Frequency Effects of Multi-Word Sequences on L2 Learning: Unfolding the Complexity of L2 Syntax Modeling

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Abstract

Innatists suggest that second language (L2) syntactic representation consists of abstract rules and posit that only minimal input is necessary to induce these rules: no multi-word sequences are supposed to exist in the mind. Conversely, emergentists postulate that L2 syntactic representation consists of multi-level components (words, phrases, sentences, etc.) accumulated from the input, and thus item frequency is supposed to have an effect in syntactic processing. Since neither standpoint has been found to be decisive, this study conducted a quasi-productive task to further clarify syntactic representation in the minds of L2 learners. The results of a psycholinguistic test—in which three-word sequences were presented on the screen word-by-word—indicated that words from frequent sequences in the input were activated more quickly in Japanese EFL learners exhibiting higher proficiency; this indicates that items frequently occurring in the input can be more readily used in L2 syntactic production, supporting the account of emergentists.

Keywords: syntactic representation, multi-word sequence, language exposure, reaction time, proficiency

Syntax plays a crucial role in developing second language (L2) skills

(for reading, Berman, 1984; Yano, Long, & Ross, 1994; Chen, 2014; Shiotsu & Weir, 2007; for writing, Taguchi, Crawford, & Wetzel, 2013; Yang, Lu, & Weigle, 2015; for listening, Felser, Roberts, Gross, & Marinis, 2003; Papadopoulou & Clahsen, 2003; Yi'an, 1998; Shirzadi, 2014; for speaking, Iwashita, Brown, McNamara, & O'Hagan, 2008). Conversely, whereas the syntax of first language (L1) is acquirable without much trouble in most cases, the full attainment of L2 syntax is usually difficult, especially for adults (Coppieters, 1987; Johnson, 1992; Johnson & Newport, 1989, 1991; Patkowski, 1980; Sorace, 1993). Syntactic elements that are not included in one's L1 have been shown to be difficult to learn (Hawkins & Hattori, 2006; Roberts & Liszka, 2013; Tsimpli & Dimitrakopoulou, 2007).

Since L2 syntax acquisition is often difficult and may end in failure, attempting to understand this difficulty of full attainment has occupied much of L2 syntax research. The existence of a critical/sensitive period for L2 acquisition during which L2 language structures—including syntax—are acquired more easily by younger learners has been discussed extensively for more than five decades (Birdsong & Molis, 2001; Bley-Vroman & Chaudron, 1990; Coppieters, 1987; DeKeyser, 2000; Hyltenstam & Abrahamsson, 2000; Johnson & Newport, 1989, 1991; Lenneberg, 1967; Long, 1990; Oyama, 1976, 1978, 1979; Patkowsky, 1980, 1990; Scovel, 1988; Sorace, 1993). Recent neurolinguistic studies have shown that event-related potentials emitted in the brain during syntactic processing are different among native speakers and L2 learners of varying proficiencies (Meulman, Stowe, Sprenger, Bresser & Schmid, 2014; van Hell & Tokowicz, 2010; Weber & Lavric, 2008). These discussions are valuable for understanding L2 syntax development in detail; however, full attainment of L2 syntax may not always be a crucial point in language acquisition. Determining how to

improve a learner's interlanguage is likely to be of more interest, at least for second/foreign language learners. From this perspective, understanding how L2 syntax is represented in the mind—the theme of this study—may help. Simply put, there are two contrastive theories on this question.

From one perspective, innatists suggest that innate mechanisms specially designed for L1 acquisition can be used for L2 acquisition as well (Full Access model; Campos-Dintrans, Pires, & Rothman, 2014; Epstein, Flynn, & Martohardjono, 1996; Schwartz & Sprouse, 1996; White, 1989, 2003). This argument speculates that L2 learners can acquire syntax even if they have not been exposed to all syntactic structures in the language—a condition referred to as *poverty of stimulus*. The other perspective is founded upon the proposal by emergentists or usage-based researchers, who suggest that L2 learning is accomplished by general learning mechanisms and that the frequencies of items in the input, such as words and phrases, affect L2 syntax components (Ellis, 2007; Ellis & Larsen-Freeman, 2009; MacWhinney, 1987, 2008).

The two perspectives differ in their views of what composes syntactic representation. Innatists posit that it is a combination of abstract syntactic frameworks and that the lexis, which constitutes the semantic elements of sentences, exists outside of syntactic representation (Pinker, 1999; Pinker & Ullman, 2002). A sentence is created by a computation that embeds words in a syntactic framework. In this view, language exposure is simply a process that resets the parameters of one's syntax, which contains binary options for each principle of a structure determined by language (e.g., the pronoun-dropping parameter determines whether pronouns are omitted in the language), and learners need only minimal input for these parameter shifts; concrete information about which words co-occur with which other words is not stored in the mind. Consequently, the frequency of multi-word

sequences is not supposed to be influential. Conversely, emergentists assume that every level of experienced linguistic elements such as words, phrases, and sentences is stored in mental representation (Goldberg, 2006; Tomasello, 2003). When a learner uses the language, they are supposed to retrieve what is in the representation or use abstract syntax distilled from it via verb-island structures to create sentences (Ellis & Ferreira-Junior, 2009). In this view, item frequencies in the input unavoidably affect linguistic storage in the mind and significantly affect the formation of syntactic representation.

Pedagogically, judging which of the two perspectives above actually represents L2 learners' syntactic representation is crucial since this affects L2 acquisition. That is, if learners are affected by item frequencies in input as emergentists suggest, they must be exposed to an adequate amount and variety of input because linguistic elements are stored in the mind and are needed to extract abstract syntactic rules. Conversely, if learners can overcome the poverty of stimulus as innatists suggest, they simply need to be exposed to minimal input to acquire syntactic frameworks that are far less varied without lexis.

