THE SOUNDS OF INDONESIAN ENGLISH: ACOUSTIC PHONETIC ANALYSIS OF THE MONOPHTHONG VOWELS ACROSS GENDERS

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Abstract: This study explored the production of 11 English vowels by Acehnese Indonesian EFL students. Ten undergraduates (five males and five females) from the Pidie District, Aceh, participated, with Acehnese and Bahasa Indonesia as their first languages, and English learned formally at school since the 7th grade. Using PRAAT, recordings of vowel elicitations were measured and analyzed, revealing distinctions in vowel pairs. Statistical tests were employed to compare vowel productions between the males and females. The results showed that the females produced many of the vowel pairs similarly: /i:/-/ɪ/, /ɛ/-/æ/, /u:/-/ʊ/, /ʌ/-/ɑː/, and /ɑː/-/ɒ/. The pairs they differentiated were /ɜ:/-/ʌ/ and /ɔ:/-/ɒ/. However, the female students could not discriminate between the long and short vowel pairs. Meanwhile, the male students could distinguish the following pairs: /i:/-/ɪ/, /ɜ:/-/ʌ/, /ʌ/-/ɑː/, and /ɔ:/-/ɒ/. The others, /ɛ/-/æ/, /u:/-/ʊ,/ and /ɑː/-/ɒ/, were produced similarly. Additionally, they could distinguish the long and short vowels in the /ɜ:/-/ʌ/, /u:/-/ʊ/, /ʌ/-/ɑː/, and /ɑː/-/ɒ/ pairs, but not /i:/-/ɪ/, /ɛ/-/æ/ and /ɔ:/-/ɒ/. This study has shown complex distinctions in the production of English vowels by Acehnese Indonesian EFL students. These findings underscore the importance of considering gender-specific phonetic patterns in English language acquisition, providing valuable insights for language educators and researchers.

Keywords: Acehnese, acoustic, EFL students, English vowels, Indonesian, oral monophthongs

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English is one of the world’s lingua francas, and for most countries that do not use it as their first language, it would tend to be the second or foreign language of the speakers. In Indonesia, English is treated as a foreign language but due to its importance in the educational, economic, political, and governmental sectors, this language is officially taught from the junior high school level up to the university level. It cannot be denied that from the linguistic aspect, especially phonology, English is different from Indonesian (see Achmad & Yusuf, 2014; Ulfayanti & Jelimun, 2018; Widagsa & Putro, 2017). Therefore, it is common for students to face problems pronouncing English words.

Moreover, Indonesia is a super-diverse country with multilingual speakers. Most Indonesians speak at least two languages: one is the national language, Indonesian, and the other is their ethnic language (Al-Auwal, 2017; Aziz & Amery, 2016; Aziz et al., 2020). Therefore, it can be anticipated that their third language, in this case, English, would be affected by their first and second languages. The difficulty level in learning another language can be directly connected to the students' first language(s) in relation to the degree of linguistic differences (Sung, 2021). In terms of phonology, when some phonetic features in the target language are not found in the first language(s), students tend to produce dissimilar sounds (Fauzi, 2018). In the same vein, Goswami (2020) also found that the errors committed by Sylheti Bangla speakers of English can be attributed to the interference of the rules of their first language in learning the second language. These interferences can be phonological, morphological, and in terms of sentence structures.

Studying the production of English vowels among Acehnese-Indonesian-speaking students is essential due to persistent difficulties observed in their ability to contrast vowels and articulate diphthongs. Despite receiving English education for six to seven years during their junior and senior high school, preliminary research by Nurjannah (2022) and Nurjannah et al. (2023) indicate that many university students face challenges in accurately differentiating sounds such as /i/ and /ɪ/, as well as struggle with the pronunciation of diphthongs. The pilot results, derived from English words modeled after British English, revealed specific challenges speakers face in distinguishing pairs like 'heed' and 'hid', 'head' and 'had', and 'hard' and 'hod'. These difficulties may be linked to the linguistic influence of Acehnese as their native language (L1) and Indonesian as their second language (L2) on the acquisition of English as their third language (L3).

Problem of the Study

In their attempts to speak in English, Indonesian language learners frequently produce a variety of pronunciation errors that significantly reduce their intelligibility in the English language (Moedjito & Harumi, 2008). As observed by Achmad and Yusuf (2014), the dissimilarities of the vowel systems found in L1 (Acehnese) and L2 (Indonesian) eventually influence the production of their English sounds. These previous findings motivated this study on the production of English vowels by Indonesian students, especially those from Aceh, because studies, such as this in the area of phonology, show incongruities between perceived and intended sound and the actual, pronounced sound of a language (Oladipupo, 2014).

Analyzing the vowel production of a language speaker can be done by measuring the formants of the vowel itself. The accuracy of pronunciation produced by a speaker can be recognized from the values of formants of the vowels in vowel space (Widagsa & Putro, 2017).

Vowel Inventories of English, Indonesian, and Acehnese

The uniqueness of Acehnese and Indonesian vowels contributes to the intricacy of English vowel acquisition among students. Acehnese, the most widely used language in Aceh, possesses ten oral monophthongs, as reported by Pillai and Yusuf (2012). On the other hand, Indonesian is characterized by six oral monophthongs, identified by Soderberg and Olson (2007) and Wijana (2003). The distinctiveness of certain English vowels, such as /ɪ/, /æ/, /ɒ/, /ɜ/, /aː/, and the diphthongs /ei/, /əʊ/, /ae/, which are not present in either Acehnese or Indonesian, adds complexity to the students' pronunciation challenges. Recognizing these linguistic influences is crucial for tailoring effective language teaching strategies. Table 1 shows the monophthong inventories of Acehnese, Indonesian, and English.

Table 1. The Monophthong Inventories of Acehnese, Indonesian, and English

	Acehnese	**Indonesian**	**English***
Front Vowels	i	I	iː
	e	i	ɪ
	ɛ	e	ɛ
		ɛ	æ
Central	ɯ	ə	ʌ
	ə	ɐ	ɜː
	ʌ		
	a		
Back	o	u	ɒ
	u	ʊ	uː
	ɔ	o	ʊ
		ɔ	ɔː
			ɑː

*Based on Received Pronunciation

Based on Table 1, the similarities and differences between the vowel sounds in Acehnese, Indonesian, and English are evident. The similarities include, for example: /i/ and /iː/, where all three languages have a close front unrounded vowel (/i/ in Acehnese and Indonesian, /iː/ in English. In relation to /e/ and /ɛː/, Acehnese and English share an open-mid front unrounded vowel (/ɛ/ in Acehnese, /e/ in English), while Indonesian has an open-mid front unrounded vowel (/ɛ/). In terms of /ə/, all three languages have this schwa. Where /a/ is concerned, Acehnese and Indonesian both have an open front unrounded vowel (/a/), while English has an open back unrounded vowel (/ɑː/). Finally, Acehnese and Indonesian both have a close back rounded vowel (/u/), while English has a close back rounded vowel (/uː/).

