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ACOUSTIC ANALYSIS OF AN ACEHNESE DIALECT: PIDIENESE ORAL MONOPHTHONG VOWELS[1]

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Abstract

This study reports the characteristics of monophthong oral vowels of an Acehnese dialect, spoken in Pidie, Aceh, Indonesia. Ten Pidienese female speakers were recorded to produce ten target vowels using a carrier sentence. Approximately 300 vowel tokens were analysed using Praat version 6.0.19. The data is also compared to the North Aceh dialect vowels. Formant plots and t-tests were done to study their similarities and differences. The results showed that /i/ and /u/ are produced similarly, but the vowels, /ɛ/, /ə/ and /o/ are produced completely different because they are unalike in terms of height and dimension. Meanwhile, the vowels /e/, /ɯ/, /ʌ/, /a/ and /ɔ/ are produced differently, where the Pidienese speakers produced them lower in the vowel space. This study contributes to the documentation and preservation of Acehnese, considering that it is only spoken by the Acehnese ethnic out of hundreds of ethnic groups that exist in Indonesia.

Keywords: Acehnese, Pidie dialect, phonology, acoustic analysis, vowels, Praat software

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ANÀLISI ACÚSTICA D'UN DIALECTE D'ACEH:
LES VOCALES MONOFTONGADES ORALS DEL DIALECTE PIDIE

Resum

Aquest estudi tracta sobre les característiques de les vocals orals monoftongades d'un dialecte d'Aceh, parlat a Pidie, Aceh, Indonèsia. Es van enregistrar deu parlants femenines de Pidie per produir deu vocals utilitzant una oració com a base. Es van analitzar aproximadament 300 mostres de vocals utilitzant la versió 6.0.19 de Praat. Les dades es van comparar també amb les vocals del dialecte del nord d'Aceh. Es van fer gràfiques de formants i proves-*t* per estudiar-ne les similituds i diferències. Els resultats van mostrar que /i/ i /u/ es produeixen de manera similar, però les vocals /ɛ/, /ə/ i /o/ es produeixen de manera completament diferent perquè no són iguals en termes d'alçada i dimensió. Per altra banda, les vocals /e/, /ɯ/, /ʌ/, /a/ i /ɔ/ es produeixen de manera diferent, ja que els parlants del dialecte pidie les articulen més baixes en l'espai vocal. Aquest estudi contribueix a la documentació i preservació del dialecte d'Aceh, tenint en compte que només el parla l'ètnia acehnesa entre centenars d'ètnies que existeixen a Indonèsia.

Paraules clau: dialecte d'Aceh, dialecte pidie, fonologia, anàlisi acústica, vocals, Praat

ANÁLISIS ACÚSTICO DE UN DIALECTO ACHINENSE:
LAS VOCALES MONOFTONGADAS ORALES DEL DIALECTE PIDIE

Resumen

Este estudio trata sobre las características de las vocales orales monoftongadas de un dialecto de Aceh, hablado en Pidie, Aceh, Indonesia. Se grabaron diez hablantes femeninas de Pidie para producir diez vocales utilizando una oración como base. Se analizaron aproximadamente 300 muestras de vocales utilizando Praat versión 6.0.19. Los datos se compararon también con las vocales del dialecto del norte de Aceh. Se realizaron gráficas de formantes y pruebas-t para estudiar sus similitudes y diferencias. Los resultados mostraron que /i/ y /u/ se producen de manera similar, pero las vocales, /ɛ/, /ə/ y /o/ se producen de manera completamente diferente porque no son iguales en términos de altura y dimensión. Por otro lado, las vocales /e/, /ɯ/, /ʌ/, /a/ y /ɔ/ se producen de manera diferente, ja que los hablantes del dialecto pidie las articularon más bajas en el espacio vocal. Este estudio contribuye a la documentación y preservación del dialecto de Aceh, considerando que solo lo habla la etnia acehnesa de entre cientos de etnias que existen en Indonesia.

Keywords: Achinense, dialecto pidie, fonología, análisis acústico, vocales, Praat

1. Introduction

Acehnese, one of the local languages spoken in Aceh Province, Indonesia (Wee 2010), is a branch of the Austronesian language families and it originates from the Chamic language (see, for example, Asyik 1987, Blust 2013, Durie 1985, Thurgood 2007). Chamic is spoken in Champa, a South East Asian mainland, and it is known to

relate to Mon-Khmer language (Cowan 1991, Thurgood 2007). The Chamic languages are still spoken in some areas of Vietnam (Thurgood 2007).

Asyik (1987) divides Acehnese into four main dialects representing some number of regencies in Aceh, i.e., Greater Aceh, North Aceh, Pidie dialect, and West Aceh. The Greater Aceh dialect is spoken in the Aceh Besar Regency, the North Aceh dialect in East Aceh, the North Aceh and the Bireuen Regencies, the Pidie dialect in Pidie and Pidie Jaya Regencies, and the West Aceh dialect in Aceh Jaya, West Aceh, Nagan Raya, and the South Aceh Regencies (Zulfadli 2014). From the four main dialects, the North Aceh dialect is regarded as the standard Acehnese language due to its phonological homogeneity and syntactical complete e.g., affixes, adverbs, pronouns, nouns, and verbs (see, for example, Asyik 1987, Durie 1985, Hanafiah & Makam 1984, Sulaiman et al. 1977, Sulaiman et al. 1983).

