Acoustic Disparities between English and Igbo Front Vowels

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Abstract

Acoustic phonetics refer to the study of the properties of speech in form of sound waves. It is interested in sound as soon as it leaves the mouth, just before it enters the hearer's ears. Acoustics is the study of the properties of sounds usually with the use of instruments like computer. This works focuses on portraying the properties of the front vowels sounds in English and Igbo language with the aim of identifying and describing their similarities and differences. This would be carried out with the use of a computer program called Praat. The data used in this work is from existing literature on the classification of English and Igbo front vowels. The work concludes that the similarities between the acoustic properties of the English and Igbo front vowel sounds are greater than their differences.

Keywords: Acoustic, Front vowels, Sound Waves, Praat

1) Introduction

Phonetics is the branch of linguistics that is concerned with study of the production, identification and classifications of speech sounds. It is literally the study of speech sounds, the production of the sounds, identifying the individual sounds and distinguishing (and properly) classifying them based on their various characteristics. These features could be in terms of place of articulation, manner of articulation, speech organs involved in the

production of the sounds, etc. There are three major branches of phonetics; the articulatory phonetics, the acoustic phonetics and the auditory phonetics. While the articulatory phonetics deals with the production of speech sounds, the organs of speech responsible for the production of particular sounds; the acoustic phonetics deals with the ways by which speech sounds are transmitted in the form of waves. This is the only branch of phonetics that gives us a clue of what happens in the air (that is when the sound waves leave the producer's mouth, just before it gets to the hearer's ears).

The auditory phonetics on the other hand deals with all the processes that are executed in the hearer's ears. It helps the phonetician to depict how the hearer perceived the produced speech sound and the processes that take place before the sound is fully perceived and understood by the hearer. Speakers communicate using speech sounds of the language, not necessarily with the movements of the tongue or the other articulators. This means is that, what the hearer needs to effectively understand the speaker might not be the proper articulation or movement of the speaker's tongue, but the speech sounds that the hearer deduced from the speaker.

Acoustic phonetics studies the acoustic signals which are the basic or primary means by which speakers transmit messages to the hearers. It deals with acoustic aspects of speech sounds. Acoustic phonetics investigates properties such as the amplitude of a wave form, its duration, its fundamental frequency, spectrum, and the relation between these properties and other branches of phonetics.

Acoustics is an aspect of the science of sound, that is, it is the science of wave in motion through the gas, liquid or solid mediums, and the result of such movement of waves. According to Pickett (1980:1), it is the scientific study of speech sounds which focuses especially on the sound patterns that function in language.

It is a branch of linguistics that deals with the sound code of speech. This branch of phonetics is the foundation of this work. Proper analysis of the acoustic signal will give detailed insight into the mechanisms underlying the production of speech sounds and the mechanisms that aid in perception by which the produced speech sounds are perceived by listeners.

Pickett (1980:2) further describes sound waves thus;

> Sound is the impulse we experience when the pressure fluctuations in our environment make an impact on our eardrums. Sound is the variation in air pressure that can be detected by the human ear. It can be demonstrated as a wave that is characterized by the transmission of energy in the form of increased and decreased pressure through a medium, which makes it a travelling pressure fluctuation. Sound waves usually rely on the movement of particles that make up the medium through which they are transmitted, either through air, water or any other medium for their realization. There are two types of sound waves that can be produced by the impactation of the pressure fluctuations on the eardrum; the periodic and the aperiodic sound waves. While the periodic sounds refer to the involvement of a pattern that repeats itself, the periodic sounds do not involve any repeating pattern. The aperiodic sound waves involve both the simple and complex periodic sound waves. The simple periodic waves entail that there is only one frequency component present while the Complex periodic signals involve the repetition of a nonsinusoidal pattern, and in all cases, complex periodic signals consist of more than a single frequency component. All nonsinusoidal periodic signals are considered complex periodic.

> The sounds of a language are divided into consonants and vowels. The vowels of a language are classified in terms of how far the raised body of the tongue is from the back of the mouth. This is known as the backness of the tongue. There are three height distinctions among vowels: front, back, and central. The front vowels are produced relatively forward in the mouth, the back vowels are produced far back in the mouth, while the central vowels are the vowels whose tongue positions are roughly between the front and back vowels.

