PO targets than DO targets even after they were presented with the DO primes (PO: 44.58%, 45.83%, DO: 35.42%, 35.00%) in Condition A. The proportion of the PO target productions after a PO prime presentation with the same verb between the primes and targets was the largest (62.08%) in all target productions. In Condition B, participants produced more PO targets than DO targets after they were presented with the PO primes (PO: 57.50%, 49.17%, DO: 33.33%, 38.33%). Then again, they produced more PO targets than DO targets even after they were presented with the DO primes (PO: 45.83%, 50.00%, DO: 41.25%, 39.58%). The proportion of the PO target productions after a PO prime presentation with the same verb between the primes and targets

was the largest (57.50%) in all target productions. In Condition C, participants produced more PO targets than DO targets after they were presented with the PO primes (PO: 65.45%, 53.18%, DO: 18.18%, 28.18%); however, they produced more PO targets than DO targets even after they were presented with the DO primes (PO: 45.45%, 47.73%, DO: 35.91%, 32.27%). The proportion of the PO target productions after a PO prime presentation with the same verb between the primes and targets was the largest (65.45%) in all target productions.

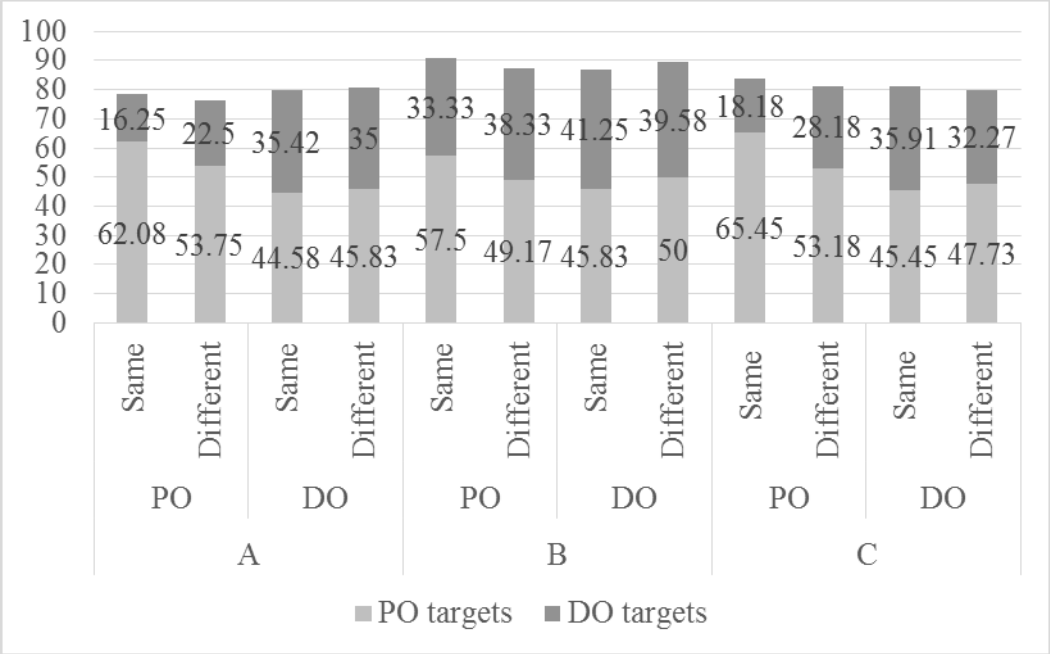

Figure 10. Overall proportions (%) of responses based on primes' presentation conditions and verb differences in written production.

3.4.2.2 Primes' presentation conditions and targets' syntactic structures

The data from Experiment 1b were analyzed as in Experiment 1a. Table 4 provides the result of the overall mean numbers of responses, relative proportions (%), and SDs for Experiment 1b.

According to the results of the PO primes, the main effect of sentence structures was significant (F (2, 64) = 21.38, $p < .01$, *partial* $\eta^2 = .40$). In all three conditions, the proportion of the Priming structures was significantly larger than the proportions of the Alternate and Other structures (Alternate: *adjusted* $p = .00$, Other: *adjusted* $p = .00$). According to the results of the DO primes, the main effect

of sentence structures was significant (F (2, 64) = 11.34, $p < .01$, *partial* $\eta^2 = .26$). There was no significant difference between the proportions of Priming and Alternate structures; however, the proportion of the Other structures was significantly larger than the proportions of the Priming and Alternate structures (Priming: *adjusted p* = .00, Alternate: *adjusted p* = .00).

Table 4

Experiment 1b: Overall Mean Numbers of Responses, Relative Proportions (%), and SDs

		Priming			Alternate			Other		
Prime		*N*	*%*	*SD*	*n*	*%*	*SD*	*n*	*%*	*SD*
A	PO	23.17	57.92	8.74	7.75	19.38	8.71	9.08	22.71	6.89
	DO	14.08	35.21	10.67	18.08	45.21	7.77	7.83	19.58	6.32
B	PO	21.33	53.33	10.87	14.33	35.83	11.98	4.33	10.83	2.53
	DO	16.17	40.42	11.82	19.17	47.92	10.21	4.67	11.67	3.28
C	PO	23.73	59.32	9.81	9.27	23.18	5.08	7.00	17.50	9.62
	DO	13.64	34.09	6.50	18.64	46.59	7.71	7.73	19.32	10.17

Note. A = presentation of a prime once; B = presentation of a prime once with a question; C = presentation of primes twice.

The results showed evidence of a syntactic priming effect after the presentation of the PO primes in all conditions, although, the differences across all conditions were not observed. Therefore, the result suggests three possibilities: (a) participants could "catch" the spoken prime even only once, (b) guiding their attention to semantic processing inhibited the activation of target syntactic structures, or (c) hearing the same spoken prime twice was not enough to enforce the target syntactic structures.

3.4.2.3 Primes' sentence structures and verb differences

The data from Experiment 1b were analyzed as in Experiment 1a. Table 5 shows the result of the overall mean numbers of responses and relative proportions (%), and SDs based on verb differences

for Experiment 1b.

Table 5

Experiment 1b: Overall Mean Numbers of Responses, Relative Proportions (%), and SDs Based on Verb Differences

			PO targets			DO targets		
	Prime	Verb	*n*	*%*	*SD*	*n*	*%*	*SD*
A	PO	Same	12.42	62.08	4.44	3.25	16.25	4.41
		Different	10.75	53.75	4.77	4.50	22.52	4.85
	DO	Same	8.92	44.58	4.40	7.08	35.42	5.58
		Different	9.17	45.83	3.64	7.00	35.00	5.36
B	PO	Same	11.50	57.50	5.89	6.67	33.33	6.61
		Different	9.83	49.17	5.15	7.67	38.33	5.43
	DO	Same	9.17	45.83	5.02	8.25	41.25	6.30
		Different	10.00	50.00	5.38	7.92	39.58	5.65
C	PO	Same	13.09	65.45	5.17	3.64	18.18	2.54
		Different	10.64	53.18	4.92	5.64	28.18	2.87
	DO	Same	9.09	45.45	3.86	7.18	35.91	3.43
		Different	9.55	47.73	4.27	6.45	32.27	3.80

Note. A = presentation of a prime once; B = presentation of a prime once with a question; C = presentation of primes twice.

Unlike in the case of spoken production in Experiment 1a, the interaction between the primes' sentence structures and verb differences was not observed when the verbs remained the same between the primes and targets as in the case of the PO targets in Condition A, thus suggesting that the process

of writing down was more time consuming than speaking, and the activation of a syntactic structure would have decayed because of the lowered the magnitude of the lexical boost effect in written production.

In the case of the PO targets in Condition B, the interaction between the sentence structures of the primes and the verb differences was significant (F (1, 11) = 6.60, $p < .05$, *partial* $\eta^2 = .38$). The simple main effect of sentence structures of the primes was significant, and the syntactic priming rate was significantly higher when the verbs remained the same unlike in Experiment 1a where no interaction was observed (F (1, 11) = 5.76, $p < .05$, *partial* $\eta^2 = .34$). The result shows that focusing participants' attention to semantic processing did not decay the lexical boost effect, and it enhanced syntactic priming.

In the case of the PO and DO targets in Condition C, the interaction between the sentence structures of the primes and the verb differences was significant, which is similar to the case of spoken production (PO targets: F (1, 10) = 6.80, $p < .05$, *partial* $\eta^2 = .40$; DO targets: F (1, 10) = 6.59, $p < .05$, *partial* $\eta^2 = .40$). The simple main effect of sentence structures of the primes was significant, and the syntactic priming rate was significantly higher when the verbs remained the same (PO targets: F (1, 10) = 9.17, $p < .05$, *partial* $\eta^2 = .48$; DO targets: F (1, 10) = 6.69, $p < .05$, *partial* $\eta^2 = .40$). Thus, it seems that hearing the same prime twice enhanced the activation of a syntactic structure with lower preference.

3.5 Hypothesis Verification

3.5.1 Research Question 1, 2

To address the research questions 1 and 2, which asked whether syntactic priming effect occurs with the presentations of spoken primes, and whether the differences in primes' syntactic structure and verb differences affect syntactic priming, a syntactic priming effect was observed with the PO primes and with repetition of verbs between the primes and targets in both spoken and written production.

3.5.2 Research Question 3

Research question 3 asked whether the presentation of conditions of the primes' differences affect syntactic priming. In spoken production, a significant difference was observed between Conditions A and B; however, the presentation conditions of the primes' differences did not affect syntactic priming

in written production.

3.5.3 Research Question 4

Research question 4 enquired whether syntactic priming rates differ by comparing the results of spoken production (Experiment 1a) and written production (Experiment 1b). The result shows that the priming rate with the PO primes in Conditions A and C in spoken production was higher than that in written production (A: 78.1, 57.9, C: 69.1, 59.3). On the other hand, the DO production was increased in written production (A: 10.6, 35.2, B: 17.7, 40.4, C: 12.0, 34.1).

4. EXPERIMENT 2: Effects of Proficiency Differences on Syntactic Priming in the Language Production of Japanese EFL Learners

In Experiments 1a and 1b, the study used a picture description task with spoken primes to investigate whether the differences of output modality and verb affect Japanese EFL learners' syntactic priming.

In Experiment 2, a picture description task with spoken primes was also conducted to investigate whether the differences of learners' proficiency levels (i.e., upper or lower) and output modality (i.e., spoken or written) affect Japanese EFL learners' syntactic priming in three different conditions (i.e., Conditions A, B, and C) from Experiments 1a and 1b. The study investigated the effects of proficiency differences on the operation of learners' syntactic information to observe the part of L2 language acquisition process.

4.1 Research Questions

The following research questions were addressed in this study:

Research Question 1: Do the differences of learners' proficiency levels (i.e., upper or lower) affect syntactic priming?

Research Question 2: Do the differences of learners' proficiency levels affect syntactic priming in three presentation conditions of the primes (i.e., Conditions A, B, and C)?

4.2 Hypotheses

The result can be hypothesized that, for research question one, the magnitude of the syntactic priming differs according to the differences of learners' proficiency levels. As Japanese lower level learners tend to rely on lexical items with incomplete construction of syntactic structures in lemma representations, they would fail in both syntactic and semantic processing. On the other hand, language- and item-specific syntactic representations are gradually added for upper level learners; therefore, they would be able to focus on both syntactic and semantic processing. Thus, the priming rate of upper level learners is higher than that of lower level learners. For research question two, the differences of learners' proficiency levels affect the syntactic priming in three presentation conditions

of the primes.