Based on several findings from the previous studies on the Pidie dialect, it has different characteristics compared to other Acehnese dialects (see, for example, Al-Harbi 2003, Asyik 1987, Durie 1985). The Pidie dialect has some differences in producing the phoneme [ə] that is pronounced closer to [ɯ], and [ʌ] is produced closer to [ɔ]. Asyik (1987) further explains another dialect marker, where Pidie dialect speakers rather produce a far back [a] compared to the [a] in standard Acehnese. However, those studies were conducted through an auditory approach, in relation to the vowel characteristics of Pidie dialect as previously mentioned. This present study adopts a more scientific approach by analysing the acoustic features of the vowel sounds.

1.1 Acehnese vowels

Vowels are speech sounds produced no impediment to the flow of air from the lungs so that the breath stream escapes easily through the mouth (McMahon 2002). Typically, vowels are divided into monophthongs, diphthongs and triphthongs. A monophthong is a steady state vowel with no appreciable change in quality (Ladefoged & Disner 2012). Meanwhile, on diphthongs or triphthongs there is a change in tongue

height and/or tongue fronting resulting in a change in vowel quality from the onset to offset of these vowels (Ladefoged & Disner 2012; Fromkin, Rodman & Hyams 2003; McMahon 2002).

In Acehnese, there are 10 monophthongs and 12 diphthongs (Pillai & Yusuf 2012). Moreover, according to Asyik's (1987) inventory on the Acehnese vowels, there are 12 diphthongs that are divided into centring diphthongs (/iə/, /ɯə/, /uə/, /ɛə/, /ʌə/, /ɔə/) and rising diphthongs (/ui/, /əi/, /oi/, /ʌi/, /ɔi/, /ai/). Asyik (1987) and Pillai & Yusuf (2012) have based their studies on the North Acehnese dialect. In the meantime, Al-Harbi (2003), who conducted a study about Acehnese and recorded a Pidie dialect speaker as his respondent, provides a vowel chart that is reproduced from Asyik (1987). Al-Harbi mentioned that in the Pidie dialect the sound /ʌ/ is pronounced nearer to the sound /ɔ/ in other dialects, Al-Harbi mentions and uses the symbol [ɨ] in spite of the vowel being more like [ɯ] in the vowel space. However, he did not mention the recording and data analysis process that he used.

Unlike previous studies that analysed the Acehnese vowels through an auditory approach, Pillai & Yusuf (2012) studied the characteristics of the vowels through an acoustic approach. With the acoustic theory of speech production, the study made use of "an idealized model of the vocal tract in order to predict how different vocal tract shapes and actions contribute to the acoustic signal" (Fant 1970, as cited in Harrington 2012: 81). Empirically, sounds travel through the air in the form of sound waves (McMahon 2002). In acoustic studies, sounds that are produced by the vocal tract and transmitted from the speaker to the hearer are recorded with devices. Each vowel and consonant have particular acoustic characteristics. For vowels, different formant configurations characterize each vowel. Ladefoged & Johnson (2011) explain that the first and second formants (or F1 and F2) on the spectrogram correspond to the height and front-back characteristics of vowels. The F1 is related to vowel height whilst F2 corresponds to the front/back dimensions of vowels (Jacobi 2009, Watt & Tillotson 2001). On the spectrogram, the vowels are characterized by relatively thick, horizontal bands (formants) (Milroy & Gordon 2003).

In the acoustic analysis of the Acehnese vowels, Pillai & Yusuf (2012) used the Praat (Boersma & Weenink 2007); they presented the F1 and F2 measurements of Acehnese monophthong vowels (see Table 1) and their positions in the vowel space (see Figure 1), the positions, quality and trajectories of Acehnese diphthongs. Thus, the study by Pillai & Yusuf (2012) offered a sharper representation of the characteristics and qualities of Acehnese vowels in the vowel space compared to the traditional presentation of Acehnese vowels. Since this study focuses on monophthongs, therefore the findings on diphthongs are not discussed further.

Vowels	Average F1 and SD (Hz)	Average F2 and SD (Hz)
i	428.7 (27.7)	2653.2 (130.1)
ɯ	470.2 (50.3)	1623.8 (154.3)
u	462.8 (37.9)	1367.3 (114.8)
e	503.6 (49.3)	2517.8 (112.30)
o	531.2 (38.9)	1013.3 (85.6)
ɛ	629.1 (52.8)	2386.1 (141.8)
ʌ	643.1 (49.4)	1895.0 (331. 6)
ɔ	668.8 (43.5)	1412. 1 (113.3)
a	877.0 (51.4)	1831.4 (65.5)
ə	546.9 (27.2)	1824.8 (122.3)

Table 1. F1 and F2 (averages and standard deviations) for Acehnese oral monophthongs (reproduced from Pillai & Yusuf 2012: 1036)