This work aims at describing the front vowels of two languages: English and Igbo and identifying the disparities between the front vowels of the two languages if any. It achieves this aim by analyzing the speech sound waves in terms of their acoustic properties using Praat (a computer open- software developed by Paul Boersma and David Weenink, that enables sounds to be played, visualized, annotated and analyzed in terms of its acoustic properties to distinguish between the properties of the sounds such as the amplitude, the pitch, its frequency, and the spectrum). We present a few studies that will enable the proliferation of data in this work and literature in general.

2) Literature Review

Pickett (1980:1) notes that 'acoustic phonetics is a part of the general field of speech science, or experimental phonetics, which also includes physiological phonetics'. He states that 'speech science is basic to scientific study of a very broad range of interesting problems, including speech perception and hearing, child language acquisition, teaching of language and speech, pathologic

speech and language, speech communication technology and speech processing, synthetic speech, automatic recognition of spoken messages, speech communication aids for handicapped people, personal voice characteristics and voice identification, signing, dialects, phonetic comparison of languages, linguistics, and general communication theory when speech is a prime example. Acoustic phonetics contributes to each of these processes."

According to Ladefoged & Johnson (2006:7), Speech sounds, like other sounds, can differ from one another in three ways. They can be the same or different in (1) pitch, (2) loudness, and (3) quality. Thus, two vowel sounds may have exactly the same pitch in the sense that they are said still on the same note on the musical scale, and they may have the same loudness, yet still may differ, in the sense that one might be the vowel in *bad* and the other the vowel in *bud.* The authors also point out 'that speech sounds might have the same vowel quality but differ in the sense that one was said on a higher pitch or that one of them was spoken more loudly'. Sounds, according to them consist of small variations in air pressure that occur very rapidly one after another. These variations are caused by actions of the speaker's vocal organs that are (for the most part) superimposed on the outgoing flow of lung air. Thus, in the case of voiced sounds, the vibrating vocal folds chop up the stream of lung air so that pulses of relatively high pressure alternate with moments of lower pressure. Variations in air pressure in the form of sound waves move through the air somewhat like the ripples on a pond. When they reach the ear of the listener, they cause the eardrum to vibrate. A graph of a sound wave is very similar to a graph of the movements of the eardrum (Ladefoged & Johnson 2006:7).

Vowels are speech sounds produced without any obstruction in the vocal tract. This entails that the airstream flows out freely without blockage or friction during the production of vowels

(Anabogu et al 2001:72). According to them, for the description of any vowel, three basic factors are used:

(1) The part of the tongue that is highest in the mouth during the production of the vowel.
(2) The height of the tongue during its production
(3) The shape of the lips – whether the lips are rounded or unrounded during its production.

The state of the glottis and the place of articulation are not used as descriptive labels for vowels. This is because vowels are generally voiced, and there is no particular place of articulation of the organs since vowels are produced by the approximation of the organs.

To describe a vowel based on the part of the tongue that is highest in the mouth during its production, one talks of that part of the tongue that bunches up in the production of the vowel- is it the front part, the central part or the back part? If it is the front part, the vowel is described as a front vowel. For example, [i, e, a,] are front vowels. On the height of the tongue, is the tongue high or low in the mouth? In other words, has the tongue bunched up to a point of coming close to the palate or is it open in relation to the palate? This is why a vowel can be described as high or close and low or open. For example, [i] is a close front vowel or a high front vowel; [a], on the other hand is an open front vowel or a low front vowel. Whether the lips are rounded during the production of a vowel is another important factor in its description. For instance, in the production of the vowel [u] the lips are rounded. The vowel is described as a rounded vowel.

Part of the problem in describing vowels is that there are no distinct boundaries between one type of vowel and the other. When

talking about consonants, the categories are much more distinct. A sound may be a stop or a fricative, or a sequence of the two. But it cannot be halfway between a stop and a fricative. Vowels are different. It is perfectly possible to make a vowel sound that is halfway between a high vowel and a mid -vowel. In theory, (as opposed to what a particular individual can do in practice), it is possible to make a vowel at any specified distance between any of the two vowels. (Ladefoged & Johnson 2006:87).

According to Zsiga (1997:232), "the Igbo vowels can be described by contrasting the features, high, round and ATR (advanced tongue root). [-ATR] vowels are marked with the IPA symbols for retracted tongue root while the [+ATR] vowels are left unmarked". The front vowels in the Igbo language are unrounded while the back vowels are rounded. In Igbo vowel harmony, the vowels are classified with properties such as high and low. For example, the vowels [i e o u] are classified as the high vowels while the vowels [a, ị, ọ, ụ] are classified as the low vowels. The front vowels include [i ị e a] while the back vowels are [o ọ u ụ].