In Condition A with presentation of a prime once, the priming rate of upper level learners is higher than the priming rates of lower level learners as in previous studies with EFL learners. Conditions B and C were set to investigate the effects of proficiency differences on the magnitude of syntactic priming effect. Since Condition A is not intended to focus participants' attention to neither sentential meaning nor syntactic structure, Condition B encourages participants to focus their attention to sentential meaning and divert attention from syntactic structures. Focusing attention to semantic processing might promote upper level learners' syntactic representations to become more abstract, and the magnitude of syntactic priming effect would get lower. On the other hand, lower level learners' activation of syntactic representations might be inhibited by semantic processing. Condition C is intended to focus participants' attention to both sentential meaning and syntactic structure. Hearing primes twice would enable lower level learners to catch the primes, and enforce the activation of syntactic structures because they rely on the specific lexical items. Therefore, the priming rate of lower level learners would be higher than that of upper level learners.

4.3 Methods

4.3.1 Participants

The participants consisted of 171 Japanese undergraduate learners at a university located in Kansai area (spoken production: 85, written production: 86). Participants were all native speakers of Japanese, and their age ranged from 19 to 22 years old. The length of their previous English study ranged from 7 to 10 years. The participants attended one day experiment. The study was conducted from December 2015 to June 2017 with spoken or written targets. Informed consent was obtained from all the participants. The participants' English proficiency was measured with the Versant Speaking Test (total score: 20~80) with spoken production and Oxford Quick Placement Test (Oxford University Press, 2001: total score: 60) with written production. Two different measurements were used because of the different output modality.

Table 6 shows the results of the English proficiency tests of the participants in Experiment 2. Participants were randomly allocated to three conditions: (a) presentation of a prime once (Condition A), (b) presentation of a prime once with a question (Condition B), and (c) presentation of primes twice (Condition C). The participants' mean scores in the Versant Speaking Test with spoken

production (A, B, C) were 37.71, 38.03, and 38.43, respectively: The scores are equivalent to A2 (elementary) level of the CEFR. Their mean scores in the Oxford Quick Placement Test with written production (A, B, C) were 39.21, 39.75, and 40.17, respectively: The scores are equivalent to B1 to B2 (lower to upper intermediate) level of the CEFR. The data of two participants in A1- levels was excluded from the analysis.

Table 6

Mean Scores and SDs of the English Proficiency Tests, and Numbers of Participants across Conditions in Experiment 2

	Spoken Production			Written Production		
	A (n = 28)	B (n = 29)	C (n = 28)	A (n = 28)	B (n = 28)	C (n = 30)
M	37.71	38.03	38.43	39.21	39.75	40.17
SD	6.80	8.10	8.40	4.51	3.40	5.57
C1~	0	0	0	1	0	2
B2	0	1	1	12	14	15
B1	3	3	3	15	14	13
A2	12	12	12	0	0	0
A1	12	12	12	0	0	0

Note. A = presentation of a prime once; B = presentation of a prime once with a question; C = presentation of primes twice.

According to the score of English proficiency tests, majority of participants in the current study were lower level learners ranging from A1 to A2 level in the Versant Speaking Test, and B1 to B2 level in the Oxford Quick Placement Test. They were divided into two groups (i.e., upper or lower). Learners in A2 level in the Versant Speaking Test and learners in B2 level in the Oxford Quick Placement Test were considered as upper level learners, and learners in A1 level in the Versant Speaking Test and learners in B1 level in the Oxford Quick Placement Test were considered as lower level learners in this study. Participants were divided into the two levels according to the CEFR levels, because the previous study showed that the score of the Oxford Quick Placement Test is normally one

or two levels higher than that of the Versant Speaking Test (Harada & Morishita, 2013). The data of participants in A1 and A2 levels in the Versant Speaking Test, and the data of participants in B1 and B2 levels in the Oxford Quick Placement Test were extracted and compared on three conditions for investigating the effects of proficiency differences.

The number of upper level learners (A, B, C) were 12, 12, 12 with spoken production, and 12, 14, 15 with written production. Their mean scores and SDs were 40.33 (2.56), 40.42 (2.43), 39.17 (3.41) with spoken production, and 42.67 (1.65), 42.36 (2.19), 42.80 (2.54) with written production, respectively. The number of lower level learners (A, B, C) were 12, 12, 12 with spoken production, and 15, 14, 13 with written production. Their mean scores and SDs were 32.75 (1.69), 31.67 (1.93), 32.33 (1.93) with spoken production, and 35.80 (2.61), 37.14 (1.96), 35.31 (2.49) with written production, respectively. In the English proficiency tests, significant differences were observed among two proficiency levels, namely, upper and lower, with both spoken and written production (spoken production: $F(1, 66) = 171.60$, $p < .01$, *partial* $\eta^2 = .72$, written production: $F(1, 77) = 156.04$, $p < .01$, *partial* $\eta^2 = .67$).

4.3.2 Materials

The materials were identical to those in Experiments 1a and 1b.

4.3.3 Procedure

The procedure was identical to that of Experiments 1a and 1b.

4.4 Results and Analysis

According to the result of questionnaire, it was confirmed that the participants listened and understood the primes without difficulties, and none of them noticed the target structures. In Condition A, the spoken primes were presented only once to the participants, and in Condition B, after hearing the spoken primes once, the participants were instructed to answer a question about the spoken primes. In Condition C, the same spoken primes were presented twice.

4.4.1 Output Modalities and Learners' Proficiency Differences in Conditions

In Experiment 2, the participants listened to the spoken primes, and produced the targets either

in spoken or written forms.

Transcribed target responses were divided into “Priming”, “Alternate”, and “Other” groups. The sentence structures (i.e., Priming, Alternate, or Other) and verb differences between the primes and targets (i.e., same or different) as within-participant factors were analyzed in a two-way ANOVA to investigate the occurrence of syntactic priming effect. Throughout the analyses, *p*-values less than .05 were considered to be statistically significant, and partial eta-squared (η^2) values are reported as effect sizes. Table 7 provides the result of the overall mean numbers of responses, relative proportions (%), and SDs based on learners’ proficiency differences in spoken production, and Table 8 shows the result in written production.

According to the results of the PO primes, the simple main effect of sentence structures was significant in Condition A regardless of learners’ proficiency levels with spoken and written production (spoken production upper: F (2, 22) = 12.71, $p < .01$, *partial* $\eta^2 = .54$; lower: F (2, 22) = 4.28, $p < .05$, *partial* $\eta^2 = .28$; written production upper: F (2, 22) = 17.64, $p < .01$, *partial* $\eta^2 = .62$; lower: F (2, 28) = 13.35, $p < .01$, *partial* $\eta^2 = .49$). The proportion of the Priming structures was significantly larger than the proportions of the Alternate and Other structures except the case of lower learners with Other structures in spoken production (spoken production upper: *adjusted p* s = .00, .01; lower: *adjusted p* s = .00, .01; written production upper: *adjusted p* s = .00, .89; lower: *adjusted p* s = .00, .79). Therefore, the syntactic priming effect with PO primes was observed, and the result confirmed that Japanese EFL learners’ syntactic representations were shared between comprehension and production (Branigan, Pickering, & Cleland, 2000).

The learners’ proficiency levels (i.e., upper or lower) and output modality (i.e., spoken or written) as between-participant factors were analyzed in a two-way ANOVA to investigate the effects of learners’ proficiency levels on syntactic priming effect in each condition. According to the results of the PO Priming in Condition A, the simple main effect of learners’ proficiency levels was significant (F (1, 47) = 6.91, $p < .05$, *partial* $\eta^2 = .13$). Thus, the proportion of the PO Priming of upper level learners was significantly larger than the proportions of the PO Priming of lower level learners with spoken and written production. The results demonstrated that learners’ proficiency levels affects the magnitude of syntactic priming effect. However, these differences were not significant for the PO priming in Conditions B and C.

Moreover, according to the results of the DO Priming, the simple main effect of output modality

was significant in all conditions (A: F (1, 47) = 8.53, p < .01, *partial* η^2 = .15; B: F (1, 48) = 9.55, p < .01, *partial* η^2 = .17, C: F (1, 48) = 5.22, p < .05, *partial* η^2 = .10), indicating that the proportion of the DO Priming in written production was significantly larger than the proportions of the DO Priming in spoken production.

Table 7

Spoken Production: Overall Mean Numbers of Responses, Relative Proportions (%), and SDs Based on Learners' Proficiency Differences

			Priming			Alternate			Other		
Prime		Levels	*n*	*%*	*SD*	*n*	*%*	*SD*	*n*	*%*	*SD*
A	PO	Upper	27.42	34.27	12.37	2.67	3.33	6.46	9.92	12.40	10.54
		Lower	18.00	22.50	8.06	6.92	8.65	6.71	15.08	18.85	8.66
	DO	Upper	4.00	5.00	8.41	25.67	32.08	12.54	10.33	12.92	9.22
		Lower	7.33	9.17	6.07	18.42	23.02	7.54	14.25	17.81	7.61
B	PO	Upper	21.25	26.56	8.35	5.67	7.08	6.83	13.08	16.35	9.15
		Lower	18.00	22.50	7.93	6.33	7.92	5.76	15.67	19.58	7.27
	DO	Upper	6.75	8.44	8.25	21.33	26.67	10.30	11.92	14.90	10.66
		Lower	8.75	10.94	8.21	14.67	18.33	8.40	16.58	20.73	7.87
C	PO	Upper	23.00	28.75	9.18	7.58	9.48	7.61	9.42	11.77	4.89
		Lower	23.25	29.06	11.72	7.83	9.79	10.72	8.92	11.15	8.39
	DO	Upper	8.58	10.73	8.08	26.00	65.00	7.38	10.17	12.71	5.95
		Lower	9.25	11.56	11.93	21.25	26.56	8.09	9.50	11.88	8.35

Note. A = presentation of a prime once; B = presentation of a prime once with a question; C = presentation of primes twice.

Table 8

Written Production: Overall Mean Numbers of Responses, Relative Proportions (%), and SDs Based on Learners' Proficiency Differences

			Priming			Alternate			Other		
Prime		Levels	*n*	*%*	*SD*	*n*	*%*	*SD*	*n*	*%*	*SD*
A	PO	Upper	26.00	32.50	8.29	6.83	8.54	8.67	7.17	8.96	4.45
		Lower	22.20	27.75	6.55	9.20	11.50	6.70	8.60	10.75	6.71
	DO	Upper	12.08	15.10	11.45	21.83	27.29	9.69	6.08	7.60	4.62
		Lower	12.93	16.17	6.72	18.07	22.58	5.81	9.00	11.25	6.86
B	PO	Upper	21.64	27.05	10.09	13.79	17.23	11.43	4.57	5.71	2.68
		Lower	19.79	24.73	9.97	14.07	17.59	11.65	6.14	7.68	5.10
	DO	Upper	17.64	22.05	12.25	17.57	21.96	10.58	4.79	5.98	3.21
		Lower	16.36	20.45	12.75	16.93	21.16	10.43	6.79	8.48	5.86
C	PO	Upper	23.47	29.33	8.09	8.73	10.92	6.61	7.80	9.75	7.97
		Lower	17.62	22.02	10.26	10.08	12.60	7.82	12.31	15.38	9.06
	DO	Upper	13.87	17.33	8.00	18.40	23.00	7.44	7.73	9.67	8.13
		Lower	15.77	19.71	8.90	10.85	13.56	7.08	13.38	16.73	9.75

Note. A = presentation of a prime once; B = presentation of a prime once with a question; C = presentation of primes twice.

4.4.2 Primes' Presentation Conditions and Learners' Proficiency Levels

The learners' proficiency levels (i.e., upper or lower) and primes' presentation conditions (i.e., A, B, or C) as between-participant factors were analyzed in a two-way ANOVA to investigate the syntactic priming effect in each condition. Figures 11, 12 and 13 show the overall proportions (%) of

participants' responses based on output modalities and learners' proficiency differences in Conditions A, B and C.

