

Effect of Position on the Realization of Vowels in Sundanese

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Abstract: *In this study, the acoustic realization of vowels at various positions of the word in Sundanese is investigated. It is found that, due to domain initial strengthening mechanism, vowels tend to be fully realized at word initial position. This is the case with the first formant of /a/ and the second formant of /i/. In a tri-syllabic word, the energy of the final syllable is normally weak, so is the articulation strength, therefore, vowels at the word final position are usually not fully realized, as are in the cases of the second formant of vowel /i/ and the first formant of vowel /u/.*

Keywords: *Formant, position, Sundanese, vowel, word*

I. INTRODUCTION

This paper investigates the formant realization of vowels at different positions of the word in Sundanese. Vowels are the basic elements of the phonetic system of a language, and they are sounds that form the peak of syllables. The traditional cardinal vowel system describes them in terms of the characteristic of tongue height, tongue backness and roundedness. Vowel height refers to the vertical position of the tongue, and it is related to the first formant (F1), which is the lowest resonance of the voice. Height can be defined by the inverse of the F1 value: The higher the frequency of the first formant, the lower the vowel is. Vowel backness refers to the position of the tongue relative to the back of the mouth in articulating a vowel. It is related to the second formant (F2) of the voice. For a front vowel, like /i/, the frequency of F2 is comparatively high, which usually corresponds to a position of the tongue more forward in the mouth, while for a back vowel, like /u/, F2 is low, corresponding to the tongue positioned towards the back of the mouth.

The acoustic features of vowels are fairly well understood. Different vowels are realized in acoustic parameters of the vowels by values of the formants, which are acoustic resonances of the vocal tract shown up as dark bands on a spectrogram. The vocal tract is actually a resonant cavity, and the height of the jaw, the shape of the lips, and tongue position affect the parameters of the resonant cavity, resulting in various formant values. The acoustics of vowels can be seen on the spectrograms, which presents the acoustic energy at different frequency, and how they change with time. It is shown from previous research work that, children are capable of producing vowels contrastively at the age of three [1, 2], in spite of the fact of having to compensate for the changes in vocal tract size [3]. The vocal tracts of children are small, which result in higher formant values, and the formant values decrease as vocal tract size increases [4-6].

Vorperian and Kent [7] explored the difference between the vowel space areas of children and adults, and found a gradual lowering of formants through the development of vowels, which is confirmed by Flipsen and Lee [8]. It is also argued that, rather than due to the vocal tract size, there may be an articulatory origin for the larger vowel space area in children. It may be children's larger speech movements, which results in vowels articulated at the extremes of the vowel area [9-11]. Ladefoged and Maddieson [12] investigated a dialect of Eastern Arrernte, where there are only two vowels, and they assume that vowel /i/ is not a phoneme in that dialect. The two-vowel system is well-examined in the languages of Kaytetye and Western Anmatyerr. Henderson [13] presents interesting diagrams, which shows a centralized vowel space, relative to the normal vowel quadrilateral. He writes about forty pages in the description of the vowels, and roughly half of the content concerns central vowels. He argues that there are fairly large ranges of free variation in the production of the vowels, and it is clear that the variations do not belong to strict allophones in the sense of complementary distributions, but a kind of free variation resulting from coarticulatory processes.

In Arrernte phonology there is an interesting feature, i.e., for words that are lexically considered to be consonant-initial, they are analyzed as having an underlying initial /e/, based on various morpho-phonemic rules, including stress assignment rules [14]. The initial /e/ will not be realized in phrase-initial position. However, in phrase-medial position, the underlying /e/ is often realized so as to break a sequence of consonants between the words. The underlying form of Central Arrernte words is considered to be consonant-final. However, there is usually a final vowel added at the end of a phrase. Choi [15] listed a number of languages that have been argued as having a vertical vowel system, i.e., languages consisting strictly of a height contrast of vowels. It is probably reasonable in describing Central Arrernte as a language with a vertical vowel system as well. Although the high vowel in the language is clearly front /i/, as opposed to /e/, there is no front and back contrast in the vowel system.