We have earlier stated that this paper focuses on the disparities on the properties of a sound based on some of the acoustic properties. It is important we define some of these properties. According to (Ladefoged & Johnson 2006:24), Frequency is a technical term for an acoustic property of a sound- namely: the number of complete repetitions (cycles) of a pattern of the air pressure variation occurring in a second. The unit of frequency measurement is the hertz, usually abbreviated Hz. if the vocal folds make 220 complete opening and closing movements in a second, we say that the frequency of the sound is 220 Hz.

The pitch of a sound is an auditory property that enables a listener to place it on a scale going from low to high, without considering its acoustic properties. In practice, when a speech sound

goes up in frequency, it also goes up in pitch. For the most part, at an introductory level of the subject, the pitch of a sound may be equated with its fundamental frequency, and, indeed, some books do not distinguish between the two terms, using pitch for both the auditory property and the physical attribute.

There are computer programs that can analyse sounds and show their components. The display produced referred to as the Spectogram. In spectrograms, time runs from left to right, the frequency of the components is shown on the vertical scale, and the intensity of each component is shown by the degree of darkness. "It is therefore a display that shows, roughly speaking, the dark bands for concentrations of energy at particular frequencies----showing the source and filter characteristics of speech" (Ladefoged & Johnson 2006:194). The sound spectrogram gives a picture of the acoustic properties of a sound.

3) **Methodology**

The data for this work were elicited from native speakers of the language who was required to articulate the sounds. The articulated sounds were recorded and analysed using the Praat software to determine the features. The analysis is experimental.

4) **Data Presentation and Analysis**

We have classified both the English and Igbo vowels in this work. The vowels /a, e, i, o, u, y/ represent the different vowel sounds in English either by occurring alone or by combining with one another or with /r, w/. There are about 21 vowel sounds in English. The front vowels include [i], [i], [e], [ɛ] and [æ]. When these vowels are produced in isolation, the position of the vocal tract

is constant with the highest portion of the tongue in the front part of the mouth. The front of the tongue is very high in the production of / i / and moves gradually down and backward as [e], [ɛ] and [æ] are produced. The Igbo vowels on the other hand are about 8 in number which include [a, e, i, ị, o, ọ, u, ụ]. The front vowels in Igbo are [i], [ị], [e], [a]. The front vowels of both languages English and Igbo are edited using the Praat acoustic software in order to determine if they have the same properties or not.

The English front vowels and usage:

[i] as used in feet
[I] as used in bit
[e] as used in lane
[Ɛ] as used in bet
[æ] as used in bat

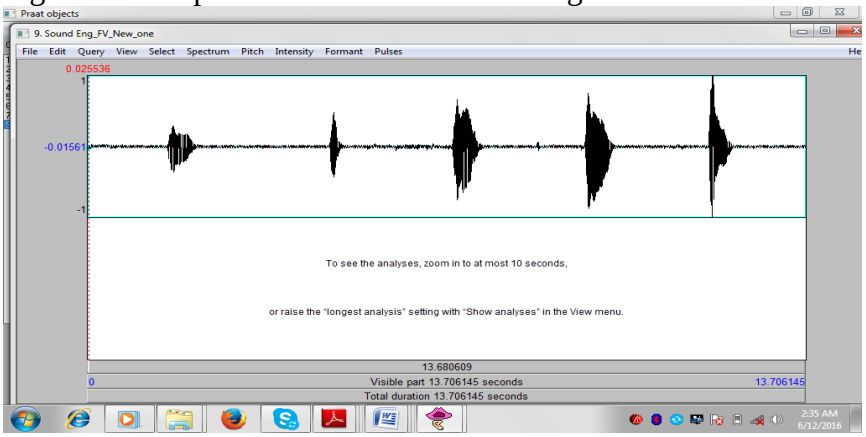
The Igbo front vowels and usage:

[i] as used in ísí ‘head’
[ị] as used in í□sī□ ‘to tell’
[e] as used in ézè ‘king’
[a] as used in àkpà ‘bag’

