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A Study on the Temporal Pattern of Segments in Sundanese

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Abstract:- *In this study, the temporal pattern of segment in various syllable structure in Sundanese is investigated, and it is found that, due to the initial strengthening mechanism, the initial consonant of the first syllable is significantly longer than that of the following consonant, and coda is also longer than the second consonant of the syllable. Vowels in open syllable are longer than those in closed syllable. Sundanese is sensitive to syllable weight to some extent, with segments in heavy syllables longer than those of the light syllables. Due to final lengthening mechanism, segments in the final position of a syllable or a word are longer than the preceding ones.*

Keywords: *Consonant, duration, syllable, vowel*

I. INTRODUCTION

The temporal properties of speech have been studied for a variety of languages, including English, Swedish, and Dutch. Early studies generally dealt with segmental duration in a linear model, for example, Klatt [1] argued that, for each phonetic segment, there is an inherent duration, and that the duration of a certain segment is affected by a number of rules as a function of the context where the segment occurs. Later studies in phonological theory have given research on duration a new perspective [2-4]. These new approaches also show that, in addition to the intrinsic segment length, levels of the prosodic boundaries, like syllable, foot, and phrase, may also affect phonetic duration. They argue that there is no need to make reference to syllable structure, since it falls out from the patterns of gestural coordination [5].

Since phonological theories explicitly make reference to the patterns of timing, it is of necessary for detailed investigation on the mapping between phonological and phonetic timing. The difference between words with short and long-vowel has frequently been described as syllable contact, noted as ‘checked’ vs. ‘free’ vowels or ‘close’ vs. ‘loose’ contact [6]. These terms stand for the notion that long and short vowels differ in the way of the transition from the vowel into the subsequent consonant. It is argued that contact is loose if the maximum intensity of the vowel decreased before the onset of the subsequent consonant. When the subsequent consonant onset occurs near the maximum point of the vowel, contact is close. It is proposed that long vowels exhibit loose contact, while short vowels have close contact. In short-vowel words, the onset of the postvocalic consonant occurs earlier than in long-vowel words, and this makes the consonant longer in duration compared to consonants following long vowels. An account concerning the close and loose contact would have to be linguistically universal, predicting that consonants after short vowels are longer in all languages with vowel length contrast.

Investigation on word-final consonants in monosyllabic words in Dutch was done in Nooteboom’s dissertation [7]. By observing the lip contacts to measure the durations of closing and opening of the lips, Nooteboom collected data for the ‘CVrt’ words spoken by two speakers, and it was shown that the final /t/ was about 40 ms longer when following a short vowel, as compared to a long vowel. Adopting the same approach, Nooteboom also gathered data for the intervocalic consonants in Dutch non-words in the type [pVpVpVp]. It was found that consonant following short vowel was longer than consonant following long vowel. Moreover, for disyllabic words, it is reported in the textbook on Dutch phonetics [8] that the medial consonant following short vowels is much longer than following long vowels. In the textbook, the segmented waveforms are shown for the disyllabic words ‘mate’ (extent) and ‘matte’ (dull), and the [t] in ‘matte’ is much longer in duration than that in ‘mate’. Actually, these data suggest that the total duration of vowel plus consonant is nearly constant for both of the short and long vowel word, demonstrating a compensation mechanism whereby the consonant is lengthened by about the same extent that the vowel is shortened.

In a preliminary study, Jongman and Sereno [9] found that there was no difference in duration between the intervocalic consonants following long or short vowels in disyllabic words in Dutch, and later study by Kuijpers [10] supported the findings. Kuijpers investigated the development of the voicing contrast in children. In one of the experiments, children aged four and six, as well as adults, produced 37 disyllabic words, with a long or short vowel in the first syllable, followed by one of the stop consonants and then by schwa. Of the 37 words, twenty eight were of the CV(:)CVC type, while seven were of the CCV(:)CVC type. It was shown that, in none of the age groups was the medial consonant duration significantly affected by the length of the foregoing vowel.

