



Acoustic Analysis of English Monophthong Vowels Produced by Junior High School Students Using Praat

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ABSTRACT

This study used the Praat software to analyze the acoustic characteristics of English monophthong vowels produced by junior high school students as non-native speakers. The study applied a quantitative descriptive method and focused on the first formant (F1) and second formant (F2) frequencies to examine vowel production accuracy. The participants were four junior high school students, and the data were collected through audio recordings of selected English words containing target vowels. The recordings were analyzed and compared with native speaker pronunciation models taken from the Oxford Learner's Dictionaries. The results showed that the students' vowel production was different from native speaker patterns. Most vowels produced by the students had higher F1 values, which indicated lower tongue positions, and inconsistent F2 values, which showed inaccurate frontness or backness of the tongue. Only a few vowels, such as /e/ and /ɪ/, were close to native pronunciation. In contrast, vowels such as /i:/, /u:/, /ʌ/, and /æ/ showed clear differences in tongue position and articulation. The findings indicated that the students still had difficulties controlling tongue height and tongue position when producing English vowels. These differences were influenced by first language interference, limited exposure to native pronunciation, and a lack of pronunciation practice.

Keywords: Acoustic Phonetics, Praat, Monophthong Vowels, Formant Frequencies, Pronunciation Accuracy



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1. Introduction

Language is humanity's primary means of communication, manifested through spoken sounds. Through language, humans can convey ideas, feelings, and information to others (dan Politik & Bangsa, 2020). Language also creates the conditions that enable individuals to communicate and collaborate in social life, and serves as the primary vehicle for social interaction (Ningrum & Tazqiyah, 2024). Naturally, language is generally used in the form of spoken utterances delivered by a speaker and received by a listener.

Linguistics is a scientific field that studies language as a system, including its structure, the process of acquisition, and its use in producing and understanding meaning (Ganie et al., 2019). In linguistic studies, phonetics is the branch that examines speech sounds in terms of their physical aspects, including how they are produced, transmitted, and perceived (Roach, 2009). One important area within phonetics is acoustic

phonetics, which analyzes speech sounds in terms of measurable properties such as frequency. One of the key elements in the study of speech sounds is the vowel. A vowel is a speech sound produced without significant obstruction in the vocal tract, allowing air to flow freely (Carding & Mathieson, 2018). Vowels are essential to the construction of syllables and have a big impact on how clear a speaker's voice is. In contrast to diphthongs, this study's analysis is restricted to monophthong vowels, which are single, stable vowel sounds without a glide from one location to another (Ladefoged & Disner, 2012). In acoustic phonetics, vowel sounds are commonly analyzed through formant frequencies, particularly the first formant (F1) and the second formant (F2). Tongue position (frontness or backness) is reflected in F2, whereas tongue height is related to F1 (Lee et al., 2016). According to Peter Ladefoged (2006), every vowel contains three formants or overtone frequencies. The first formant (F1) is connected to vowel height, while the second formant (F2) relates to the frontness or backness of the vowel. A higher F1 value indicates a lower tongue position during pronunciation. These parameters are essential for determining vowel quality and are widely used to compare pronunciation differences between speakers, including non-native and native speakers.

In this research, the author analyzed vowel sounds using the Praat software. Praat is software designed for phonetic analysis and developed by Paul Boersma and David Weenink of the Institute of Phonetic Sciences at the University of Amsterdam. This software provides various features that support the acoustic analysis of sounds, including measurements of frequency, intensity, and duration. In the context of vowel analysis, Praat is used to measure formant values, specifically F1 and F2, which are then compared to a native speaker's pronunciation model as a standard reference. There is a relatively straightforward relationship between tongue height, the front-back positioning of the tongue, and the relative values of the first and second formants (F1 and F2), where the first formant (F1) is associated with vowel height (Widya & Agustiana, 2020). Praat makes it easy for users to record, modify, and analyze sound signals in detail. Users can import audio files into the software for analysis, such as measuring fundamental frequency (pitch), intensity, and the duration of sounds or specific phonetic segments. Additionally, Praat can generate various visualizations, such as graphs and spectrograms, to support the analysis and interpretation of acoustic data (Boersma & Van Heuven, 2001).