Other languages with a small number of vowels are the Central Chadic languages, which are generally spoken in Cameroon. Only little phonetic study has been done on these languages, and Wolff [16] argued that there are apparently two vowels in those languages. The vowels in the languages have many of the same features as noted for the above-mentioned languages. The number of vowel contrasts varies depending on their positions in the word, and they are affected by word-level and higher level prosodies. Tabain and Breen [17] examined the formant and duration patterns of two central vowels in Central Arrernte, and found that the contrast between the two vowels is minimal, with no contrast in initial position or in final position. They argued that the main function of vowels in that language is to provide formant cues for the neighboring consonants. Pettinato, et al [18] investigated vowel space area development in childhood and adolescence, and found that large vowel space area does not prevent children from hyper-articulating vowels, and the manner in which this is achieved may not be adult-like.

The present study explores the effect of position on the production of vowels in Sundanese. It is aimed to examine the variation of vowels at word initial, medial and final position, and acoustic realization of first and second formant values will be analyzed.

II. METHODOLOGY

2.1. Studying Materials

The materials used in this study are taken from a database of Sundanese vocabulary, which contains about 2000 words. There are five vowels in Sundanese, i.e., /a, i, u, e, o/, and as the three vowels of /a, i, u/ are the basic ones in languages, only these three vowels will be examined in this study. The vowels may occur at word initial, word medial and word final positions. For example, in 'juragan' (boss), vowel /u/ occurs in at the initial position, and /a/ occurs at medial and final positions. In 'titinggi' (centipede), vowel /i/ occurs at initial, medial and final positions.

2.2. Procedure and measurements

This study aims to give an investigation of the effect of position on the vowels in Sundanese. Vowel quality is related to the formant values, so the first and the second formant values are examined, which are extracted using Praat [19]. An ANOVA is conducted for the comparison of the formant values at the three positions, and S-N-K test is done for further analysis. Statistic is done in SPSS.

III. RESULT

3.1. Vowel /a/

3.1.1. The first formant

Fig. 1 presents the mean values of the first formant of vowel /a/ at initial, medial and final position of word. Results from ANOVA show that there is significant difference for the formant values at the three positions: $F(2, 1993) = 7.82, p < 0.001$. Further S-N-K test result shows that they fall into two subsets, with the F1 value lower at word medial position than the other two cases. However, there is no significant difference between the formant values at the initial and final positions.

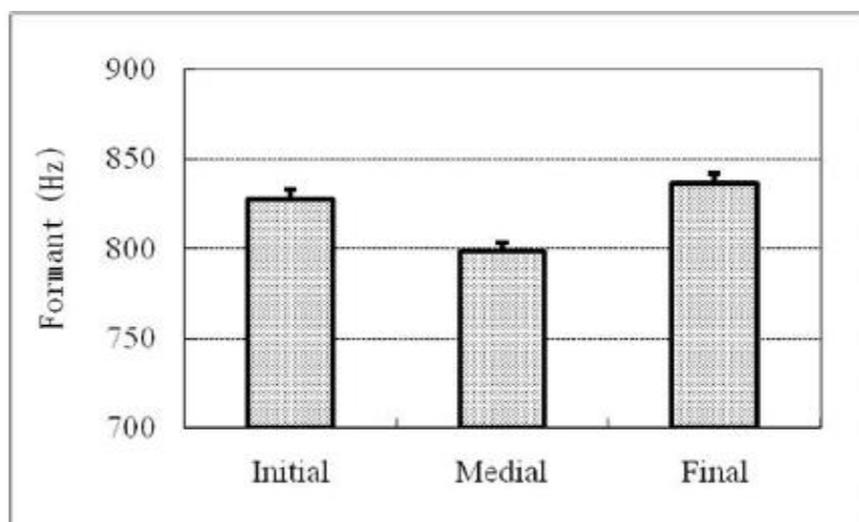


Fig. 1. The F1 values of vowel /a/ at word initial, medial and final position

3.1.2. The second formant

In Fig. 2, the average values of the second formant of vowel /a/ at the three positions are displayed, and

ANOVA result demonstrates that significant difference exists for the formant values: $F(2, 1993) = 5.24, p = 0.005$. It is revealed from further S-N-K test result that, the formant values fall into two subsets, with value higher at word final position, and lower at word medial position. However, there is no significant difference between the values of the initial and the medial positions, nor is there significant difference between the initial and the final positions.