Acoustic Analysis

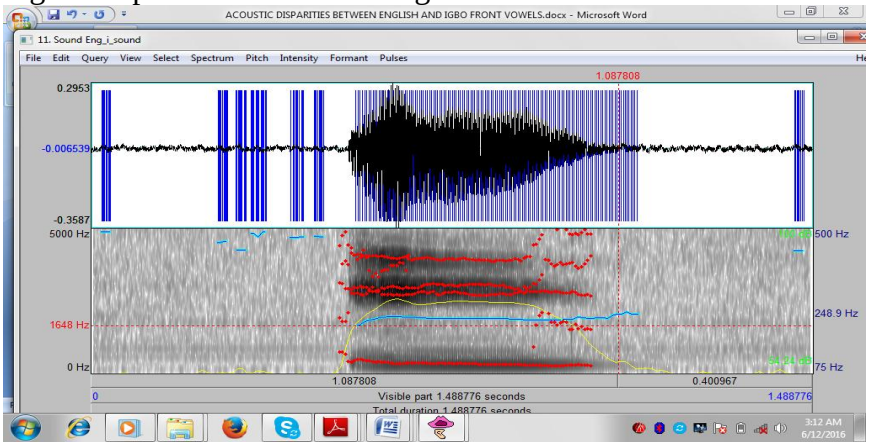
Here, we present the spectrogram of each front vowel in isolation as produced by a female speaker. Each representation of the spectrogram will give insight to the spectrum, pitch, intensity, formant and pulses of each sound.

Fig.1. a representation of the English front vowels.



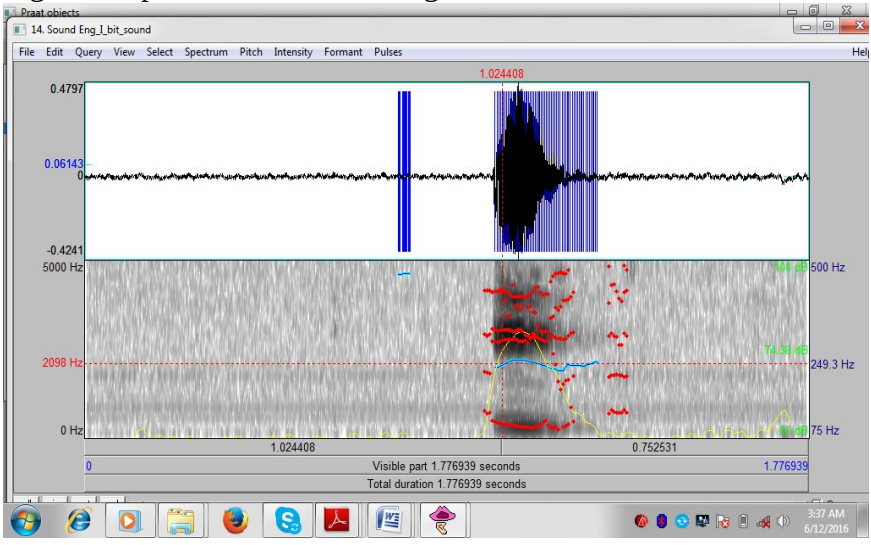
The spectrogram above is a representation of the English front vowel sounds. We shall now select the individual vowels alone and show their various representations.

Fig.2. a representation of the English /i/ sound



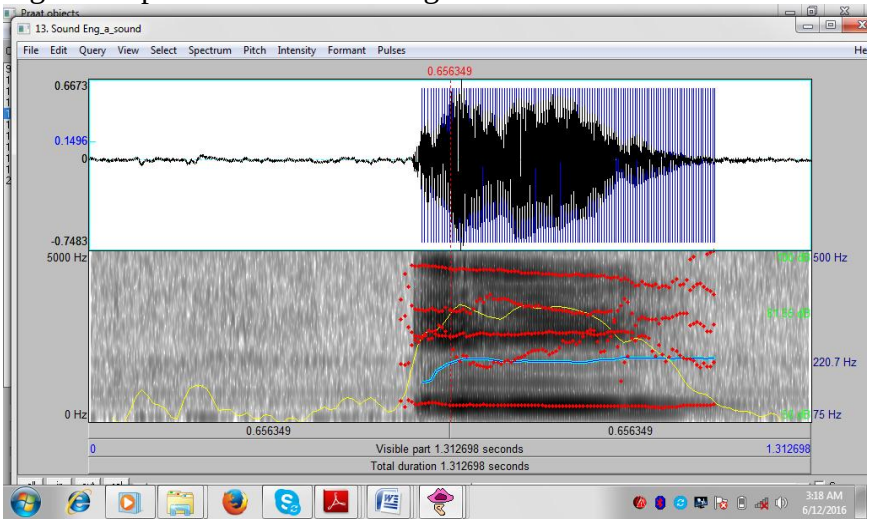
Praat shows the measurement of sounds using the spectrogram. In the spectrogram, the gray shades show the intensity of the resonance frequencies called the formants. The red dotted lines in the spectrogram represent the formants. In measuring vowels, it is only the value of the first and second formant that is required. While the first red line from below which is the first formant shows the height of the vowel, the second red line is the second formant which shows the frontness or backness of the vowel. It is important to note that, the more front the vowel, the higher the second formant. From the spectrogram in Fig.2, the [i] sound is represented below with the frequency of 248.9Hz. The blue line is used to indicate the pitch while the yellow line marks the intensity of the sound.

