# Intrinsic fundamental frequency in Igbo

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*Intrinsic Fundamental Frequency (IF0) is a phenomenon that reveals a correlation between vowel height and fundamental frequency whereby high vowels produce higher F0 than low vowels. Some reports in the literature consider IF0 to be universal (Whalen & Levitt, 1995), though Connell's (2002) study reports a neutralization of IF0 in Mambila. This paper studies this phenomenon as it concerns Ìgbò, a west Benue-Congo tone language spoken predominantly in the southeastern part of Nigeria. Ìgbò has eight phonemic vowels, /**a e i ɪ o ɔ u ʊ** /, which follow a two-tone system, high and low. In an attempt to establish the existence or otherwise of IF0 in Ìgbò, this paper examines the correlation between phonemic vowel height and fundamental frequency. Results confirm the existence of IF0 in the language bearing on a positive correlation between pitch and vowel height. It is further shown that IF0 is generally reduced for low tone.*

**Keywords:** *Fundamental frequency, vowel height, vowel backness, pitch-height relation*

## 1. Introduction

Ìgbò is a west Benue-Congo language spoken predominantly in the southeastern part of Nigeria. It is one of the African languages whose pitch differences are applied to words in order to distinguish two or more words that have similar consonants and vowels. Pitch differences used in this way are called tones. In other words, Igbo is a tone language because it manipulates tone contrastively on lexical items. This paper seeks to examine intrinsic pitch in Igbo. Intrinsic pitch (also known as Intrinsic Fundamental Frequency (IF0)) describes the phenomenon in which there exists a correlation between vowel height and pitch (F0). Most scholars perceive IF0 as "an automatic consequence of successful vowel production" (See Whalen, Gick & LeSourd 1999: 2).

Ìgbò has eight phonemic vowels, /**a e i ɪ o ɔ u ʊ**/, which follow a two-tone system, high and low. 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). In Ìgbò, tone is expressed on the pitch values of vowels and syllabic nasals but this study limits itself to vowels. Igbo 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** |

The ultimate goal of this study is to present an instrumental analysis of the intrinsic pitch in Igbo. This is done by examining the vowels of Igbo and determining the degree and conditions under which the vowels exhibit this phenomenon, following Gonzales (2009).

## 2. Review of related previous work

There is a significant amount of scholarly work on intrinsic pitch (IF0). Our interest lies on the studies that have been carried out on African tone languages. Whalen & Levitt's (1995) study of 31 languages reports that intrinsic pitch exists for African tone languages such as Ịṣẹkiri (Ladefoged 1968), Hausa (Pilszczikowa-Chodak 1972) and Yoruba (Hombert 1977). Other studies on intrinsic pitch in African tone languages include: Shryock, Ladefoged & Williamson (1996/7) for Defaka, Snider (2001) for Chumburung, Connell (2002) for Ibibio, Kunama, Mambila and Dschang, and Gonzales (2009) for Shona. We shall provide a brief overview of three works relevant to this particular study: Whalen & Levitt (1995), Connell (2002), and Gonzales (2009).

Whalen and Levitt's (1995) study reveals that intrinsic pitch/ intrinsic fundamental frequency (IF0) is gradient. This is because the pitch of mid vowels like /**e, o**/ will fall in between those of high and low vowels. Furthermore, they claim that there is no significant difference in IF0 having compared front and back vowels of the same vowel height. This affirms the assertion that IF0 is a function of height. In addition to the preceding observations, the study also observes that in tone languages, IF0 becomes neutralized in low tone environments.

Connell's (2002) study of four African tone languages: Ibibio, Kunama, Mambila and Dschang reveals the existence of IF0 for Ibibio, Kunama, and Dschang. However, IF0 is identified as having little or no effect in Mambila. Gonzales (2009) confirms the existence of IF0 in Shona. The study further shows that front vowels have higher IF0 than back vowels; a finding that runs counter to the claim that African tonal languages should not show a front-back distinction for IF0.

## 3. Methodology

In order to investigate intrinsic pitch (also referred to as intrinsic fundamental frequency) in Igbo, four native Igbo speakers comprising two adult males and two adult females were asked to read a word list of 20 CV (2 consonants x 5 vowels x 2 tones) tokens with an average of three repetitions. Test items were recorded in the carrier phrase **ɔ́ tʃɔ̀rɔ̀ i ́/I ́**_____ (S/he wants to _____). The speech data were recorded digitally at a sample rate of 44.1 kHz, 16 bit wav files in mono quality over four elicitation sessions, one session per speaker. The digital recordings were transferred onto a laptop computer and saved as .wav files in Praat. Signal processing, segmentation and TextGrid annotation were conducted in Praat (version 5.1.25). F0 measures were made for the vowels following initial voiced nasal consonants /**m, n**/ in both meaningful and nonsense words, controlling for tone and lexical context.