The differences that can be noted from Table 1 are /iː/ and /ɪ/, where Acehnese and Indonesian lack a clear distinction between long and short /i/, while English has both quality and durational contrasts between /iː/ and /ɪ/ (short). For /æ/, English has an open front unrounded vowel (/æ/) that is not present in Acehnese or Indonesian. Then there are /ʌ/ and /ɜː/: Acehnese has a mid-central unrounded vowel (/ʌ/), while English has a mid-central unrounded vowel (/ɜː/). In English /ʌ/ is an open-mid to open central vowel. Indonesian lacks this sound. For the pair /ɒ/ and /ɔː/, Acehnese has an open back rounded vowel (/ɒ/), while English has an open-mid back rounded vowel (/ɔː/). Indonesian lacks this sound. In terms of /o/ and /ʊ/: Acehnese has a close-mid back rounded vowel (/o/), while English has a near-close near-back rounded vowel (/ʊ/). Indonesian lacks these specific sounds. Finally, /ɑː/, English has an open back unrounded vowel (/ɑː/) that is not present in Acehnese or Indonesian. These comparisons highlight both similarities and differences in the vowel sounds across Acehnese, Indonesian, and English. However, these depictions do not provide the approximate measurements or the phonetic characteristics of these vowels by male and female speakers.

Previous research, including the work by Pillai and Yusuf (2012), provides valuable insights into the phonetic characteristics of Acehnese vowels. This knowledge is foundational in understanding the challenges faced by Acehnese-Indonesian speaking students when acquiring and producing English vowels. Additionally, Soderberg and Olson (2007), as well as Wijana (2003), have documented the phonetic features of Indonesian monophthongs. These studies collectively underscore the significance of considering the linguistic backgrounds of Acehnese and Indonesian speakers to enhance the acquisition of English vowels and inform targeted language instruction.

Gender in Acoustic Phonetics Studies

The investigation into acoustic theories of speech production, as elucidated by researchers such as Fant (1981) and Stevens and House (1955), focuses on the shape of the vocal tract to the acoustic signal. Abdul-Rahman (2006) notes the continuous variation in the shape of supraglottal cavities and associated resonances during speech, underscoring the dynamic nature of the acoustic mechanisms involved in human communication.

A critical factor influencing the acoustic characteristics of speech is the gender-specific variation in vocal tract length. Studies, such as Maragakis (2008), highlight that adult females typically have a vocal tract length of around 13 cm, whereas adult males may exhibit variability with lengths exceeding 18 cm. This discrepancy results in gender-specific differences in formant frequencies, where women, due to their shorter vocal tracts, produce higher resonance frequencies compared to men. The significance of these variations extends beyond mere acoustic nuances, impacting the clarity of speech. Flynn (2011), Foulkes and Docherty (1999), Simpson (2009), and Wang and van Heuven (2006) collectively affirm that females, with formant frequencies approximately 10% to 15% higher, tend to produce more distinctive speech compared to their male counterparts.

Given these gender-related disparities, Jacobi (2009, p. 27) emphasizes the necessity of incorporating a normalization procedure in variation analysis to account for sex differences. This procedural adjustment becomes imperative for differentiating linguistic effects from inherent biological sex characteristics. In the realm of gender-related vocal tract variations, Jacobi's assertion underscores the importance of nuanced considerations in acoustic studies to ensure a comprehensive understanding of the interplay between biological and linguistic factors influencing speech production.

English Vowels Produced by Non-native Speakers

There are several prior studies on acoustic measurement related to the formant values of the English vowels produced by non-native speakers of English. Giacomino (2012) researched Spanish male and female students and found that they have problems producing short and long vowels of /i/ and /ɪ/, and /u/ and /ʊ/. The informants also could not distinguish between /ɔ/ and /ɑ/. Meanwhile, Pillai et al. (2010) who examined the English monophthongs produced by female Malaysian speakers, found that they were produced differently from British English ones. There was generally a lack of quality contrast between the following vowel pairs: /i:/ and /ɪ/, /e/ and /æ/, and /ʌ/ and /ɑ:/. Another study by Yamaguchi and Chiew (2020) on Japanese English found that the English vowels produced by Japanese speakers tended to be centralized, with speakers having difficulty producing open back vowels. Additionally, the centralized vowel /a/ is substituted for five vowels (/æ/, /ə/, /ʌ/, /ɜ/, /ɑ/).

In the Indonesian context, Widagsa and Putro (2017) found that the production of English vowels by Indonesian speakers is influenced by Indonesian vowels. This results in Indonesian students facing difficulties in producing some English vowels. Their findings revealed that the vowel space of the five male Indonesian English speakers was somewhat more compact than the British native speakers. This is prominent in the production of the following vowels, /ɑ/, /ɒ/, and /ɔ/. Furthermore, Fata et al. (2017), who examined the production of English vowels by Indonesian students, provided the average first (F1) and second formant (F2) values of each vowel produced by the female and male students but the difference was not statistically measured.

An investigation into how bilingual Acehnese-Indonesian learners of English perceive English vowel contrasts was conducted by Masykar et al. (2022). They concentrated on the learners' perception of five sets of vowel contrast in English that are new, similar, and identical to the Acehnese and Indonesian vowels: /ɪ/-/i/, /æ/-/ɛ/, /ʌ/-/ɑː/, and /ʊ/-/u:/. The students were randomly given an AX test consisting of repetition and simple pairs of English vowel differences in CVC word contexts. After conducting statistical analysis and interpreting the data using models of speech perception and production, the study found that Acehnese-Indonesian bilinguals exhibited better discrimination between particular vowel pairs. Specifically, they were better at distinguishing between the vowel pairs /æ/-/ɜː/ and /ɑː/-/ɔː/ compared to other pairs such as /ɪ/-/iː/, /ʌ/-/ɑː/, and /ɑː/-/ɔː/. Additionally, when comparing vowel pairs where one vowel is shared between Acehnese and Indonesian to pairs where both vowels are novel to these languages, there was moderate differentiation. Participants responded more accurately to pairs with a vowel similar in both Acehnese and Indonesian, as opposed to pairs with either uncommon or entirely novel vowels in these languages.