Several previous studies similar to this one have been conducted in the field of acoustic phonetics, particularly vocal analysis using the Praat software. One such study was conducted by Nasution and Syarfina (2023), who analyzed the pitch and vocal formants (F1, F2, and F3) of cover singers on YouTube with the aim of identifying the highest and lowest values of these parameters. The results showed that the highest pitch values were produced by female speakers, while the lowest values were produced by adolescent speakers, and there were variations in formant values among speakers. Another study by Widya and Agustiana (2020) examined the accuracy of English vowel pronunciation by comparing formant values between non-native and native speakers, using data from an Oxford-based online dictionary as a standard pronunciation model. The results showed that non-native speakers still face difficulties in distinguishing certain vowel types, particularly those influenced by first language interference. Additionally, a study by Azzahra, Syarfina, and Sembiring (2024) analyzed the comparison of English vowel formants between native and non-native speakers, focusing on the first formant (F1). The results of the study show variations in F1 values between the two groups of speakers, where some vowels produced by non-native speakers approach the native pattern, but pronunciation errors influenced by tongue position, vowel quality, and first language interference are still found.

However, these studies have not specifically focused on vowel production among junior high school students as non-native speakers, particularly in the context of acoustic analysis using Praat. Most previous research has involved adult participants or general learners, leaving a gap in understanding how younger non-native learners produce English vowel sounds at the acoustic level. Considering that pronunciation development begins at an early stage of language learning, it is important to examine the acoustic characteristics of vowel production among students at the junior high school level.

Therefore, this study aims to analyze the acoustic properties of English monophthong vowel sounds produced by junior high school students using Praat by examining the formant values of F1 and F2. These values are compared with those of a native speaker model to identify similarities and differences in vowel production. The objective is to determine the extent to which students vowel production aligns with or deviates from standard native pronunciation based on the resulting acoustic patterns.

2. Method

One method for investigating and comprehending the significance that people or groups attach to a social or human issue is qualitative research (Creswell & Creswell, 2017). This study employs a quantitative descriptive approach to analyze the acoustic characteristics of English vowel sounds produced by junior high school students as non-native speakers. The focus of this study is on formant frequencies, specifically the first formant (F1) and the second formant (F2), to identify vocal production characteristics and compare them with the pronunciation model of native speakers.

The research data consists of audio recordings of the vowels produced by the participants. Participants were asked to pronounce several English words containing the target vowels. The monophthong vowels analyzed in this research include /ə/, /æ/, /ɔ:/, /ɪ/, /e/, /ɑ:/, /ʌ/, /ɜ:/, /ʊ/, /u:/, /ɒ/, and /i:/. The recording process was conducted under controlled conditions to ensure the quality and clarity of the audio data. In addition, native speaker data was obtained from the Oxford Learner's Dictionaries, which provide standard pronunciation models for the English language. This data was used as a reference in the process of comparing it with the vowel productions generated by the participants.

Data analysis was conducted using the Praat software. The analysis focused on measuring formant values, specifically F1 and F2, for each recorded vowel sound. These values were then compared between non-native speakers (students) and the native speaker model to identify similarities and differences in the production of English monophthong vowel sounds. Next, the data was analyzed by extracting formant values from the recordings, which were then interpreted based on the resulting acoustic patterns. This comparison was used to determine the extent to which the student vowel production aligns with or deviates from the standard pronunciation of native speakers.

3. Result and Discussion

Native speakers refer to individuals who have acquired English as their first language and use it naturally in daily communication, while non-native speakers are those who learn English as a second or foreign language. Native speakers typically produce vowel sounds with more stable and standardized acoustic patterns, whereas non-native speakers may show variations influenced by their first language. This distinction is important because it provides a basis for comparing vowel production, particularly in terms of formant frequencies (F1 and F2). One method for investigating and comprehending the significance that people or groups attach to a social or human issue is qualitative research.

Based on this distinction, the following table presents the formant frequency values (F1 and F2) of selected vowel sounds produced by native speakers, obtained from recordings in the Oxford based online Dictionary.