F0 values were measured at each vowel's onset and 20, 40, 60, 80 and 100 msec after this onset. Figure 1 is an example of the first token of the word **mì** 'dive' produced by a male speaker exploited for analysis in Praat. To examine the intrinsic pitch, five Igbo vowels, /**i, ɪ,**

**u, ʊ, a**/ delineated along high vs. low and front vs. back, were examined. We assumed the possibility that +ATR and -ATR behave differently with respect to IF0. Snider did find a non-significant effect in Chumburung, as mentioned in Connell (2002). So, speech materials were designed to have tokens of +ATR /**i, u**/ to compare with /**a**/ (all with the same tone) and tokens of -ATR /**ɪ, ʊ**/ to compare with /**a**/ (the choice of /**a**/ is due to the absence of a low +ATR vowel in Igbo). With the tokens of +ATR /**i, u**/ compared with /**a**/, we were able to comment on IF0 by vowel height. We also compared the F0 height difference in the first set /**i, u** and **a**/ with that of the second /**ɪ, ʊ** and **a**/. Then, we were able to comment on ATR's effect on F0 (Connell 2012, pers. comm.). Following Liberman &Pierrehumbert (1984), pitch range of utterances was checked, i.e. the difference between F0 maximum and F0 minimum.

Tone minimal pairs were selected from naturally-occurring monosyllabic CV words. The initial vowel tone was altered from high to low tone in order to create tone minimal pairs. In a monosyllabic CV word, C is a bilabial or an alveolar nasal while V is the target vowel. A nasal was chosen because it has been observed that nasals do little to perturbate the F0 of the following vowel (cf. Chávez-Péon 2005). A complete list of the speech materials is given in Table 1.

Table 1: Tone minimal pairs. **dialectal*

| **Tone** | **Minimal Pairs** | |
|---|---|---|
| | High | Low |
| **/ḯ / vs. /ì /** | **mí** | **mì** 'dive' |
| | **ní** | **ni̖** 'bury' |
| **/ú/ vs. /ù/** | **mú** | **mù** |
| | ***nú** 'push' | **nù** |
| **/ɪ́/ vs. /ɪ̀/** | **mÍ** 'slip' | **mÌ** 'bear (fruit), suck' |
| | **nÍ** | ***nÌ** 'endure' |
| **/ʊ́/ vs. /ʊ̀/** | **mʊ́** 'learn' | **mʊ̀** 'I' |
| | **nʊ́** 'hear' | ***nʊ̀** 'fight' |
| **/á/ vs. /à/** | **má** 'know' | **mà** 'stab' |
| | **ná** 'receive' | **nà** 'and' |

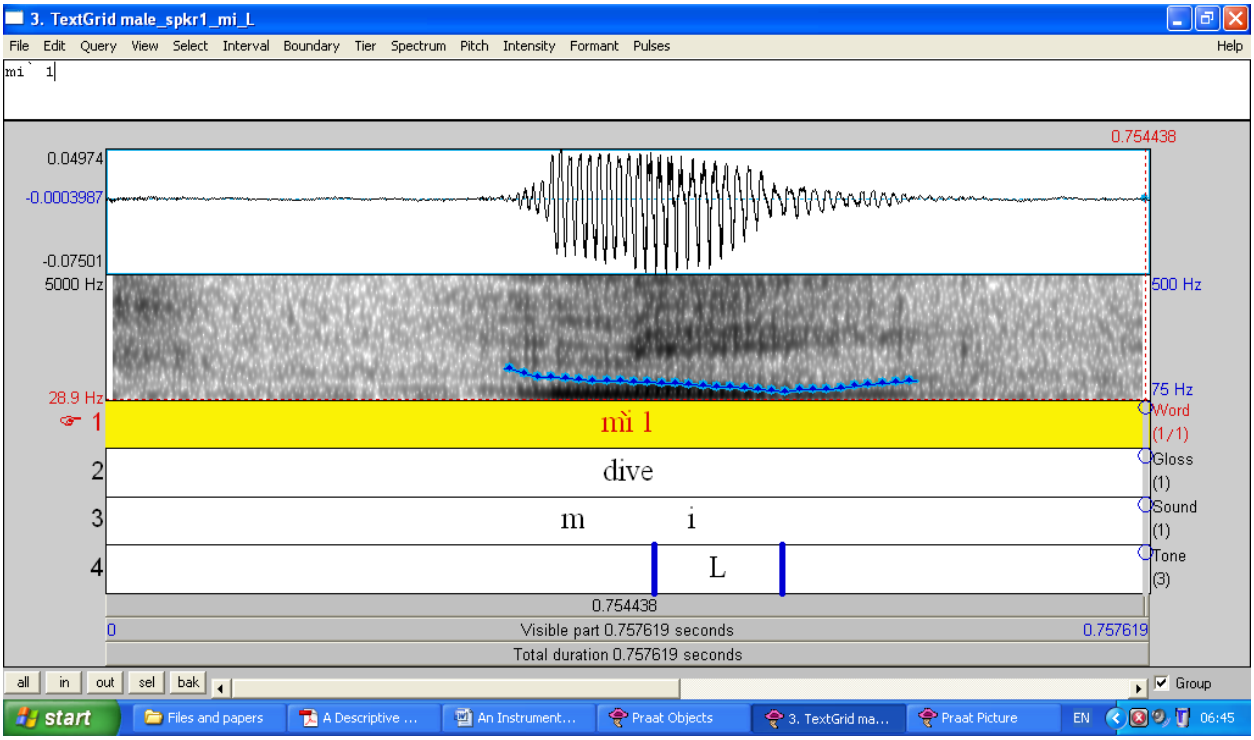


Figure 1: Sound and TextGrid of **mì** 'dive' produced by a male speaker

## 4. Findings

### 4.1 *Overall f0 means*

This section presents a discussion of the speakers' fundamental frequency mean values.