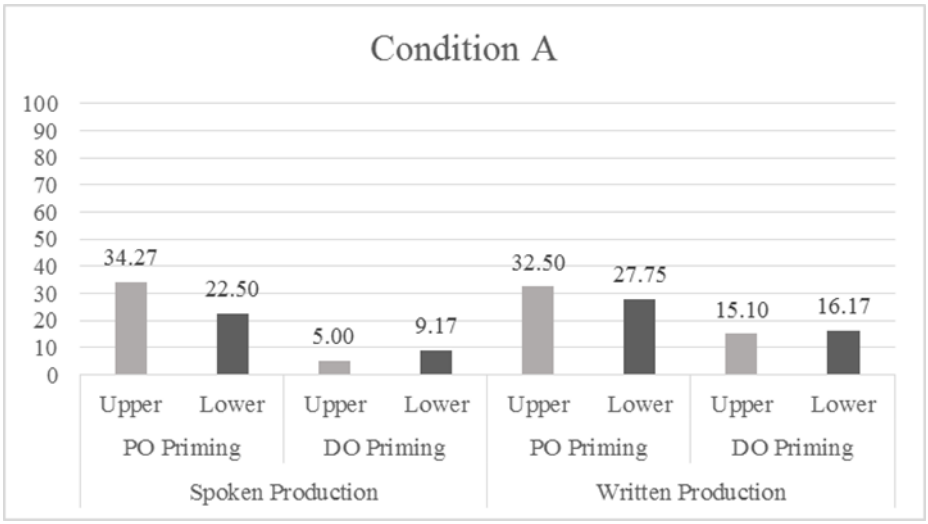

Figure 11. Overall proportions (%) of responses based on output modalities and learners' proficiency differences in Condition A.

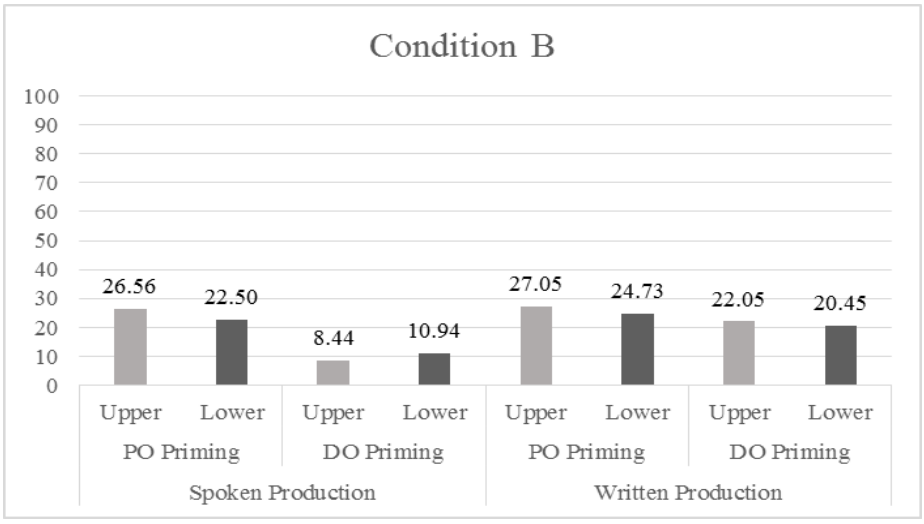

Figure 12. Overall proportions (%) of responses based on output modalities and learners' proficiency differences in Condition B.

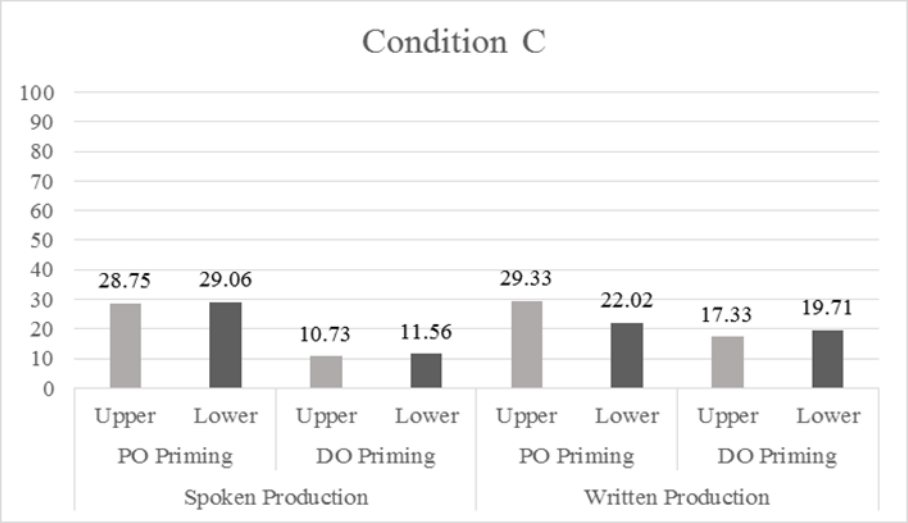

Figure 13. Overall proportions (%) of responses based on output modalities and learners' proficiency differences in Condition C.

According to the results, the interaction between the learners' proficiency levels and primes' presentation conditions was not significant. In Condition B, the proportion of the PO and DO Priming of upper level learners was smaller than the PO and DO Priming in Condition A. In Condition C, the proportion of the PO and DO Priming of lower level learners was larger than the PO and DO Priming in Condition A. However, these differences were not significant.

4.5 Hypothesis Verification

4.5.1 Research Question 1

To address the research question 1, which asked whether the differences of learners' proficiency levels affect syntactic priming, the learners' proficiency levels affects the magnitude of syntactic priming effect with PO primes with spoken and written production.

4.5.2 Research Question 2

Research question 2 asked whether the differences of learners' proficiency levels affect syntactic priming in three presentation conditions of the primes. The proportion of the PO Priming of upper level learners was significantly larger than the proportion of the PO Priming of lower level learners in Condition A.

5. EXPERIMENT 3: Effects of Syntactic Priming Training on the Occurrence of Interactive Alignment in the Language Production of Japanese EFL Learners

Experiments 1 and 2 investigated whether the differences of output modality (i.e., spoken or written) and learners' proficiency differences (i.e., upper or lower) affect Japanese EFL learners' syntactic priming. However, the experiments were conducted within a relatively short period of time, and the targets immediately followed the primes. Therefore, it has not clarified whether observed syntactic priming effect was caused by the temporary occurrence of the residual activation or by acquisition of target structures by implicit learning. Experiment 3 conducted a learning experiment using syntactic priming effects to observe the persistence of syntactic priming effects. It aimed to research whether the knowledge of target structures is changing from declarative to procedural knowledge by repeated exposure of the structures.

In this experiment, a picture description task with spoken primes and targets was conducted to investigate whether Japanese EFL learners' syntactic priming effect persists with the lag intervened between primes and targets. In the pretest, learning sessions, immediate posttest and delayed posttest, the participants described pictures in either forms after listening to the primes with a PO, DO, or filler, and repeating it.

5.1 Research Questions

The following research questions were addressed in this study:

Research Question 1: Does syntactic priming effect observed without lags persist with lags intervened between primes and targets?

Research Question 2: Do the differences in the lag conditions (i.e., no-lag or long-lag) affect the magnitude of syntactic priming in immediate or delayed posttest?

5.2 Hypotheses

The result can be hypothesized that, for research question one, syntactic priming effect persists with lags inserted between primes and targets as results of studies with English native speakers. For research question two, no-lag condition would show the highest priming rate in the immediate posttest,

but long-lag condition alone shows sustained production of target structures when the priming rate in no-lag condition decay rapidly in the delayed posttest as results of the study with EFL learners.

5.3 Methods

5.3.1 Participants

The participants consisted of 34 Japanese undergraduate learners at a university located in Kansai area. Participants were all native speakers of Japanese, and their age ranged from 19 to 22 years old. The length of their previous English study ranged from 7 to 10 years. The participants attended two days experiment. The study was conducted from June to July 2017. Informed consent was obtained from all the participants. The participants' English proficiency was measured with the Oxford Quick Placement Test (Oxford University Press, 2001: total score: 60). Table 9 shows the results of the English proficiency tests of the participants.

Table 9

Mean Scores and SDs of the English Proficiency Tests, and Numbers of Participants across Conditions in Experiment 3

	no-lag (n = 17)	long-lag (n = 17)
M	39.82	40.00
SD	3.63	3.77
B2	10	9
B1	7	8

Participants were randomly allocated to two conditions: (a) no filler inserted (no-lag), (b) fillers inserted between a prime and a target (long-lag). The participants' mean scores in the Oxford Quick Placement Test were 39.82 (no-lag), and 40.00 (long-lag), respectively: The scores are equivalent to B1 (lower intermediate) to B2 (upper intermediate) level of the CEFR. In the English proficiency test, no significant difference was found among two conditions, namely, no-lag and long-lag, showing that the scores were equivalent across the conditions. The experiment was only conducted on learners with B1 or B2 levels of English proficiency. The data of one participant in long-lag condition who did not

attend the experiments in after 24 to 30 hours after the immediate posttest was excluded from the analysis.

5.3.2 Materials

The materials are identical to those in Experiments 1 and 2; in addition, four more lists were added for the long-lag condition, and each list contained four to six filler sentences between primes and targets. Filler sentences that were unrelated to both target sentence structures and intransitive verbs were also prepared.

5.3.3 Procedure

The experiment was conducted individually in a quiet room in two straight days. Table 10 shows the study schedule for participants.

Table 10

Study Schedule

Day	Session	Task	Condition
1	Pretest: priming	Picture description	Long-lag
	Learning session: priming	Picture description	No-lag / long-lag
	Immediate posttest: priming	Picture description	Long-lag
2	Delayed posttest: priming	Picture description	Long-lag
	Proficiency Test	Oxford Quick Placement Test	
	Questionnaire	Language background and sleep duration questionnaire	

On the first day of the experiment, participants are randomly allocated to two conditions (see the next section for details.). As in Experiments 1 and 2, the experimental files are presented on a computer screen. Participants are seated in front of the computer in a quiet booth, and are given instructions from the researcher. They are told that the researcher is interested in what kinds of sentences Japanese EFL learners can produce. In all sessions, priming experiment was conducted with the only variable being the lag conditions. Participants were instructed to listen to the spoken primes, repeat it and

describe the target pictures. In the pretest, immediate posttest, and delayed posttest, they were randomly presented with one of the four lists; 30 sentences, including 10 PO sentence structures, 10 DO sentence structures, and 10 fillers. In the learning session, they were presented with two lists; 60 sentences, including 20 PO sentence structures, 20 DO sentence structures, and 20 fillers. Participants performed the pretest, immediate posttest, and delayed posttest for 20 minutes each, and the learning session for 40 minutes. They took Oxford Quick Placement test for 30 minutes, and they then filled out a language background and sleep duration questionnaire for 5 minutes. Participants in both conditions had delayed posttest, a proficiency test, and a questionnaire on the second day, and delayed posttest was conducted 24 to 30 hours after the immediate posttest was conducted.

5.3.3.1 Lag conditions

The experiment was conducted using a syntactic priming method. It was predicted that hearing the primes and repeating them promote syntactic priming in target elicitation (Shin & Christianson, 2012). Therefore, participants were instructed to listen to the primes, repeat it and describe the targets. They were allocated to two conditions (i.e., no-lag or long-lag) to investigate the persistence of the syntactic priming effect.

In the no-lag condition, the target picture immediately followed the spoken primes, and no filler intervened between primes and targets. At the beginning of each trial, the participants would see the message "Ready?" on the computer screen, and press the "Enter" key to start. Then, participants would listen to the primes, repeat it as soon as they heard the primes, and press the "Enter" key. After that, a target picture would appear on the computer screen, and the participants would use the verb presented below the target picture to describe the picture in one sentence, by speaking as quickly as they could. This prime-target condition purely involves explicit memory process with lexical repetitions, and to increase the possibility of the occurrence of priming (Hartsuiker et al., 2008).

On the other hand, in the long-lag condition, four to six filler sentences are intervened between primes and targets. Sequence of events on the long-lag condition is illustrated in Figure 14.