3.1. Acoustic Characteristics of Native Speaker Vowels

Table 1. Vowels of Native Speakers

Vowels	Words	F1	F2
/ ɒ /	Hot / hɒt /	1496 Hz	2717 Hz
/ ə /	About / ə'boʊt /	604 Hz	1052 Hz
/ e /	Bed / bed /	649 Hz	2177 Hz
/ ɜ: /	Bird / bɜ:d /	472 Hz	1759 Hz
/ ɑ: /	Car / kɑ: (r) /	595 Hz	939 Hz
/ ʌ /	Cup / kʌp /	483 Hz	2195 Hz
/ æ /	Cat / kæt /	989 Hz	2286 Hz

/ɔ:/	Door /dɔ:/	802 Hz	882 Hz
/ʊ/	Put /pʊt/	411 Hz	1447 Hz
/i:/	Sheep /ʃi:p/	288 Hz	3151 Hz
/u:/	Too /tu:/	285 Hz	1741 Hz
/ɪ/	Sit /sɪt/	411 Hz	2156 Hz

The table above presents the first formant (F1) and second formant (F2) frequencies of a number of English vowel sounds produced by native speakers, with data taken from the Oxford Dictionary. F1 relates to the height of the tongue position (vowel height), where a low F1 value indicates a high tongue position (close vowel), while a high F1 value indicates a low tongue position (open vowel). Meanwhile, F2 relates to the forward-backward position of the tongue (frontness and backness), where a high F2 value indicates a front vowel, and a low F2 value indicates a back vowel (Ladefoged & Johnson, 2011). The vowel /ɒ/ in the word “hot” has a high F1 value (1496 Hz) and a relatively low F2 value (2717 Hz), which indicates that this vowel is low (open vowel) with a tendency toward the back (back vowel), although its F2 value is still quite high compared to extreme back vowels. The vowel /ə/ in the word “about” shows a moderate F1 value (604 Hz) and a relatively low F2 (1052 Hz), which reflects the characteristics of a central vowel with a neutral tongue position. The vowel /e/ in the word “bed” has a medium F1 (649 Hz) and a high F2 (2177 Hz), indicating that this vowel is a front vowel with a semi-open tongue position (mid-front vowel). The vowel /ɜ:/ in the word “bird” has a relatively low F1 (472 Hz) and a mid-range F2 (1759 Hz), indicating a mid central vowel with a slightly high tongue position. The vowel /ɑ:/ in the word “car” shows a mid F1 (595 Hz) and a low F2 (939 Hz), which indicates a back vowel with a fairly wide opening (open back vowel). The vowel /ʌ/ in the word “cup” has a relatively low mid F1 (483 Hz) and a fairly high F2 (2195 Hz), indicating a tongue position slightly toward the mid front with a moderate opening (open mid central/front vowel). The vowel /æ/ in the word “cat” has a high F1 (989 Hz) and a high F2 (2286 Hz), which indicates a front vowel with a wide opening (open front vowel). The vowel /ɔ:/ in the word “door” shows a mid F1 (802 Hz) and a low F2 (882 Hz), which indicates a back vowel with a mid-open degree of openness (mid back vowel). The vowel /ʊ/ in the word “put” has a low F1 (411 Hz) and a mid range F2 (1447 Hz), which indicates a near high back vowel. The vowel /i:/ in the word “sheep” has a very low (288 Hz) and a very high F2 (3151 Hz), clearly indicating a high front vowel. The vowel /u:/ in the word “too” has a very low F1 (285 Hz) and a relatively low F2 (1741 Hz), indicating a high back vowel. The vowel /ɪ/ in the word “sit” has a low F1 (411 Hz) and a high F2 (2156 Hz), reflecting a front vowel with a slightly high tongue position (near a high front vowel).