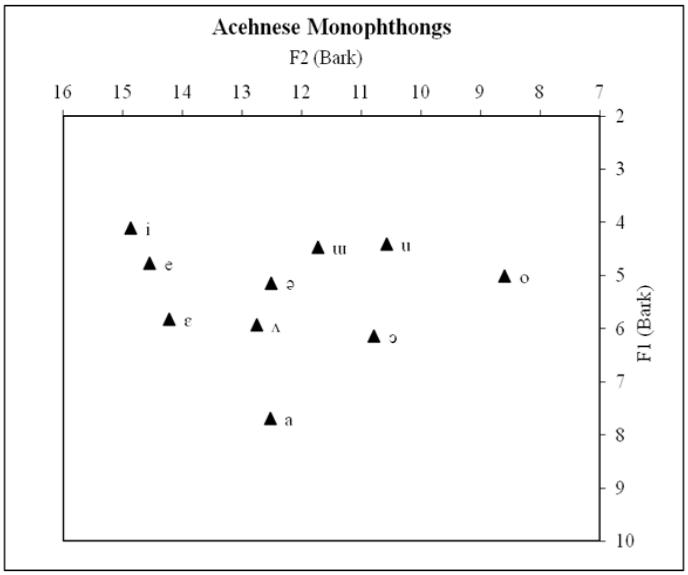

Figure 1. Formant plot of the standard Acehnese oral monophthong vowels or North Aceh dialect (reproduced from Pillai & Yusuf 2012: 1037)

1.2 Problem of study

To complement the study by Pillai & Yusuf (2012), we extended the research to vowels produced by speakers of other Acehnese dialects spoken in Aceh. Studying the vowels of every main dialect that are still spoken by these people is important, because of the 6.000 languages in the world, Acehnese is among the 650 languages and dialects spoken in Indonesia (Masinambow & Haenen 2002). It is possible that about half of these languages are about to die out during the course of the next century (Crystal 1999).

In the case of Indonesia, as a multilingual and multicultural country, Indonesian is the national language spoken in all formal situations and as a lingua franca among Indonesians. This situation resulted in the Indonesians using it more than their own mother tongues or heritage languages in their daily lives (Alamsyah et al. 2011, Al-Auwal 2017, Aziz & Amery 2016). Specifically, to Acehnese, Aziz & Amery (2016: 104) even proclaim that Indonesian as a "killer language" to Acehnese as it has been replaced the use of Acehnese by its people even in the home domain. Therefore, efforts to preserve, maintain and document the Acehnese language and its dialects that still exist today can be considered as a priority for Acehnese linguists. For that reason, this study intends to complement the study by Pillai & Yusuf (2012) by further analysing and documenting the characteristics of monophthong oral vowels of another widely spoken Acehnese dialect that is in Pidie, Aceh, Indonesia.

2. Methods

This research was conducted in the Pidie Regency, the origin region that the Pidie dialect is spoken. The data used in this study were recorded from native Pidie dialect respondents. In addition, to ensure the validity of data source, previous studies correlated to this study, such as Al-Harbi (2003), Asyik (1987), Durie (1985), Pillai & Yusuf (2012), and Yusuf (2013) were referred to.

2.1 Respondents

Ten female respondents were purposively chosen for this research. The criteria for selecting the respondents for the research were as follows: (1) females between 45 to 65 years old, (2) speak Acehnese in their daily lives, (3) have lived in Pidie most of their lives, (4) no impairment of their vocal tracts/organs of speech, and (5) not suffering from dementia or senility.

2.2 Data collection

Elicitation was used in order to collect the data. Words are elicited and recorded to establish minimal pairs if these were available (Chelliah & de Reuse 2011). The elicited words in the wordlist were produced in a carrier sentence by the respondents. The word list was adapted from Pillai & Yusuf (2012), where ten words, each containing the Acehnese oral monophthong vowel, were used to elicit the target vowels. As many studies put the target words in a carrier sentence, such as "Say ___ again" to be said by the informants repeatedly, this study also has required each of the respondents to produce each word in this carrier sentence: *Lon ucap* ___ *sigoe teuk* [Say ___ again]. In addition, following Ladefoged (2003) the target vowel were inserted between two consonants to avoid influences from neighbouring sounds.

In order to gain obtain worthy recordings, several conditions were applied in collecting the data. They were (1) avoiding nasals, liquids and approximants immediately preceding the target vowels thus minimizing possible co-articulatory influences on the following target vowels, (2) each word in the carrier sentence was repeated three times by every respondent, (3) all the oral monophthongs in the target words were in closed CVC syllables (Yusuf 2013), where C is a stop, fricative or affricate. The recording was done at the Phonetics Laboratory of Faculty of Education and Teacher Training, Syiah Kuala University. The laboratory is a sound proof room and was deemed adequate for recording.

2.3 Data analysis

Praat version 6.0.19 (Boersma & Weenink 2016) was used to record and collect the data. Every recording was saved into a WAV file for further analysis. Then, the techniques to analyse the data were as follows: first, the data were segmented, then annotated, and measured by the frequency in Hertz. LPC (Linear Predictive Coding) analysis was used to track each formant. Although, the LPC spectrum is generally reliable, there may be instances where it does not identity the correct formant correctly. Therefore, the data were also checked manuallly by visual inspcection of the spectograms. The F1 and F2 of each oral monophthong were measured at the mid-point of the vowel because it is the position where it is at "its most steady state and is least influenced by preceding and following sounds" (Pillai, Don, Knowles & Tang 2010: 163). Figure 2 shows the spectrogram and the midpoint of F1 and F2 measurements of /i/ from the production of the word *dit* 'small amount'.