Table 2: F0 mean values of vowels in Hertz

| Speaker | Tone | /i/ | /u/ | /ɪ/ | /ʊ/ | /a/ |
|---|---|---|---|---|---|---|
| Female 1 | H | 245.2 | 256.1 | 249.8 | 256.0 | 207.2 |
| Female 2 | H | 246.5 | 240.2 | 241.3 | 233.9 | 212.3 |
| Male 1 | H | 187.1 | 186.4 | 203.0 | 192.0 | 140.8 |
| Male 2 | H | 183.1 | 183.0 | 184.4 | 183.3 | 167.4 |
| Female 1 | L | 176.1 | 171.1 | 177.1 | 171.6 | 161.1 |
| Female 2 | L | 176.5 | 167.6 | 171.3 | 170.5 | 152.7 |
| Male 1 | L | 132.8 | 132.0 | 130.5 | 123.7 | 106.8 |
| Male 2 | L | 118.3 | 117.6 | 115.1 | 112.9 | 106.4 |

The vowels were all preceded by sonorant consonants /m, n/. The F0 mean values of the vowels set the basis for assessing vowel height and vowel backness as patterns associated with IF0. These will be discussed in the following subsections.

Table 3: Pitch range in Hertz

| Speaker | Tone | F0 Max | F0 Min | Range |
|---|---|---|---|---|
| Female 1 | H | 243.6 | 242.6 | 1.0 |
| Female 2 | H | 235.7 | 233.6 | 2.1 |
| Male 1 | H | 183.0 | 179.0 | 4.0 |
| Male 2 | H | 180.7 | 179.1 | 1.6 |
| Female 1 | L | 172.6 | 167.5 | 5.1 |
| Female 2 | L | 170.8 | 164.0 | 6.8 |
| Male 1 | L | 130.5 | 115.7 | 14.8 |
| Male 2 | L | 116.4 | 111.5 | 4.9 |

It is expected that a pitch-height relation would increase for high tone and diminish for low tone as is the case for Shona vowels (cf. Gonzales 2009). Conversely, the pitch-height relation increased for low tone and diminished for high tone given the increased and decreased pitch range of the vowels respectively, something we have no explanation for at present. The findings illustrate that within the high tone environment, the F0 values for Female Speakers 1&2 and Male Speaker 2 are closer in range than those for the Male Speaker 1. Within the low tone context, Male Speaker 1 has the highest pitch range; while F0 values for Female Speakers 1&2 and Male Speaker 1 are close in range. The result suggests that Male Speaker 1 has a very high pitch range.

4.1.1 *Vowel height*

Table 4: F0 mean values for high and low vowels, and IF0 given in Hertz

| Speaker | Tone | /i, u/ | /a/ | IF0 |
|---|---|---|---|---|
| Female 1 | H | 250.6 | 207.2 | 43.4 |
| Female 2 | H | 243.3 | 212.3 | 31.0 |
| Male 1 | H | 186.7 | 140.8 | 45.9 |
| Male 2 | H | 183.0 | 167.4 | 15.6 |
| Female 1 | L | 173.6 | 161.1 | 12.5 |
| Female 2 | L | 172.0 | 152.7 | 19.3 |
| Male 1 | L | 132.4 | 106.8 | 25.6 |
| Male 2 | L | 117.9 | 106.4 | 11.5 |

In all cases, high vowels /**i, u**/ have greater F0 means than the low vowel /**a**/. The difference is calculated by deducting the F0 mean of /**a**/ from F0 mean of the combined /**i, u**/. There are positive IF0 values indicating a positive correlation between pitch and vowel height.

4.1.2 *Vowel backness*

Table 5: F0 mean values for front and back vowels given in Hertz, with higher F0 in bold

| | **Speaker** | **Tone** | **/i/** | **/u/** |
|---|---|---|---|---|
| **/i/ vs. /u/** | Female 1 | H | 245.2 | **256.1** |
| | Female 2 | H | **246.5** | 240.2 |
| | Male 1 | H | **187.1** | 186.4 |
| | Male 2 | H | **183.1** | 183.0 |
| | Female 1 | L | **176.1** | 171.1 |
| | Female 2 | L | **176.5** | 167.6 |
| | Male 1 | L | **132.8** | 132.0 |
| | Male 2 | L | **118.3** | 117.6 |
| **/ɪ/ vs. /ʊ/** | **Speaker** | **Tone** | **/ɪ/** | **/ʊ/** |
| | Female 1 | H | 249.8 | **256.0** |
| | Female 2 | H | **241.3** | 233.9 |
| | Male 1 | H | **203.0** | 192.0 |
| | Male 2 | H | **184.4** | 183.3 |
| | Female 1 | L | **177.1** | 171.6 |
| | Female 2 | L | **171.3** | 170.5 |
| | Male 1 | L | **130.5** | 123.7 |
| | Male 2 | L | **115.1** | 112.9 |

In Table 5, it is observed that for Female Speaker 2 and Male Speakers 1&2, the front vowels /**i, ɪ**/ have higher F0 means than their back counterparts /**u, ʊ** /, while the F0 values for Female Speaker 1, in a high tone context, shows the reverse. The F0 values for Female Speaker 1, in a high tone context, support Whalen & Levitt's (1995) claim that vowel backness is not a factor in IF0, but that /**u**/ has a tendency to have a higher F0 than /**i**/.

