Experimental Analysis of Voicing Contrast in Igbo

Linda Chinelo Nkamigbo*
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Abstract
This study presents experimental evidence to support the two-way voicing contrast of Igbo stops and fricatives. It also focuses on the phonetic details of Igbo stops and fricatives. Digital recordings of the stops and fricatives were made at a sample rate of 44,100Hz and subsequently analysed in Praat. The study looked into the Voice Onset Time of Igbo consonants and observed that the VOT for Igbo stops falls within the range of 12ms and 84ms with velar stops having a longer VOT. The general appearances of the segments in the spectrograms show that for voiced segments there is a major concentration of energy at some higher frequencies while voiceless segments have more energy in the lower frequencies with considerable amount between 1,000 and 3,000 Hz. The spectral slices that were viewed revealed that the peaks of voiced segments have higher amplitudes than those of the voiceless segments.

Introduction
Igbo is a West Benue-Congo language spoken predominantly in the southeastern part of Nigeria. It is spoken in Abia, Anambra, Ebonyi, Enugu, Imo and some parts of Bayelsa, Delta and Rivers states. It is worthy of mention that the variety of Igbo under investigation is the Standard variety. Digital recordings of Igbo stops and fricatives were made with the Edirol and copied onto my Fujitsu Siemens computer. Subsequently, the analysis was done using Praat

version 5.1.25 developed by Paul Boersma and David Weenink (retrieved 31 March, 2010).

Wide band spectrograms and spectral slices were displayed. The view range was set at 1,000-10,000 Hz. The choice of this view range is due to the need to see fricatives. The spectral settings were dependent on the spectrogram settings. This paper tries to determine the VOT of Igbo consonants. The measurements of durations were made on expanded waveforms; Praat showed the duration when portions of the waveforms were selected. VOT was plotted in MS Excel for the voicing contrast and it became very apparent that voiced sounds have more VOT than their voiceless counterparts.

Voicing Contrasts

The release of a stop may be described in terms of the movement of air through the glottis and the vocal tract relative to the three phases of movement of the supralaryngeal articulators: ‘closing phase’, ‘closure’ and ‘release phase’ (Watkins, 2000:85). In Igbo, the airstream associated with stops is pulmonic egressive airstream. Stops that have identical place and manner of articulation are differentiated by voicing.

Maddieson (1984) surveys voicing contrasts in some languages of the world and observes that only five languages in his database make use of four-way voicing contrast. The four-way voicing contrast is plain voiceless, aspirated voiceless, plain voiced and voiced aspirated stops. Similarly, Watkins (2000) reveals that Wa, a Northern Mon-Khmer language spoken in an area on the border between China’s

Yúnnán Province and Burma's [Myanmar's] Shan State, makes use of four-way voicing contrast like that observed in Maddieson (1984). Dixit (1989), Schiefer (1992) and Davis (1994) have presented phonetic details of a similar system of contrasts in Hindi.

There is a two-way voicing contrast in Igbo. The two-way voicing contrast of Igbo stops and fricatives is voiced and voiceless stops and fricatives. Igbo stops include voiced bilabial plosive /b/ and its voiceless counterpart /p/; voiced alveolar plosive /d/ and its voiceless counterpart /t/; and voiced velar plosive /g/ and its voiceless counterpart /k/. Igbo fricatives are voiced labio-dental fricative /v/ and its voiceless counterpart /f/; voiced alveolar fricative /z/ and its voiceless counterpart /s/; voiceless palatal fricative /ʃ/ and voiced velar fricative /ɣ /.

Voice Onset Time (VOT)

Voice Onset Time has received enormous scholarly attention since the classic experiments of Lisker and Abramson (1964). They measured voice onset time as "the interval between the release of the stop and the onset of glottal vibration, that is, voicing" (Lisker & Abramson 1964:389). Lisker and Abramson demonstrated that voice onset time may be thought of as a continuum which languages carve up in different ways for the purposes of stop consonant perception (Watkins, 2000:89).