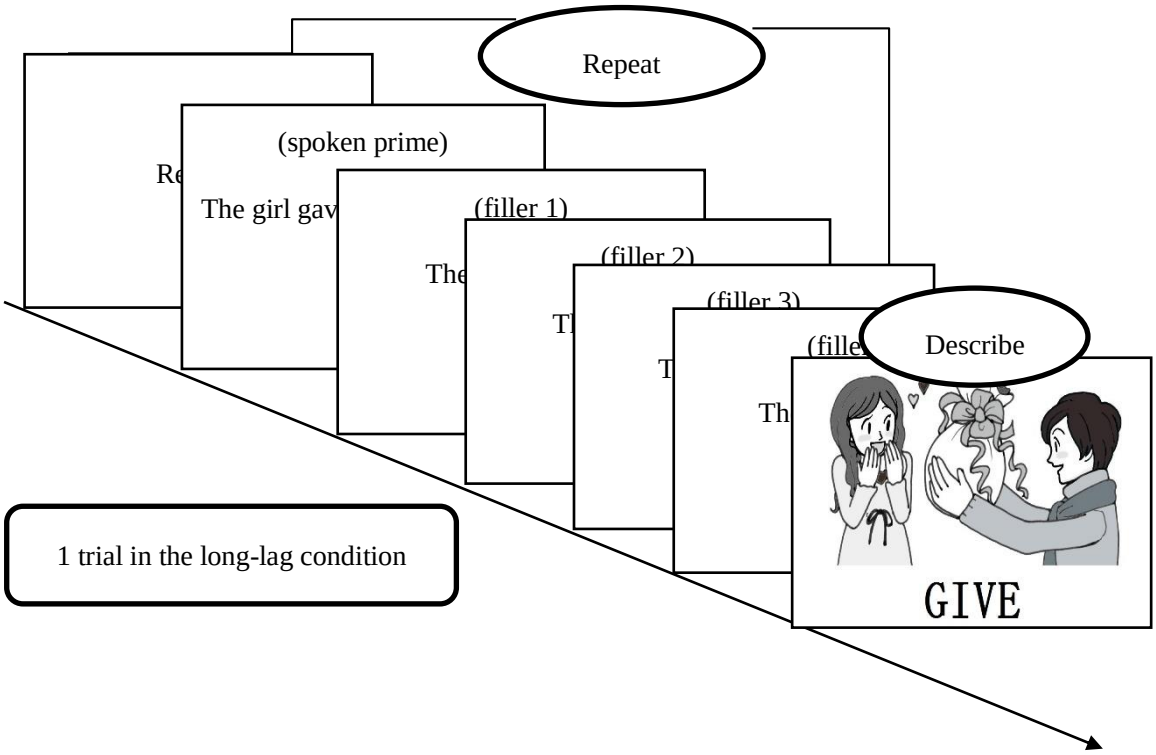

Figure 14. Sequence of events on the long-lag condition.

Participants in this condition did not describe targets right after the primes. Instead, they heard and repeated the fillers which were unrelated to both target sentence structures after they heard and repeated the primes. At the beginning of each trial, the participants would see the message "Ready?" on the computer screen, and press the "Enter" key to start. Then, participants would listen to the primes, repeat it as soon as they heard the primes, and press the "Enter" key. After they pressed the key, participants also listen to the four to six fillers continuously, repeat it and press the "Enter" key. After that, a target picture would appear on the computer screen, and the participants would describe the target picture in one sentence, by speaking as quickly as they could. The explicit memory of syntactic structures cannot persist over four filler sentences intervened between primes and targets from the studies using recall and recognition tasks (Bock & Brewer, 1974; Sachs, 1967). Therefore, the long-lag implicit condition involves purely implicit-learning processes (Shin & Christianson, 2012). The total number of primes and target pictures were same as the number in the no-lag condition; however, 150 filler trials were added to pretest, immediate posttest and delayed posttest, and 300 filler trials were added to the learning session.

5.4 Results and Analysis

According to the result of questionnaire, it confirmed that the participants listened and understood the primes without difficulties, and none of them noticed the target structures. In addition, participants' self-reported duration of sleep was 6 hours 31 minutes for the no-lag condition and 6 hours 23 minutes for the long-lag condition, and the difference in duration of sleep between the lag conditions was not significant.

5.4.1 Baseline

As described in Experiment 2's procedure, the Phase 1 was intended to investigate the participants' original proportional tendency for PO, DO, and other sentence structures; therefore, participants were randomly presented with 30 target pictures to either speak or write about it using the given verbs. The data of the participants from Experiment 2 was analyzed to investigate Japanese EFL learners' original proportional tendency for PO, DO, and other sentence structures before the learning sessions. Table 11 provides the result of the overall total and mean numbers of responses and relative proportions (%) in spoken production.

Table 11

Spoken Production: Overall Total Numbers, Mean Numbers of Responses and Relative Proportions (%), Based on Types of Syntactic Structures

Structure	*n*	*%*	*M*
PO	604	41.94	8.39
DO	237	16.46	3.29
Other	599	41.60	8.32

According to the Baseline data of spoken targets, the large portion of overall proportion of syntactic structures produced by participants was PO sentence structures (41.94%), and other sentence structures followed (41.60%). On the other hand, only small portion was DO sentence structures (16.46%). Therefore, Japanese EFL learners had a tendency to produce more PO sentence structures than DO sentence structures (*adjusted p* = .00), and the production of DO sentence structures was significantly less than others (*adjusted p* = .00). Table 12 provides the result of the overall total and

mean numbers of responses and relative proportions (%) in written production.

Table 12

Written Production: Overall Total Numbers, Mean Numbers of Responses and Relative Proportions (%), Based on Types of Syntactic Structures

Structure	*n*	*%*	*M*
PO	676	40.72	8.14
DO	473	28.49	5.70
Other	511	30.78	6.16

According to the Baseline data of spoken targets in Experiment 1a, the large portion of overall proportion of syntactic structures produced by participants was PO sentence structures (40.72%), and other sentence structures followed (30.78%). On the other hand, only small portion was DO sentence structures (28.49%). Therefore, Japanese EFL learners had a tendency to produce more PO sentence structures than DO and other sentence structures (*adjusted p* = .02).

5.4.2 Overall Data

After conducting the experiments, all of the participants' responses were IC recorded and transcribed.

5.4.2.1 Target produced in a picture description task

The overall total number of target production was compared based on types of prime to investigate whether the syntactic priming effect occurred with PO and DO sentence structures. Transcribed target responses were divided into "Priming", "Alternate", and "Other" groups. Table 13 provides the result of the overall total numbers, mean numbers of responses, and relative proportions (%) for no-lag condition, and Table 14 provides the data for long-lag condition.

Table 13

No-lag Condition: Overall Total Numbers, Mean Numbers of Responses and Relative Proportions (%), Based on Types of Syntactic Structures and Verb Differences

Prime	Verb	PO			DO			Other			*Total*
		n	*%*	*M*	*n*	*%*	*M*	*n*	*%*	*M*	
PO	Same	237	63.88	13.94	86	23.18	5.06	48	12.94	2.82	371
DO		155	47.69	9.12	114	35.08	6.71	56	17.23	3.29	325
PO	Different	208	56.83	12.24	94	25.68	5.53	64	17.49	3.76	366
DO		161	50.16	9.47	115	35.83	6.76	45	14.02	2.65	321

Table 14

Long-lag Condition: Overall Total Numbers, Mean Numbers of Responses and Relative Proportions (%), Based on Types of Syntactic Structures and Verb Differences

Prime	Verb	PO			DO			Other			*Total*
		n	*%*	*M*	*n*	*%*	*M*	*n*	*%*	*M*	
PO	Same	222	66.07	13.88	36	10.71	2.25	78	23.21	4.88	336
DO		133	51.15	8.31	63	24.23	3.94	64	24.62	4.00	260
PO	Different	211	61.52	13.19	50	14.58	3.13	82	23.91	5.13	343
DO		133	53.41	8.31	52	20.88	3.25	64	25.70	4.00	249

Each participant had a picture description task five times in consecutive 2 days: the pretest, the learning session (two sessions), the immediate posttest and the delayed posttest. In the no-lag condition, out of 1,700 items, 663 “Alternate” responses (39.00%), and 271 “Other” responses (15.94%) were excluded from the data analysis. In the long-lag condition, out of 1,600 items, 558 “Alternate” responses (34.88%), and 395 “Other” responses (24.69%) were excluded from the data analysis.

The raw data of participants’ overall responses was examined. Participants produced more PO targets than DO targets after they were presented with the PO primes in both conditions (PO: no-lag same: 63.88%, different: 56.83%, long-lag same: 66.07%, different: 61.52%, DO: no-lag same:

47.69%, different: 50.16%, long-lag same: 51.15%, different: 53.41%); moreover, they produced more DO targets than PO targets after they were presented with the DO primes (PO: no-lag same: 23.18%, different: 25.68%, long-lag same: 10.71%, different: 14.58%, DO: no-lag same: 35.08%, different: 35.83%, long-lag same: 24.23%, different: 20.88%). Therefore, the syntactic priming effect was observed with PO and DO sentence structures in both conditions.

5.4.2.2 Target production with failed primes' repetition

Experiment 3 only analyzed the targets with the participants' accurate repetition of the primes to assure participants' understanding about target syntactic structures. Thus, 317 responses for the no-lag condition (18.65%) and 412 responses for the long-lag condition (25.75%) with failed primes' repetition were excluded from the main analysis. However, the total numbers of responses and its relative proportions with failed primes' repetition were also analyzed to investigate whether the syntactic structures participants originally have difficulties or eases to search or retrieve for the usage. Overall total numbers of responses with failed primes' repetition and relative proportions based on types of syntactic structures for no-lag condition is shown in Table 15, and the data for long-lag condition is shown in Table 16.

Table 15

No-lag Condition: Overall Total Numbers of Responses with Failed Primes' Repetition and Relative Proportions (%), Based on Types of Syntactic Structures and Verb Differences

		PO		DO		Other		
Prime	Verb	*n*	*%*	*n*	*%*	*n*	*%*	*Total*
PO	Same	26	48.15	18	33.33	10	18.52	54
DO		65	65.00	17	17.00	18	18.00	100
PO	Different	26	44.07	23	38.98	10	16.95	59
DO		61	58.65	23	22.12	20	19.23	104

Table 16

Long-lag Condition: Overall Total Numbers of Responses with Failed Primes' Repetition and Relative Proportions (%), Based on Types of Syntactic Structures and Verb Differences

		PO		DO		Other		
Prime	Verb	*n*	*%*	*n*	*%*	*n*	*%*	*Total*
PO	Same	39	60.94	7	10.94	18	28.13	64
DO		95	67.86	15	10.71	30	21.43	140
PO	Different	28	49.12	11	19.30	18	31.58	57
DO		93	61.59	17	11.26	41	27.15	151

Proportion of failed primes' repetition does not involve with fillers; therefore, it was predicted that there was no difference between the conditions. However, the number of responses with failed primes' repetition of no-lag condition was smaller than that of long-lag condition, indicating participants' tiredness with a great number of repetitions of fillers in long-lag condition. Moreover, they tended to fail accurate repetitions more after they were presented with DO primes than PO primes (no-lag same: 100, different: 104, long-lag same: 140, different: 151). They tended to produce PO targets with failed primes' repetitions (no-lag same: 65, different: 61, long-lag same: 95, different: 93). The results showed that the participants could not repeat the primes with DO sentence structure accurately with the lack of information of DO sentence structure as declarative knowledge in the cognitive mechanism.

5.4.3 Effects of Lag Conditions on Syntactic Priming

The syntactic priming effects for two lag conditions were compared to investigate whether the syntactic priming effect occurs and persist with lags intervened between primes and targets. Therefore, sentence structures (i.e., Priming, Alternate, or Other) and the priming sessions (i.e., pretest, immediate posttest, or delayed posttest) as within-participant factors were analyzed in a two-way ANOVA. Moreover, effects of lag conditions differences on the magnitude of the syntactic priming in the immediate and delayed posttest have been analyzed. The lag conditions (i.e., no-lag or long-lag) as a between-participant factor and priming sessions (i.e., pretest, immediate posttest, or delayed posttest) as a within-participant factor were also analyzed in a two-way ANOVA. Throughout the

analyses, *p*-values less than .05 were considered to be statistically significant, and partial eta-squared (η^2) values are reported as effect sizes. Overall proportions (%) of PO prime-PO target responses based on lag conditions and sessions differences are reported in Figure 15, and the proportions of DO prime-DO target responses are reported in Figure 16.

