A Lexicon and Behavioral Study on the Status of the Syllable in Japanese

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Labrune (2012) recently proposed that the moras are not the immediate constituent of the syllable but of the foot in Japanese. This contradicts with more traditional models of Japanese prosody that acknowledge the presence of the syllable inside the foot. Labrune's proposal is important given the prevalent assumption in the literature that the syllable is a prosodic unit present in all languages (Selkirk 1984). The present study further explored the nature of the prosodic structure in Japanese. The result from a statistical analysis of distributions of segments within the bisyllabic words in Japanese was consistent with prosodic structures where the onset consonant is not directly linked to the syllable node in Japanese. A speeded word-repetition experiment indicated that a mora type undergoes some forms of changes more often when they are positioned lower in the mora hierarchy. Specifically, the lower a mora class is positioned in the mora hierarchy, the more likely it undergoes changes in productions. Discussions of the current findings are provided to the effect that positing the syllable unit in Japanese phonology may not be necessary, lending further indirect support for the prosodic model of Japanese along the line of Labrune (2012).

Keywords: mora, syllable, foot, lexicon study, word-repetition task

1. Introduction

Cross-linguistically individual segments inside phonological words are known to be systematically organized into higher-level metrical units. The syllable is one such unit and its existence is well supported by an extensive body of linguistic as well as behavioral evidence. As such, it is not surprising that the syllable is envisioned by many phonologists to be a universal prosodic constituent (Selkirk 1984). In line with this, many existing ac-

counts of Japanese phonological phenomena have also assumed the presence of the syllable within the language's prosodic system — specifically as a unit positioned between the other two well-established units in Japanese phonology, i.e., intermediate between the feet and the mora.

In line with this, Hayes (1989), for instance, adopts the prosodic model depicted in <Figure 1.a> in which a CVC string in Japanese constitutes a bimoraic foot within which a heavy syllable is present. The syllable is composed of an onset consonant with no moraic weight and a nucleus vowel followed by a coda consonant, both of which weigh one mora each. The model proposed by Kubozono (1989) also posits the presence of the syllable, as in <Figure 1.b>. The difference between <Figure 1.a> vs. <Figure 1.b> is that in the latter an onset consonant is grouped with a nucleus to constitute a mora unit, which is then attached to the syllable node. In the former, however, the onset consonant is attached to the syllable node directly. Both of these models are consistent with the traditional accounts of Japanese phonology such as McCawley (1968), which made use of the syllable in accounting for a number of phonological facts. Under these syllable-based models, Japanese has either a light (i.e., (C)V or CyV) or a heavy (i.e., (C)VC or CyVC) syllable.[1)]

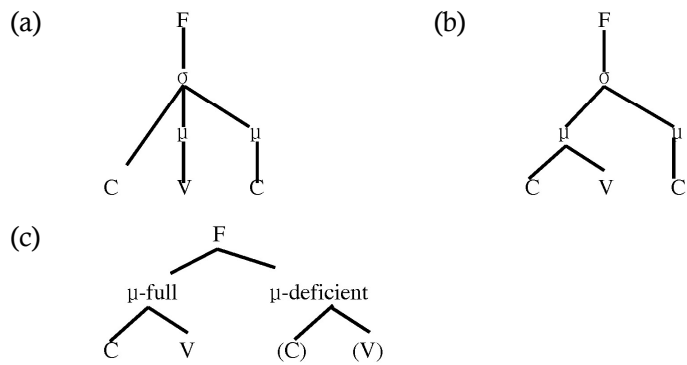

Figure 1. Representations of Prosodic Structure in Japanese (F: foot, σ: syllable, μ: mora).

1) Note that traditionally the category of the heavy syllable in Japanese also includes less frequently occurring syllable forms of CVVN or CVRQ — i.e., syllables that contain a long vowel followed by a moraic nasal (N) and those that contain a diphthong (R) followed by a part of an obstruent geminate (Q), respectively.

Recently, however, Labrune (2012) provided a quite detailed *syllable-free* account of many Japanese phonological phenomena by relying only on the mora unit immediately under the foot, as depicted in <Figure 1.c> (Labrune 2012:143). Importantly, this model distinguishes two major types of moras (i.e., full vs. deficient moras), and they are further subdivided according to a scalar mora hierarchy (more about regular-mora vs. deficient-mora and the Labrune's mora hierarchy in the text below). As a piece of evidence supporting her claim, Labrune (2012) cites a series of naturally-occurring speech error studies by Kubozono (1995, 2006). Kubozono's studies have shown that when slips of tongue occur, as in *Kyoono Kikujiroo* (proper name) > *Kikuno Kikujiroo*, one heavy syllable is replaced by two successive light syllables more often than by one light syllable (Labrune 2012:120). Labrune points out that this shows that the syllable as a prosodic unit lacks cognitive reality in Japanese. This should be because if the unit on which speech errors operate in Japanese is the syllable, one would expect one heavy syllable to be replaced with one light syllable more often than with two syllables. The speech error phenomenon, on the other hand, can be readily explained under the mora-based approach, namely that two moras *(kyo.o*) are replaced by two moras (*ki.ku*) (where the dot represents the mora boundary).

