2

Quality of Javanese and Sundanese Vowels

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Abstract

The aim of this study is to describe the vowel systems of Javanese and Sundanese. The acoustic properties of vowels in Javanese and Sundanese vowels have not been instrumentally examined. The current study seeks to investigate to what extent the vowels produced by Javanese and Sundanese speakers match the impressionistic description of the Javanese vowels found in Wedhawati et al. (2006) and Sundanese vowels described by Crothers (1978). We recorded the vowel production of four Javanese and four Sundanese native speakers and measured the formant frequencies F_1 and F_2. The results confirm that the Javanese schwa is considerably higher than its Sundanese counterpart. Javanese schwa was also found to be higher than Javanese /e/ and /o/. Sundanese male speakers (but strangely not the female speakers) produced a closed central vowel /ɨ/. Overall, the results fit Crothers' description mentioning that Sundanese has one closed and one mid central vowel in a 7-vowel sound system. Overall, the findings of the formant frequencies of the Javanese and Sundanese vowels are consistent with the description of the vowels in the earlier studies by Wedhawati et al. (2006) and Crothers (1978). In addition, the durations of Javanese and Sundanese are phonetically short, between 60 and 100 ms for all vowels.

Keywords: *acoustic analysis, formants, vowel quality, phonation, Javanese, Sundanese*

2.1 Introduction

Javanese has the most first-language speakers of any Austronesian language (Ogloblin, 2005; Oakes, 2009). Javanese is spoken by about 65 million people and considered the thirteenth most widely spoken language in the world (Comrie, 2003). Nothofer (1982) classifies Javanese as a member of the Malayo-Polynesian subgroup, which includes Malay, Madurese, Sundanese, and Lampung. Javanese is spoken primarily in the central and eastern region of Java Island (Oakes, 2009). There are three dialects of Javanese, which are mutually intelligible: Solo-Yogyakarta, East Javanese, and West Javanese (NVTC, 2007; Cole, Hara, & Yap, 2008). The Solo-Yogyakarta dialect is spoken in the center of Java and is considered the standard form of Javanese. The East Java dialect is spoken in Surabaya, Malang, and Pasuruan, and the West Javadialect is spoken in Banten, Cirebon, and Tegal (Gordon, 2005). The present study examines the vowel quality of the Solo-Yogyakarta dialect.

Sundanese is spoken by approximately 34 million people in Indonesia, making it the second most widely spoken first language in Indonesia after Javanese (Lewis, 2009). Sundanese is spoken in the western half of the island of Java (Hardjadibrata, 1985) (see Figure 2.1). Sundanese has four dialects: Banten, Bogor - Karawang, Priangan, and Cirebon (Nothofer, 1977; Muslim et al., 2010). The Banten dialect is spoken in Karesidenan Banten, the Bogor-Karawang dialect is spoken in Tangerang, Bogor, Purwakarta, Krawang, and Subang, the Priangan dialect is spoken in Karesidenan Priangan, and the Cirebon dialect is spoken in Karesidenan Cirebon, Brebes, and Cilacap. The subjects in the current study spoke the Bogor-Karawang dialect of Sundanese.

Figure 2.1 Map of traditional languages spoken on the island of Java (Source: Simons & Fennig, 2018).

2.2 Javanese and Sundanese Vowels

The current study aims to describe the vowel system of Javanese and Sundanese. The study will further examine whether the Javanese and Sundanese-accented vowels in Standard Indonesian are identical to their Javanese and Sundanese counterparts. Javanese comprises six vowel phonemes: /a, ə, i, u, e, o/ (Uhlenbeck, 1963; Horne, 1961; Clynes & Rudyanto, 1995). In the view of most scholars, it has four allophonic pairs: [i] - [ɪ], [u] - [ʊ], [e] - [ɛ], and [o] - [ɔ] (Dudas, 1976; Wedhawati et al., 2006; Nothofer, 2009). According to Wedhawati et al. (2006), the Javanese vowels are classified as high front /i - ɪ/, high back /u - ʊ/, mid front /e - ɛ/, mid central /ə/, mid back /o - ɔ/, and low central /a/ (Wedhawati et al., 2006).

