# VOWEL HEIGHT, CONSONANT TYPE AND THE REALIZATION OF THE H TONE IN IGBO

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## Abstract

*Two distinctive tones are often recognized in Igbo – the high tone and the low tone; in addition, there is a third tone, a downstepped high (whose occurrence is restricted). These tones are expressed on the pitch values of vowels. The thrust of this paper, however, lies on the high tone. Tone in Igbo, as in other tone languages, results from pitch variations, and pitch is actually the auditive correlate of acoustic 'fundamental frequency'. Fundamental frequency (Fo) of a given tone in Igbo varies according to vowel height. Furthermore, consonant types perturb pitch in Igbo. This paper examines the acoustic phonetic nature of the high tone in Igbo with an ultimate goal of contributing to an understanding of degrees of tone height in the language. Four adult native Igbo speakers read CV words for the study. With a reference point at the onset of a vowel, Fo values were measured at the onset and 20msec after this onset. In an attempt to establish the varying heights of the Igbo high tone, this paper examines the correlation between vowel height and fundamental frequency (Fo) as well as the effects of consonant types on Fo. Results reveal varying degrees of the high tone thus: extremely high, very high and normal high. This study contributes to the Igbo phonetic tone inventory size.*

## 1. Introduction

This study investigates the phonetics of tone (high tone, precisely) in the standard dialect of the Igbo language. The phonetic correlate of tone is the fundamental frequency (Fo), which we perceive as pitch. The term 'tone' is used in the African linguistic literature with reference to the contrastive suprasegmental properties of pitch. Igbo is a register tone language.

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In a register tone language as noted by Crystal (2008:409),

> The critical feature is the relative height of the syllabic pitches, and not the direction in which they move. Level pitches are central, and if the language makes use of changing pitches, the end-points of the falls or rises are identified with one of the level pitches.

Research on tone types has also found that there is an interaction between the degree of glottal aperture and pitch (Hombert 1975, Ladefoged & Maddieson 1985, Thongkum 1988, Gordon & Ladefoged 2001). These authors claim that increased glottal tension causes pitch raising while decreased glottal tension causes pitch lowering. The temporal dynamics of pitch are considered significant in the production and perception of tone (Bao 1999, Gordon 2001, Avelino 2003, Liu & Samuel 2004, Khouw & Ciocca 2007).

Phonetic studies by House and Fairbanks [1953], Lehiste and Peterson [1961], Mohr [1971], Lea [1972, 1973], Lofqvist [1975] and Hombert [1976] show how a voicing distinction in prevocalic position can affect the fundamental frequency of the following vowel. Unfortunately, all these phonetic studies are based on non-tonal languages. Thus, they can explain how a non-tonal language can acquire two tones from the loss of some voicing distinction in prevocalic position but we do not have any strong basis for believing that these data can be extended to languages that are tonal. For example, the behavior of voiced or voiceless consonants at different frequency points is unknown (Hombert, 1977). The problem of this study hinges on Hombert's (1977) assertion: Is a voiceless consonant going to perturb the frequency of a high tone? Therefore, this study attempts to investigate the relationship between consonants, vowels and high tone in Igbo. High tone is chosen for this present study because it is the most occurring tone in Igbo words.

The paper is organized into five sections. Section two below presents the questions that guide the study and the research methodology; section three gives a background to Igbo phonology; section four presents the data and discusses the findings of the research while section five concludes the work.

## 2. Research Questions and Methodology

The following questions guide this research: (1)What are the effects of voicing contrast on the pitch of the following vowels? (2) What is the

correlation between vowel height and Fo in Igbo?And (3) How will consonant type and vowel height result in varying degrees of the Igbo high tone?