Kawahara (2012), however, provided a number of experimental findings that converge to suggest that the syllable does play a role in Japanese. For example, Kawahara (2012) indicates that the syllable is made use of by Japanese-learning children as well as by adults in their speech segmentation such that words like *kurejoN* 'crayon' can be counted with three gestures by Japanese-speaking children (not four, which is the expected result if the segmentation occurs only in the mora).

Existing studies briefly reviewed above indicate that the debate on the syllable as a valid prosodic unit in the Japanese prosodic system is important because it has implication not only for the utility of the syllable in Japanese phonology but more generally for the universality of the syllable. The major goal of the present study is to contribute to this line of research. To this end, this work focuses on evaluating the contrasting predictions that the three major models of Japanese metrical structure

in <Figure 1> make. Specifically, in regard to this research objective, the present study reports two sets of empirical findings, one from a lexicon study of Japanese bisyllabic words (Section 2) and the other from behavioral data gathered in a speeded word-repetition task (Section 3).

First, a study of Japanese lexicon was performed to explore the question of whether the nucleus vowel forms a *single* prosodic unit with its preceding consonant (independent from its following coda consonant). The prosodic structures presented in <Figure 1.b> and <Figure 1.c> predict this, whereas the one in <Figure 1.a> does not. Second, a word-repetition experiment was carried out to examine whether there is an effect of a mora hierarchy on speech error patterns in a word-repetition task. The prosodic model in <Figure 1.c> predicts that the full mora (i.e., the first mora unit consisting of an onset consonant and a vowel) will behave differently from the deficient mora (i.e., the second mora consisting only of a coda consonant). Cririically, this model further predicts that a deficient mora consisting of an obstruent consonant will also behave differently from a deficient mora consisting of a more sonorous coda consonant, e.g., the moraic nasal. The models in <Figure 1.a> and <Figure 1.b> do not make these predictions.

To anticipate the important components of the current findings, firstly, I will show that in terms of the distribution of the segments inside bisyllabic words, the nucleus vowel in Japanese is significantly more strongly associated with its preceding onset than with its following coda (Section 2). Secondly, it will be shown that in a speeded word-repetition task the lower a mora class is positioned in the mora hierarchy (as defined in Labrune 2012), the more likely it undergoes changes in productions (Section 3). I will then provide a discussion of the current findings (Section 4) where it will be suggested that the present findings are best consistent with the predictions laid out by the model in <Figure 1.c> and accordingly that it has an explanatory advantage over the other syllable-based alternatives in <Figure 1.a> or <Figure 1.b>.

2. Lexicon Study

2.1. Background

As stated above, the prosodic structures in <Figure 1.b> and <Figure 1.c> posit a sub-syllabic unit that encompasses the onset consonant and the vowel (indepedent from the coda), while there is no such unit in <Figure 1.a>. When it comes to inferring the presence of a linguistic structure/unit, one method that has been used quite extensively in previous literature is to use distributional information (for review, see Frisch 2013). Applied to the current study, the idea is that if two adjacent segments in Japanese belong to the same prosodic unit, then the distribution of those segment sequences should be more constrained relative to the baseline condition where two adjacent segments would belong to two independent units and thus can combine freely. Under this distributional perspective, the shared prediction of both <Figure 1.b> and <Figure 1.c> would be that onset-vowel sequences (positioned within the same single first mora) will co-occur statistically more or less often than predicted by the baseline. This type of constrained segment association pattern, however, is not expected under <Figure 1.a> where the onset and the vowel lie independently *across* two distinct constituents or where at least they do not belong to the same prosodic constituent.

2.2. Lexicon Analysis

To test these contrasting predictions, a Japanese lexicon study was performed. For this lexicon analysis, a total of 1,722 words with the phonological form of /CVCCVC/ (e.g., /hakken/ 'discovery') were manually extracted from an unabridged Japanese dictionary. The majority of the extracted words (i.e., 1,587/1772) were listed as noun in the dictionary. This study extracted word forms with /CVCCVC/, not /CVC/ forms, since as is well-known Japanese phonology severely contrains the inventory of the coda consonant in the simple /CVC/ forms, allowing only a nasal singleton consonant in the position.

To quantify the degree of association between adjacent segments, for

all CV and VC sequences in the current /CVCCVC/ wordlist (less than the final VC, again due to the restriction on word-final coda consonants), I calculated its Pearson's *r* (a statistic that is typically adopted assessing dichotomous data — see Perruchet & Peereman (2004) for details of this statistic).[2] To complement the Pearson's *r* values, chi-square values for all CV and VC sequences (testing the independence of the segment sequences) were also separately calculated. It turned out that these two measures of associations (i.e., Pearson's *r* values and chi-square values) were significantly correlated with each other ($F(1,96) = 419.8$, adjusted $R^2 = 0.811$, $p < 0.001$). Thus, in this study only the absolute Pearson's *r* values are reported. Since the Pearson's *r* values were not normally distributed, the non-parametric Mann-Whitney tests (instead of the *t*-tests) were performed for the purpose of statistical test in this study.