The existing studies on the acoustic measurements of English vowels produced by non-native speakers reveal several gaps and limitations that necessitate the current study. Giacomino's (2012) research on Spanish students highlighted difficulties in producing specific vowel pairs, such as /i/ and /ɪ/, and /u/ and /ʊ/. Pillai et al. (2010) found a lack of vowel contrast in typical vowel pairs among Malaysian speakers. Yamaguchi and Chiew's (2020) study on Japanese English identified centralized vowels and substitutions, impacting open-back vowels. In the Indonesian context, Widagsa and Putro (2017) identified interference from Indonesian vowels affecting the production of English vowels, while Fata et al. (2017) did not statistically prove if there were gender differences in the production of vowels in their study. Masykar et al.'s (2022) investigation into bilingual Acehnese-Indonesian learners emphasized discrimination patterns in English vowel contrasts and showed that particular pairs were challenging to differentiate when it comes to perception.

The limitations in previous studies, such as insufficient statistical analyses, lack of gender-based comparisons, and inadequate representation of the vowel space, underscore the need for this present study to be conducted on Acehnese learners of English. Specifically, this research addresses the impact of Acehnese and Indonesian linguistic influences on English vowel production, considering the unique characteristics of these languages and their potential effect on pronunciation. Additionally, the current study aims to provide a more comprehensive analysis, incorporating robust statistical tests and measurements in the Bark scale, addressing the shortcomings observed in prior research. The research questions to be answered are:

(1) What are the characteristics of the production of English monophthong vowels among Acehnese-Indonesian learners of English?

(2) To what extent do male and female learners of English differ?

This research focused on the British English accent because the respondents of this study had been learning English based on British English pronunciation from their university lecturer for the past two years. Specifically, it contributes to research on the varieties of English that are now developing in countries where English is spoken as a non-native language. This research adds Indonesian English to the body of linguistic studies on English varieties worldwide. It highlights the importance for practitioners of English as an international language to enhance their learners' awareness of different English accents and pronunciations (Candan & Inal, 2020). It is also expected that this research can serve as a pilot for further studies, particularly on English pronunciation by students in Indonesia. The Speech Learning Model (SLM), for example, aims to account for variance in how quickly or slowly learners pick up on producing and understanding phonetic segments (such as vowels and consonants) in a second language (L2) (Flege, 2005). Thus, differences in the learnability of phonetic segments in an L2 are important as pronunciation is among the contributors to intelligibility for international communicative purposes (Suntornsawet, 2019).

METHOD

In this study, the quantitative method was used to allow the researchers to examine the acoustic properties related to Indonesian English vowels. The vowels were measured using PRAAT 5.3.5.3 (Boersma & Weenink, 2019). PRAAT is a free and open-source computer software that enables the analysis of sounds including measurements like formant frequencies, durations, and pitch. As Styler (2023, p. 86) puts it: "PRAAT is unquestionably powerful software. Although there are other packages and tools which may offer some improvements in some specific domains, there is no other program which can do even half of what PRAAT can do without resorting to scripting". Thus, it is common to find PRAAT being used in published papers in the area of phonetic research.

Informants

The informants of this study were ten undergraduate students studying in their fourth semester at a private college in the Pidie District in Aceh, Indonesia. They comprised five females and five males. The participants were selected based on their English proficiency scores, specifically targeting those with average scores ranging from 75 to 85 in their English classes. This ensured a relatively homogeneous group in terms of English proficiency. This approach helped control for variations in language ability and facilitated a focused analysis of Acehnese production of English vowels within a more consistent linguistic context. The English course for these students is only 90 minutes a week. It is part of their *Mata Kuliah Umum* (MKU, or General Common Courses). In the context of higher education in Indonesia, particularly in universities, MKU refers to general courses that cover broad topics and are typically mandatory for all students regardless of their major. These courses aim to provide students with a well-rounded education by exposing them to various disciplines outside their specific field of study. MKU often includes subjects such as philosophy, sociology, culture, ethics, and the English language, contributing to a comprehensive and interdisciplinary learning experience. The students' other English language exposures may extend beyond textbooks and lectures, such as engagement in extracurricular activities, social media, and occasional interaction with foreigners. These varied experiences can shape their language learning experiences, including influencing their English vowel production.

Meanwhile, the inclusion of social variables in this study, specifically focusing on male and female participants, was driven by its aim to explore gender-based differences in English vowel production. Gender plays a role in phonetic variation, and studying both male and female speakers allows for a more comprehensive understanding of these variations. The choice of ten participants was influenced by practical constraints such as resource availability, time constraints, and the depth of analysis required since data collection is through elicitation from each student, not a survey or filling in the questionnaire. A smaller sample size allowed for a more detailed and focused examination of individual participant characteristics and linguistic patterns. These students all came from the same district, the Pidie District in Aceh. This district was chosen as the regional background due to its linguistic diversity and potential influence on the participants' Acehnese dialect, which, in turn, might affect their learning of English vowels. In phonetic studies, it is important that the informants were of the same origin and place of residence. The participants' ages were between 20 to 21 years old. All spoke Acehnese as their first language, and Bahasa Indonesia as their second language. Acehnese is the mother tongue of the Acehnese ethnic group in the Aceh Province, while Indonesian serves as the national language of the country and the lingua franca of the archipelago. Meanwhile, English is a foreign language that is officially taught in public schools from secondary education to university levels, as mandated by the Ministry of Education of Indonesia. Therefore, the participants in this study began learning English in grade 7 of their secondary school education and continued studying until their fourth semester at university. Upon entering university, they were taught English by two lecturers who claimed to use a British accent. The lecturers also provided textbooks and reading materials based on British English.

These informants were also chosen based on some criteria relevant to this study. They were all native speakers from the same origin and place of residence (i.e. the Pidie district) and had not relocated from their place of residence throughout their lives, apart from occasional short holidays to other destinations. The informants also studied at the same private college within the same department. They had no dental problems, no lip deformation (i.e. harelip or orofacial cleft), and no hearing problems.

Data Collection

To collect the data for this research, the researchers used a word list to elicit speech (Yusuf & Pillai, 2013) as shown in Table 2. It is one of the ways to ensure that all target vowels (11 English oral monophthongs) within the same phonetic environment can be obtained from the informants (King, 2006). Before recording, a meeting session of about 15 minutes was done with all ten informants to explain the procedure of the recording process. Each informant was recorded in a soundproof room, the Beat Studio, that is available at the private college. Each recording with one informant took about 7 minutes. They were asked to say each word in the word list, which contained the target vowel, in the carrier sentence, "Please say _____ again". This was done to ensure that the target vowel sounds were all produced in the same phonetic context (King, 2006; van Heuven et al., 2002). There were also supporting words next to each target word to help the students say the target words should they be confused about how to say them (Pillai & Delavari, 2012). Table 2 shows the target words that contained the target vowels for this research; these words were obtained from the work of Ladefoged and Johnson (2011) and the supporting words were taken from Pillai and Delavari (2012).