Several empirical studies have supported innatists' arguments (Campos-Dintrans, Pires, & Rothman, 2014; Foucart & Frenck-Mestre, 2012; Gess & Herschensohn, 2001; Hettiarachchi & Pires, 2016; Hopp, 2005; Marsden, 2009; Rothman & Iverson, 2007). In a grammaticality judgment task, the resetting of the null-subject parameter (see Hyams, 1989, for detail) based solely on classroom-type input was shown to be possible for English-L1 learners of Spanish who had not obtained much exposure in natural settings (Rothman & Iverson, 2007). In a task judging whether pictures presented to the participants were in accordance with the sentences they read and heard, English learners of Japanese were shown to be able to

learn complicated sentence-meaning constraints yielded by scrambled word orders that seldom appeared in Japanese input and were not included in the instruction (Marsden, 2009). English and Japanese learners of German showed acquisition of remnant movement—a usually untaught and seldom-occurring syntactic constraint that regulates movements of words belonging to the same phrase (Müller, 1996)—in a grammaticality judgment task (Hopp, 2005). All these studies have evidenced that L2 learners are able to understand complex syntactic aspects without much exposure, although the studies only explored receptive knowledge in tasks that asked learners to judge pre-constructed sentences. It is unclear whether they are able to produce and use the focal syntactic features.

Emergentists have explored the effects of multi-word-sequence frequencies. Second language speakers of English and Italian were shown to be sensitive to frequencies of pairs comprising nouns and adjectives in frequency judgment tasks (Siyanova & Schmitt, 2008; Siyanova-Chanturia & Spina, 2015). L2 learners of English needed more time to read low-frequency verb + *out* collocations compared to high-frequency collocations in a self-paced reading task (Kim & Kim, 2012). Advanced non-native speakers of Chinese were found to be affected by frequency and contingency—co-occurrence probability—when reading two-word Chinese adverbial sequences embedded in sentence contexts (Yi, Lu, & Ma, 2017). It has also been found that sensitivity to sequential frequency interacted with proficiency. In a study with non-native speakers of English whose L1s were variant, only high-proficiency participants sensed frequency differences of three-word binomial phrases and their reversed phrases (such as *bride and groom and groom and bride*) when they read them with their eye movements tracked (Siyanova-Chanturia, Conklin, &

Van Heuven, 2011). These studies showed that frequency indeed plays a role in phrase recognition. However, the involvement of frequency in the L2 productive syntactic process—which would yield another, more direct piece of evidence against the hypothesis of innatists—does not seem to have been examined yet. Besides, it has been suggested that L2 speakers' productive use of multi-word units occurs less frequently than that by L1 speakers (Arnon & Christiansen, 2017) and that L2 productive syntax is independent of them (Bardovi-Harlig & Stringer, 2017).

Overall, either standpoint has been explored only with the receptive knowledge of L2 learners. Neither standpoint is decisive yet and the surface contradiction between the evidences for both standpoints may have been yielded by the different methods for examining syntactic representation. To establish effective teaching methods, however, it is necessary to know whether learners need a certain amount of exposure—as emergentists suggest—or minimal input—as innatists suggest. Hence, to further test the frequency effect, this study attempted to add data from a task eliciting more productive knowledge than conventional methods, simulating the process in which a learner promptly builds a syntactic structure in accordance with the context. In a psycholinguistic test, participants were asked to build three-word syntactic sequences with choices on the computer screen and the decision times were recorded word-by-word to explore whether the frequencies of multi-word items in the input interact with L2 sequential production as well—which is not theoretically supported by innatists who hypothesize that each sentence is computed with an abstract syntactic structure and lexis that is independent from the structure in the theory.

Besides selection between the two models, the interaction with explicit

knowledge should also be considered to understand the elements that build L2 syntactic representation. With some exceptions, L2 learners usually receive some instructions on grammar and word order. This type of learned knowledge may facilitate the assigning of a syntactic role to each constituent of a sentence. Although it has been suggested that this type of explicit knowledge is separately represented in the mind from (implicit) mental representation for language use and does not improve the syntactic representation directly (Ellis, 1994, 1996; Krashen, 1982; Paradis, 1994; Schacter, 1987), learning without it yields significant shortcomings in learners' accuracy (Lightbown, Spada, & White, 1993) and attracting learners' attention to grammatical points has been proven to be effective (Dekeyser, 1997; Doughty, 2004; Doughty & Williams, 1998; Ellis & Laporte, 1997; Lightbown, Spada, & White, 1993; Long, 1983; Norris & Ortega, 2000; Spada, 1997). Hence, this study included tests of subcategorization, parts of speech, and word order—all of which are useful for explicitly understanding English syntax—to understand whether these kinds of explicit knowledge interact with the development of L2 syntactic representation as well as sequential frequency.

In summary, it has been discussed that two perspectives are proposed for L2 syntax representation and that the role of frequency differs between them. To explore syntax representation for more effective L2 learning, this study examined how item frequencies in the input interact with EFL learners' syntactic representation for building sentences. Besides, the involvement of proficiency in the interaction was also observed to look into the developmental aspect in detail; three pieces of explicit knowledge were added as variables to broadly understand the development of L2 syntax representation.

Research Questions

This study addressed the following research questions:

RQ1. Is L2 syntactic representation based on item frequencies in the input?

RQ2. Does proficiency interact with the influence of frequency?

RQ3. Does explicit knowledge contribute to the development of L2 syntactic representation?

Method

Participants

Fifty-three students at a Japanese university who had studied English during secondary and tertiary education for more than seven years participated in this study. One participant did not attend the second half of the survey, and his data were excluded from the analysis. Hence, the data of the other 52 participants were analyzed. None of the participants had lived outside Japan for more than one year; therefore, they had all learned English as a foreign language. Their proficiencies were diverse, with the converted average TOEIC score of 407 (SD＝108, Min＝285, Max＝865) obtained from the VELC Test (VELC Test, 2016) results mentioned later. In the correlation table provided by the Educational Testing Service (TOEIC, 2018), most of the participants (48 out of 52) were categorized as A2, while two were categorized as B1 and two as B2 on the six-point scale of the Common European Framework of Reference for Languages (Council of Europe, 2018).

Materials

The following five tests were conducted in this study to understand whether syntax representation reflects item frequencies in the experienced

English input (with the psycholinguistic test of syntax), whether proficiency interacts with the frequency influence (with the VELC test measuring listening and reading proficiency), and whether explicit syntactic knowledge contributes to syntax representation development (with the other three tests: the parts of speech, subcategorization, and word order tests).