It is also shown that in most research work on other languages there is no temporal difference between the intervocalic consonants preceded by long or short vowels. Fischer-Jorgensen [11] investigated closure durations for voiced stops preceded by short and long vowels in thirty three Danish non-words, produced by seven speakers. Port [12] examined medial stops preceded by long and short /i/ in two words and two non-words of English produced by 10 speakers. Heuven [13] measured medial /p/ preceded by different vowels in four English words, produced by five speakers. Braunschweiler [14] investigated voiced and voiceless medial consonants in thirty six German words, spoken by four speakers. In none of these studies is there any consistent temporal effect of the preceding vowel on the medial consonant. Jongman [15] investigated the durational pattern of minimal Dutch word pairs containing long and short vowels, and got the same result. Suomi, et al [16] compared the phonetic realization of quantity in Northern Estonian and Northern Finnish in selected word structures, and found that besides cross-language differences in the durational realization of the quantity contrast, it was also observed that the patterns of accentual lengthening in the two languages are highly consistent with predictions of the timing framework.

The present study will investigate the effect of syllable structure on the temporal pattern of segments in Sundanese. It is aimed to display the durations of vowels and consonants in various syllable structures. Statistic analysis will be done on the durational pattern.

II. METHODOLOGY

2.1. Studying materials

In Sundanese, there are six common syllable structures, as are listed below,

CV: bulu (feather) lini (earthquake);
CVC: tas (bag) rok (skirt)
CCV: kridit (credit) jepretan (slingshot);
CVV: panonpoe (the sun) leutik (small)
CVVC: haneut (warm) laleur (fly)
VC: niup (to blow) es (ice)

The length of syllable is variable in Sundanese. In a word may, there may be one syllable, like ‘cai’ (water); two syllables, like ‘langit’ (sky), or three syllables, like ‘guludug’ (thunder). In this study, only segments durations of three-syllable words are investigated. The durations of consonants and vowels are investigated separately, i.e., consonants, vowel of the first syllable are analyzed first, and then those of the second and third syllable are analyzed.

2.2. Procedure and measurements

This study aims to investigate the temporal pattern of segments of three-syllable words in Sundanese, so durations of consonants and vowels of each syllable are investigated. The end points of each segment are marked on the software of Praat [17]. An ANOVA is performed for the comparison of the durations of consonants and vowels of various structures of a specific syllable, and S-N-K test is done for further analysis. Statistic is done in SPSS.

III. RESULT

3.1. Consonant of the first syllable

Fig. 1 presents the mean consonant duration of various syllable structure of the first syllable, where CVC1 and CVC2 refer to the consonants at the initial and coda position respectively, while CCV1 and CCV2 refer to the first and the second consonant respectively. Results from ANOVA demonstrate that there is significant difference for the durations of consonants of the five cases: $F(4, 767) = 10.1$, $p < 0.001$. Further S-N-K test result shows that the data fall into two subsets, with consonants shorter in the second position of the CCV structure than the other cases, and there is no significant difference among the durations of consonants in the CV, CVC1, CVC2, CCV1 structures.

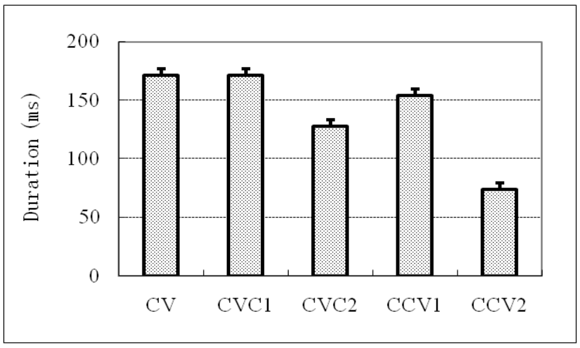

Fig. 1. Duration of consonants of the first syllable

3.2. Vowel of the first syllable

In Fig. 2, the average durations of vowels of various syllable structures of the first syllable are shown, and ANOVA result displays that significant difference exists for the duration values: $F(3, 412) = 6.69$, $p < 0.001$. It is demonstrated from further S-N-K test result that, similar to that of consonant, the duration values fall into two subsets, with vowel in the CVC structure shorter than the other cases, and no significant difference is found for vowel durations in the V, CV and CCV structure.