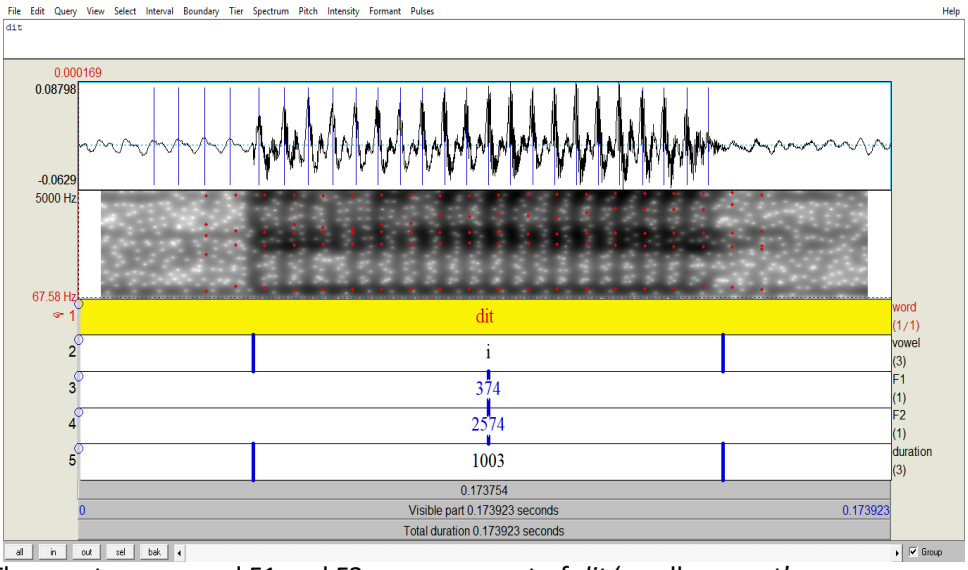

Figure 2. The spectrogram and F1 and F2 measurement of *dit* 'small amount'

The measurements were further saved in Excel files. Here, the frequencies in Hertz were converted into a Bark scale to create vowel plots in the vowel space (Deterding 2003). Zwicker & Terhardt's formula was used to convert the

measurements in Hertz to Bark (1980), where F is the frequency in Hertz and Z the frequency in Bark: Z = 13 arctan (0.00076F) + 3.5 arctan(F/7500)2. T-tests were performed to further study the extent of similarity or differences between the productions of these vowels compared to the standard Acehnese oral monophthong vowels from Pillai & Yusuf (2012).

3. Results and Discussion

3.1 Pidie dialect oral monophthong vowels

Ten Pidie oral monophthong vowels were measured based on their productions by ten female respondents. Each vowel was embedded in a target word where each respondent repeated it three times, thus presenting a total of 30 tokens for each vowel. The average formant frequency measurements, the standard deviations (SD) and also the average values in Bark for the F1 and F2 for each vowel produced by the respondents is shown in Table 2. The value in parentheses is the standard deviation value and the standard deviation value in Bark. The measurements in Table 1 and the vowel plots in Figure 3 answer the first research question of this study.

Target word	Vowel	Ave. F1 and SD	Ave. F2 and SD	Ave. F1 Bark and SD	Ave. F2 Bark and SD
dit	/i/	426 (57.53)	2730 (90.61)	4.08 (0.52)	15.04 (0.20)
peut	/ɯ/	506 (42.91)	1846 (111.37)	4.79 0.37 ()	12.58 (0.40)
cut	/u/	497 (38.95)	1347 (101.65)	4.71 (0.34)	10.47 (0.51)
pét	/e/	618 (52.68)	2443 (101.09)	5.73 (0.43)	14.37 (0.25)
tet	/ə/	670 (54.61)	1993 (151.85)	6.15 (0.43)	13.08 (0.50)
pôt	/o/	659 (50.39)	1177 (104.84)	6.06 (0.40)	9.57 (0.59)
cèt	/ɛ/	766 (76.14)	2283 (87.53)	6.89 (0.56)	13.95 (0.24)
göt	/ʌ/	734 (34.55)	1703 (129.21)	6.65 (0.26)	12.05 (0.51)
cop	/ɔ/	750 (63.66)	1443 (101.67)	6.77 (0.48)	10.94 (0.48)
pat	/a/	953 (49.63)	1800 (108.61)	8.21 (0.33)	12.41 (0.40)

Table 2. The averages and standard deviations of F1 and F2 for Pidie oral monophthong vowels

Based on Table 2, the vowel was plotted in an F1/F2 chart reflecting the vowel space as seen in Figure 3.