In order to investigate the varying degrees of the high tone in Igbo and in the process answer the above questions, ten native Igbo speakers comprising five adult males and five adult females (ages: 19, 25, 37, 42 & 51 years) were asked to read a word list of 120 CV (15 consonants x 8 vowels x 1 tone) tokens with an average of five repetitions. Acoustic recordings were originally sampled at 44.1 kHz but downsampled to 16 kHz before analysis in mono quality over four elicitation sessions, one session per speaker. The data were transferred onto a laptop computer and were synchronously acquired using Praat (Boersma&Weenink2010). A script was written to extract F0 measures at 2 even time indices – one at the vowel onset and the other 20 msec after the onset – along the duration of each vowel along with its total duration. Meaningful and nonsense CV words were spoken, controlling for high tone. The aim was to obtain CV words combining with the Igbo vowels /a e i ɪ o ɔ u ʊ/. Plosives, fricatives, affricates and nasals were chosen leaving out glides and liquids. The reason is because glides and liquids share periodic glottal source with vowels. The pitch values represent the average of all tokens for the ten speakers. The mean values of the ten speakers were taken and presented in tables.

## 3. Phonological Background

This section discusses the consonants, vowels and tones of Standard Igbo.

*Igbo Consonants*

Table 1 below shows the consonant sounds of Standard Igbo, transcribed using the International Phonetic Alphabet (IPA). There are 28 consonant phonemes in the inventory. Igbo has a two-way voicing contrast. Between pairs of consonants having the same place and manner of articulation, the primary distinction is voiced vs. voiceless. The phonemes /ʧ/, /ʤ/, /ʃ/, /ɣ/, /ɦ/, /ɲ/ and /ŋ/ are orthographically represented as *ch*, *j*, *sh*, *gh,h*, *ny* and *ṅ*.

**Table 1** Standard Igbo Consonants

| Labial | | Alveolar | | Palatal | | Velar | | Glottal |
|---|---|---|---|---|---|---|---|---|
| p | b | t | d | | | k | g | |
| | | | | | | kp | gb | |
| | | | | | | kw | gw | |
| | | | | ʧ | ʤ | | | |
| f | v | s | z ʃ | | ɣ | | | ɦ |
| | m | | n | ɲ | ŋ | | | |
| | | | | | | ŋw | | |
| | | | l | j | | | w | |
| | | | r | | | | | |

*Igbo Vowels*

Standard Igbo has eight vowels. The vowels are grouped into two sets which are delineated along an important phonetic parameter, ±ATR (Advanced Tongue Root). For the + ATR vowels, the tongue root is advanced for the articulation of the affected vowels while the −ATR vowels involve the retraction of the tongue root in their articulation. The two sets in Igbo are:

(1)

| [+ATR] | | [-ATR] | |
|---|---|---|---|
| i | u | ɪ | ʊ |
| e | o | a | ɔ |

These vowels are presented in table 2 below.

**Table 2** Standard Igbo Vowels

| | | | | |
|---|---|---|---|---|
| High | i | ɪ | u | ʊ |
| Mid | e | | o | ɔ |
| Low | a | | | |

*Tone in Igbo*

Two distinctive tones are often recognized in Igbo – the high tone and the low tone; in addition, there is a third tone, a downstepped high. The high

and low tones occur freely while the downstep tone has a restricted occurrence. The downstep tone cannot be found word initially rather word medially and finally, and it must be preceded by a high tone or another step tone. The restricted distribution of the downstep tone means that Igbo downstep tone is simply a high tone that is downstepped i.e. reduced in height. It has long been accepted that the application of different tones to certain lexical items in Igbo yields different meanings (cf. Schon, 1861; Ward, 1936; Uwalaka, 1996). For example:

| | | | | | |
|---|---|---|---|---|---|
| **(2)** | **isi** 'head' | **akwa** | 'cry' | **ọkụ** | 'fire' |
| | **isì** 'smell' | **akwà** | 'cloth' | **ọkụ̀** | 'fishing' |
| | **isī** 'to cook' | **àkwa** | 'egg' | **ọ̀kụ̀** | 'bowl' |
| | **ìsì** 'blindness' | **àkwà** | 'bed/bridge' | **ọ̀kụ** | 'hitter' |

High tones are left unmarked. However, information on the grammatical functions of tone in Igbo could easily be obtained from introductory books and journals (See Nwachukwu, 1995; Ezeuko & Chira, 2005; Anagbogu, Mbah & Eme, 2010 for example).