Sundanese comprises seven vowels (Crothers, 1978; Van Zanten & Van Heuven, 1984; Sudaryat et al., 2007). According to Crothers (1978) and Sudaryat et al. (2007), Sundanese vowels are classified as high front /i/, high central /ɨ/, high back /u/, mid front /e - ɛ/, mid central /ə/, mid back /o - ɔ/, and central low /a/. Conforming to the standardized orthography showed by Tamsyah (1996), Hardjadibrata (2003), and Danadibrata (2006), Kurniawan (2013) mentions that /ɨ/ represents a central unrounded vowel and is produced in a higher position than the schwa /ə/.

Van Zanten & Van Heuven (1984) showed that /i/ and /u/ are closer to one another in Javanese accented Bahasa Indonesia than in Sundanese accented Bahasa Indonesia. Moreover, they also found that the position of schwa in Javanese is much higher than in Sundanese. The Javanese-accented schwa was in fact found to be higher than that of the /e/ and /o/ counterparts, both in sound production and in the perceptual representation of the vowel system. The Javanese and Sundanese vowel are illustrated in Figure 2.2.

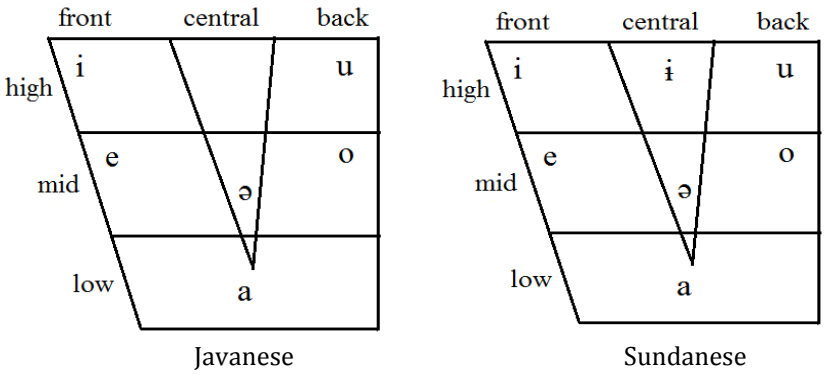

Figure 2.2 The positions of the vowels of Javanese vowel inventory (left) (Dudas, 1976) and Sundanese (right) (Crothers, 1978).

2.2.1 Vowel quality in Javanese and Sundanese

Vowel quality in Javanese and Sundanese is claimed to be influenced by phonation differences, which are correlated with the stops in the preceding syllables (Fagan, 1988; Hayward, 1993, 1995; Thurgood, 2004). Fagan (1988) analyzed acoustic differences between the slack-voiced stops /b/, /d̰/, /ɖ/, and /g/ and the stiff-voiced stops /p/, /t̰/, /ʈ/, and /k/ followed by /a/. His study shows that Javanese slack-voiced stops are characterized by a lower F_0, a lower F_1, and a higher F_2. Fagan (1988) claims that vowels following stiff-voiced stops are pronounced with a clear voice, while vowels following slack-voiced stops are pronounced with breathy voice.

A later investigation by Hayward (1993) yielded similar results: Javanese vowels are pronounced with lower F_1 and F_0 after the slack-voiced /b/. She also observed a high F_2 after voiced stops. Hayward (1995) extended her study by comparing the Voice Onset Time (VOT) of the stiff-voiced /p/ and the slack-voiced /b/, as well as the vowels /i/, /u/, /ɔ/, and /a/ following the stops. Her study shows that Javanese slack-voiced stop /b/ is characterized by having a lower F_0 at the vowel onset and was pronounced with negative VOT. Hayward (1993) summarized that the slack-voiced stop /b/ characterizes breathiness in Javanese, and the breathiness is manifested in the vowels, not in the consonants themselves.

In her acoustic study of Javanese vowels /u/, /ɔ/, and /a/, Thurgood (2004) found that vowels after the stiff-voiced stops /p/ and /k/ or the slack-voiced stops /b/ and /g/ have different formant frequencies. The vowel /a/ is the only vowel which is characterized as

having a lower F_0 after the voiced stops. The vowel /ɔ/ was articulated with a lower F_0 after a velar stop, higher F_0 after a bilabial stop. The vowel /u/ was articulated with a higher F_0 after bilabial and velar stops. The raising of F_2 was found after slack-voiced stops in all vowels. Thurgood (2004) concluded that the phonetic realization of vowels after slack-voiced and stiff-voiced stops in Javanese includes the distinct breathy voice used for emphasis.

