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Analysis of Distinctive Formant Frequencies on Singers Singing English Song

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Abstract: Vowels, as fundamental components of human speech across all languages, are cued acoustically by formants, resonance frequencies of the vocal tract shape during speech sound. In analyzing formant frequencies, a software called Praat can be used, which is an open-software tool for the analysis of speech in phonetics. This study was conducted to compare formant frequencies of three singers pronounced the same vowels while singing English song titled Easy on Me by Adele. The data of this study was analyzed by descriptive qualitative research using content analysis. The analysis of the data was done to find out the frequencies of first (F1) and second (F2) formant which were extracted using Praat software. Based on the findings, it can be concluded that British singer produced the lowest F1 for the mid vowel /ə/ in <gold>, the lowest F2 for the central vowel /ə/ in <gold>, and the highest F2 for the front vowel /i:/ in <me>, meanwhile, the highest F1 was produced by American singer for the mid vowel /ə/ in <river>.

Keywords: Formant Frequencies, F1, F2, Singers, Vowels.

Introduction

Each singer has their own way of singing style. When singing the same song, different singers will produce different frequencies of vowels. One key point to support this, is the existence of timbre. Timbre is the attribute that distinguishes sounds of equal pitch, loudness and duration. It contributes to our perception and discrimination of different vowels and consonants in speech, instruments in music and environmental sounds. ANSI in Titze, et al (2016) believe that timbre is the attribute of auditory sensation in terms of which a listener can judge that two sounds similarly presented and having the same loudness and pitch are dissimilar. Acoustically, timbre is thus largely related to the frequency spectrum in the voice. Regulation of the spectrum involves adjusting the relative amplitudes of individual harmonics, which can be accomplished at the source or by the choice of vowels and allophonic variations of the vowels.

Ladefoged (2010) defines vowel as a syllabic speech sound pronounced without any stricture in the vocal tract. Vowel is one of the two principal classes of speech sounds and one of the segmental features alongside consonant. Vowels vary in quality, in loudness and also in quantity (length). They are usually voiced and are closely involved in prosodic variation such as tone, intonation and stress. Vowels are significant components of all the world's languages, and they play a critical role in our ability to comprehend speech. Abercrombie in Koffie (2021) explains that classification of vowels are based on 6 features namely the aperture, the horizontal of axis (backness), articulatory feature (roundness), tense, cavity, and duration. Aperture, that is the various degrees at which mouth is open during articulation, divides vowels into high vowels /i, ɪ, u, ʊ/, mid vowels (e, ɛ, ʌ, ə, o, ɔ/, and low vowels /æ, a, ɒ /. The horizontal axis of backness indicates the movement of the

tongue, whether it moves toward the front of the mouth or back into the throat. On this basis of this horizontal movement, vowels have been classified as front, central, and back. Vowels /i, ɪ, e, ɛ, æ/ belong to front vowels as the tongue moves forward toward the front teeth. Vowels like /u ʊ, o, ɔ, a/ are produced when the tongue retreats in the throat, are classified as back vowels. Vowels /ʌ, ə/ are belong to central vowels as the tongue does not seem to move forward or backward.

Articulatory feature round has to do with the posture of the lips. In producing the vowels /i, ɪ, e, ɛ, æ, a/ in the words <see>, <sit>, <sue>, <say>, <set>, <sat>, and <sod>, the lips are spread as though one were smiling. For the vowels /u, ʊ, o, ɔ/ in the words <sue>, <soot>, <soak>, and <salt>, the lips are clearly rounded. Tense has to do with whether the muscles in the neck tense up or not. In producing the vowels /ɪ, u, e, o/ in the words <see>, <say>, and <soak>, the muscle in the neck allegedly tense up. Presumably, when the vowels /ɪ, ʊ, ɛ, ɔ, ʌ, æ/ in the words <sit>, <soot>, <set>, <salt>, <such>, and sat are produced, there is no tenseness. Cavity denotes whether the air molecules flows through the mouth or the nose, vowels that have feature nasal are those that are produced with an appreciable air quantity flowing through the nostrils. Duration has to do with whether the vowel is pronounced for a short time or long time.