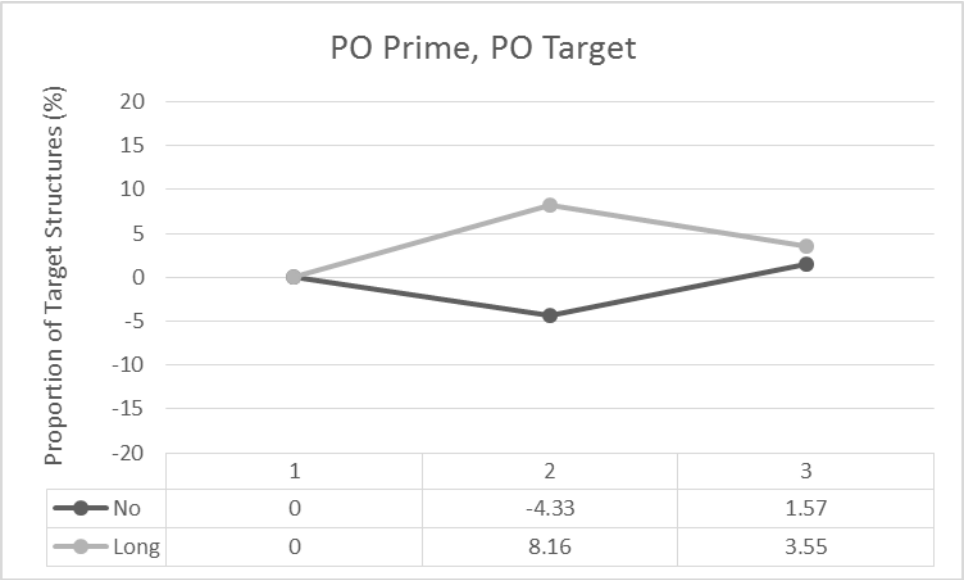

Figure 15. Overall proportions (%) of PO prime-PO target responses based on lag conditions and sessions differences (1: pretest, 2: immediate posttest, 3: delayed posttest).

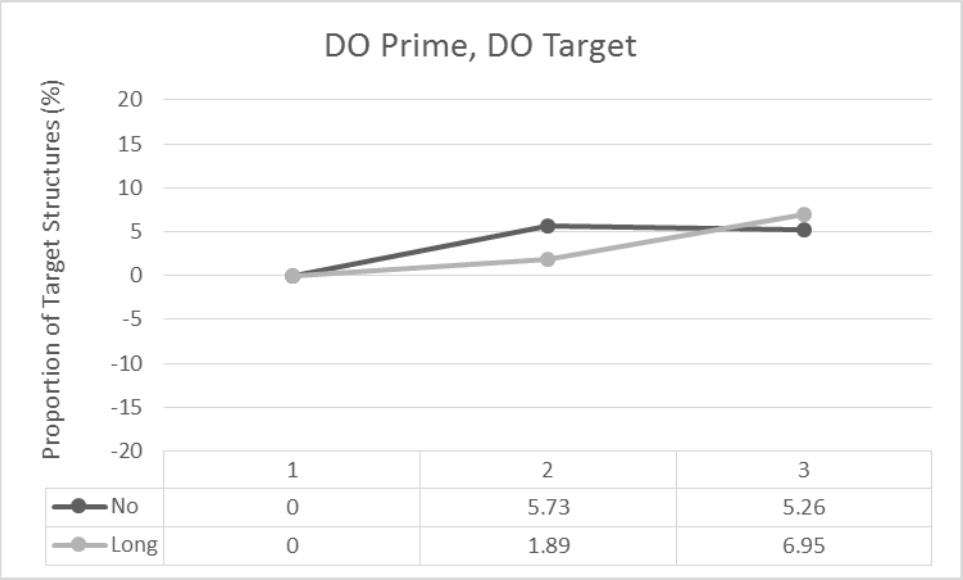

Figure 16. Overall proportions (%) of DO prime-DO target responses based on lag conditions and sessions differences (1: pretest, 2: immediate posttest, 3: delayed posttest).

According to the results of the PO primes in the long-lag condition, the simple main effect of sentence structures and priming sessions were significant (priming sessions: F (4, 60) = 5.05, p < .01, *partial* η^2 = .25; sentence structures: F (2, 30) = 17.36, p < .01, *partial* η^2 = .54). The proportion of the PO Priming was significantly larger than the proportions of the Alternate and Other structures (Alternate: *adjusted* p = .00, Other: *adjusted* p = .00).

For the immediate posttest, the proportion of the PO Priming was significantly larger than the proportions of the Priming in the pretest in the long-lag condition (8.16%) (*adjusted* p = .03). Moreover, the interaction between the lag conditions and priming sessions was significant (F (1, 31) = 5.18, p < .05, *partial* η^2 = .14). Therefore, the proportion of cumulative PO Priming between pretest and immediate posttest in the long-lag condition was significantly larger than the proportions of cumulative PO Priming in the no-lag condition (*adjusted* p = .01). However, there was no significant increase between the proportions of Priming in pretest and immediate posttest with PO and DO primes in the no-lag condition. From the results, the persistent syntactic priming effect was observed with PO primes with lags intervened between primes and targets.

For the delayed posttest, the simple main effect of priming sessions was significant for PO and DO Priming (PO Priming: F (1, 31) = 5.05, p < .05, *partial* η^2 = .14, DO Priming: F (1, 31) = 4.62, p < .05, *partial* η^2 = .13). Thus, the proportion of cumulative Priming in the delayed posttest was significantly larger than the proportions of the Priming in the pretest for both syntactic structures in both lag conditions (no-lag PO: 1.57%, DO: 5.26%, long-lag PO: 3.55%, DO: 6.95%). However, the simple main effect of lag conditions was not observed, and there was no effects of lag conditions on the syntactic priming effect in the delayed posttest.

5.4.4 Priming Effects in the Sessions

The syntactic priming effects for PO and DO sentence structures in two lag conditions were investigated to compare the priming effects in the pretest, immediate posttest and delayed posttest. Priming effects based on lag conditions and sessions differences in the pretest are described in Figure 17, the priming effects in the immediate posttest are shown in Figure 18, and the priming effects in the delayed posttest are reported in Figure 19.

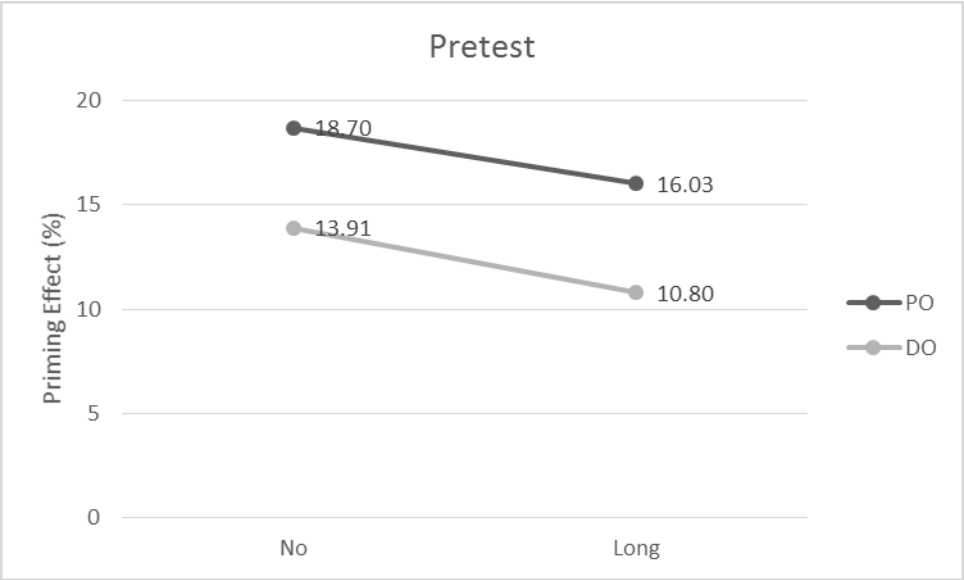

Figure 17. Priming effects in percent (percentage of PO responses in the PO condition (DO condition) minus the percentage of PO responses (DO responses) in the DO condition (PO condition)) based on lag conditions and sessions differences in the pretest.

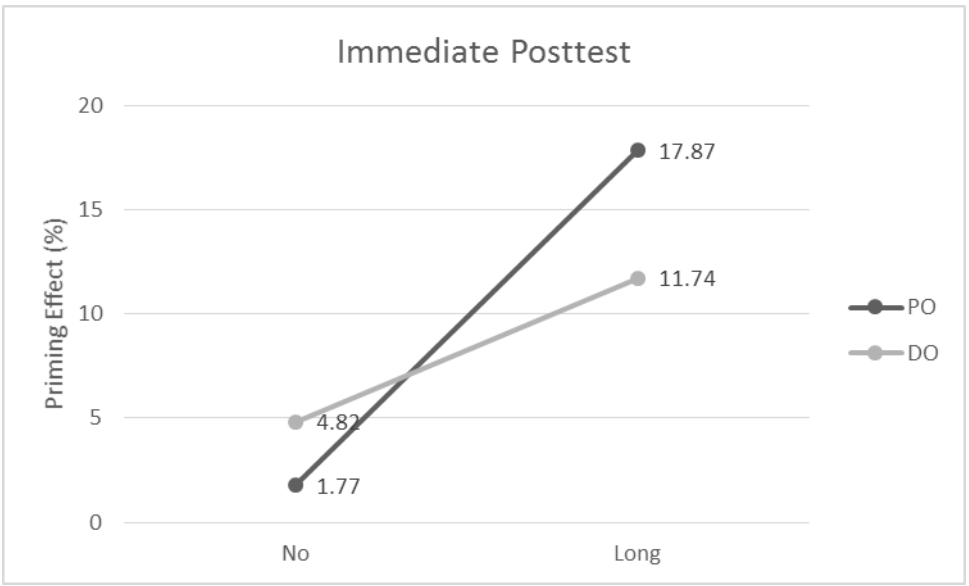

Figure 18. Priming effects in percent (percentage of PO responses in the PO condition (DO condition) minus the percentage of PO responses (DO responses) in the DO condition (PO condition)) based on lag conditions and sessions differences in the immediate posttest.

Figure 19. Priming effects in percent (percentage of PO responses in the PO condition (DO condition) minus the percentage of PO responses (DO responses) in the DO condition (PO condition)) based on lag conditions and sessions differences in the delayed posttest.

In the pretest, the PO priming rate was significantly higher than the DO priming rate in both conditions (F (1, 31) = 19.23, $p < .01$, *partial* $\eta^2 = .38$). However, the PO and DO priming rates in the long-lag condition were lower than the priming rates in the no-lag conditions, but these priming rates did not differ significantly.

In the immediate posttest, the PO priming rate was significantly higher than the DO priming rate in both conditions (F (1, 31) = 10.98, $p < .01$, *partial* $\eta^2 = .26$), and the interaction between the lag conditions and priming sessions was significant (F (1, 31) = 5.18, $p < .05$, *partial* $\eta^2 = .14$). The PO and DO priming rates in the no-lag condition were lower than the priming rates in the pretest, but the priming rates in the long-lag condition did not differ.

In the delayed posttest, the PO priming rate was significantly higher than the DO priming rate in both conditions (F (1, 31) = 11.26, $p < .01$, *partial* $\eta^2 = .27$). The PO priming rate got lower than the priming rate in the immediate posttest, but the DO priming rate got higher. However, these changes were not significant.