A recent study by Gordon et al. (2012) reported F_1 values of Javanese vowels by two speakers and found that F_1 distinguished between four heights where /i/ - /u/ (high) and /e/ - /o/ (mid) show roughly the same F_1 within the pairs. Schwa was found to be in a height category by itself, in between high and mid. Gordon et al. (2012) did focus on F_1, maximum intensity, acoustic energy, and perceptual energy of the vowels; the study did not measure F_2.

The present chapter is limited to the investigation of vowel quality independent of consonantal context - hence, although two consonantal contexts were used, we will only discuss vowel quality of the mean formant values averaged over the consonantal contexts.

Van Zanten & Van Heuven (1984) specifically reported that the central vowel /ə/ realization in Standard Indonesian appears to be more back and closed for the Javanese speakers than for their Sundanese and Toba Batak groups. The central vowel as pronounced by the Javanese speakers is in a mid-position, almost exactly half-way between /e/ and /o/, which contradicts the more recent findings by Gordon et al. (2012). The central vowel of the Sundanese speakers is considerably more closed. The Sundanese speakers have relatively closed realizations of /i/ and especially /u/. Toba Batak, on the other hand, has no central vowel in its phoneme system.

There is little recent published data on acoustic measurements of Javanese and Sundanese vowels which can be compared to the present study. For instance, Wedhawati et al. (2006) described the Javanese vowel system but did not acoustically examine the data. Thus, it is hard to reach conclusions regarding the accuracy of the tongue position of the speakers when they pronounced Javanese vowels.

The current study investigates to what extent the Javanese and Sundanese vowels produced by the Javanese and Sundanese speakers is identical to, respectively, the Javanese vowel system as described by Wedhawati et al. (2006) and to the Sundanese vowel system described by Crothers (1978). We predict that the Javanese speakers produce the Javanese central vowel /ə/ as found by Wedhawati et al. (2006) and Van Zanten and Van Heuven (1984). We also expect to find that the position

of schwa pronounced by Javanese speakers is considerably higher than its Sundanese counterpart. Following Crother's (1978) description, Sundanese has one closed /ɨ/ and one mid /ə/ central vowel in a 7-vowel sound system. Overall, the present study seeks to characterize the vowel quality of Javanese and Sundanese vowels produced by Javanese and Sundanese speakers, respectively.

2.3 Materials and Methods

2.3.1 Participants

We collected speech data from 4 L1 Javanese speakers (2 male, 2 female, M_{age} = 34.75, SD = 6.9) and 4 L1 Sundanese speakers (2 male, 2 female, M_{age} = 35, SD = 4.7). The participants use the Javanese or the Sundanese language for daily interactions. The Javanese participants were considered to speak the Solo and Yogyakarta dialect while the Sundanese participants were considered to speak the Priangan dialect. All the participants demonstrated normal speech and hearing abilities.

2.3.2 Stimuli

Javanese vowels /i/, /e/, /a/, /ə/, /u/, and /o/ and Sundanese vowels /i/, /a/, /ə/, /ɨ/, /e/, /u/, and /o/ were inserted in /b/...$C and /h/...$C where $ refers to a syllable boundary. The target vowels and the syllables were embedded in a carrier phrase, *Kula ngendika ... malih* "I say … again" for Javanese speakers, and *Abdi nyarios ... deui* "I say … again" for Sundanese speakers. The participants read the lists three times in random order. In total, the Javanese dataset comprises 3 repetitions × 6 vowels × 4 speakers = 72 items, and the Sundanese dataset comprises 3 repetitions × 7 vowels × 4 speakers = 84 items. The list of stimulus words is shown in Table 2.1.

Table 2.1 Javanese and Sundanese vowels in /b/...$C and /h/...$C sequences.