Psycholinguistic test. A psycholinguistic test was developed to understand the relationship between sequence-level input and syntactic representation of the EFL learners. Several studies have found that textbooks are the main source of English input for EFL learners (Alsaif & Milton, 2012; Milton & Vassiliu, 2000); multi-word sequences frequently found in textbooks that were likely to be used by this study's participants were thought to best reflect learners' experiences and were chosen for use as the sequence-level input in this study. The number of words in each sequence was limited to three since larger constituent series (e.g., four or five) were less likely to yield frequent sequences, and learners may not have stored information of longer sequences in the mind.

To find frequent sequences in the textbooks, a corpus was compiled from 24 top-selling, government-authorized textbooks published by three companies for Japanese three-year (senior) high school education. The textbooks were scanned and converted into PDFs by a company specializing in the field; a corpus was created by the author from these PDFs via text file extraction. Frequent items were extracted from the corpus using Antconc (Anthony, 2014)—specifically, 24 three-word sequences (20 of which began with a verb) occurring between four and 27 times—in an attempt to include many types of subcategorizations for sequences beginning with a verb; sequences not beginning with a verb were also included to observe the nature of L2 syntax from several aspects. As for

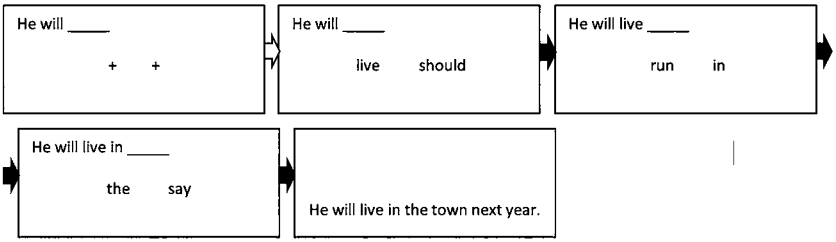
infrequent items, 24 three-word sequences sharing beginning words with the corresponding frequent sequences were chosen from those appearing in the Corpus of Contemporary American English (COCA; Davies, 2014) but almost never (one time or never) occurring in the textbook corpus. In effect, 24 pairs of frequent and infrequent three-word sequences sharing the first word (or the first two words) were created. The two sequences in each pair were preceded by the same context and followed by different ones; the author searched for the contexts using the Google engine and checked their grammaticality and suitability for the study.

Eventually, the 24 pairs were divided in half so that the subcategorizations of the verb-beginning sequences and sequences not starting with a verb were distributed as evenly as possible between the two groups. As a result, four lists of 12 sentences—two with frequent three-word sequences and two with infrequent three-word sequences—were compiled (see the lists in Appendix A). In an ANOVA, no difference was found among the four lists in the average textbook frequency of all sequences' constituent words in the list ($p = .94$) in reference to a word list with frequencies also compiled from the textbook corpus.

The sentences were presented under two conditions with a psychological experiment software package, E-Prime 2.0. A trial in Condition A proceeded as below: After the preceding context of a sentence and fixation points (+ +) were presented at the top left and in the middle of the screen, respectively, the first word of the three-word sequence and a distracter were displayed horizontally in the middle with the context remaining at top left; the participant was asked to indicate which word is syntactically correct to follow the context as quickly and accurately as possible with the bottom left (corresponding to the

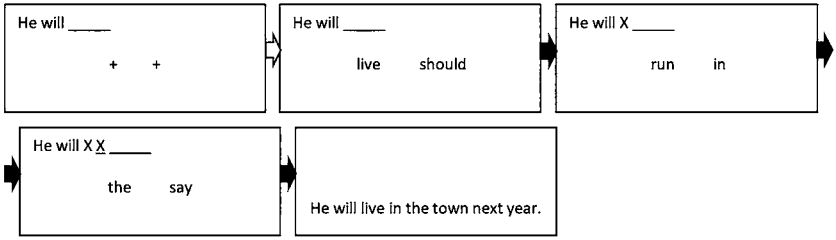
word displayed on the left) or bottom right (corresponding to the word displayed on the right) key on the keyboard; a distracter was asyntactic in the context and did not appear in the 48 sentences including the three-word sequences (Appendix A) to avoid any interference. Another method—where a distracter was syntactically possible in the context and a participant would be asked to select the more plausible word to follow the context—was discarded because syntactically possible combinations with distracters, which may have been met by a participant, were thought to interfere with the frequency effect to explore in this study. The reaction time from each presentation of a word and a distracter to the keystroke and the response (correct or incorrect) were recorded for analysis. After the keystroke, the correct word was added to the context regardless of what the participant chose, and the second word of the sequence appeared with a distracter in the same manner as the first word. The procedure was repeated for the second and third words of the sequences until the third word was chosen, after which the whole sentence was presented at the bottom for reference. All the stimuli were displayed in black 48-point Times New Roman bold font on a white background (see the flow of a trial in Figure 1). In Condition B, each word chosen by a participant was added as "X" to the context, as in Figure 2. Thus, the chosen word(s) had to be remembered by the participant until they completed the trial. This apart, no other difference existed between Conditions A and B.

A participant was presented with a set of 12 frequent sequences and 12 infrequent sequences selected from among eight combinations counterbalanced in the list each 12 sequences were from, the presentation method (Condition A or B) of each 12 sequences, and the order of the two methods (see Table 1); a participant met only the high- or low-



*Each black arrow indicates that the reaction time to the left slide was measured.

Figure 1　*Trial Flow of Condition A*



*Each black arrow indicates that the reaction time to the left slide was measured.

Figure 2　*Trial Flow of Condition B*

frequency sequence of all 24 pairs of sequences selected above. In a block of 12 sentences, the sentences were presented randomly, before each of which five practice sentences—formatted in the same manner as the test sentences and consisting of words that would not appear in the test sentences—were presented and answered by a participant.