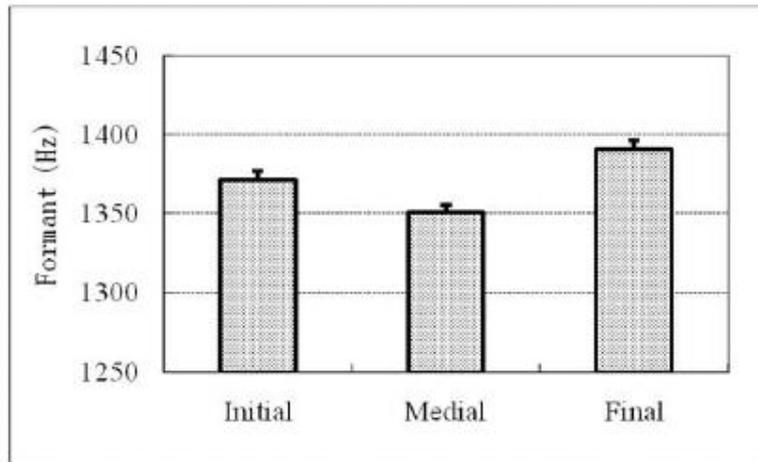


Fig. 2. The F2 values of vowel /a/ at word initial, medial and final position

3.2. Vowel /i/

3.2.1. The first formant

The formant values of vowel /i/ are analyzed in this subsection. Fig. 3 displays the mean values of the first formant at the three positions, and ANOVA results show that there is significant difference for the formant values of vowel /i/ in the three cases: $F(2, 709) = 12.1, p < 0.001$. Further S-N-K test result demonstrates that, the formant values fall into two subsets, with the formant value lower at the medial position than the other two cases. However, there is no significant difference between the formant values at the initial and final positions of word.

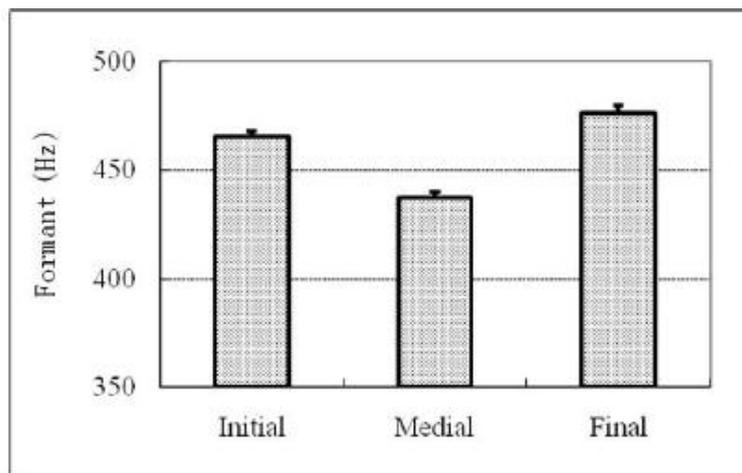


Fig. 3. The F1 values of vowel /i/ at word initial, medial and final position

3.2.2. The second formant

The average formant values of the second formant of vowel /i/ at the three positions are presented in Fig. 4. Results from ANOVA show that there is significant difference for the formant values of the vowel in the three cases: $F(2, 709) = 6.23, p = 0.002$. Further S-N-K test result displays that the data fall into two subsets, with formant values higher at word initial position than at word final position. However, there is no significant difference between formant values at word initial position and word medial position, nor is there significant difference between word final position and word medial position.