VOT clearly distinguishes voiced stops from voiceless stops. There are no stops with VOT between -20ms and 0ms. On the basis of these measurements, it can be stated that there is vocal fold vibration prior to the burst in all stops which are classified here as phonologically 'voiced'. Languages differ in terms of their use of Voice Onset Time. Ladefoged (2003) observes that Navajo has voiceless aspirated velar stops with a VOT of over 150ms, whereas the comparable stops in Scottish Gaelic have a mean VOT of about 75ms.

Data Presentation and Analysis

The data were analysed by looking at the voicing contrast of stops at different places of articulation namely bilabial, alveolar and velar. The voicing contrast for fricatives was processed by looking at only the alveolar fricatives. This is because frication is less significant to voice onset time.

<u>Waveforms and the measurement of duration</u>

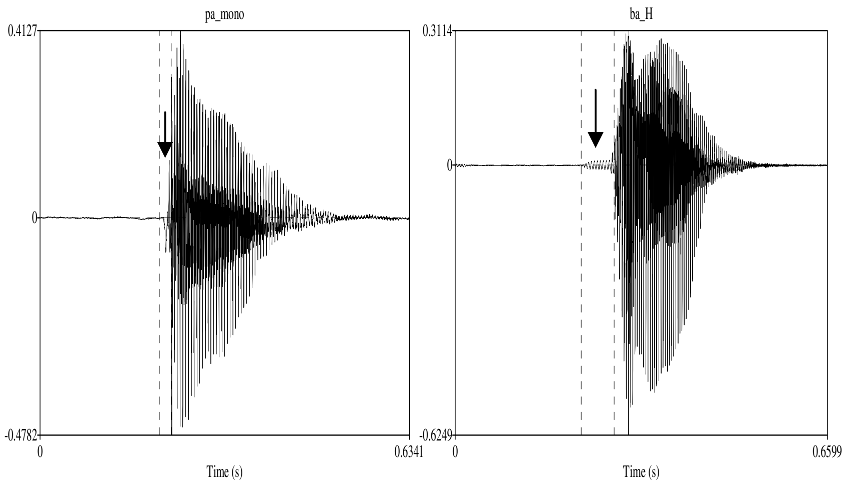


Figure 1.1 The waveforms of /p/ and /b/ in word-initial position. The arrows indicate possible burst.

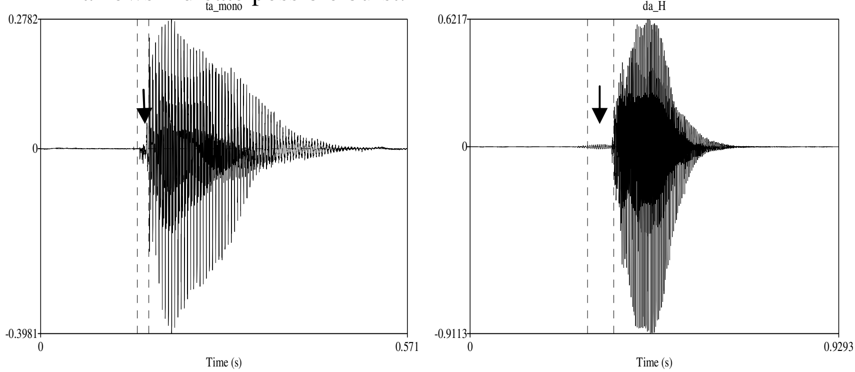


Figure 1.2 The waveforms of /t/ and /d/ in word-initial position. The arrows indicate possible burst.

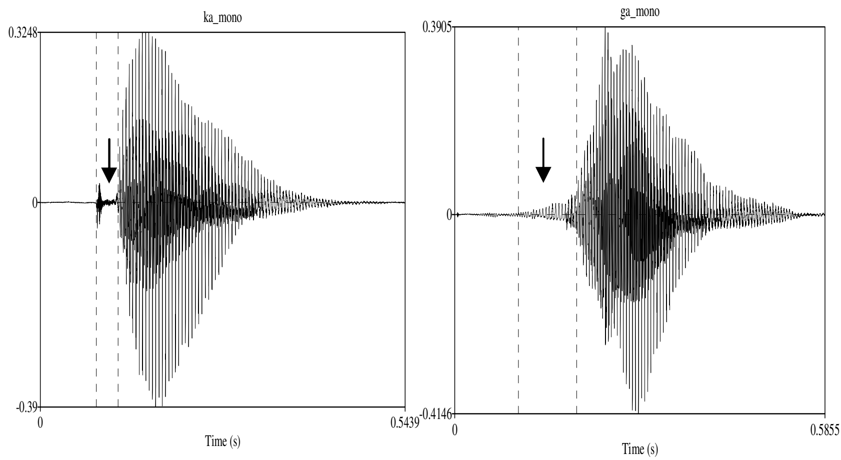


Figure 1.3 The waveforms of /k/ and /g/ in word-initial position. The arrows indicate possible burst.