4.1.3 *ATR's effect on f0*

Table 6: F0 mean values and IF0 of +ATR vowels

| **Speaker** | **Tone** | **/i, u/** | **/a/** | **IF0** |
|---|---|---|---|---|
| Female 1 | H | 250.6 | 207.2 | 43.4 |
| Female 2 | H | 243.3 | 212.3 | 31.0 |
| Male 1 | H | 186.7 | 140.8 | 45.9 |
| Male 2 | H | 183.0 | 167.4 | 15.6 |
| Female 1 | L | 173.6 | 161.1 | 12.5 |
| Female 2 | L | 172.0 | 152.7 | 19.3 |
| Male 1 | L | 132.4 | 106.8 | 25.6 |
| Male 2 | L | 117.9 | 106.4 | 11.5 |

Table 7: F0 values and IF0 of -ATR vowels

| Speaker | Tone | /ɪ, ʊ/ | /a/ | IF0 |
|---|---|---|---|---|
| Female 1 | H | 252.9 | 207.2 | 45.7 |
| Female 2 | H | 237.6 | 212.3 | 25.3 |
| Male 1 | H | 197.5 | 140.8 | 56.7 |
| Male 2 | H | 183.8 | 167.4 | 16.4 |
| Female 1 | L | 174.3 | 161.1 | 13.2 |
| Female 2 | L | 170.9 | 152.7 | 18.2 |
| Male 1 | L | 127.1 | 106.8 | 20.3 |
| Male 2 | L | 114.0 | 106.4 | 7.6 |

In a high tone context, -ATR vowels have greater IF0 with the exception of Female Speaker 2 while in a low tone context, +ATR vowels have greater IF0 with the exception of Female Speaker 1. We will say that Female Speakers cannot provide steady IF0. For present purposes the reason for this decision is nil.

4.2 *F0 means per interval*

F0 values were measured at each vowel's onset and 20, 40, 60, 80 and 100 msec after this onset in order to determine if IF0 was more prominent at certain points than others. Results are presented in the following subsections.

4.2.1 *Speaker 1 (Female)*

Table 8: Intervals of high tone vowels F0 means

| Time | 0 ms | 20 ms | 40 ms | 60 ms | 80 ms | 100 ms |
|---|---|---|---|---|---|---|
| F0 | Mean | Mean | Mean | Mean | Mean | Mean |
| /ɪ́ / | 240.4 | 245.3 | 246.1 | 246.1 | 245.6 | 245.4 |
| /ú/ | 237.3 | 248.5 | 252.6 | 255.7 | 256.1 | 256.2 |
| /ɪ́/ | 232.9 | 239.8 | 241.7 | 243.8 | 246.5 | 249.1 |
| /ʊ́/ | 240.7 | 248.4 | 251.3 | 253.7 | 254.6 | 255.2 |
| /á/ | 211.8 | 211.6 | 209.9 | 207.6 | 206.9 | 208.1 |

Table 9: Intervals of low tone vowels F0 means

| Time | 0 ms | 20 ms | 40 ms | 60 ms | 80 ms | 100 ms |
|---|---|---|---|---|---|---|
| F0 | Mean | Mean | Mean | Mean | Mean | Mean |
| /ɪ̂ / | 184.3 | 180.9 | 176.3 | 173.8 | 168.6 | 162.9 |
| /ù/ | 179.0 | 173.6 | 170.9 | 167.9 | 163.8 | 155.2 |
| /ɪ̀/ | 186.9 | 185.0 | 180.9 | 174.6 | 169.1 | 160.9 |
| /ʊ̀/ | 183.1 | 181.6 | 178.6 | 175.7 | 172.1 | 168.0 |
| /à/ | 171.1 | 169.2 | 167.8 | 168.8 | 167.4 | 164.9 |

In a high tone context, vowel backness plays a significant role in the manipulation of vowel F0 for Female Speaker 1 (cf. Table 8). The vowels behave differently. For /**í**/ F0 increase is within 20 ms and 60 ms, then, F0 decreases from 80 ms. For /**ú, ɪ́, ʊ́** / F0 increases as time progresses. For /**á**/ F0 decreases up to 80 ms and increases from 100 ms. In a low tone context, there is a straight forward phenomenon. F0 decreases as time progresses.