As shown in <Table 1>, for the first C_1VC_2 component of the bisyllabic /$C_1VC_2C_3VC_4$/ words, the mean absolute Pearson's *r* value for C_1Vs was 0.069, while the comparable value for VC_2s was 0.026. According to the Mann-Whitney tests, the difference in the two mean Pearson's *r* values is highly significant ($W = 1938$, $p < 0.001$). To provide some indication of the generality of the results, I also provide type frequency measures in addition to Pearson's *r* values in <Table 1>. The present lexicon study thus indicates that segments within C_1Vs are more strongly associated than VC_2s in the first /CVC/ components of the /CVCCVC/ words in Japanese.

Table 1. Mean Absolute Pearson's *r* Values and Type Frequency of CV and VC Sequences in Japanese /$C_1VC_2C_3VC_4$/ Words

		N	Mean absolute Pearson's *r* values (Std. Dev.)	Mean type frequency
C_1VC_2	C_1V	58	0.069 (0.049)	29.68
	VC_2	40	0.026 (0.024)	43.05
C_3VC_4	C_3V	61	0.068 (0.055)	28.14

2) As with other statistical measures of correlation, the Pearson's *r* statistic ranges from -1 (negative correlation) to +1 (positive correlation). Since this study is concerned only with the strength of association (not the direction), only the absolute Pearson's *r* values are reported here.

<Table 1> also shows that the mean Pearson's *r* value of C_3Vs in the 2nd syllable (i.e., 0.068) is nearly identical to that of the C_1Vs in the 1st syllable (0.069). The two means are not statistically different according to the Mann-W test ($W = 1832$, $p > 0.05$). This suggests that the relatively stronger correlation of the onset and the vowel (as opposed to that of the vowel and the coda) may not be limited to the first CVC component of the /CVCVCC/ words. Rather, it may also generalize into the second CVC component of the words considered in this study.[3)]

2.3. Discussion

To the extent that distributional patterns involving segment sequences are informative of the presence/absence of linguistic constitutents, the present lexicon study suggests that the distribution of the onset consonant and the vowel is quite likely to be constrained by a shared single unit in Japanese metrical structure. In other words, the onset consonant should be positioned inside a prosodic unit that also immediately dominates the nucleus vowel — the onset and the nucleus should be thus the immediate daughter of the same mother node. In this sense, prosodic models that are consistent with this finding are those that are depicted in <Figure 1.b> and <Figure 1.c>, but not the one in <Figure 1.a>. To summarize the lexicon study, evidence from the distribution patterns make it possible that when an onset consonant is present it appears not to be directly attached to the syllable node, with only the nucleus vowel's being associated to a mora unit in Japanese. Instead, the onset and the nucleus are combined to be attached to a prosodic constituent, i.e., the mora. This particular interpretation of the current finding is based on the widely-held idea in the literature that segment sequences occurring within the same prosodic constituent should exhibit a greater degree of cohesiveness than those that occur across two independent units (Frisch 2013).

The distributional pattern that this study found is also consistent with results from the existing phonetic and phonological studies in Japanese, showing essentially that there exists a strong cohesiveness between the onset

3) As a reviewer suggested, in order to confirm this a lexicon study of CV vs. VC sequences in forms longer than two-syllable words will be needed.

and the vowel and also that the coda, when present, forms an independent unit (for detailed review, see Labrune 2012). For example, Campbell and Sagisaka (1991) showed that an onset consonant before /a/ (which is an intrinsically long vowel) is shorter than before /i/ and /u/ (the shortest vowels in Japanese). Temporal compensation such as this, however, is not observed across the vowel and the coda. In a similar vein, a vowel preceding a part of geminate consonant (i.e., the /Q/ in a /CVQCV/ word) is longer than a vowel preceding a singleton consonant in a CVCV word (Idemaru 2005). This kind of compensatory temporal effect is unexpected if /Q/ forms a unit with its preceding vowel, referred to as the rime in many Indo-European languages including English (Maddieson 1985). In sum, as Kubozono (2006) noted, the current lexicon study along with the relevant sound patterns in Japanese suggest that there is a strong interdependence between the onset and the vowel and at the same time that the coda consonants must be independent of a preceding vowel.

3. Speeded Word-repetition Experiment

3.1. Background

Having established that the distributional information is consisitent with the models where the onset and the vowel form a single prosodic unit separate from the coda, in this section I focus on evaluating the contrasting predictions that the two models depicted in <Figure 1.b> and <Figure 1.c> make. Specifically, I report results from a speeded word-repetition experiment, which was designed to examine whether there is an effect of (what is referred to as) the mora hierarchy on speech error data that might incur in speeded word-repetition tasks.

