Aplinesia:
Journal of Applied linguistics Indonesia, Volume 1(1)¸March 2017

An Acoustic Study of Sundanese Vowel Sounds and Its Implication on the Teaching of English to the Sundanese Speakers

Suhendra Yusuf

Abstract: *The purpose of this study is to determine the quality of Sundanese vowel sounds. The study attempts to measure the formant frequency, duration, fundamental frequency, and spectrum of the vowels using a sound spectrograph. A comparison is made between the quality of Sundanese and English vowel sounds to see whether this can be used for practical purposes, e.g., for the teaching of English to Sundanese speakers.*
Key words: *vowel quality, spectrographic analysis, Sundanese, English*

Introduction

This study is primarily a spectrographic analysis of the Sundanese vowel sounds. The study will be confined to the analysis and description of the formant pattern, the duration, the fundamental frequency, and the spectrum of the vowels. Formant is defined as a resonance of a vocal tract. Duration is the period of time during which a vowel persists and used to distinguish similar vowels spectrally. Fundamental frequency is the lowest frequency of a periodic signal, the first harmonic of the voice. Spectrum is a graph displaying a distribution of signal energy as a function of frequency; a scheme of intensity by frequency (Kent and Read, 1992).

Sundanese belongs to the Malayo-Polynesian branch of the Austronesian family (Campbell, 1991), spoken by almostt 40 million people of West Java (BPS, 2007). In addition, Sundanese is also spoken by 500,000 - 600,000 speakers at 12 districts in the Central Java (Prawiraatmaja, 1986) and other places, such as in transmigration areas. According to van Syoc (1959), there are six distinct dialect areas of Sundanese: Banten, Jakarta, Tambun, Cirebon or Cilamaya, Karawang, and Southern Sundanese. Sudaryat (1985) mentions also ten dialects: Ciamis, Tasikmalaya, Cirebon, Kuningan, Sumedang, Subang, Purwakarta, Bogor, Serang, and Banten. There are other places which are considered to have different dialects: Sukabumi, Cianjur, and Garut, and Bandung, the capital of West Java Province. These dialects are different from each other not only in pronunciation but also in morphological processes and meaning.

Sundanese has seven monophthongal vowels including two central vowels (Cohn, 1992; Van Zanten 1988; Nothofer, 1975; Van Syoc, 1959). Most of the studies on Sundanese have been done to determine the isoglosses of dialects of the language (e.g. Ayatrohaedi, 1978 and some research projects from Pusat Bahasa), to describe the phonology and morphology of the

Suhendra Yusuf is an associate Professor, English Deparment, Nusantara Islamic University; International Quality Control, PIRLS Study IEA 2006, his e-mail address: hendrayusuf@yahoo.com

language (e.g. Robins 1953a, 1953b, 1957, and 1959; van Syoc 1959; Cohn 1990; and PPPB's research), and syntax (e.g. Oosting 1884, Grashuis 1891, Coolsma 1904, Ardiwinata 1916, Adiwidjaja 1951, Wirakusumah and Djajawiguna 1957), lexicography (Riggs 1862), and sociolinguistics (Rusyana 1975). Study of acoustic phonetics has been neglected so far.

However, two studies by Van Syoc (1959) and Cohn (1990) have used spectrograph to support their studies. In his analysis of the phonology and morphology of the language, Van Syoc has utilized spectrograph to see the juncture and intonation of several Sundanese sentences. The spectrograms show the lengthening of the final vowels in [bade?] 'desire, want', [lingih] 'to sit, remain', and [manga??ankat] 'Let's go'. He asserts that in spite of the lengthening of the final [a] in [manga?], the pause between [manga?] and [?ankat] is subtle; and the two glottal stops merge into one. The spectrogram also shows that in that sentence, the final vowel is lengthened a great deal, picturing the juncture before silence.

In her study on phonetic and phonological rules of nasalization, Cohn (1990) also has used spectrographic analysis of some Sundanese words, especially in detecting the behavior of glides and glottal stop. She believes that glides' insertion in Sundanese is a result of the phonetic formant transitions between the unlike vowels.

To sum up, the use of spectrograph in the two studies by Van Syoc and Cohn has been concentrated on several words to support their main purposes of their studies which are on the phonological and morphological systems of Sundanese in Van Syoc's study, and on the search of nasalization rules in Cohn's dissertation. The present study will be focussed on examining the acoustic quality of Sundanese vowel sounds spectrographically and will be limited to the measurement of the formant pattern, the spectrum, the fundamental frequency, and the duration of the language.