Fig.3. A representation of the English /I/ sound



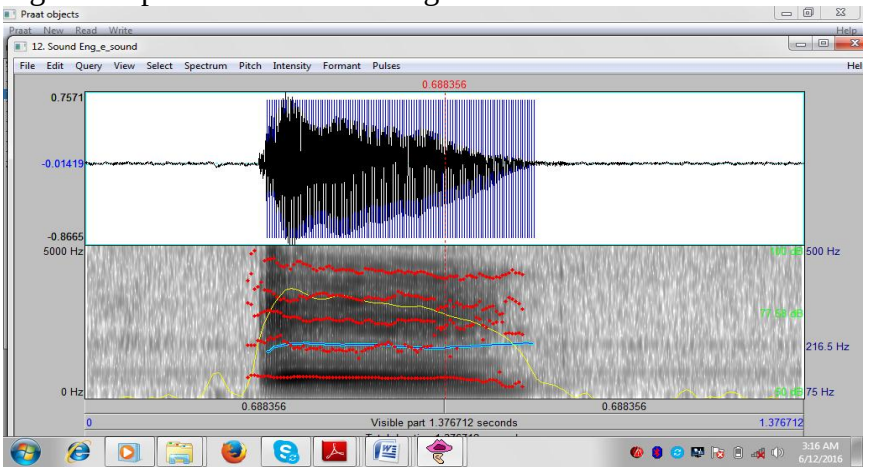
The yellow line shows the intensity of the sound while the blue vertical lines on the sound waves. In Fig.3, the second formant in the [I] sound shows a slightly higher frequency than the /i/ sound which is represented with the frequency of 249.3Hz. The lower the frequency, the closer the formant to the roof of the mouth.

Fig.4. A representation of the English /a/ sound.



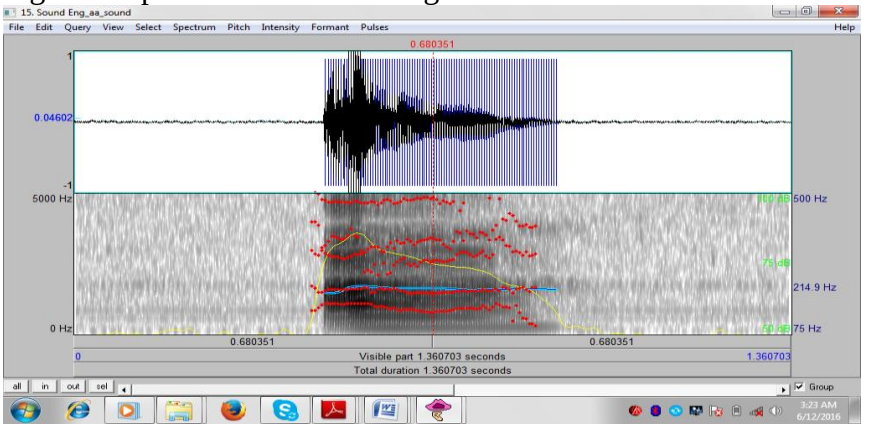
The /a/ sound in Fig.4 shows a lower frequency of 220.7Hz, marked by the second formant on the spectrogram. This is lower than the frequency of the /i/ and /I/ sounds. The representation of the /a/ sound in Fig.4 shows a lower pitch compared to /i/ and /I/ sounds.

Fig.5. A representation of the English /e/ sound.