Subcategorization test. Two versions (Test A and Test B) of a subcategorization test were developed using the 20 verbs appearing in the lists of the psycholinguistic test; 10 verbs were used for Test A and the other 10 for Test B. The participants took one of the tests in which

Table 1 *Material List Distribution among the Combinations in the Psycholinguistic and Word Order Tests*

		Combination							
		A	B	C	D	E	F	G	H
First half	Condition List	A 1-High	B 1-Low	A 2-Low	B 2-High	B 1-High	A 1-Low	B 2-Low	A 2-High
Second half	Condition List	B 2-Low	A 2-High	B 1-High	A 1-Low	A 2-Low	B 2-High	A 1-High	B 1-Low
Word order test		1-Low 2-High	1-High 2-Low	1-Low 2-High	1-High 2-Low	1-Low 2-High	1-High 2-Low	1-Low 2-High	1-High 2-Low

they were asked to circle the subcategorization of each verb from the following choices: SV, SVC, SVO, SVOO, and SVOC. This classification is taught or written in textbooks for secondary education in Japan to understand which arguments a verb accompanies. It is considered effective for consciously understanding English syntax; most students are familiar with the terminology and can connect a verb to its common subcategorization type. To clarify what each subcategorization denotes, however, the subcategorizations were illustrated with sample sentences in the test. Some tested verbs belong to more than one subcategorization, but participants were asked to choose only the most common one. The average frequencies of the verbs in the textbooks were not significantly different between the two versions ($p = .52$; see Appendix B for the format and tested verbs). The test was found to be moderately reliable; Cronbach's alphas were .70 for Test A and .69 for Test B.

Parts of speech test. Parts of speech are a component of basic syntactic-

relationship knowledge; knowing the part of speech of a word is necessary to consciously build syntactic structures. Hence, two versions of a parts of speech test (Test A and Test B) were developed, each being compiled with either set of 10 verbs used in the subcategorization test and a separate set of 10 nouns, 10 adjectives, and 10 adverbs frequently occurring in the textbooks. The participants were asked to circle the part of speech of each word from the four choices—noun, verb, adjective, and adverb—which were written in the participants' L1 (Japanese); some words exhibit the function of more than one part of speech, but participants were asked to choose only the most common one. In other words, they needed to know the part of speech a word most typically belongs to, rather than the part of speech under which the word may possibly be categorized. On a test sheet, the parts of speech and subcategorization tests were placed vertically, and the version of both tests was selected in a counterbalanced manner so that a verb did not repeat. The average frequencies of the words in the textbooks were not significantly different between the two versions ($p = .50$; see Appendix C for the format and tested words). Cronbach's alphas were .78 for Test A and .66 for Test B.

Word order test. In educational settings, rearrangement of words in order is a common task to consciously understand syntactic structures and to assess learners' syntactic knowledge, though the relationship between the knowledge to perform the task well and the ability to produce syntactic structures has not been clearly established. Thus, a word order test that shared material with the psycholinguistic test was conducted to explore this relationship. As shown in Table 1, any of the eight combinations in the psycholinguistic test consisted of either the 1-High and 2-Low or the 1-Low and 2-High lists of sentences; two versions of the word

order test were made with the two groups of sentences (Test A and Test B; see Appendix D for the format and tested sequences); a participant encountered different groups of sentences in the two tests. In the word order test, a participant was asked to rearrange scrambled three-word sequences placed between the sentential context (the target three-word sequences were also shared between the two tests). The reliability of this test was skewed between the two versions; the Cronbach's alpha for Test A was .76, but that for Test B was .26. The extremely low score seemed to be caused by a ceiling effect; nine out of the 24 items were correctly answered by every participant, and the average score was 0.93 in Test B. This flaw was, however, redressed in a GLMM analysis as mentioned later with addition of the test types as a random effect variable.

VELC Test. To measure the proficiency of each participant, the VELC Test (VELC Test, 2016; see also Kumazawa, Shizuka, Mochizuki, & Mizumoto, 2016 for its validity)—a measurement of English listening and reading comprehension skills widely used in Japan—was conducted. This test was chosen from among several English proficiency tests because the scores are standardized and reliably obtained by the item response theory-based method (see Lord, 2012 for the theory in detail), and its duration (70 minutes) was suitable for use in a 90-minute session.

Procedure

The participants took three of the five tests mentioned above (the psycholinguistic, subcategorization, and parts of speech tests) on one occasion, along with a paper multiple-choice vocabulary test and an online vocabulary size test used in another study; they took the other two (the word order and VELC tests) on another occasion to prevent

interference and because of time constraints: it was not possible to fit all the tests into a 90-minute class time. The three-word sequences presented to a participant in the psycholinguistic test and word order test were different, but they began with the same words; hence, conducting the word order test shortly after the psycholinguistic test would have skewed the results. To minimize this potential interference, an interval of two weeks or longer was provided between the two occasions.

On the first occasion, up to three participants took the tests together based on the available number of PCs for the psycholinguistic test. First, they were shown the content of the tests and told how their personal information would be treated, after which they were asked to provide informed consent. Of the three tests prepared for this occasion, the psycholinguistic test was conducted first. After the instructions were explained, participants performed a five-sentence practice and a 12-sentence test in Condition A or B. Then, an explanation about the other condition was presented and participants performed another five-sentence practice and a 12-sentence test. The psycholinguistic test lasted approximately 15 minutes, after which the subcategorization and parts of speech tests were conducted, taking about 10 minutes. On the second occasion, the word order test was conducted first for about 10 minutes, followed by the VELC test, which took 70 minutes. These two tests did not require a computer; therefore, up to nine participants gathered at the site.

Analysis

Analyses using the Generalized Linear Mixed Model (GLMM)—which can measure both fixed effects of independent variables as conventional methods (e.g., ANOVA) and random effects yielded from participants and items to minimize errors occurring from sampling (see Quené & van den Bergh,

2008, for details)—with Laplace approximation were conducted both for the reaction times of correctly answered items and for binary scores (one or zero) of the psycholinguistic test items. Reaction times do not usually exhibit gaussian distribution; therefore, those measured in this study were postulated to be gamma-distributed and fit in a GLMM analysis with an identity link function, referring to a study comparing the fitness of assumed reaction-time distributions in a GLMM analysis (Lo & Andrews, 2015). The binary scores, which were not gaussian either, were fit with a logit link function.

To explore the research questions, the scores in the subcategorization test, the parts of speech test, the word order test, and the VELC test (overall proficiency), the frequency band (high or low) of three-word sequences in the textbook corpus, the frequency of a three-word sequence in the textbook corpus, and the condition (Condition A or B) of presenting stimulus in the psycholinguistic test were placed in and out several times as fixed-effect variables with observations at AIC indices (Akaike, 1987) to identify a model that could best explain the effects on the syntactic representation. Participants, items, and item lists of the psycholinguistic test were set as random effect variables; types of subcategorization, parts of speech, or word order tests were set as random effect variables only when the score in each test was set as a fixed effect variable. The reaction time and binary score (one or zero) for a word in a three-word sequence in the psycholinguistic test were set as the dependent variables and analyzed separately.