3.2. Acoustic Analysis of Non-Native Speakers Vowel Production

Table 2. Vowels of Non-native Speakers (Participant 1, Male)

Vowels	Words	F1	F2
/ɒ/	Hot /hɒt/	756 Hz	1555 Hz
/ə/	About /ə'boʊt/	581 Hz	1041 Hz
/e/	Bed /bed/	491 Hz	1904 Hz
/ɜ:/	Bird /bɜ:d/	566 Hz	1995 Hz
/ɑ:/	Car /kɑ: (r)/	829 Hz	1407 Hz
/ʌ/	Cup /kʌp/	838 Hz	1389 Hz

/ æ /	Cat / kæt /	831 Hz	1822 Hz
/ ɔ: /	Door / dɔ: /	614 Hz	936 Hz
/ ʊ /	Put / pʊt /	685 Hz	1440 Hz
/ i: /	Sheep / ʃi:p /	439 Hz	2656 Hz
/ u: /	Too / tu: /	471 Hz	1020 Hz
/ ɪ /	Sit / sɪt /	631 Hz	1857 Hz

The table above shows the F1 and F2 values of a non-native speaker (male, middle school student), which, when compared to the previous data from native speakers, reveal a number of fairly clear differences in acoustic patterns. The F1 values for the non-native speaker tend to be higher for some vowels, indicating that their tongue position is relatively lower (more open) compared to that of native speakers. For example, for the vowel /i:/ (sheep), F1 increases from approximately 288 Hz (native) to 439 Hz (non-native), indicating that this front high vowel is not produced as high by non-native speakers. The same pattern is observed for the vowel /u:/ (too), where F1 increases from 285 Hz to 471 Hz, indicating a lower tongue position. Regarding F2, non-native speakers also exhibit lower values for front vowels, meaning their tongue position is less advanced compared to native speakers. For example, the vowel /i:/ shows a decrease in F2 from 3151 Hz (native) to 2656 Hz (non-native), indicating that the “frontness” quality is not as pronounced in native speakers. A similar pattern occurs with /e/ (bed) and /ɪ/ (sit), where F2 values are lower than those of native speakers, indicating a shift toward more central vowels. Additionally, some back vowels such as /ɔ:/ (door) and /u:/ (too) show F2 values that are relatively similar or slightly lower, though not always consistent, indicating variation in the production of back vowels. For the vowel /æ/ (cat), it is observed that the F1 frequency in non-native speakers (831 Hz) is slightly lower than in native speakers (989 Hz), meaning this vowel is not opened as fully as in native speakers.

Table 3. Vowels of Non-native Speakers (Participant 2, Female)

Vowels	Words	F1	F2
/ ɒ /	Hot / hɒt /	870 Hz	1573 Hz
/ ə /	About / ə'boʊt /	627 Hz	1413 Hz
/ e /	Bed / bed /	766 Hz	1957 Hz
/ ɜ: /	Bird / bɜ:d /	641 Hz	1735 Hz
/ ɑ: /	Car / kɑ: (r) /	925 Hz	1659 Hz
/ ʌ /	Cup / kʌp /	1009 Hz	1764 Hz
/ æ /	Cat / kæt /	846 Hz	1283 Hz
/ ɔ: /	Door / dɔ: /	756 Hz	1320 Hz
/ ʊ /	Put / pʊt /	490 Hz	797 Hz
/ i: /	Sheep / ʃi:p /	386 Hz	2838 Hz
/ u: /	Too	403 Hz	1012 Hz