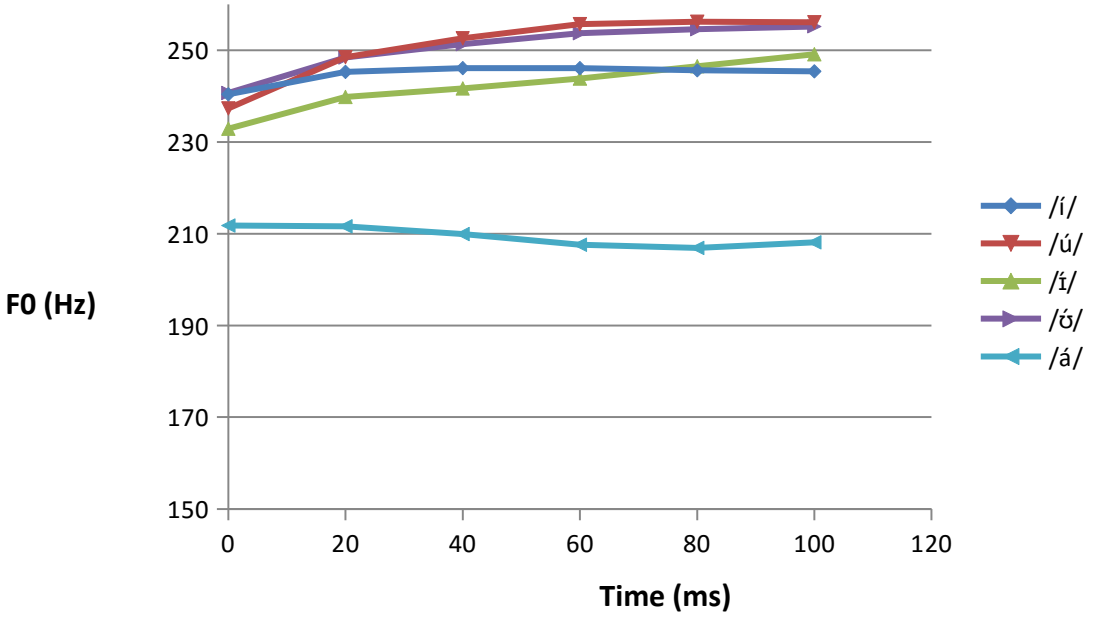


Figure 2: Graph showing intervals of high tone vowels F0 means for Speaker 1 (Female)

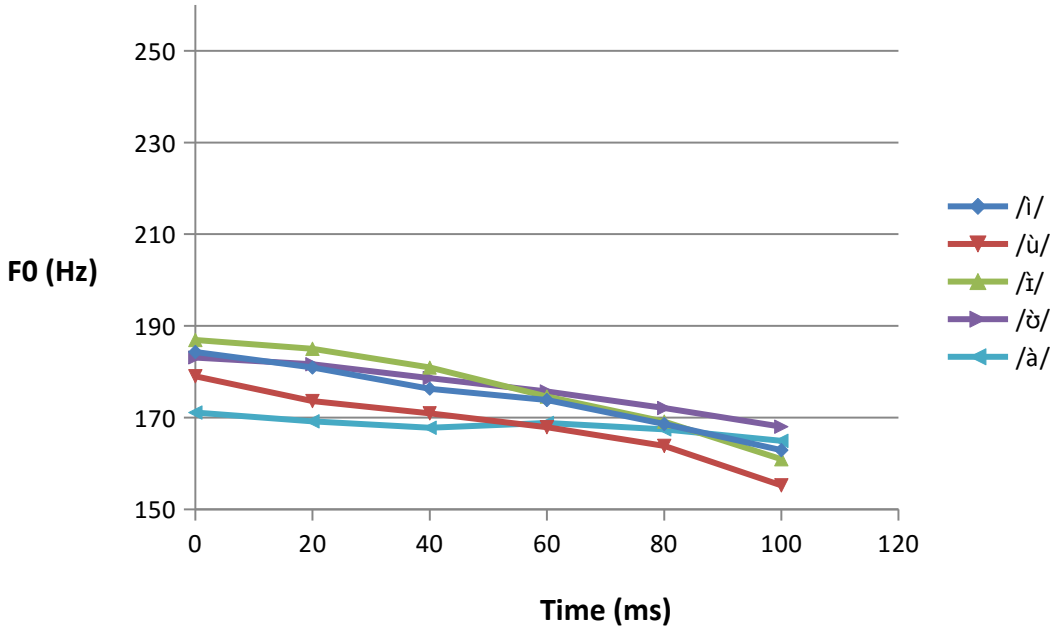


Figure 3: Graph showing intervals of low tone vowels F0 means for Speaker 1 (Female)

4.2.2 *Speaker 2 (Female)*

Table 10: Intervals of high tone vowels F0 means

| Time | 0 ms | 20 ms | 40 ms | 60 ms | 80 ms | 100 ms |
|---|---|---|---|---|---|---|
| F0 | Mean | Mean | Mean | Mean | Mean | Mean |
| /ǐ/ | 234.6 | 239.9 | 243.8 | 245.4 | 246.2 | 245.2 |
| /ú/ | 223.0 | 229.1 | 234.1 | 237.9 | 239.5 | 240.2 |
| /ɪ́/ | 229.0 | 233.3 | 234.8 | 238.3 | 240.5 | 241.6 |
| /ʊ́/ | 233.5 | 233.8 | 233.9 | 233.8 | 233.4 | 232.1 |
| /á/ | 213.4 | 214.6 | 215.3 | 214.2 | 214.1 | 213.5 |

