Conversational quality assessment of advanced video conferencing systems

John Beerends, Niels Neumann
TNO
Netherlands

Abstract

With the covid-19 pandemic outbreak the number of users of advanced video conferencing systems such as Zoom, Microsoft Teams, Skype, FaceTime (and so on) has increased significantly. The end-to-end conversational speech quality of these systems is, in many cases, below expectation mainly because of large delays and the underestimated effect of degradations caused by the interaction of the microphone and loudspeaker with the send and receive room. This paper proposes a practical quality assessment approach based on ITU recommendations.

Introduction

In recent decades, several advanced video conference technologies have been introduced that degrade the conversational quality of a voice link in a complicated manner. With the COVID-19 pandemic outbreak, the number of users of these conferencing systems, such as Zoom, Microsoft Teams, Skype, FaceTime as well as other systems, has increased significantly. Despite significant advances in signal processing, that allow high quality conversations over these systems, the end-to-end conversational speech quality is in many cases below expectation. This is mainly caused by long delays and the underestimated effect of degradations caused by the interaction of the microphone and loudspeaker with the send and receive room. In order to have a high quality experience, the video and audio have to be in sync leading to an increased delay in these systems due to the extra processing time needed for the video coding. This increased delay in turn leads to a lower conversational quality, especially in cases where partners in the conversation often interrupt each other.

Furthermore, users will try to get the video image correctly framed by using a self-view image and thus taking distance from the camera whereby in most cases the microphone distance will also increase beyond the normal distance used in telephony. This increased distance degrades the conversational quality more than one would expect because the binaural decolorization is not able to compensate the room acoustic degradations. In “live” situations, this binaural decolorization maintains high quality even at large mouth/loudspeaker to ear distances. This leads to a hollow sound quality and decreased intelligibility in online conferencing. This problem can be solved by using a close coupled microphone in combination with a headphone. The disadvantage of the headphone is that it decreases the natural side tone in one’s ear. Also, it blocks the natural background sound from one’s own environment, leading to an uncomfortable talking quality. A correct, direct, feedback from microphone to headphone can restore the side tone degradation, but is rarely correctly implemented.

When the video and audio signals are correctly synchronized, the intelligibility degradation in the speech path can be partly compensated by the lip-sync information.

The problem with modern video conferencing is that it uses the Internet, forcing the use of advanced coding schemes, packetization, buffering and error protection technologies that increase the end-to-end delay and sometimes lead to short signal interruptions. Packet loss can cause short signal interruptions that can lead to situations where the overall perceived end-to-end quality is high, but the speech is temporarily not correctly perceived and the intelligibility is lower than one expects based on the speech quality.

The increased usage of audiovisual links in communication has urged the development of special tests to assess the overall conversational quality of these links in an efficient, reproducible manner that allows pinpointing of the major problems. This method should take into account all aspects that contribute to the overall perceived conversational quality. These aspects include the listening quality and intelligibility (how I perceive the other), talking quality (how I perceive myself), the interaction quality (how easy can we interrupt each other, double talk distortions) and the video quality (lip sync).

If an audiovisual presentation is multi/broadcasted and participants do not use interruptions, the impact of delay is marginal and large buffers can be used, thus allowing to have a significantly higher audiovisual streaming quality. However, as soon as interactions between meeting participants are foreseen, a short delay is a necessity in order to have an acceptable conversational quality. This paper is focused on the conversational quality of video conference links between two participants (however the protocol naturally extends towards group communication).

One can assess the conversational audio visual quality with subjective tests (ITU-T Rec., 2007); (ITU-T Rec., 2007) however the resulting subjective score of such tests is highly dependent on the experimental context. Especially the amount of switching between partners significantly influences the final outcome of the assessment. Furthermore, if insight is needed into the underlying causes of a low conversational quality, a better approach is to break down the overall quality into the different main components. In this paper a subjective/objective test protocol is given that separately assesses the four different main quality aspects that contribute to the overall conversational quality for both the A and B side of the link (Richards, 1973).

- One-way listening quality and intelligibility - how does A perceive the voice and background noise of the B-side (and vice versa)?
- One-way talking quality - how does A perceive his own voice (side tone/echoes) and background noise switching of the B-side during talking (and vice versa)?
- Two-way interaction quality- how easily can A interrupt B (and vice versa) and are there disturbing artefacts audible during double talk?
- One-way viewing quality - how does A perceive the video quality of the B-side (and vice versa), including lip-sync assessment?

The first quality aspect is related to distortions introduced by the microphone/room, the coding and transport of the speech signal and by the play back loudspeaker/room. It can be assessed in a listening-only experiment.

The second quality aspect involves the side tone path from one's own mouth to one's ear and becomes especially important when headphones are used. With headphones, the natural side tone

path should be simulated by feeding the correct signal from one's microphone back to the headphone. In the case of hands free, we have a natural acoustic side-tone path but echoes may degrade the talking quality. It also involves the perceived switching of the background noise of the B-side which may occur during voice onsets on the A-side. Talking quality can be assessed in a talking-only experiment.

The third quality aspect, the two-way interaction quality, is dominated by the end-to-end delay and the double talk capabilities of the system under test. Often, echoes and background noise switching become audible under double talk conditions. This two-way interaction quality aspect is difficult to quantify and requires two-way speech activity on the link.

Finally, the video-related quality aspect quantifies the contribution of the video signal to the overall conversational quality. This aspect is of minor importance as one can achieve high conversational quality without a video signal. In the case of low video quality where the audio and video are not in lip-sync, a still picture of high quality may be preferred instead, allowing for a lower end-to-end audio delay.

For each of the four quality aspects, objective assessments can be carried out. For one-way listening ITU-T recommendation P.863 was developed for end-to-end speech quality measurements (Beerends, Schmidmer, Berger, Obermann, Ullman, Pomy and Keyhl, 2013a), (Beerends, Schmidmer, Berger, Obermann, Ullman, Pomy and Keyhl, 2013b, ITU (2014). For one-way talking and two-way interaction, development work has been carried out, but for this class of distortions, the relations between objective and subjective measurements are not clear and highly dependent on the experimental context as shown in (Appel and Beerends, 2002), ITU (2015) and ITU (2019). For two-way interaction the influence of delay is important. It can be measured objectively and taken into account in the calculation of an overall conversational speech quality ITU (2015), ITU (2019) and ITU (1996b). [8], [9], [10]. However, especially double talk distortions and background noise switching during talking are difficult to assess objectively. Video quality can be assessed using ITU-T recommendationsJ.247 and J.341 (ITU 2008 and ITU 2016[11], 12]), but objective lip-sync quality is difficult to measure.

This paper proposes a combined subjective/objective test protocol that determines the conversational quality of a voice link by using trained listeners that run a number of controlled experiments. For an exact controlled B-side voice link, the protocol uses a HATS (Head And Torso Simulator) or loudspeaker at the B-side. If no HATS or loudspeaker is available, a second trained subject can be used in the test. The complete subjective/objective test protocol is split in five steps:

a) One-way listening, speech quality

b) One-way talking, echo/side tone/switching/background noise quality

c) Two-way interaction, full/semi-full/half duplex quality, double talk capabilities

d) Two-way interaction, impact of delay

e) Video impact assessment

Note that the rooms in which the audio sets are placed have a significant influence on the final quality judgment, especially if one of the sets uses hands-free operation at a large microphone distance. The method uses experts that give opinion scores that are anchored by the judgment of

predefined distortions. Each of the five tests is carried out by two experts at both the A and B-side giving a MOS for the first four aspects and a MOS correction for the video impact. The end-to-end conversational quality of the video conference link is determined by the worst contributing factor.

Note that the proposed test protocol only provides a rough estimate of the conversational quality. Exact measurements are almost impossible and only the listening quality can be measured with high accuracy using ITU-T recommendation P.863 (ITU-T Rec., 2014).The philosophy of this paper is that it is better to be roughly correct than exactly wrong.

The subjective/objective test protocol for determining the conversational quality of a videoconferencing link

In the test as described in this paper, the quality of a connection between A and B is assessed at the A side of the connection by the expert listener using a HATS artificial mouth or loudspeaker on the B-side. The HATS/loudspeaker plays speech recordings that are made in a dry acoustic environment at close distance from the mouth (about 10 cm) using a microphone that delivers a natural spectral balance of the voice at this distance when played back over the artificial mouth of the HATS/loudspeaker. The background noise level in the recording environment should be below 30 dBA, the reverberation time below 0.5 seconds for frequencies above 300 Hz and below 1 second for frequencies above 50 Hz.
If two HATS are available, the artificial ear of the second HATS at the A-side can be used to make a recording that can be processed by ITU-T recommendation P.863 as shown in Beerends, Schmidmer, Berger, Obermann, Ullman, Pomy and Keyhl, (2013a), Beerends, Schmidmer, Berger, Obermann, Ullman, Pomy and Keyhl, (2013b) and ITU (2014) allowing for an objective listening quality assessment that can be reproduced with high accuracy. Speech material that is played over the HATS/loudspeaker should be recorded and played back at the levels normally used in the audio visual link.

When no HATS or loudspeaker is available, the protocol can be carried out with a "live" voice at the B-side using the natural background noise present at the B-side.

When the test is completed, the same test must be repeated at the B-side of the connection with the role of A- and B-side interchanged.

The protocol consists of the following five tests:

a) One-way listening speech quality. Examples are available for calibrating the expert opinion in two languages, one female Igbo talker and one male Dutch talker. Natural, high quality speech is played back over the HATS/loudspeaker on the B-side (female and male test signals are available) or short, known, sentences are spoken by a subject on the B-side. Linear (timbre), non-linear and level distortions should all be taken into account. The ITU-T P.800 (ITU, 1996b) ACR listening quality scale (Absolute Category Rating, see Table 1) is used. The P.800 listening quality scale is anchored in the following way:

5 = excellent = the speech quality is essentially the same as the natural voice at the B-side (female and male examples)

4 = good = the speech signal is only marginally distorted, female and male anchor examples distorted by a linear band filter 50-4000 Hz

3 = fair = speech quality that is clearly distorted, female and male anchor examples distorted by a linear narrow band filter 300-3400 Hz; female and male anchor examples distorted by packet loss.

2 = poor = speech quality that is severely distorted, female and male anchor examples distorted by a linear narrow band filter 300-2000 Hz; female and male anchor examples distorted by packet loss.

1 = bad = unacceptable low speech quality showing severe intelligibility problems, female and male anchor examples distorted by severe packet loss.

More degradation examples, including room reverberation degradations, can be found in:http://beesikk.nl/JohnBeerends/SpeechQualityExamples.htm

Note that a high quality reproduction is necessary for correct assessment of the anchor speech files. The authors suggest to download the anchor speech files and use a high quality headphone for the optimal assessment.

This test results in a **MOS-LISTEN (A) and (B)** for both sides of the connection.

Opinion	**Absolute Category Rating ACR**	**Degradation Category Rating DCR**
5	Excellent	Degradation is inaudible
4	Good	Degradation is audible but not annoying
3	Fair	Degradation is slightly annoying
2	Poor	Degradation is annoying
1	Bad	Degradation is very annoying

Table 1. Definition of the ACR and DCR MOS scales used in the test protocol, taken from ITU-T P.800 (ITU, 1996b).

b) One-way talking, side tone/echo quality. The expert talks at the A-side and listens for echo and side tone distortion. The reference is the natural side tone. Linear, non-linear and level distortions and echoes and background noise switching should be taken into account. Speech should be produced at varying levels between soft and loud and degradations in the background noise of the B-side, such as noise switching at voice onsets, should be taken into account. The ITU-T P.800 (1996b) DCR opinion scale (Degradation Category Rating, see Table 1) is used, anchored in the following way:

5 = no echo, no side tone distortion or audible background noise switching, equivalent to the natural acoustic situation

4 = audible but not annoying echo, side tone distortion or background noise switching

3 = slightly annoying echo, side tone distortion or background noise switching

2 = annoying echo, side tone distortion or background noise switching

1 = very annoying echo making normal conversations difficult

This test results in a **MOS-TALK (A) and (B)** for both sides of the connection.

c) Two-way interaction, full/semi-full/half duplex quality, double talk capabilities. This test requires two experts, one on each side of the connection. The expert at the B-side counts fast and continuously: *1, 2, 3, 4, 5, 1, 2, 3, 4, 5, 1, 2, 3, 4, 5, 1, 2, 3, 4, 5…etc (use varying speech levels),* the expert at the A-side speaks with pauses using short consonant vowel consonant (cvc) words*: pause, <cvc1>, pause, <cvc2>, pause, …etc*. In the assessment, the quality of the continuous counting voice from the B-side (*1, 2, 3, 4, 5*) is evaluated at the A-side and the *cvc* speech quality produced at the A-side is judged at the B-side, together with the quality with which A perceives his own voice. During double talk, no distortion or echo from one's own voice should be audible. Speech should be produced at varying levels between soft and loud. The ITU-T P.800 1996b DCR opinion scale (Degradation Category Rating) is used in the assessment with 5 = no semi-full/half duplex degradation audible. The same anchoring is used as under b).

This test results in a **MOS-INTERACTION (A) and (B)** for both sides of the connection.

d) Two-way interaction, delay. Objective measurement of the end-to-end delay, preferably with speech. For mean one-way delays up to 72 ms, the DCR MOS is 5.0 (excellent), for larger delays the DCR MOS rating = 11.5 – 3.5*LOG(mean one-way delay [ms]) (see Figure 1). This quality rating is roughly in line with recommendations G.107 (ITU-T Rec., 2015) and G.114 (ITU-T Rec., 1996a). For delays above 1,000 ms the service is no longer considered to be a conversational service. If no objective measurements can be made, an alternative procedure can be used that is based on an interactive counting protocol. In this test two subjects take turn using the following test protocol: subject A starts the procedure with counting word "one", while at the same time he starts a timer, next B counts "two" after receiving "one", etc until expert A receives "ten" from the B-side, at which point he stops the timing. This procedure is calibrated in a face-to-face test until the START STOP time ***T*** is about 4.5 seconds (4500 ms). Over the voice link the mean one-way delay is estimated by ***0.1*(T - 4500) ms***.

This test results in a **MOS-DELAY** by applying the transformation as given in Fig.1.

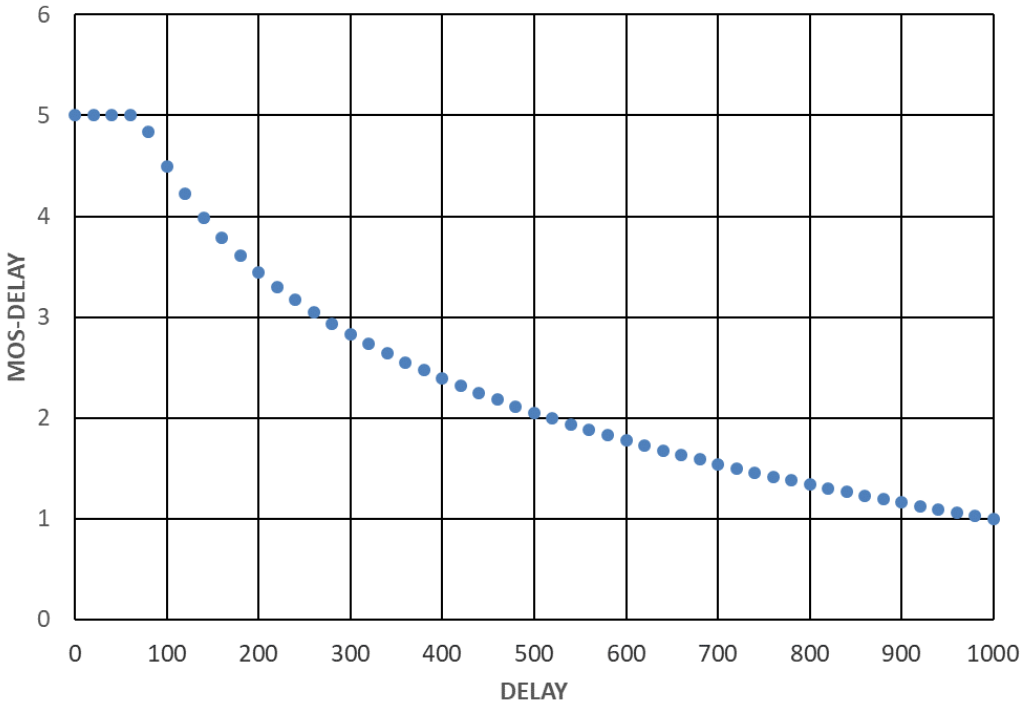

Fig. 1: Impact of delay on the conversational quality

For mean one-way delays up to 72 ms, the DCR MOS is 5.0 (excellent), for larger delays the DCR MOS rating = 11.5 – 3.5*LOG(mean one-way delay [ms]).

e) Video quality. If the video and audio are clearly out of sync, the video quality impact is set to zero. If the video is of full High Definition TV quality (>1000 lines vertical resolution) with no clearly visible degradations and perfect lip-sync, the overall audio MOS value is increased by 0.5 MOS. For non-perfect lip-sync and lower video resolutions the overall MOS increase is lower than 0.5 and is estimated with Table 2. The video quality assessment can be determined for both the A- and the B-side.

Table 2. Impact of the video signal quality on the final conversational MOS, the maximum increase in MOS is only obtained for perfect lip-sync with high quality full HD video resolution (>1000 lines of vertical resolution).

Video assessment	**Increase in conversational MOS**
Ideal reference full HD resolution with perfect lip-sync	0.5
Difference with Ideal is visible but not annoying	0.4
Difference with Ideal is visible and slightly annoying	0.3
Difference with Ideal is visible and annoying	0.1
Difference with Ideal is visible and very annoying	0.0

Each of the five tests is carried out by two experts at both the A and B-sides, giving seven MOS for the first four tests (a, b, c, d), MOS-LISTEN (A), (B), MOS TALK (A), (B), MOS-DELAY and MOS INTERACTION (A), (B). The end-to-end conversational quality of the speech link is defined as the minimum over the seven MOS scores in the four different audio tests (a, b, c, d) increased by the video impact of the lowest quality of the A and B sides, leading to a theoretical a maximum MOS of 5.5.

Conclusion

A fast and simple method for the measurement of the conversational quality of a video conferencing link is presented that provides stable results on a five point MOS scale. It uses a combined subjective/objective test protocol with expert listeners. Subjects can be trained in a short training session to become expert listeners.

In the protocol, the three main factors that contribute to conversational quality are assessed. These include the listening quality (how I perceive the other), talking quality (how I perceive myself) and interaction quality (how easily can we interrupt each other? - double talk distortions).

The listening quality experiment uses pre-recorded speech that is played over a HATS/loudspeaker, or a live talking subject. The talking quality experiment uses a single expert. The interaction quality is determined by measuring the round trip delay and by an assessment of two experts, one on each side of the audiovisual link.

The method uses predefined anchoring conditions and an objective end-to-end delay measurement that is mapped to the subjective conversational quality impact. The final conversational quality is determined by the worst contributing factor, compensated with a correction factor of maximum 0.5 MOS for links with high definition video that is in exact lip-sync with the speech signal. The theoretical maximum MOS score in this approach is 5.5.
The conversational MOS values for high quality telephony links lie between 3.0 and 4.0.

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A reanalysis of the syllable in Igbo language: acoustic insight from Abankeleke Igbo

E. Chinwe Obianika, Ebonyi State University, Abakaliki
obianikac@gmail.com, chinweobianika@ebsu.edu.ng 08036756912

Abstract

The history of the study of the Abankaleke speech form is such that a closer observation is necessary to present a concrete evidence of perceptual observations. This work therefore sets out to acoustically examine the syllable structures of Izii and Ezaa dialects in Abankaleke Igbo to establish their uniqueness. The data are collected through personal interview. Three respondents are randomly selected- one for Izii, Ezaa and Standard Igbo respectively- and the data are recorded, transcribed and analyzed electronically using the Speech Tools Analyzer version 3, 0.1 (1996-2007) and Phonology Assistant version 2.2 (1995-2005) software packages developed by the Summer Institute of Linguistics (SIL) International. The result of the perceptual analysis, which is confirmed by the instrumental analysis reveal that in addition to the syllable structures observable in the Standard Igbo, Izii and Ezaa dialects also have closed syllables. Furthermore, Ezaa dialect also has consonant clusters. The occurrence of vowel reduction in other related dialects of Igbo and the geographical proximity between Izii, Ezaa and the Korin language is suggested as an explanation for the occurrence of codas in Izii and Ezaa, and consonant clusters in Ezaa. However, this feature is not widespread in these dialects. Hence we conclude that the Igbo language has consonant clusters and closed syllables. However, Izii dialect has a syllable structure that is more similar to that of the Standard Igbo than Ezaa dialect since the latter more instances of closed syllables in addition to consonant clusters which are absent in Izii.

1 Introduction

Igbo language in the recent past has enjoyed the attention and interest of scholars. The outcome of this has been increased knowledge and understanding of the form and function of the language. Many of the studies carried out are on the dialects. In spite of this, a lot of ground still needs to be covered. This is because some of the dialects have received attention more than others. One of the dialects that have received less attention is the Abankaleke cluster of the Northern/Wawa Igbo (Ikekeonwu (1986) classification), specifically Izii and Ezaa. Many scholars who have studied the dialect cluster in the past have come up with different degrees of perception of the peculiarity of the cluster when compared with other dialects of the Igbo language. Such scholars include Meier and Meier (1964-1970), Bendor-Samuel (1975), Ikekeonwu (1986), Hoffman (1987), Ukpabi (2003), Udoh (2004), Anyanwu (2005) and Nwaozuzu (2008). The earlier scholars such as Meier and Meier (1964-1970), Bendor-Samuel (1975) and Hoffman (1987) have it that the perceptible difference in these dialects is enough to classify them as a separate linguistic system other than Igbo. However, the more recent works of Ikekeonwu (1986), Nwaozuzu (2008) and others (and indeed among Igbo language academic circles) have it that the Abankaleke dialect clusters are bona fide dialects of the Igbo language.