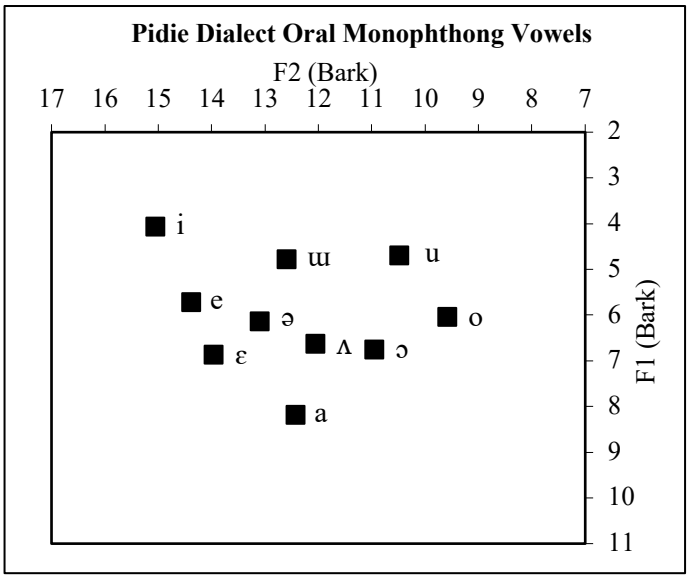

Figure 3. Formant plot of the Pidie oral monophthong vowels

Furthermore, to answer the second research of this study, Figure 4 presents the formant plots of standard Acehnese oral monophthong vowels based on the North Aceh dialect as found by Pillai & Yusuf (2012) with the formant plots of the Pidie oral monophthong vowels found in this study. The purpose was to obtain a better picture of the formant plots of the vowel productions between the two Acehnese dialects.

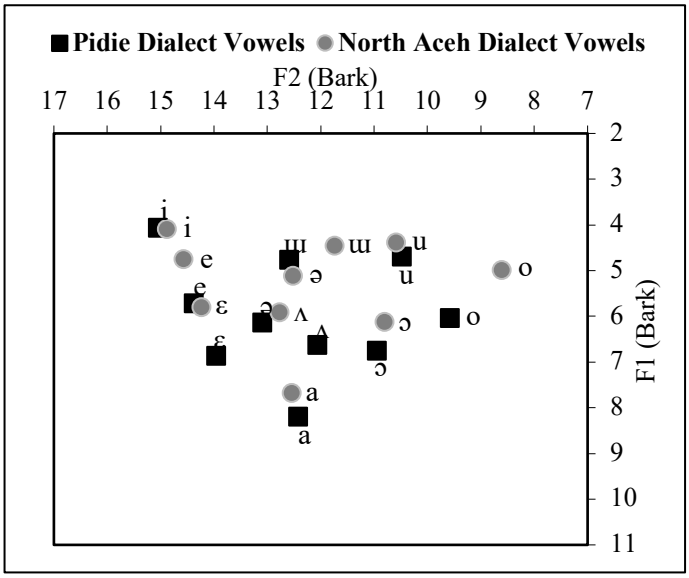

Figure 4. Formant plots of the North Aceh and Pidie oral monophthong vowels

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The formant position of the vowels /i/, /e/, /ɛ/, /ɯ/, /ə/, /ʌ/, /a/, /u/, /ɔ/ and /o/ in general are similar to the Acehnese vowel inventory of Al-Harbi (2003), Asyik (1987), Durie (1985) and Pillai & Yusuf (2012). These vowels were also all produced in the Pidie dialect, as described by Al-Harbi (2003) and Durie (1985). Unlike most of the previous work on Aceh, this study has provided approximate quality measurements of the Pidie vowels from the vowel analysis of acoustics cues (F1 and F2) in Praat. Vowels in the Pidie dialect are as follows: [i], [e], [ɛ] the front vowels; the central vowels [ɯ], [ə], [ʌ], [a] are central vowels, and the back vowels [u], [ɔ], [o]. The characteristics of these vowels are further discussed in the following sub sections. Their similarities and differences with the North Aceh dialect vowels were also examined.

a) Front vowels

The scatter plot of the three front vowels of Pidie oral monophthongs as produced by the ten respondents are as shown in Figure 5.

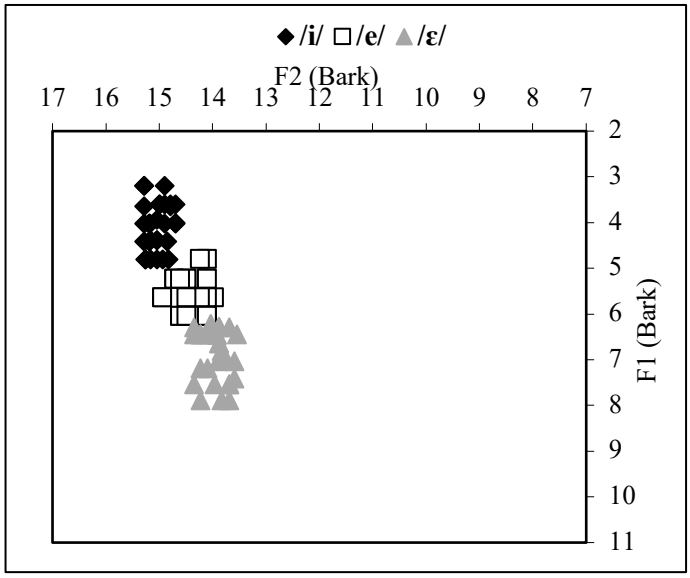

Figure 5. The scatter plot of Pidie front vowels

The vowel /i/ was extracted from the target word *dit* 'few.' The measurements show an average value F1 is 426 Hz and its F2 is 2730 Hz for F1 and F2 respectively.

