Vowel Coarticulation in Shona

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Abstract

Shona has breathy voiced consonants and modal voiced consonants. This paper reports the coarticulatory effects on vowels in environments that follow breathy voiced consonants and modal voiced consonants in Shona. The hypothesis in this study is that breathy voiced consonants have coarticulatory effects on the following vowels. From the result, coarticulatory effects could be observed in the differences in F0 values and the duration. On the other hand, the difference in F1 values was too small to support the coarticulatory effects on the following vowels. Moreover, coarticulatory effects on the following vowels could not be verified in H1-H2 values.

1 Introduction

In Shona, a language spoken in Zimbabwe, modal and breathy phonation can be observed. Although some previous studies show phonetic characteristics of breathy voice sounds, coarticulatory effects on vowels following breathy voiced consonants in Shona are still underinvestigated. This current study focuses on the vowels in environments following breathy and modal voiced consonants. By comparing their effects on the following vowels, the effects of breathy voiced consonants on the following vowels are analyzed. This paper targets three different vowels, [a], [i] and [o]. I hypothesize that there are coarticulatory effects on vowels in the post breathy environment in Shona. This current study elucidates coarticulatory effects on vowels regarding vowel duration, and F0, F1 and H1-H2 values. This paper is organized as follows: 2. Acoustic correlates of breathiness, 3. Methods, 4. Results, 5. Discussions, and 6. Conclusion. Section 2 introduces some previous studies about the phonetic feature of breathy voiced sounds. Section 3 presents experimental methods to measure breathiness in the current study. Section 4 describes the results of this experiment. Section 5 presents the analysis of the results. Section 6 concludes this paper.

2 Acoustic correlates of breathiness

In this section, several possible ways to measure breathiness are discussed. Analysis of data in this paper was conducted based on the measurements discussed in this section.

Gordon (2001) states that in breathy voiced vowels, "the harmonic closest to the first formant has much lower amplitude than the fundamental" (p.17). H2 (the 2nd harmonic) is greatly lower in amplitude than H1 (the 1st harmonic) in the breathy phonation, but on the other hand, H2 is slightly lower than H1 in the modal phonation. In short, breathy voiced vowels show the higher value of H1-H2 than those of modal voiced vowels. Thus, it is possible to measure breathiness of sounds based on the H1-H2 value.

The other two ways to measure breathiness is based on the F0 and F1 values of sounds. Breathy voiced sounds show a lower F0 value in Chong because of the larynx lowering. (Gordon, 2001, p.17). Moreover, breathy voiced vowels show lower F0 and F1 values than those of modal voiced vowels in Kedang, which is caused by increased pharyngeal width (Gordon, 2001, p.18). These phenomena can be observed because the larynx lowering for breathy phonation makes the vocal tract longer so that the resonance frequency gets lower. Considering that some languages show correlations between breathy voiced sounds and low F0 and F1 values, I assume that breathy voiced sounds also have lower F0 and F1 values than modal voiced sounds in Shona.

The last measurement for breathiness is to measure the duration of vowels. Gordon (2001) observes "breathy voiced vowels are substantially longer than modal vowels in Kedang and Jalapa Mazatec" (p.18). Therefore, duration of vowels after the breathy voiced consonants is used as one of the criteria to measure breathiness in this paper.

3 Methods

All of the data were collected by recording a single Shona speaker, who pronounced a list of 18 words containing breathy voiced consonants and modal voiced consonants. The speaker is a female from Zimbabwe and speaks the Manyika dialect with knowledge of Zezuru, Karanga and Ndau dialects in the Shona group. She did not have any illnesses or hearing problem that would have affected her speech.

The list of words can be divided into two main categories: words beginning with breathy voiced consonants, and words containing modal voiced consonants. This paper uses the following four measurements as discussed in Section 2 to analyze the phonation effects on vowels following breathy voiced consonants and modal voiced consonants: (1) H1-H2, (2) F0 at the midpoint, (3) F1 at the midpoint, and (4) duration. Based on the values obtained from these measurements, this paper discusses effects of breathy voiced consonants on the phonation of the following vowels. All of the data were analyzed and annotated using the software Praat.

3.1 *Stimuli* This study targets [a], [i], and [o] vowels among the five different types of vowels in Shona. This research focuses on these three vowels because their places of articulation are not close to each other. As shown in Table 1, there are three words for each vowel for breathy and modal phonations, so there are 18 words in total. Each word is recorded three times in a row, resulting in a total of 54 tokens.

Table 1: Dataset collected from recordings of Shona 001.