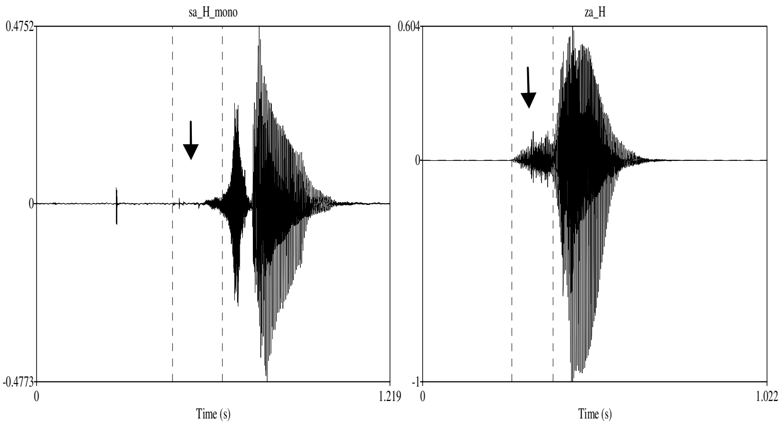


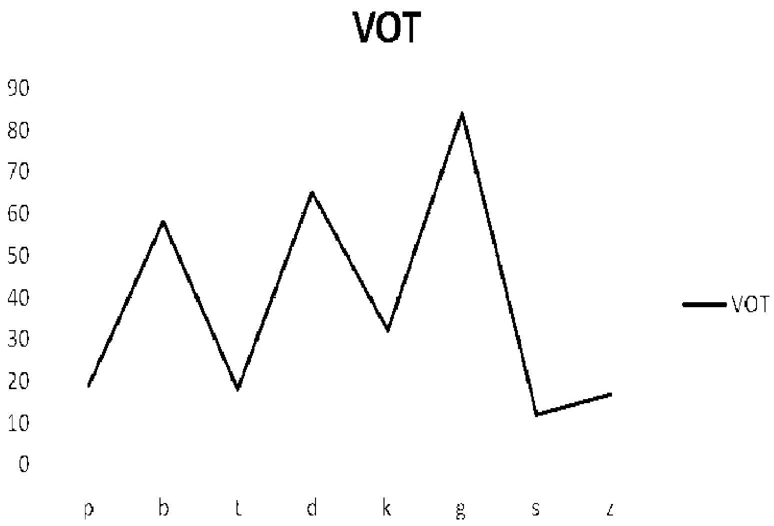
Figure 1.4 The waveforms of /s/ and /z/ in word-initial position. The arrows indicate possible frication.

It can be averred from figures 1.1 to 1.3 that voiceless stops have shorter bursts than their voiced counterparts. In figure 1.1, the duration of /p/ burst is 19ms while that of /b/ is 58ms. Similarly, the duration of /t/ burst in figure 1.2 is 18ms while /d/ measures 65ms. In particular, voice onset time has been found to be longer with more back articulations (see Byrd 1993 for English data).

Ladefoged (2003:98) affirms, “Stops that are made further back in the mouth usually have a longer VOT”.

Ladefoged's assertion is supported by figure 1.3. The duration of /k/ burst is 32ms while that of /g/ is 84ms. The flat lines in figures 1.1 to 1.4 indicate closure. There is absolutely no voicing during the closures. Flat lines could be seen in all the waveforms because the sound segments are at word-initial position and they are not preceded by voiced sounds. Voiced sounds are usually fully voiced only when they occur intervocalically.