Vowel sounds are produced when the vocal fold vibration is unobstructed, allowing a clear passage of air through the mouth, shaped by different positions of the jaw, tongue, and lips. For instance, the vowel sound /i/ (as in “heed”) is produced with the tongue close to the front of the mouth, whereas /a/ (as in “had”) is produced with the tongue further back. These articulatory positions create distinct vowel sounds, distinguished acoustically by the value of the lowest two vocal tract resonance frequencies, which are known as the first and second formants (F1 and F2). Formants are considered the primary acoustic cues to vowel identity. Reuter (2009) defines formants as distinctive frequency components of the acoustic signal produced by speech, musical instruments, or singing. In acoustics, a formant is usually defined as a broad peak, or local maximum, in the spectrum. The formant with the lowest frequency is called F1, the second F2, and the third F3. The fundamental frequency or pitch of the voice is sometimes referred to as F0, but it is not a formant. The first two formants are important in determining the quality of vowels, and are frequently said to correspond to the open/close (or low/high) and front/back dimensions (which have traditionally been associated with the shape and position of the tongue). Thus, it can be concluded that the first formant (F1) is inversely related to vowel height, the higher the vowel, the lower F1 value. The second formant is related to the degree of backness of a vowel, the more front the vowel, the higher F2 value. Thomas (2011) suggests that front vowels have higher F2, while low vowels have higher F1. Lip rounding tends to lower F1 and F2 in back vowels and F2 and F3 in front vowels.

To analyze formants and to bring the value of formants listing, a Praat software is available and accessible. Widayanti (2022) states that The PRAAT application provides a feature to record voice directly using an installed device, but it is still a computer-based program, so it is not yet available for mobile. After getting the sound recording, PRAAT can then dissect the sound into a detailed spectrogram and produce separate, more detailed parts of the sound. Spectrogram consists of low and high frequencies in the form of sound signals. In addition, it is also possible to measure the pitch, intensity and formant of the sound as a whole and display a graph to illustrate the results using Praat software.

Research Methods

This study employed descriptive qualitative research by using content analysis

approach. According to Bengtsson (2016), the purpose of content analysis is to organize and elicit meaning from the data collected and to draw realistic conclusion from it. The data of this study was collected from the performance on Youtube music video singing the song by Adele "Easy on Me", which only focuses on several words (lyrics) as the samples.

Result and Discussion

1. Participants

There are three female participants on this study: Adele, who is the original singer of the song, represents British singer, Madilyn Bailey who did the cover of the song, represent American singer, and Aina Abdul who also did the cover represents Malayan singer.

First Participant

Full Name	: Adele Laurie Blue Adkins, MBE
Born	: May, 5th 1988
Age	: 35 years old
Occupation	: Singer
Nationality	: British
Language	: English

Second Participant

Full Name	: Madilyn Bailey Wold
Born	: September, 2nd 1992
Age	: 31 years old
Occupation	: Singer
Nationality	: American
Language	: English

Third Participant

Full Name	: Nurul Aina
Born	: October, 25th 1993
Age	: 30 years old
Occupation	: Singer
Nationality	: Malaysian
Language	: Malay (First language), English (Second Language)

2. Procedure

To bring the data of this study, the researcher firstly downloaded the video files from Youtube application, and then converted them into audio files. The audio files of each participant were brought to Praat software and were saved into wav file as the wav file is one of the accessible audio format of Praat. Then the audio files were cut into several segments, in which each segment contains one word. After that, the selected segments were analyzed to find out the formant frequencies of the English vowels. Praat software is used to bring the data of F1 and F2 frequencies, and to process and to show the data in comparison, the researcher used Ms. Excel.

3. Data and Data Analysis

a. Data

Content analysis is a systemic and objective means of describing and quantifying phenomena, especially in textual data, involving the direct examination of communication in its various forms, such as written text, speech, images, or even symbolic matter. The data of this study was taken from the lyrics of Adele's song Easy on Me, and only eight words were taken as the samples to examine the vowels. Here are the lyrics of the song, and the sample words are marked in bold, italic, and underline letters.

There ain't no ***gold*** in this ***river***
That I've been ***washin'*** my ***hands*** in forever
I know there is hope in these ***waters***
But I can't bring myself to ***swim***
When I am drowning in this silence
Baby, let ***me*** in

b. Data Analysis

Data analysis was conducted to firstly classify the vowels in relation to F1 (high, mid, and low vowels) and F2 (front, central and back vowels), and secondly to bring the F1 and F2 value from the Praat software extraction in order to show the vowels comparison produced by the participants. The result of the analysis is showed in these following tables:

Classification	Vowels	Words
High	ʊ	<gold>
	ɪ	<river>
	ɪ	<washin'>
	ɪ	<swim>
	i:	<me>
Mid	ə	<gold>
	ə	<river>
	ə	<waters>
	ɔ	<waters>
	ʌ	<but>
Low	ɒ	<washin'>
	æ	<hands>

Table 1. The Classification of Vowels in Relation to F1

Classification	Vowels	Words
Front	ɪ	<river>
	ɪ	<washin'>
	æ	<hands>
	ɪ	<swim>
	i:	<me>
Central	ə	<gold>
	ə	<river>
	ə	<waters>