	/ tu: /		
/ ɪ /	Sit	826 Hz	2283 Hz
	/ sɪt /		

Table 3 presents the formant frequency values (F1 and F2) of female non-native speakers (junior high school students), which, upon analysis, reveal patterns that also differ from those of native speakers. In general, the F1 values for these participants tend to be higher, indicating that many vowels are produced with a lower (more open) tongue position compared to the standard for native speakers. For example, for the vowel /ʌ/ (cup), the F1 value reaches 1009 Hz, indicating a fairly wide vowel opening—even more open than the typical characteristic. A similar pattern is observed for /ɑ:/ (car) and /e/ (bed), which also have relatively high F1 values, signaling a tendency toward more open vowel production. Regarding F2, there is significant variation in terms of the front–back position of the tongue. In some front vowels like /i:/ (sheep), the F2 value is quite high (2838 Hz), indicating that this vowel is still produced as a front vowel, even though its F1 value is higher than that of native speakers (meaning it is not as high/close as in native speakers). However, for the vowel /æ/ (cat), the F2 value is actually lower (1283 Hz), indicating a shift toward a more back or more central vowel, thereby reducing its “front vowel” quality. This demonstrates inconsistency in maintaining the articulatory position of front vowels. Additionally, back vowels like /ʊ/ (put) have a very low F2 value (797 Hz), indicating a tongue position that is very far back, perhaps even more extreme than that of a native speaker. Meanwhile, the vowel /u:/ (too) also exhibits a low F2 (1012 Hz), consistent with the characteristics of a high back vowel, but the higher F1 value (403 Hz) indicates that the vowel is not produced as high (close) as in native speakers. Central vowels such as /ə/ and /ɜ:/ show relatively varied values, but still reflect a tendency toward centralization.

Table 4. Vowels of Non-native Speakers (Participant 3, Male)

Vowels	Words	F1	F2
/ ɒ /	Hot / hɒt /	816 Hz	1317 Hz
/ ə /	About / ə'boʊt /	893 Hz	1431 Hz
/ e /	Bed / bed /	713 Hz	2261 Hz
/ ɜ: /	Bird / bɜ:d /	597 Hz	1338 Hz
/ ɑ: /	Car / kɑ: (r) /	857 Hz	1434 Hz
/ ʌ /	Cup / kʌp /	899 Hz	1411 Hz
/ æ /	Cat / kæt /	745 Hz	2252 Hz
/ ɔ: /	Door / dɔ: /	616 Hz	1432 Hz
/ ʊ /	Put / pʊt /	629 Hz	1358 Hz
/ i: /	Sheep / ʃi:p /	947 Hz	2543 Hz
/ u: /	Too / tu: /	476 Hz	889 Hz
/ ɪ /	Sit / sɪt /	657 Hz	2428 Hz

Table 4 shows the formant values (F1 and F2) of a male non-native speaker (Participant 3), which exhibit a fairly pronounced deviation when compared to native speakers. The F1 values for this participant tend to be high, indicating that many vowels are produced with a lower (more open) tongue position than that of native speakers. This is clearly evident in certain vowels such as /ə/ (about) with an F1 of 893 Hz, /ʌ/ (cup) at 899 Hz, and even /i:/ (sheep) reaching 947 Hz. These values differ significantly from the characteristic of the /i:/ vowel in native speakers, which should have a low F1, thus indicating that high vowels are not produced

accurately. Regarding F2, it is observed that some front vowels such as /e/ (bed) and /æ/ (cat) still have relatively high F2 values (above 2200 Hz), indicating that the tongue position remains in the front. However, for other vowels such as /ɜ:/ (bird), /ʌ/ (cup), and /ə/ (about), the F2 values fall within the mid range (around 1300–1400 Hz), indicating a tendency toward central vowels (centralization). Meanwhile, back vowels such as /u:/ (too) have a low F2 (889 Hz), which aligns with the characteristics of back vowels, but the relatively high F1 value (476 Hz) suggests that this vowel is not as high (close) as in native speakers. One of the most notable findings is in the vowel /i:/ (sheep), where the F1 value is very high (947 Hz), and F2 is also high (2543 Hz). This condition indicates that although the tongue moves forward (front vowel), the desired tongue height is not achieved, so the resulting vowel tends to resemble a front open vowel like /æ/ rather than the high vowel /i:/. This suggests difficulty in controlling the vertical dimension of the tongue.