5.5 Hypothesis Verification

5.5.1 Research Question 1

To address the research question 1, which asked whether syntactic priming effect persists with lags intervened between primes and targets, syntactic priming effect persisted with the PO primes with lags intervened.

5.5.2 Research Question 2

To address the research question 2, which asked whether differences in the lag conditions affect the magnitude of syntactic priming in immediate or delayed posttest, the proportion of the PO Priming in the immediate posttest in the long-lag condition was significantly larger than the proportions of PO Priming in the no-lag condition.

6. GENERAL DISCUSSION

6.1 Summary of the Results

In Experiments 1a and 1b, a picture description task with spoken primes was conducted to investigate whether the differences of output modality and verb affect Japanese EFL learners' syntactic priming. The participants described pictures in either forms after listening to the primes with a PO, DO, or filler. Three conditions were randomly assigned to the participants to determine whether focus on contents or repetition of a prime would enforce syntactic structures. The results showed that a priming effect was observed in both modalities with the PO primes and with repetition of verbs between the primes and targets in both spoken and written production. These results demonstrated that the participants of the present study had the same tendency as the previous study with higher priming rates for the PO sentence structure (Morishita, 2011a), indicating that the acquisition of PO knowledge and the sharing of a lexical item between a prime and a target promote more syntactic priming effect. Therefore, the results indicate that learners successfully heard and understood the controlled primes. Comparison of results with spoken and written modalities shows that the priming rates were higher with PO primes compared to DO primes but they were lower when participants focused their attention on the contents in condition B in spoken production. The results indicate that PO knowledge was acquired by the participants and structure activation was inhibited when they focused on sentential meanings. Furthermore, the DO production was increased in written production, indicating increased production of the structure with lower preference. Therefore, the results indicate that learners transited the knowledge of the structure from declaratives to procedural knowledge when they heard spoken forms. Furthermore, a different output modality affects syntactic priming differently.

In Experiment 2, a picture description task with spoken primes was also conducted to investigate whether the differences of learners' proficiency levels and output modality affect Japanese EFL learners' syntactic priming in three different conditions from Experiments 1a and 1b. The participants were divided to upper or lower level learners according to the proficiency test scores, and described pictures in either forms after listening to the primes with a PO, DO, or filler. The results demonstrated that the proportion of the PO Priming of upper level learners was significantly larger than the proportion of the PO Priming of lower level learners, indicating that the differences of learners' proficiency levels affect the magnitude of syntactic priming. Moreover, the effects of learners'

proficiency differences were observed only in Condition A.

In Experiment 3, a picture description task with spoken primes and targets was conducted to investigate whether Japanese EFL learners' syntactic priming effect persists with the lag intervened between primes and targets. The participants attended 2 day experiment, and described pictures in either forms after listening to the primes with a PO, DO, or filler, and repeating it in the pretest, learning sessions, immediate posttest and delayed posttest. As a result, persistent syntactic priming effect was observed with the PO primes with lags intervened between primes and targets. By comparing the results in different lag condition, the proportion of the PO Priming between pretest and immediate posttest in the long-lag condition was significantly larger than the proportions of PO Priming in the no-lag condition. However, there was no effects of lag conditions on the syntactic priming effect in the delayed posttest.

6.2 Comparison between Spoken Production and Written Production

Experiments 1a and 1b examined how Japanese EFL learners operate syntactic representations in language production by investigating the occurrence of syntactic priming effect, and to investigate whether the way and the magnitude of operating syntactic representations differ between two modalities (i.e., speaking or writing).

To address the research questions 1 and 2, which asked whether syntactic priming effect occurs with the presentations of spoken primes, and whether the differences in primes' syntactic structure and verb differences affect syntactic priming, a syntactic priming effect was observed with the PO primes and with repetition of verbs between the primes and targets in both spoken and written production. These results demonstrated that the participants of Experiments 1a and 1b had the same tendency as the previous study with higher priming rates for the PO sentence structure (Morishita, 2011a), indicating that the acquisition of PO knowledge and the sharing of a lexical item between a prime and a target promote more syntactic priming effect. The results show that a syntactic priming effect was observed in both modalities, indicating that learners successfully heard and understood the controlled primes. This result confirmed that participants operated their syntactic representations as Pickering and Branigan (1998)'s model mentioned. Thus, links between combinatorial node *NP, PP* and the lemma was activated by the presentation of spoken primes, and a prior exposure of the structures enforced syntactic processing when they encounter the same structures again. Therefore, enforcement

of the syntactic processing led to promotion of the production of the same structures.

Research question 3 asked whether the presentation conditions of the primes' differences affect syntactic priming. In spoken production, a significant difference was observed between Conditions A and B; however, the presentation conditions of the primes' differences did not affect syntactic priming in written production. This difference was observed because the cognitive load of Condition B, which needs semantic processing, seemed heavier in spoken production with a shorter duration for production compared with that of written production. Therefore, the activation of the target structure was inhibited, and it lowered the syntactic priming rate.

Research question 4 enquired whether syntactic priming rates differ by comparing the results of spoken production (Experiment 1a) and written production (Experiment 1b). The result shows that the priming rate with the PO primes in Conditions A and C in spoken production was higher than that in written production (A: 78.1, 57.9, C: 69.1, 59.3). There are two possible reasons why the difference was observed. One reason is that the lexical boost effect, which was observed when the verbs remained the same between primes and targets, had decayed in written production, because a written output requires more time than a spoken production. Another possible reason is that the input modality using spoken primes affected the syntactic priming rate. Thus, the results of the current study differed with the results of English native speakers in that the differences of the output modality did not affect the operation of the speaker's or writer's knowledge of sentence structures (Cleland & Pickering, 2006). On the other hand, the DO production was increased in written production (A: 10.6, 35.2, B: 17.7, 40.4, C: 12.0, 34.1), and the result indicates the tendency of increased production of the structure with lower preference. This tendency is similar with Hartsuiker et al.'s (2008) result with increased production of the DO sentence structure in written production compared with the result of spoken production. Therefore, the result suggests that participants implicitly learned and began using more DO sentence structures. The results demonstrated that differences in the output modality had different effects on syntactic priming. The verb differences affect the syntactic priming rate in both modalities, whereas the presentation of prime sentences conditions did not affect the syntactic priming rate, and the DO production was increased in written production. This finding suggests that in comparison to English native speakers who are unaffected by the modality differences, Japanese EFL learners' way and the magnitude of operating syntactic representations differ between spoken and written production.

By presenting spoken primes, learners' syntactic structures were activated and syntactic

processing was also promoted. Therefore, the result confirmed that Japanese EFL learners' syntactic representations were shared between comprehension and production. Thus, it suggests that syntactic priming facilitates L2 development, and if Japanese EFL learners can hear and understand the given input properly, spoken input might promote their grammatical encoding which intervene with a smooth output production.

The current study investigated whether the differences of output modality affect Japanese EFL learners' syntactic priming. However, the experiments were conducted within a relatively short period of time. As such, the observed syntactic priming effect could have been caused by the occurrence of the temporary lexical boost effect, and, in actuality, the participants might not have acquired the target syntactic structures. Therefore, an investigation on whether the syntactic priming effect, which was observed in this study, would continue for a longer period remains an avenue for further research.

6.3 Effects of Learners' Proficiency Differences on Syntactic Processing

The aim of Experiment 2 was to examine how Japanese EFL learners' production of syntactic structures automatize by investigating the effects of learners' proficiency differences on the occurrence of syntactic priming effect. A picture description task with spoken primes was conducted to investigate whether the differences of learners' proficiency level and output modality affect Japanese EFL learners' syntactic priming in three different conditions.

To address the research question 1 asked whether the differences of learners' proficiency levels affect syntactic priming with spoken primes. Learners' proficiency differences affect the magnitude of syntactic priming effect. The results show that priming effect was observed with PO primes in both modalities regardless of proficiency levels, indicating that learners' syntactic representations are shared between comprehension and production (Branigan, Pickering, & Cleland, 2000).

In the case of PO and DO primes with lower level learners, learners tended to produce other structures, and neither target structures were produced. The result shows that learners' syntactic representations had not been internalized for both combinatorial nodes, thus, they could not utilize the prime to produce the same sentence structure.

In the case of PO primes with upper level learners, the proportion of the PO Priming was significantly larger than the proportions of the PO Priming of lower level learners regardless of output modality differences. Thus, the effects of learners' proficiency differences on the magnitude of

syntactic priming effect were observed. On the other hand, the effects of proficiency differences on the occurrence of syntactic priming effect were not observed with DO Priming. Upper level learners' links between combinatorial nodes and lemmas got activated with presentation of PO primes, and the residual activation promoted learners to produce the same sentence structures. However, links between combinatorial nodes *NP, PP* and lemmas had not been internalized with presentation of DO primes, and it prohibited the production of the sentence structures. The difference between the results of PO and DO primes might be due to the difference in cognitive complexity (Hulstijn & Graaff, 1994). DO sentence structure is recognized as complex because it involves multiple thematic arguments.

It can be assumed that the degree of operating syntactic representations will change with increased syntactic experiences in longer term. If upper level learners in the current study are exposed to more input, the syntactic representations for both sentence structures will be fully internalized. Thus, both sentence structures might be activated to the same degree, and learners will not be susceptible to syntactic priming effect.

In addition, correlation between learners' proficiency differences and output modality was not observed. The result showed that the differences in output modality did not affect the automatization of syntactic production for participants in the current study. However, the result also indicated that the proportion of the DO Priming in written production was significantly larger than the proportion of the DO Priming in spoken production, indicating the tendency of increased production of the structure with lower preference. As it was mentioned in Experiments 1a and 1b, this tendency is similar with Hartsuiker et al.'s (2008) result with increased production of the DO sentence structure in written production compared with the result of spoken production. Therefore, the results revealed that the differences in output modality did not affect upper and lower learners' degree of operating syntactic knowledge; however, the proportion of the PO and DO sentence structures was biased.

Research question 2 asked whether the differences of learners' proficiency levels affect syntactic priming in three presentation conditions of the primes. The results mentioned that priming effect with upper level learners was higher than that of lower level learners only with presentation of a prime once (Condition A). There were no significant differences; however, the proportion of the PO and DO Priming of upper level learners in Condition B was smaller than the PO and DO Priming in Condition A, and the proportion of the PO and DO Priming of lower level learners in Condition C was larger than the PO and DO Priming in Condition A.

According to the L2 processing model of Hartsuiker and Bernolet (2017), learners in the early developmental stage tend to rely on specific lexical items. Learners in the middle stage have language- or item-specific representations and the representations become more abstract with increased exposure to L2. Thus, upper level learners tend not to be influenced by priming effect.

In Condition B, upper level learners' priming effect decayed compared to the Condition A. It is unlikely that upper level learners' syntactic representations had not internalized enough. Instead, it is possible that focusing learners' attention to the semantic processing led their representations more abstract so they were not sensitive to the priming effect. On the other hand, in Condition C, lower level learners' priming effect increased compared to the Condition A. It is likely that lower level learners' syntactic representations which had not been internalized, were formed by repetition of primes, and it led to the subsequent production using primes' sentence structures.

The current study investigated how Japanese EFL learners' production of syntactic structures automatize by examining the effects of learners' proficiency differences on the occurrence of syntactic priming effect. From the results, learners' syntactic representations were shared between comprehension and production in both modalities regardless of their proficiency levels, and upper level learners' operation of sentence structure knowledge was more automatized compared to lower level learners. Moreover, manipulating primes' presentation conditions had effects on learners' syntactic processing. Thus, manipulating the amount of input and frequency for exposure to target structures for further studies might promote the occurrence of the syntactic priming effect.

6.4 Effects of Lags on Persistence of Syntactic Priming

The aim of Experiment 3 was to investigate how Japanese EFL learners' production skills of syntactic structures are learned by investigating the mechanism of syntactic priming effects and the effects of repeated exposure of the syntactic structures. A picture description task with spoken primes and targets was conducted to investigate whether Japanese EFL learners' syntactic priming effect persists with the lag intervened between primes and targets.