Parameters for acoustic descriptions: The sound spectrograph is considered as "the single most useful device for the quantitative analysis of speech" (Lieberman and Blumstein, 1988). Kent and Read (1992) believe that vowels are the simplest sounds to analyze and describe acoustically. At least in common understanding, vowels are connected with "a steady-state articulatory configuration and a steady-state acoustic pattern." The following parameters for the acoustic description are summarized from Kent and Read (1992). These parameters are formant pattern, spectrum, duration, and fundamental frequency.

Vowel formant pattern: Formant pattern has been a key cue for vowel perception. Experiments in synthetic speech have supported the fact that those patterns are primary features that determine the machine in perceiving vowels. Kent and Read based on Fry et. al. (1962) studies believe that if vowels are synthesized by using the formant frequencies reckoned from natural speech, the results are sufficient. Many applications have also used this technique and the results are usually satisfactory. To make generated speech machine or a 'formant synthesizer', modern speech synthesis frequently depends on formant frequency specification of speech sounds. Delineating vowels by using formant

patterns as primary cues has several benefits: (i) frugality and economy: it is sufficient to stipulate only the first three formants, or even only the first two formants, to obtain a suitable outcome; (ii) the formant patterns of vowels are usually connected with the formant patterns of neighboring consonants; and (iii) formants can be seen clearly in acoustic analysis of speech.

Vowel spectrum: We can describe vowels by looking at their spectra. Some researchers even claim that in distinguishing vowels, spectrum is better than formant pattern. The five spectral change variables (tilt, depth of valleys, log shifts in frequency and intensity, shifts in relative position of peaks, and shifts in slopes close to peaks) have affected vowel identification. In spectral tilt, the spectrum is revolved along a mid-frequency value to modify the germane amplitudes of the low-frequency and high-frequency parts.

The effects are usually small. A spectral difference where the depth of the spectral valleys is changed ensues in relatively slight effect on vowel identification as well. Logarithmic shifts have also very little effects on vowel perception/identification, except on loudness. The other two, shifts in the relative position of spectral peaks and a spectral alternation in which the slope (rate of change in spectrum) alters close to a spectral peak have large effects on vowel identification. We can summarize by saying that any spectral modification that changes the position of a peak might significantly affect the phonetic interpretation of the vowel spectrum.

Vowel duration: The next parameter is vowel duration. Very significantly vowels vary in their durations, even though duration is overlooked in the traditional F1-F2 chart. Some factors that motivate vowel duration are tense-lax or long-short feature of the vowel, vowel height, sylllable stress, speaking tempo, voicing of preceding or following consonant, and syntactic or semantic factors such as utterance position or word familiarity. Some experiments have shown that even though duration is not by itself adequate in identifying any individual vowel, it assists the listener to discriminate analogous vowels spectrally, such as [ə] versus [e] or to pinpoint vowels in a more general category such as tense versus lax or low versus high vowels.

Vowel fundamental frequency: Vowels are also different in their fundamental frequencies. The differences are frequently overshadowed by several other factors that control phonation, such as word stress, speaker emotion, and intonation. However, whenever these factors are controlled, we can definitely examine the differences in their fundamental frequencies. Among other things, the first principle is that fundamental frequency varies with vowel height: high vowels have a slightly higher fundamental frequency on the average than low vowels.

In this present study, the simple target model is utilized and all the parameters of acoustic description of vowels will be examined by using the data from Sundanese.

Method

Five native speakers of Sundanese representing two different dialects served as the subjects of this study. They are one female and four males who range from twenty to thirty-six years of age. The subjects are representing the dialects where they come from.

Each speaker was requested to read each word in the stimulus materials five times. This was based on the assumption that every individual would produce the same vowel differently in different production. Each production was then measured quantitatively and the means of all productions were counted. A total of a hundred and five words were produced and recored from each speaker.

In addition to the recorded data, other information about the individual and social background of the speakers were gained through informal interview. All speakers had moved from their hometown to the other places at least once. One speaker was born in Bandung, spent her childhood in Garut, and then went back to Bandung to pursue her undergraduate, and now lives and makes her living in Bandung. She claimed herself that she was from Bandung. Another speaker was born in Garut, spent his childhood there, and pursued his undergraduate and then made his living in Bandung. The other speakers had to move to other places because of various reasons. However, as mentioned earlier, the speakers can be considered as representing the places and the dialects where they come from.