Results

The results of the tests are summarized in Table 2. As for the reaction times, a model with the lowest (best) AIC index of 42485.73 was found to be the best fit, where the main effects of the VELC score (overall proficiency;

$F = 22.57$, $p < .001$), the condition of stimulus presentation ($F = 9.04$, $p = .003$), and the frequency of a three-word sequence ($F = 2.35$, $p = .13$) and the interaction between the VELC score and the frequency of a three-word sequence ($F =$ Infinity, $p < .001$) were included as fixed effects. Specifically, more proficient learners were able to choose words that fit the sentences more quickly; they benefited from the items' frequent occurrences in the textbooks in the decision. Table 3 summarized the average reaction times of three proficiency groups divided by VELC test scores for high- and low-frequency items. A post-hoc analysis showed that the frequency effect was observed in only the more proficient Groups A (scoring more than 500 in VELC; $F = 5.98$, $p = .015$) and B (scoring 450–500 in VELC; $F = 6.41$, $p = .011$). The least proficient Group C (scoring less than 450 in VELC) did not get a frequency benefit ($F = 2.44$, $p = .118$). Besides this proficiency-related effect, more time was found to be necessary for the whole population to judge Condition A—with answered items visible on the screen.

As for the analysis of binary scores, two almost equally best models were obtained with a slight difference in AIC. A model with only the fixed main effect of the word order test ($F = 2798$, $p < .001$) had an AIC index of 3953.83; the model with the lowest AIC index, 3950.85, was yielded with the only fixed main effect of the VELC score ($F = 11.42$, $p < .001$). Since the difference between the two indices was not significantly distant, it can be interpreted that the VELC score reflected grammatical knowledge measured by the word order test of this study. The results suggest that similar knowledge was likely to be used in the word order and psycholinguistic tests, although the knowledge is not useful for shortening the time required to build a sentence in the latter. Together with reaction time results, the low-frequency items were found to be built more slowly

Table 2 *Descriptive statistics*

	Mean	Standard Deviation	Lower 95% Confidence Limit	Upper 95% Confidence Limit	Minimum	Maximum
*Reaction time in the psycholinguistic test (N=52)	1963	710	1765	2161	904	4128
Binary score in the psycholinguistic test (N=52)	0.71	0.20	0.65	0.76	0.40	1.00
Parts-of-speech Test A (N=25)	0.81	0.11	0.76	0.85	0.45	0.93
Test B (N=27)	0.84	0.08	0.81	0.88	0.63	0.95
Subcategorization Test A (N=25)	0.55	0.25	0.45	0.65	0.10	1.00
Test B (N=27)	0.60	0.24	0.51	0.70	0.10	1.00
Word order Test A (N=26)	0.86	0.12	0.81	0.91	0.46	1.00
Test B (N=26)	0.93	0.06	0.91	0.95	0.80	1.00
VELC (N=52)	473.1	68.4	454.0	492.1	364	715

*Only those of correct responses were counted.

Table 3 *Reaction time by proficiency*

Group	Frequency band	Mean	*SD*	Lower 95% Confidence Limit	Upper 95% Confidence Limit	Minimum	Maximum
A (N=14) (500– in VELC)	High	1443	504	1152	1734	795	2819
	Low	1633	388	1409	1857	1163	2594
B (N=18) (450–500 in VELC)	High	1975	837	1559	2391	859	4029
	Low	2206	948	1734	2678	942	4230
C (N=20) (–450 in VELC)	High	2077	710	1745	2409	1169	3287
	Low	2219	626	1927	2513	1410	3722

in the psycholinguistic test, but the accuracy rate was comparable to that of the high-frequency items.

Discussion

As discussed in the introduction of this paper, two contrastive models for L2 syntactic representation have been proposed by innatists (Campos-Dintrans, Pires, & Rothman, 2014; Epstein, Flynn, & Martohardjono, 1996; Schwartz & Sprouse, 1996; White, 1989, 2003) and emergentists (Ellis, 2007; Ellis & Larsen-Freeman, 2009; MacWhinney, 1987, 2008). The key to disentangling these arguments was understanding the frequency effect of sequential items in the input. The results of this study demonstrated that frequencies of three-word sequences in learners' input indeed quickened their building by more proficient EFL learners in a quasi-productive task. This indicates that more frequent sequences in the input become easier to retrieve in L2 production as learners become more proficient. On the other hand, any subcategorization, parts of speech, or word order knowledge did not significantly contribute to shortening the reaction time. Conversely, the binary scores, which showed the ability to accurately form syntactic sequences, seemed independent of input frequency but correlated with proficiency or knowledge of rearranging multi-word sequences in order on paper. Since this effect was observed in Condition B in which a participant was not able to see all constituents in a sequence at once, as well as in Condition A in which a participant was able to see all words in the preceding context when choosing a word to fit the context, the knowledge seems to be involved in monitoring the order of a three-word sequence accumulated word-by-word in the mind, as well as in reference to the part of a sequence displayed on the screen together with the words to be

selected. Low-frequency sequences were found to take more time to build but were aligned as accurately as high-frequency sequences with explicit word order knowledge, whereas explicit knowledge did not quicken the building process. This indicates that possessing only explicit knowledge is not sufficient to promptly build syntactic sequences; without proper input and resultative developed syntactic representation in the mind, finding syntactic components to suit the context seems difficult.

Overall, the results of this study were compatible with the theory of emergentists, which assumes that all input a learner is exposed to is stored in the mind (Ellis, 2007; Ellis & Larsen-Freeman, 2009; MacWhinney, 1987, 2008). The frequencies of multi-word sequences affected syntactic processing of the psycholinguistic task, suggesting that L2 multi-level syntactic constructions in the input are mentally stored and that being exposed to more input is likely to be beneficial for more prompt use of phrases and sentences. Whereas most preceding studies focused on the recognition of multi-word sequences (Kim & Kim, 2012; Siyanova & Schmitt, 2008; Siyanova-Chanturia, Conklin, & Van Heuven, 2011; Siyanova-Chanturia & Spina, 2015; Yi, Lu, & Ma, 2017), the results of this study demonstrated that the frequency effect was also observed for L2 proficient learners in a quasi-productive task during which participants were not presented three-word sequences at once but had to build syntactic structures (with provided components) on their own. To more quickly build sequences during the task, the forms of relevant words in the context needed to be readily accessible in the mind; namely, sequential information stored in the mind has facilitated the activation of a word form to suit the context (see Figure 3). This finding is not compatible with a claim that L2 productive syntax is independent of multi-word units (Bardovi-Harlig & Stringer, 2017).