## 4. Data Presentation and Discussion of Findings

Fo values of Igbo vowels spoken by ten native Igbo speakers comprising five adult males and five adult females (ages: 19, 25, 37, 42 & 51 years), with an average of five repetitions were measured; the average was taken (See Appendix 1) and presented below.

**Table 1** Average Fo values of tones with different vowels

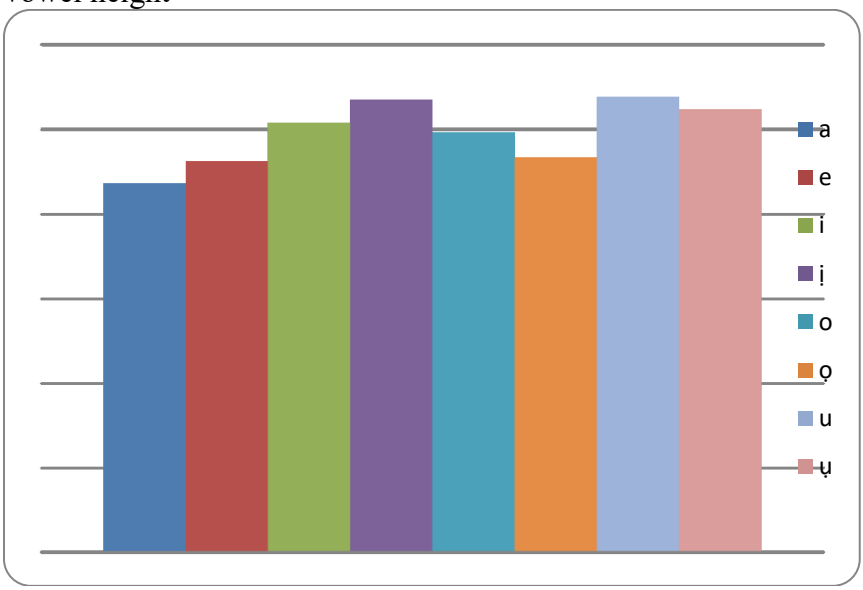
| | |
|---|---|
| Á | 217.92 |
| É | 231.36 |
| Í | 254.08 |
| Ɨ́ | 267.51 |
| Ǿ | 248.36 |

| | |
|---|---|
| ọ́ | 233.25 |
| ʊ | 269.36 |
| ụ́ | 261.82 |

The Fo values of the vowels are higher when the vowels are preceded by voiceless consonants than when they are preceded by voiced consonants (cf. tables 1-8 in appendix).

For the correlation between vowel height and Fo in Igbo, a bar chart has been presented in figure 1 below to show the rising of pitch proportionately with vowel height. The high vowels /i ɪ u ʊ/ have the highest Fo values; the mid vowels /e o ɔ/ have higher Fo values than the low vowel /a/.

**Figure 1** A bar chart showing the rising of pitch proportionately with vowel height




## 5. Summary and Conclusion

In this paper, I examined more closely the acoustic-phonetic nature of the high tone in Igbo. This study has shown how the Igbo high tone is affected by voiced/voiceless consonants in prevocalic position. Voiceless

consonants have a greater effect on high tones than voiced consonants. Furthermore, there is a correlation between vowel height and Fo. Hence, pitch values of high vowels become higher than those of mid and low vowels. These experimental data show that an already existing tone system can multiply the number of its tones owing to the voicing contrast in prevocalic position. Tone systems are not static. A language can acquire tones and then increase the complexity of this tone system. The process of acquisition of tones has been termed *tonogenesis* (Matisoff 1970, 1973). Naturally, because differences in fundamental frequency are the phonetic correlates of the phonological category "tone", varying degrees of the high tone in Igbo have been observed. These degrees - extremely high, very high and normal high - contribute to the size of Igbo phonetic tone inventory.