Materials: The stimulus materials consist of disyllabic words mostly taken from a monolingual dictionary of Sundanese, i.e., Kamus Umum Basa Sunda (1985), which are very common words that the subjects know.

The use of voiceless stops in the material is based on Van Zanten's (1986) observation that it is easier to determine the vowel quality of a language acoustically when this vowel is embedded in a voiceless stop consonant. The vowels were analyzed by using an AC coupled Kay Electronics DSP Sona-Graph Model 5500.

The above words were spoken and recorded in isolation following the technique used by Skelton (1950). Accordingly, it is possible that some vowel sounds would be apparently varied when they are spoken in context and it is certainly factual that a word is usually used in context; however, there are good arguments for using words in isolation as the basis of this study. Firstly, as mentioned in the previous section that this study will ignore stress, word stress can be altered under the pressure of sentence stress (e.g. in Spanish, the word /a'ora/ may be pronounced /'aura/ or even /'ara/ in sentence like ahora viene). Secondly, intonation in Sundanese plays a very important role and has been associated with polite or impolite manner. Thirdly, this thesis is not about the pronunciation of the word as a word; it is concerned with the sound of the vowel under certain environments, without considering meaning or subjective response. And, fourthly, this procedure is in fact technically the more practical and efficient.

The words were listed in such a way so that the word containing the vowel to be measured did not appear successively. This is particularly important to keep the naturalness of the production.

Recording: The recording was conducted at the recording studio. It was done under as nearly analogous conditions as possible in order to get the accurate and homogenous data. The subjects were asked to read the materials at approximately the same rate of speed, about two hundred syllables per minute, at the distance from the microphone of four to six inches, following the technique used by Skelton (1950). Before the recording, the subjects were asked to practice reading the materials several times to adjust the reading speed, the distance from the microphone, and the distance/duration from one word to another, which is determined from two to three second. After everything was set up, the recording was started. Each speaker was recorded a total of 105 words and it took less than 15 minutes to complete the reading task.

Measuring: The measurement was done by setting up the machine into the intended target, and by moving the cursors. Some samples of the spectrogram were printed in a Gray scale printer model 5511.

In measuring the formant frequency, duration, and spectrum of the vowel sounds, the machine was set up, dividing the monitor into three empty space for formant pattern (in the lower channel), spectrum, and sound wave (upper channel). The attention was paid to the first two spaces because the sound wave was not the intent of the study. When the monitor was ready, the cassette was played, and one by one the recorded speech was displayed on the monitor.

To measure the fundamental frequency of the vowel, the machine has to be set up to 05, and made the monitor displaying the two channels: the lower channel is the spectrogram of a word/vowel, and the upper channel indicates the speech waveform which also shows the fundamental frequency of the speech. The speech data then has to be displayed again one by one.

Results and Discussion

The formant frequency: This section is to present the overall picture and the relative position of vowels in the vowel-quadrilateral graph. The graphs demonstrate a variety of patterns and positions of vowels in every production of the subjects of this study. However, generally the position of female vowels are higher than that of male vowels. As seen in the graphs, the two central vowels in female production are very close to each other, some even are very close to the production of vowel /e/. In male productions, on the other hand, the vowel /Ĕ/[1] is slightly higher than the Sundanese schwa /ə/, and it is close to the production of vowel /u/. The next graph is five quadrilaterals which show the means of all of the vowels as produced by all speakers.

[1] Phoneme /Ĕ/ is a high central vowel like in the word *beureum* ‘red’

The quadrilaterals portray not only the lower position of the female production as compare to the position of male vowels (male F-1 is lower than female F-1), but also the more fronting position of all vowels (male F-2 is lower than female F-2). The only exception is the degree of backness of vowels /u/ and /o/ which are almost as same as those of male vowels. The data show that the F-2 for those two vowels in female speaker is as same as in male speakers.