Table 2. Target Words for Elicitation

Vowel	Word	Supporting word
iː	Heed	Need
ɪ	Hid	Sit
ɛ	Head	Bed
æ	Had	Bad
ʌ	Hud	But
ɑː	Hard	Card
ɒ	Hod	Dog
ɔː	Horde	Horse
ʊ	Hood	Book
uː	Who'd	Soon
ɜː	Heard	Bird

(Pillai & Delavari, 2012, p. 478)

Every informant was recorded directly into the laptop using PRAAT while the Audio-Philips SMH7410U head-worn microphone was also used to ensure the quality of voice spoken by the informants. Each informant read every target word in the carrier sentences six times to produce 66 tokens for every target vowel. Therefore, the total number of tokens for the eleven English oral monophthongs from the ten informants is 660 tokens; from this number, 330 tokens were from the female students and 330 tokens were from the male students. The recording was saved into WAV files and then transcribed and analyzed in PRAAT.

Data Analysis

Each token was measured for their F1 and F2 at the midpoint of the vowel in Hertz (Yusuf et al., 2021). These formant frequencies were used to analyze the characteristic of monophthongs (Deterding, 2003; Jurgec, 2005; Man, 2007; Pillai et al., 2010; Sharbawi, 2006; Verhoeven & van Bael, 2002). The measurements in Hertz were transferred to an MS Excel file and converted to the Bark scale. The conversion from Hertz to Bark was done because the raw Hertz formant frequencies of different speakers are not directly comparable, and, thus, it is not ideal to plot formant values in Hertz from different speakers on the same formant chart (Watt et al., 2010). Zwicker and Terhardt (1980) suggest that converting formant values from Hertz to the Bark scale corresponds to how we hear frequencies. The Bark scale is known as a psycho-acoustical scale that uses more perceptually accurate representations of audio and spoken signals (Melnik-Leroy et al., 2022). It is further designed for the filtering of the analysis of auditory signals such as speech (Stevens, 2000).

The average values of each vowel were then plotted on an F1-F2 chart. These vowel charts provide a scientific description and approximate representation of the qualities of individual vowels (Watt & Tillotson, 2001). Even though some studies plot these vowels on an F2-F1 vs. F1 chart, Pillai et al. (2010) explain that the tongue is the primary speech organ involved in producing vowels, and F1 and F2 relate to the amount of tongue elevation and retraction during the creation of each vowel. While F2 has a direct correlation with tongue advancement/retraction (although it is also impacted by lip rounding), F1 connects inversely to vowel height. Despite issues relating to the representation of back vowels in the former, this method is used by many contemporary researchers to show the placement of vowels in the vowel space, including Standard Southern British English (Deterding, 2007), Malaysian English (Pillai et al., 2010), and Dutch (van Heuven et al. 2002), among others. Finally, t-tests were conducted at http://vassarstats.net/ to compare the average value between Indonesian male and female vowels' production. A fixed-level p-value of .0001 (i.e. $p<.0001$) means that the difference between the groups was attributed to chance only 1 time out of 10,000.

FINDINGS AND DISCUSSION

Findings

This section presents the findings of this present study on the phonetic characteristics of the English monophthongs as produced by the male and female speakers of Acehnese from Pidie, Aceh, Indonesia.

Female Monophthongs

Each of the five female Indonesian students produced each target word six times, resulting in a total of 30 tokens for each vowel, and 330 tokens from the 11 English monophthongs. Table 3 shows the average duration, F1, and F2 of each vowel in both Hertz and Bark scales.

Table 3. F1 And F2 Average Values for Indonesian—Female Students' English Monophthongs

Vowel	Target word	Duration (Sec)	F1 (Hz)	F2 (Hz)	F1 (Bark)	F2 (Bark)
iː	Heed	0.365	450	2937	4.29	15.472
ɪ	Hid	0.133	455	2881	4.331	15.361
ɛ	Head	0.194	927	2418	6.921	14.285
æ	Had	0.225	811	3078	7.217	14.814
ʌ	Hud	0. 23	887	1664	7.752	11.890
ɑː	Hard	0.199	865	1552	7.596	11.381
ɒ	Hod	0.223	847	1441	7.477	10.919
ɔː	Horde	0.195	630	1312	5.830	10.271
ʊ	Hood	0.179	450	1216	4.291	9.756
uː	Who'd	0.223	472	1262	4.483	10.018
ɜː	Heard	0.189	694	1643	6.323	11.789

The measurements were converted from Hertz into the Bark scale, and the position of each vowel based on their average F1 and F2 values was plotted onto a vowel chart to show the distribution of the vowels in the vowel space as shown in Figure 1.

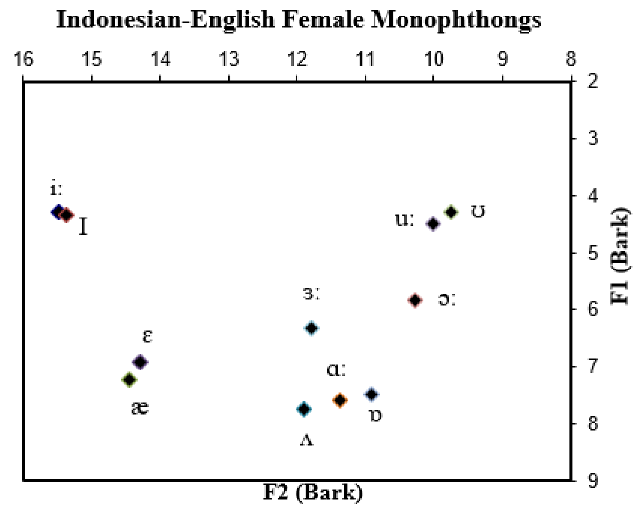

Figure 1. Vowel Chart for Indonesian Female Students' English Monophthongs

Figure 2 shows the distribution of each production of the front vowels, /i/, /ɪ/, /ɛ/ and /æ/, by the female students.

