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Comparative Formants Analysis of English Vowels Using PRAAT

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A B S T R A C T

This research focuses on the comparative formant analysis of English vowels between native and non-native speakers using PRAAT software. The study aims to investigate the comparison of the acoustic properties of English vowels to understand the pronunciation differences encountered by non-native speakers. By analyzing the formant frequencies of monophthongs in English vowels, specifically the first formant (F1), this research seeks to identify any significant differences between English native speaker and five non-native speakers, whose first language is Indonesia. The data collected from speech samples will be descriptively analyzed to determine variations in formant patterns. The finding shows that the F1 values of the vowels show variations among the non-native speakers compared to the native speaker. There are still monophthongs that these participants mispronounce, indicating that the learner's understanding is an obstacle to their fluency in speaking and pronouncing the sounds correctly. The research findings imply that these mispronunciations are linked to differences in tongue height, vowel backness, and vowel quality between native and non-native speakers. The results underscore the analysis of F1 values for 12 words containing vowel monophthongs, highlighting these variations. This suggests that the learner's understanding of these phonetic aspects is crucial for achieving fluency in vowel production and pronunciation.

Introduction

English is one of the most widely spoken languages in the world, with many people using it as a second language. However, non-native speakers often face challenges in accurately pronouncing English vowels due to differences in their native language phonetic systems. One way to analyze these differences is through formant analysis, which examines the acoustic properties of vowels. Formants are acoustic resonances that are produced by the vocal tract and play a crucial role in distinguishing between different vowels in a language. and by comparing the formants of native and non-native speakers, we can gain insights into the pronunciation difficulties faced by the latter. The study of formants in speech has been a significant area of research in phonetics and linguistics. With the advancement of technology, tools like PRAAT have made it easier to analyze and compare formants across different languages. Several studies (Johnson, 2010) have shown the importance of formant analysis in understanding vowel production and perception. However, there is a lack of comprehensive research that compares the formant patterns of English vowels using PRAAT. This study aims to fill this gap by conducting a comparative formant analysis of English vowels.

The urgency of this research lies in the importance of effective communication in today's globalized world to have a better understanding of the acoustic properties of English vowels. With English being a lingua franca in many fields such as business, academia, and technology, the ability to accurately produce English vowels is crucial for non-native speakers. By understanding the specific differences in formant patterns

between native and non-native speakers, we can develop targeted interventions to improve pronunciation and communication skills. This knowledge is essential for various applications, such as speech's recognition technology, language teaching, and dialectology. Without a detailed analysis of formants, we may miss out on crucial information about vowel production and perception in English.

Johnson (2012) explains that understanding speech involves more than just processing acoustic signals. Typically, when we listen to someone, we concentrate on comprehending their meaning. In linguistics, this is often expressed as "we speak to be heard, to be understood." As listeners, we aim to grasp the words being spoken rather than focusing on how they are spoken. However, in phonetics, attention is given to the sound of the words themselves, considering the phonetic details of pronunciation that are usually unnoticed in everyday communication. In speech perception, listeners pay close attention to these phonetic details, which are essential for understanding how speech sounds are produced and perceived.

One study by Smith and Johnson (2005) compared the formant frequencies of English vowels produced by native speakers and non-native speakers. The results showed that non-native speakers had higher formant frequencies for certain vowels, indicating a deviation from the typical formant patterns of native speakers. This deviation could be attributed to differences in the articulation and phonetic patterns of non-native speakers.

According to Durão (Richards & Weber) (2007), the software used in this study is PRAAT, a phonetic program for analyzing speech sounds, even if the speech is altered. PRAAT allows live voice recording using a computer but is not available for mobile phones. Once recorded, PRAAT can break down the audio into detailed spectrograms, showing both low and high frequencies. It can also measure and graph overall pitch, intensity, and sound control. Additionally, PRAAT analyzes speech intonation, which can vary between speakers. Some speakers end their words with a falling intonation, while others use a rising intonation. PRAAT analyzes the sound according to the chosen settings.

Kent and Read (2002) explained that the first formant (F1) is usually the most intense formant because it interacts with the amplitudes of other formants. Essentially, F1 is boosted by the low-frequency tails of other formants' curves, making it more prominent. Voice judgments are closely linked to F1's amplitude since it tends to be the strongest. When evaluating vocal characteristics, especially in second-language (L2) accents, F1 is given the most attention. Although F2 and F3 are also important, they have a much smaller impact on vocal understanding compared to F1.