Table 5. Vowels of Non-native Speakers (Participant 4, Female)

Vowels	Words	F1	F2
/ ɒ /	Hot	670 Hz	1591 Hz
	/ hɒt /		
/ ə /	About	657 Hz	1448 Hz
	/ ə'boʊt /		
/ e /	Bed	768 Hz	2108 Hz
	/ bed /		
/ ɜ: /	Bird	698 Hz	1610 Hz
	/ bɜ:d /		
/ ɑ: /	Car	647 Hz	1599 Hz
	/ kɑ: (r) /		
/ ʌ /	Cup	755 Hz	1464 Hz
	/ kʌp /		
/ æ /	Cat	850 Hz	1623 Hz
	/ kæt /		
/ ɔ: /	Door	640 Hz	1385 Hz
	/ dɔ: /		
/ ʊ /	Put	464 Hz	1070 Hz
	/ pʊt /		
/ i: /	Sheep	418 Hz	2565 Hz
	/ ʃi:p /		
/ u: /	Too	450 Hz	870 Hz
	/ tu: /		
/ ɪ /	Sit	583 Hz	2380 Hz
	/ sɪt /		

From the data, the vowel /i:/ in the word *sheep* has the lowest F1 value (418 Hz) and the highest F2 value (2565 Hz). This means it is a high and front vowel. A similar pattern can be seen in /ɪ/ (*sit*), which also has a high F2 (2380 Hz), but its F1 is slightly higher, so it is a bit lower than /i:/. On the other hand, vowels like /u:/ (*too*) and /ʊ/ (*put*) have low F2 values (870 Hz and 1070 Hz). This shows that they are back vowels. Their F1 values are low to medium, which means the tongue is still in a relatively high position. For open vowels, /æ/ (*cat*) has the highest F1 value (850 Hz). This shows that it is the most open or the lowest vowel in the data. Meanwhile, /ʌ/ (*cup*) and /e/ (*bed*) also have quite high F1 values (755 Hz and 768 Hz), which means the tongue is lower than in mid or high vowels. Central vowels like /ə/ (*about*) and /ɜ:/ (*bird*) have middle values for both F1 and F2. This fits their role as mid-central vowels, where the tongue is not too high or low, and not too front or back. Finally, back open vowels like /ɒ/ (*hot*) and /ɔ:/ (*door*) have relatively lower F2 values compared to front vowels, which shows that the tongue is placed toward the back. Their F1 values are quite high, which means these vowels are more open.

3.3. Comparison of Mean Formant Values Between Native and Non-Native Speakers

To provide a more general representation of students vowel production, the mean values of F1 and F2 from the four participants were calculated and compared with those of the native speaker model. The results are presented in Table 6.

Table 6. Comparison of Mean Formant

Vowels	F1 Participants Mean	F1 Native	F2 Participants Mean	F2 Native
/ɒ/	778 Hz	1496 Hz	1509 Hz	2717 Hz
/ə/	690 Hz	604 Hz	1333 Hz	1052 Hz
/e/	685 Hz	649 Hz	2058 Hz	2177 Hz
/ɜ:/	626 Hz	472 Hz	1670 Hz	1759 Hz
/ɑ:/	815 Hz	595 Hz	1525 Hz	939 Hz
/ʌ/	875 Hz	483 Hz	1507 Hz	2195 Hz
/æ/	818 Hz	989 Hz	1745 Hz	2286 Hz
/ɔ:/	657 Hz	802 Hz	1269 Hz	882 Hz
/ʊ/	567 Hz	411 Hz	1159 Hz	1447 Hz
/i:/	548 Hz	288 Hz	2655 Hz	3151 Hz
/u:/	360 Hz	285 Hz	948 Hz	1741 Hz
/ɪ/	674 Hz	411 Hz	2237 Hz	2156 Hz

The table presents a comparison between the vowel production of participants and native speaker benchmarks based on acoustic analysis of F1 and F2 formant frequencies obtained using Praat. This comparison aims to identify similarities and differences in vowel realization and to evaluate the extent to which student pronunciation approximates standard native speaker norms. The comparison of mean formant values between participants and native speakers reveals a systematic pattern of deviation in students vowel production. Although a small number of vowels show partial similarity, the overall acoustic patterns indicate that the student pronunciation does not fully align with native speaker norms. The results show that students vowel production has a low to moderate level of similarity to native speakers. Only a few vowels are close to native pronunciation, while most vowels show clear and consistent differences in tongue height and tongue position. These differences show that students have not fully mastered English vowel pronunciation.