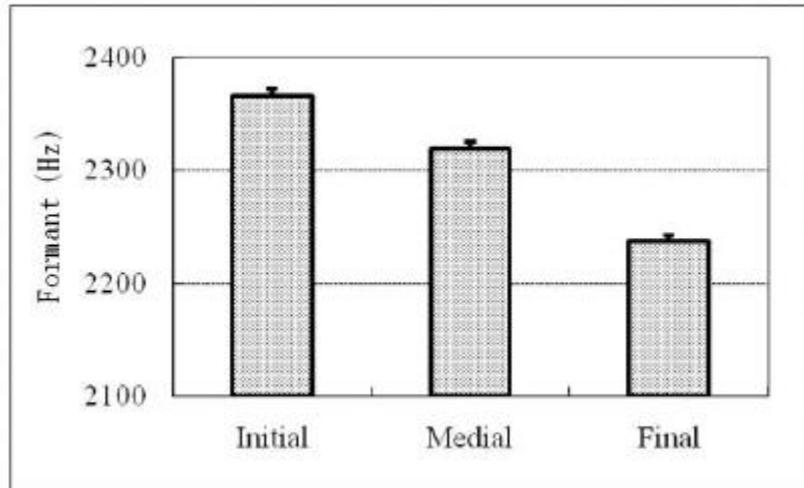


Fig. 4. The F2 values of vowel /i/ at word initial, medial and final position

3.3. Vowel /u/

3.3.1. The first formant

In Fig. 5, the average values of the first formant of vowel /u/ at various position of word are shown, and ANOVA result displays that significant difference exists for the formant values: $F(2, 716) = 53.9, p < 0.001$. It is demonstrated from further S-N-K test result that, the formant values fall into two subsets, with the F1 values higher at word final position than the other two cases. However, there is no significant difference between formant values of vowel /u/ at word initial and medial positions.

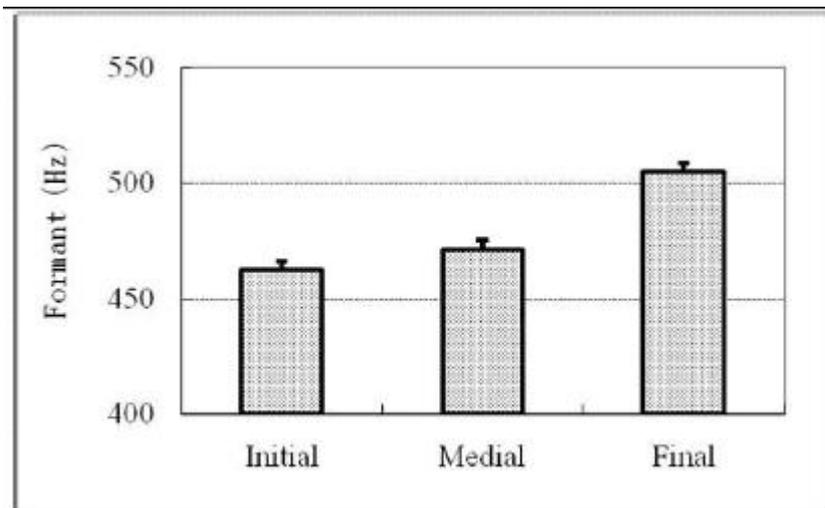


Fig. 5. The F1 values of vowel /u/ at word initial, medial and final position

3.3.2. The second formant

Fig. 6 displays the mean values of second formant of vowel /u/ at the three positions, and ANOVA results show that there is significant difference for the formant values in the three cases: $F(2, 716) = 18.4, p < 0.001$. Further S-N-K test result shows that, the formant values fall into three subsets, with the formant the highest at word final position, the lowest at word medial position, and intermediate at word initial position.