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# Appendix 1

Mean values of the pitch of the vowels on high tones

**Table 1: Mean values of the pitch of the vowel 'a' on a high tone**

| CV Words | Fo values at vowel onset (Measured in hertz) | Fo values at 20 msec after the vowel onset (Measured in hertz) |
|---|---|---|
| Pá | **218.2** | **222.9** |
| Bá | **216.5** | **219** |
| Tá | **221** | **218.9** |
| Dá | **206** | **207.6** |
| Ká | **228.2** | **224.2** |
| gá | **207.1** | **215** |
| má | **218.6** | **219.6** |
| ná | **220** | **215.5** |
| ṅá | **221.7** | **228.7** |
| chá | **232.8** | **227.3** |
| já | **226.5** | **227.7** |
| fá | **228** | **226.4** |
| vá | **218.2** | **219.6** |
| sá | **226.3** | **218.1** |
| zá | **179.7** | **195.1** |

**Table 2: Mean values of the pitch of the vowel 'e' on a high tone**

| CV Words | Fo values at vowel onset (Measured in hertz) | Fo values at 20 msec after the vowel onset (Measured in hertz) |
|---|---|---|
| pé | **238.7** | **233.9** |
| bé | **223.4** | **226.6** |
| té | **236.1** | **231.2** |
| dé | **221.9** | **223.5** |
| ké | **235.6** | **228.8** |

| | | |
|---|---|---|
| gé | **212.2** | **224.3** |
| mé | **229.3** | **227.7** |
| né | **229.8** | **224.8** |
| ṅé | **227.8** | **225.3** |
| ché | **232.1** | **247.7** |
| jé | **232.9** | **232.1** |
| fé | **238.4** | **236** |
| vé | **235.8** | **224.8** |
| sé | **245.1** | **235.1** |
| zé | **231.4** | **234.2** |

**Table 3: Mean values of the pitch of the vowel 'i' on a high tone**

| **CV Words** | **Fo values at vowel onset (Measured in hertz)** | **Fo values at 20 msec after the vowel onset (Measured in hertz)** |
|---|---|---|
| pí | **282.9** | **282.6** |
| bí | **266.5** | **268.4** |
| tí | **275.9** | **271.5** |
| dí | **266.9** | **269** |
| kí | **294.2** | **291.4** |
| gí | **215.9** | **239.2** |
| mí | **269.5** | **272.3** |
| ní | **258.6** | **269** |
| ṅí | **292.2** | **297.1** |
| chí | **292.5** | **285.1** |
| jí | **284** | **274** |
| fí | **282.9** | **274.2** |
| ví | **274.6** | **272.1** |
| sí | **279** | **274.3** |
| zí | **267.9** | **272.3** |

**Table 4: Mean values of the pitch of the vowel 'ị' on a high tone**

| CV Words | Fo values at vowel onset (Measured in hertz) | Fo values at 20 msec after the vowel onset (Measured in hertz) |
|---|---|---|
| pị́ | **293.6** | **292.6** |
| bị́ | **275** | **276.7** |
| tị́ | **282.9** | **285.4** |
| dị́ | **246.1** | **254.1** |
| kị́ | **290.3** | **290.1** |
| gị́ | **227.1** | **256.1** |
| mị́ | **250.5** | **253.2** |
| nị́ | **261.7** | **262.4** |
| ṅị́ | **261.8** | **263.1** |
| chị́ | **277.9** | **275.4** |
| jị́ | **267.9** | **265.9** |
| fị́ | **286.4** | **282.2** |
| vị́ | **265.7** | **255.7** |
| sị́ | **267.1** | **268.7** |
| zị́ | **258.7** | **269** |