All of the Sundanese vowels are lower than their counterparts in English, except for the vowel /i/, as performed consistently by both male and female speakers of the two languages. In the female speakers, the Sundanese vowels /i/ and /u/ are almost as high as /Ĕ/ and /ə/; while /e/ is between the English vowels /ʌ/ and /æ/, and Sundanese /o/ is between the English /o/ and /a/. The Sundanese /a/ is the lowest of all the vowels. The two central vowels /ə/ and /Ĕ/ are, in this female production, lower than the English schwa. In male speakers, on the other hand, the position of Sundanese /i/, /e/, /o/, and /u/ are roughly between /i/ and /Ĕ/, /ə/ and /ə/, /ə/ and /a/, and /ə/ and /u/ respectively. Even though the Sundanese /a/ is the lowest, it is not as low as in the female speaker. The vowel /ə/ is lower than the English schwa, but the /Ĕ/ sound is slightly higher than this English central vowel.

To summarize, the relative position of the seven Sundanese vowels varies in every production of the native speakers of Sundanese. However, the means of all productions show that the male speakers have lower F-1 and F-2 than the female speaker. While the two central vowels /ə/ and /Ĕ/ are relatively close to each other in the female speaker, the /ə/ is closer to the /e/ and the vowel /i/ is closer to /u/ in male speakers. Compared to the English vowel system, the position of the Sundanese vowels are relatively lower than those of English.

Vowel duration: The duration of Sundanese vowels varies from one speaker to the others. We almost can not make a difference between vowels by looking only at their durations. What is significant in this study is that the duration of the vowel in the final position is always twice or three times longer than that in the initial or medial position. The male speakers consistently pronounce the initial vowels relatively longer than the medial vowels. In female speaker, on the other hand, the initial position of vowels /i/, /a/, and /u/ are slightly longer than those vowels of the medial position; while the medial position of vowels /i/, /e/, and /o/ are longer than those vowels of the initial position.

Compared to the duration of English vowels, Sundanese vowels are relatively shorter than that of English. Peterson and Lehiste (1960) reported that the average of 'intrinsic' durations of syllable nuclei for vowels in American English are 240, 180, 200, 330, 230, 260, 310, 200, and 260 msec respectively. This study was based on the production of five speakers of American English and did not make a male-female distinction. The next graph compares the means of vowel durations of English and Sundanese. The average of Sundanese duration is 124.3, 140.3, 45.3, 138, 140.8, 135.8, and 130.5 msec for vowels /i, e, ə , Ĕ, a, o, u/ respectively.

In summary, duration of Sundanese vowel sounds can not be used for identifying the quality of the vowels because of its various length of every production by native speakers. It can be reported that the longest vowel in female production is /e/ (154.7 msec in average), followed by /a/ (149 msec), /Ĕ/ (138.4 msec), /o/ (136.2 msec), /i/ (133.6 msec), /u/ (133.5 msec), and the shortest /ə/ (45.2 msec). In male productions, the longest vowel is / Ĕ / (137.6 msec), followed by /o/ (135.4 msec), /a/ (132.5 msec), /u/ (127.5 msec), /e/ (125.9 msec), /i/ (115 msec), and /ə/ (45.3 msec). Compared to the duration of the English vowels, the Sundanese vowels have shorter duration than that of English.

Fundamental frequency: The fundamental frequency of the Sundanese vowel sounds also varies with every production of every speaker. Some productions are in conformity with the theory which says that the fundamental frequency is associated with vowel height. That is, high vowels have relatively higher fundamental frequency and low vowels have lower frequency. While the position of vowels has no effect in fundamental frequency of female speaker, the vowels in word final position in male productions are consistently higher than those of the initial and medial positions.

Compare to the fundamental frequency of the English vowel sounds, the Sundanese vowel sounds have lower frequency both for male and female speakers, except for vowel /o/ which is a little bit higher than the English vowel /o/ in Lehiste and Peterson's study.

Vowel spectrum: The spectrum of the seven Sundanese vowels varies from one speaker to another; however, the pattern of the graph of the spectrum is almost always identical for every vowel.

The position of the vertical cursors in the above graphs are exactly in the first and second formants of the vowels which also point to the peaks of those formants in the spectrum graphs, while the horizontal cursors mark the vowels (which also show the duration of the vowels). The spectrum graphs also portray the peaks of the other formants, e.g. for vowel /a/, we can see the peaks of F-3, F-4, and F-5. These patterns of vowel are always identical. The changes in the pattern are usually very slight for every production of the vowels. The following graphs show those changes for every vowel of each speaker. The observation is limited to the difference between the amplitude of the first and the second formant since these two formants are very significant in determining the position of the vowels in the vocal tract in the traditional articulatory descriptions of vowels.