Table 11 *Intervals of low tone vowels F0 means*

| Time | 0 ms | 20 ms | 40 ms | 60 ms | 80 ms | 100 ms |
|---|---|---|---|---|---|---|
| F0 | Mean | Mean | Mean | Mean | Mean | Mean |
| /ǐ/ | 189.4 | 184.4 | 181.8 | 176.9 | 172.4 | 168.4 |
| /ù/ | 180.9 | 176.9 | 174.0 | 171.6 | 164.1 | 160.7 |
| /ɪ̀/ | 184.9 | 183.1 | 179.6 | 173.6 | 168.1 | 161.3 |
| /ʊ̀/ | 173.1 | 173.1 | 170.2 | 166.3 | 162.2 | 158.1 |
| /à/ | 161.8 | 159.3 | 155.3 | 153.1 | 146.8 | 144.7 |

In a high tone context, for /**í**/ F0 increases up to 80 ms and decreases from 100 ms. For /**ú, ɪ́**/ F0 increases as time progresses. For /**ʊ́**/ there is an insignificant rise and fall within 0 ms to 80 ms; F0 decreases from 100ms. For /**á**/ F0 is highest at 40 ms. The pitch contour rises up to 40 ms and falls. In a low tone context, F0 decreases as time progresses.

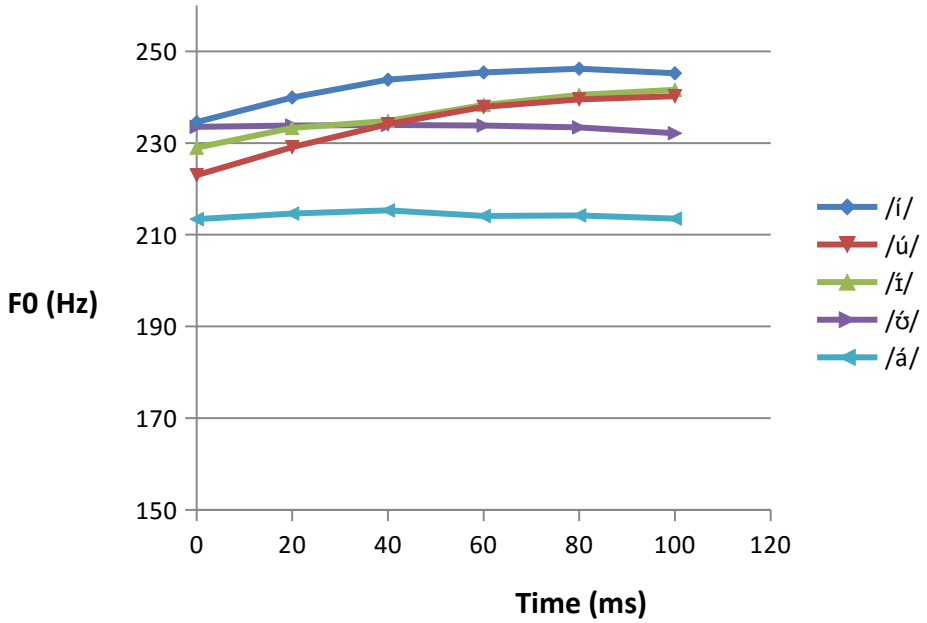


Figure 4: Graph showing intervals of high tone vowels F0 means for Speaker 2 (Female)

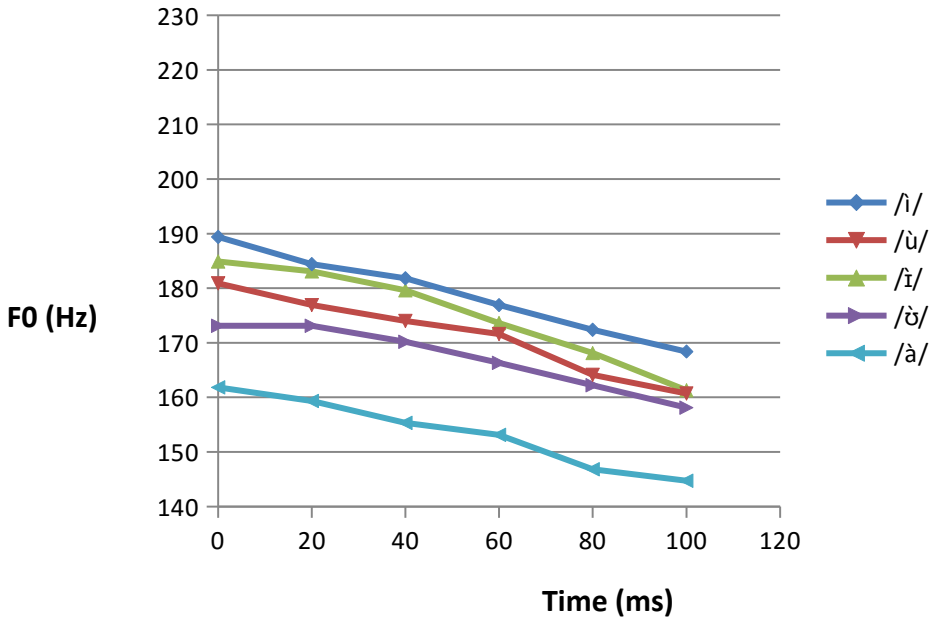


Figure 5: Graph showing intervals of low tone vowels F0 means for Speaker 2 (Female)