Given the above situation, there is need to investigate this Igbo dialect cluster more closely to reveal the peculiarities and as such lend weight or otherwise to the stance of the more recent scholars. To do this effectively, a prosodic unit, the syllable is chosen as the linguistic unit of investigation. The choice is based on the fact that, according to Zec (2007:163), “once the principles of syllable organization are properly stated, they subsume most of the generalizations

about segment sequencing". There is also the fact that, to the knowledge of the researcher, there has not been any acoustic investigation of language data from this dialect cluster to authenticate the auditory perception. Such an investigation is deemed necessary because according to Obianika (1999) any objective analysis of prosodic data should incorporate instrumental analysis to substantiate the phenomenon and extricate the analysis from subjectivity. In the light of the above, this paper intends to engage in an acoustic analysis of the syllable in Izii and Ezaa dialects of Abankaleke Igbo.

1.1 Objective

The differing opinions which characterize the history of the study of the speech form of the Abankaleke people calls for a closer and authentic investigation. All the previous studies have been perceptual in design. This study therefore intends to do an acoustic analysis of the structure of the syllable in Izii and Ezaa dialects of Abankaleke Igbo. It intends to find out the possible concatenations of phonemes in syllables in Izii and Ezaa dialects and to use the formant features obtainable from the acoustic analysis to validate or refute any generalizations that could be made from the perceptual findings.

1.2 Methodology

The sampling technique used is random sampling. Two adults who are L_1 speakers of Izii and Ezaa respectively are sampled. The third respondent is an educated adult who speaks Igbo as $L_{1..}$ He supplied the Standard Igbo data. Structured personal interview is adopted to elicit three tokens of each word from the three respondents. One hundred and fifty words of basic items adapted from the Ibadan 400 Basic items wordlist are used and the data are recorded electronically. The data analysis is carried out with the Speech Tools Analyzer version 3, 0.1 (1996-2007) and Phonology Assistant version 2.2 (1995-2005) software packages developed by the Summer Institute of Linguistics (SIL) International. These are used in recording, transcribing and in the acoustic analysis of the data.

2.1 The Syllable

Zec (2007) in line with Hocket (1955), Haugen (1956), Fudge (1969), Kahn (1976), Selkirk (1982) argues that the syllable as an organizing principle for grouping segments in any given language is highly constrained. The set of occurring sequences presents only a fraction of the much larger set that would have resulted if there were no restrictions on concatenation of members of its segment inventory. A number of propositions have been proffered to account for these restrictions, but the most acceptable is the syllable. Kahn (1976) defines the syllable as a prosodic unit 'larger than the segment and smaller than the word".

According to Zec (2007), words and sometimes longer sequences are exhaustively parsed into syllables so that the sequencing principles that characterize the syllable naturally extend to larger constituents. He maintains that the syllable is a representational device that encompasses the principles of segment sequencing. "Once the principles of syllable organization are properly stated, they subsume most of the generalizations about segment sequencing".

Clark, Yallop and Fletcher (2007), Zec (2007) and Ashby and Maidment (2005) agree that languages differ in how the universal principles of segment sequencing are manifested but that they do so in constrained and predictable ways. The simplest syllable structures would consist of

a nucleus which is nearly always a vowel (or the most sonorant part) and the two margins, the onset and the coda which are usually consonants. Below is the representation of the most basic types of syllables:
CVC – a syllable with all the principal parts
CV – a syllable that contains only the onset and the nucleus
VC – a syllable that contains only the nucleus and the coda
V – a syllable that contains only the nucleus.

Some generalizations could be made with regard to universal syllable structure. The nucleus is the most basic and stable across languages. The asymmetry lies in the left and the right margins. According to Zec (2007) onsets are highly desirable and codas are less preferred in languages. Onset desirability is portrayed by the fact that every language allows syllables with onsets and no language allows only onsetless syllables. On the other hand, codas are avoided in many languages and they are never required in all environments. Furthermore, the onset as well as the coda may include more than one consonant according to the structure of the particular language.

Emenanjo (1978), Iloene (1997 & 2007) and Ikekeonwu (1999) opine that the Igbo language has predominant CV syllable structure that is, the sequence of one consonant followed by a vowel constitutes a syllable. The consonant element (the onset) is optional and there is no coda in Igbo. In other words, the Igbo language allows no closed syllables. However, the syllabic nasal can occur syllable initial (onset) and minimally at syllable final positions. When the syllabic nasal is syllable final, it functions as the nucleus of the syllable. Since tone operates at the level of the syllable and that every syllable in a tone language bears a tone, the syllabic nasal bears the tone when it functions as the nucleus of a syllable in the Igbo language.
Emenanjo (1978) expresses the foregoing schematically:
(C) T
S
Where T = Tone
(C) = Optional onset consonant
S = Syllabic element (vowel or syllabic nasal)
The implication of the above submission is that there are two basic Igbo syllable types: V and CV. Examples:
V
Ó/Ọ – Ọ́ dì m̀má i/ị – Í mèrè n ∃kè ọ́má
É- É gbúlá m̀mádụ̀
N – N ńkụ́ [ŋkʊ] ṁ↓a [ŋma] ńtụ́ [ŋtʊ]
‘Firewood’ ‘beauty’ ‘nail’
CV .
pá– ‘carry’
tá– ‘chew’
ké – ‘tie’
mú – ‘sharpen’

However, very minimally, we have the following syllable structures in the Igbo language:
(N) CVN
m̀bèm̀ - an elegy
VCVN
dụḿ - lion

2.2 Instrumental Work

The syllable structure of the Izii and Ezaa dialects is to be considered in this work using acoustic instruments. Donwa-Ifode (1995) discusses the advantages of incorporating instrumental investigation in the analysis of prosodic language data. This is necessary because our discipline has to be as objective and scientific as possible. According to her, it is an extension and aid to our bodily faculties. In other words, we first make observations through our senses of hearing, sight and touch; then we make hypothesis which the instruments confirm, negate or modify. Thus, the instrumental work serves as a check on the excesses of subjectivity by our observations. Furthermore, instrumental work adds detail to our observations. She however observes that instruments have their limitations because it is easy to abuse the use of instruments. For this reason, their use is secondary and not primary as they are means to an end and not an end in themselves. Because of these advantages of the use of acoustic instruments in analyzing language data, a number of linguists working on the Igbo language incorporate acoustic findings in their work. Some of these works are discussed below.

Uguru (2006) sets out to authenticate Ika intonation patterns. Using the judgment sampling technique, she collects samples from two informants - two adult male speakers of Igbo and English respectively. The data were analyzed using the praat system package developed by Paul Boersma. The wavelengths of four intonation patterns, HR, LR, FR and RF in the two languages were measured based on the waveforms.

In her findings, with respect to waveforms, she opines that differences in phonemes and some individual differences in pronunciations may have resulted in certain dissimilarities. The same factors according to her may have resulted in differences in pitch contours of both languages. Also the tunes of both languages, though similar, are not strictly the same while the shapes and directions of rise and fall of their pitch contours are basically the same. Among other things, she concludes that Ika has stress and that the stress is fairly fixed as the nucleus tends to occur sentence-finally. In all according to her, in spite of the relative differences between the intonation patterns compared in English and Ika, it can be said, generally, that the degree of similarity between them is considerably high.

The relationship between the work of Uguru (2006) and the present work lies in the fact that this work will also undertake an acoustic analysis of its data drawn from a different variety of the Igbo language. The difference also lies in the aspect of the speech form studied in addition to the fact that while Uguru (2006) did a comparative work on the intonation patterns of Ika (a dialect of a tone language – Igbo), and that of an intonation language, English, this present work focuses on an acoustic analysis of the syllable in two dialects of Igbo namely, Izii and Ezaa.

Ikekeonwu (1993) aims at establishing the fact that grammatical motivation may not be the compelling reason for the features of downstep and that downdrift may not be automatic after all in the Igbo language. Among other things, she opines that downstep is influenced by what she describes as 'Tonal Intonation Group' (TIG). In her analysis, downstep is seen as 'an intonation feature arising as a result of the need for focus or emphasis on particular syllables within the TIG. Using instrumental analysis, Ikekeonwu explains that phonetically, the syllable with the Focal High Pitch (FHP) is higher than all the other syllables in the TIG and that it usually falls on the lexical item being focused on or on the following syllable to the right. Her work is related to this

present one in that it incorporates instrumental findings in the analysis of tonal behaviour in Igbo associative constructions among other categories of utterances and this present work intends to also incorporate instrumental findings in the analysis of the syllable structure of Izii and Ezaa dialects of the Igbo language.

Also, Obianika (1999) incorporates acoustic investigation in her autosegmental analysis of tone in Igbo associative constructions. In her work, she investigates the behaviour of tone in constructions of the noun-noun type. Among other things, she finds out that the previous accounts that the occurrence of the downstep on the first syllable of the second noun in some of these constructions come as a result of the existence of a floating low tone in the deep structure is not consistently applicable in all the cases. She also finds out from the acoustic analysis that there is a consistent pitch rise or lowering in the cases investigated confirming the auditory findings. In line with the submissions of Ikekeonwu (1993), she opines that the rise in pitch in the associative constructions is motivated by a need for focus or emphasis and so could not have emanated from an underlying structure. The above work is related to this work in the sense that in as much as both works are investigating different aspects of the Igbo language, they incorporate the acoustic approach in addition to the perceptual analysis before arriving at a conclusion.

3.0 Basic Phonology of Izii and Ezaa Dialects

We shall discuss the basic phonology of the two dialects under study in this section. First, the Izii data will be presented, followed by that of Ezaa.

Table 1: Izii consonant Chart

	Bilabial	Labio dental	Alveolar	Labio lized alveolar	Palato αλϖεολαρ	Palatal	velar	Labialised velar	Labio velar	glotal
Plosives	p b		t d			C ɟ	k g	kw gʷ	kp gb	
Nasals	m		n			ɲ	ŋ	ŋʷ		
Fricatives	ɸ β	f v	s z		ʃ ʒ		ɣ			h
Affricates	pf bv		ts dz		tʃ dʒ					
Laterals			l	ɭʷ						
Approximants						j		w		
Rolls			r							

3.1.1 Izii Consonants

/p/ as in pàtá /pàtá/ ‘carry’
/b/ as in ẹ́bà /ébà/ ‘fat’
/t/ as in ótùbò /ótùbò ‘navel’
/d/ as in ẹ̀gbụ̀dụ̀ /ɛ̀gbɔ̀dɔ̀/
/c/ as in èkḭ́tchà /ɛ̀kɪ́cà ‘left (side)’
/ɟ/ as in djèidjè / ɟèíɟè/ ‘walk’
/k/ as in éká /ə́ká / ‘hand’
/g/ as in gìdé /gìdé/ ‘hold’
/kp/ as in ọkpụ / ɔ́kpʊ/ ‘bone’
/gb/ as in ègbúsh /ə̀gbʊ́ʃ/ ‘hair’

/kw/	as in ékwooshí/	ékwòóʃĩ/ ‘leaf’
/gw/	as in àgwà	/àgwà/ ‘beans’
ŋw/	as in nwáànyì	/ ŋwáàɲì/ ‘women’
/m/	as in ímí	/ímí/ ‘nose’
/n/	as in ọ́nụ́	/ ɔ́nʊ́/ ‘mouth’
/ɲ/	as in ẹnya	/ ə́ɲá/ ‘eye’
/ŋ/	as in ńkụ́	ŋkʊ́/ ‘firewood’
/ɸ/	as in ophe	/óɸé / ‘soup’
/β/	as in aabha	/ /àáβà/ ‘year’
/f/	as in yéfù	/jéfù/ ‘untie’
/v/	as in ḿvọ	ḿvɔ/ ‘nail (finger or toe)’
/ts/	as in ụtsọ	òtsɔ́ ‘sweet (tasty)’
/dz/	as in udzumini	/ùdzúmini/ ‘rainy season’
/s/	as in sàá	/sàá/ ‘wash’
/z/	as in ézé	/ézé/ ‘tooth’
/pf/	as in ḿphu	/ɱpfʊ́/ ‘palm’
/bv/	as in óbvú	/óbvu/ ‘thorn’
/r/	as in íré	/íré/ ‘tongue’
/l/	as in ólú	/ólú/ ‘neck’
/lʷ/	as in lwaa	/lʷàá/ ‘return’
/ʃ/	as in ishi	/ íʃi / ‘head
/ʒ/	as in ọgadzi	/ɔ́gaʒ/ ‘guinea fowl’
/tʃ/	as in nshi	/ŋʧ/ ‘ear’
/dʒ/	as in èjíàgbà	/ɛ́dʒɪɛ̀gba/ ‘beard’
/j/	as in yéfù	/jéfù/ ‘untie’
/ɣ/	as in oghu	/òɣú/ ‘cotton’
/ɦw/	as in imeehwo	/ímeɛɦwɔ/ ‘intestine’
/h/	as in èhụ́	/èhʊ́/ ‘body’

3.1.2 Izii vowels

In Izii dialect, there are nine vowels. / i ɪ e ɛ a u ʊ o ɔ /.

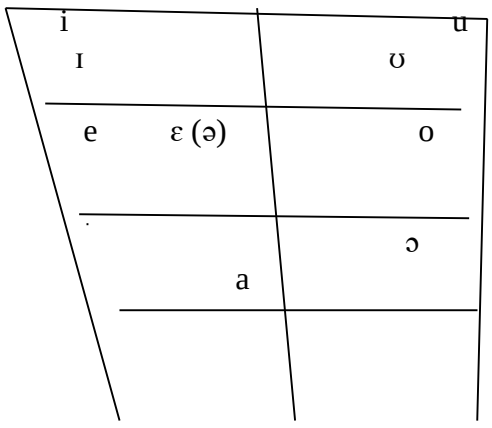

Fig 1: Izii vowel chart

/i/ as in Íkwè /Íkwè/ ‘mortar’
/ ɪ/ as in ìgbúlọ̀ /ìgbúlɔ̀/ ‘wall’
/e/ as in égẹ́ /égbé/ ‘kite’
/ɛ / as in èhú̱ /ɛ̀hó/ ‘body’
/a/ as in àgbà /àgbà/ ‘jaw’
/u/ as in ú↓swe /ús^{w}e/ ‘red’
/ʊ/ as in ụ̀ụ́tsụ̀ /ŏtsɔ̀/ ‘dawn’
/o/ as in òghú /òɣú/ ‘thread’
/ɔ as in ọkpụ /ɔ́kpʊ/ ‘bone’

3.2.1 EZAA CONSONANTS

The Ezaa dialect consonants are presented in the following table.

Table 2: Ezaa consonants

	Bilabial	Labio Dental	Dental	Alveolar	Labio lized alveolar	Palato alveolar	Labio Palato alveolar	palatal	velar	Labialised velar	Labio velar	glotal
Plosives	p b			t d					k g	kw gw	kp gb	
Nasals	m			n				ɲ	ŋ	nw		
Fricatives	kf	f v		s z		ʃ ʒ			ɣ			h
Affricates	pf	tv		ts dz		tʃ dʒ			kv			
Laterals				l								
Approximants								j			w	
Rolls				r								

Ezaa Consonants

/p/ as in pàtá /pàtá/ ‘carry’
/b/ as in ẹbha /ɛβα ‾/ ‘fat’
/t/ as in ìtè /ìte/ ‘pot’
/d/ as in mgbodo /ḿgbòdo/ ‘wall’
/k/ as in èkich èkítʃ/ ‘left’
/g/ as in ọgadz /ɔgàʒ / ‘guinea fowl’
/kp/ as in ọkpụ / ɔ́kpó /‘bone’
/gb/ as in ègbúshi /égbuʃì/ ‘hair (head)’
/kw/ as in ẹkwa /ékwa/ ‘cloth’
/gw/ as in ágwọ /ágwɔ/ ‘snake’
/m/ as in imi /ímí/ ‘nose’
/n/ as in ọnụ /ɔ́nó/ ‘mouth’
/ɲ/ as in ẹnya /éɲa/ ‘eye’
/ŋ/ as in ñùána /ŋɔ̀ána/‘drink’
/ŋw/ as in nwóke /ŋwóke/‘man’

/pf/ as in oɸ /opf/ 'word'

/kf/ as in ụtapf /òtapf/ 'thigh'

/f/ as in phụrụ /ɸòróàɸr/ 'stand (up)'

/v/ as in ḿvọ ḿvɔ/ 'nail (finger or toe)'

/s/ as in ìsé /ìsé/ 'five'

/z/ as in é↓ze /é↓ze/ 'tooth'

/tv/ as in útvú /útvu/ 'mountain'

/ts/ as in ụtsọ≅ /ótsɔ/ 'sweet (tasty)'

/dz/ as in udzumini /ùdzúmíní 'rainy season'

/ʃ/ as in àshbók /àʃbok/ 'groundnut'

/ʒ/ as in ọgadz /ɔgàʒ/ 'guinea fowl'

/ɣ/ as in ghụọọ /ɣòɔ́ɔ/ 'wash (body)'

/h/ as in ẹhṵ́ /əhó/ 'body'

/hw/ as in éhwọ́ ≅ /éhwɔ/ 'belly'

/tʃ/ as in ntch /ŋtʃ/ 'ear'

/dʒ/ as in újúrí /údʒuri/ 'orange'

/j/ as in agụiyi /ágóíjí/ 'crocodile'

/w/ as in owu /òwú/ 'thread'

/l/ as in ólú /ólú/ 'neck'

/r/ as in ire /íré/ 'tongue'

3.2.2 EZAA VOWELS

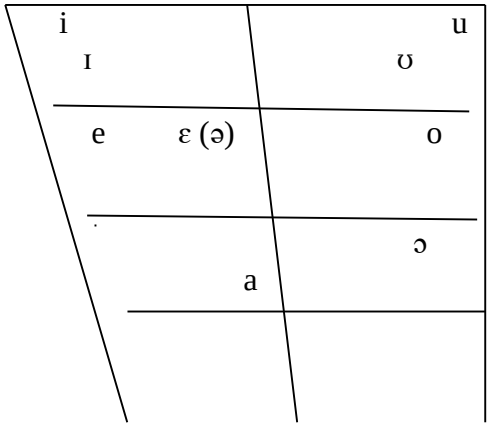

Fig 2: Ezaa vowel chart

The vowels of Ezaa dialect are nine : / i ɪ e a ɛ u ʊ o ɔ /.

/i/ as in ire /íré/ 'tongue'

/I/ as in èkịch /èkítʃ/ 'left (side)'

/e/ as in épfí /épfí/ 'cow'

/Ɛ/	as in	ẹgbụsh	/ègbóʃ/	'hair'
/a/	as in	ánwụ́	/áŋwó/	'sunshine'
/u/	as in	úte	/úte/	'mat'
/ʊ/	as in	ụ́za	/ʊ́za/	'pepper'
/o/	as in	óshi	/ójí/	'stick'
/ɔ/	as in	ọ́nụ́	/ɔ́nʊ/	'mouth'

3.3. Izii and Ezaa Syllable Structures

We present in this section the auditory perception of the syllable structures of both Izii and Ezaa dialects. The syllable structures of Izii and Ezaa dialects are unique in that as dialects of Igbo, it is surprising that they have onsets and codas as well as consonant clusters. We have a few instances of consonant clusters involving plosives and trills particularly in Ezaa dialect. Generally, they have the following syllable structures.

CVC - onset, nucleus and coda
CCV - consonant cluster as onset and nucleus
CV - onset and nucleus
V - only nucleus.

3.3.1 Izii Syllable Structure

Table 3: Izii syllables exemplified

(C)VC (onset (optional) and coda)	CV (onset and nucleus)	V (nucleus)
ègbúsh /égbóʃ/ 'hair'	/ èhụ́ /èhó/ 'body'	ẹji /édʒɪ/ 'hair'
ọgadz /ɔgàʒ/ 'guineafowl'	ẹka /éka/ hand'	ẹnya /éɲá/ 'eye'
opf /oɸ/ 'word'	ọnụ /ɔ́nʊ' 'mouth'	ali /àlɪ/ 'earth'
ncha /ńtʃa/ 'soap'	Ophe /óɸé/ 'soup'	ụzọ /ózɔ̀ 'path'
	ébvùụ /ébvɔ̀ 'fear'	áshwá /áʃʷa/ 'market'

In the examples above, we find that there are syllables with both onsets and codas and that there are others with only codas and no onsets. The cv structure is more prevalent than any other in Izii dialect. Finally, we have the syllable with only v, the nucleus.