Just like formant pattern and fundamental frequency, the spectrum of the Sundanese vowels has also been assiciated with vowel height. That is, high vowels have relatively higher spectrum and low vowels have lower amplitude.

Conclusion

The frequency of the first formant as portrayed in the spectrogram undoubtedly shows the relative vowel height, and the distance between the first and second formants indicates the degree of backness. The overall picture

and the relative position of vowels in the vowel-quadrilateral graph have been presented in the preceding chapter. The graphs demonstrate a variety of patterns and positions of vowels in every production of the subjects of this study. However, generally the positions of the vowels are higher for female than for male speakers. The two central vowels in female speech are very close to each other, some nearly converging on the vowel /e/. In male speech, on the other hand, the vowel / Ĕ / is slightly higher than schwa /ə/, and it is nearly converges on the vowel /u/.

The quadrilaterals portray not only the overall lower position of vowels for female than for males, but also the more fronting position. The only exception is the degree of backness of vowels /u/ and /o/ which are almost as same as those of male vowels. The data show that the F-2 for those two vowels in female speaker is as same as in male speakers.

The next parameter examined in this study is vowel duration. Very significantly vowels vary in their durations, even though duration of Sundanese vowels varies from one speaker to the next. We can not distinguish among vowels by looking only at their durations. What is significant in this study is that the duration of the vowel in the final position is always twice or three times longer than in the initial or medial position.

In this study, the male speakers consistently pronounce the initial vowels relatively longer than the medial vowels. For the female speaker, on the other hand, vowels /i/, /a/, and /u/ in the initial position are slightly longer than those vowels of the medial position; while in medial position, vowels /i/, /e/, and /o/ are longer than those vowels of the initial position.

In short, the duration of Sundanese vowel sounds can not be used for identifying the quality of the vowels. The longest vowel in female production is /e/ (154.7 msec in average), followed by /a/ (149 msec), / Ĕ / (138.4 msec), /o/ (136.2 msec), /i/ (133.6 msec), /u/ (133.5 msec), and the shortest /ə/ (45.2 msec). In male productions, the longest vowel is / Ĕ / (137.6 msec), followed by /o/ (135.4 msec), /a/ (132.5 msec), /u/ (127.5 msec), /e/ (125.9 msec), /i/ (115 msec), and /ə/ (45.3 msec).

The seven Sundanese vowel sounds are also different in their fundamental frequencies. This fundamental frequency varies with every production of every speaker. Some evidence conforms to theory which says that the fundamental frequency is associated with vowel height. That is, high vowels have relatively higher fundamental frequency and low vowels have lower frequency.

The result of this study indicates that two speakers, speaker-2 and speaker-3, go along with what has been predicted by the theory, even though the difference between /i/ and /e/ in speaker-3 is very small (0.5 Hz). What is very interesting is that the fundamental frequency of vowel /i/ is the highest (132.6 Hz) in speaker-4, while in speaker-3, it is the second (128.3 Hz) after the highest vowel /u/ (129 Hz). The difference is only 0.7 Hz. Speaker-5 produces vowel /i/ (120.2 Hz) as high as vowel /o/ (120.1 Hz) and puts /u/ as the highest. Speaker-1, on the other hand, puts vowel / Ĕ / as having the highest frequency (214.6 Hz) which is followed by the vowel /i/ (211.3 Hz),

while speaker-2 pronounces /i/ (120.3 Hz) as almost high as / Ĕ / (120.9 Hz) but lower than the highest /u/ (123.3 Hz).

While the position of vowels has no effect on fundamental frequency for the female speaker, the vowels in word final position in male productions are consistently higher than those of the initial and medial positions.

The spectrum of the seven Sundanese vowels varies from one speaker to another; however, the pattern of the graph of the spectrum is almost always identical for every vowel. Similar to vowel formant patterns and their fundamental frequencies, the spectrum of the Sundanese vowels has also been associated with vowel height. That is, high vowels have relatively higher spectrum and low vowels have lower amplitude.