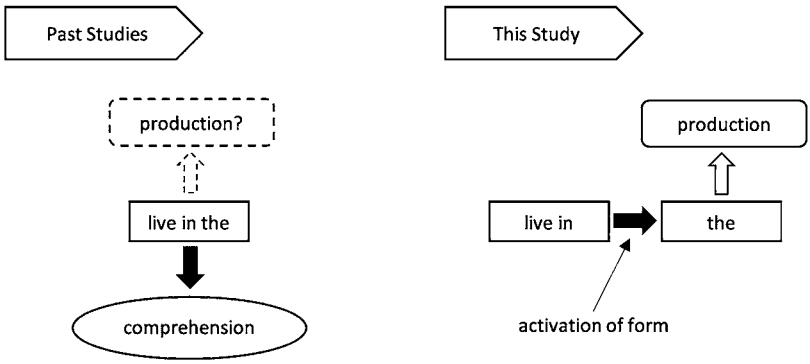


Figure 3　*Activation Processes Postulated from Past and This Studies*

This study observed sequential activation word-by-word, but it is not difficult to imagine that multi-word sequences are also activated using this information because it has already been found that linguistic units exceeding one word are stored (Kim & Kim, 2012; Siyanova-Chanturia, Conklin, & Van Heuven, 2011; Siyanova & Schmitt, 2008; Siyanova-Chanturia & Spina, 2015; Yi, Lu, & Ma, 2017) and can be recalled for productive use (this study). It is reasonable that more proficient learners were more affected by sequential frequency since they were likely to have been exposed to more input than less proficient learners. Similar interaction was also evidenced by Siyanova-Chanturia, Conklin, and Van Heuven (2011). Learners may need to frequently meet syntactic sequences, which were consequently found to be related to prompt syntactic production and proficiency.

It should be admitted that the syntactic processing observed in this study was somewhat different from language production in real life; second language learners have to utter sentences or other syntactic

components without any hints such as the choices provided in this study. However, the central finding of this study is that word knowledge is activated by sequential information stored in the mind. Although choices were presented, it was necessary to activate the word beforehand for it to be chosen more quickly in the psycholinguistic task; the production of syntactic structures was found to be linked to stored sequential information (i.e., the stimulation of a former part of a frequently occurring sequence activates the production of the latter part). Namely, the condition of this study is not very different from real L2 conversations in which previous utterances stimulate the mind and prompt the speaker's speech.

The view of innatists that each utterance is computed with an abstract syntax structure and lexis, which are assumed to be separately represented in the mind (Pinker, 1999; Pinker & Ullman, 2002), does not theoretically conform to the sequential frequency's influence found in this study; sequential representation has not been hypothesized to exist by innatists. More frequent meetings with syntactic components were found to be meaningful for L2 syntax development in this study, which is not compatible with the pedagogical implications of Full Access approaches (Campos-Dintrans, Pires, & Rothman, 2014; Epstein, Flynn, & Martohardjono, 1996; Schwartz & Sprouse, 1996; White, 1989, 2003), in which L2 learners are thought to develop syntactic representation comparable to that of L1 speakers without a large amount of exposure (Hopp, 2005; Marsden, 2009; Rothman & Iverson, 2007). These studies may have explored the ability to monitor syntactic correctness—knowledge such as that measured in the word order test of this study—since the tasks asked for only sentence grammaticality. It has also been shown that real language use is not fully reflected in explicit tasks eliciting syntactic knowledge (Roberts & Liszka, 2013).

For L2 syntax development, it is evident now that learners need adequate and diverse exposure: a structure needs to be encountered with various constituents. To further clarify the relationship, quantifying the correlation between sequential input and syntactic development may help; although some studies have already explored the manipulation of constituents in the input on learning syntactic structures (Mcdonough & Nekrasova-Becker, 2014; Year & Gordon, 2009), more thorough and detailed studies are necessary for more efficient L2 learning. Emergentists have claimed that abstract syntax is made from concrete verb-island structures (e.g., Ellis & Ferreira-Junior, 2007). Exploring the amount and types of input necessary for syntactic development via this stage may be one approach.

Pedagogically, this study indicates that learning material should include diverse constituents for a target structure. It is often the case that a structure with the same constituent is repeated; this kind of practice may be useful for explicit knowledge development since highlighting the point is easier with familiar words. Such less heterogeneous sequential input, however, may hamper L2 syntax development, preventing learners from cultivating rich, detailed syntactic representation. Language teachers should note that a structure should be explained with constituents that are as diverse as possible. This kind of consideration may allow more syntactic structures to be ready for activation in learners' minds.

Conclusion

To delineate the two major models proposed for L2 syntactic representation, this study conducted a quasi-productive psycholinguistic test in which participants built three-word sequences in a given context with choices alongside paper-pencil tests; the results indicated that cumulative

item frequencies in the input calculated from a textbook corpus affected the time required to choose a word in the task for proficient learners, indicating that words likely to follow an incomplete syntactic structure are activated on the basis of the past experience of proficient L2 learners. Since this study adopted word-by-word presentation, activation is considered to have occurred for each word, indicating that the observed effect was not only obtained by component as in past studies but also successively word-by-word, each of which was activated by preceding words in the context. The results are in line with emergentists' arguments that all language input is stored in the mind and plays a role in syntactic processing. Conversely, the results cannot support the standpoint of innatists that hypothesizes no sequential representation in the mind (Pinker, 1999; Pinker & Ullman, 2002).

A limitation of this study concerns its method. The sequence building task theoretically addresses syntactic processing, but this is still different from making natural utterances. To more persuasively demonstrate the emergentists' view of L2 syntactic representation, evidence from other perspectives is necessary as well. Another limitation is the participants' characteristics: They were all Japanese L1 speakers. English, the target L2 in this study, and Japanese are distant in syntax and whether the effect of input frequencies observed in this study is also applicable to other L1-L2 relationships should also be investigated in the future; particularly, if L1 and L2 are cognates, input frequencies in L1 and L2 and false friends may complicatedly interfere with one another.