3.3.2 Ezaa Syllable Structure

Table 4: Ezaa syllables exemplified

V–only nucleus	**cv-onset + nucleus**	**cvc- onset + nucleus + coda**	**ccv-onset cluster + nucleus**
/édʒɪ/ 'bad'	/ʃ́ii/ 'small'	/ égbóʃ/ 'hair'	/ɔ̀griɲà/'old person'
/éɲá/ 'eye'	/éká/ 'hand'	/ɔ̀gàʒ/ 'guinea fowl'	/óglogò/ 'long '

/óhwé/ ‘soup’	/èɦó/ ‘body’	/ótápf/ ‘thigh’	/dʒèémgbrmgbúr/ ‘turn around’
/màá/ ‘know’	/ózà/ ‘pepper’	/àʃbók/‘groundnut’ /onyebɔgrɪŋa/ ‘older person’	/ḿkprób/ ‘ heart’

In Ezaa dialect, in addition to the presence of syllables consisting of only a vowel and those with onsets, we also have syllables with both onsets and codas as well as others with consonant clusters.

3.4 Spectrographic Evidence of Consonant Clusters and Closed Syllables in Izii and Ezaa

In the following section, we will analyze the data using acoustic instruments. Firstly, we present the Izii data.

3.4.1 Izii Closed Syllables

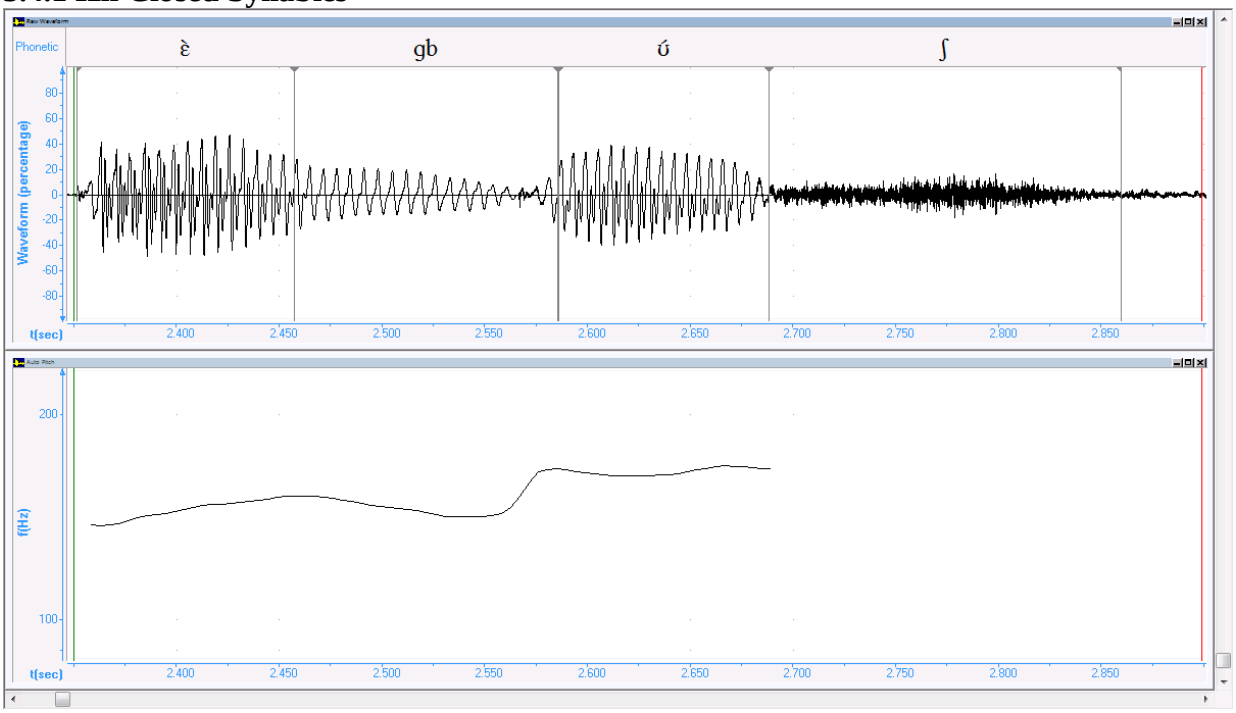

Fig. 3: A closed syllable in Izii /gbɔʃ/

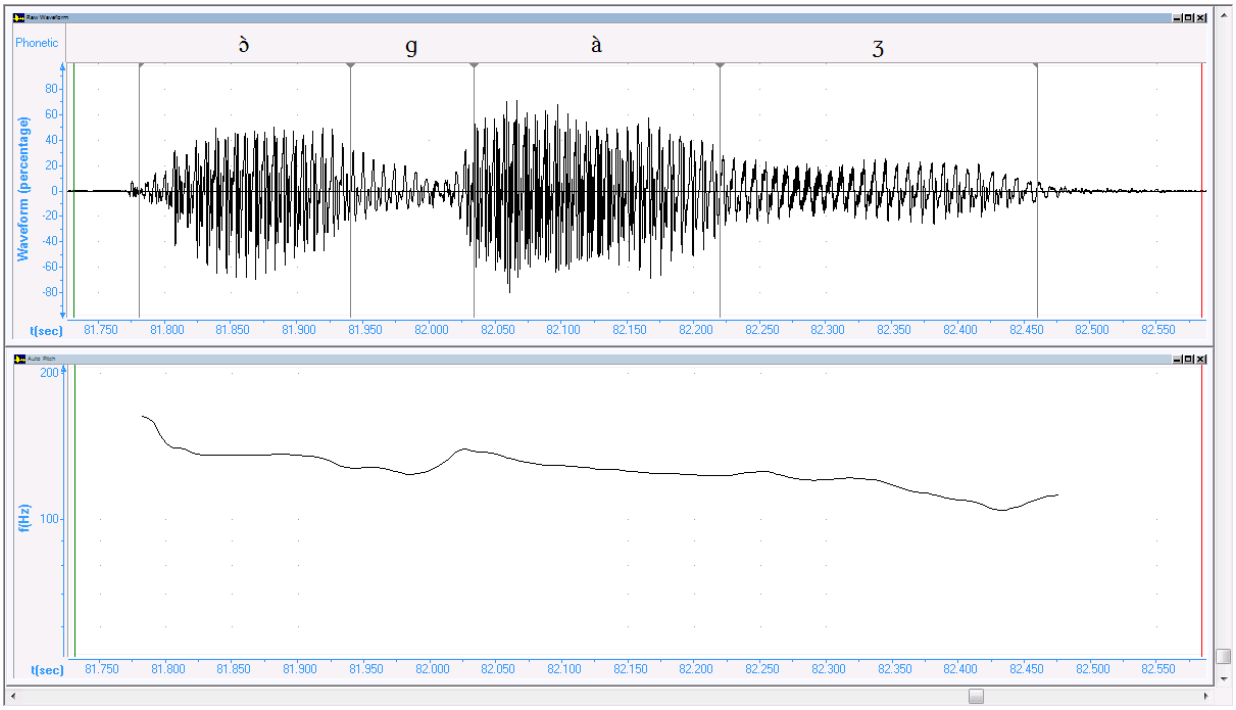

Fig. 4: A closed syllable /ɔ̀gàʒ/ in Izii.

In figures 1 and 2 above, we see the spectrograms of closed syllables in Izii dialect. The spectrograms show the first three segments as voiced. The vertical striations correspond to the vibrations of the vocal cords while the last segment in Table 1 shows random noise pattern indicative of the friction resulting from the articulation of the voiceless fricative /ʃ/. The absence of vertical striations at the end of the word after the fricative indicates the absence of a vowel confirming that the last syllable is closed. Also in Table 2, though the vertical striations indicate that the segment is voiced, there is no evidence that another segment is following it indicative of a closed syllable.

3.4.2 Ezaa Closed Syllables

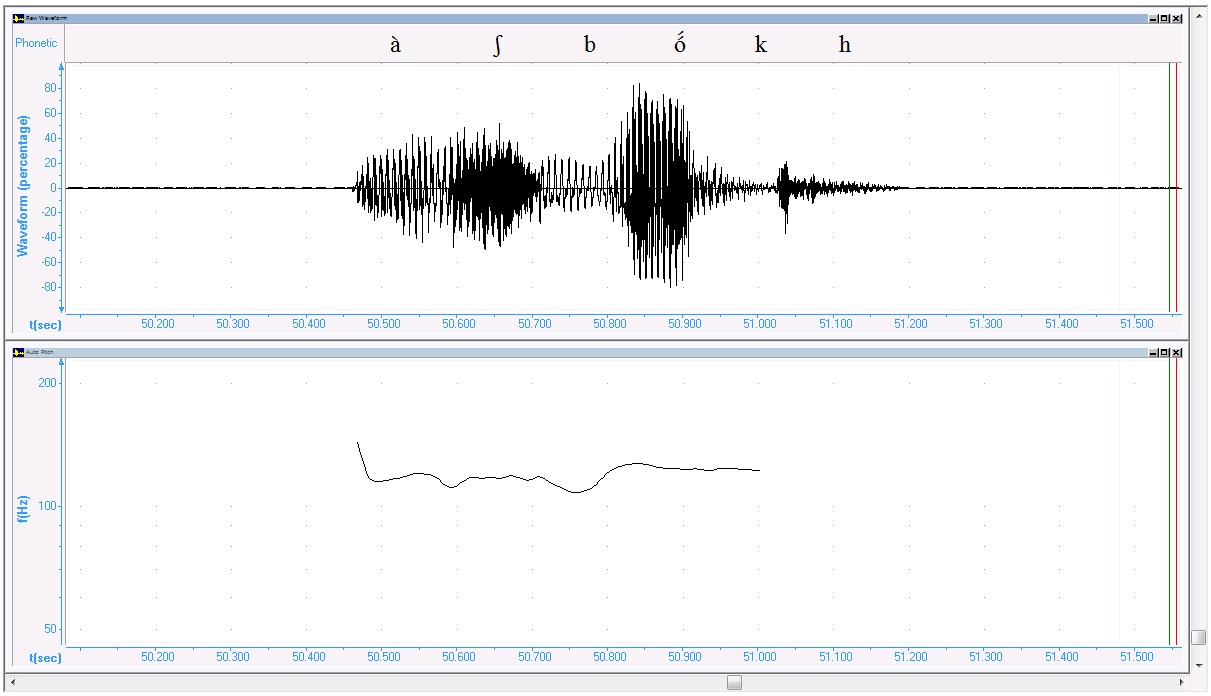

Fig. 5: Closed syllables in Ezaa dialect /à̱ʃ/ and /bókẖ/ (first and second syllables)

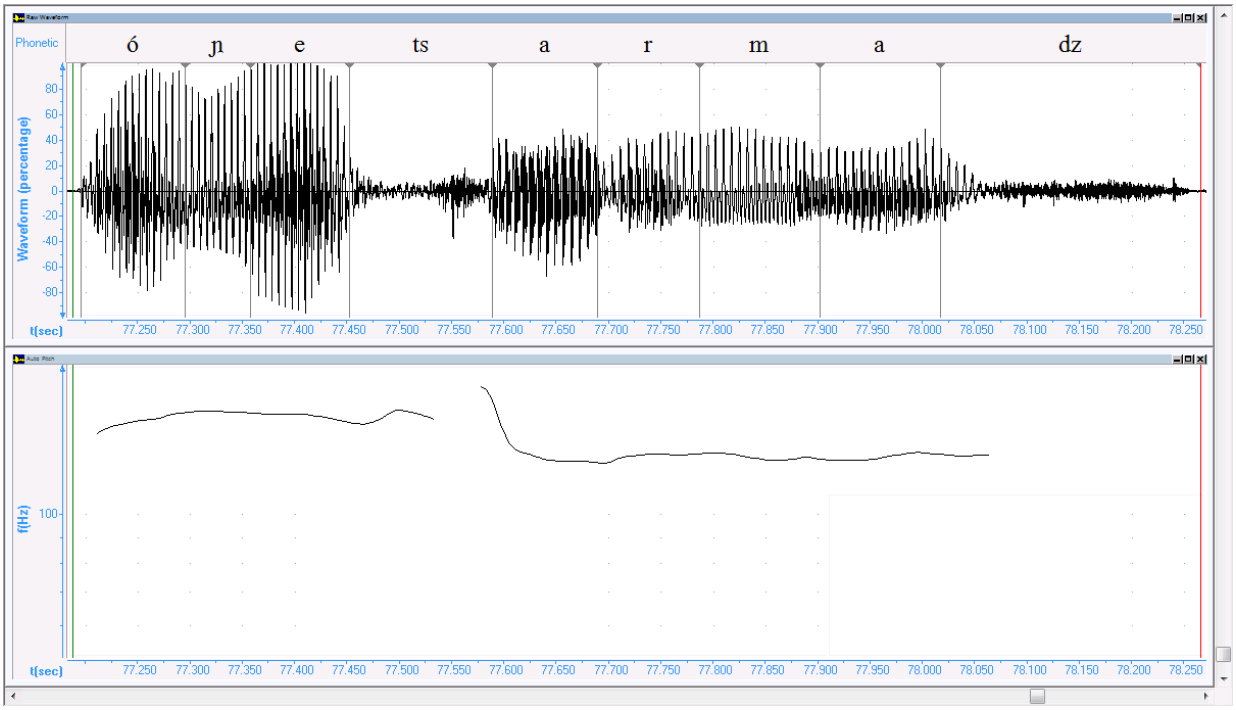

Fig. 6: Closed syllables in Ezaa dialect /tsar/ and /madz/

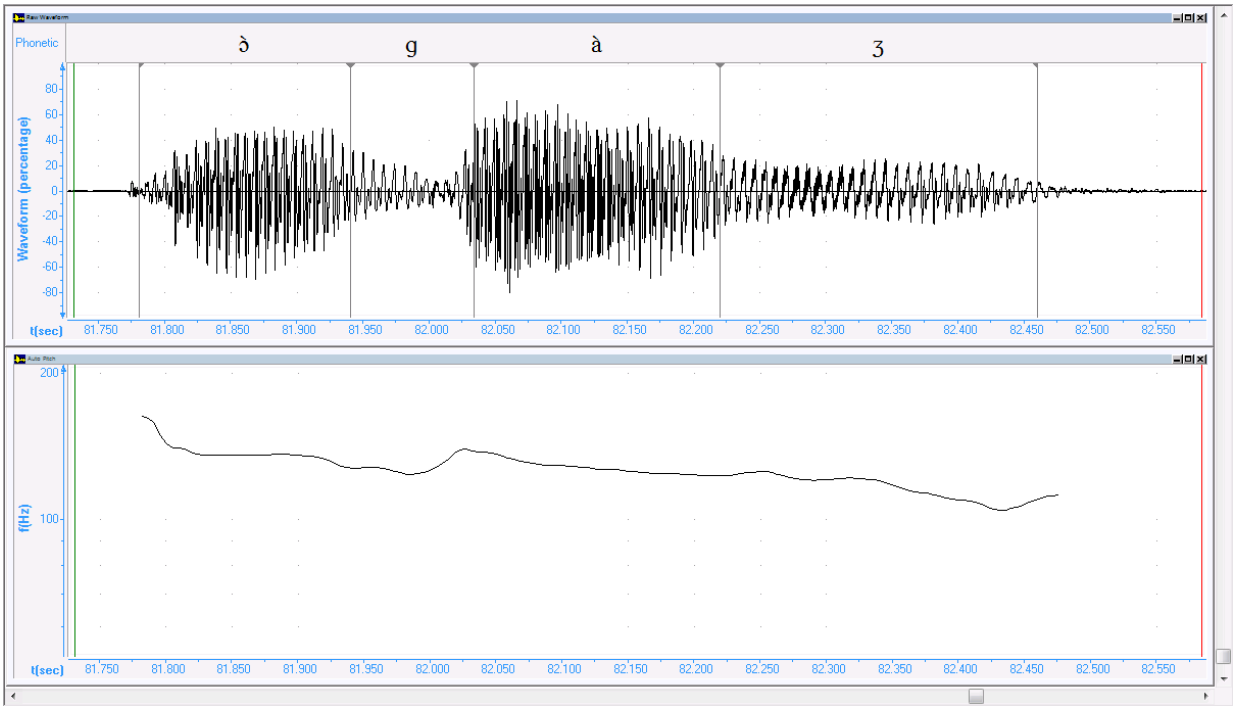

Fig. 7: A closed syllable in Ezaa /ɔ̀gàʒ/

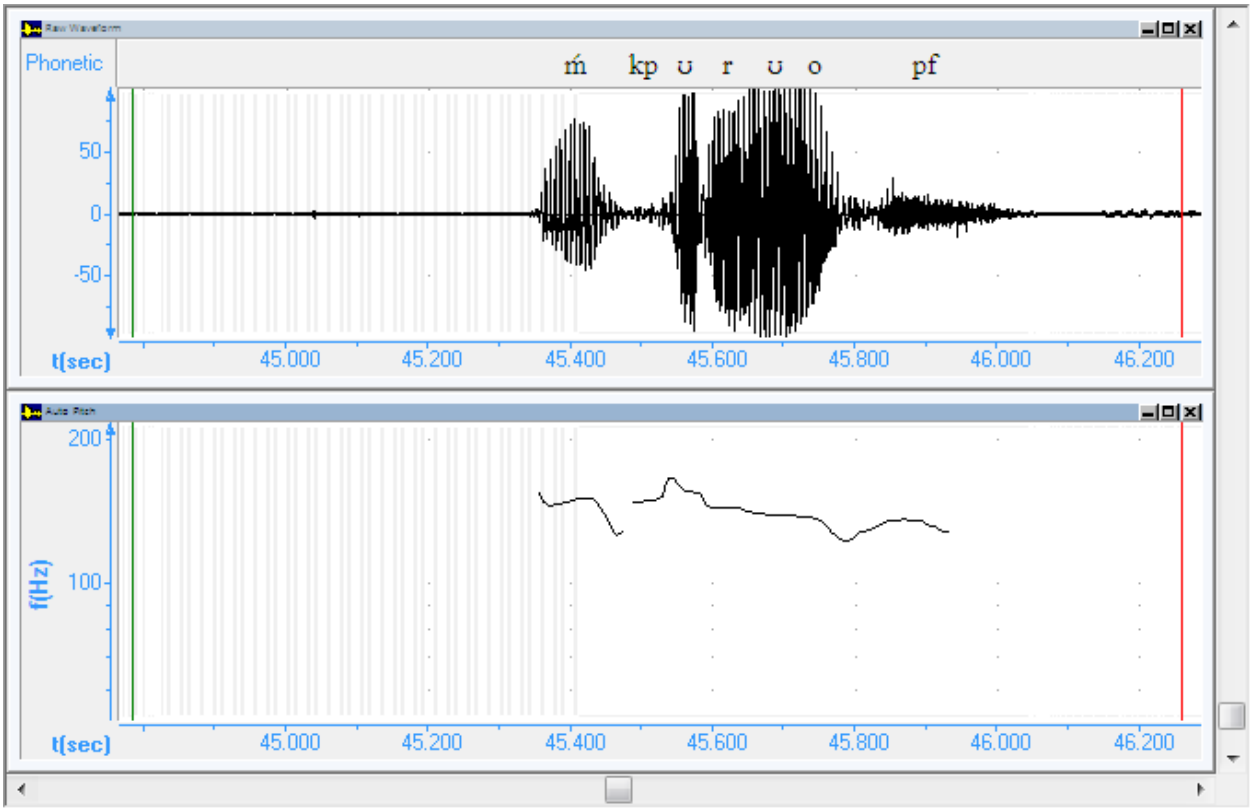

Fig. 8: A closed syllable in Ezaa (last syllable) / ópf/

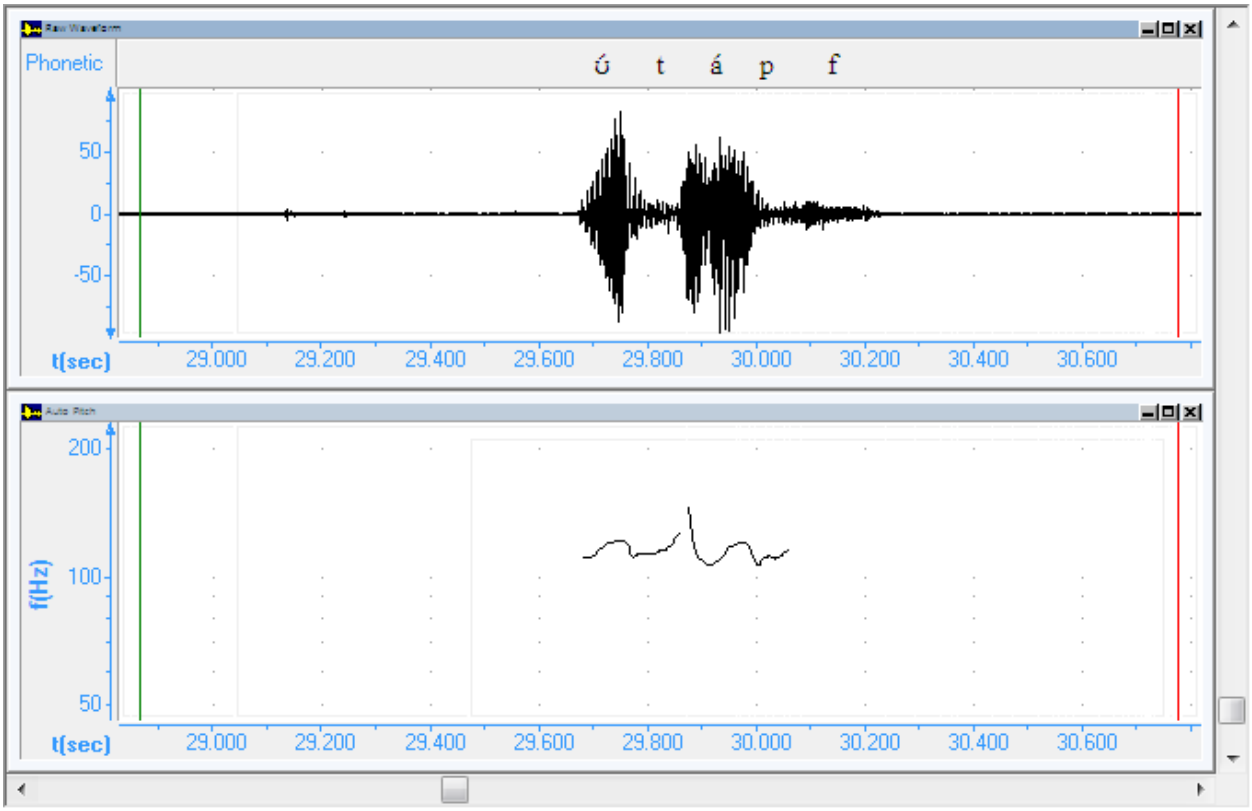

Fig. 9: A closed syllable in Ezaa dialect /tàpf/

In figures 3-7 above, we have spectrograms showing the occurrence of closed syllables in Ezaa dialect. The syllables /àʃ/ /bókh/ /tsar/ /madz/ /ˀgàʒ/ /ópf/ and /tàpf/ are closed. The wave forms indicate that there are no patterns (vertical striations) after the last consonants that suggest the presence of vowels. Note should be taken that the segment /ʃ/ in Figure 3 though a voiceless sound is voiced in this environment through voice assimilation from the two adjacent sounds /à/ and /b/. The wave forms therefore confirm the auditory perceptions.