/b/...$C sequences			
Javanese	Target Word	Transcription	English Gloss
/a/	***ba****dhe*	/'**ba**dhe/	will (be)
/ə/	***be****cik*	/'**bə**cɪk/	main
/i/	***bi****narung*	/'**bi**naruŋ/	in a row
/o/	***bo****dho*	/'**bo**do/	stupid
/u/	***bu****deg*	/'**bu**'dəg/	deaf
/e/	***be****lekan*	/'**be**leʔan/	sore eyes
Sundanese	Target Word	Transcription	English Gloss
/a/	***ba****tur*	/'**ba**tur/	colleague
/ə/	***be****legbeg*	/'**bə**ləgbəg/	murky
/i/	***bi****tu*	/'**bi**tu/	explode
/o/	***bo****lotot*	/'**bo**lotot/	goggle
/u/	***bu****ni*	/'**bu**ni/	sealed
/e/	***be****ntes*	/'**be**ntes/	clear
/ɨ/	***beu****reum*	/'**bɨ**rɨm/	red
/h/...$C sequences			
Javanese	Target Word	Transcription	English Gloss
/a/	***ha****kekat*	/'**ha**kekat/	truth
/ə/	***he****mpas*	/'**hə**mpas/	smash
/i/	*wa****hi****ng*	/wa'**hi**ŋ/	sneeze
/o/	***ho****bi*	/'**ho**bi/	hobby
/u/	*dhu****hu****r*	/du'**hu**r/	high
/e/	***he****bat*	/'**he**bat/	great
Sundanese	Target Word	Transcription	English Gloss
/a/	***ha****ndap*	/'**ha**ndap/	under
/ə/	***he****nteu*	/'**hə**ntɨ/	no
/i/	***hi****deung*	/'**hi**dɨŋ/	black
/o/	***ho****ream*	/'**ho**ream/	lazy
/u/	***hu****rung*	/'**hu**ruŋ/	sparkle
/e/	***he****rang*	/'**he**raŋ/	shine
/ɨ/	***heu****rin*	/'**hɨ**rin/	narrow

2.3.3 Procedure

Participants were audio recorded one by one in a sound attenuated room. Before the recording started, participants filled in a demographic questionnaire and signed a consent form. Participants were then familiarized with the equipment, stimuli, and procedures for the production experiment. The stimuli (in the carrier phrase) were shown on a computer screen in random order. Immediately after a sentence appeared, participants read it aloud in a natural tone. The display of the monitor is set to 10 seconds. Speakers cut the sentences into three parts: *ngendik/nyarios xxx malih/deui* so that the speech becomes more intelligible. Recordings were made on a digital audio recorder (H4N Zoom, 44.1 kHz, 16 bit) using an adjustable microphone headset (Sennheiser PC 141). The microphone was placed 3 cm away from the right-hand corner of the participant's mouth.

2.3.4 Analysis

Using Praat (Boersma & Weenink, 2013), the beginnings and end points of the target vowels were located in the spectrogram. The first formant (F_1) and second formant (F_2) were estimated using the Burg Linear Predictive Coding (LPC) algorithm. Formant tracks were overlaid on the wideband spectrogram. Whenever a visual mismatch occurred between the tracks and the formant bands in the spectrogram, the model order of the LPC analysis was changed by trial and error until a satisfactory match was obtained. The values of F_1, F_2 and duration were then stored for offline statistical analysis.

After the formant frequency values were estimated, we took the mean of the /b/...$C items and /h/...$C items because the purpose of the current study is not to examine the effect of these contexts, but rather to describe the vowels of the Javanese and Sundanese independently of context.

Because the current data set was very small (n = 4 per group, k = 3 per vowel per context), we decided to present the data using descriptive statistics only. Formant frequencies will be plotted in vowel plots for descriptive purposes.

For plotting purposes, formant frequency measurements in hertz were converted to psychophysically more realistic Bark units using the formula suggested by Traunmüller (1990). Since the vocal tracts of female speakers are some 15 percent smaller than those of male speakers, the values of F_1 and F_2 values for the same vowel are different across speakers of different gender. In order to compare vowel formants

across different speakers, vowel normalization was applied to the Bark-scaled measurements. We used z-normalization of F_1 and F_2 frequencies (Lobanov, 1971). To get the z-normalized scores, the speaker's mean formant frequency (for either F_1 or F_2) is subtracted from each token-individual formant frequency, and the difference is then divided by the speaker's standard deviation. Z-normalized F_1 values below 0 refer to relatively close/high vowels, whilst values larger than 1 correspond to open vowels. Positive z-values for F_2 correspond to front vowels, whilst negative F_2 values refer to back vowels.