Figure 3 shows that this vowel is positioned as a front high vowel in the vowel space. Nevertheless, Figure 4 shows that the Pidie dialect [i] is positioned similarly to the North Aceh dialect [i]. This is confirmed by t-tests conducted between the /i/ production of these two dialects, where there was no significant difference in the F1 and F2 average values (F1: $t(58) = 0.26$, $p = 0.795$); F2: ($t(58) = 2.73$, $p = 0.008$).

The vowel /e/ was obtained from the target word *pét* 'shut (the) eyes'. The average values for F1 and F2 are 2443Hz respectively, and thus, its position as shown in Figure 3 in the vowel space is as a front mid vowel. The t-test between the Pidie dialect and North Aceh dialect [e] show that there was a significant difference between the F1 average values ($t(58) = 8.64$, $p < .0001$), but no significant difference was found between the F2 average values ($t(58) = 2.76$, $p = 0.007$). Accordingly, Figure 4 also depicts that this vowel was produced lower and a bit more back by the Pidie dialect respondents in the vowel space compared to the North Aceh dialect respondents.

The vowel /ɛ/ that was extracted from the target word *cèt* 'paint' resulted in an F1 average value at 766 Hz and F2 at 2283 Hz. Figure 3 illustrates this vowel as a front mid-low vowel. Moreover, Figure 4 shows this vowel to be produced lower and more back in the vowel space compared to the North Aceh dialect respondents. This is substantiated by the t-test of [ɛ] production between the two dialects, where there were significant differences in their F1 and F2 average values (F1: $t(58) = 8.18$, $p < .0001$); F2: ($t(58) = 3.44$, $p < .0.001$), which implies that /ɛ/ tends to be produced differently by both group of respondents.

b) Central vowels

The scatter plot of the four central vowels of Pidie oral monophthongs as produced by the ten respondents is shown in Figure 6.

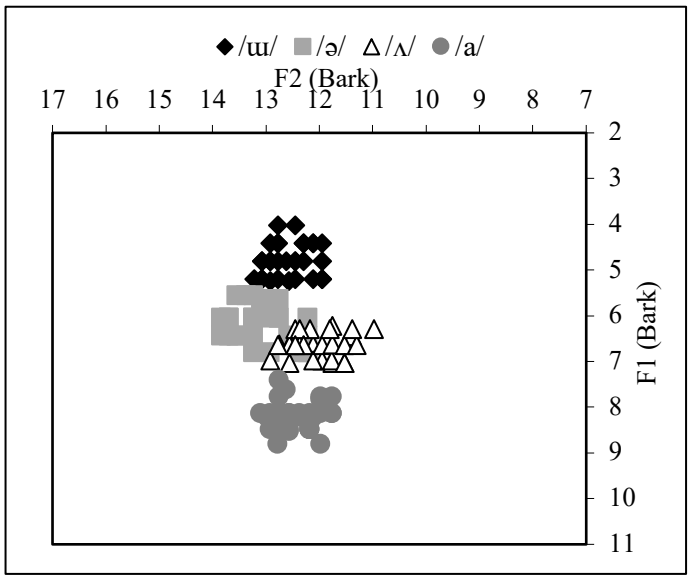

Figure 6. The scatter plot of Pidie central vowels

For the vowel /ɯ/, 30 tokens were extracted from the target word *peut* 'four.' The average value of its F1 is 506 Hz and F2 is 1846 Hz, that indicated that this vowel is a central high vowel (see Figure 3). T-tests conducted between this Pidie dialect [ɯ] production compared to the North Aceh dialect respondents show there was no significant difference between the F1 average values ($t(58) = 2.98$, $p = 0.004$), but a significant difference was found in the F2 average values ($t(58) = 6.38$, $p < .0001$). This indicate that the Pidie [ɯ] is produced lower and more fronted compared to the North Aceh /ɯ/ as seen in Figure 4.

From the target word *tet* 'burn', /ə/ was extracted and analysed. The average value of F1 is 670 Hz and the average value of F2 is 1993 Hz. It is classified as a central mid vowel in the vowel space as shown in Figure 3. Asyik (1987) and Durie (1985) mentions that the Pidie [ə] is pronounced near to [ɯ] and this can be seen in Figure 6 where some of the scatter plots of [ɯ] and [ə] overlap. Nevertheless, this study confirms that these two vowels were produced differently by the Pidie dialect respondents based on the t-test results between their F1 and F2 average values (F1: ($t(58) = 13.03$, $p < .0001$; F2: $t(58) = 4.2$, $p < .0001$). Moreover, the formant plot in Figure 3 also illustrates that [ɯ] is positioned higher than [ə] in the Pidie dialect vowel space.