The answer to the research questions "Is L2 syntactic representation based on item frequencies in the input?" and "Does proficiency interact with the frequency influence?" is summarized as follows: The syntactic representation of more proficient (upper A2–B2 in CEFR levels; Council

of Europe, 2018) L2 learners was found to be sequential-frequency based. With respect to the question "Does explicit knowledge contribute to the development of L2 syntactic representation?" the results did not show any evidence for its influence on quickening retrieval of words fitting the context; namely, the knowledge did not seem directly related to syntactic representation, which is utilized in promptly recalling syntactically plausible words. However, it was found that the ability to align words in order on paper may be used as a monitor for word order being activated in the mind and could contribute to syntactic accuracy.

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Appendix A. Material Lists for the Psycholinguistic Test

List	Sentence	The three-word sequence			Sequential frequency in the textbooks	Distracters		
1-High	He will live in the town next year.	live	in	the	24	should	run	say
1-High	She does not go to school on foot.	go	to	school	17	never	it	thus
1-High	She will work in the laboratory.	work	in	the	11	happy	cut	remember
1-High	She will be proud of herself.	be	proud	of	12	would	know	white
1-High	He will get ready for both tests soon.	get	ready	for	5	must	hear	wash
1-High	This will become a better place.	become	a	better	4	into	write	sell
1-High	He does not use the Internet .	use	the	Internet	14	did	visit	buy
1-High	Her sisters play the piano together.	play	the	piano	16	our	make	bring
1-High	He will solve the problem very easily.	solve	the	problem	12	engineer	teach	meet
1-High	I will do my best today.	do	my	best	9	food	spoken	think
1-High	I will show you some *pitcutures.	show	you	some	7	from	take	happen
1-High	Students will read the book today.	read	the	book	8	freedom	start	see
2-High	I usually finish my homework before dinner.	finish	my	homework	8	always	learn	our
2-High	We can catch the train there.	catch	the	train	7	might	drink	its
2-High	She may have the same interest.	have	the	same	12	they	begin	here
2-High	She will tell you the information later.	tell	you	the	13	festival	enjoy	find
2-High	Return home and lend me your hands.	lend	me	your	11	entrance	close	hold
2-High	He is spending most of his weekends watching movies.	most	of	his	8	dry	many	invite

2-High	I practice soccer in the park .	in	the	park	23	them	help	lose
2-High	She does not like the young man .	the	young	man	19	eat	that	more
2-High	This is a good idea .	a	good	idea	25	are	those	receive
2-High	He will agree with you .	agree	with	you	27	under	sleep	sit
2-High	He will come to the ceremony.	come	to	the	23	onto	build	moreover
2-High	She will give him a birthday present tomorrow.	give	him	a	5	should	swim	graduate
1-Low	He will live around the town next year.	live	around	the	0	should	run	say
1-Low	She does not go to parties alone.	go	to	parties	0	never	it	thus
1-Low	She will work until the midnight.	work	until	the	0	happy	cut	remember
1-Low	She will be good with computers if necessary.	be	good	with	0	would	know	white
1-Low	He will get comfortable in their house.	get	comfortable	in	0	must	hear	wash
1-Low	This will become a standard tool.	become	a	standard	0	into	write	sell
1-Low	He does not use the water .	use	the	water	0	did	visit	buy
1-Low	Her sisters play the tape every day.	play	the	tape	0	our	make	bring
1-Low	He will solve the crime .	solve	the	crime	0	engineer	teach	meet
1-Low	I will do my work today.	do	my	work	0	food	spoken	think
1-Low	I will show him a hint tomorrow.	show	him	a	0	from	take	happen
1-Low	Students will read a map .	read	a	map	0	freedom	start	see
2-Low	I usually finish my work at five.	finish	my	work	0	always	learn	our
2-Low	We can catch a bus there.	catch	a	bus	1	might	drink	its
2-Low	She may have the only clue.	have	the	only	0	they	begin	here

2-Low	She will tell people the truth next year.	tell	people	the	0	festival	enjoy	find
2-Low	Return home and lend him the money.	lend	him	the	0	entrance	close	hold
2-Low	He is spending most of each week outside Fukuoka City.	most	of	each	0	dry	many	invite
2-Low	I practice soccer in the stadium.	in	the	stadium	0	them	help	lose
2-Low	She does not like the bad people.	the	bad	people	0	eat	that	more
2-Low	This is a great dish.	a	great	dish	0	are	those	receive
2-Low	He will agree with us.	agree	with	us	0	under	sleep	sit
2-Low	He will come around the corner.	come	around	the	0	onto	build	moreover
2-Low	She will give someone a hard time someday.	give	someone	a	0	should	swim	graduate

*A word of a test sentence was found to have been misspelled (pictures as pitcutures) in the data analysis phase, but the word was shown after participants finished choosing the three words in the test (the word was in a sentence for reference). Hence, no adjustment was conducted statistically about this flaw.

Appendix B. Subcategorization Test

[Instruction] Referring to the examples, circle the subcategorization each verb takes.

(The instructions of all original materials were written in Japanese.)

SV examples:

He is running in the park.

The volcano erupted yesterday.

*Neither complement nor object after the verb.

SVC examples:

The story sounds funny.

The food tasted good.

*One complement is placed after the verb.

SVO examples:

He uses a special tool for repairing this machine.

I cooked the dinner.

*One object is placed after the verb.

SVOO examples:

I'll buy you a beer tonight.

I'll get you something cold to drink.

*Two objects are placed after the verb.

SVOC examples:

I found the problem difficult.

She had her car repaired at that gas station.

*One object and one complement are placed in order after the verb.