2.4 Results

2.4.1 Formant Frequencies

Table 2.2 presents the means ($\bar{x}$) and standard deviations (SD) of the measured F_1 and F_2 values of the six Javanese vowels and seven Sundanese vowels, produced by the four speakers for each language. All values in the table are in hertz (Hz).

Table 2.2 Mean ($\bar{x}$) and Standard Deviation (SD) in Hz of the six Javanese and seven Sundanese vowels produced in a carrier sentence. F_1 and F_2 values are broken down by regional language and by gender, N = 12 per cell.

Vowel	Gender	Javanese				Sundanese			
		F_1		F_2		F_1		F_2	
		$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
/i/	female	381	67	2200	119	405	26	2236	46
	male	345	30	2179	142	307	32	2349	191
/e/	female	579	46	2073	159	569	20	2199	164
	male	486	27	1954	44	504	61	1863	85
/a/	female	788	88	1723	111	812	52	1702	115
	male	625	105	1650	272	599	49	1413	72
/o/	female	513	70	1108	50	648	86	1238	90
	male	473	82	1160	170	412	18	1030	82
/u/	female	451	53	1272	114	475	16	1151	53
	male	473	82	1160	170	378	35	979	39
/ə/	female	489	31	1614	214	571	46	1647	138
	male	405	51	1682	198	488	15	1356	250
/ɨ/	female	514	45	1709	95	-	-	-	-
	male	347	18	1479	17	-	-	-	-

Figures 2.3a-d present F_1 and F_2 mean values (in Bark units, after within-speaker z-transformation) of the six Javanese vowels produced by Javanese speakers and the seven Sundanese vowels produced by Sundanese speakers. The large phonetic symbols in the plots are placed at the centroids of the vowels, i.e. at the intersection of the mean F_1 and mean F_2 coordinate values. The individual vowel tokens are indicated by smaller-sized symbols. Spreading ellipses were drawn at ±1 SD along the two principal components optimally characterizing the scatter of the individual tokens around the centroid, theoretically capturing the most typical 46% of the distribution.[2]

[2] Figure 2.3 was produced using the Visible Vowels on-line facility (Heeringa & Van de Velde, 2017).