**Table 5: Mean values of the pitch of the vowel 'o' on a high tone**

| CV Words | Fo values at vowel onset (Measured in hertz) | Fo values at 20 msec after the vowel onset (Measured in hertz) |
|---|---|---|
| pó | **253.4** | **249.5** |
| bó | **243.1** | **249.2** |
| tó | **250.3** | **247** |
| dó | **239.7** | **246.1** |
| kó | **253.4** | **253.8** |
| gó | **229.5** | **244.8** |
| mó | **247.8** | **247.3** |
| nó | **252.1** | **250.7** |
| ṅó | **257.1** | **251.6** |
| chó | **250.7** | **259.7** |
| jó | **252.7** | **255.5** |
| fó | **258.9** | **256.6** |
| vó | **237.1** | **230.6** |
| só | **255.3** | **251.7** |
| zó | **244.4** | **251.2** |

**Table 6: Mean values of the pitch of the vowel 'ọ' on a high tone**

| CV Words | Fo values at vowel onset (Measured in hertz) | Fo values at 20 msec after the vowel onset (Measured in hertz) |
|---|---|---|
| pọ́ | **254.5** | **254.3** |
| bọ́ | **235.5** | **239.6** |
| tọ́ | **244.8** | **244.6** |
| dọ́ | **210.1** | **217.6** |
| kọ́ | **242.7** | **234.9** |
| gọ́ | **211** | **221.9** |
| mọ́ | **240.2** | **241.3** |
| nọ́ | **231.9** | **232.7** |
| ṅọ́ | **242** | **224.6** |
| chọ́ | **249.5** | **235.6** |
| jọ́ | **231.9** | **236.2** |

| | | |
|---|---|---|
| fọ́ | **235.3** | **231.5** |
| vọ́ | **229.3** | **226.9** |
| sọ́ | **230.9** | **230.7** |
| zọ́ | **209.2** | **207.9** |

**Table 7: Mean values of the pitch of the vowel 'u' on a high tone**

| CV Words | Fo values at vowel onset (Measured in hertz) | Fo values at 20 msec after the vowel onset (Measured in hertz) |
|---|---|---|
| pú | **263.4** | **263.6** |
| bú | **259** | **261.2** |
| tú | **280.7** | **261.2** |
| dú | **265.8** | **265.1** |
| kú | **266.9** | **267.8** |
| gú | **261.4** | **264.6** |
| mú | **264.3** | **267.8** |
| nú | **276.6** | **271.7** |
| ṅú | **269.6** | **279.8** |
| chú | **275.3** | **273.6** |
| jú | **265.7** | **266.4** |
| fú | **281.9** | **279.5** |
| vú | **272.6** | **264.5** |
| sú | **275.9** | **276** |
| zú | **261.4** | **264.6** |

**Table 8: Mean values of the pitch of the vowel 'ụ' on a high tone**

| CV Words | Fo values at vowel onset (Measured in hertz) | Fo values at 20 msec after the vowel onset (Measured in hertz) |
|---|---|---|
| pụ́ | **272** | **272.5** |
| bụ́ | **256.5** | **260.6** |
| tụ́ | **273.2** | **270.9** |
| dụ́ | **258.6** | **263.3** |
| kụ́ | **273.3** | **269.2** |
| gụ́ | **250.1** | **267.5** |
| mụ́ | **251.3** | **260.5** |
| nụ́ | **251.2** | **253.2** |
| ṅụ́ | **255.9** | **261.5** |
| chụ́ | **264** | **265.1** |

| | | |
|---|---|---|
| jú | **258.5** | **258.1** |
| fụ́ | **274.6** | **267.5** |
| vụ́ | **268.2** | **267** |
| sú | **270.8** | **266.9** |
| zụ́ | **249.2** | **261.9** |