The arrows in figure 1.4 delineate frication. The fricative /z/ has a noisy waveform with greater amplitude than /s/. While /z/ measures 17ms, /s/ measures 12ms. Charts 1 (a) and (b) below show that voiced sounds have greater VOT than their voiceless counterparts.



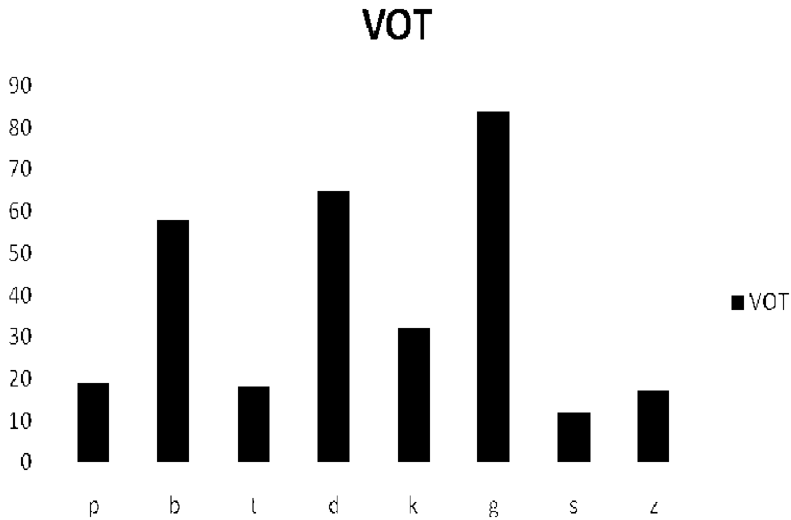


Chart 1(b) Bar chart of voice onset time showing voicing contrasts.

Back consonants have greater amplitudes than their front counterparts. This can be readily seen in chart 1b. For voiced segments /g/ has the greatest amplitude while for voiceless segments /k/ has the highest amplitude.

<u>Spectrograms and voicing contrasts</u>

Segments are easily identifiable in spectrograms. This section provides several remarks about the general appearances of Igbo stops and fricatives.