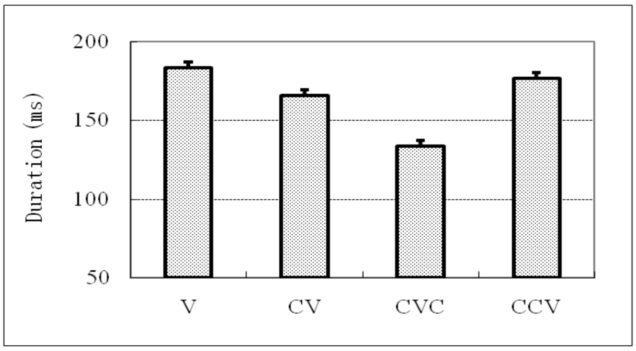

Fig. 2. Duration of vowels of the first syllable

3.3. Consonant of the second syllable

In this subsection, the durations of consonants of the second syllable are analyzed. Fig. 3 displays the mean durations of consonant in various syllable structures, where CVC1 and CVC2 refer to the consonants at the initial and coda position respectively. ANOVA results show that there is significant difference for the duration of consonants in the four cases: $F(3, 455) = 15.2$, $p < 0.001$. Further S-N-K test result shows that, the duration values fall into two subsets, with the durations longer in the CVC2 and the CVV structure, and shorter in the CV and the CVC1 structure. However, there is no significant difference between the duration of consonants in the CVC2 and the CVV structure, nor is there significant difference between the CV and CVC1 structure.

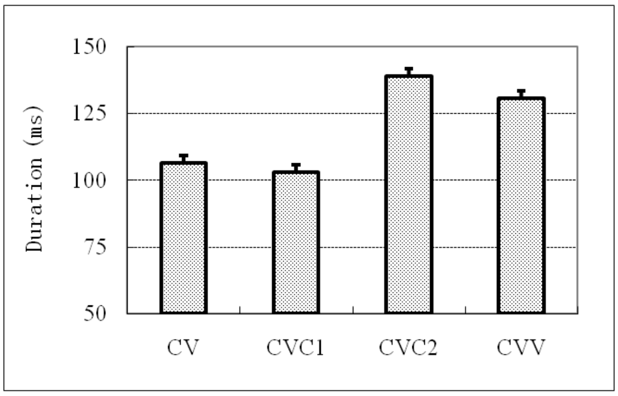

Fig. 3. Duration of consonants of the second syllable

3.4. Vowel of the second syllable

The average vowel duration of syllable structures of CV, CVC and CVV in the second syllable is presented in Fig. 4. Results from ANOVA demonstrate that there is significant difference for the durations of vowels in the three cases: $F(2, 387) = 18.2$, $p < 0.001$. Further S-N-K test result shows that the data fall into three subsets, with vowels the longest in the CVV structure, the shortest in the CVC structure, and intermediate in the CV structure.