Test A

*Bold items are answers.

be	(	SV	**SVC**	SVO	SVOO	SVOC)
go	(	**SV**	SVC	SVO	SVOO	SVOC)
come	(	**SV**	SVC	SVO	SVOO	SVOC)
give	(	SV	SVC	SVO	**SVOO**	SVOC)
tell	(	SV	SVC	SVO	**SVOO**	SVOC)
become	(	SV	**SVC**	SVO	SVOO	SVOC)
play	(	SV	SVC	**SVO**	SVOO	SVOC)
catch	(	SV	SVC	**SVO**	SVOO	SVOC)
finish	(	SV	SVC	**SVO**	SVOO	SVOC)
lend	(	SV	SVC	SVO	**SVOO**	SVOC)

Test B

have	(	SV	SVC	**SVO**	SVOO	SVOC)
do	(	SV	SVC	**SVO**	SVOO	SVOC)
get	(	SV	SVC	**SVO**	SVOO	SVOC)
use	(	SV	SVC	**SVO**	SVOO	SVOC)
live	(	**SV**	SVC	SVO	SVOO	SVOC)
work	(	**SV**	SVC	SVO	SVOO	SVOC)
show	(	SV	SVC	SVO	**SVOO**	SVOC)
read	(	SV	SVC	**SVO**	SVOO	SVOC)
agree	(	**SV**	SVC	SVO	SVOO	SVOC)
solve	(	SV	SVC	**SVO**	SVOO	SVOC)

Appendix C. Parts-of-speech Test

[Instruction] Circle the part of speech of each word.

Test A

*Bold items are answers.

still	noun	verb	adjective	**adverb**
large	noun	verb	**adjective**	adverb
small	noun	verb	**adjective**	adverb
book	**noun**	verb	adjective	adverb
school	**noun**	verb	adjective	adverb
agree	noun	**verb**	adjective	adverb
together	noun	verb	adjective	**adverb**
have	noun	**verb**	adjective	adverb
show	noun	**verb**	adjective	adverb
tomorrow	noun	verb	adjective	**adverb**
lesson	**noun**	verb	adjective	adverb
happy	noun	verb	**adjective**	adverb
solve	noun	**verb**	adjective	adverb
long	noun	verb	**adjective**	adverb
again	noun	verb	adjective	**adverb**
world	**noun**	verb	adjective	adverb
famous	noun	verb	**adjective**	adverb
child	**noun**	verb	adjective	adverb

just	noun	verb	adjective	**adverb**
live	noun	**verb**	adjective	adverb
life	**noun**	verb	adjective	adverb
back	noun	verb	adjective	**adverb**
new	noun	verb	**adjective**	adverb
time	**noun**	verb	adjective	adverb
do	noun	**verb**	adjective	adverb
really	noun	verb	adjective	**adverb**
work	noun	**verb**	adjective	adverb
important	noun	verb	**adjective**	adverb
sometimes	noun	verb	adjective	**adverb**
read	noun	**verb**	adjective	adverb
now	noun	verb	adjective	**adverb**
thing	**noun**	verb	adjective	adverb
get	noun	**verb**	adjective	adverb
ill	noun	verb	**adjective**	adverb
here	noun	verb	adjective	**adverb**
different	noun	verb	**adjective**	adverb
late	noun	verb	**adjective**	adverb
use	noun	**verb**	adjective	adverb
hand	**noun**	verb	adjective	adverb
friend	**noun**	verb	adjective	adverb

Test B

often	noun	verb	adjective	**adverb**
catch	noun	**verb**	adjective	adverb

true	noun	verb	**adjective**	adverb
day	**noun**	verb	adjective	adverb
year	**noun**	verb	adjective	adverb
well	noun	verb	adjective	**adverb**
finish	noun	**verb**	adjective	adverb
good	noun	verb	**adjective**	adverb
become	noun	**verb**	adjective	adverb
play	noun	**verb**	adjective	adverb
be	noun	**verb**	adjective	adverb
yesterday	noun	verb	adjective	**adverb**
sure	noun	verb	**adjective**	adverb
young	noun	verb	**adjective**	adverb
away	noun	verb	adjective	**adverb**
today	noun	verb	adjective	**adverb**
lend	noun	**verb**	adjective	adverb
story	**noun**	verb	adjective	adverb
bad	noun	verb	**adjective**	adverb
only	noun	verb	adjective	**adverb**
water	**noun**	verb	adjective	adverb
word	**noun**	verb	adjective	adverb
hard	noun	verb	**adjective**	adverb
very	noun	verb	adjective	**adverb**
man	**noun**	verb	adjective	adverb
give	noun	**verb**	adjective	adverb
way	**noun**	verb	adjective	adverb
people	**noun**	verb	adjective	adverb
country	**noun**	verb	adjective	adverb

almost	noun	verb	adjective	**adverb**
always	noun	verb	adjective	**adverb**
high	noun	verb	**adjective**	adverb
part	**noun**	verb	adjective	adverb
great	noun	verb	**adjective**	adverb
big	noun	verb	**adjective**	adverb
old	noun	verb	**adjective**	adverb
tell	noun	**verb**	adjective	adverb
come	noun	**verb**	adjective	adverb
soon	noun	verb	adjective	**adverb**
go	noun	**verb**	adjective	adverb

Appendix D. Word order test

[Instruction] Rearrange the words in parentheses and make each correct sentence. Only the rearranged four words are needed as an answer.

Test A consisting of 1-high and 2-low list sentences

This will (a better become) place.
I usually (my finish work) at five.
She may (only have the) clue.
We can (bus a catch) there.
She will (proud of be) herself.
He will (the live in) town next year.
Return home and (the him lend) money.
She will (the people tell) truth next year.

She will (a give someone) hard time someday.
He will (ready get for) both tests soon.
This is (dish a great).
He will (with agree us).
Students will (book the read) today.
I will (my best do) today.
He will (solve problem the) very easily.
I will (you show some) pitcutures.
She will (the work in) laboratory.
He is spending (most each of) week outside Fukuoka City.
She does not (school to go) on foot.
He will (come the around) corner.
Her sisters (piano the play) together.
I practice soccer (stadium in the).
She does not like (the people bad).
He does not (Internet use the).

Test B consisting of 1-low and 2-high list sentences

This will (a standard become) tool.
I usually (my finish homework) before dinner.
She may (same have the) interest.
We can (train the catch) there.
She will (good with be) computers if necessary.
He will (the live around) town next year.
Return home and (your me lend) hands.
She will (the you tell) information later.

She will (a give him) birthday present tomorrow.

He will (comfortable get in) their house.

This is (idea a good).

He will (with agree you).

Students will (map a read).

I will (my work do) today.

He will (solve crime the).

I will (him show a) hint tomorrow.

She will (the work until) midnight.

He is spending (most his of) weekends watching movies.

She does not (parties to go) alone.

He will (come the to) ceremony.

Her sisters (tape the play) every day.

I practice soccer (park in the).

She does not like (the man young).

He does not (water use the).