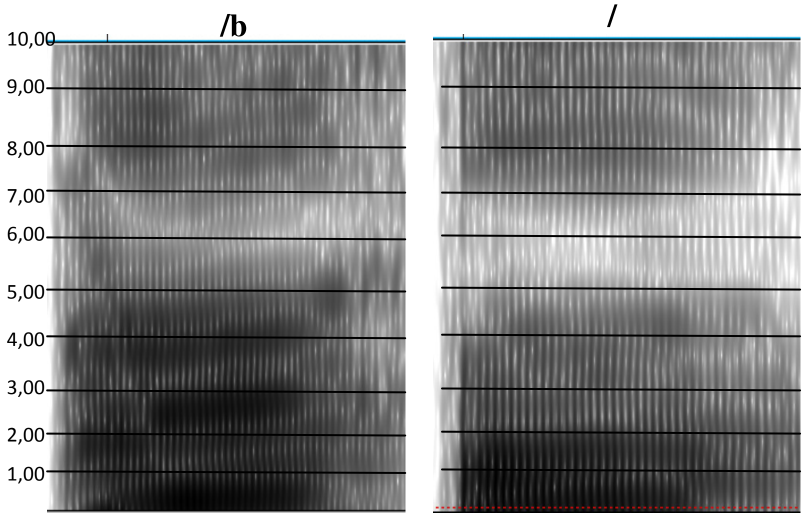


Figure 2.1 Spectrograms of /b/ in *ba* and /p/

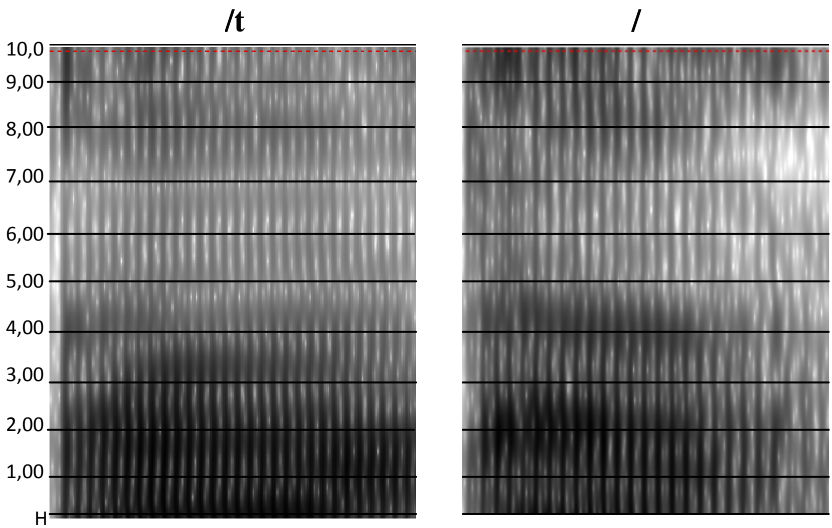


Figure 2.2 Spectrograms of /t/ in *ta* and /d/ in

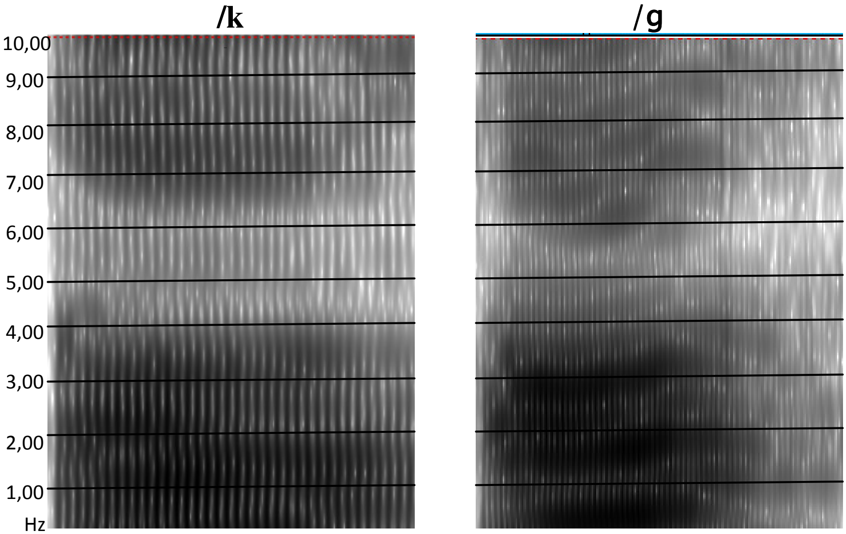


Figure 2.3 Spectrograms of /k/ in *ka* and /g/ in

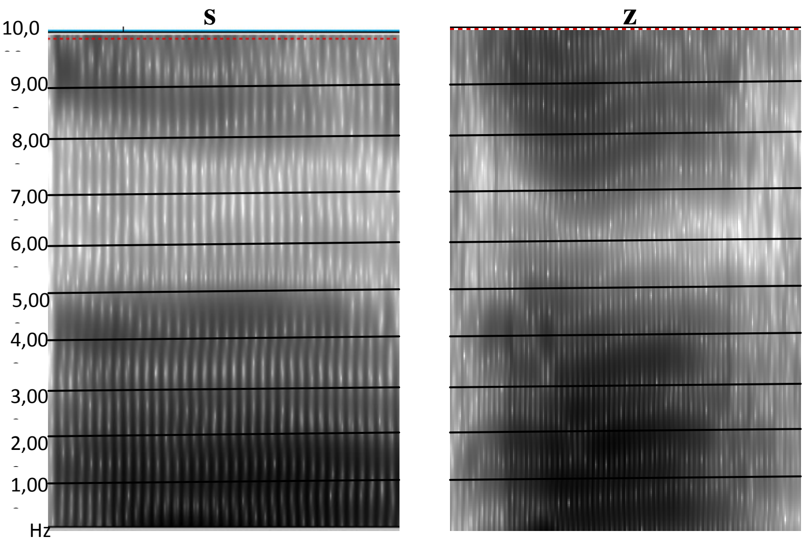
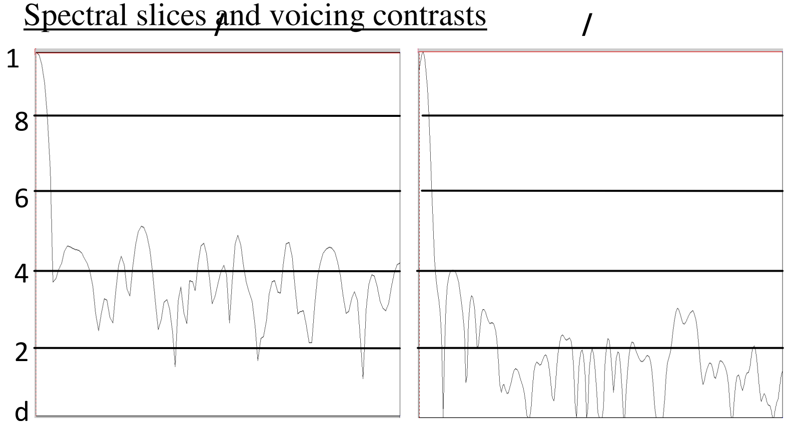