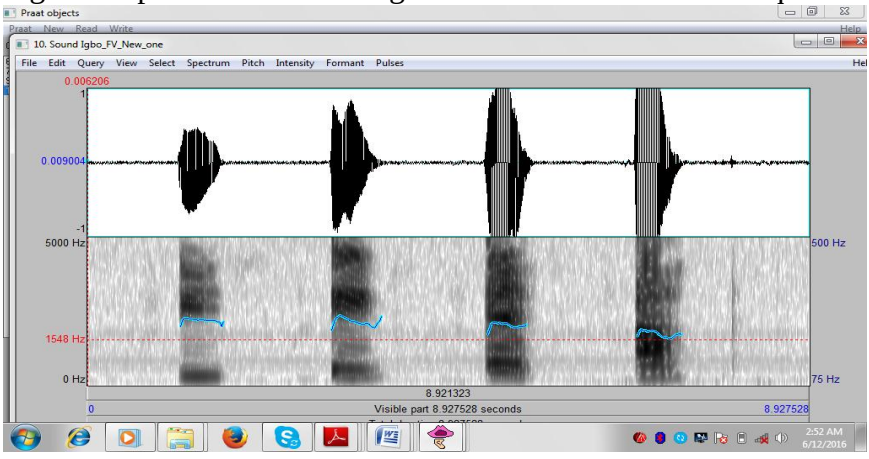
The representation of the [ɛ] sound is represented with the frequency of 216.5Hz in Fig. 5. While the pitch is lower compared to /a/, they both have almost the same intensity.

Fig.6. A representation of the English /æ/ sound.



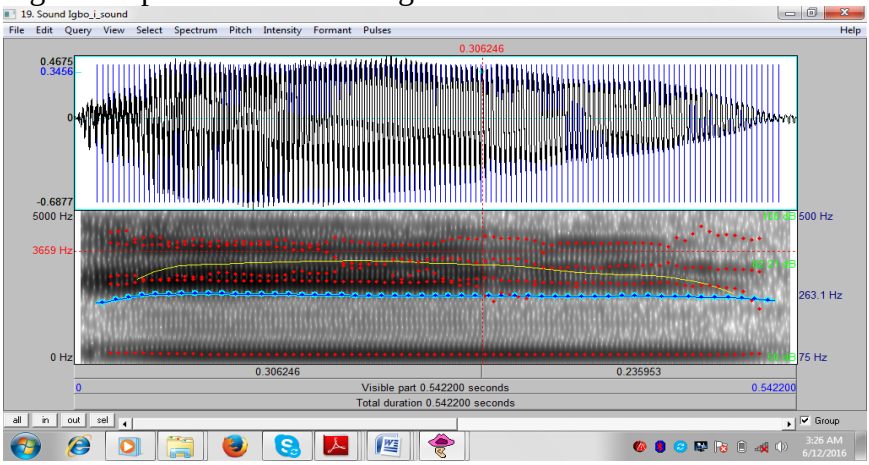
The [æ] sound as shown in Fig. 6 shows the frequency of 214.9Hz, with a lower pitch when compared to other front vowels.

Fig.7. A representation of the Igbo front vowel sounds in a sequence.



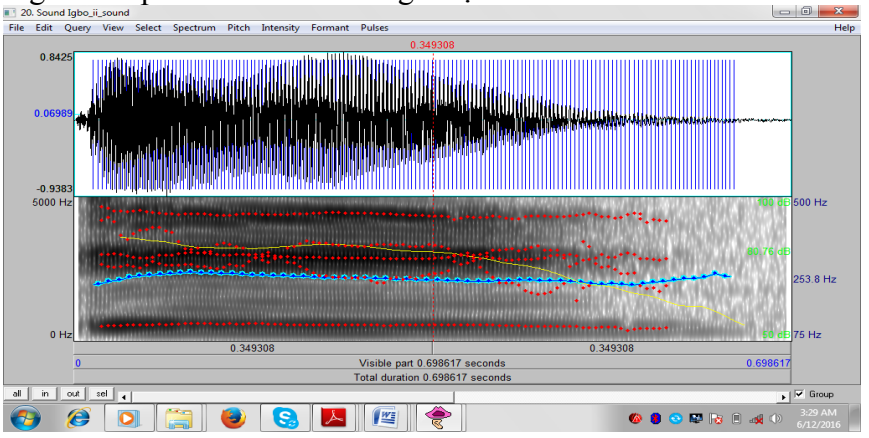
The representation of the Igbo front vowels in Fig.7 shows the first bar representing /i/ has the F1 and F2 widely apart followed by the /ị/, /e/ and /a/ sounds, showing a gradual closure between the first and second formant frequencies. This is almost the same as what is applicable to the English front vowels. The individual Igbo front vowels are represented as follows:

Fig.8. A representation of the Igbo /i/ sound



The [i] sound in Fig.8 shows a frequency of 263.1Hz. It shows a higher pitch to the English /i/, a greater intensity and a high formant.