3.4.3 Consonant Clusters in Ezaa Dialect

We present below spectrographic evidence of consonant clusters in Ezaa dialect.

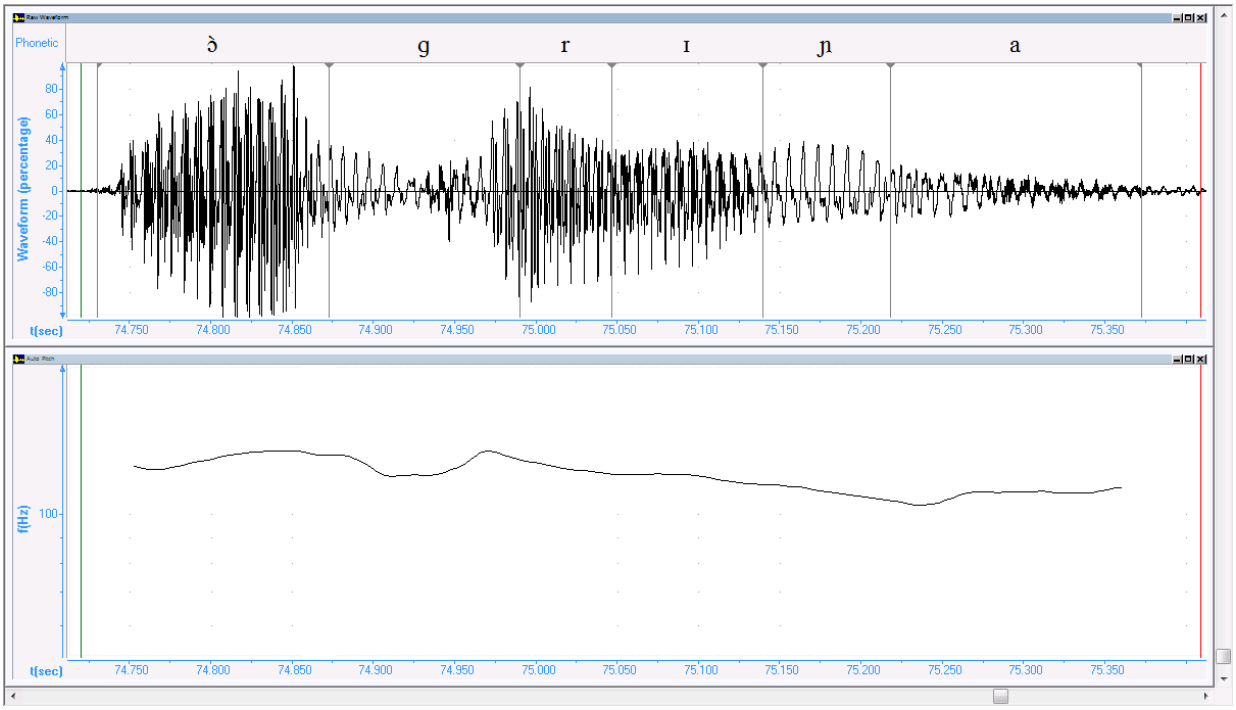

Fig. 10: Consonant clusters in Ezaa dialect /gr/

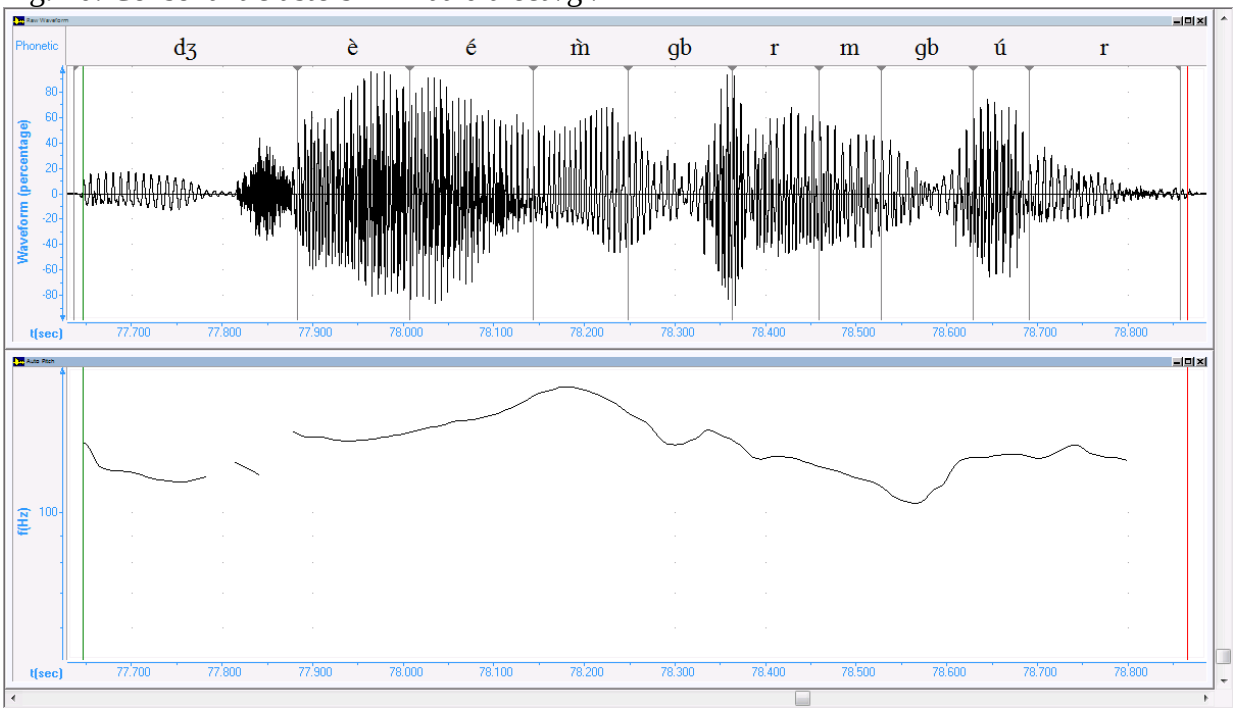

Fig. 11: Consonant clusters in Ezaa dialect /gbrm/

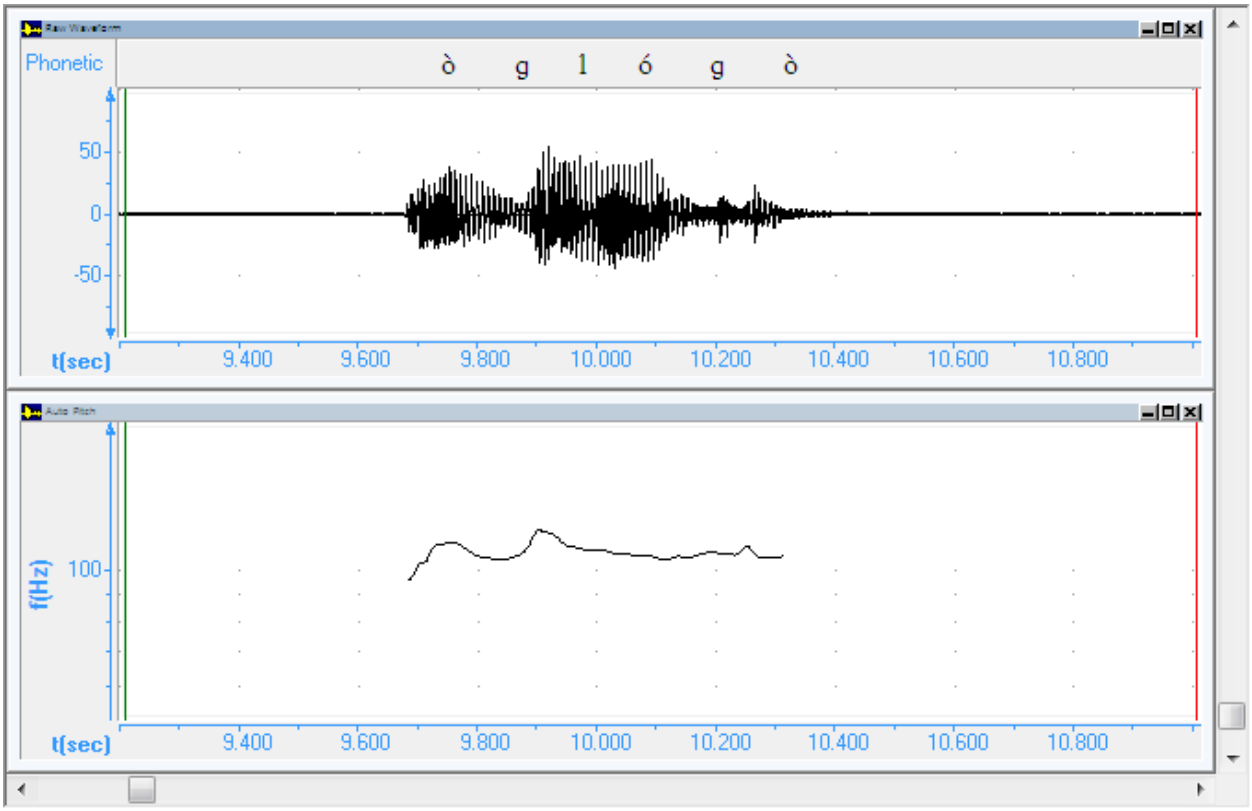

Fig. 12: A consonant cluster in Ezaa dialect /gl/

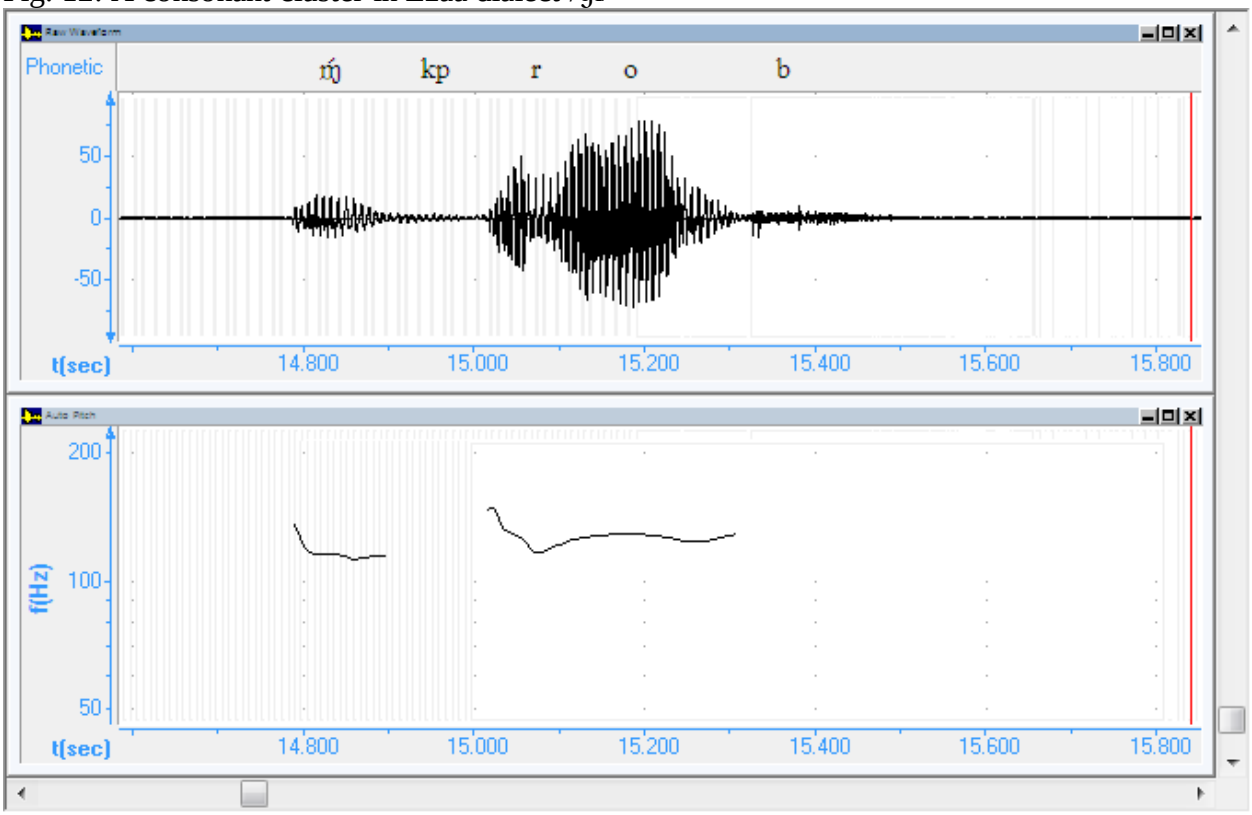

Fig. 13: A consonant cluster in Ezaa /kpr/

In figures 8-11 above, we present spectrograms showing consonant clusters in Ezaa dialect. The wave forms indicate that the consonants (/gr/ /gbr/ kpr and (/gl/) occur as clusters. Though there are also vertical striations in the wave form of voiced consonants (in this case plosives), they are not exactly the same. They are more prominent in vowels than in voiced consonants and trills or laterals and absent in voiceless consonants. It should be noted that the consonants involved in each case are mainly plosives and trills (/gr/ /gbr/ kpr) or marginally plosive and lateral (/gl/).

The occurrence of closed syllables in Izii and Ezaa dialects and consonant clusters in Ezaa may be attributed to an ongoing process of sound change in the Igbo language. A look at the classification of Igbo dialects by Nwaozuzu (2008) shows that there is a pattern of change that is taking place. The dialects of the West Niger Group, the North Eastern and the Northern Group of dialects (these are mostly at the geographical periphery of the Igbo heartland) all have nine to ten vowel systems. Each of these dialect groups also have features of vowel reduction where the schwa is used in place of the reduced vowel. On the other hand, the rest of the dialect Groups operate eight vowel systems with the vowels always fully realized. The case of the Izii and Ezaa dialects of the North Eastern dialect group could be seen as a case of lose of a reduced vowel especially when the occurrence is at syllable final position resulting in closed syllables as seen in Izii and Ezaa and consonant clusters in Ezaa. The case of this vowel lose in Ezaa is observed to be more common than in Izii because of the proximity of the speakers of Ezaa with the speakers of Koring, a language that is reported to have evidence of closed syllables. We therefore posit that the syllable structure of Izii and Ezaa dialects is a resultant factor of a language that is undergoing a structural change. A closer look at other related dialects of the Igbo language may well confirm this fact.

4.1 Summary

This work looks at the syllable structure of Izii and Ezaa dialects of Igbo to ascertain the extent to which the result of the perceptual analysis would be confirmed by the acoustic findings.
The general structure of the syllable across languages is presented with the syllable structure of the Standard Igbo as outlined in Emenanjo (1978). The uses and the necessity of the acoustic analysis of language data are also stressed with instances of acoustic analysis of different aspects of language presented.

The result of the auditory perception of Izii and Ezaa data as presented reveals that in addition to the occurrence of the syllable structure of the Standard Igbo, there are instances of syllables with onsets and codas in both Izii and Ezaa dialects. Furthermore, Ezaa dialect also has consonant clusters. The occurrence of vowel reduction in other related dialects of Igbo and the geographical proximity between Izii, Ezaa and the Koring language are suggested as explanation for the occurrence of codas in Izii and Ezaa and consonant clusters in Ezaa. The occurrence of these features is further confirmed by the instrumental analysis.

4.2 Conclusion

From our findings we conclude that, in spite of previous claims that the Igbo language has neither consonant clusters nor codas, there are both consonant clusters and codas in the Igbo dialects studied in this work. It is also pertinent to note that the Izii dialect has a syllable structure that is more similar to that of the Standard Igbo than the Ezaa dialect. Our assertion is based on the fact that Izii has fewer instances of closed syllables than Ezaa; Ezaa has more instances of closed syllables in addition to the occurrence of consonant clusters which are absent in Izii. However, we

conclude that Izii and Ezaa are dialects of Igbo language in spite of their unique features since they share many features with the Standard Igbo.

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ACOUSTIC ANALYSIS OF LATERAL IN AKEGBE-UGWU LECT

Ani, Esther Ngozi
Department of Linguistics, Igbo and Other Nigerian Languages, University of Nigeria, Nsukka
esther.ani.pg80850@unn.edu.ng

Abstract
This study explores the acoustic analysis of lateral in Akegbe-Ugwu lect. The aims are to: identify the acoustic features of lateral /l/ in Akegbe-Ugwu lect, examine the acoustic differences in the articulation of the lateral in Akegbe-Ugwu and investigate why the lateral is not commonly found in the lexical items of Akegbe-Ugwu lect. The method of data collection is oral interview; ten (10) respondents are interviewed with a digital audio recorder, while data is analysed acoustically using Praat. The results of this study show that: the phonetic environment of the lateral is influential in determining the quality and quantity or acoustic properties; thirty percent (30%) of the respondents realised /l/ by allowing the body of the tongue to interact between alveolar ridge thereby realising the lateral /l/ as rhotic /ɾ/ as a result of mother tongue influence and the reason why lateral /l/ is not commonly found in the lexical item of Akegbe-Ugwu lect is because, most of the lexical items where the phoneme lateral /l/ is found in standard Igbo are substituted with the phoneme /n/ - a voiced alveolar nasal in Akegbe-Ugwu which leads to dearth of lateral /l/. This study suggests that future research should endeavour to investigate the acoustic analysis of vowels and the acoustic analysis of liquids as well.

Introduction
In phonetics acoustics describes the intrinsic physical properties of speech sounds. The oscillation of these inherent properties of speech sounds begins from the mouth of the speaker to the ear of the receptor. It cannot be properly described by mere observation only but with an addition of the use of acoustic instruments and software like the computer, PRAAT and Palatograph. These instruments help to explore the intensity (loudness), pitch (length), duration (period), quality and frequency of the sounds of a language. It is because of instrument in the analysis of acoustics that is also known as instrumental analysis.

Acoustics was introduced in early twentieth century by Wallace Clement Sabine of Harvard University with the objective to measure reverberation (sound) period which is the time taken for sound of a specified standard intensity to expire until it becomes barely audible. Notwithstanding, the advances in acoustic phonetics is related to technological development, as such, acoustic phonetics is said to have begun with the invention of the sound spectrograph in the 1940s (see Bird and Harrington, 2001).

This study is an acoustic analysis of the lateral in Akegbe-Ugwu lect. Akegbe-Ugwu is made up six communities. It strives to use instrument to analyse the physical properties of lateral in Akegbe-Ugwu lect. Laterals just are produced when the tongue is positioned in such a way as to narrow its profile from side to side so that a greater degree of airstream is around one or both sides than over the centre of the airstream oscillates beside the regions of the tongue, but it is obstructed by the tongue from going through the middle of the mouth. In most cases, during the production of laterals, thetip of the tongue get in touch with the upper teeth as it is dental sound or the upper gum – the alveolar, although there are other likely areas contact could be made during the production lateral.

Over the years, literature show that not much has been done on laterals especially in the Akegbe-Ugwu lect or in the other lects under the Northern Igbo dialect cluster.This study intends to only consider the alveolar lateral approximant /l/ which is the most common lateral in Akegbe-Ugwu lect, without venturing into other types or variants of lateral like, velar /ɬ/ (dark l), fricative, affricative, flap and clicks. The objectives of this study are to: identify the acoustic features of lateral */l/* in Akegbe-Ugwu lect, examine the aacoustic differences in the articulation of lateral in Akegbe-Ugwu and investigate why lateral is not commonly found in the lexical items of Akegbe-Ugwu lect. The beneficiaries of this study include but not limited to: future researchers and speakers of Akegbe-Ugwu lect, at least it will reduce to an extent dearth of raw materials as it concerns the lect under study.

In the methodology, primary and secondary data are used, for the primary data, ten participants– five males and five females whose ages range from 18 to 74 years are interviewed with samples of four tokens. The token are recorded with the aid of a digital audio recorder and wave pad (an authenticated phone application used for sound recording). Then, the study draws from literatures of existing works as its secondary source. However, this study is an acoustic-based, so the spectrographic analysis is done in Praat (version 6.0 32-bit-en-win by Boersma and Weenink, 2017).