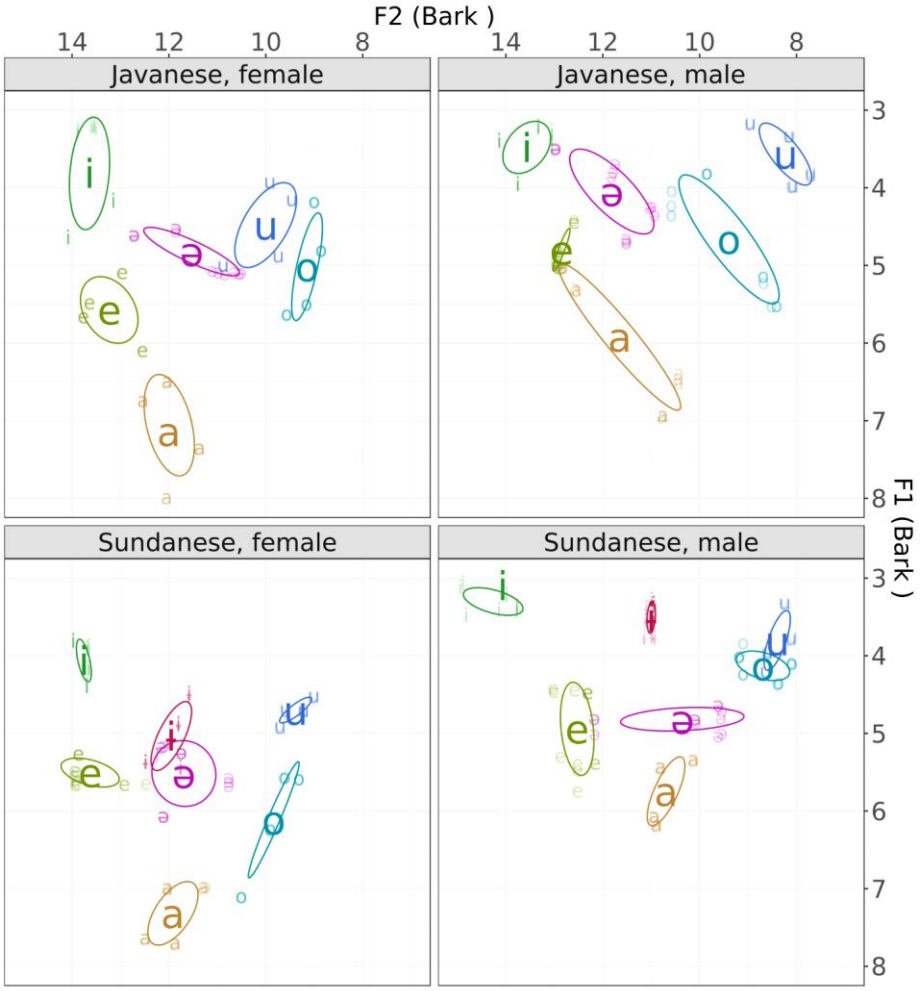

Figure 2.3a-d Javanese and Sundanese vowels plotted in an F_1 by F_2 plane (Barks).

In Figures 2.3a and b, Javanese has one high front vowel /i/, one mid front vowel /e/, one low vowel /a/, one mid central vowel /ə/, one high back vowel /u/, and one mid back vowel /o/. The vowel space area of the Sundanese male speakers is smaller than that of the females. But the relative distances between /i/, /e/ and /a/ are approximately the same, for both genders.

In Figures 2.3c-d, there are seven vowels: front /i/, mid front /e/, one low /a/, high central /ɨ/, mid central /ə/, high back /u/, and mid

back o/. Interestingly, /e/ and /ə/ for Sundanese males are more open than for Sundanese female speakers and /o/ for Sundanese males is more closed than for the female speakers. Interestingly, the /ɨ/ ~ /ə/ contrast is almost absent for the female speakers but still clear for the male speakers. Conversely, /u/ ~ /o/ are virtually the same for the males but kept clearly distinct by the females.

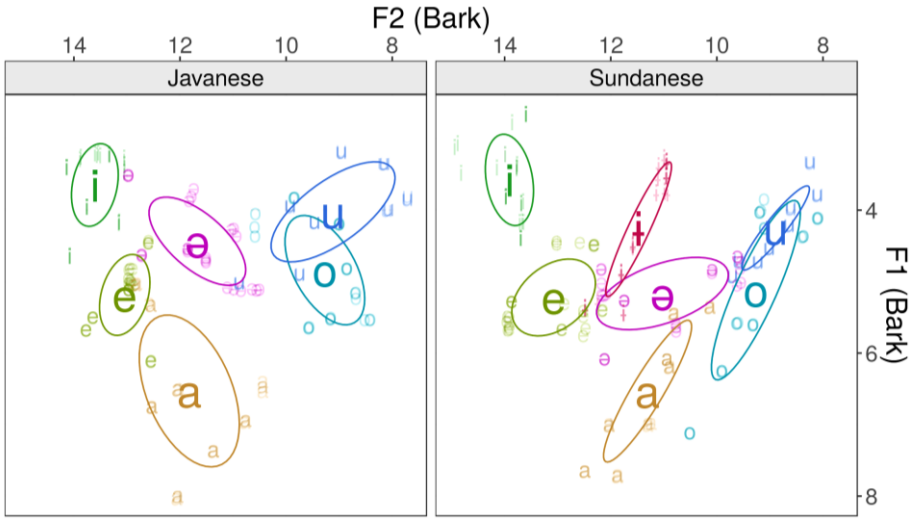

Figure 2.4a-b Javanese and Sundanese vowels plotted in an F_1 by F_2 plane across gender (Barks).

In Figure 2.4a-b, we present the plot of z-normalized F_1 and F_2 across male and female speakers. From the plot, it is shown that the Javanese /ə/ is higher than the Sundanese group. Sundanese speakers produce vowel /ɨ/ in a mid-high central vowel.