4.2.3 *Speaker 3 (Male)*

Table 12: Intervals of high tone vowels F0 means

| **Time** | **0 ms** | **20 ms** | **40 ms** | **60 ms** | **80 ms** | **100 ms** |
|---|---|---|---|---|---|---|
| **F0** | **Mean** | **Mean** | **Mean** | **Mean** | **Mean** | **Mean** |
| **/ǐ/** | 165.0 | 171.1 | 176.7 | 183.1 | 187.6 | 188.6 |
| **/ú/** | 163.3 | 169.9 | 174.3 | 179.5 | 183.1 | 185.8 |
| **/ɪ́/** | 184.2 | 194.3 | 199.6 | 202.3 | 204.5 | 205.7 |
| **/ʊ́/** | 169.8 | 176.4 | 183.9 | 190.5 | 193.3 | 193.5 |
| **/á/** | 139.1 | 143.3 | 142.3 | 139.1 | 139.6 | 140.5 |

Table 13: Intervals of low tone vowels F0 means

| **Time** | **0 ms** | **20 ms** | **40 ms** | **60 ms** | **80 ms** | **100 ms** |
|---|---|---|---|---|---|---|
| **F0** | **Mean** | **Mean** | **Mean** | **Mean** | **Mean** | **Mean** |
| **/î/** | 139.4 | 133.2 | 125.7 | 118.4 | 114.1 | 109.7 |
| **/ù/** | 132.1 | 129.4 | 124.5 | 120.2 | 113.8 | 105.9 |
| **/ɪ̀/** | 142.9 | 140.2 | 136.2 | 135.3 | 128.9 | 121.4 |
| **/ʊ̀/** | 139.9 | 134.3 | 131.2 | 126.1 | 120.8 | 115.8 |
| **/à/** | 125.3 | 121.3 | 114.4 | 103.6 | 100.7 | 98.8 |

In a high tone context, F0 increases as time progresses whereas in a low tone context, F0 decreases as time progresses. We have perfect pitch contours for this speaker (cf. Figures 6 and 7).

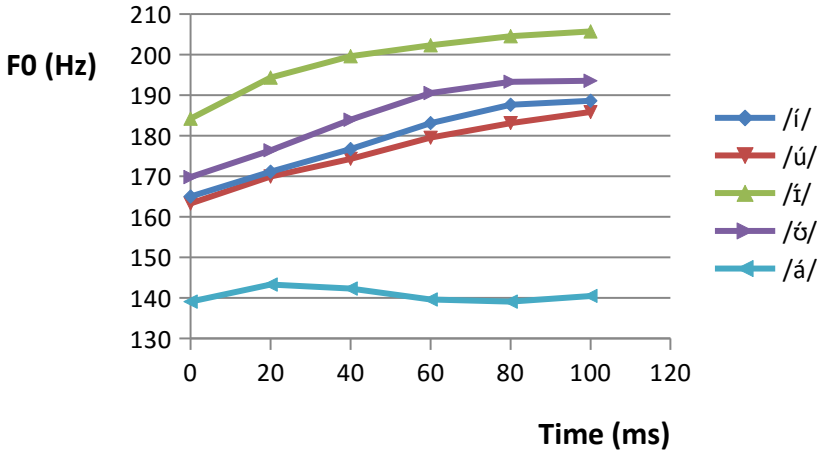


Figure 6: Graph showing intervals of high tone vowels F0 means for Speaker 3 (Male)

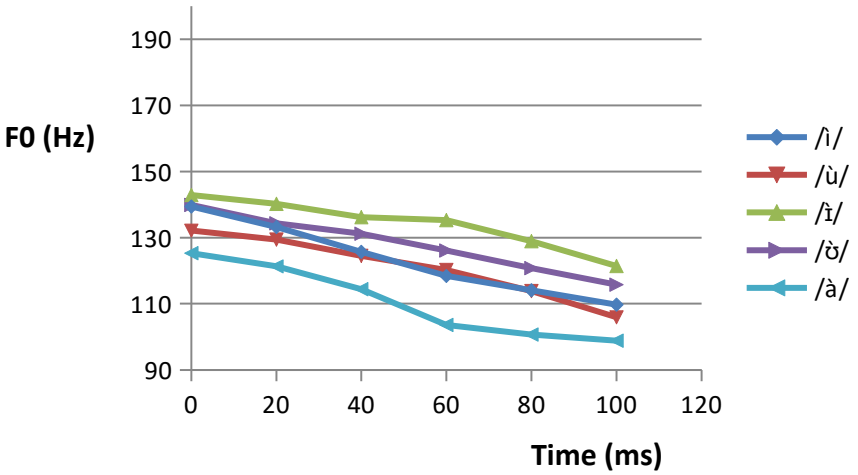


Figure 7: Graph showing intervals of low tone vowels F0 means for Speaker 3 (Male)