Laterals

Yusuf (2007: 43) opines that lateral approximants are produced when the central portion of the air is blocked by the tongue but the air passes by the sides of the blade of the tongue: /litɬ/ 'little', /laien/, 'lion'. Igbo: [ala] 'land', [ule] 'examination'. From the example given one can easily say that there are two variant of lateral: when it is at the word middle it is realised as /ɬ/ while at the word initial it is realised as /l/, that is why Clark, Yallop and Fletcher (2007) aver that the distinction between dark /l/ (also known as velarised or pharyngealised /l/) and light /l/ (also known as non-velarised or clear /l/) has long been observed, and the two variants have traditionally been classified as allophones of the same phoneme. Nevertheless, they are allophones of the same lateral approximant, their variation is necessitated by environment.

According to Kent and Read (2002) from an articulatory point of view, lateral sounds typically engage lingual contact along the mid-sagittal line of the vocal tract, with airflow around one or both sides of the tongue. However, the main articulatory differences between dark /l/ and light /l/ include increased tongue-root retraction and/or increased posterior tongue body for the dark realisation as observes by Narayanan, Alwan and Haker (1997) in Rodrigues *et al.* (2019).

Acoustic Phonetics

Harrington (2010:1) admits that "acoustic phonetics is emerged from three different disciplines: engineering/electronics, linguistics/phonology, and psychology/cognitive science respectively."Agbedo (2000:36) avers acoustic phonetics deals with "physical properties of speech sound, the nature of sound between mouth and ear. The sound we produce disturbs the air molecules nearest our mouth and thus displaces them. They in turn dislodge other molecules in a similar fashion and so on in chain reaction until the energy generated by the vocal organs dies away at a distance from the speaker." And we speak excessively without considering some acoustic properties like: frequency, duration, intensity, pitch, waveform and amplitude.

Frequency

Amjed (2016) states that the term fundamental frequency stands for the course of the lowest frequency in a harmonic vibration; therefore it is also called F0. Frequency is measured in Hertz

(Hz). Frequency is a technical term for an acoustic property of a sound –namely "the number of complete repetitions (cycles) of variations in air pressure occurring in a second the fundamental frequency is the lowest frequency of all other sinus components in a spectrum" (Ladefoged, 1975, 162).

Duration

Benward and Saker (2003) assert that in music duration is an amount of time or how long or short a note, phrase, section, or composition lasts. It is the length of time a pitch, or tone, is sounded. A note may last less than a second, while a symphony may last more than an hour. One of the fundamental features of rhythm, or encompassing rhythm, duration is also central to meter and musical form. In duration, release plays an important part in determining the timbre of a musical instrument and is affected by articulation. Duration is measures in minutes.

Intensity

Fahy (2017) says that sound intensity is the time averaged product of sound pressure and acoustic particle velocity. Both quantities can be directly measured by using a sound intensity p-u probe comprising a microphone and a particle velocity sensor, or estimated indirectly by using a p-p probe that approximates the particle velocity by integrating the pressure gradient between two closely spaced microphones. It is measured in decibel (dB).

Pitch

Pitch according to Klapuri (2006) is a perceptual property of sounds that allows their ordering on a frequency-related scale, or more commonly, pitch is the quality that makes it possible to judge sounds as "higher" and "lower" in the sense associated with musical melodies. It can be decided only in sounds that have a frequency that is lucid and established enough to differentiate from ordinary noise. Little wonder why Powers (2003) states that it is a major auditory attribute of musical tones, along with duration, loudness, and timbre

Waveform

Crecraft & Gorham (2002) and He, Li & Stoica (2002) contribute that the waveform of a signal is the shape of its graph as a function of time, independent of its time and magnitude scales and of any displacement in time. In acoustics, it is usually applied to steady periodic sounds- variations of pressure in air or other media. In these regard, the waveform is an element that is independent of the frequency, amplitude, or phase shift of the signal. It can also be used for non-periodic signals, like chirps and pulses.

Amplitude

Amjed (2016) also says that the amplitude of a wave refers to the maximum amount of displacement of a particle on the medium from its rest position. In a sense, the amplitude is the distance from (positives Maximum) position. Similarly, the amplitude can be measured from (negatives Maximum) position. The amplitude of a periodic variable is a measure of its change over a single period

Empirical studies

Ahn (2017) carries out a study on acoustic study of the word-final lateral approximant in Korea, with aim to examine the static and dynamic properties of the Korean lateral from a production study by measuring the duration, the three formants and the time-normalized trajectories. He

applies the coarticulatory effect and lexicality in data collection and Praat was since is an acoustic analysis based. As a result, he discovers that the duration of the lateral approximant in Korean is constant irrespective of the preceding vowel contexts and that the three formants of the lateral are severely influenced by the preceding contexts. The study concludes that the initial part of the lateral articulation share similar acoustic properties with the preceding vowels, but as the articulation continues, it becomes unaffected by the vowels.

Rodrigues, Martins, Silva and Jesus (2019) investigates the lateral /l/ velarisation as a continuum with aim to explore the controversial question about /l/ velarisation. The acoustic data were collected from ten EP speakers, producing trisyllabic words with paroxytone stress pattern, with the liquid consonant at the middle of the word in onset, complex onset and coda positions. The results of the study show that: /l/ is produced on a continuum in European Portuguese (EP). The consistent low F2 indicates that /l/ is velarised in all syllable positions, but variation especially in F1 and F3 revealed that /l/ could be "more velarised" or "less velarised" dependent on syllable positions and vowel contexts.

Data Presentation and Analysis

Here, we consider the inherent properties of a lateral; the lateral */l/* sound is realised in Akegbe-Ugwu lect by raising the tongue against the roof of the buccal cavity; subsequently, hindering the air stream at the centre of the mouth. The characteristic features are evident in articulation of /l/ either at the onset, medial or coda. For example, from the data, lateral occurs in *e**l**ochukwu*, ***l**ozoo*, *O**l**uchi*, and *u**l**u*.

Table 1: Acoustic Features of Lateral /l/

Token	**Duration**	**Pitch**	**Intensity**	**Format1**	**Format2**
Elochukwu	0.082	257.432	81.181	433.121	2201.708333
Lozoo	0.082	195.108	78.857	618.853	2168.478
Oluchi	0.08	262.31	80.08	615.815	2019.166667
Ulu	0.076	178.412	78.925	547.818	2263.543667

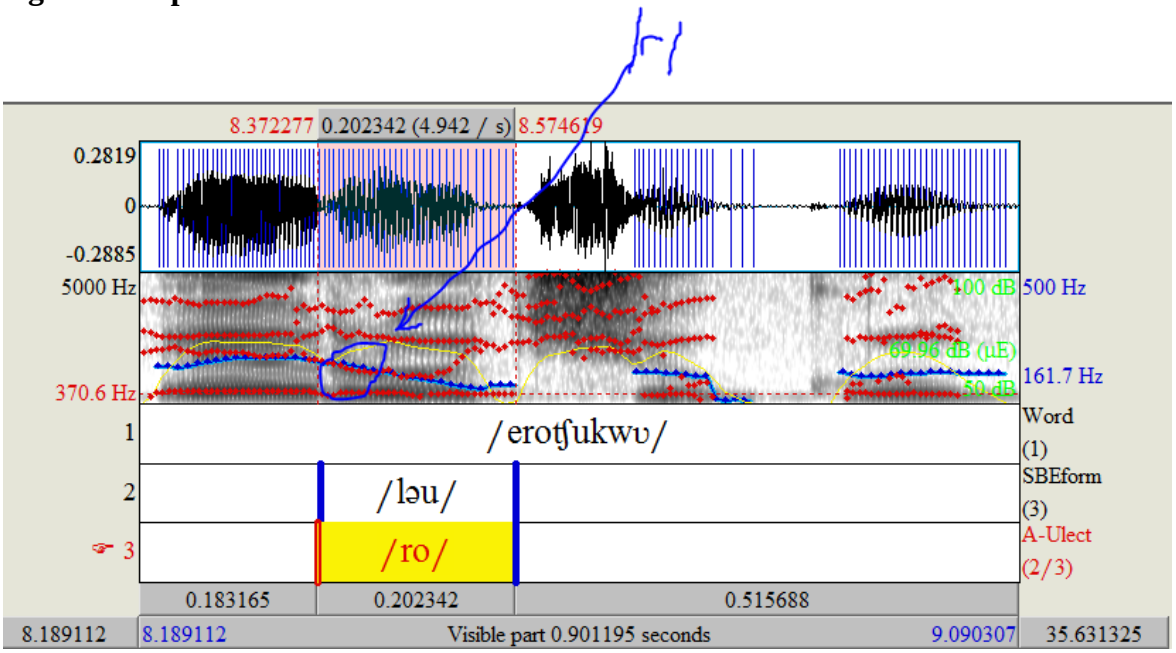
The above table x-rays the average acoustic features of lateral in the inherent tokens. It shows that acoustic properties of /l/ at word initial in ***l**ozoo* and similarly at syllable initial like *e**l**ochukwu*, *O**l**uchi*varied from /l/ at word medial in *u**l**u*. It implies that phonetic environment of lateral is influential in determining the quality and quantity – properties.

The Acoustic Differences in the Articulation of Lateral in Akegbe-Ugwu Lect

From the data, it was discovered that thirty percent (30%) of the respondents understudy realises /l/ by allowing the tongue to interact with the hard palate thereby realising the lateral /l/ as rhotic /ɾ/. This differentiation in articulation implies that some speakers Akegbe-Ugwu lect have variant

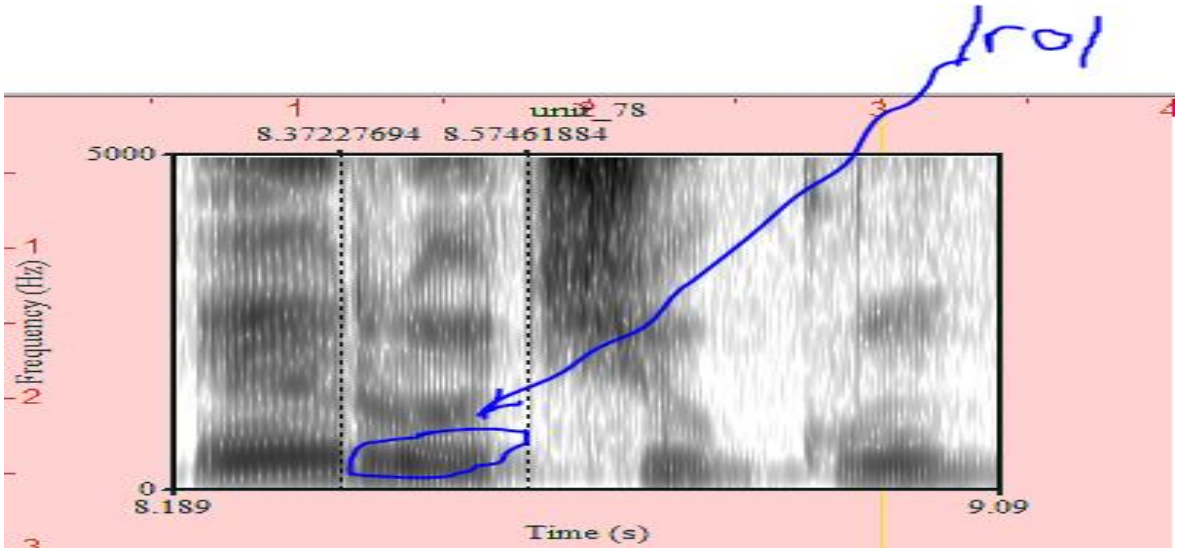
form of lateral from characteristic feature of lateral as rhotic /r/. This variance in articulation implies that Akegbe-Ugwu lect has a variant form of the lateral which has the characteristic feature of the lateral. Also, from the data, it is evident that three out of the ten respondents of Akegbe-Ugwu have varied articulations for lateral. However, the variant realisations do not deduce that this thirty percent of Akegbe-Ugwu have deficiency in the articulation of lateral, rather it could be what Sociolinguists perceive as variation. The respondents that belong to this category have greater influence of mother tongue interference. Analysis revealed that the thirty percent (30%) that used front of the tongue and hard palate as articulators for /l/ have substituted /l/ for /r/ because of mother tongue influence. It implies that they (30% percent of the respondents) were not conscious of phoneme properties of the /l/ and /r/. It therefore changes tokens like *Elochukwu*, *lozoo,Oluchi* and *ulu* to erochukwu, *rozoo,Oruchi* and *uru* which semantically hold no water.

Figure 1: Representative Praat Picture



In Fig. 1 above, the articulation of /l/ as /ɾ/ has 65dB (intensity) which considers consonant qualities and also the vowel feature for the sound has 205.9Hz (F0) while the duration was 19ms (duration). Both /l/ and /ɾ/ are vowel-like phonemes which have properties of consonant and vowel. The encircled portion describes the point of realisation of the phoneme /ɾ/ by thirty percent of the respondents who realised /l/ as /r/ for the articulation of *elochukwu* as *erochukwu.*

Figure 2: Spectrum slide



The encircled portion in Figure 2 above clearly proves that /ɾ/ that was substituted for /l/ for thirty percent (30%) of the respondents is vowel-like. For instance, there seems not to be any phonetic difference in the onset and offset phoneme for/ɾo/ because of the complexity in resonance of the two phonemes. Therefore, the vowel feature of offset phoneme (/o/) and the onset phoneme that is vowel-like make resonance complex as identified in the level of darkness presented on the spectrum slide (see Figure 2).

Why Lateral is not Commonly Found in Akegbe-Ugwu Lect

Form the data gathered in this study, we discover that there is serious shortage in the occurrence of the lateral phoneme /l/ in the lexical items of the dialect. The phonetic reason behind the linguistic gap or dearth of the lateral /l/, in the following token: *ulo – uno, lee – nee, ule – une, elu – enu or ala – ana;* is that, most of the lexical items where the phoneme lateral /l/ is found in standard Igbo are substituted with the phoneme /n/- a voiced alveolar nasal in Akegbe-Ugwu. This different realisationdoes not bring about any semantic difference rather it is just a phonetic difference from the standard Igbo, that is, a little deviation or variation.

Summary and Conclusion

In the acoustic properties of the lateral /l/ in Akegbe-ugwu lect, it is discovered that the phonetic environment is influential in determining the quality of /l/, looking at the acoustic properties in the following tokens: *elochukwu, lozoo, oluchi* and *ulu*. From the different articulations of the lateral /l/, the findings show that thirty percent (30%) of the respondents realised /l/ by allowing the tongue to interact with the alveolar ridge thereby realising the lateral /l/ as rhotic /ɾ/.This difference in these articulation implies that some speakers Akegbe-Ugwu lect have the variant form of the lateral which characteristically features as the rhotic /ɾ/ due to mother tongue influence. Finally, this study discovers that the reason why the lateral /l/ is not commonly found in the lexical item of Akegbe-Ugwu lect is because,most of the lexical items where the lateral /l/ phoneme is found in standard Igbo are substituted with the phoneme /n/ - a voiced alveolar nasal in Akegbe-Ugwu lect. This study fills the existing vacuum as it concerns the study of laterals specifically in Igbo and in many other languages of the world. The study identifies the acoustic properties/features of lateral, gives the different articulation of the phoneme lateral /l/ and explains why there is a dearth of the lateral in Akegbe-Ugwu lect. The study finally recommends that future research should conduct acoustic investigations into vowels and liquids in general.

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TONE IN ABANKALEKE IGBO: AN ACOUSTIC ANALYSIS

Obianika E. Chinwe

Ebonyi State University, Abakaliki, Nigeria
obianikac@gmail.com,chinweobianika@ebsu.edu.ng

Abstract
There have been speculations among scholars in the past on the reason for the perceptible difference in the tonal pattern of the Abankeleke Igbo. Prominent among these is that there is a feature of the upstep tone in this dialect group especially in Izii and Ezaa dialects that is absent in most other Igbo dialects. This paper therefore sets out to investigate the truth or otherwise of this claim in Izii and Ezaa dialects by analyzing the tone levels operational in these dialects and in the Standard Igbo and to compare them with those of the Standard Igbo. The data are collected through personal interview. Three respondents are randomly selected; one for Izii, Ezaa and Standard Igbo respectively. An adapted version of the Ibadan wordlist of 400 Basic Items was used and the data were recorded electronically. The data were transcribed and analyzed electronically using the Speech Tools Analyzer version 3, 0.1 and the Phonology Assistant version 2.2 software packages developed by the Summer Institute of Linguistics (SIL) International. The result of the perceptual analysis, which is confirmed by the instrumental analysis reveals that there is a feature of the high raising tone in Izii and Ezaa which is absent in most other Igbo dialects (among other factors) that contributes to the peculiar tonal phenomenon perceptible in the speech form of this dialect group.

Keywords: Acoustic analysis, Tone, Pitch, Dialect, Speech form

Introduction
Izii and Ezaa are two major dialects of the Northern/Wawa Dialect Cluster of the Igbo language according to Ikekeonwu (1986) classification. They are the most popular and most controversial of the other dialects of the cluster. They are controversial, (especially Izii) because some of the speakers believe that their speech form is another linguistic system other than Igbo. This is based on the early studies of the Izii by missionaries/scholars such as Meir and Meir (1964-1970) and Bendor Samuel (1975). However, this claim is not supported by more recent linguistic and historical findings by scholars including Ikekeonwu (1986), Ukpabi (2003), Udoh(2004), Anyanwu (2005), Nwaozuzu (2008) and Obianika (2012). Moreover, Ikekeonwu (1986) points out that the Izii dialect is of particular interest because of its tonal patterning. According to Ikekeonwu, the phonological phenomenon called the "upstep" is a feature of the Izii dialect which may have accounted for much of the perceptible difference between Izii and many other dialects of Igbo. It is against this backdrop that this study intends to find out the tonal patterning perceptible in the dialects of Izii and Ezaa and to inculcate the acoustic analysis so as to authenticate the perceptual findings. The research sets out to investigate the tone levels operational in Izii and Ezaa dialects of the Igbo language, using both the auditory and acoustic methods, with the view to finding out the particular tone levels, the range of the pitch at which each of the tone levels is realized for each of the dialects and the effect of specific consonants on the tone levels.

Acoustic Analysis, Pitch and Tone
Acoustic phonetics mainly has to do with speech reception, that is, what happens from the time speech leaves the mouth, goes through a medium (water, glass or air) to reach an object (the hearer).We cannot discuss acoustics in isolation without also bringing in speech perception. These two are so related that some speech perception researchers do not make clear distinctions between the two. What the listener perceives are a set of acoustic stimuli containing information ranging from relatively low to high frequencies at varying intensities. Sound perception is wholly concerned with the conversion of acoustic stimuli from sound pressure to units of meaningful speech units. Acoustic properties include frequency, intensity (acoustic measurement for loudness),

duration and phase. The use of instruments in acoustic investigations has been viewed as an indispensable aspect that the process is also referred to as instrumental phonetics. Acoustic Experimentation is therefore a system of investigation which involves the use of acoustic instruments in describing and analyzing language data.

Pitch is the extent to which a sound is high or low and it depends on the rate of vibration of the vocal cords. The tauter the vocal cords are, the faster they vibrate and the higher the pitch of the perceived sound (Katamba, 1989:186). The speed at which the vocal cords vibrate can be measured in terms of the number of times they complete cycles of opening and closing per hundredth millisecond. The unit is called fundamental frequency (f_o), which is also the rate at which the speech pressure waveforms repeat. Ladefoged (1982) and Ashby and Maidment (2005) agree that the rate of vibration of the vocal cords determines the F_o, as the higher the pitch, the higher the F_o and the higher the pitch perceived by the hearer. The unit of measurement for the F_o is the Hertz (Hz). It is not the absolute Hz values of a fundamental frequency contour that matters but the relative values because female speakers generally produce sounds with higher pitch than males. This is because typically, women have smaller larynx and shorter vocal cords than men (Ashby and Maidment, 2005:154).

Languages utilise pitch in different ways. Pitch may mark words in tone languages or categories higher than the word such as sentences, clauses et cetera. In such a case, the language is said to be an intonation language. In intonation languages, pitch may also perform other functions such as accentuation (allocation of primary stress to the most salient syllable of a word) and syntactic functions. It could also be used to convey attitudinal meanings and structure discourse (Uguru, 2006). On the other hand, pitch may function mainly on the domain of the syllable. Within the lexicon, every syllable is marked for a relative contrastive pitch height. Such a language is said to be a tone language.
Pike (1948) defines a tone language as a language having a lexically significant, contrastive but relative pitch on each syllable. Goldsmith (1982:49) opines that in a tone language, the lexical entry present in a given structure includes (or, conceivably consists simply of) complete tonal melody….." a tone language is that which utilizes tone as a necessary and integral part of every syllable which makes for differences in meaning and marks grammatical distinctions between otherwise identical constructions.

Welmers (1959:2) suggests that Pike's (1948) definition may be too strong. He therefore proposes that the definition be modified thus: "a tone language is a language in which both pitch phonemes and segmental phonemes enter into the composition of at least some morphemes". The need for the amendment of Pike's definition becomes apparent when we consider the fact that some morphemes in tone languages 'lack a pitch phoneme (tone), while other such morphemes may consist solely of a tone (with no segment)'. However, Hyman (1975) points out that in tone languages sometimes, there are restrictions on the occurrence of tones. These restrictions can either be phonological or grammatical and because of these restrictions, there will be redundancy in the distribution of tone.