Figure 2.4 Spectrograms of /s/ in *sa* and /z/

In figure 2.1, /p/ has most energy below 2,000 Hz while /b/ has most energy between 1,000 and 4,000 Hz. For /b/ there is a great deal of energy between 8,000 and 10,000 Hz. In figure 2.2, /t/ has most energy below 3,000 Hz while /d/ has most energy between 1,000 and 3,000 Hz. Some amount of energy could also be seen around 4,000 Hz and between 8,000 and 10,000 Hz for /d/. Similarly, in figure 2.3, /g/ has darker parts in the spectrogram than /k/. /g/ has most energy between 1,000 and 4,000 Hz. This shows that /g/ has more energy concentration than /k/. The situation in figure 2.3 repeats itself in figure 2.4. /s/ has lighter portions in the spectrogram than /z/. /z/ has most energy between 1,000 and 4,000 Hz. Dark parts of the spectrogram show a lot of amplitude or energy. Acoustically, voiceless sounds are very easy to identify because they are characterized by silence. There are empty patches of the spectrograms in figures 1.1 to 1.4 which delineate silence.

<u>Spectral slices and voicing contrasts</u>



. *Figure 3.1* Spectral slices of /b/ and

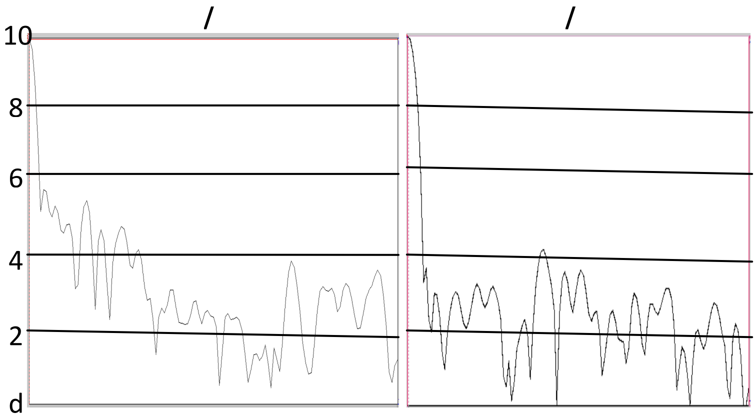


Figure 3.2 Spectral slices of /d/ and /t/.

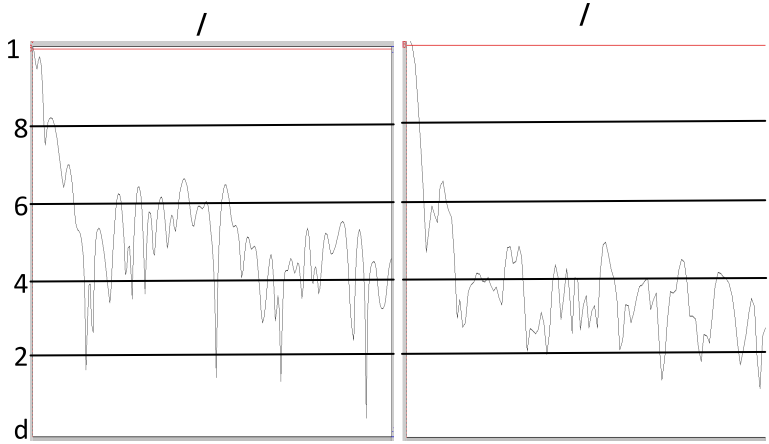


Figure 3.3 Spectral slices of / g / and /k /.