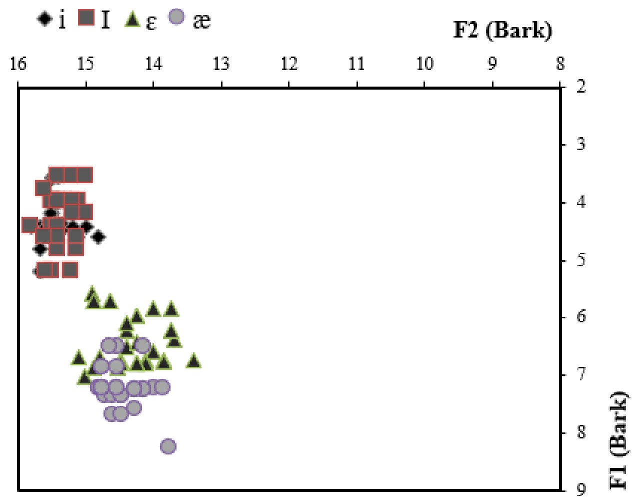

Figure 2. Scatter Plot for Indonesian-English /i/, /ɪ/, /ɛ/ and /æ/ Produced by Female Students

Figure 2 illustrates that there is variability in the way that these vowels were produced by the female students. As can be seen in Figure 2, the productions of /iː/ from 'heed' and /ɪ/ from 'hid' overlap considerably, and this indicates that the female students did not contrast these two vowels. Furthermore, t-tests show that there was no significant difference between the average F1 and F2 values of /iː/ and /ɪ/ produced by these female speakers (F1: $t(58)=-0.31$, $p=0.3788$); F2: $t(58)= +2.04$, $p=0.0230$). The t-test of the average durations between /iː/ and /ɪ/ also showed no significant difference ($t(58)=+1.12$, $p=0.1337$). This further confirms that /iː/ and /ɪ/ were produced similarly by the female students, and thus, they did not distinguish between the production of these vowels.

Figure 2 also shows the distribution of the front-mid /ɛ/ and the front low /æ/. The scatter plot shows that some students produced /æ/ lower than /ɛ/ in the vowel space. However, t-tests of the average F1 and F2 values of /ɛ/ from 'head' and /æ/ from 'had' showed no significant difference between the two vowels (F1: $t(58)=-0.61$, $p=0.2721$, F2: $t(58)=+1.73$, $p=0.0445$). This suggests that the female students did not distinguish between the English /ɛ/ and /æ/ productions.

The scatter plot for the central vowels, /ɜː/ and /ʌ/ is shown in Figure 3 where there is no overlap between the two vowels. Thus, there was a significant difference between the average F1 values of the two vowels ($t(58)=-10.85$, $p<.0001$). This can be seen in Figure 3, where /ɜː/ from 'heard' is higher than /ʌ/ from 'hud' in the vowel space. On the other hand, there was no significant difference in their average F2 values ($t(58)=-1.04$, $p=0.1513$). This is to be expected as both these vowels are centrally placed in the vowel space ($t(58)=+2$, p=0.0251). Meanwhile, referring to Figure 1, it is seen that /ʌ/ from 'hud' and /ɑ:/ from 'hard' are produced very close to each other in the vowel space. This was confirmed by the t-tests which found no significant differences between the average F1 and F2 values of the two vowels (F1: $t(58)=+1.89$, $p=0.0688$, F2: $t(58)=+3.37$, $p=0.0021$). There were also no significant differences in their average durations ($t(58)=-3.97$, $p= 0.0004$), which indicates that there was no quality and length contrast between the vowels.

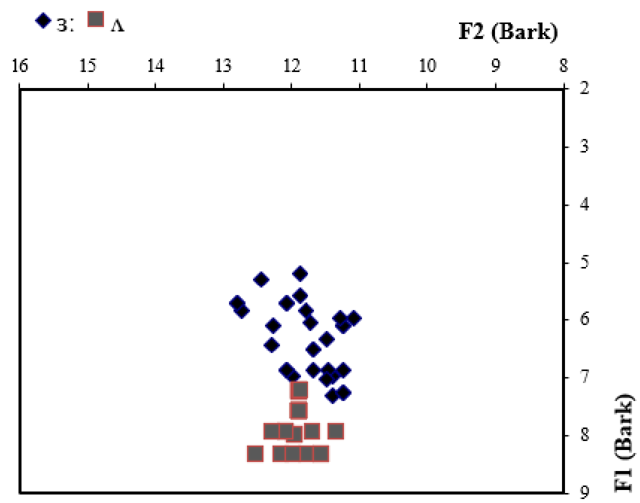

Figure 3. Scatter Plot for Indonesian-English /ɜ:/ and /ʌ/ Produced by Female Students

For back vowels, the scatter plot for /u:/, /ʊ/, /ɔ:/, and /ɒ/ is shown in Figure 4. Some overlaps can be observed between the back vowels /u:/ from 'who'd' and /ʊ/ from 'hood' in this figure. Despite the expected higher position of /u:/, the students produced /ʊ/ slightly higher than /u:/, contrary to the anticipated pattern. The results of the t-test support this observation, as there were no significant differences between the average F1 and F2 values of these vowels /u:/ and /ʊ/: (F1: $t(58)=+2.05$, $p=0.0224$; F2: $t(58)=-1.56$, $p=0.0621$). There were also no significant differences in their average durations ($t(58)=-2.37$, $p=0.0106$), which indicates that there was no quality and length contrast between the vowels.

Another pair of back vowels examined were the rounded mid /ɔ:/ and lower back /ɒ/. Figure 4 shows that /ɔ:/ from 'horde' was produced higher than /ɒ/ from 'hod' in the vowel space as might be expected. In fact, significant differences between the average F1 and the F2 values of these two vowels were found (F1: $t(58)=-18.4$, $p<.0001$; F2 $t(58)=+4.65$, $p<.0001$). However, there was a lack of length contrast as there was no significant difference between the durations of these vowels ($t(58)=+2.54$, $p=0.0068$).

Furthermore, Figure 4 shows an overlap between /ɑ:/ from the word 'hard' and /ɒ/ from the word 'hod' in the vowel space. The similarity in the production of the vowels /ɑ:/ and /ɒ/ by the female speakers was verified by the t-test results which showed no significant differences between the average F1 and F2 values of the two vowels (F1: $t(58)=-1.2$, $p=0.1175$; F2: $t(58)=+2.61$, $p=0.0057$).

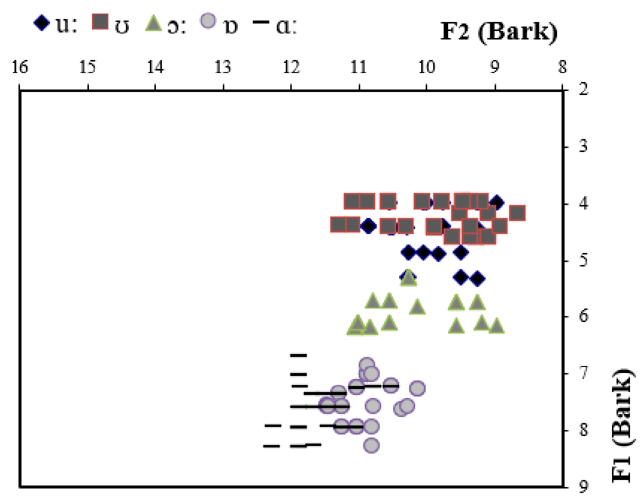

Figure 4. Scatter Plot for Indonesian-English /u:/, /ʊ/, /ɔ:/, /ɑ:/ and /ɒ/ Produced by Female Students

Male Monophthongs

Similar to the female students, each of the five male Indonesian students produced each target word six times, resulting in a total of 30 tokens for each vowel, and 330 tokens from the 11 English monophthongs. Table 4 shows the average duration, F1, and F2 of each vowel in the Hertz and Bark scales.