Ladefoged (2006) describes formants as resonant frequencies produced by the vibration of air in the vocal tract, regulated by the action of the vocal folds. These vibrations create impulses that act like sharp taps in the air, generating multiple frequencies. He suggests that formants are best understood through analogy rather than phonetic dictionaries. For example, consider the vowel [i] as a musical note repeated continuously, like [iiiiiii], with each repetition slightly lower than the previous one. Each repetition represents a different formant: Formant One (F1), Formant Two (F2), Formant Three (F3), and so on. These abbreviated forms are commonly used and play a significant role in voice biometric analysis for speaker verification and forensic investigations.

Ladefoged and Johnson (2015) further explain the benefits of using comparative acoustic vowel plots, which are effective for comparing different dialects. These plots arrange vowel sounds similarly to the International Phonetic Alphabet (IPA) vowel chart, with frequencies separated according to the Bark scale, which measures auditory similarity. This method visually represents how similar or different sounds are. They

advocate for using these acoustic vowel spaces in teaching English to non-native speakers, encouraging teachers to create comparative vowel spaces for better instruction.

In a more recent study by Lee et al. (2019), formant analysis was conducted using the software PRAAT to compare the vowel production of native English speakers and non-native speakers from various language backgrounds. The results showed that non-native speakers exhibited variability in their formant frequencies, with some vowels being closer to the native speaker norms than others. This variability suggested in non-native speech can vary depending on the vowel being produced.

Another study by Garcia and Martinez (2021) focused on the formant transitions of English vowels produced by native and non-native speakers. Formant transitions refer to the movement of formants from one vowel to another in connected speech. The results indicated that non-native speakers had slower and less accurate formant transitions compared to native speakers, which could contribute to their perceived accent.

The main objective of this study is to conduct a comparative formant analysis of native and non-native speakers of English vowels using PRAAT software. By analyzing the formant frequencies of different vowel sounds produced by Native and Non-Native speakers, we aim to identify specific phonetic differences that may contribute to pronunciation difficulties for non-native speakers. This research will provide valuable insights into the acoustic properties of English vowels and help inform language teaching practices for non-native speakers. This study aims to provide a more extensive analysis by comparing the formant patterns of all English vowels. Additionally, the variability in formant values due to factors like speaker differences and dialectal variations poses a challenge in accurately comparing formants across different speakers.

Marzuki (2021) examined pronunciation errors by IKIP Budi Utomo Malang students in the English Department. The study found that S-1 English students had both substantial and non-significant pronunciation faults. A significant mistake is a divergence in consonants, vowels, or consonant clusters that might alter the meaning of a speech. Conversely, non-significant errors do not always alter the meaning of a statement. Several factors were identified as the causes of pronunciation errors, such as the distinctions between the speech sound in English and Indonesian, the similar phonetic features with different distributions between the two languages, the influence of the student's home language, and a lack of exposure to and oral practice with English pronunciation.

Previous studies of formant analysis have shown that formants play a crucial role in distinguishing between vowels in different languages. Formants are resonant frequencies that are produced by the vocal tract during speech production. Studies have indicated that native speakers of a language tend to have distinct formant patterns for vowels compared to non-native speakers. This difference in formant patterns can affect the intelligibility and perceived accent of non-native speakers.

This study is important for several reasons. Firstly, it contributes to the field of phonetics by providing a detailed analysis of the acoustic properties of English vowels in native and non-native speakers. Secondly, it has practical implications for language teaching and learning, as the findings can be used to develop targeted interventions to improve the pronunciation skills of non-native speakers. Lastly, this research can help bridge the communication gap between native and non-native speakers, ultimately facilitating better cross-cultural understanding and collaboration.

One alternative solution to address the research problem is to use other acoustic analysis software or techniques to compare formants in English vowels. However, PRAAT is widely used in phonetic research and has been proven to be effective in formant analysis. Another alternative solution could be to focus on a specific subset of

English vowels rather than analyzing all vowels. This could help in reducing the complexity of the analysis but may limit the generalizability of the findings. The chosen solution for this research is to conduct a comparative formant analysis of all English vowels using PRAAT. By analyzing a comprehensive set of vowels, we can provide a more complete picture of the formant patterns in English. This approach will allow us to identify similarities and differences in formant values across vowels and speakers, contributing to a better understanding of English vowel production and perception.