Specifically, under the prosodic model in <Figure 1.c> the first CV mora is expected to behave qualitatively differently from the second mora consisting only of a coda consonant. This prediction is based on the model proposed in Labrune (2012), where two major types of moras (i.e., the full vs. the deficient mora) are acknowledged (see <Figure 2> below). An empirical fact relevant for distinguishing the full mora from the deficient one is that unlike the full moras the deficient moras are not able

to receive pitch accent except under some special cases (Labrune 2012). In this model, the basic prosodic unit of Japanese is the full mora with two structural positions — a position preferrably filled by an onset consonant and another position ideally realized by a vowel (see <Figure 2.a>). The deficient moras, on the other hand, are considered to be marked and hence correspond to the 'special' mora in the traditional Japanese phonology literature. Examples of deficient moras directly relevant to this study are shown in <Figure 2.b>. Here we see that underlyingly /Q/ (the first part of an obstruent geminate) has an empty slot in the vowel position and therefore contains no featural specification of its own other than the [+cons] (merely indicating that it is not vocoid). The representation of /N/ (the moraic nasal) is the same as that of /Q/ except that the former contains an additional [+nas] specification (Vs inside the parenthesis in <Figure 2.b> indicate an empty position at the phonological level).

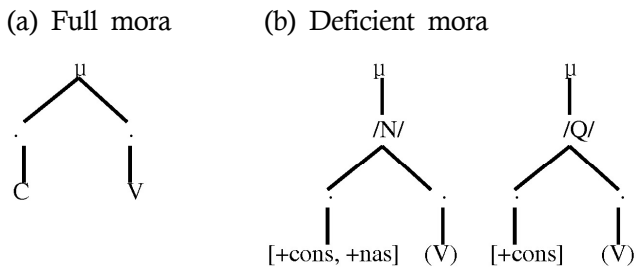

Figure 2. Full vs. Deficient Mora (adopted from Labrune 2012:135-136).

For this study, it is of a particular importance that the full vs. deficient mora distinction is not a dichotomous one. Rather the distinction is understood to constitute a gradient scalar hierarchy according to their acoustic prominence. As indicated in (1) below, since the full moras contain a sound sequence consisting of a consonant and a vowel, it is the most sonorous and thus acoustically prominent one. This is followed by onset-less vowels which are considered to be weaker than the full CV mora (this assumption is based on Burzio 1994). On the lowest end of the hierarchy, we find /Q/ that completely lacks any vocalic feature. In the middle is positioned the moraic nasal /N/, which is acoustically more prominent due to its having the additional nasality feature.

(1) Japanese Moraic Hierarchy (Labrune 2012:141)
CV > V > N > Q

To the extent that Japanese speakers are sensitive to the moraic structures specified in <Figure 2>, we may expect Japanese speakers' behavioral differences in their processing of the full vs. the deficient moras. More importantly, this model further makes it explicit that the way Japanese speakers process the deficient mora consisting of a less sonorous coda consonant will be different from the way they process the deficient mora consisting of a more sonorous coda.[4] If these predictions were borne out, then the findings can be used in support of <Figure 1.c> over <Figure 1.b>.

3.2. Word-repetition experiment

To test these predictions, this study made use of the well-established fact that phonological speech errors are often incurred when phonemes are repeated in a natural (Noteboom 1973) or in a laboratory setting (Dell 1984; Yoshida 2001). Noteboom (1973) reported that the two word-initial phonemes /l/ and /h/ in 'left hemisphere' are often erroneously substituted with each other such that a slip of the tongue 'heft lemisphere' occurs. Importantly, it has been demonstrated previously that the likelihood that this type of speech error occurs increases significantly when the word-initial consonants /l/ and /h/ are followed by the same vowel, here /ɛ/ (Dell 1984). Thus, 'heft lemisphere' (where /ɛ/ is repeated across the phrase) incurs more speech errors than other types of phrases, for example, as in 'r/i/ght h/e/misphere' (where no single vowel is repeated across the phrase). Importantly for the current study, Dell (1984) has additionally shown that the likelihood that a speech error occurs also increases when the words involved in the error share the same word-final consonant, such that the shared word-final consonant /l/ in 'deal ball' incurs a speech error like 'beal dall' as effective as the shared vowel /æ/ in 'mad back' increases the error rates of /m/ and /b/. Yoshida (2001)

4) Here I use the term 'coda', simply referring to the consonant that occurs in the post nucleus position, with no theoretical commitment to the presence/absence of the syllable node in Japanese.

and Kim and Lee (2015) also reported a set of findings that are congruent with this for Japanese.

In an effort to extend these existing studies, the present experiment asked Japanese speakers to recite words with repeated segments in a laboratory setting. They were told to perform the task in fast speech style. Particularly, the participants performed this taks under time pressure, through which it was hoped to induce them to make speech errors. As stated above, the major goal of the present experiment was to investigate whether the mora hierarchy plays a role in determining the types and rates of phonological errors.