Table 4. F1 And F2 Average Values for Indonesian Male Students' English Monophthongs

Vowels	Target words	Duration (sec)	F1 (Hz)	F2 (Hz)	F1 (Bark)	F2 (Bark)
i:	Heed	0.195	415	2463	3.984	14.418
ɪ	Hid	0.354	372	2881	3.592	15.361
ɛ	Head	0.206	639	2012	5.900	13.134
æ	Had	0.222	674	2301	6.177	13.330
ʌ	Hud	0.181	769	1389	6.902	10.656
ɑ:	Hard	0.219	691	1279	6.307	10.118
ɒ	Hod	0.185	663	1201	6.086	9.696
ɔ:	Horde	0.258	489	1370	4.629	9.450
ʊ	Hood	0.165	431	1252	4.123	9.974
u:	Who'd	60.244	426	1466	4.075	10.002
ɜ:	Heard	0.181	521	1446	4.915	10.942

Figure 5 shows the 11 monophthongs plotted in the vowel space. Compared to the female students' English vowel production (see Figure 1), those of the male students are less spread in the vowel space.

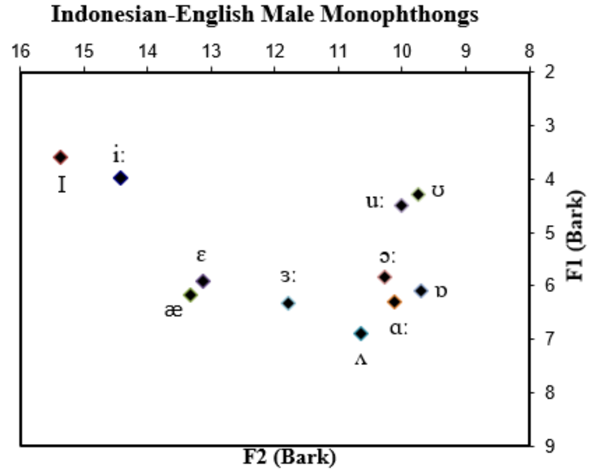

Figure 5. Vowel Chart for Indonesian Males Production of English Monophthongs

Figure 6 shows the scatter plot for the front vowels /i/, /ɪ/, /ɛ/ and /æ/. The pair /i:/ from 'heed' and /ɪ/ from 'hid' are produced as high front vowels in this figure. Unlike the female students, the male students distinguished the two vowels in terms of their quality contrast. As confirmed by the t-test results, there were significant differences between the average F1 and F2 values of these vowels (F1: $t(58)=+4.73$, $p<.0001$; F2: $t(58)=+24.22$, $p<.0001$). However, there is no significant difference in the average durations of these vowels ($t(58)=+0.04$, $p=0.4841$), indicating that length was not contrasted.

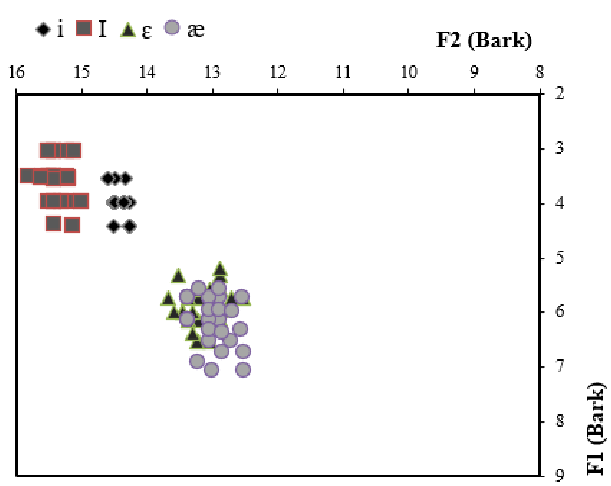

Figure 6. Scatter Plot for Indonesian-English /i/, /ɪ/, /ɛ/ and /æ/ of Male Students

Figure 6 shows that The front-mid /ɛ/ from 'head' and the front low /æ/ from 'had' were conflated. This was confirmed by the t-tests which found no significant differences between the average F1 and F2 values of the two vowels (F1: *t*(58)=-2.7, *p*=0.0045, F2: *t*(58)=+1.91, *p*=0.0305). Thus, both male and female students did not distinguish this vowel pair. For the central vowels of /ɜ:/ and /ʌ/, the scatter plots are shown in Figure 7.

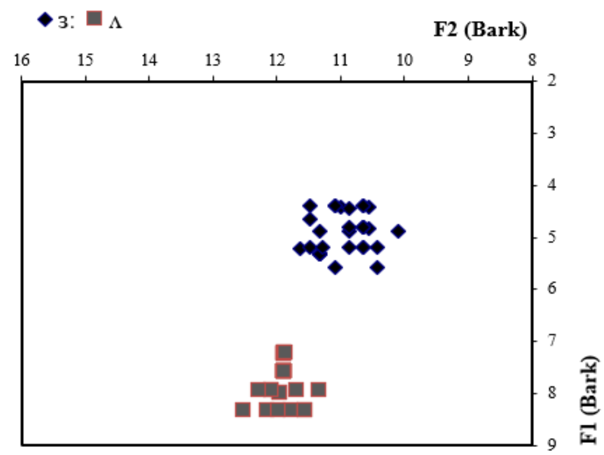

Figure 7. The Scatter Plot for Indonesian-English /ɜ:/ and /ʌ/ of Male Students

Figure 8 displays the scatter plot for /u:/, /ʊ/, /ɔ:/, and /ɒ/ produced by the male students. It would be expected that the vowel /u:/ from 'who'd' would have been produced higher than /ʊ/ from 'hood' in English. However, the male students appeared to conflate these vowels as can be seen in Figure 8 where there is an overlap between the two vowels. This was validated by the t-test results where there were no significant differences between the average F1 and F2 of these vowels /u:/ and /ʊ/ (F1: *t*(58)=-0.54, *p*=0.2956; F2: *t*(58)=-0.06, *p*=0.4762). This is similar to the female students, who also did not differentiate the production of /u:/ and /ʊ/. However, the male students displayed length contrast duration, with /u:/ being produced significantly longer than /ʊ/ (*t*(58)=-6.42, *p*<.0001).