Research Method

Research Design

This study is comparative research that aims to analyze the formants of English vowels produced by native speakers and non-native speakers using PRAAT software. The research will focus on comparing the formant frequencies of vowels in the speech of native English speakers and non-native English speakers to identify any potential differences in pronunciation. The primary target of this research is to determine whether there are significant differences in the formant frequencies of English vowels between native and non-native speakers. By comparing the formants of vowels produced by both groups, the study aims to provide insights into the pronunciation patterns of non-native speakers and potential areas for improvement in English language learning.

Research Subjects

The research subjects for this study will include one native English speaker and five non-native English speakers. Native speaker will be selected from regions where English is the first language, while non-native speakers will be individuals who have learned English as a second language. The participants will be asked to read a set of words consisting of each 12 monophthongs in the English language /a:/, /u:/, /i:/, /3:/, /ɔ:/, /ɪ/, /ʊ/, /e/, /ə/, /æ/, /ʌ/, /ɒ/ for formant analysis.

Research Method

The research will involve recording the speech samples of both native and non-native speakers reading a standardized set of words. The recorded samples will then be analyzed using PRAAT software to extract the formant frequencies of the English vowels. The formant values that will be analyzed is the first format (F1) which will be compared between the native and non-native speakers to identify any differences in pronunciation.

Data Analysis Techniques

The data collected from the formant analysis will be analyzed descriptively to determine if there are any significant differences in the formant frequencies of English vowels between native and non-native speakers based on the formant value.

Result and Discussion

This research concentrates specifically on English vowel sounds, focusing on monophthongs. Monophthongs are pure vowel sounds that allow unrestricted airflow through the mouth. The shape and volume of the mouth cavity, influenced by the tongue, lips, and jaw, produce each vowel sound. A monophthong occurs when a single vowel sound is present in a syllable, represented by one symbol, such as [ʊ]. There are two types of monophthongs: five long monophthongs and seven short monophthongs.

Table 1. Native Speaker's Value of Formant 1 (F1)

Native Speaker	Calm /a:/	Cool /u:/	Leap /i:/	Turn /3:/	All /ɔ:/	Sit /ɪ/	Boot /ʊ/	Bed /e/	Letter /ə/	Rat /æ/	Bus /ʌ/	Pot /ɒ/
	993	692	614	855	951	928	644	890	841	690	942	977

Table 2. Non-Native Speakers' Value of Formant 1 (F1)

Non-Native Speaker (NNS)	Calm /a:/	Cool /u:/	Leap /i:/	Turn /3:/	All /ɔ:/	Sit /ɪ/	Boot /ʊ/	Bed /e/	Letter /ə/	Rat /æ/	Bus /ʌ/	Pot /ɒ/
NNS 1	926	453	320	710	798	370	402	831	800	892	791	873
NNS 2	995	524	386	612	840	425	394	845	753	738	833	858
NNS 3	918	501	461	676	828	702	409	732	581	832	892	727
NNS 4	956	433	398	638	804	590	398	792	621	790	892	823
NNS 5	937	498	439	640	837	620	410	756	694	774	788	815

The F1 values for the vowels show variations among non-native speakers compared to the native speaker. For the vowel /u:/ (Cool) Non-native speakers 1, 4, and 5 have lower F1 values that reached 453, 433,498 than the native speaker at 692, indicating potential differences in tongue height and vowel backness during vowel production.

For the vowel /a:/ (Calm) Non-native speaker 2 reached 995 and Non-native speaker 4 reached 956 having F1 values closer to the native speaker's 993, while non-native speakers 1 and 3 have lower F1 values, indicating potential differences in tongue height and vowel quality during production. It is a similar situation for the other vowels. For the vowel /i:/ (Leap) all Non-native speakers reached far below the native speaker's value at 614. Non-native speaker 1 has the lowest F1 value at 320. For the vowel /3:/ (Turn) Non-native speaker 1 is the closest F1 value at 710, while non-native speakers 2, 3 ,4, and 5 have F1 values lower than the native speaker. For the vowel /ɔ:/ (All) Non-native speakers 2, 3, and 5 have F1 values reaching 840, 828, and 837 closer to the native speaker, while non-native speaker 1 has a lower F1 value of 798. For the vowel /ɪ/ in the word Sit Non-native speakers 1 and 2 have F1 reached 370 and 425 which is lower than the native speaker at 928, while non-native speakers 1, 3, and 5 have higher F1 values. For the vowel / e / in the word Bed Non-native speakers 1 and 2 have F1 values closer to the native speaker that reach 831 and 845, while non-native speakers 3, 4, and 5 have lower F1 values. For the vowel /ə/ in the word Letter, Non-native speakers 1 have F1 values closer to the native speaker, while non-native speakers 2, 3, 4, and 5 have lower F1 values. For the vowel / ə / in the word Letter Non-native speaker 1 has F1 values at 800 closer to the native speaker at 841, while non-native speakers 1, 2, 3, and 4 have lower F1 values. For the vowel / æ / in the word Rat Non-native speaker 1 has a higher F1 value reaching 892, while non-native speakers 2, 3, 4, and 5 have F1 values closer to the native speaker. For the vowel /ʌ/ in the word Bus Non-native speakers 3 and 4 have F1 reached values 892 which closer to the native speaker's value 942, while non-native speakers 1, 2, and 5 have lower F1 values. For the vowel /ɒ/ in the word Pot Non-native speakers 1, 2, and 4 have F1 have reached values 873, 858, 823 closer to the native speaker, while non-native speakers 3 and 5 have lower F1 values reached 727 and 788.