3.3. Material

In the present experiment, Japanese speakers were asked to produce sequences of CVC nonsense word forms that contained repeated segments. Since Japanese phonology allows only two types of consonants in the post-nucleus word final position, i.e., /N/ and /Q/, the target CVC nonwords in the current experiment had either of the two consonants in that position. The target nonwords used in this experiment are shown in <Table 2>. These items are based on a modified version of the stimuli used in Kim & Lee (2015). The major goal of Kim & Lee (2015) was to investigate whether the onset-vowel (as opposed to the vowel-coda) sequences in Japanese CVC items behave as a cohesive unit in a short-term memory task. Unlike Kim & Lee (2015), however, the present study focused on investigating whether the mora hierarchy (proposed by Labrune 2012) plays a role in the types and rates of speech errors — specifically those errors that are associated with the coda consonants. To this end, in the present study the mora hierarchy of the coda consonants were systematically manipulated. In addition, care was taken to control for the potential effect of vowel types in the target stimuli, namely that all of the five vowels of standard Japanese were included in the stimuli.

There were a total of 10 target nonword lists, each of which consisted of five consecutive CVC nonsense words. In each list, there were a sequence of nonwords where the same vowels were repeated (e.g., /a/-/a/ in /tiN, seQ, s**a**N, m**a**Q, kuN/). Sequences of words sharing the same

vowel appeared in the middle position of the word lists. Given that the repeated phoneme effect can in principle operate both forwards and backwards (Dell 1984), /s**a**N, m**a**Q/, for example, could potentially be erroneously produced as /**m**aN, **s**aQ/ or /sa**Q**, Xa**N**/ (here 'X' stands for the second component of the geminates). In the former, the onset consonants are switched, while in the latter it is the coda consonants that are switched. Efforts were made to control for the potential effect of coda repetition. To this end, two types of word lists were prepared — i.e., the first half contained words where /N/ and /Q/ alternated (e.g., /ta**N**, so**Q**, pu**N**, pu**Q**, si**N**/), while the second half had either of /N/ or /Q/ appeared consecutively (e.g., /tuQ, piN, se**Q**, te**Q**, koN/). Finally, note that due to the phonotactic constraints governing the coda consonants in Japanese, the expected surface pronounced form of the sequence /teN, suQ, toN, poQ, saN/ is [teN.sut.tom.pos.saN].

Table 2. Materials for the Word-repetition Task

Repeated vowels	N and Q alternated in coda	Repeated vowels	N and Q not alternated in coda
1. (a-a)	/tiN, seQ, saN, maQ, kuN/	6 (a-a)	/tiQ, peQ, kaQ, kaQ, suN/
2. (e-e)	/tuN, hiQ, peN, beQ, soN/	7. (e-e)	/tuQ, piN, seQ, teQ, koN/
3. (i-i)	/toN, haQ, kiN, miQ, peN/	8. (i-i)	/toN, maQ, siQ, kiN, seN/
4. (o-o)	/teN, suQ, toN, poQ, saN/	9. (o-o)	/teN, puQ, koQ, soN, maN/
5. (u-u)	/taN, soQ, puN, puQ, siN/	10. (u-u)	/taQ, poN, nuN, ruN, giN/

3.4. Participants

Twelve native speakers of Japanese (5 male, 7 female) participated in the present study. They were all undergraduate students recruited from the Tokyo University community and were paid for their participation.

3.5. Procedure

The procedure adopted for the current study is based on Yoshida (2001) and Kim and Lee (2015). Participants' productions of the target words were recorded in a quiet room. Participants saw a sequence of five CVC nonwords written in Japanese character *hiragana* on the laptop screen. They

were asked to recite the words silently for eight seconds. As soon as the sequence disappeared from the screen, a visual instruction appeared on the screen, asking the participants to repeat the sequence as quickly as possible for six seconds. After participants repeated the stimuli, another visual instruction appeared on the screen, instructing the participants at this time to repeat the sequence once again for four seconds. The entire set of wordlists was given twice in a random order to each of the participants. They were given four practice sets prior to the main experiment. The entire procedure of the experiment was run with the help of a Japanese-Korean bilingual speaker using the SuperLab experiment running tool.

3.6. Results

3.6.1. Coding recorded speech errors

The current word-repetition experiment aimed to test the extent to which the mora hierarchy modulates patterns of speech errors in a word-repetition task. The prediction was that speech errors involving the deficient moras will occur significantly more often than the ones involving the full mora. In addition, more speech errors will be incurred involving the deficient moras consisting of an obstruent than the ones consisting of a nasal consonant. To this end, speech errors were coded as involving the types and the positions of the errors, i.e., the onset, the vowel, or the coda. For example, from the input target sequence /teN,sut,to**m**,po**s**,saN/, a participant errornaeoulsy produced [teN.sut.to**p**.po**N**.saN]. In this case, the third word in the word list (/tom/) was erroneously produced as [top] and the fourth word (/pos/) again errorneously as [poN]. These tokens were coded as substitution errors targeting consonants in coda position, i.e., /m/ in the coda position was substituted with [p] and /s/ in the coda was substituted with [N]. Cases of substitution errors involving segments in the onset and vowel positions were coded in the same manner. Segments in the original list were often not pronounced at all, as in for instance /ruɲ.giN./ as [ru.giN]. This was coded as deletion error, where a consonant in the coda was simply elided.