Yip (2007) quoting Hyman (2001) defines a tone language as one in which an indication of pitch enters into lexical realization of at least some morphemes. With this definition of Hyman, is the motive to also capture accentual languages such as Japanese or Lithuanian (Blevins 1993 and Welmers 1973) as a sub-type of tone language in which words have one tone (or several) or no

tones, and the tone is associated with a particular syllable or Mora. Tone languages are of two types: the contour tone languages and register tone languages. The classical definition of tone language by Pike (1948) and echoed by Katamba (1989), Nwachukwu (1995), Uguru (2006) and Mbah and Mbah (2010) have it that contour tone languages are languages which involve the changing state of the transition from one pitch to the other in their description of tone. Hulst and Smith (1982) point out that the level tone languages recognize only the points at which the pitch is either raised or lowered. These levels range from high through mid to low. The intervals between these pitches are assumed to be automatic and so of little significance.

The above stance gives the false impression that there is an exclusive dichotomy between level tone languages and contour tone languages: that contour tones do not occur in level tone languages and vice versa. In practical terms though, instances of contour tone may be observed in level tone languages and vice versa. In addition to Welmer's (1959) contribution, Mazaudon (1973) in Hyman (1975) studies Tamang, one of the languages of Nepal and comes up with the fact that of the four contrastive tones of Tamang, there is not always a perfect one-to-one correspondence in pitch between a given tone on a monosyllabic versus a disyllabic word. For instance, tone 4 is realized as an L tone in a monosyllabic word where it usually falls on utterance final position while on two syllables it is realized as a L followed by a falling tone from H to M, that is L-HM. In her argument, it is not possible to assign an individual tone to each syllable, recognize a two-way tonal contrast with a moveable accent, or to assign tone only to the first syllable of each word through a phonological rule or a rule spreading each tone over a word. According to Mazaudon, either of these approaches would fail in one way or the other.

Furthermore, while it is possible to classify tone languages into register and contour tone languages, it is not the case that register tone languages lack contour tones as mentioned earlier. Hyman (1975:217) points out that such languages (register tone languages) frequently have rules of tonal assimilation ("spreading" rules) by which falling and rising tones are derived. Register tone languages may also have contour tones as a result of two morphemes coming together. In the Igbo language, examples in 1 below illustrate this point:

Example 1:

ụtụ́tụ̀ → ụụ́tụ̀ → ụ̌tụ̀ "morning"

àgbọ́ghọ̀ → àgbọ́ọ̀ → àgbộ̀ "young girl"

In the example above, first, consonant deletion takes place then vowel elision occurs. These processes result in a floating tone which gets associated to the initial vowel. The output is a rising glide. Foràgbọ́ghọ̀ also, the consonant 'gh' /ɣ/ is deleted followed by the elision of 'o' /ɔ/. The tone on the vowel is left floating and is then associated to the final vowel resulting in a falling glide.

Some Igbo language scholars such as Emenanjo (1978) and Mbah and Mbah (2010) uphold the view that Igbo language has two basic tones; high and low plus a downstepped high which is regarded as a grammatical tone. However in more recent works, the downstep tone in Igbo has been shown to perform lexical functions indicating that it is an independent tone.

The following examples in Williamson (1986) are from Onitsha dialect of Igbo:

Example 2:

HH	**HS**
álụ́ "a bite"	á↓lụ "abomination"
ámá "open place"	á↓ma "mark, sign' street"
ńgó "reward, pay"	ń↓go "upper part"

ńné "mother" ń↓ne "many, plenty"
ọ́dụ́ "advice/warning" ọ́↓du ̩ "pestle"

The above data further confirms the fact presented by Mbah and Mbah (2010) that dowstepped high tone in Igbo is not just a grammatical tone but also an inherent tone for some words generated at the base component. In addition to Williamson's (1986) examples one could cite other examples where the downstep contrasts with low tone in some lexical items.
Example 3:

ọ́↓dụ "pestle"	ọ́dù "tail/market stall"
é↓lo "mushroom"	élò "suggestion/advice"
e↓zu "lake (Agulu Lake)"	ézù "to meet"

These examples are from Aguata dialect of the Igbo language and further clarify the claim that downstep is an independent tone in Igbo and not just a grammatical tone.
In another related work, Okorji (2002) examines the Inland West Igbo dialects with a view to finding out their phonological and prosodic similarities and dissimilarities. Six dialects are selected to represent the dialect cluster. These are Umuchu, Ekwuluọbịa, Ọka, Enugwuukwu, Ọraukwu and Enuọnịcha dialects. Only the tonal aspect of her analysis is of major interest to this present work. She examines the tonal interaction in segments, words, phrases and sentences and finds out that the high and low tones are basic tones in Inland West Igbo dialects while the down step, the high –falling glide, the low-rising glide and upstep are non-basic. Furthermore, she discovers that there is a direct link between syllable and tonology in the dialect cluster and that downdrift and downstep are applicable to all the representative dialects while upstep obtains only in Aguata-Amaiyi dialect representatives.
Having discussed tone in languages in general and particularly in the Igbo language and its features in some dialects of the Igbo language, let us now see the tone levels that are operational in the dialects under study; Izii and Ezaa dialects.

Methodology

The study will combine both perceptual and acoustic methods of analysis in this study. The sampling technique used is random sampling. The data for this study is gathered from the Izii and Ezaa dialects of the Northern/Waawa group of Igbo dialects according to Ikekeonwu (1986) classification. Izii and Ezaa dialects are chosen because they are the most controversial and the most popular of the dialects of the Northern group of dialects of the Igbo language. These two dialects are spoken in Ebonyi State in the South Eastern part of Nigeria. Izii is spoken mainly in Ebonyi, Izii and Abakaliki Local Government Areas while the majority of Ezaa speakers live in Ezaa North and Ezaa South Local Government Areas. However, there are Ezaa speaking communities in Edda, Ohaukwu, Ishielu and Ivo Local Government Areas. Two adults who are L_1 speakers of Izii and Ezaa respectively are sampled. Structured personal interview is adopted to elicit three tokens of each word from the three respondents. One hundred and fifty words of basic items adapted from the Ibadan 400 Basic items wordlist are used and the data arerecorded electronically. The data analysis is carried out with the Speech Tools Analyzer version 3, 0.1 (1996-2007) and Phonology Assistant version 2.2 (1995-2005) software packages developed by the Summer Institute of Linguistics (SIL) International. These are used in recording, transcribing and in the acoustic analysis of the data.

Tone in Izii and Ezaa Dialects

Tone levels perceptible in the two dialects are outlined in the following section. First, the Izii tonal system will be presented followed by that of Ezaa.

Tonemes of Izii Dialect

The Izii dialect has the high, the low and the downstep tones just as it is in the Standard Igbo. In addition to these,the high raising tone is observed in the Izii dialect. It is a level tone that occurs in languages. While the upstep occurs after high tones, the high raising occurs after low tones and is usually a feature of tonal dissimilation. In the Izii dialect, it occurs between two low tones and also occurs as a result of dissimilation and so is not phonemic in the Izii dialect. The examples are as follows;

Example 4:

a. /ìgbéríì/ "guinea corn"
b. /àʃimókù/ "groundnut"
c. /ḿkpúrù/ "room"
d. /ɛ́ɟʷéàa/ "guest/stranger"
e. /èkǿtàra/ "right (side)"
f. /ɛ̀kícà "left"
g. /rìáɔ̀rìrì/ "cry"

The examples of the other tones are presented below as they occur in the Izii dialect;

Table 1: Izii Dialect Tonemes

High Tone	Low Tone	DownStep	High Raising
/oʃɔ́ka/ "arm" /ɛ̀gbúʃɪ/"hair" /ìtɔkʊ/ "cookingpot" /ŋ́tʊ/ "ashes" /ótá/ "bow"	/àgba/ "jaw" /ɪgbàkpɔ/ pepper" /ɛ̀gbʊdʊ/ "bush" /àlɪ/ "earth" /òkpu/ "cap/hat"	/ɔ̀kwo↓ɦe/ "grinding stone" /útú↓te/ "mat" /ɔ̀kpɔ́↓kɔ́/ "compound"	/àʃimókù/ "groundnut" /ḿkpúrù/ "room" /ɛ̀ɟʷéàa/ "guest" /èkǿtàra/ "right" /ɛ̀kícà/ "left"

Tonemes of Ezaa Dialect

Ezaa dialect has the high, the low and the down step tones as they occur in the Standard Igbo. In addition to these, the high raising tone is also observed in the Ezaa dialect and is exemplified below**;**

Example 5:

/ìgbéri/ "guinea corn"
/àkáhò / "old"
/ɛ̀kǿtàr/ "right (side)"
/ɛ̀kíca/ "left"

The other tones that are mentioned above as observed in the Ezaa dialect are presented in the following table.

Table 2: Tonemes of Ezaa Dialect

High Tone	Low Tone	DownStep	High Raising

/ə́ka/ "hand" /ʃíi/ "small" /ŋ̀wɦɔkh/ "crab" /úhwu/ "village" /ɔnó/ "mouth"	/ɔgraŋà/ "old person" /ɔ̀gaʒ/ "guineafowl" /ìβɛ/ "ashes" /èdʒ/ "bad"	/méé/ "blood" /mgbɛeŋá/ "sleep" /ɛ́whʊrʊogwihwé/ "grinding stone"	/ìgbéri/ ""guinea corn /àkáhɔ̀/ "old" /èkǫ́tàr/ "right(side)" /èkítʃa/ "left"

Also in Ezaa dialect, we observe the existence of gliding tones. Basically, there are rising glides and marginally falling glides. The examples are as follows:

Gliding Tones in Ezaa

Table 3: Gliding Tones in Ezaa Dialect

Rising Glide Rising Glide	**Falling Glide**
/ɛ̌hwà/ "name" /ědʒ/ "snail" /íʃìŏts/"dawn" /ěwv/ "fear" /ɔ̌kpà/ "leg"	/ŋwêtʃa/ "dog" /akahwɔ̀/ "old"

In the above data, only the two examples /íʃìŏts/ and /ŋwêtʃa/ could be explained as occurring as a result of elision. /íʃìŏts/ 'dawn' may have occurred as a result of intersegmental coordination in the pronunciation of the two words /ísí/ and /ɔ̀tsɔ́tsɔ̀/ after the deletion of the first /ts/ and the elision of the first /ɔ/. The high tone which is left floating now attaches to the next vowel. The last vowel /ɔ̀/ does not surface because the dialect allows closed syllables. The example on falling glide is very marginal in the dialect and could be explained as a product of assimilation process. The two words 'nwá' and 'èchà' when pronounced as one word are realized as 'nwêchà'/ŋwêtʃà/ as the last vowel of the initial word is elided and its tone which is left floating is now associated to the following vowel (the initial vowel of the second word). The result is a falling glide on the vowel /ê/.

Spectrographic Evidence of High Raising Tone in Izii and Ezaa Dialects

In this section, we present the spectrographic evidence of the high raising tone in Izii and Ezaa dialects. First, that of Izii will be presented followed by that of Ezaa and finally the gliding tones in Ezaa dialect.

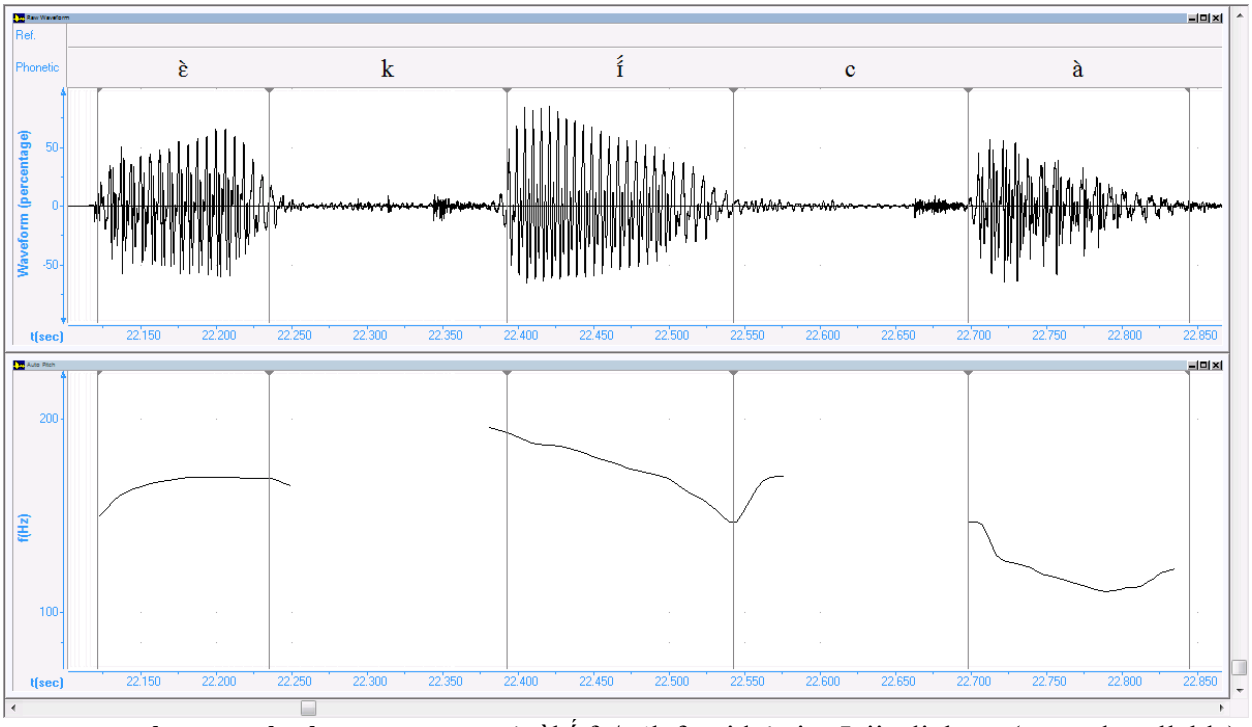

Figure 1 showing high raising tone/ èkǵtʃa/ 'left side' in Izii dialect (second syllable).

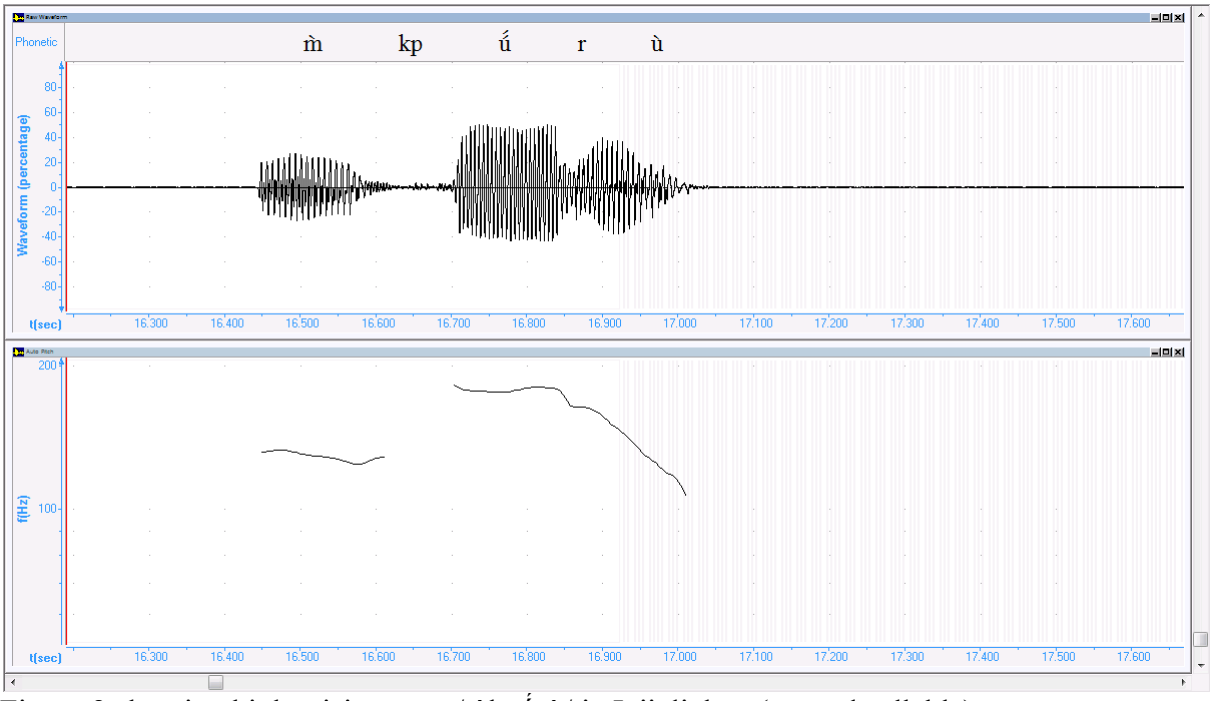

Figure 2 showing high raising tone /m̀kpú̇rù/ in Izii dialect (second syllable)

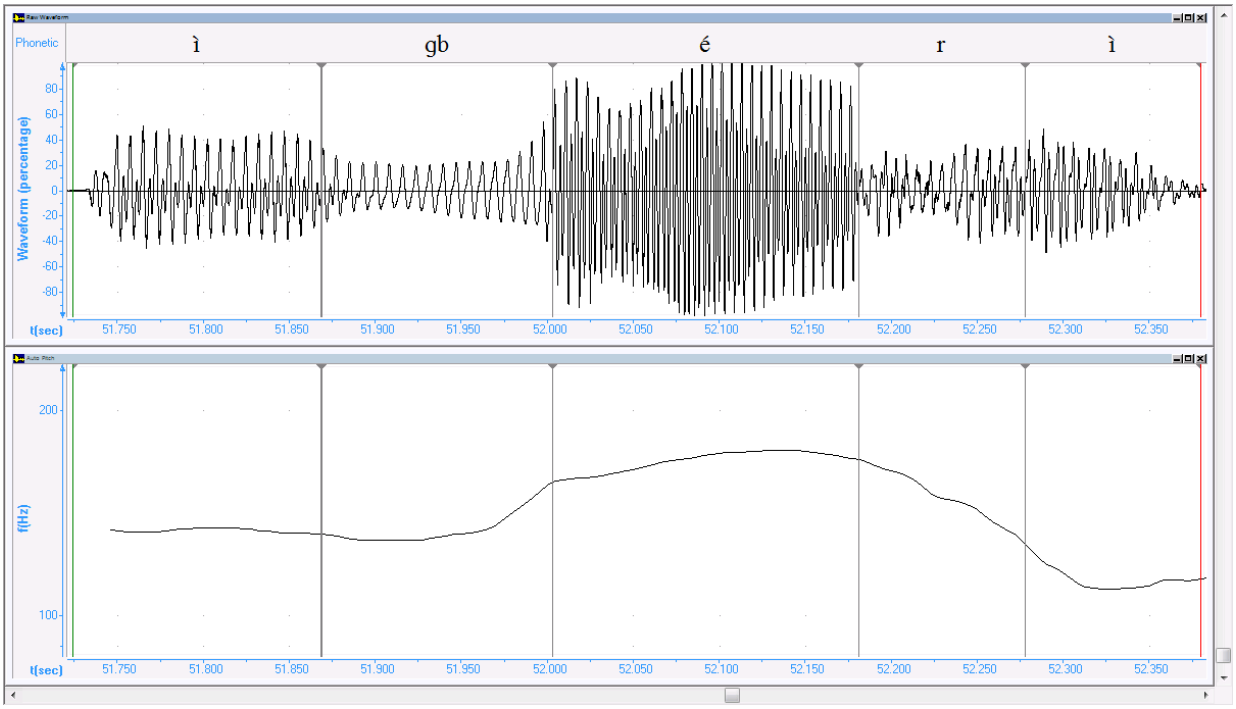

Figure 3 showing high raising tone/ìgbéri/in Izii dialect(second syllable).