## Appendix 11

Pitch trackings of /a/ and /i/

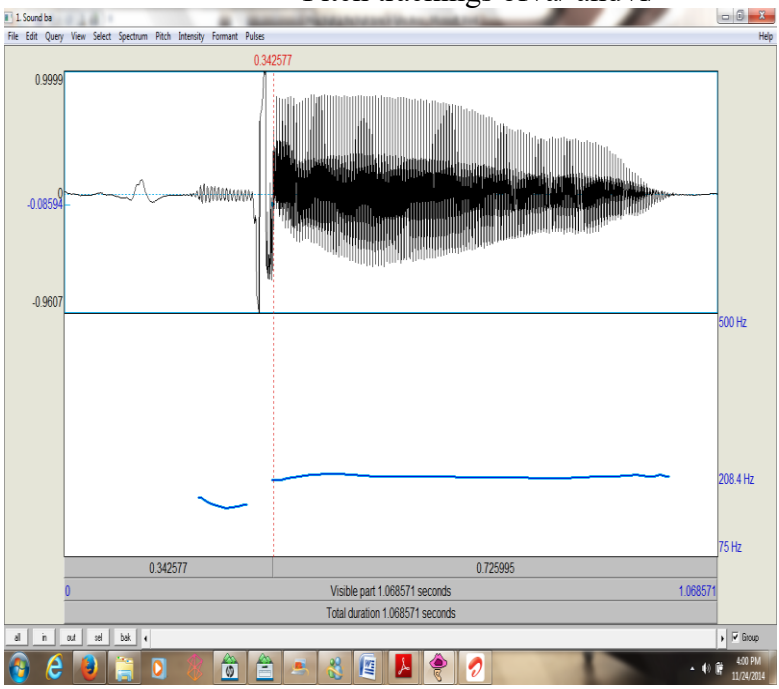


Figure 1: Pitch tracking of /á/ in 'bá' with Fo measurement taken at the vowel onset.

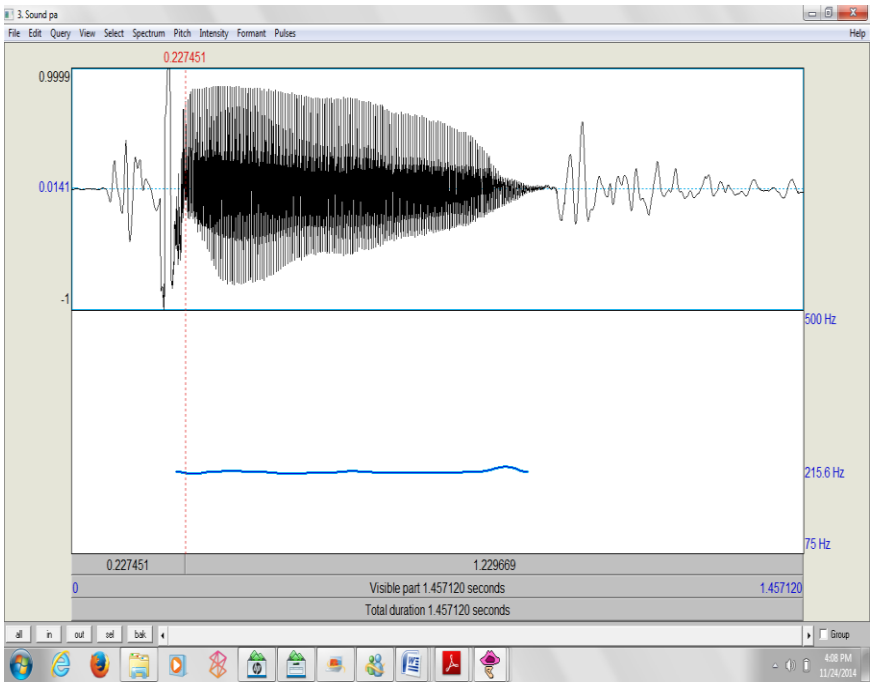


Figure 2: Pitch tracking of /á/ in 'pá' with Fo measurement taken at the vowel onset.