The female students showed that there was no quality and length contrast between the vowels /ʌ/ from 'hud' and /ɑ:/ from 'hard'. Therefore, for the male students, these vowel production were also observed. Figure 3 also shows that these two vowels are produced close to each other in the vowel space by the male students, but not as close as the female students. This was confirmed by the t-tests which found a significant difference between the average F1 values (F1: t(58)=+4.96, p=<.0001), but no significant difference between the average F2 values (t(58)=+3.48, p=0.0016). This is expected because /ʌ/ is a central vowel and /ɑ:/ is a back vowel. A significant difference in their average durations is found (t(58)=-7.34, p=<.0001), which indicates that there was a length contrast between the vowels.

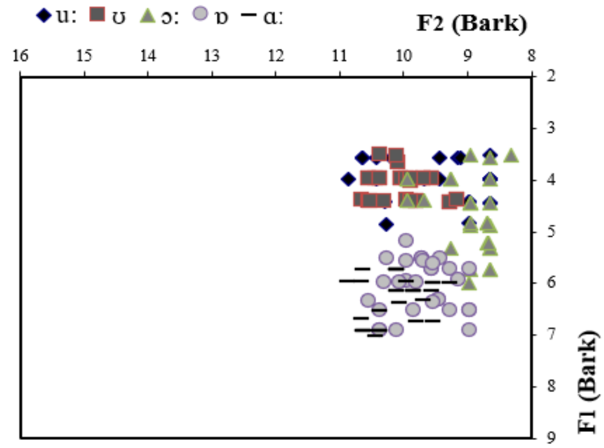

Figure 8. Scatter Plot for Indonesian-English /u:/, /ʊ/, /ɔ:/, /ɑ:/ and /ɒ/ Produced by Male Students

Figure 8 shows the scatter plot of the mid /ɔ:/ from ‘horde’ and lower back /ɒ/ from ‘hod’. With /ɔ:/ appearing higher than /ɒ/ in the vowel space, a significant difference between the average F1 values of these vowels was found ($t(58)$=-9.11, p<.0001). However, since both are back vowels, no difference between the average F2 values of the two vowels was found ($t(58)$=+0.53, p=0.2991). Similar to the female students, there was no durational difference between these vowels for the male students ($t(58)$=+1.31, p=0.0977). The sounds /ɔ:/ and /ɒ/ are not typical pairs in English, however, they are contrasted in this study because the vowel sound /ɔ/ is found in both Indonesian and Acehnese, unlike /ɒ/, which is absent. Additionally, while the sound /ɑ/ is present in both Indonesian and Acehnese, the vowel /ɒ/ is not.

Finally, Figure 8 shows considerable overlap between /ɑː/ from ‘hard’ and /ɒ/ from ‘hod’ as both are low back vowels. Similar to the production of these vowels by the female speakers, there were no significant differences between the average F1 and F2 values between the two vowels (F1: $t(58)$=-1.8, p=0.0385; F2: $t(58)$=+3.69, p=0.0002). What distinguishes these vowels in English is lip rounding, in which lip rounding is for ‘hod’.

Discussion

The results of the study revealed the English vowel qualities produced by Indonesian female and male students. Figure 9 illustrates the vowel space occupied by the Indonesian female and male students’ English vowels, which indicates a slight difference where the vowel space of the female students appears more peripheral than that of the male students. Accordingly, peripheral vowels are more distantly positioned from one another compared to central ones, due to a more careful production of the target words (Pillai, 2014). The literature further points out that the vocal tracts of females are shorter and have higher resonance frequencies than males (Flynn, 2011). This results in them generating sounds that are more intelligible than males (Wang & van Heuven, 2006). Consequently, females tend to have more dispersed vowels in the vowel space compared to males (Heffernan, 2007). Similar to Fata et al. (2017) who also studied the English vowel production of Indonesian male and female students, the males in this study produced English oral monophthong vowels higher and farther back compared to the females, who produced them more fronted and lower.

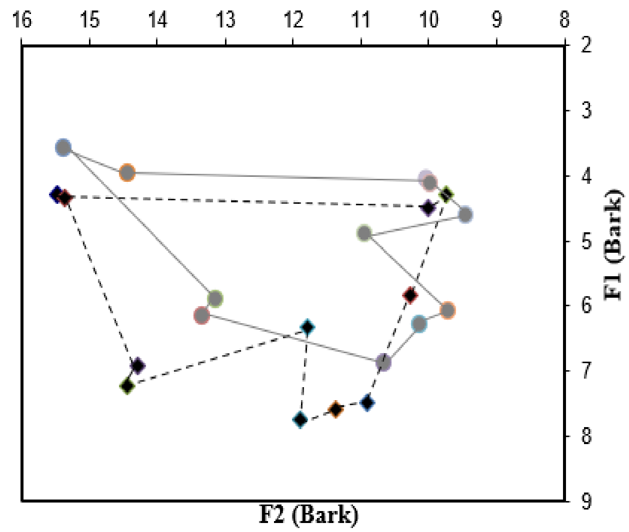

Figure 9. The Vowel Spaces of English Monophthongs Produced by Indonesian Females and Males

The results show that the female students conflated the typical vowel pairs /i:/-/ɪ/, /ɛ/-/æ/, /u:/-/ʊ/, and /ɑː/-/ɒ/, but contrasted the /ɔ:/-/ɒ/. The male students also contrasted this pair, but unlike their female counterparts they did not conflate /i:/ and /ɪ/. Additionally, the males displayed length contrast for /i:/-/ɪ/, /ɑː/-/ɒ/, and /ɒ/-/ɔ:/, while the females only did so for the latter. Table 5 summarizes the findings of this study for the typical pairs of English vowels. Similar findings, where there is a lack of vowel contrast have been reported in Malaysian English (Pillai et al., 2010). For example, Pillai (2014) found that Malay students in Malaysia tended to produce /ɛ/ and /æ/ similarly so that words like ‘beg’ and ‘bag’ are produced as homonyms. A similar pattern was also observed among Thai students, where these two vowels are conflated (Pillai & Salaemae, 2012).