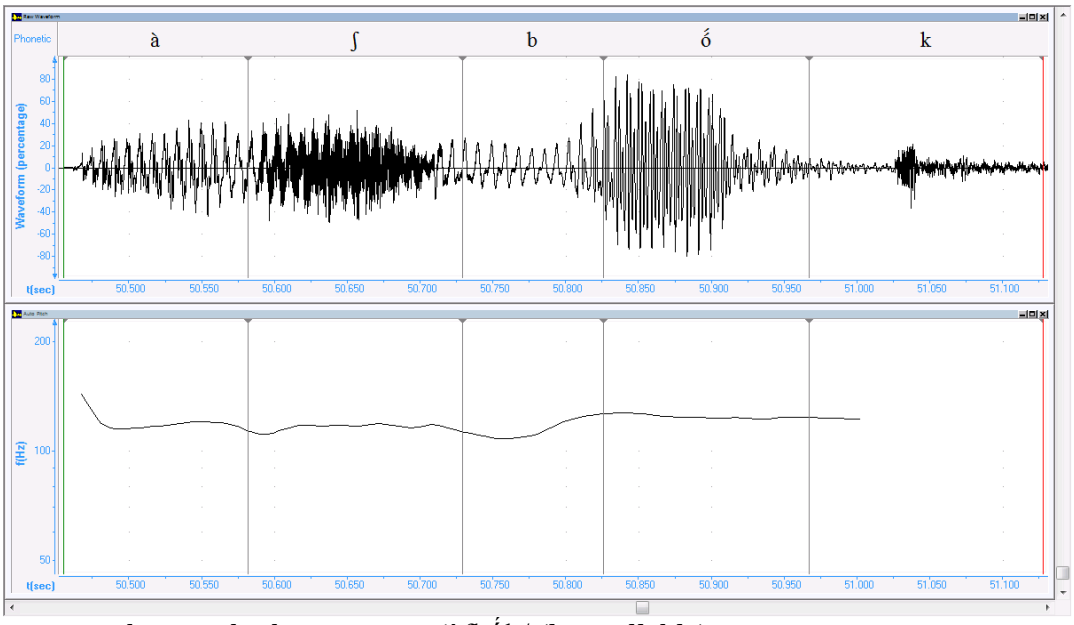

Figure 4 showing high raisig tone /àʃbǿk/ (last syllable)

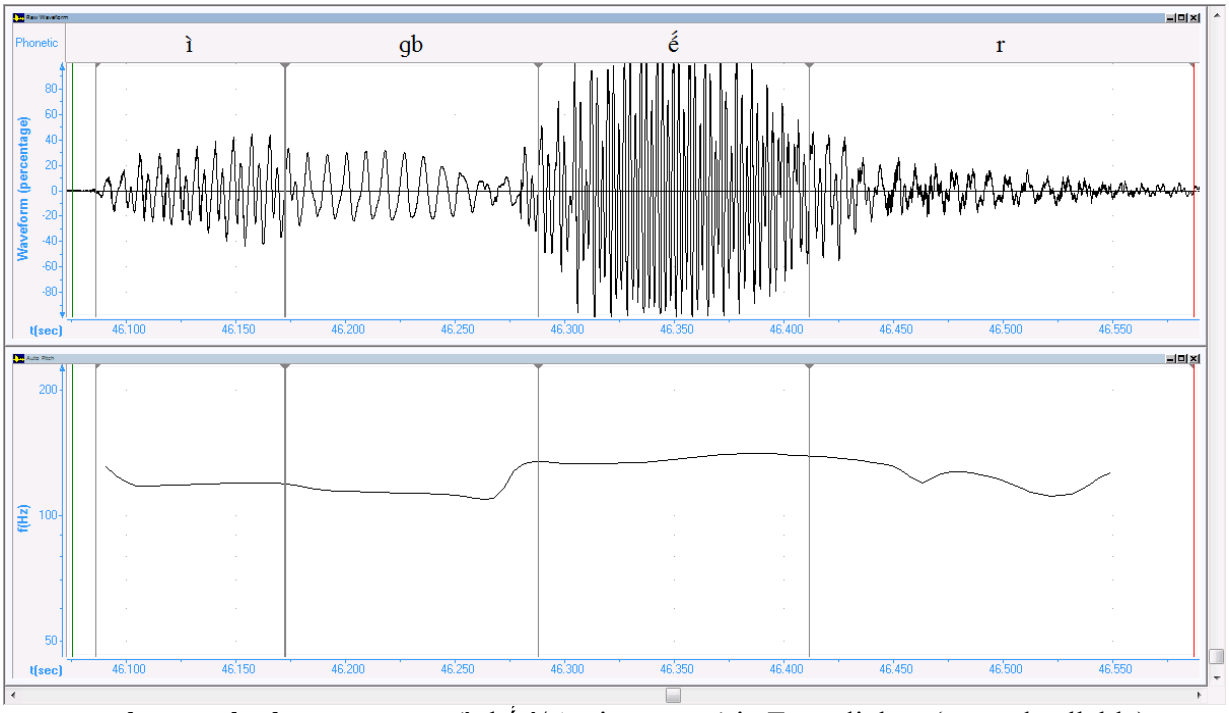

Figure 5 showing high raising tone /ìgbérì/ 'guinea corn' in Ezaa dialect (second syllable)

In figures 1-5, we see that the pitch levels of the second syllables which are following low tones should have been a bit lowered ordinarilly as high tones following low tones are known to have lowered pitches induced by the preceeding low tone but this is not the case. Given the fact that velar plosives are known to raise the pitch of vowels following them, it should be noted that it is not all the syllables that bear the high raising tone that follow velar plosives. Figure 6 is an example in both Izii and Ezaa dialects. The pitch is rather raised to between 15-20Hz, an unusual hieght for a high tone following a low tone. The usual pitch range of high tones following lows is about 10hz. The indication is that the tone is a high raising tone and not just a high tone. The high raising tone is known to follow a low tone unlike the upstep which follows a high tone. However, the high raising tone is not observed to be phonemic in the Izii dialect.

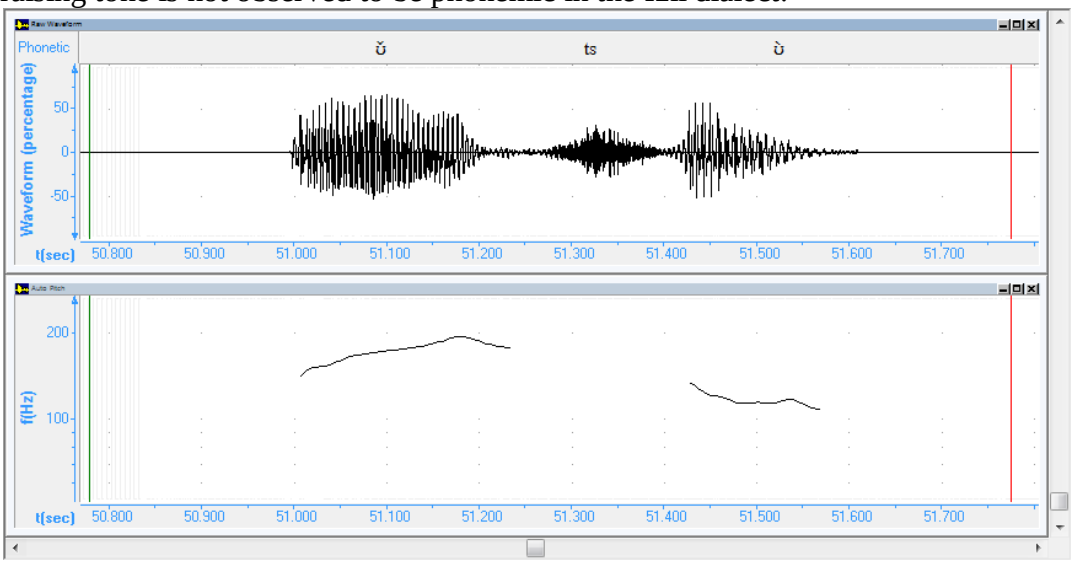

Figure 6: Low rising glide in Izii dialect

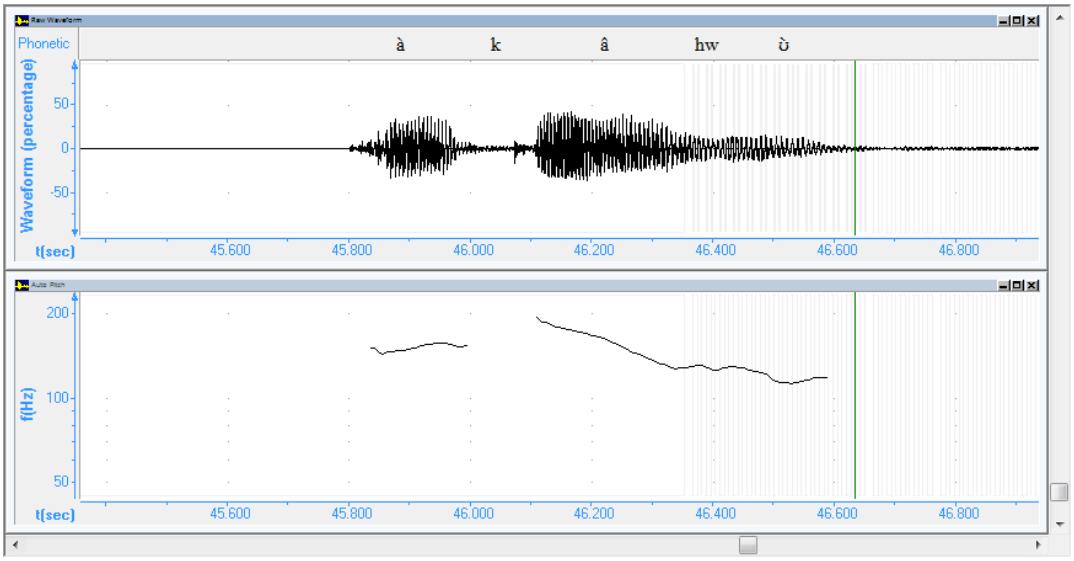

Figure 7 High falling glide in Izii dialect

In figures 6 and 7 above, we observe that the glides could be explained to occur as a result of phonological processes of elision and deletion as explained in 3.3 above.

Pitch Levels of Tone in Specific Linguistic Items

We shall look at nouns in the dialects and in SI to observe the pitch levels and compare how they vary in Izii, Ezaa and the SI. The data selected are those which are cognates in at least two varieties. The pitch level indicated in each word is the syllabic element with the highest pitch and is underlined.

Table 4: Tone and Pitch Levels in Specific Linguistic Items in Izii, Ezaa and the Standard Igbo

Izii	F_o	**Ezaa**	F_0	**SI**	F_o	**Gloss**
1. /íʃi/	170 hz	/íʃi̲/	140hz	/ísi̲/	150hz	"head"
2./ ɛ́ŋa̲/	155hz	/ɛ́ŋa̲/	130hz	/áŋá/	148hz	"eye"
3./n̲tʃì/	198hz	/n̲tʃ/	160hz	/n̲tì/	170hz	"ear"
4./ɛ́z↓e/	160hz	/ɛ́z↓e/	130hz	/ɛ́z↓e/	155hz	"teeth"
5/ótù̲bò	199hz	/otù̲bò/	170hz	/ótù̲bò/	150hz	"navel"
6./mv́ɔ/	197hz	/mvɔ/	120hz	/m̲bɔ/	155hz	"nail(finger/toe)"
7./íkpɛ̀re/	200hz	/íkpɛ̀re/	170hz	/íkpɛ̀re/	180hz	"knee"
8./óoʃi̲/	165hz	/óʃi̲vur uevʊr/	155hz	/úkwùósi̲si	165hz	"tree"
9./ɔ́bà/	160hz	/íʃiɔ̲bà/	170hz	/ɔ́bà/	150hz	"calabash"
10/ɔ́gɔ̀/	180hz	/ɔ́g/	145hz	/ɔ́gɔ̀/	160hz	"hoe"
11/ótá/	170hz	/ótá/	120hz	/ótá/	165hz	"bow"
12/áʃʷa̲/	160hz	/áfwa̲/	140hz	/áhia̲/	155hz	"market"
13/ɛ̀gbʊ̲dʊ/	145hz	/ɔ́fwɪa̲/	165hz	/ɔ́hɪa̲/	160hz	"bush"

14/úbvu/	160hz	/útvu̲/	155hz	/úgwu̲/	155hz	"mountain"
15/à̲lı/	145hz	/ɛ́dʒ↓a̲/	150hz	/à̲nı/	135hz	"earth(soil)"
16/épù̲tʃı/	187hz	/ɛ́kpɔ̲tɔ/	195hz	/ápì̲tı/	160hz	"mud"
17/iku̲ku	150hz	/ìku̲k/	165hz	/ìku̲ku/	130hz	"wind"
18/é̲bvò	192hz	/ě̲wv/	180hz	/é̲gwù/	170hz	"fear"
19/ŋ́ʃ̲ì/	170hz	/ɔ̲́v/	195hz	/ɔ̲́gwò/	180hz	medicine(charm)

In the examples in Table 4 above, all the cognate linguistic items have similar tone patterns. Even in a few cases where the word for one item is not a cognate in one of the varieties, the tone pattern is the same: /épù̲tʃı/ (Izii), /ɛ́kpɔ̲̀tɔ/ (Ezaa) and /á̲pìtı/ (SI) (e.g.16). The same goes for e.gs.12 and 14. For e.g.18, the tone pattern for 'fear' in Izii and SI are the same (HL) but in Ezaa, it is a rising glide. Also, e.g.15 has the word as cognates for Izii and SI but a different word and tone pattern for Ezaa. In e.gs.13 and 19, the words are different in the three varieties and the tone patterns are also different. In all, for the examples given, 14 lexical items are cognates in the three varieties, 2 are different words (e.gs.8 and 16) but the same tone pattern in the three varieties, 5 items are different words for Izii and Ezaa. Five of the words are different in Izii and SI while four are differ in Izii and SI. A total of five words are different in Ezaa and SI. Other words that are not cognates have different tone patterns.

Variation in Pitch Levels

The average of the three recorded tokens is presented here. The range of pitch levels in the varieties is not the same. In Izii dialect, the highest pitch level reached is 200 Hz (e.g. 7) and the lowest is 145 Hz (e.g. 13 or 14). For Ezaa, the highest pitch is 195 Hz (e.g.16) and the lowest is 120 Hz (e.gs.6 and11). In SI, the highest pitch recorded is 180 Hz (e.g. 7) and the lowest is 130 Hz (e.g. 17). Generally, the pitch range for low tone in word initial position for the three varieties is between 150-140 Hz for medial position is 200-145 hz and for final position is 140-120 Hz.

It is of interest to note that the highest pitch recorded for Izii and Ezaa dialects are for low tones and that they come after the voiceless labio-velar plosive /kp/ though in different words. This shows that absolute pitch may not be relevant in delineation of level tones in tone languages. Another fact here is that consonants do have effect on the pitch levels of the vowels with which they occur. In this case, the pitch is raised where there should have been a pitch lowering (that is, lower than the preceding high tone) considering the fact that the low tone is following a high tone in this environment.

Effect of Consonants on the F_0 of Tone

Selected words are analyzed below to determine the level of influence exerted on the fundamental pitch levels at which tones are realized and the role of adjacent segments in determining the pitch levels. We observe that in general, when a vowel follows a consonant (especially voiceless plosives) the vowel starts with high pitch then drops to the normal level but because tone levels are not determined by absolute pitch, the perception of the tone level of the syllable is not affected.

For example, the word /ótù̲bo/ (navel) Table 4 e.g. 5) in the three varieties starts with a high tone but we discover that the second syllable starts with the voiceless alveolar plosive /t/ and influences the low toned /ù/ to start with the highest pitch in the word recorded for the three varieties: Izii 199 Hz, Ezaa 170 Hz and SI 150 Hz. Other examples are e.gs. 7, 12, 14, 16, (Izii) e.gs. 12, 13, and 17(Ezaa). For SI we have e.g. 11, 12 and 13 on Table 14.

It is of interest to note that the highest pitch recorded for Izii and Ezaa dialects are for low tones and that they come after the voiceless labio-velar plosive /kp/ though in different words. This shows that absolute pitch may not be relevant in delineation of level tones in tone languages. Another fact here is that consonants do have effect on the pitch levels of the vowels with which they occur. In this case, the pitch is raised where there should have been a pitch lowering (that is, lower than the preceding high tone) considering the fact that the low tone is following a high tone in this environment.The spectrogram below is a further illustration of this fact. The example is from the Ezaa dialect.

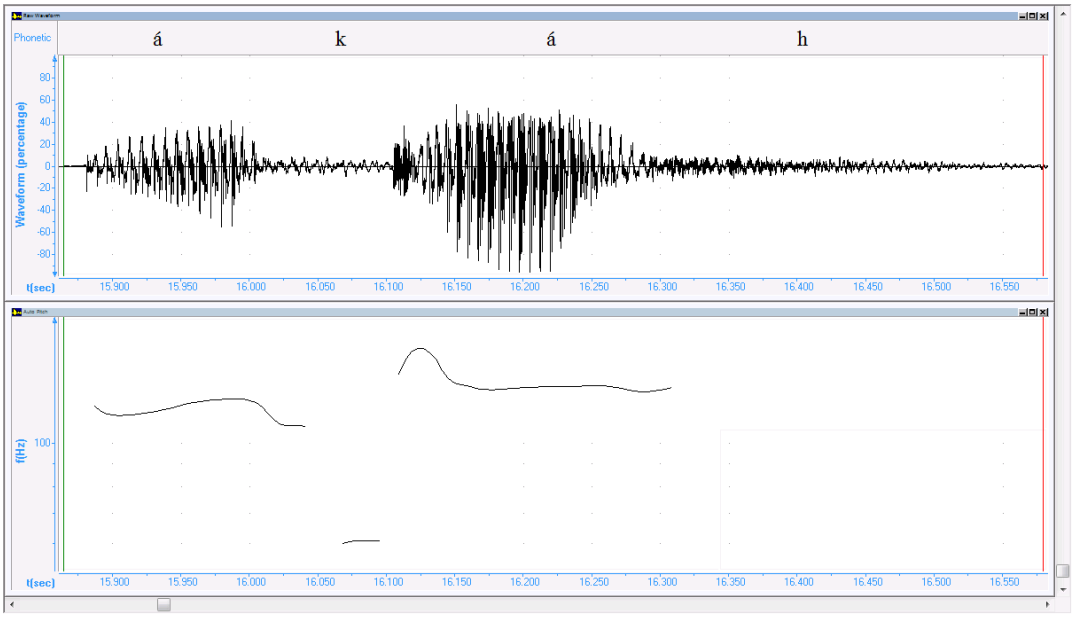

Figure 8: Ezaa data showing effect of [k] on the pitch of the following vowel [a] in the word /àkáh/

In figure 8 above, we notice that the two syllables are high toned but the second syllable which should have been lower than the first in pitch because of the effect of downdrift is higher by at least 30Hz because of the influence of the preceding voiceless velar plosive /k/.

Implications to Research

In the literature, there have been speculations on the reason for the perceived peculiarity in the speech form of the Abankaleke Igbo. Prominent among these is the suspicion that the peculiarity is due to the occurrence of upstep tone in these dialects. By this research, it is now cleared that this feature is not observable in these dialects especially at the lexical level in Izii and Ezaa dialects.

Conclusion

From the discussions above, we conclude that the tone levels operational in the Izii and Ezaa dialects of the Igbo language are the high, low, downstep and the glides (rising and falling glides) and that though the high raising tone occurs in these dialects that it is not phonemic as evidenced from our data in both the perceptual and acoustic analyses. Furthermore, we conclude by inference that the upstep is not obtainable in these dialects at least at the lexical level since it is not observed in our data. Also, the pitch range for the different tone levels in the dialects are recorded as follows; for Izii dialect, the highest pitch level reached is 200 Hz (e.g. 7) and the lowest is 145 Hz (e.g. 13 or 14). For Ezaa, the highest pitch recorded is 195 Hz (e.g.16) and the lowest is 120 Hz (e.gs.6 and11). In SI, the highest pitch recorded is 180 Hz (e.g. 7) and the lowest is 130 Hz (e.g. 17).

Generally, the pitch range for low tone in word initial position for the three varieties is between 150-140 Hz for medial position is 200-145 Hz and for final position is 140-120 Hz.Finally, we conclude that in line with what is obtainable in the literature that the pitch of tone on vowels following voiceless consonants especially when aspirated is usually raised. This is exemplified in e.gs. 7, 11, 12, 13 and 16 in Table 4 for the three varieties and in figures 6 and 7.

Future Research

In as much as this work studied the tone levels obtainable in the Abankaleke dialects, it focuses on the lexical level. Moreover, as the suspected source of the peculiarity of the speech form is not observed at the lexical level which this work pursued, it would be worth while studying the tone patterns operational in these dialects at other levels of higher constructions such as phrases, clauses and sentences as the upstep may well be a grammatical tone or a feature of intonation.

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A SCRUTINY OF THE PHONOLOGICAL PROCESSES IN THE ÌMÌLÌKÈ DIALECT OF ÌGBÒ

Nweya, Gerald Okechukwu[1] & Eze, Juliana Chizobam[2]
Department of Linguistics and African Languages, University of Ibadan, Ibadan, Nigeria[1]
Department of Igbo, Federal College of Education, Okene, Kogi State[2]
08030777027; 0805090124

Abstract
In this study, we focused our attention on the phonological processes in the Imilike dialect of Igbo. The Imilike dialect is grouped among the Northern Group of Dialects [NGD} (Nwaozuzu 2008, 2017) which otherwise, is known as the general Nsukka group of dialects. By and large, the standard Igbo which the Imilike dialect is part and parcel of is one of the *Kwa* group of languages spoken predominantly in the South-East and in some parts of the South-South geopolitical zones of Nigeria. This work is a survey research, which aims at ascertaining the pattern of the phonological processes inherent in the dialect. In the process of the research, we discovered that there are secondary articulations that have their occurrence in the dialect. These secondary articulations include the following: secondary articulation, assimilation, insertion, elision/deletion and vowel harmony. Oral interview, observation, and a review of related literature were used as methods of data collection.
Keywords: Phonological processes, secondary articulation, assimilation, insertion, elision

Introduction

In an attempt to make utterances by the native speakers of any given language, sounds segments are combined to form words. This attempt at speech production makes the segments of the neighbouring sounds to become juxtaposed, and sometimes this phenomenon causes the segments to undergo changes. In the linguistic parlance, these changes are referred to as phonological processes. Now, in discussing phonological processes, we have primary articulation which is the main point of articulation and secondary articulation, which is an additional point of articulation. In the Ìmìlìkè dialect, two types of secondary articulations were discovered, which are: palatalisation and labialisation. Other types of phonological processes discovered in the dialect are: Assimilation, insertion, elision/deletion, and vowel harmony.