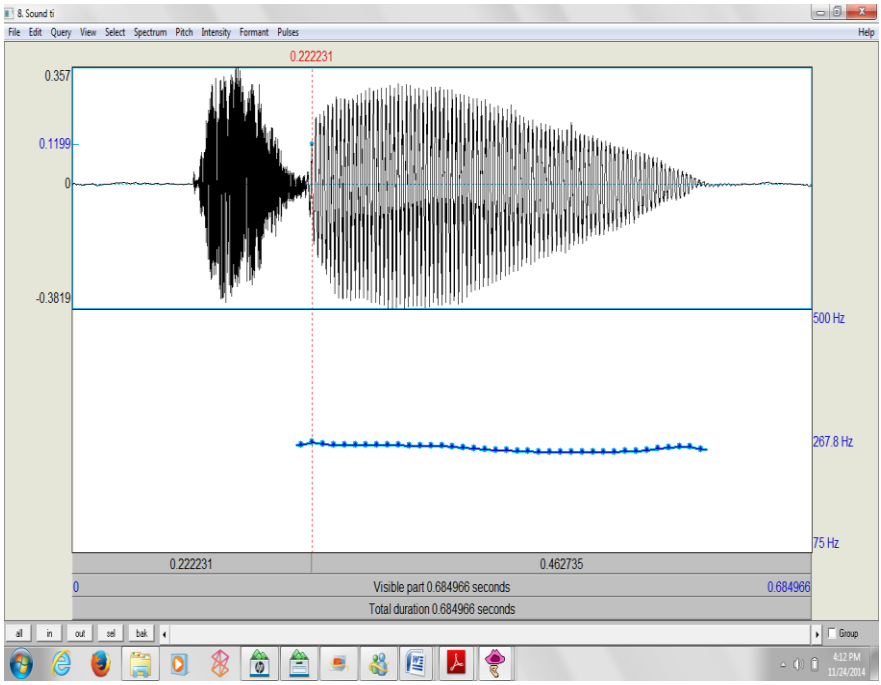


Figure 3: Pitch tracking of /i´/ in 'tí' with Fo measurement taken at the vowel onset.

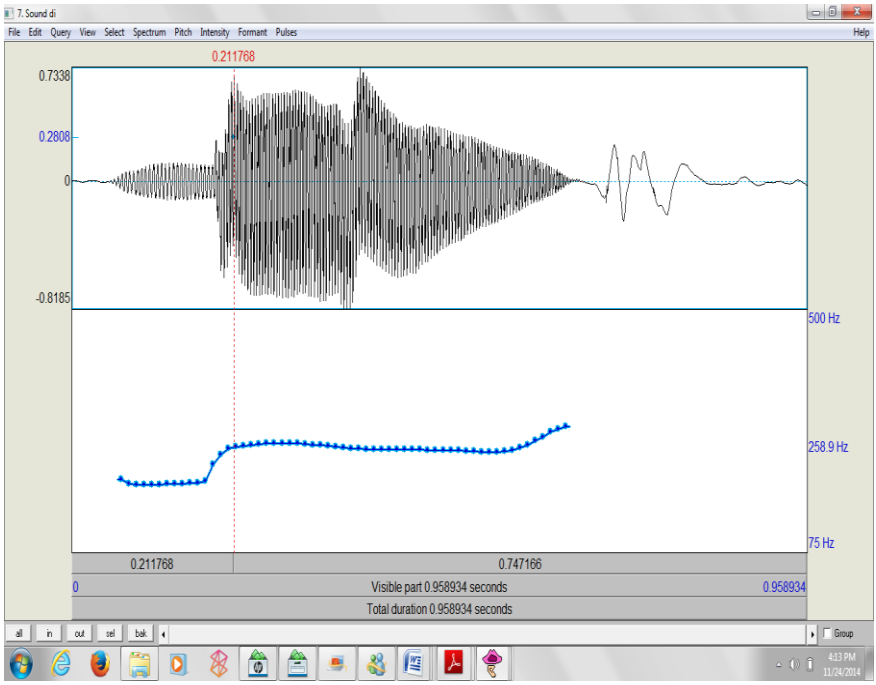


Figure 4: Pitch tracking of /i´/ in 'di´' with Fo measurement taken at the vowel onset.