Comparison of the results with the English vowel sounds: The purpose of this comparison is both to examine the overall picture of Sundanese vowel formant patterns, durations, fundamental frequencies, and spectra as compared to other languages, in this case, to English; and to see whether this comparison can be used for practical purposes, e.g., for the teaching of English to Sundanese speakers, or vice-versa. The results on the vowel formant patterns show that the positions of the Sundanese vowels are relatively lower than those of English, except for the vowel / Ĕ /, as performed consistently by both male and female speakers of the two languages. In the female speaker, the Sundanese vowels /i/ and /u/ are almost as high as /Ĕ/ and /ə/; while /e/ is between the English vowels /æ/ and /ʌ/, and Sundanese /o/ is between the English /o/ and /a/. The Sundanese /a/ is the lowest of all the vowels. The two central vowels /ə/ and /Ĕ/ are, in this female production, lower than the English schwa. In male speakers, on the other hand, the position of Sundanese /i/, /e/, /o/, and /u/ are roughly between /i/ and /Ĕ/, /e/ and /ə/, /ə/ and /a/, and /ə/ and /u/ respectively. Even though the Sundanese /a/ is the lowest, it is not as low as in the female speaker. The vowel /ə/ is lower than the English schwa, but the /Ĕ/ sound is slightly higher than this English central vowel.

Compared to the duration of English vowel sounds, Sundanese vowels are relatively shorter than that of English. The average of duration of American English vowels /i, I, e, ʌ , æ , a, o, µ , u/ as reported by Peterson and Lehiste (1960) is 240, 180, 200, 330, 230, 260, 310, 200, and 260 msec respectively. This study was based on the production of five speakers of American English and did not make a male-female distinction. The average of Sundanese duration is 124.3, 140.3, 45.3, 138, 140.8, 135.8, and 130.5 msec for vowels /i, e, ə , Ĕ, a, o, u/ respectively.

Compare to the fundamental frequency of the English vowel sounds, the Sundanese vowel sounds have lower frequency both for male and female speakers, except for vowel /o/ which is higher than the English vowel /o/ in Lehiste and Peterson's study. The fundamental frequency for the English vowels /i, I, e, ʌ , æ , a, o, µ , u/, as reported by Peterson and Barney (1952) is respectively 235, 232, 223, 210, 212, 216, 221, 218, 232, and 231 Hz for female speaker, and 136, 135, 130, 127, 124, 129, 130, 133, 137, and 141 Hz for male speaker. The Sundanese fundamental frequency for vowel /i/, /e/, /ə/, /Ĕ/, /a/, /o/, and /u/ in this study is 214.6, 204.9, 202, 211.3, 204.7, 196.7, and

208.5 Hz, for female speaker and 119, 119.6, 113.7, 125.4, 114.4, 119.3, and 126.3 Hz for male speakers.

And finally, in comparison to English, the following numbers indicate the spectra of the vowel sounds of the two languages. The data of English spectrum which is taken from Peterson and Barney (1952) show that vowels /i, I, e, ʌ , æ , a, o, µ , u/ have the following differences between F-1 and F-2 amplitude: 20, 20, 15, 11, 9, 10, 4, 7, 11, and 14 dB. The Sundanese counterparts for vowels /i/, /e/, /ə/, /Ĕ/, /a/, /o/, and /u/ are 23.9, 11, 6.8, 15.9, 3.6, 5.3, and 22.7 dB for female speaker, and 21, 12.5, 9, 18.4, 5.5, 6.8, and 21.2 dB for male speakers. We can see that the Sundanese vowels /i/ and /u/ is relatively higher than those of English, and /e/ and /o/ are lower than their counterparts. The English /a/ is in between male and female /a/. And, finally, Sundanese /Ĕ/ is higher than the English /ə/.

Those comparisons reveal the evidence that the Sundanese, when he has to pronounce English vowels, has to raise his vowel sounds almost for all vowels. For the female Sundanese speaker, her vowels /i/ and /u/ are as high as vowels /Ĕ/ and /ə/; meaning that she has to raise her tongue if she wants to pronounce vowels /i/ and /u/. At the same time, she has also to pull out her tongue a little bit to the backward position because the Sundanese vowel pattern has a more fronting position than that of English. So do vowels /e/, /o/, and /a/. The same thing has to be done by the Sundanese male speaker. The vowel quadraterals show the relative positions of the vowels of the two languages and efforts have to be made by either Sundanese speaker who want to pronounce English vowels or vice versa in order to be able to produce the correct pronunciation.

The Sundanese speaker produces shorter duration than the English. The comparison between the vowel duration of the two languages indicates that the duration of English vowels is as twice as that of the Sundanese. The Sundanese learning English have to be aware of these differences and have to produce the English vowels longer than theirs.