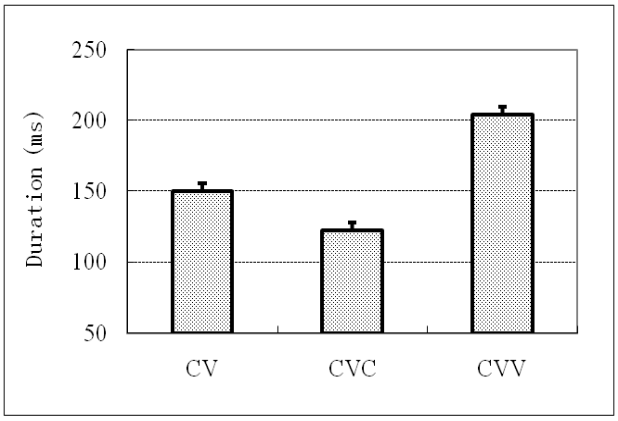

Fig. 4. Duration of vowels of the first syllable

3.5. Consonant of the third syllable

In Fig. 5, the average durations of consonants of various syllable structures of the third syllable are shown, where CVVC1 and CVVC2 refer to the consonants at the initial and coda position respectively. ANOVA result displays that significant difference exists for the duration values: $F(4, 684) = 97.2$, $p < 0.001$. It is demonstrated from further S-N-K test result that, the duration values fall into two subsets, with consonants in the CVC2 and the CVVC2 structures longer, and those shorter in the CV, CVC1 and CVVC1 structures. However, there is no significant difference between the CVC2 and the CVVC2 structures, nor are there significant differences among the CV, CVC1 and CVVC1 structures.

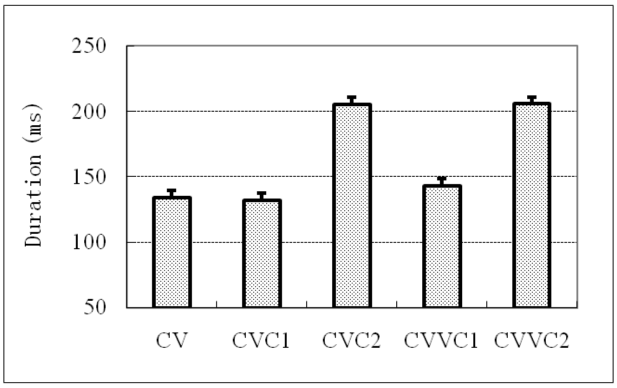

Fig. 5. Duration of consonants of the third syllable

3.6. Vowel of the third syllable

Fig. 6 displays the mean durations of vowels of various syllable structures of the third syllable, and ANOVA results show that there is significant difference for the durations of vowels in the four cases: $F(3, 519) = 191.4$, $p < 0.001$. Further S-N-K test result shows that, the duration values fall into four subsets, with the durations the longest in the CV structure, the second longest in the CVVC structure, the shortest in the CVC structure, and the second shortest in the VC structure.

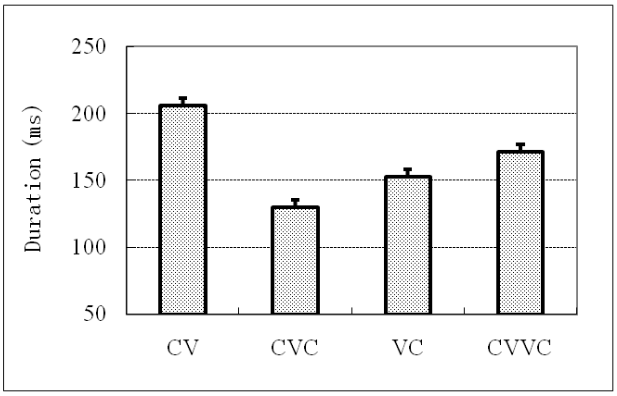

Fig. 6. Duration of vowels of the third syllable

IV. DISCUSSION

Results from the previous section shows that, for consonant of the first syllable, among the structures of CV, CVC, CCV, consonant in the second position of the CCV structure is significantly shorter than the other cases. The reason for this is that, when a consonant occurs in the initial position of a syllable, there is no preceding segment, which leaves enough room for the segment to be lengthened due to the initial strengthening mechanism. This is the case with the first consonant in all the three structures. When a consonant is at the last position of a syllable, as there is no following segment in that syllable, this leaves much room for the last consonant to be prolonged. However, when a consonant is in the inter-segmental position of a syllable, there is no much room for it to be lengthened, therefore, consonant at the second position of the CCV structure is shorter than the other cases.