In terms of similarity, the vowel /e/ demonstrates the closest approximation to native pronunciation, as both F1 and F2 values are relatively similar. This suggests that students are able to maintain an appropriate tongue height and frontness for this vowel. A similar tendency is observed in /ɪ/, where the F2 values are comparable to native speakers, indicating relatively accurate front vowel positioning. However, the higher F1 value still indicates a slight lowering of the tongue, showing that the production is not fully like native speaker.

Despite these limited similarities, the majority of vowels exhibit clear and consistent deviations. High vowels such as /i:/ and /u:/ show significant differences in both F1 and F2 values. The vowel /i:/ is produced with a higher F1 and lower F2, indicating that it is articulated with a lower and less front tongue position than required. Similarly, /u:/ shows a substantially lower F2 value, suggesting that the vowel is produced too far back and lacks the appropriate degree of tongue advancement. These patterns indicate difficulty in maintaining the articulatory precision required for high vowels. The central vowels such as /ə/ and /ɜ:/ display instability in their production. The variation in both F1 and F2 values suggests that students are not able to consistently maintain a neutral tongue position, resulting in shifts toward either front or back vowel spaces. This inconsistency reflects a lack of control in producing mid-central vowel qualities.

More pronounced deviations are observed in low and mid vowels. The vowel /ʌ/ shows a large discrepancy in both F1 and F2, indicating that it is produced significantly lower and more back than the native target. Similarly, /ɑ:/ exhibits a higher F2 value than expected, suggesting a fronting tendency, even though it should be realized as a back vowel. In contrast, /æ/ is produced with a lower F2 value, indicating that it is not sufficiently fronted. These findings highlight difficulties in maintaining both vowel openness and front-back distinction. Back vowels such as /ɒ/, /ɔ:/, and /ʊ/ also demonstrate inconsistent patterns. The differences in F2 values suggest that students do not consistently produce these vowels with accurate backness, with some

vowels shifting toward a more central position. This indicates a reduced distinction between vowel categories, which may affect intelligibility.

These findings are consistent with phonetic theory, which posits that F1 is related to tongue height and F2 to tongue position (Ladefoged & Johnson, 2011). The differences in F1 and F2 values in this study show that students still have difficulty controlling their tongue height and front-back position when producing English vowels. This also supports previous studies that found that non-native speakers often have difficulty distinguishing vowel sounds, especially high and back vowels. These difficulties are usually caused by the influence of the first language, which may have a simpler vowel system and fewer vowel contrasts.

4. Conclusion

Based on the acoustic analysis, it can be concluded that the student vowel production does not fully match native speaker pronunciation. Although some vowels, such as /e/ and /i/, are relatively close to native patterns, most vowels show clear differences in both F1 and F2 values. These differences indicate that the students are not yet able to produce vowels with accurate tongue height and tongue position.

The results show that the level of similarity between students and native speakers is still low to moderate. Many vowels are produced lower, more central, or more back than the native target. For example, high vowels tend to be produced with higher F1 values, which means the tongue is not raised enough. In addition, several vowels show lower or higher F2 values than expected, indicating that the tongue is not placed correctly in terms of frontness and backness. These patterns suggest that students still have difficulty controlling the articulatory features needed for accurate vowel production.

The findings also show that vowel distinctions are not always clear. Some vowels that should be different are produced in a similar way, which may reduce the clarity of pronunciation. This indicates that students still have limited ability to differentiate vowel categories in English, especially when the differences are subtle. The findings also suggest that first language influence plays an important role in shaping students' pronunciation. Since the students' first language has fewer vowel distinctions, it may affect their ability to produce accurate English vowels. As a result, students tend to simplify vowel production and reduce the differences between sounds. This leads to more centralized vowel production and less precise articulation. The lack of exposure to native pronunciation and limited practice may also contribute to these deviations. Without sufficient input and practice, students may not develop an accurate awareness of vowel quality and may continue to rely on patterns from their first language.

For the last, it can be concluded that students have not yet achieved native-like pronunciation. Their vowel production still shows systematic differences from native speaker patterns, especially in terms of tongue height and tongue position. To improve their pronunciation accuracy, students need more practice, greater exposure to native speech, and more focused training on vowel distinctions.

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