The fundamental frequency and the spectrum of vowel sounds are associated with the vowel height. High vowels have relatively higher fundamental frequency and spectrum and low vowels have lower ones. Similar to what has to be done with the differences in formant patterns, the speakers of the two languages have to make a difference between those aspects of vowel quality, and adjust their vowel pitch whenever they want to produce the language.

Directions for further research: This study provides the very basic description of the physical quality of the seven Sundanese vowel sounds. The subjects of this study are only five from millions of the native Sundanese speakers, and the stimulus materials for this study have been designed for a very limited data because of time constraints. A study with a larger number of speakers is now needed to be conducted in order to be able to see the dialectal differences between the native speakers. The stimulus materials need to be elaborated as well, so that not only the vowel in a certain environment that is examined, but also the vowels in all environments.

A more systematic study on acoustic phonetics of Sundanese consonants also need to be done. Nasal consonants have been studied by Cohn (1990) in comparison with the nasal consonants of other languages, in this case English and French. However, her data were very limited in scope and were based on the production of three native speakers. The more elaborated study by speakers of various dialects might be very meaningful. The other Sundanese consonants need to be examined acoustically as well in order to have a better understanding of the language.

Finally, the study of suprasegmental phonemes of the language also needs to be done acoustically. More study on stress, accent, and intonation of the language needs to be conducted, paying special attention to dialect differences. The previous study on the intonation of the language by Van Syoc (1959) has to be used with caution not only because of the author's insufficient handling of his data but also because his study was based only on the production of one native speaker.

References

Anderson, Stephen R. 1972. 'On nasalization in Sundanese'. Linguistic Inquiry, 3.

Ayatrohaedi. 1978. Bahasa Sunda di Daerah Cirebon (Sundanese in Cirebon). PhD. Dissertation. Universitas Indonesia.

Cohn, Abigail C. 1990. Phonetic and phonological rules of nasalization. UCLA Ph.D. dissertation.

Cohn, Abigail C. 1992. 'The consequences of dissimilation in Sundanese'. Working papers of the Cornell phonetics laboratory no. 7, March 1992.

Kamus Umum Basa Sunda (Sundanese dictionary). 1985. Lembaga Bahasa Jeung Sastra Sunda (LBSS). Bandung.

Kent, Ray D., and Charles Read. 1992. The acoustic analysis of speech. Singular Publishing Group, Inc. San Diego.

Ladefoged, Peter. 1975. A course in phonetics. Harcourt Brace Jovanovich, Inc. New York.

Lehiste, I. 1967. Readings in acoustic phonetics. Cambridge, M.A. M.I.T. Press.

Lehiste, I and Peterson, G.E. 1961. Transitions, glides, and diphthongs. Journal of the acoustical society of America, 33, 268-277.

Lieberman, Philip and Sheila E. Blumstein. 1988. Speech physiology, speech perception, and acoustic phonetics. Cambridge University Press, Cambridge.

Peterson, G.E. and I. Lehiste. 1960. Duration of syllable nuclei in English. Journal of the Acoustical Society of America, 24, 693-703.

Prawiraatmadja, Dudu, et.al. 1986. Perkembangan bahasa Sunda sesudah Perang Dunia II. Pusat Pembinaan dan Pengembangan Bahasa.

Robins, R.H. 1953. 'The phonology of the nasalized verbal forms in Sundanese'. BSOAS 15, 138-45.

Robins, R.H. 1957. 'Vowel nasality in Sundanese: a phonological and grammatical study' in Studies in linguistics analysis. Basil Blackwell, Oxford.

Robins, R.H. 1983. Sistem dan struktur bahasa Sunda. Jambatan, Jakarta.

Skelton, Robert B. 1950. A spectrographic analysis of Spanish vowel sounds. Ph.D. Dissertation. University of Michigan.

Stevens, Alan M. 1977. 'On local ordering in Sundanese '. L.I. 8. 155-62.

Sudaryat, Yayat. 1985. Pedaran basa Sunda (Describing Sundanese). Fa. Ekonomi, Bandung.

Van Syoc. 1959. The phonology and morphology of the Sundanese language. Ph.D. Dissertation. University of Michigan.

Van Zanten, Ellen. 1989. The Indonesian vowels: acoustical and perceptual explorations. Ph.D. dissertation the University of Leiden.

Yusuf, Suhendra. 1998. Fonetik dan Fonologi. Gramedia, Jakarta