The entire recordings were transcribed by a Korean speaker with advanced oral and written proficiency in Japanese. After this initial round,

in order to assess the reliability of the transcriptions, a native speaker of Japanese (naïve to the current experiment) listened to the entire recording and checked the first round transcriptions. Discrepancies among the two transcribers (less than 9% of the entire transcription) were resolved in favor of the native Japanese speaker's judgment.

3.6.2. Error counts

Based on the error-encoding criteria specified above, a total of 526 speech errors were identified. The frequencies of errors as a function of their type and position are shown in <Table 3>. Note that vowel deletion refers to cases where the entire word containing the vowel was not produced. Frequencies of speech errors in <Table 3> inform us of several noteworthy patterns. First, more errors were incurred from stimuli where /N/ and /Q/ alternated in coda position compared to those where /N/ and /Q / did not (311 vs. 215). This suggests that not only the repeated vowels but also the alternations of the same codas influence the frequency of speech error productions. Second, a lot more errors occurred when the participants repeated the words in the fast than in the slow speech (447 vs. 79). This is congruent with previous findings that speech errors occur more often when participants are under time pressure. Third, when errors occurred, there were more substitutions than deletions (420 vs. 106). This indicates that when CVC forms are repeated, participants tend to produce forms that are also CVC. Finally and criticially for the present study, the number of errors that are associated with the coda position was far greater than those with the onset and the vowel position combined (450 vs. 76).

Table 3. Frequencies of Errors as a Function of Their Type and Position

	N and Q alternated						
	Fast speech			Slow speech			Row total
	Coda	Onset	Vowel	Coda	Onset	Vowel	
Substitution	211	30	1	15	5	1	263
Deletion	38	0	0	5	0	5	48
Subtotal	249	30	1	20	5	6	311

	N and Q not alternated						
	Fast speech			Slow speech			Row total
	Coda	Onset	Vowel	Coda	Onset	Vowel	
Substitution	103	20	2	25	6	1	157
Deletion	42	0	0	11	5	0	58
Subtotal	145	20	2	36	11	1	215
Total	394	50	3	56	16	7	526
	Fast total: 447			Slow total: 79			

Not only that numerically more errors occurred from the consonants in the coda position, but also more distinct error types occurred in that position (compared to the onset and the vowel position). This is shown in <Figure 3>, which is based on a pool of error data where the same types of errors produced by multiple participants were counted only once. The dotted line in the figure represents the mean distinct errors from stimuli where /N/ and /Q/ did not alternate in coda position, while the solid line the mean distinct errors from stimuli where /N/ and /Q/ alternated. Across the two conditions, it was apparent that there were more distinct errors from the consonants associated with the coda position and that this was particularly true for the stimuli where /N/ and /Q/ alternated.

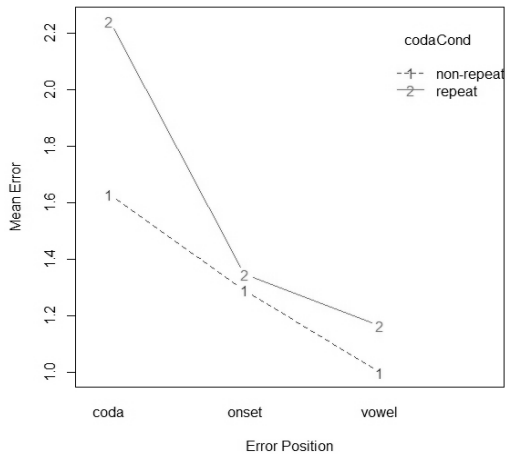

Figure 3. Mean Occurrences of Distinct Error Types.

In sum, the results suggest that the current participants made speech errors involving the deficient moras (i.e, the coda /N/ or /Q/) to a much greater extent than those involving the full mora (i.e., the CV component). The preponderance of the deficient mora errors thus warranted a further investigation into the details of this error type. <Table 4> informs us of what happened when coda consonants were substituted with another consonant (N = 450).[5] As shown on the last row of <Table 4>, there were overall more speech errors where the obstruent codas underwent some types of changes (i.e., (162+126/450)*100 = 64%) than the nasal codas did (i.e., (107+55/450)*100 = 36%). More specifically, about half of the errors (48%) involved cases where an obstruent coda was substituted with a nasal coda. Compared to this, the number of errors where a nasal coda was substituted with an obstruent coda was cut about in half (25.1%). Obstruent codas were also deleted slightly more often (12.2%) than nasal codas (9.1%). The finding that obstruent codas are more susceptible to changes than nasal codas was held true across the two types of coda presentation conditions (N and Q alternated, 60.2% vs. 39.8%; N and Q not alternated, 69.6% vs. 30.4%).