	ʌ	<but>
Back	ʊ ɒ ɔ	<gold> <washin'> <waters>

Table 2. The Classification of Vowels in Relation to F2

No.	Words	IPA	Vowels	British		American		Malayan	
				F1	F2	F1	F2	F1	F2
1.	gold	gəʊld	ə	308	917	586	1080	485	1063
			ʊ	353	1021	434	1073	370	1093
2.	river	ˈrɪvə(r)	ɪ	395	1647	665	1938	419	1365
			ə	465	1607	875	1693	537	1511
3.	washin'	ˈwɒʃɪn	ɒ	716	1535	765	1369	801	1808
			ɪ	575	2145	559	1904	757	1877
4.	hands	hændz	æ	688	1912	688	1540	661	1529
5.	waters	ˈwɔːtəz	ɔ	700	1489	730	1649	712	1192
			ə	551	1632	779	1839	476	1624
6.	but	bʌt	ʌ	687	1510	482	1429	632	1834
7.	swim	swɪm	ɪ	675	2077	540	1628	710	2038
8.	me	miː	iː	853	2461	738	2254	530	1866

Table 3. The Extraction Value of F1 & F2 among the Participants

4. Findings and Discussion

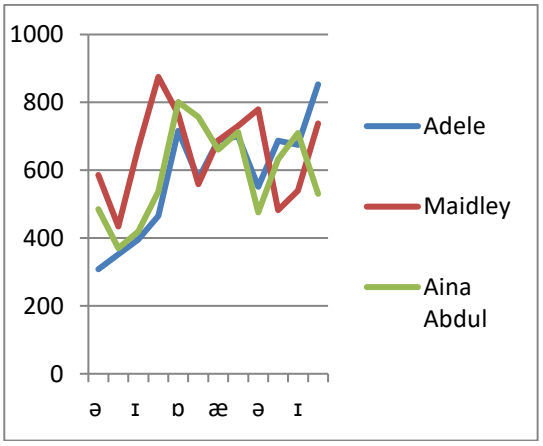

Figure 1 The Value of F1 among the Participants

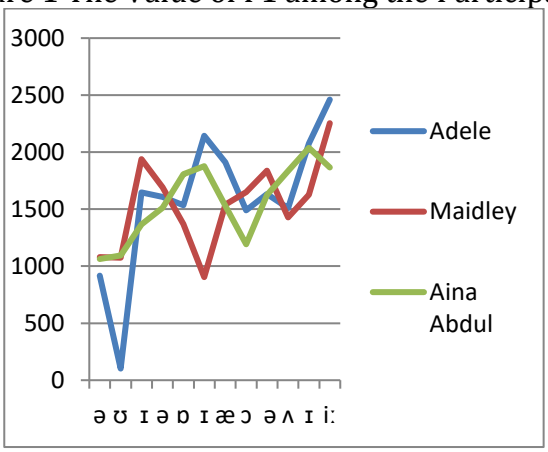

Figure 2 The Value of F2 among the Participants

Based on the data analysis, it is found that the highest F1 goes to American who produced 875 score for uttering mid vowel /ə/ in <river>, meanwhile the lowest F1 frequency goes to British who produced 308 while uttering mid vowel /ə/ in <gold>. In extracting F2 frequency, the data suggested that British got both the highest and the lowest score of F2 frequency, in which the highest reached the score 2461 in front vowel /i:/ for the word <me>, whereas the lowest score reached the score 917 in central vowel /ə/ for the word <gold>. Front vowels have higher F2 than back vowels, which is proved by the findings of the data, /i:/ in <me> which belongs to front vowel has the highest F2 frequency than other vowels. Vowel /ʊ/ in <gold> which belongs to back vowels has lower frequency than other vowels in the data (note: some participants tend to devoice vowels /ə/ in <gold>). The data also suggested that the formants frequencies among the singers vary different values even though the singers pronounce the same vowels like vowels /ə/ in <gold> <river> <water> and /ɪ/ in <river> <washin'> <swim>. This indicates that frequencies of F1 and F2 are not only determined by the shape of vocal tracts of the speakers, or by the vibration while uttering the words, it also affected by the consonants bringing the vowels. But most importantly, in singing context, the variance of formant frequencies is largely influenced by the timbre produced by the singers as timbre is the basic quality which allows us to distinguish between different voices, and in this case, vowels specifically.

Conclusion

It has been known for many years that formant frequencies are important in determining the phonetic content of speech sounds. There are lots of software that might be used to extract the value of formant frequencies, and one of the most popular software is Praat. Praat is used to bring formant listing F1, F2, F3, and F4. But using only the data of F1 and F2 are sufficient enough to identify the vowels contrasts in most languages especially in English. Based on the findings of this study, it can be drawn that timbre has major role in varying the frequencies of formants. The data also suggests that F1 has lower frequency than F2. The result of this study suggests that F1 has frequencies from 300 Hz to 900 Hz, and F2 has frequencies from 900 Hz to 2500 Hz. Front vowels have higher F2 than back vowels, while low vowels have higher F1 than high vowels.

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