Fig.9. A representation of the Igbo /ị/ sound



The [ị] sound is represented with 253.8Hz. this is lower than the frequency of the /i/ sound that has 263.1Hz with a lower formant, intensity and pitch, compared to /i/.

Fig.10. A representation of the Igbo /e/ sound

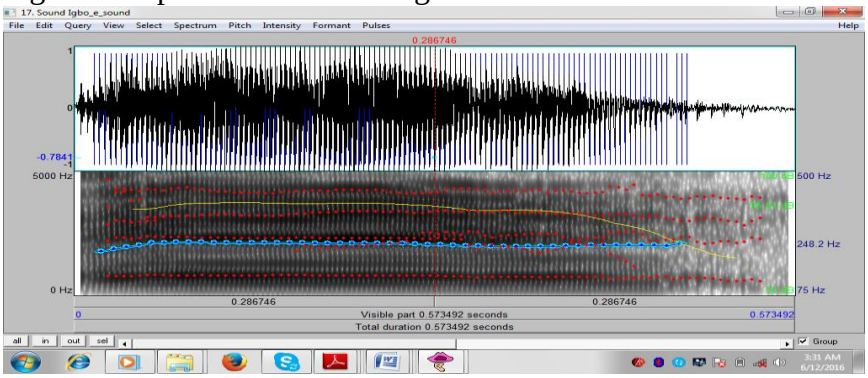
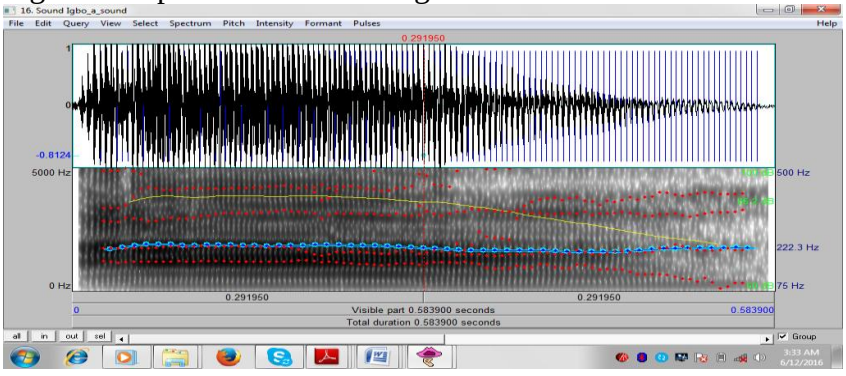


Fig. 10 represents the [e] sound showing the frequency of 248.2Hz. This is lower than the frequency of /ị/ showing a lower pitch but a higher intensity.

Fig.11. A representation of the Igbo /a/ sound.



The [a] sound is represented in Fig.11 showing the lowest frequency of 222.3Hz amongst the Igbo front vowels, following the same hierarchy with the English front vowels.

5) Findings, Summary and Conclusion

The work gives illustrations of the spectrograms of the English front vowels and the Igbo front vowels showing their properties: pitch, intensity, formant, pulses and frequencies. The purpose of this was to point out the differences in the properties of these vowel sounds if any. The work finds that amongst the English front vowel sound, the /i/ has the highest frequency of 249.3Hz followed by the /i/ sound showing the frequency of 248.9Hz. This finding is almost similar to the Igbo front vowels where the /i/ has the highest frequency of 253.8Hz, also followed by the /i/ with the frequency of 253.8Hz. Another finding is that both the English /æ/ sound and the Igbo /a/ sound have the highest occurrence in their first formants among other sounds. While the English /æ/ has its first formant as 756.9002802992679Hz, the Igbo /a/ shows 1084.0226353888045Hz. These findings support the universality of acoustics.

Finally, in a general view from the acoustic analysis of the front vowels, the Igbo front vowels tend to have higher frequencies than the English front vowels. These values are however dependent on the vocal tract length of the speaker. They are not the absolute values of the formant frequencies that specify phonetic information. This work therefore concludes that there are more similarities in the acoustic properties of the English and Igbo front vowels than there are differences.

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