Table 4. Frequencies of Deficient Mora Errors as a Function of the Segment Type

	/N/ and /Q/ alternated	
	<Input>	
	Obstruent	Nasal
<Output>		
Obstruent	2.2% (6)	34.2% (92)
Nasal	46.8% (126)	0.7% (2)
Deletion	11.1% (30)	4.8% (13)
Subtotal	60.2% (162)	39.8% (107)

5) Note that in the to-be-remembered stimuli, there were more words whose coda was a nasal. Thus, if everything else is equal, we might expect more errors involving the change of the nasal codas to something else. As shown in <Table 5>, the coda obstruents, however, changed more often than the coda nasals did.

	/N/ and /Q/ not alternated	
	Obstruent	Nasal
Obstruent	6.0% (11)	11.6% (21)
Nasal	49.7% (90)	3.3% (6)
Deletion	13.8% (25)	15.4% (28)
Subtotal	69.6% (126)	30.4% (55)
Total (N = 450)	64% (288)	36% (162)

<Table 5> provides the details of the coda substitution errors. It not only shows that obstruent codas underwent changes more often than nasal codas but also that when an obstruent coda is substituted with another segment, it is by far the most often substituted with a nasal coda consonant. Obstruent codas targeted by this process seem to be not limited to a particular obstruent type. That is, every obstruent type attested in the coda position in the current target stimuli underwent this process. To add a note here, when such substitutions occur, the place of articulation of the error forms is quite likely to be identical to that of the input segments. Thus, for instance, when a coda /k/ was substituted with a nasal coda, it was substituted with /ŋ/ far more often (85.4%) than with other alternative nasal codas (14.6%).

Table 5. Frequency Information of the Coda Substitution Errors

N and Q alternated					
Input Obstruent	Output		Input Nasal	Output	
/p/	t	1	/m/	p	77
	s	2		t	5
	m	22		s	1
	ŋ	1		k	3
/t/	n	6		N	1
/s/	t	2		ŋ	1
	N	79	/N/	p	1
/k/	s	1		t	2
	m	2		s	3
	N	1			
	ŋ	15			

N and Q not alternated					
/p/	s	2	/m/	N	2
	m	25	/n/	t	2
/t/	s	4		l	2
	n	14	/N/	t	3
/s/	t	2		s	16
	k	1		n	2
	N	13			
	ŋ	1			
/k/	p	1			
	s	1			
	n	1			
	N	4			
	ŋ	32			
Total		288			162

3.6.3. Discussions

In the current word-repetition experiment, I focused on evaluating the contrasting predictions that the models depicted in <Figure 1.b> and <Figure 1.c> above make. Under both models, given a CVC segment sequence, CV forms the first mora that is distinct from the second mora consisting of the final C. The major difference between the two models, however, is that in <Figure 1.c> the first mora is a full mora consisting of a consonant and a vowel, while the second mora is a deficient one in which the segmental specification for the V position is empty. Critically, in <Figure 1.b>, however, no such structural distinction is made for different mora types. Rather, in <Figure 1.b>, the second mora simply consists of one segment, while the first mora two segments.

Of a more direct relevance to this study is that under <Figure 1.c> the second mora contains a structurally empty position — in this case a vowel slot with no phonetic content. This gives rise to the prediction that Japanese speakers will process the /N,Q/ mora differently from the CV mora. In the current word-repetition task, I found behavioral evidence supporting this. That is, Japanese speakers made speech errors that are associated with the /N,Q/ mora far more often than those associated

with the CV mora. One plausible explanation of this finding is that being deficient and thus less prominent moras, the /N,Q/ moras are highly prone to errors during word-repetition tasks that occur especially under time pressure. Under <Figure 1.b>, however, the discrepancy in the frequency of errors between the first vs. the second mora should be attributed to some other factors. As a reviewer pointed out, one possibility is to say that there is a general processing disadvantage for the segments appearing in the final position. That is, since the second mora by definition appears in the later portion of the foot, the second mora is subject to changes to a greater extent than the first one.

Importantly, however, <Figure 1.c> further predicts that not every segment in the final position will behave in the same manner. That is, /Q/, a segment not specified other than [+consonantal] and thus being the least sonorous mora, is expected to be subject to erroneous changes more often than /N/, a more sonorous mora with [+nasal] specification. The model in <Figure 1.b>, on the other hand, is not explicit about whether these two types of special moras will behave differently. To account for the current finding, one is required to make additional assumptions further distinguishing these moras. Note, however, that this is precisely what the model in <Figure 1.c> has as its built-in feature. Critically, it is not clear whether positing the syllable node contributes to our understanding of the current finding. In this sense, the syllable may be thought to be at best redundant, and thus <Figure 1.c> may be argued to have a descriptive advantage over <Figure 1.b>.