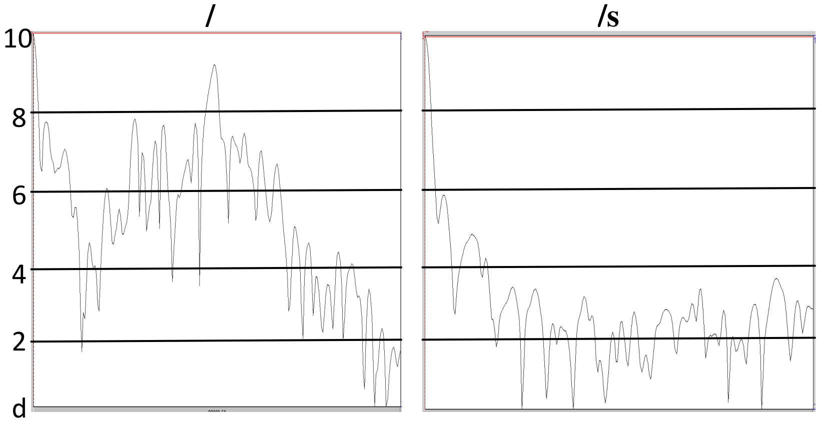


Figure 3.4 Spectral slices of /z/ and /s/.

Figures 3.1 to 3.4 reveal that voiced sounds have higher amplitude of the harmonics than their voiceless counterparts. In figure 3.1, the amplitude of the peak of /b/ is 51.3 dB while that of /p/ is 40 dB. Figure 3.2 reveals that the amplitude of the peak of /d/ is 55.7 dB while that of /t/ is 41.4 dB. Figure 3.3 shows that the amplitude of the peak of /g/ is 82.1 dB while that of /k/ is 64.3 dB. In figure 3.4, the amplitude of the peak of /z/ is 92.5 dB while that of /s/ is 58.9 dB. It is noteworthy that the peak is the point where the highest energy is.

Summary and Conclusion

Igbo makes use of two-way voicing contrast which is evident in voiced and voiceless stops and voiced and voiceless fricatives. Voiced stops have greater bursts than their voiceless counterparts. In the same manner, voiced fricatives have greater frication than their voiceless counterparts. The disparities in bursts and frication could be seen in figures 1.1 to 1.3 and charts 1 (a) and (b). The appearances of stops and fricatives in spectrograms delineated the voicing contrast under question. Voiced segments have darker parts in the spectrograms than their voiceless counterparts.

Spectral slices were viewed and peaks were measured. The measurements revealed that voiced sound segments have higher amplitudes than their voiceless counterparts. The highest amplitude for voiceless stops is 64.2 dB while the highest amplitude for voiced stops is 82.1 dB with velar stops having the greatest values. VOT measurements for the investigated consonants are as follows: /p/ = 19ms, /b/= 58ms, /t/ = 18ms, /d/ = 65ms, /k/ = 32ms, /g/ = 84ms, /z/ = 17ms, /s/ = 12ms. The consonants have most energy at the following frequencies: /p/ = below 2,000 Hz; /b/ = between 1,000 and 4,000 Hz and between 8,000 and 10,000 Hz; /t/ = below 3,000 Hz; /d/ = between 1,000 and 3,000 Hz and between 8,000 and 10,000 Hz; /g/ = between 1,000 and 4,000 Hz; /z/ = between 1,000 and 4,000 Hz; /k/ and /s/ show only light portions in the spectrograms. The amplitude measurements of the consonants' peaks are: /p/ =40 dB, /b/ =51.3 dB, /t/ =41.4 dB, /d/ =55.7 dB, /k/ =64.3 dB, /g/ =82.1 dB, /s/ =58.9 dB, /z/ =92.5 dB.

In conclusion, velar stops have greater voice onset time and amplitude than bilabial and alveolar stops.

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**Linda Chinelo Nkamigbo is of the Department of Linguistics, Nnamdi Azikiwe University, Awka*