To address the research question 1, which asked whether syntactic priming effect persists with lags intervened between primes and targets, persistent syntactic priming effect was observed with the PO primes in the long-lag condition. The result demonstrated that the participants of Experiment 3 had the same results with Hartsuiker et al. (2008), indicating that the learners were changing

knowledge of PO sentence structure from declarative to procedural by repeated exposure to the structure in implicit learning mechanism. Moreover, the priming rate for both syntactic structures in the no-lag condition were lower in the immediate posttest, indicating the priming rate of no-lag condition purely involving explicit memory process with lexical repetitions tended to decay rapidly.

Research question 2 asked whether differences in the lag conditions affect the magnitude of syntactic priming in immediate or delayed posttest. From the results, the proportion of cumulative PO Priming in the immediate posttest in the long-lag condition was significantly larger than the proportions of cumulative PO Priming in the no-lag condition, indicating repeated exposure of the syntactic structures with spaced intervals (lag) is effective for learners to sustain and retrieve the knowledge. Moreover, the proportion of cumulative Priming in the delayed posttest was also significantly larger than the proportions of the Priming in the pretest for both syntactic structures in both conditions, but the effects of lag conditions were not observed. The results were consistent with the results of Shin and Christianson (2012) with increased production of target structures from pretest to posttest after the learning session; but, the effects of lag condition differences observed with DO Priming in a previous study were not observed in the present study.

The results of Experiment 3 showed the increase of syntactic priming effect in both immediate and delayed posttests in the long-lag condition, and the increase of syntactic priming effect in the delayed posttest in the no-lag condition. Thus, the results are consistent with a multi-factorial account which supports that syntactic priming is caused by both lexicon-external and implicit-learning mechanisms (Bock & Griffin, 2000; Chang et al., 2006). Therefore, the activation of syntactic priming effect can decay quickly with repetitions of primes, but, at the same time, it can also sustain for a longer period with lags.

However, the result was contradicted with Chang et al. (2006), asserting that less frequent and unexpected structures yield greater error than more frequent structures; therefore, they cause a greater adjustment in the error-based learning mechanism. There are two possible reasons why the contradicted result with DO Priming was observed. First possible reason is that the repetition of primes enforced the syntactic priming effect, indicating learners self-primed by producing the PO sentence structures. In addition, learners tended to produce PO targets with failed DO primes' repetitions promoting self-priming. Second possible reason is that the differences in cognitive complexity affected the results as mentioned in Experiment 2 (Hulstijn & Graaff, 1994). In Shin and Christianson (2012),

effects of lag conditions were not observed with the phrasal-verb structure compared with DO sentence structure. According to Hulstijn and Graaff (1994), DO sentence structure is considered as complex because it involves multiple thematic arguments, whereas the phrasal-verb structure is simple involving only two components with one of them is a function word. Thus, for complex structure, explicit instruction speeded priming; on the other hand, for the simple structure, simplicity led to the ceiling effects in all lag conditions. Therefore, the effects of lag conditions on cumulative PO Priming not with DO Priming in the immediate posttest might be caused by the differences of cognitive complexity between PO and DO sentence structure, indicating that saliency of PO sentence structure accompanied with a preposition was higher than the DO sentence structure. Therefore, repeated exposure with lags (spaced intervals) might be more effective to promote the production of syntactic structures with high saliency.

In addition, the effects of lag conditions were only observed with the immediate posttest, and the result contradicted with the result of L2 vocabulary acquisition studies and few grammar acquisition studies such as Miles (2014) with increased usage of target vocabularies or structures in the delayed posttest for learners who had spaced distribution compared to massed distribution. However, the target structures used in Miles (2014) such as adverb-verb word order, almost in a determinative and verbal phrase are all at the lexical levels and the target structures need more careful examination; therefore, the current results showed that the acquisition of L2 syntactic structures needs more time compared to the L2 vocabulary acquisition.

By investigating the syntactic priming effect in each session, the PO and DO priming rates in the long-lag condition were lower than the priming rates in the no-lag conditions in the pretest. The result showed the same tendency with Hartsuiker et al. (2008) with the decline of the priming rate as the number of fillers increased between primes and targets. In the delayed posttest, the PO priming rate got lower than the priming rate in the immediate posttest, but the DO priming rate got higher. The result indicated that a simple structure involves only the declarative memory system with rapid decay of the priming effect; on the other hand, more complex structures like the DO sentence structure involve procedural memory which might cause consolidation of the grammatical generalizations through the sleep in implicit learning processes, and that maintained performance next day of the priming sessions (Shin & Christianson, 2012). However, the difference between PO and DO Priming was not significant in the current study; therefore, further studies are needed to investigate the

cumulative priming effect with longer intervals between the immediate and delayed posttests.

The results provided the evidence that the syntactic presentations were consolidated by repeated exposure to the sentence structures, and the consolidation of the representations eventually leads to the automatization of syntactic processing. Experiment 3 used both same and different verb conditions; however, additional attention should be directed to the input frequency. McDonough and Kim (2009) conducted oral communicative activities to EFL learners with presentation of high-type-frequency or low-type-frequency materials. The result demonstrated that learners participating in a priming activity with high-type-frequency material produced more accurate wh-questions than learners with low-type-frequency material, indicating input frequency plays an important role to promote learners to detect lexical frameworks and develop them to more abstract. Therefore, an investigation on whether input frequency would affect the magnitude of syntactic priming in language production is left open.

7. CONCLUDING REMARKS AND FURTHER RESEARCH

The syntactic priming effect (interactive alignment) occurs if Japanese EFL learners can hear and understand the given input properly, and spoken input might promote their grammatical encoding which intervene with a smooth output production. However, in comparison to English native speakers who are unaffected by the modality differences, Japanese EFL learners' way and the magnitude of automatization in operating syntactic representations differ between spoken and written production. The magnitude of the automatization in L2 syntactic processing depends on the learners' proficiency levels, and upper level learners' operation of sentence structure knowledge is more automatized compared to lower level learners, and learners' proficiency differences have effects on syntactic processing in different primes' presentation conditions. Leaners' syntactic representations can be consolidated by repeated exposure to the syntactic structures, and the consolidation leads to the automatization of L2 syntactic processing.

Taken together, the current study provided evidence that the occurrence of syntactic priming facilitates L2 development. Further studies are needed to explore the effects of input frequency on syntactic priming effect, and an investigation on whether the syntactic priming effect, which was observed in this study, would continue for a longer period remains an avenue for further research.

REFERENCES

Bahrick, H. P. (1979). Maintenance of knowledge: Questions about memory we forgot to ask. *Journal of Experimental Psychology: General, 108*, 296–308. doi:10.1037/0096-3445.108.3.296

Bird, S. (2010). Effects of distributed practice on the acquisition of second language English syntax. *Applied Psycholinguistics, 31*, 635–650. doi:10.1017/S0142716410000172

Bloom, K. F., & Shuell, T. J. (1981). Effects of massed and distributed practice on the learning and retention of second-language vocabulary. *Journal of Educational Research, 74*, 245–248. doi:10.1080/00220671.1981.10885317

Bock, J. K., & Brewer, W. F. (1974). Reconstructive recall in sentences with alternative surface structures. *Journal of Experimental Psychology, 103*, 837–843. doi:10.1037/h0037391

Bock, J. K., Dell, G. S., Chang, F., & Onishi, K. H. (2007). Persistent structural priming from language comprehension to language production. *Cognition, 104*, 437–458. doi :10.1016/j.cognition. 2006.07.003

Bock, K., & Griffin, Z. M. (2000). The persistence of structural priming: Transient activation or implicit learning? *Journal of Experimental Psychology: general, 129,* 177–192. doi:10.1037/0096-3445.129.2.177

Bock, K., & Loebell, H. (1990). Framing sentences. *Cognition, 35*, 1–39. doi:10.1016/0010-0277(90)90035-I

Branigan, H. P., Pickering, M. J., & Cleland, A. A. (1999). Syntactic priming in written production: Evidence for rapid decay. *Psychonomic Bulletin & Review, 6*, 635–640. doi:10.3758/BF03212972

Branigan, H. P., Pickering, M. J., & Cleland, A. A. (2000). Syntactic co-ordination in dialogue. *Cognition, 17*, 13–25. doi:10.1016/S0010-0277(99)00081-5

Branigan, H. P., Pickering, M. J., Stewart, A. J., & McLean, J. F. (2000). Syntactic priming in spoken production: Linguistic and temporal interference. *Memory & Cognition, 28*, 1297–1302. doi:10.3758/BF03211830

Carpenter, S. K., Cepeda, N. J., Rohrer, D., Kang, S. H. K., & Harold, P. (2012). Using spacing to enhance diverse forms of learning: Review of recent research and implications for instruction. *Educational Psychology Review, 24*, 369–378. doi:10.1007/s10648-012-9205-z

Chang, F., Dell, G. S., Bock, J. K., & Griffin, Z. M. (2000). Structural priming as implicit learning: A

comparison of models of sentence production. *Journal of Psycholinguistic Research, 29*, 217–229. doi:10.1023/A:1005101313330

Chang, F., Dell, G. S., & Bock, J. K. (2006). Becoming syntactic. *Psychological Review, 113*, 234–272. doi:10.1037/0033-295X.113.2.234

Cleland, A. A., & Pickering, M. J. (2006). Do writing and speaking employ the same syntactic representations? *Journal of Memory and Language, 54*, 185–198. doi:10.1016/j.jml.2005.10.003

Collins, L., & White, J. (2011). An intensive look at intensity and language learning. *TESOL Quarterly, 45*, 106–133. doi:10.5054/tq.2011.240858

Council of Europe. (2001). *Common European framework of reference for languages: Learning, teaching, assessment.* Cambridge, England: Cambridge University Press.

Ebbinghaus, H. (1885). *Memory: A contribution to experimental psychology.* New York: Teachers College.

Ellis, N. C., Romer, U., & O'Donnell, M. B. (2016). *Usage-based approaches to language acquisition and processing: Cognitive and corpus investigations of construction of grammar.* Malden, MA: Wiley-Blackwell.

Flower, L., & Hayes, J. (1981). A cognitive process theory of writing. *College Composition and Communication, 32*, 365–87. doi:10.2307/356600

Garrod, S., & Anderson, A. (1987). Saying what you mean in dialogue: A study in conceptual and semantic coordination. *Cognition, 27*, 181–218. doi:10.1016/0010-0277(87)90018-7

Harada, Y., & Morishita, M. (2013). Language processing and proficiency of Japanese learners of English: Versant English Test and Oxford Quick Placement Test. *IEICE Technical Report, 113*, 1-6.

Hartsuiker, R. J., Bernolet, S., Schoonbaert, S., Speybroeck, S., & Vanderelst, D. (2008). Syntactic priming persists while the lexical boost decays: Evidence from written and spoken dialogue. *Journal of Memory and Language, 58*, 214–238. doi:10.1016/j.jml.2007.07.003

Hartsuiker, R. J., & Bernolet, S. (2017). The development of shared syntax in second language learning. *Bilingualism: Language and Cognition, 20*, 219–234. doi:10.1017/S1366728915000164

Hayes, J. R. (1996). A new framework for understanding cognition and affect in writing. In C. M. Levy & S. Ransdell (Eds.), *The science of writing: Theories, methods, individual differences, and applications* (pp. 1–27). Mahwah, NJ: Lawrence Erlbaum.

Hulstijn, J., & de Graaff, R. (1994). Under what conditions does explicit knowledge of a second language facilitate the acquisition of implicit knowledge? A research proposal. *AILA Review, 11*, 97–112.