2.4.2 Duration

Table 2.3 presents the means ($\bar{x}$) and standard deviations (SD) of the duration of six Javanese vowels and seven Sundanese vowels, produced by the four speakers for each language. All values in the table are in miliseconds (ms).

Table 2.3 Mean ($\bar{x}$) and Standard Deviation (SD) in ms of the six Javanese and seven Sundanese vowels produced in a carrier sentence. Duration values are broken down by regional language and by gender. *N* = 12 per cell.

Vowel	Gender	Javanese		Sundanese	
		x̄	SD	x̄	SD
/i/	female	93	34	87	18
	male	80	23	60	10
/e/	female	56	6	101	20
	male	91	22	57	30
/a/	female	78	31	93	3
	male	76	18	78	20
/o/	female	74	15	81	18
	male	79	9	99	14
/u/	female	95	26	130	16
	male	84	43	92	5
/ə/	female	67	27	98	15
	male	62	36	97	23
/ɨ/	female	-	-	185	40
	male	-	-	110	19

The results showed that the Javanese and Sundanese vowel durations are quite short between 60 and 100 ms for all vowel types, with the exception of /u/ (110 ms) and /ɨ/ (150 ms) for the Sundanese speakers.

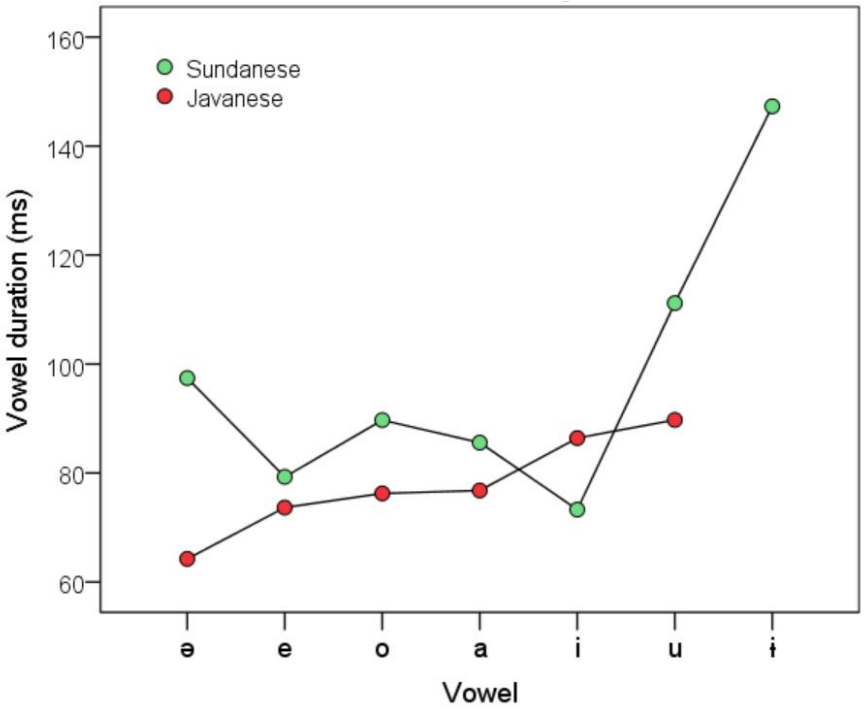

Figure 2.5 Javanese and Sundanese vowel durations across gender.

In Figure 2.5, we present the duration of vowels of Javanese and Sundanese across male and female speakers. From the graph, it is apparent that the duration of Javanese vowels is between 60 and 90 ms. For Sundanese, the durations are between 75 to 150 ms.

2.5 Discussion

In the present study, we examined the vowel quality of Javenese and Sundanese vowels by measuring the frequencies of the first two formants. The means per language group present a clear picture of general tendencies of difference in the first two-formant frequencies.

First, similar to Wedhawati et al. (2006), visual inspection of the mean values revealed that the Javanese female and male speakers produce a high front /i/, a mid front /e/, a low /a/, a mid central /ə/, a high back /u/, and a mid-back /o/.