Based on the findings of the tables above, it shows that the Non-Native Speaker (NNS) have the ability to pronounce several monophthongs almost similarly to the native's utterance. The participant NNS2 has produced the utterance as a native like-

manner whose produce at 993. For vowel /a:/ in the word ‘calm’, although 4 of 5 participants produced below the native’s value, the range of Non-Native Speaker (NNS) value measured between 918-995 which is very close to the native.

When pronouncing words that contain the vowel /æ/ in the word ‘rat’, the participants overproduce and reach a value between 738-892 which exceeds the native’s value of 690. The utterance of the vocal sound slightly changes into /e/ as in bed.

In several monophthongs such as /ɒ/, /e/, /ə/, /ʌ/, /u:/, /3:/, /ɔ:/ the participants' value not as high as the native, which represent the quality of their voice when pronouncing these vowels sounds less than the native. The gap in the values is not far for some participants, and the others almost reach the same level as the native.

There were three monophthongs that these participants produced and reached far below the native. Which are the sounds of /ʊ/, /i:/, /ɪ/, they have been mispronouncing these monophthongs into one similar sound of /I/. it is possible to happen as the Non-Native Speaker tends to ignore the difference between long and short vowel sounds.

Based on the figures above, all of the sound waves that belong to the Non-Native Speaker show a similar form of waves when pronouncing the word ‘bus’ which contains monophthong /ʌ/. It also projects a similar form as the native, except for the end of the recording, the native has a stable waveform from the beginning to the end. It is possible because the manner of how the speaker produces affects the duration of the vowel sound that lasts on echoes until it stops. Despite the value of the formants showing that the NNS has reached below the native, the figure is proof that they have pronouns in English words that contain a certain vowel in a correct way that is almost native-like.

This is applied to the other examples of the vowel sound that the participants have pronounced, although they might not be able to reach the same level as the native because in most cases, the Non-Native Speakers would never be as precise as the native since that certain language is not their first or mother language. However, they have the ability and skills to practice and become native-like. The number shows the gap is small for some words, which is also supported by the sound wave diagram.

In other cases, there are still monophthongs that these participants mispronounce, as the writer said earlier, that the differences between short and long vowels are common in English learners when practicing their utterances. It is possible to happen as the participants were born and raised in Indonesia also their first language is Indonesia which has a similar vowel sound to English. Furthermore, the knowledge of this learner is possibly the obstacle to their fluency in speaking and pronouncing the sounds correctly.

Conclusion

Drawing from the analysis above, the analysis of F1 values for 12 words containing vowel monophthong between native and non-native speaker highlight variations in tongue height, vowel backness, and vowel quality, which may contribute to differences in vowel production and pronunciation between the native speaker and non-native speaker. It may be inferred that comparing native speakers with comparison speakers fails to demonstrate the precision of the value, as the range of values can occasionally be strikingly close. When compared to other collaboration devices, the use of digital devices in forensic linguistics can offer a comparative viewpoint, albeit, with closer examination. Consequently, it may be said that each participant's voice, both the original voice and the voice of comparison, has a distinct character. This demonstrates how diverse voices belong to different people. Thus, it is possible to provide both the difference and the formant value at the same time. There are more complex issues related to this kind of research, such as the comparative among types of gender and ages during

learning and practicing English Language as a second language. Therefore, hopefully, the next research will find and solve more complex issues related to phonology, especially using PRAAT to analyze the sound.

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