Table 5. The Summary of Data Analysis

Vowel Pairs	Females		Males	
	Quality	Duration	Quality	Duration
/i:/- /ɪ/	Similar	Similar	Different	Similar
/ɛ/-/æ/	Similar	NA	Similar	NA
/ɜ:/-/ʌ/	Different	Similar	Different	Different
/u:/-/ʊ/	Similar	Similar	Similar	Different
/ɔ:/-/ɒ/	Different	Similar	Different	Similar
/ʌ/-/ɑː/	Similar	Similar	Different	Different

Masykar et al.'s (2022) perception study suggest challenges faced by Acehnese-Indonesian learners in distinguishing particular English vowel pairs. These perceptual challenges may influence the production of vowels. Additionally, the parallel findings with other Southeast Asian learners, such as Malay and Thai students, as reported by Pillai (2014) and Pillai and Salaemae (2012), suggest broader regional linguistic influences impacting vowel production in English. The recurrence of similar vowel merging patterns across different studies and contexts underscores the need for targeted language instruction strategies that address these persistent challenges among learners in the region.

The lack of length contrast between the typical vowel pairs may be attributed to the fact that both Indonesian and Acehnese do not differentiate between short and long vowels (Achmad & Yusuf, 2014). Consequently, /iː/- /ɪ/ tends to be conflated and produced closer to /ɪ/, especially by the female students. Meanwhile, the vowel /æ/ does not exist in both the Indonesian (Ulfayanti & Jelimun, 2018; Wijana, 2003) and Acehnese vowel systems (Pillai & Yusuf, 2012). As a result, the sounds /ɛ/-/æ/ are typically produced as /ɛ/ which exists in both Indonesian and Acehnese.

Furthermore, the sound /ʌ/ exists in the Acehnese vowel system (Pillai & Yusuf, 2012), but not in Indonesian (Ulfayanti & Jelimun, 2018). Conversely, the sound /ɜː/ does not exist in both languages. Consequently, as the students are familiar with /ʌ/, the sounds /ɜː/-/ʌ/ are pronounced as /ʌ/, especially by the female students. Concerning the pair /uː/-/ʊ/; the sound /u/ exists in both Indonesian (Ulfayanti & Jelimun, 2018; Wijana, 2003) and Acehnese (Pillai & Yusuf, 2012), while /ʊ/ is only present in Indonesian (Ulfayanti & Jelimun, 2018). Since there is no duration contrast for vowels in both Indonesian and Acehnese, both male and female students tend to pronounce these two sounds as /u/ in English.

The vowel /ɔ/ is present in both Indonesian and Acehnese, whereas /ɒ/ is not; leading the students to often pronounce these two vowels as /ɔ/ in their English speech. Furthermore, the sound /ɑ/ exists in both Indonesian and Acehnese, but the vowel /ɒ/ does not. This may be the reason that students tended to replace /ɒ/ with /ɑ/. Additionally, data from Widagsa and Putro (2017), although obtained solely from Indonesian male speakers, also indicate significant differences in the production of /ɑ/, /ɒ/, and /ɔ/ by Indonesian English speakers compared to British English speakers. The influence of both Indonesian and Acehnese also appears to affect perception as shown in Masykar et al. (2022) where it was reported that Acehnese-Indonesian learners perceive pairs with one vowel similar to those in Acehnese-Indonesian better than pairs with either both vowels or one vowel unfamiliar in Acehnese and Indonesian.

The Implications of the Study on English Language Learning

The differences in vowel production found in this study are phonemic and can cause some misinterpretations due to variations in pronouncing English words. Jenkins (2002) identified three key characteristics of pronunciation: specific segmental aspects, nuclear stress, and effective use of the articulatory setting. She argued that these features have a significant impact on intelligibility. Understanding how Indonesian students produce English sounds, in this case, monophthongs, can provide useful insights for the teaching and learning of English pronunciation. Linking the findings to the students' first and second languages provides even more information about the possible influences from languages like Acehnese and Indonesian on their production of English sounds. Such understanding of the actual production and possible influences from other languages can help English language educators make more informed pedagogic decisions in terms of materials to be used and teaching methods. Additionally, knowing that there is empirical evidence of similarities with neighboring varieties of English can also be a teaching and learning opportunity especially when it comes to intelligibility and understanding of regional varieties of English, including Indonesian accented English.

Furthermore, English teachers can gain significantly from recognizing the importance of understanding and using phonetics and phonology in teaching foreign languages. Quintana-Lara (2014, p. 207) argues that "physical representations of speech sounds and spectrographs allow learners to objectively see and modify those non-accurate features in their oral production which may impede effective communication in the target language". Therefore, when students have phonetic awareness and skills in English, they can accurately discern consonants (by place and manner of articulation), and vowels (by tongue position, tongue height, lip rounding, and the characteristics of monophthongs, diphthongs, and triphthongs of the language) (Hismanoglu, 2012). Despite the diverse varieties of English among groups of non-native English learners (Yusuf, 2019), examining the similarities and differences between the sounds produced by a diverse group of speakers can assist students in better comprehending and being understood by their interlocutors (Istiqomah et al., 2021). Today, the obsolete objective of achieving native-like fluency in pronunciation instruction has been replaced with the objective of intelligibility or the degree to which one's speech is understandable to others with varied first and second language backgrounds (Loewen, 2015).

CONCLUSIONS

Based on the research findings, it is evident that the qualities of the English oral vowels produced by the male and female students are somewhat similar (see Table 5). The results showed that the females produced many of the vowel pairs similarly: /iː/-/ɪ/, /ɛ/-/æ/, /uː/-/ʊ/, /ʌ/-/ɑː/, and /ɑː/-/ɒ/. The pairs they differentiated were /ɜː/-/ʌ/ and /ɔː/-/ɒ/. However, the female students could not discriminate between the long and short vowel pairs. Meanwhile, the male students could distinguish the following pairs: /iː/-/ɪ/, /ɜː/-/ʌ/, /ʌ/-/ɑː/, and /ɔː/-/ɒ/. The others, /ɛ/-/æ/, /uː/-/ʊ,/ and /ɑː/-/ɒ/, were produced similarly. Additionally, they could distinguish the long and short vowels in the /ɜː/-/ʌ/, /uː/-/ʊ/, /ʌ/-/ɑː/, and /ɑː/-/ɒ/ pairs, but not /iː/-/ɪ/, /ɛ/-/æ/ and /ɔː/-/ɒ/. To conclude, there is generally a lack of vowel contrast between vowel pairs where vowel quality and duration are concerned. However, the males show a higher tendency to maintain length contrast compared to the females.

While this study provided empirical evidence of the production of vowels by a group of Indonesian students from Aceh based on acoustic analysis, it is not without limitations. The first limitation is in the sample size, while the second lies in the instrument used, which was a word list. Future studies should comprise a bigger sample and include other speaking contexts. Additionally, since this study only focused on monophthongs, future studies should look into diphthongs as well as consonants to build a more complete picture of the production of English sounds by speakers with similar and different language backgrounds.

ACKNOWLEDGMENTS

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