Second, as found in Crothers (1978), Sundanese has seven vowels: front /i/, mid front /e/, low /a/, high central /ɨ/, mid central /ə/, high back /u/, and mid-back /o/. Earlier Sundanese vowel inventory studies claim that Sundanese has a high central vowel /ɨ/ (Crothers, 1978; Sudaryat et al., 2007). Our results demonstrate that the Sundanese male speakers still produce a high-central vowel /ɨ/, but the Sundanese female speakers do not seem to produce the vowel at all. The Sundanese female speakers' vowel /ɨ/ is visually indistinct from schwa.

The overall finding is inconsistent with Crothers (1978) and Kurniawan (2013) mentioning that vowel /ɨ/ in Sundanese is pronounced with a high central unrounded position of the tongue. Our results showed that vowel /ɨ/ is a high-mid central vowel, whereas it is a high central vowel in Crothers (1978).

This study shows that the Sundanese male speakers pronounce the vowel /ɨ/ differently than the females. The male pronunciation is compatible with Crothers (1978). It is possible that the Sundanese female speakers have lost the contrast between the high and the mid central vowels. This phenomenon where the Sundanese female speakers are losing the contrast between the two central vowels could be caused by language change occurring under the influence of Indonesian, which does not have this contrast. It is important to note that vowel /ə/ by Javanese speakers is higher than that of the Sundanese speakers. This result agrees with Van Zanten & Van Heuven (1984) who found that the Javanese schwa is higher than the Sundanese schwa. The Javanese schwa /ə/ is indeed shown to be higher than /e/ and /o/ in the Javanese sound system.

The durations of Javanese and Sundanese are phonetically short (between 60 and 100 ms) for all vowels. The exception is Sundanese /u/ (110 ms) and /ɨ/ (150 ms). The measurements of durations in the present study were taken from the Javanese and Sundanese in unstressed open CV syllables. The open CCV syllables were at the beginning of a two or three-syllable word inserted in a carrier sentence. Note that vowels in open syllables are longer than in closed syllables. However, at the same time, in unstressed syllables, vowels are likely to be shortened.

2.6 Conclusion

Previous studies by Van Zanten and Van Heuven (1984) and Van Zanten (1986) have presented the Standard Indonesian vowel system produced

by the Javanese and Sundanese speakers. The current study aimed at extending the previous studies by investigating to what extent the Standard Indonesian vowels spoken with a Javanese or Sundanese accent as found in Van Zanten and Van Heuven (1984) and Van Zanten (1986) are similar to the Javanese and Sundanese vowels produced by the Javanese and Sundanese speakers.

The current study found that the Javanese schwa /ə/ is considerably higher than that of the Sundanese speakers. The Javanese schwa is higher than /e/ and /o/ produced by the Javanese speakers. For the Sundanese speakers, it is found that /ɨ/ is produced in closed central position, only for the male speakers. The results of the formant frequencies of the Javanese and Sundanese vowels confirm the description of the vowel system by Wedhawati et al. (2006), Van Zanten and Van Heuven (1984), Crothers (1978), and Kurniawan (2013).

It is important to note that Javanese schwa /ə/, which is remarkably closed and front, could possibly lead to pronounciation problem in L2. Some English words such as *cup, butter* and *but* would be problematic for the Javanese speakers. Both Javanese schwa /ə and vowel /a/ appear to be pronounced in the front part of the mouth and would therefore not be a good substitute for English /a/. English vowel /a/ is open and back position and thus Javanese speakers are expected to show a pronunciation problem with the vowel. Therefore, in chapter 4 of this thesis, potential pronunciation problems with the English vowel /a/ and schwa /ə/ among the Javanese and Sundanese speakers will be explored.

This study is limited to the vowel sound production of the Javanese and Sundanese speakers. It would be interesting for future research to extend the present study by exploring the effects of the onset consonant on the vowel production of these groups of speakers. Also, the present study has a relatively small sample size. Future studies should repeat the current experiment with a larger sample size in order to reach firmer conclusions.

Furthermore, the scope of the present study does not focus on the gender-related difference especially as the data set is too small to make the inferential analysis worthwhile. However, it seems reasonable to expect significant differences in the vowel production between male and female groups. The present results in the visual plots of Javanese and Sundanese speakers showed that the differences in vowel production between genders may well be significant.

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