Regarding the comparison of /ə/ between the Pidie dialect and the North Aceh dialect, Figure 4 shows that Pidie [ə] is produced lower and more fronted than the North Aceh [ə] (see Figure 4). This is confirmed by the t-tests where there were significant differences both between their F1 and F2 average values (F1: ($t(58) = 11.24$, $p < .0001$; F2: $t(58) = 4.65$, $p < .0001$). This suggests that /ə/ is produced differently by both dialect respondents.

The vowel /ʌ/ was extracted from the target word *göt* 'good.' The measurements show that the F1 average value is 734 Hz and the F2 average value is 1703 Hz. In Figure 3, it is shown to be positioned as a central mid-low vowel in the vowel space. Figure 4 further portrays Pidie [ʌ] to be lower and more back than North Aceh [ʌ]. The t-test between the F1 average values shows that there was a significant difference ($t(58) = 8.23$, $p < .0001$), however, there was no difference in terms of their F2 average values ($t(58) = 2.92$, $p = 0.004$).

The target word *pat* 'where' was used to extract the vowel /a/ in the wordlist. It was found that the F1 average value is 953 Hz and the F2 average value is 1800 Hz. In the vowel space, it is a central low vowel (see Figure 3). Based on an auditory study, Asyik (1987) found Pidie dialect speakers tend to produce [a] far back compared to the North Aceh dialect speakers. T-tests were conducted between the [a] produced by the Pidie dialect and North Aceh dialect respondents and the results showed that there was significant difference in the F1 average values ($t(58) = 5.82$, $p < .0001$), and this can be seen in Figure 4 where Pidie [a] is produced lower than North Aceh [a]. However, there was no significant difference in the F2 average values ($t(58) = 1.48$, $p = 0.144$); this means that they are produced similarly in terms of the front/back dimension and this is in contrast to Asyik (1987).

c) Back vowels

The scatter plot of the three back vowels of Pidie oral monophthongs as produced by the ten respondents are as shown in Figure 7.

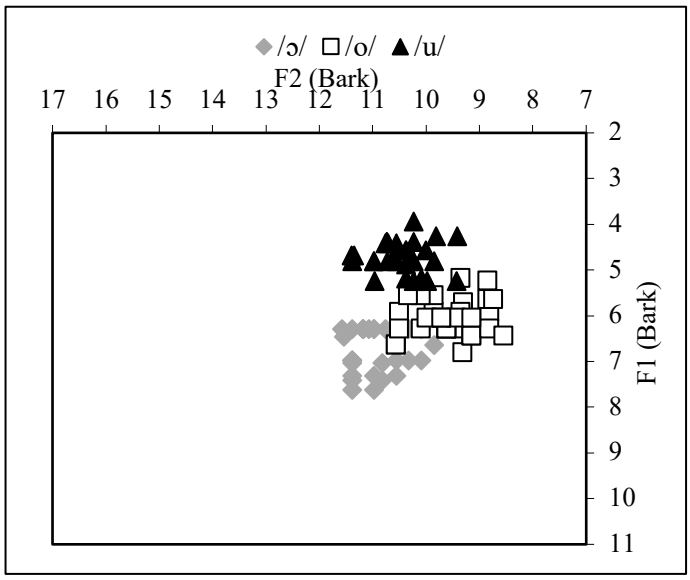

Figure 7. The scatter plot of Pidie back vowels

The vowel /u/ was extracted from the target word *cut* 'small.' The measurements show the average value of its F1 is 497 Hz and its F2 is 1347 Hz. In Figure 3, this vowel is positioned as the back high vowel in the vowel space. Asyik (1987) mentions some sound may change among Pidie dialect speakers, such as the change of /u/ to /ɯ/ in some Acehnese words. An example Asyik (1987) provided is the word *rukok* /rukɔʔ/ 'cigarette' that becomes *reukok* /rɯkoʔ/ 'cigarette'. T-tests were comparing [ɯ] and [u] produced by the Pidie dialect respondents showed no significant differences between the F1 average values ($t(58) = 0.85$, $p = 0.398$), but a significant differences in the F2 average values ($t(58) = 17.95$, $p < .0001$). The results indicated that these vowels are two different vowels in terms of its dimensions, where [ɯ] is a high mid vowel and [u] is the high back vowel as shown in Figure 3. Thus, to further investigate the substitution of /u/ to /ɯ/ in some words by these speakers, more data are needed, and also perhaps those recorded in spontaneous speech since the data in this study is extracted from elicited speech of only one word for each vowel. Additionally, despite the formant plot in Figure 3 show Pidie [u] to be a bit lower than North Aceh [u], t-tests revealed that /u/ was produced similarly by both group of respondents because there were no significant differences in the F1 and F2 average values (F1: $t(58) = 3.45$, $p = 0.001$; F2: $t(58) = 0.74$, $p = 0.462$).

The vowel /o/ was taken from the target word *pot* 'to blow.' The average value for F1 is 659 Hz and F2 is 1177 Hz, and accordingly its position in the vowel space is as a back central vowel (see Figure 3). As displayed in Figure 4, Pidie [o] is positioned lower and more fronted compared to the North Aceh [o]. The t-tests between the Pidie dialect and the North Aceh dialect [o] further indicate that there are significant differences between their F1 and F2 average values (F1: $t(58) = 71.05$, $p < .0001$; F2: $t(58) = 6.66$, $p < .0001$). This implies that /o/ is produced differently by the Pidie and North Aceh dialect respondents.