4.2.4 *Speaker 4 (Male)*

Table 14: Intervals of high tone vowels F0 means

| **Time** | **0 ms** | **20 ms** | **40 ms** | **60 ms** | **80 ms** | **100 ms** |
|---|---|---|---|---|---|---|
| **F0** | **Mean** | **Mean** | **Mean** | **Mean** | **Mean** | **Mean** |
| /ǐ/ | 158.9 | 166.7 | 173.9 | 177.9 | 181.5 | 181.8 |
| /ú/ | 152.8 | 163.3 | 170.6 | 176.1 | 181.1 | 182.8 |
| /ɨ́/ | 172.1 | 176.1 | 182.0 | 183.3 | 183.9 | 184.2 |
| /ʊ́/ | 164.2 | 170.9 | 176.1 | 180.1 | 181.7 | 181.9 |
| /á/ | 143.9 | 146.8 | 149.4 | 152.8 | 158.5 | 160.8 |

Table 15: Intervals of low tone vowels F0 means

| Time | 0 ms | 20 ms | 40 ms | 60 ms | 80 ms | 100 ms |
|---|---|---|---|---|---|---|
| F0 | Mean | Mean | Mean | Mean | Mean | Mean |
| /ì/ | 112.8 | 118.7 | 116.5 | 115.5 | 114.8 | 119.7 |
| /ù/ | 124.6 | 121.9 | 120.6 | 117.4 | 113.6 | 108.5 |
| /ɪ̀/ | 121.3 | 117.6 | 116.4 | 112.2 | 108.3 | 104.1 |
| /ʊ̀/ | 117.7 | 116.3 | 112.6 | 110.5 | 105.6 | 100.9 |
| /à/ | 116.2 | 111.8 | 108.8 | 104.4 | 103.0 | 100.0 |

In a high tone context, F0 increases as time progresses whereas in a low tone context, F0 decreases as time progresses. Also, we have perfect pitch contours for this speaker (cf. Figures 8&9).

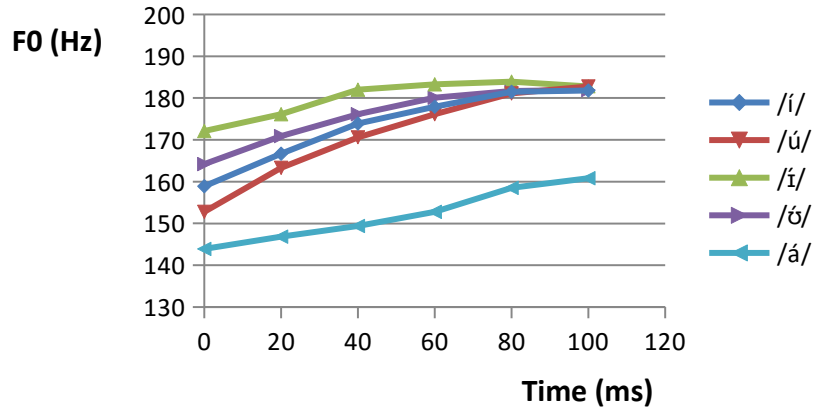


Figure 8: Graph showing intervals of high tone vowels F0 means for Speaker 4 (Male)

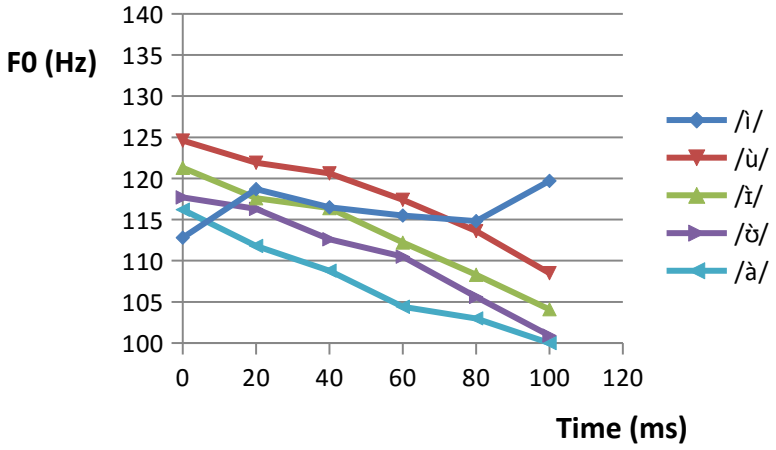


Figure 9: Graph showing intervals of low tone vowels F0 means for Speaker 4 (Male)

## 5. Summary and conclusion

In this paper, we addressed the issue of intrinsic pitch in Igbo, bearing on the general claim that IF0 is a universal phonetic effect (cf. Whalen & Levitt 1995; Whalen, Levitt, Hsiao & Smorodinsky 1995; Whalen, Gick, Kumada & Honda 1998; Connell 2002; Gonzales 2009). IF0 is a function of vowel height; high vowels have higher IF0 than low vowels i.e. the correlation between vowel height and fundamental frequency (Connell 2002). IF0 is generally reduced with low tones except for Male Speaker 1. However, IF0 gradient remains intact for Female Speakers due to their higher speaking range.

This study also observed that differences are found in F0 between high and low vowels when they are realized with both high and low tones. This finding runs counter to Ladd & Silverman's (1984) claim that differences are found in F0 between high and low vowels when they are realized with high tone and not when they are realized with low tone. However, the findings confirm the existence of IF0 in Igbo. Our results also reveal that there is no neutralization or compression of IF0 in Igbo. To a small extent, IF0 gradient exists for vowel backness in a high tone context. In a low tone context, F0 decreases as time progresses.

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