The Ìmìlìkè dialect is grouped among the Northern Group of Dialects (NGD) (Nwaozuzu, 2008, 2017) which otherwise, is known as the General Nsukka Group of Dialects of Northern Igbo language. The dialect is located in Udenu LGA of Enugu State of Nigeria. The standard Igbo from where the Ìmìlìkè dialect is taken from is one of the Kwa group of languages spoken predominantly in South-East and in some parts South-South geopolitical zones of Nigeria.

Phonological Processes in the Ìmìlìkè dialect

Perceptibly, phonological processes refer to various modifications which phonemes undergo when they are juxtaposed. Observation has shown that sound segments influence one another when they occur in adjacent positions. Sometimes, this influence becomes more prominent when sound segments are pronounced in fast or connected speech. In this paper, the various phonological processes that are obtainable in the Ìmìlìkè dialect were examined. In the process, we included the formalized rules needed for the derivation of each of the phonological process under study. Meanwhile, the following are some of the phonological processes observed in the Ìmìlìkè dialect:

(a) Secondary Articulation

(b) Assimilation

(c) Insertion

(d) Elision

(e) Vowel Harmony

Secondary Articulation

Agbedo (2000:47) defines secondary articulation as an articulation of lesser degree of stricture occurring at the same time as the main or primary articulation. While primary articulation is the main point of articulation, secondary articulation is an additional point of articulation. The two types of secondary articulations discovered in the Ìmìlìkè dialect are:

(i) Palatalisation

(ii) Labialisation

Palatalisation has been defined as the superimposition of a high front tongue position on a primary articulation. Clark, Yallop and Fletcher (2007:64) specify that "palatalisation involves raising the top and blade of the tongue to a high front positioncloser to the anterior of the hard palate."Palatalisation is represented with a superscript /ʲ/. In the Ìmìlìkè dialect, the following palatalised segments have been observed:

Phoneme	**Ìmìlìkè Dialect**		**Gloss**
1. (a.) [pʲ] as in	píé	/pʲé/	enter
(b.) [bʲ] as in	bíé	/bʲé/	slice
(c.) [mʲ] as in	mịá	/mʲá/	default
(d.) [lʲ] as in	lịá	/lʲá/	tear
(e.) [ɾʲ] as in	ryọ́	/rʲɔ́/	beg/massage
(f.) [ɾʲ] as in	ryé/	rʲé	eat

It is observable that in 1 (a-f) the palatalised consonantal segments occur before high front vowels /ɪ/ and /i/. Hence, a formal rule can be formulated to indicate that a consonant is palatalised before a high front vowel thus:

A. Rule: $C \rightarrow [+\text{high}] / - \#\ \begin{pmatrix} V \\ +\text{high} \\ +\text{front} \end{pmatrix}$

The rule in (A) above indicates that a consonantal segment is palatalised before a high front vowel.

Labialisation

Labialisation involves the superimposition of lip rounding on primarily articulated speech sound. Mbah and Mbah (2000:77) state that phonetically, the symbol used to denote labialisation is a superscript [ʷ] against the labialised phoneme. Due to this phonological process, there exist a reasonable number of segments in the Ìmìlìkè dialect which are however, non-existence in the standard Ígbò.

Below are instances of labialisation in the dialect:

Phoneme	**Ìmìlìkè Dialect**		**Gloss**
2. (a)[ɣʷ] as in	chwụ́	/ɣʷɔ́/	wash
(b) [ʤʷ] as in	jwụ́	/ʤʷɔ́/	ask/refuse

(c) [h^w] as in	hwụ́	/h^wó/	see
(d) [h^w] as in	áhwụ́hwụ́	/áh^{w}óh^{w}ó/	suffering
(e) [l^w] as in	l^wù	/l^wò/	fight
(f) [s^w] as in	swé	/s^wé/	grow up
(g)[ʃ^w] as in	áshwá	/áʃ^{w}á/	market
(h)[ɹ^w] as in	ẹ́rwá	/ɛ́ɹwá/	heavy

Perceptibly, the data in 2 (a-h) above show that the labialised segments precede high back vowels. Hence, the formalised rule for the realisation of this phenomenon is as follows:

B. Rule: C → [+ labial] / - $\begin{pmatrix} V \\ +/-\text{high} \\ +\text{back} \end{pmatrix}$ #

The rule in B specifies that a consonantal segment becomes labialised before a high or low back vowel.

Assimilation

Assimilation is said to have taken place when two contagious sounds which possess distinct modes of production become identical in some or all the features of their production. Assimilation can be progressive or regressive. It is progressive when the second segment changes to become like the first, and regressive when the first segment changes to become like the second in associative construction. The implication is that through the process of assimilation, the vowel segment before the morpheme boundary gets assimilated to the first vowel segment of the second noun immediately after the morpheme boundary. Fundamentally, in the Ìgbò language generally, regressive assimilation is more prominent in occurrence than the progressive assimilation. Consequently, this is what is mostly obtainable in theÌmìlìkè dialect. Consider these instances below:

3 (a) /ùdé/ + /íʃĩ/ → /ùdéííʃĩ/
pomade/cream head "hair cream"
(b) /ánɔ́/ + /ẹ́gɔ/ → /ánɛ́ɛ́gɔ/
meat bush "bush meat"
(c) /óŋé/ + /íʃĩ/ →/óŋííʃĩ/
person head "leader"

Worthy of note is that in 3 (a-c) the vowel segments before the morpheme boundary get assimilated to the first vowel segment of the second noun immediately after the morpheme boundary. Thus, the rule for its derivation is stated below:

C. Rule: V1 + V2 → V2V2

It should be noted while V1 is the final vowel before the morpheme boundary, the V2 is the first vowel after the morpheme boundary.

Insertion

Insertion is a phonological process which takes place when a new sound segment is introduced into the syllabic structure of a language with the intention of breaking impermissible sequences. In a language, the inserted segment can either be a consonant or a vowel. By and large, Ìgbò permits only the insertion of vowels to break up the impermissible sequences in the language. Essentially, vowel insertion occurs in the language due to the fact that Ìgbò prohibits consonant cluster and coda. Being a dialect of Ìgbò, the same phenomenon is applicable to the Ìmìlìkè, since it is only vowel insertion that is permitted in the dialect.

For more clarification, vowel insertion occurs in the dialect due to the infiltration of new words into the dialect as a result of borrowing. Consequently, any borrowed word that fails to conform to the phonotactics of the dialect undergoes this process. Consider these examples:

English **Ìmìlìkè Dialect**
4 (a) table /teibl/ → tébə̀rə̀ /tébə̀rə̀/
gallon /gælən/→gálọ́ọ̀nù /gálɔ́ɔ̀nɔ̀/
(b) kettle /ketl̩/→kɛ́ńtù̩rù̩ /kɛ́ńtɔ̀rɔ̀/
(c) abroad /əbrɔd/ àbù̩rɔ́ọ̀d /àbɔ̀rɔ́ɔ̀dɔ̀/
D. Rule: Ø→ V/ C _ C

The rule of this insertion states that a vowel is inserted in the sequence of a consonant preceding another consonant.

Elision

Bashir (2015:138) opines that elision or deletion in linguistics is the omission of one or more sounds (such as a vowel, a consonant or a whole syllable) in a word or phrase. In a similar vein, Yule (2007) portrays elision as omission of a sound segment which would be present in the deliberate pronunciation of a word in isolation.From Yul–Ifode (1999)'s perspective, elision is a phonological process involving the omission, deletion or total loss of a sound segment. She goes on to explain that this process may affect a vowel or a consonant. When there is a deliberate pronunciation of a word in isolation, segments that are heard may get elided or lost in quick, fast or connected speech. Yul–Ifode still moves further to avow that elision is one of those phonological processes that cause determination or change in the structure of the syllable, or in sequences of consonants and vowels occurring in a string or across a word or morpheme boundary. In essence, elision is a phonological process that deletes a segment entirely instead of changing their feature characteristics. The Ìmìlìkè dialect attests to two kinds of elision. These are consonant elision and vowel elision.

Consonant Deletion

Essentially, this involves the deletion or omission of consonant in a word usually in rapid or connected speech. In the dialect, this could be exemplified thus:

Ìmìlìkè Dialect	**Rapid Speech**	**Gloss**
5.(a.) ọ̀kṵ́kọ̀ → /ɔ̀kɔ́kɔ̀/	/ɔ́kɔ̀/	chicken/fowl/hen/cock
(b.) áhwṵ́hwṵ́ → /áhʷóhʷó/	/áɔ́hʷó/	suffering
(c.) ɛ́kwṵ́kwɔ́ → /ɛ́kʷɔ́kʷɔ́/	/ɛ́ɔ́kʷɔ́/	book/paper/leave
(d.) ájwṵ́jwṵ́ → /ádʒʷódʒʷó/	/áɔ́dʒʷó/	asking
(e.) ọ̀jwṵ́jwṵ́ → /ɔ̀dʒʷódʒʷó/	/ɔ̀ɔ́dʒʷó/	refusing
(f.) ɔ̀jwújwú → /ɔ̀jʷújʷú /	/ɔ̀újʷú /	full

The data in 5 (a-f) above reveals that consonantal segments were elided before high back vowels /u/ and /ụ/. This can be formalised in a rule thus:

E. Rule: C → [Ø] /- $\begin{bmatrix} \text{V} \\ +\text{high} \\ +\text{back} \end{bmatrix}$

This rule states that consonant is deleted before high back vowels

Vowel Elision

This occurs when a vowel segment is deleted in rapid or connected speech as in the following words in the dialect:

Ìmìlìkè Dialect **Rapid Speech** **Gloss**

6. (a.) ḿkpọ́rọ → /ḿkpɪọ́/ seed
(b.) èbə̀lè → /èblè/ ram
(c.) átọ́rọ → /átɪọ́/ sheep
(d.) èkə̀lé → /èklé/ greeting
(e.) gọ̀rọ̀→ /gɪọ̀/ read (past)
(f.) gọ́nọ→ /gnọ́/ what

As can be observed, vowel elision occurs in the Ìmìlìkè dialect due to the existence of the central vowels [ə/ọ] which are reduced vowels. The vowels are elided in fast/automatic speech before the consonantal segments /l/, /ɪ/ or /n/. It should be noted that though the vowels are elided, its inherent tones do not phase out with them since they are still perceived in rapid speech. The rule that deletes these central vowels in connected or fast speech can be formalised thus:

F. Rule: $\begin{bmatrix} V \\ +centra \end{bmatrix} \longrightarrow Ø / C\ \_\ \begin{bmatrix} l \\ ɪ \end{bmatrix}$

As noted, this rule states that a central vowel [ə/ọ]gets elided before the consonants /l/, /ɪ/ and /n/.

Vowel Harmony

Vowel harmony is a phonological process which takes place when vowels that occur within a morpheme or across morpheme boundaries agree in certain distinctive features. Mbah and Mbah (2000:8) note that vowel harmony in Ìgbò is based on pharyngealisation. Pharyngealisation is a feature that divides the vowels in a language into two sets. The Ìmìlìkè dialect possesses eleven (11) vowels. These are: /a, e, ẹ, i, ị, o, ọ, u, ụ, ə, ọ/.While the vowels with sub-dots are pharyngealised, those without sub-dots are non-pharyngealised as in:

7. Set I (Non-pharyngealised) Set II Set I (Pharyngealised)

i	u	ɪ	ʊ
e	o	ɛ	ɔ
ə	aọ		

In the Ìgbò language generally, vowel harmony as a principle controls the distribution of vowels. And, this is equally applicable in the Ìmìlìkè dialect. As has been observed, vowels of both sets do not co-occur in one and the same morpheme. There is a natural selection, whereby the vowels occurring in a morpheme have to select themselves either from set I or set II. Look at these instances:

Ìmìlìkè Dialect

Set I	**Gloss**	**Set II**	**Gloss**
8 (a) íkē/íkē/	to tie	íkā /íkā/	to be greater/bigger
(b) éshì /éʃì/	pig	èshí/ɛʃí/	body/sickness
(c) óyī /ójī/	cold	ọ̀yí/ɔjí/	good/fine
(d) ògbə́gbə́/ògbə́gbə́/	killing	ọ̀gbə̀gbə́/ɔ̀gbə̀gbə́/	removing maize (from cob)
(e) òzəzə́ /ózə/	delivering (message)	ə̀zə̀zə́ nwá	training a child

Nonetheless, there are exceptions to the rule of vowel harmony. This occurs when the some vowels do not strictly follow the rule of selecting the appropriate vowels to be merged together in the formation of some morphemes in the dialect, and by extension in the Ìgbò language generally. To be precise, the vowels /a/ and /e/ as well as /a/ and /o/ do not strictly obey the vowel harmony principle as could be observed in the following instances:

	Ìmìlìkè Dialect	**Gloss**
9. (a)	áféré /áféré	plate
(b)	ákóró /ákóró/	axe
(c)	àkpó /àkpó/	palate,(either soft or hard palate or name of a town)

Notably, this violation of vowel harmony in the dialect as seen in 9 (a-c) is very rare. This in line with the view of Mbah and Mbah (2000:59) who acknowledged that vowel harmony is strong in the Northern Ígbó dialects. And, as has been stated at the introductory part of this paper, the Ìmìlìkè dialect is situated among the Northern Ígbó dialects.

Sometimes also, this violation can occur across morpheme boundaries, as in the following example:

	Ìmìlìkè Dialect	**Gloss**
10.	ákẹ̀+òró → ákóóró	
	"termite""moving up and down "	"black termite (flies outset of rainy season)"

As can be observed in 10, due largely tothe process of assimilation, the vowel segment before the morpheme boundary in the first morpheme or word gets assimilated to the first vowel segment of the second word immediately after the morpheme boundary. Consequently, the morpheme *ákóóró "*black termite that flies around in the day at the outset of rainy" is realised. And indeed, this is the actual pronunciation of this kind of termite among the Ìmìlìkè dialect speakers. What we are implying is that they do not actually utter "*ákẹ̀ +óró*, instead *ákóóró* is always pronounced. It should be noted that this dialect speakers refer to the milk-coloured termite that roam at night at the outset of the rainy season as *ákẹ̀*. So, we assume that the appendix *óró* to *ákẹ̀*, is just to naturally differentiate one from the other. Hence by assimilation, the type that roams in daytime became known as *ákóóró.*

Further, in discussing the phonological processes that are obtainable in the Ìmìlìkè dialect as it relates to the issues of vowel harmony, it is necessary to reveal that vowel harmony determines the choice of affixes to be attached to any verb root, the same way that it determines the choice of affixes in the standard Ígbò. Essentially, affixes are morphemes attached to a word to modify its meaning. In the dialect, the selection of the affix to be attached to a verb root in the formation of another word or to modify the verb is determined through the vowel that is already contained in the verb root. And, this is fundamentally in line with the vowel harmony principle that is obtainable in the Ìgbò language generally. Consider these examples:

Ìmìlìkè Dialect

11.**[i/ị] + verb root Infinitive Gloss**

(ai) í lé → /ílē/ to look

(aii)ị́ + ká→ /ịkā/ to be greater/bigger

The vowels [i/ ị́,**o/ọ, /u/ụ, /ə/ẹ] and[rə̀/rẹ̀] Past tense marker**

(bi) jì + rə̀ → jìrə̀ held

"hold" rv (past)

(bii) ryị́ + rẹ̀ → ryìrẹ̀ crawled

"crawl" rv (past

(ci)gó+ rə̀ → gòrə̀

"buy" rv (past) bought

(cii) gọ́ + rẹ̀→gọ̀rẹ̀

"deny" rv (past)denied

(di)jú + rə̀→ jùrə̀

"fill" rv (past) filled

(dii) wụ́ + rẹ̀→wụ̀rẹ̀

"bathe" rv (past) bathed

(ei)və́+ rə̀ →və̀rə̀

"carry"rv (past) carried

(eii) kẹ́ + rẹ̀ → kẹ̀rẹ̀

"plant" rv (past) planted

The [rə̀/rẹ̀] Stative aspectual marker

(fi) Ó rè rə̀ èré
S/he/it rot + rv (sta. pres. asp) rotten
"It is rotten".
(fi) Égō mà rẹ̀ ḿmā
Égō be-beautiful + rv (sta.pres. asp) beautiful
"Égō is beautiful".
(gi) Jè é →Jèé "go (imperative/command)"
go + open v-sfx (imp. marker)
(gii) kwù ó→kwùó "speak (imperative/command)"
speak + open v-sfx (imp. marker)

(giii) kọ̀ ọ́→"kọ̀ọ́narrate/cultivate/plant(imperative/command)"
narrate/cultivate/plant + open v-sfx (imp. marker)
(hi)Ọ́nà- èryí jī → Ọ́ nà-èryí jī "He is eating yam"
S/he/it Prog. prfx + eat yam
(hii)Hẹ́nà- à chú ẹ́kwà → Hẹ́ nà-áchú ẹ́kwà "They are washing clothes"
They/them Prog. prfx wash cloth

Perceptibly, in all the examples in 11, it is the vowel in the verb root that determined the selection of the vowel that was affixed either as a prefix or as a suffix to the already existing verb root, so as to actualise the vowel harmony principle. See 11 (aii & aii) for the formation of the infinitival form of the verbs concerned; where [i/ị] is added to the verb root.

However, it should be noted that in the dialect, the "rV" suffix used in the formation of the simple past tense whereas "r" is constant, the "V" is a variable depending on the vowel in the verb root. The variability of the "V" aspect in the formation of the "rV" past is limited, since the dialect replaces the variable "V" with the pharyngealised or non-pharyngealised central vowels [ə/ẹ] depending on the vowel in the verb root. Consequently, this gives rise to such forms as "r" +[ə/ẹ] as can be observed in the past tense form of the verbs *jìrə̀* "held", *ryịrẹ̀* "crawled", *gòrə̀* "bought" and *gọ̀rẹ̀* "denied", *jùrə̀* "filled", *wụ́rẹ̀* "bathed", *və̀rə̀* "carried", *kẹ̀rẹ̀* "planted" in the instances given from 11 (bi) all through to (eii) above. As can be observed in 11 (ei & eii) above, it was discovered that the central vowels [rə̀/rẹ̀] can as well occupy the V-slot position in the verb root in the dialect. Hence, the vowel reduplicates itself in the formation of the past tense of the verb concerned. This is unlike in the standard Ígbò, where only the major vowels occupy the V-slot position in the verb roots.

In a similar vein, either of these central vowels [ə/ẹ] also occupies the "V" slot as the "rV" aspectual marker in the formation of stative present aspectual verb form as can be seen in 11(fi & fii) above. Likewise, due to the rule of vowel harmony in the dialect, in the formation of an imperative construction, the vowel attached to the verb root has to be selected by the one already existing in the verb root. See 11 (gi, gii & giii) above.

Likewise, in the formation of a participle, which involved the prefixation of a vowel to a verb root, the examples in (hi & hii) revealed that it is still the vowel in the already existing verb root that selects the type of vowel that is prefixed to the verb concerned to form the required participle. For more clarifications, the imperative *kọ̀ọ́* meaning "narrate/cultivate/plant" is differently realised in the standard Ígbò. This is because, unlike in the Ìmìlìkè dialect where it is realised in the same manner, with heavy dependence on context to ascertain the word the speaker has in mind, the realisation of the three words "narrate/cultivate/plant" in the standard Ígbò is:

12. (a) kọ́ ọ́ →kọ́ọ́ "narrate/cultivate(imperative/command)"
narrate/cultivate + open v-sfx (imp. marker)
(b) kụ́ ọ́ → kụ́ọ́ "plant (imperative/command)"
plant + open v-sfx (imp. marker)

Looking at the verbs *ryìrẹ̀* "crawled" in (bii) and*èryí "*eating" (hi), it is important to state that the /ry/ is actually a single segment resulting from palatalisation. In transcription, it is realised thus: /r^{j}/ in the dialect. In summary, the vowel harmony principle controls all the patterns affixation in the dialect as it does in the standard Ígbò. As has been stated, the base vowels determine the choice of the vowels to be applied as affixes. It was also observable that vowel harmony spreads outward from the verb root, both leftward towards prefixes and rightward towards suffixes.

Summary and Conclusion

This paper discussed the phonological processes in the Ìmìlìkè dialect of Ìgbò. In the course of the research, we discovered that there are different types of phonological processes in the dialect, which includes secondary articulation such as palatalisation and labialization. Other types of phonological processes discovered are assimilation, insertion, elision or deletion and vowel harmony. It was observed that secondary articulation such palatalisation and labialization occurs within single words. The same thing is applicable to the phonological process of insertion. However, the occurrence of assimilation and elision or deletion is restricted since they can only occur in the environment of compound words.

One major significant point to make here is that among the types of segments (phonemes) used in the formation of words in the Ìmìlìkè dialect schwa [ə] with its allophone [ẹ] is heavily observed in the dialect. This is because, within the general Nsukka group of dialects which includes the Ìmìlìkè dialect, this segment (phoneme) i.e. schwa [ə] and its allophone [ẹ] is very fundamental in the formation of words just as any other phoneme. The main perceptible distinction between this vowel segment [ə/ẹ] and other vowels in the dialect is that it cannot be employed in the beginning of words. It can only occur word medially and word finally. In the Ìmìlìkè dialect, and by extension the Northern Group of dialects, these two vowels [ə/ẹ] are known as central vowels.

On a final note, pertaining the issue of the vowel harmony principle, it was discovered that it controls all affixation patterns in the dialect as it does in the standard Ígbò. It was noted that due to the rule of vowel harmony, the base vowels determine the choice of the vowels to be applied as affixes. Consequently, vowel harmony spreads outward from the verb root, both leftward towards prefixes and rightward towards suffixes.

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