Regarding vowel of the first syllable, result reveals that the duration of vowel in the CVC structure is shorter than vowels in the V, CV and CCV structure. The reason is similar to that for consonant. In the CV and CCV structure, there is no segment after the vowel in the syllable, so there is enough room for the vowel to be lengthened. In the V structure, there is no preceding or following segment in the syllable, so the vowel is also capable to be lengthened. On the contrary, in the CVC structure, there are consonants both before and after the vowel in the syllable, there is not much room for it to be prolonged, therefore, vowel in the CVC structure is shorter than the other structures.

As for the consonants of the second syllable, it is shown that they are longer in the CVC2 and the CVV structure, and shorter in the CV and the CVC1 structure. It is known that, in world languages, there are some language which are identified as quantity language, i.e., there are heavy and light syllables in these languages. A typical light syllable has only one mora, while a heavy syllable has two moras. A heavy syllable is normally longer than a light one. In Sundanese, CV structure is a light syllable, while CVV structure is a heavy syllable. As a heavy syllable is generally longer than a light one, the consonant will also be affected, that is, the consonant in CVV structure will be longer than that of the CV structure. For the CVC structure, the temporal pattern is that coda is longer than onset. Therefore, consonants in the CVC2 and the CVV structure are longer than those in the CV and the CVC1 structure.

In regard to vowels of the second syllable, results display that they are the longest in the CVV structure, the shortest in the CVC structure, and intermediate in the CV structure. The reason for this pattern is obvious. The CVV structure is a heavy syllable, which is normally longer than the light syllable. Therefore, the duration of VV is longer than those in the CV and CVC structure. In the CVC structure, there are segments both preceding and following the vowel in the syllable, leaving little no room for it to be prolonged, so it is shorter than that in the CV structure. As a result, the vowel is the longest in the CVV structure, the shortest in the CVC structure, and intermediate in the CV structure.

As for the consonants of the third syllable, it is demonstrated that consonants are longer in the CVC2 and the CVVC2 structures, and shorter in the CV, CVC1 and CVVC1. The reason for this pattern is also quite obvious. In the CVC2 and the CVVC2 structures, there are no segments following the coda, leaving enough room for it to be lengthened due to the final lengthening mechanism, so consonants in these structures are longer. On the contrary, there are subsequent segments following the onsets in the CV, CVC1 and CVVC1, so there is litter room for them to be lengthened. As a result, consonants are longer in the CVC2 and the CVVC2 structures, and shorter in the CV, CVC1 and CVVC1.

Coming to vowels of the third syllable, it is shown that vowel is the longest in the CV structure, the second longest in the CVVC structure, the shortest in the CVC structure, and the second shortest in the VC structure. In these four structures, only in the CV structure there is no segment following the vowel, so there is much room for it to be lengthened due to the final lengthening mechanism. Therefore, the vowel in this structure is the longest. The CVVC structure is a heavy syllable, so vowel is also quite long. In the CVC structure, there are segments preceding and following the vowel, so the vowel is short. As there is no preceding segment before the vowel in the VC structure, the vowel is longer than that in the CVC structure.

V. CONCLUSION

The effect of syllable structure on the duration of consonants and vowel is analyzed in this study, and it is found that, when a segment occurs in the inter-segmental position of a syllable, or a word, it tend to be short. On the contrary, the first consonant of a syllable or a word is usually long due to the initial strengthening mechanism. In the first syllable, there is no significant effect of syllable structure on the duration of vowels in the V, CV and CCV structure, which means that the effect of syllable structure is limited in some cases. It is shown that Sundanese is to some extent sensitive to syllable quantity, with segments longer in the CVV structure than those in the CV structure. For consonants in the CVC structure in the second syllable, coda is longer than onset, which is an instance of final lengthening. Due to the effect of final lengthening, consonants are comparatively long in the coda position of the CVC and CVVC structures in the third syllable, and vowel is the longest in the CV structure in the third syllable.

VI. ACKNOWLEDGEMENTS

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