Huttenlocher, J., Vasilyeva, M., & Shimpi, P. (2004). Syntactic priming in young children. *Journal of Memory and Language, 50*, 182–195. doi:10.1016/j.jml.2003.09.003

Indefrey, P., Hellwig, F., Herzog, H., Seitz, R., & Hagoort, P. (2004). Neural responses to the production and comprehension of identical utterances. *Brain and Language, 89*, 312–319. doi:10.1016/S0093-934X(03)00352-3

Kim, Y., & McDonough, K. (2008). Learners' production of passives during syntactic priming activities. *Applied Linguistics, 29*, 149–154. doi:10.1093/applin/amn004

Levelt, W. J. M. (1989). *Speaking: From intention to articulation.* Cambridge, MA: MIT Press.

Levelt, W. J. M., & Kelter, S. (1982). Surface form and memory in question answering. *Cognition Psychology, 14*, 78–106. doi:10.1016/0010-0285(82)90005-6

McDonough, K. (2006). Interaction and syntactic priming: English L2 speaker's production of dative constructions. *Studies in Second Language Acquisition, 28*, 179–207. doi:10.1017/S0272263 106060098

McDonough, K., & Chaikitmongkol, W. (2010). Collaborative syntactic priming activities and EFL learners: production of wh-questions. *The Canadian Modern Language Review / La Revue Canadienne des Langues Vivantes, 66*, 817–841. doi:10.3138/cmlr.66.6.817

McDonough, K., & Kim, Y. (2009). Syntactic priming, type frequency, and EFL learners' production of wh-questions. *The Modern Language Journal, 93*, 386–398. doi:10.1111/j.1540-4781.2009. 00897.x

Miles, S. W. (2014). Spaced vs. massed distribution instruction for L2 grammar learning. *System, 42*, 412–428. doi:10.1016/j.system.2014.01.014

Morishita, M. (2011a). The effect of the difference in modality on language production: A pilot study. *Journal of Business Management, 7*, 49–61.

Morishita, M. (2011b). How the difference in modality affects language production: A syntactic experiment using spoken and written sentence completion tasks. *JACET Journal, 53*, 75–91.

Morishita, M. (2013). The effects of interaction on syntactic priming: A psycholinguistic study using scripted interaction tasks. *Annual Review of English Language Education in Japan (ARELE), 24*,

141–156. doi:10.20581/arele.24.0_141

Morishita, M., Satoi, H., & Yokokawa, H. (2010). Verb lexical representation of Japanese EFL learners: Syntactic priming during language production. *Journal of the Japan Society for Speech Sciences, 11*, 29–43.

Morishita, M., & Yokokawa, H. (2014). Sentence production of EFL learners: What kind of syntactic representations they have? In H. Yokokawa, N. Sadato, & H. Yoshida (Eds.), *How foreign language operation skills get proficient?: Searching about the automatic process of language information processing* (pp. 113–135). Tokyo: Shohakusha.

Oxford University Press. (2001). *Quick placement test*. Oxford, England: Oxford University Press.

Pickering, M. J., & Branigan, H. P. (1998). The representation of verbs: Evidence from syntactic priming in language production. *Journal of Memory and Language, 39*, 633–651. doi:10.1006/jmla.1998.2592

Pickering, M. J., & Garrod, S. (2004). Toward a mechanistic psychology of dialogue. *Behavioral and Brain Sciences, 27*, 169–226. doi:10.1017/S0140525X04000056

Rohrer, D., & Taylor, K. (2006). The effects of overlearning and distributed practice on the retention of mathematics knowledge. *Applied Cognitive Psychology, 20*, 1209–1224. doi:10.1002/acp.1266

Rowland, C. F., Chang, F., Ambridge, B., Pine, J. M., & Lieven, E. V. M. (2012). The development of abstract syntax: Evidence from structural priming and the lexical boost. *Cognition, 125*, 49–63. doi:10.1016/j.cognition.2012.06.008

Sachs, J. S. (1967). Recognition memory for syntactic and semantic aspects of connected discourse. *Perception & Psychophysics, 2*, 437–442. doi:10.3758/BF03208784

Schmidtt, N. (2000). *Vocabulary in language teaching.* New York: Cambridge University Press.

Shin, J. A., & Christianson, K. (2012). Structural priming and second language learning. *Language Learning, 62*, 931–964. doi:10.1111/j.1467-9922.2011.00657.x

Toppino, T. C. (1993). The spacing effect in preschool children's free recall of pictures and words. *Bulletin of the Psychonomic Society, 31*, 27–30. doi:10.3758/BF03334130

Trofimovich, P., McDonough, K., & Foote, J. A. (2014). Interactive alignment of multisyllabic stress patterns in a second language classroom. *TESOL Quarterly, 48*, 815–832. doi:10.1002/tesq.156

Tulving, E., & Schacter, D. L. (1990). Priming and human memory systems. *Science, 247*, 302–306.

doi:10.1126/science.2296719

Wheeldon, L. R., & Smith, M. C. (2003). Phrase structure priming: A short-lived effect. *Language and Cognitive Processes, 18,* 431–442. doi:10.1080/01690960244000063

Year, J., & Gordon, P. (2009). Korean speakers' acquisition of the English ditransitive construction: The role of verb prototype, input distribution, and frequency. *The Modern Language Journal, 93*, 399–417. doi:10.1111/j.1540-4781.2009.00898.x

Yokokawa, H. (Ed.). (2006). *Kyoiku kenkyuu no tame no dainigengo database: Nihonjin eigo gakusyusya no eitango shinmitsudo <Moji hen> [Database for teaching and research of second language: English vocabulary familiarity of Japanese EFL learners <Visual version>].* Tokyo: Kuroshio Publishers.

Yokokawa, H. (Ed.). (2009). *Kyoiku kenkyuu no tame no dainigengo database: Nihonjin eigo gakusyusya no eitango shinmitsudo <Onsei hen> [Database for teaching and research of second language: English vocabulary familiarity of Japanese EFL learners <Auditory version>].* Tokyo: Kuroshio Publishers.

APPENDICIES

APPENDIX A

Example of a target picture and the expected responses in Experiments 1, 2 and 3

a. The man showed the letter to the woman (*PO sentence structure*).

b. The man showed the woman the letter (*DO sentence structure*).

APPENDIX B

The prime sentences used in Experiments 1, 2 and 3

No		Prime Sentence	Category
1	a	The girl showed the book to the boy.	(*PO sentence structure, same*)
	b	The girl showed the boy the book.	(*DO sentence structure, same*)
	c	The girl gave the book to the boy.	(*PO sentence structure, different*)
	d	The girl gave the boy the book.	(*DO sentence structure, different*)
2	a	The lawyer told the news to the woman.	(*PO sentence structure, same*)
	b	The lawyer told the woman the news.	(*DO sentence structure, same*)
	c	The lawyer sent the news to the woman.	(*PO sentence structure, different*)
	d	The lawyer sent the woman the news.	(*DO sentence structure, different*)
3	a	The mother gave the money to the child.	(*PO sentence structure, same*)

	b	The mother gave the child the money.	(*DO sentence structure, same*)
	c	The mother lent the money to the child.	(*PO sentence structure, different*)
	d	The mother lent the child the money.	(*DO sentence structure, different*)
4	a	The worker sold the food to the girl.	(*PO sentence structure, same*)
	b	The worker sold the girl the food.	(*DO sentence structure, same*)
	c	The worker gave the food to the girl.	(*PO sentence structure, different*)
	d	The worker gave the girl the food.	(*DO sentence structure, different*)
5	a	The chief sent the report to the client.	(*PO sentence structure, same*)
	b	The chief sent the client the report.	(*DO sentence structure, same*)
	c	The chief showed the report to the client.	(*PO sentence structure, different*)
	d	The chief showed the client the report.	(*DO sentence structure, different*)
6	a	The man gave the flower to the woman.	(*PO sentence structure, same*)
	b	The man gave the woman the flower.	(*DO sentence structure, same*)
	c	The man bought the flower for the woman.	(*PO sentence structure, different*)
	d	The man bought the woman the flower.	(*DO sentence structure, different*)
7	a	The woman bought the jacket for the man.	(*PO sentence structure, same*)
	b	The woman bought the man the jacket.	(*DO sentence structure, same*)
	c	The woman sold the jacket to the man.	(*PO sentence structure, different*)
	d	The woman sold the man the jacket.	(*DO sentence structure, different*)
8	a	The worker sold the fish to the mother.	(*PO sentence structure, same*)
	b	The worker sold the mother the fish.	(*DO sentence structure, same*)
	c	The worker showed the fish to the mother.	(*PO sentence structure, different*)
	d	The worker showed the mother the fish.	(*DO sentence structure, different*)
9	a	The chief showed the letter to the woman.	(*PO sentence structure, same*)
	b	The chief showed the woman the letter.	(*DO sentence structure, same*)
	c	The chief gave the letter to the woman.	(*PO sentence structure, different*)

	d	The chief gave the woman the letter.	(*DO sentence structure, different*)
10	a	The boy bought the ring for the girl.	(*PO sentence structure, same*)
	b	The boy bought the girl the ring.	(*DO sentence structure, same*)
	c	The boy sent the ring to the girl.	(*PO sentence structure, different*)
	d	The boy sent the girl the ring.	(*DO sentence structure, different*)
11	a	The teacher lent the book to the boy.	(*PO sentence structure, same*)
	b	The teacher lent the boy the book.	(*DO sentence structure, same*)
	c	The teacher sold the book to the boy.	(*PO sentence structure, different*)
	d	The teacher sold the boy the book.	(*DO sentence structure, different*)
12	a	The man lent the bike to the woman.	(*PO sentence structure, same*)
	b	The man lent the woman the bike.	(*DO sentence structure, same*)
	c	The man bought the bike for the woman.	(*PO sentence structure, different*)
	d	The man bought the woman the bike.	(*DO sentence structure, different*)
13	a	The worker sold the dress to the woman.	(*PO sentence structure, same*)
	b	The worker sold the woman the dress.	(*DO sentence structure, same*)
	c	The worker lent the dress to the woman.	(*PO sentence structure, different*)
	d	The worker lent the woman the dress.	(*DO sentence structure, different*)
14	a	The mother sent the box to the child.	(*PO sentence structure, same*)
	b	The mother sent the child the box.	(*DO sentence structure, same*)
	c	The mother gave the box to the child.	(*PO sentence structure, different*)
	d	The mother gave the child the box.	(*DO sentence structure, different*)
15	a	The teacher told the story to the class.	(*PO sentence structure, same*)
	b	The teacher told the class the story.	(*DO sentence structure, same*)
	c	The teacher sent the story to the class.	(*PO sentence structure, different*)
	d	The teacher sent the class the story.	(*DO sentence structure, different*)
16	a	The driver showed the dog to the child.	(*PO sentence structure, same*)

	b	The driver showed the child the dog.	(*DO sentence structure, same*)
	c	The driver bought the dog for the child.	(*PO sentence structure, different*)
	d	The driver bought the child the dog.	(*DO sentence structure, different*)
17	a	The boss gave the book to the man.	(*PO sentence structure, same*)
	b	The boss gave the man the book.	(*DO sentence structure, same*)
	c	The boss sold the book to the man.	(*PO sentence structure, different*)
	d	The boss sold the man the book.	(*DO sentence structure, different*)
18	a	The mother lent the money to the boy.	(*PO sentence structure, same*)
	b	The mother lent the boy the money.	(*DO sentence structure, same*)
	c	The mother showed the money to the boy.	(*PO sentence structure, different*)
	d	The mother showed the boy the money.	(*DO sentence structure, different*)
19	a	The man bought the pencil for the woman.	(*PO sentence structure, same*)
	b	The man bought the woman the pencil.	(*DO sentence structure, same*)
	c	The man lent the pencil to the woman.	(*PO sentence structure, different*)
	d	The man lent the woman the pencil.	(*DO sentence structure, different*)
20	a	The patient sent the present to the doctor.	(*PO sentence structure, same*)
	b	The patient sent the doctor the present.	(*DO sentence structure, same*)
	c	The patient showed the present to the doctor.	(*PO sentence structure, different*)
	d	The patient showed the doctor the present.	(*DO sentence structure, different*)