The vowel /ɔ/ that was extracted from the target word *cop* 'sew' and resulted in the measurements of F1 average value at 750 Hz and F2 at 1443 Hz. In Figure 3, this vowel is a back low vowel in the vowel space. In the studies by Al-Harbi (2003), Asyik (1987) and Durie (1985), the Pidie [ʌ] and [ɔ] sound similar to each other. The result of t-tests between these two vowels show that there was no significant difference in their F1 average values ($t(58) = 1.2$, $p = 0.235$); they indicate that they are positioned with the same height in the vowel space. However, there was a significant difference in their F2 average values ($t(58) = 8.63$, $p < .0001$) and this means that in terms of the vowel fronting-retraction dimension, they are produced differently where [ʌ] is more fronted in the vowel space and [ɔ] is more back as shown in Figure 3.

In addition, as seen in Figure 4, the Pidie [ɔ] is positioned to be lower and more fronted compared to the North Aceh [ɔ]. This was also confirmed by the t-tests conducted on their F1 and F2 average values, where there was a significant differences in their F1 average values ($t(58) = 5.77$, $p < .0001$), but no significant difference in their F2 average values ($t(58) = 1.13$, $p = 0.263$). This implies that [ɔ] in Pidie and North Aceh is different in terms of height in the vowel space but similar in terms of front-back dimension.

3.2 Similarities and differences between Pidie and North Aceh vowels

Based on the t-test results, Table 3 summarizes the Pidie and North Aceh oral monophthong vowels that are produced similarly and differently by the respondents.

Position	Word	Gloss	Vowel	Similar	Different	Explanation
Front Vowels	*dit*	small amount	/i/	✓		F1 = no significant difference F2 = no significant difference
	pét	close/shut (the eyes)	/e/		✓	F1 = significant difference F2 = no significant difference (Pidie /e/ is lower and more back)
	cèt	paint	/ɛ/		✓	F1 = significant difference F2 = significant difference (Pidie /ɛ/ is lower and more back)
Central Vowels	*peut*	four	/ɯ/		✓	F1 = no significant difference F2 = significant difference (Pidie /ɯ/ is lower and more fronted)
	tet	burn	/ə/		✓	F1 = significant difference F2 = significant difference (Pidie /ə/ is lower and more fronted)
	göt	good, fine	/ʌ/		✓	F1 = significant difference F2 = no significant difference (Pidie /ʌ/ is lower and more back)
	pat	where	/a/		✓	F1 = significant difference F2 = no significant difference (Pidie /a/ is lower)
Back Vowels	*cut*	small, title for women of noble descent	/u/	✓		F1 = no significant difference F2 = no significant difference
	pôt	blow, to fan	/o/		✓	F1 = significant difference F2 = significant difference (Pidie /o/ is lower and more front)
	cop	sew	/ɔ/		✓	F1 = significant difference F2 = no significant difference (Pidie /ɔ/ is lower and more front)

Table 3. Pidie and North Aceh oral monophthong vowels produced similarly and differently

From Table 3, /i/ and /u/ are produced similarly by both groups of respondents of the Pidie and North Aceh dialects. Another three vowels, /ɛ/, /ə/ and /o/ are produced completely different between both groups of the dialects respondents

because they are unalike in production in terms of height and dimension. Meanwhile, the remaining vowels /e/, /ɯ/, /ʌ/, /a/ and /ɔ/ are produced differently, where the Pidie respondents produced them lower in the vowel space compared to the North Aceh respondents.

4. Conclusions

The findings of this study have provided measurements for each vowel produced by the Pidie dialect respondents. Based on the acoustic analysis conducted on the vowels, it was posited that this dialect also recognizes ten oral monophthong vowels in Acehnese: three front vowels (/i/, /e/, and /ɛ/), four central vowels (/ɯ/, /ə/, /ʌ/ and /a/), and three back vowels (/u/, /o/ and /ɔ/). Compared to the production of these vowels by the North Aceh dialect respondents, some similarities and differences were found. Based on the t-test results and the formant plots of these vowels, the vowels /i/ and /u/ were produced similarly by both the Pidie and North Aceh dialects. Meanwhile, three vowels, /ɛ/, /ə/ and /o/ were produced very differently in the vowel space in terms of height and front-back dimension. Thus, the other five vowels /e/, /ɯ/, /ʌ/, /a/ and /ɔ/ were produced lower in the vowel space by the Pidie respondents compared to the North Aceh respondents. Thus, these findings cannot be generalized to all Pidie dialect speakers, because this study only focus on vowels elicited from certain words and produced by female respondents.

It is suggested that future related research collect data from spontaneous speech for larger data sets to further examine the characteristics of these vowels in the vowel space. Spontaneous speech may also provide other vowels that may emerge in different environments. Due to the differences in male and female vocal tract shapes and sizes, the investigation on vowel productions by male speakers is also encouraged. To conclude, the findings can be used as part of language documentation and preservation efforts considering that Acehnese language is only spoken by the Acehnese ethnic out of hundreds of group ethnics.

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