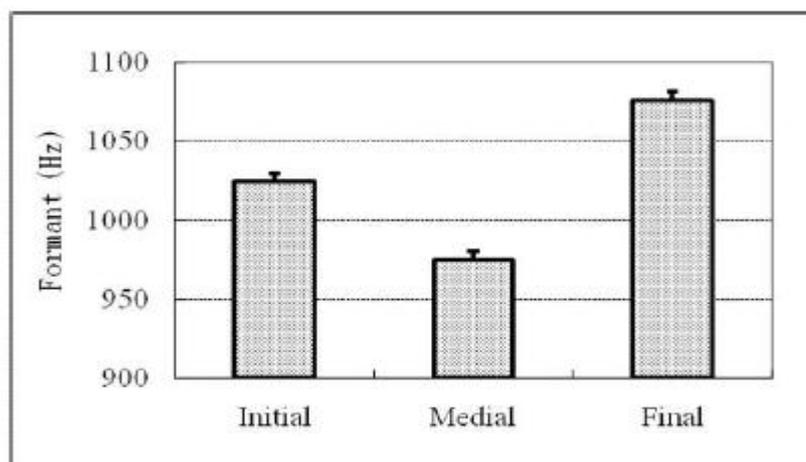


Fig. 6. The F2 values of vowel /u/ at word initial, medial and final position

IV. DISCUSSION

Results from the previous analysis shows that, for the first formant of vowel /a/, the value is lower at word medial position than at the initial and final positions. It has been reported that, segments tend to be articulatorily strengthened at the domain initial position, which is called initial strengthening. For vowel /a/, its first formant is basically high, being the highest among the vowel inventory. At word initial position, a segment is capable of being fully realized, so the F1 value is high at initial position. At the word final position, a segment tends to be lengthened, guaranteeing enough time for the vowel to be fully realized, so the F1 at the word final position is also comparatively high. As a result, the first formants of /a/ are comparatively high at the initial and final positions.

In regard to the second formant, it is displayed that the value is higher at word final position, and lower at word medial position. For vowel /a/, the basic formant pattern is that, its F1 value is high. At word final position, the duration of the vowel is comparatively long due to final lengthening mechanism, guaranteeing enough time for it to be fully realized, so the F1 value is high. As the first and second formants of /a/ are quite close to each other, when the F1 value is high, it will push the F2 to a higher position. Therefore, the second formant of /a/ at word final position is higher. At word medial position, the F1 value of vowel /a/ is comparatively low, as a result, the F2 value is also accordingly low.

As for the first formant of vowel /i/, it is demonstrated that the value is lower at the medial position than the other two cases. The basic formant pattern of vowel /i/ is that, its F1 value is low, and F2 value is high. At word initial position, segments are usually articulatorily strong, and the first formant should be low. In actually speech, the acoustic realization of phonetic sounds is not always consistent. For vowel /i/, the first formant is low at word medial position. The reason is that, in Sundanese, the realization of vowel /i/ is not as extreme as in other languages. Its first formant is not extremely low, as a result, vowel at articulatorily or prosodically strong position may not be the most extremely fully realized. Therefore, the F1 of this vowel is comparatively low at word medial position.

Regarding the second formant of vowel /i/, result shows that the value is high at word initial position, and low at word final position. The second formant of /i/ is basically high. At word initial position, the articulation of segments is strengthened, leading the vowel to be fully realized, so the F2 value is comparatively high at word initial position. At word final position, the duration of the vowel is long, and the F2 value should be high at this position. However, at word final position, the energy used in producing phonetic sound is not great, which leads to reduced strength of articulation. As a result, the F2 value of /i/ is low at word final position.

For vowel /u/, it is shown that, its first formant value is higher at word final position than at the initial and medial positions. The first formant of vowel /u/ is basically low. At word final position, the value is high, and the reason for this is similar to that of the second formant of vowel /i/. For a tri-syllabic word, the energy of the first syllable is usually great, and the articulation of the initial consonant is strong. The vowel can be fully realized, so the F1 value is relatively low. However, the energy of the final syllable is normally weak, and the articulation of segments in this syllable also tends to be weak. Therefore, the vowel at the final syllable cannot be fully realized, and the F1 value of /u/ is comparatively high.

It is shown from the result of the previous section that the second formant of vowel /u/ is the highest at word final position, the lowest at word medial position, and intermediate at word initial position. The first and the second formants of vowel /u/ are quite close to each other. As is mentioned above, the F1 value of this vowel is comparatively high at word final position, which pushes the second formant upward, so the F2 value is the

highest at word final position. On the contrary, the F1 value of vowel /u/ is comparatively low, so the F2 value is also low.

V. CONCLUSION

The present study examined the effect of position on the realization of vowels in Sundanese, and it is found that, as segments tend to be articulatorily strengthened at the domain initial position, the first formant of vowel /a/ is comparatively high. Because of the same reason, the second formant of vowel /i/ is also relatively high. At word final position, the duration of the syllable is long, guaranteeing enough time for the vowel to be realized, so the F1 value of vowel /a/ is comparatively high. In Sundanese, the first formant of vowel /i/ is not extremely low, therefore, it is fully realized at articulatorily or prosodically strong position. At word final position, the energy used in producing the phonetic sound is relatively weak, as a result, the F2 value of /i/ is low, and the F1 value of vowel /u/ is high at this position.

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