In sum, the key finding reported in this section is that Japanese speakers' speech error patterns are consistent with the idea that there exists a structural asymmetry between the CV vs. the final C moras. Stated from a different perspective, this means that it is not clear whether there is need for a more complex representation in <Figure 1.b> where the mora and the syllable node coexist, standing in a hierarchical structure. In the following section, I now provide a general discussion about the results from the lexicon and the word-repetition test and conclude the paper.

4. General Discussion and Conclusion

This paper addressed three contrasting proposals regarding the phonological representation of Japanese CVC words. To this end, I asked two primary questions. The first question was whether there is a need for grouping the onset with the vowel to a unitary prosodic unit, distinct from the coda. For this, I carried out a lexicon study of Japanese words. The result indicates that the probability that the onsets and the vowels combine significantly deviates from the expected probability if they were combined freely. This is not the case for the combination of the vowel and the coda in Japanese. The proposed interpretation of this finding is that there is a certain prosodic constitutent which may constrain the combination of the onset and the vowel. I argue that this finding constitutes indirect evidence that the onset and the vowel indeed form a unitary (moraic) unit in Japanese. As such, this finding replicates the analogous finding previously reported in Kim & Lee (2015).

The second question was whether there is a need for positing the syllable. Recently, Labrune (2012) argued that Japanese makes no use of the syllable. This model has only moras inside the feet and distinguishes subtypes of moras on an acoustic-prominence hierarchy, i.e., the CV mora on the top and the /Q/ on the bottom. Labrune's model contrasts with more traditional models of Japanese prosodic structure where the mora and the syllable coexit in a hierarchical structure. Results from the current word-repetition experiment indicate that speech error-rate is significantly higher for segments associated with the coda position and that the error-rate increases as the coda segments are less acoustically prominent. As such, this finding is congruent with the Labrune (2012)'s model, proposing that the moras constitute immediate subconstituents of the foot and that they be classified on a scalar hierarchy according to their acoustic prominence. On the basis of this, one may argue that the adaptation of the model that posits the syllable (in addition to the mora) is thus not nessarily required in accounting for the current findings. In fact, as Labrune (2012:139) suggests, there might be actually a redundancy between the mora and the syllable such that having the extra syllable node

does not independently contribute to the explanation of the current findings. Thus, I would claim that, on a par with Labrune (2012), the principle of Occam's Razor leads us to argue for the simpler prosodic representation in <Figure 1.c> over <Figure 1.b>.

I would claim that in order to advocate the position that the syllable exists as a unit independent from the mora unit, one needs to find a prosodic constituent that *entails* the presence of the syllable. To my mind, one such candidate is the rime unit, a sub-syllabic constituent consisting of a nucleus and a coda, which is well-established for many languages including English. Thus, I think that another indirect way to address the existence of the syllable in Japanese is to ask whether a rime-like unit is feasible in Japanese. In fact, the mora-based approach advanced in Labrune (2012) posits no rime, while at least some syllable-based models do posit such unit (e.g., Yoshida 1991). The results presented in this paper, however, argue against the presence of the rime unit. Firstly, if the rime exists in Japanese, we may predict greater cohesiveness between a nucleus vowel and a coda than between a nucleus vowel and an onset. The present lexicon study demonstrated that exactly the reverse is true. Secondly, the speech error data also serve as indirect evidence against the rime. If the rime were an active unit on which speech errors are operating, onsets should have behaved as an automous unit (excluding the rime). It was, however, the opposite was true — in the speech error data, codas were kept intact as a unit far more often than onsets. The current findings thus suggest that the rime may not exist as a subconstituent in Japanese. Phonetic studies cited in Labrune (2012) also go against the presence of the rime. Idemaru (2005), for instance, demonstrated that the duration of a vowel preceding a geminate consonant in /CVQCV/ is longer than a vowel preceding a singleton consonant in /CVCV/. This is quite unexpected if /VQ/ formed a rime, since in languages that do have the rime show phonetic compensation between the vowel and the coda (Maddieson 1985). As Labrune (2012:121) points out, this is better accounted for if /CVC/ sequences are parsed into /CV.C/, just as /CVCV/ is divided into /CV.CV/ (where '.' represents the mora boundary). Based on the arguments presented above, it is quite unlikely that

the rime exists in Japanese and as such the utility of the syllable in Japanese is further weakened.

To conclude, the present findings suggest that the syllable may not be necessary in describing distributional and behavioral patterns in Japanese. This raises an important implication for the traditional models in which all metrical constituents are considered to be always present in a layered fashion within the prosodic hierarchy (e.g., Selkirk 1984). Instead, contrary to what traditionally has been assumed in the literature, there might be more language-specificity when it comes to selecting relevant prosodic units from the universal inventory of prosodic constituents. Follow-up investigations into the emergence and the utility of the syllable in languages similar to Japanese will help us better understand this important issue.

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