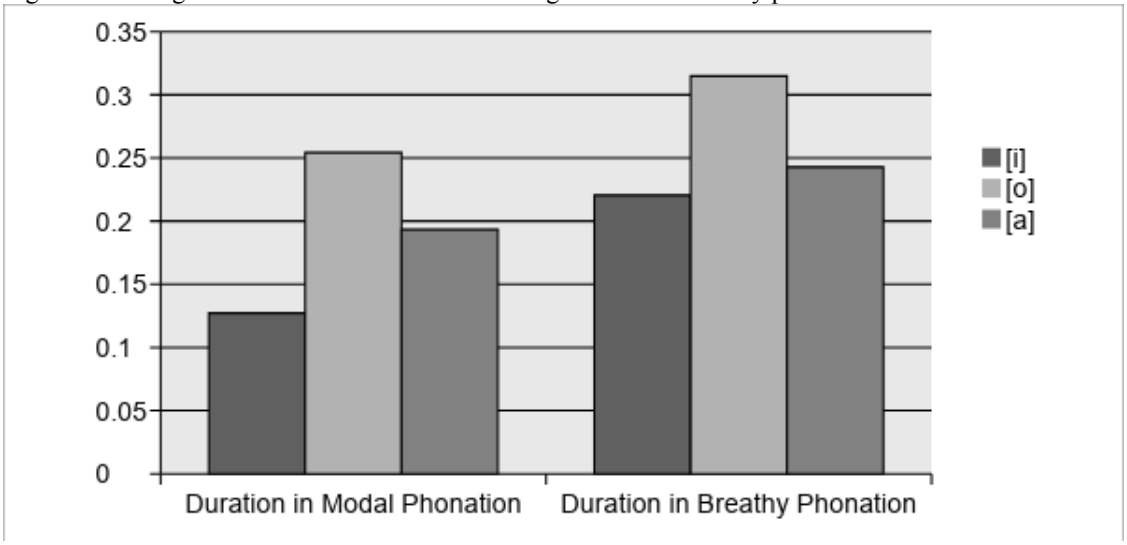
	[i]	[o]	[a]
Modal	[pinda] ‘enter’	[tonora] ‘cold’	[katsi] ‘cat’
Modal	[pikata] ‘carry piggyback’	[doroba] ‘town’	[kapi] ‘baby’s bonnet’
Modal	[mupimbira] ‘shin’	[kora] ‘thick’	[ipa] ‘give’
Breathy	[d̤ibi] ‘disinfectant place for cows’	[d̤ora] ‘money’	[d̤akisa] ‘intoxicate’
Breathy	[d̤inda] ‘stem’	[g̤ora] ‘voucher’	[d̤ara] ‘old man’
Breathy	[d̤irtza] ‘to destroy’	[d̤onza] ‘pull’	[d̤amba] ‘to loose’

3.2 *Analysis* To analyze the sound data, I used Praat for annotation. I made the decision for marking boundaries between plosives and vowels based on the periodicity of waveforms. Plosives are divided into shutting, closure and release burst stages. The release burst is a stage showing aperiodic waveforms. Furthermore, none of the plosives were aspirated in the sound data. Accordingly, it is reasonable to mark boundaries between plosives and vowels because the waveform of the release burst of plosives is aperiodic while that vowels is periodic. Additionally, several Praat scripts were used for data processing. All the raw data of the measurements are shown in the appendix.

4 Results

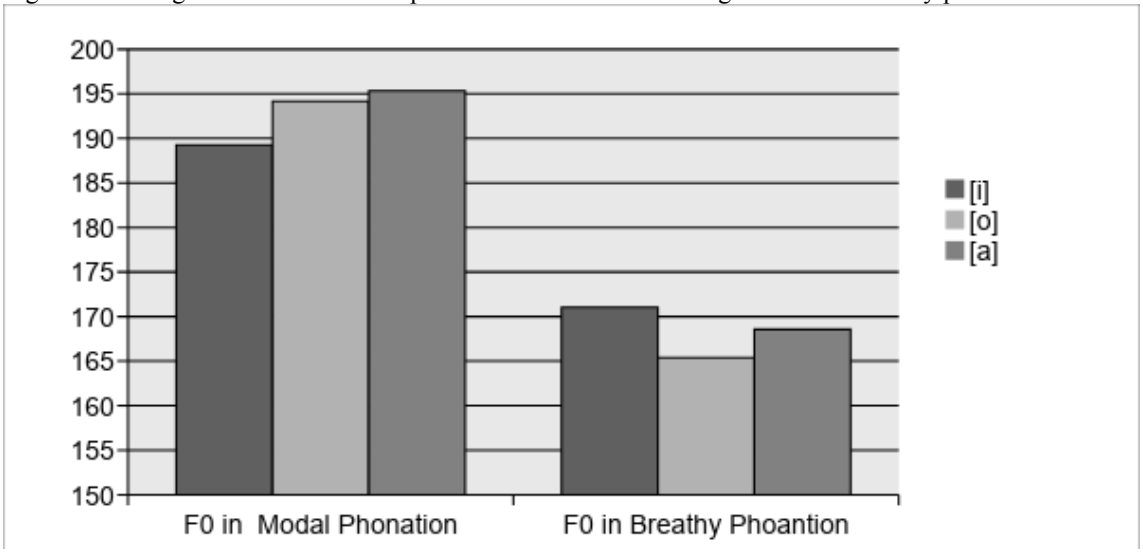
4.1 *Duration* The average duration of each vowel following modal and breathy phonations is shown in Figure 1. It is observed that vowels following breathy voiced consonants show longer durations than those following modal voiced consonants; the average duration of [i] vowel following modal voiced consonants is 0.1272 seconds while that following breathy voiced consonants is 0.2205 seconds. In the same way, the duration of [o] vowel following modal voiced consonants is 0.2543 seconds while that following breathy voiced consonants is 0.3148 seconds, and the duration of [a] vowel following modal voiced consonants is 0.1933 seconds while that following breathy voiced consonants is 0.2428 seconds.

Figure 1: Average duration of each vowel following modal and breathy phonations.



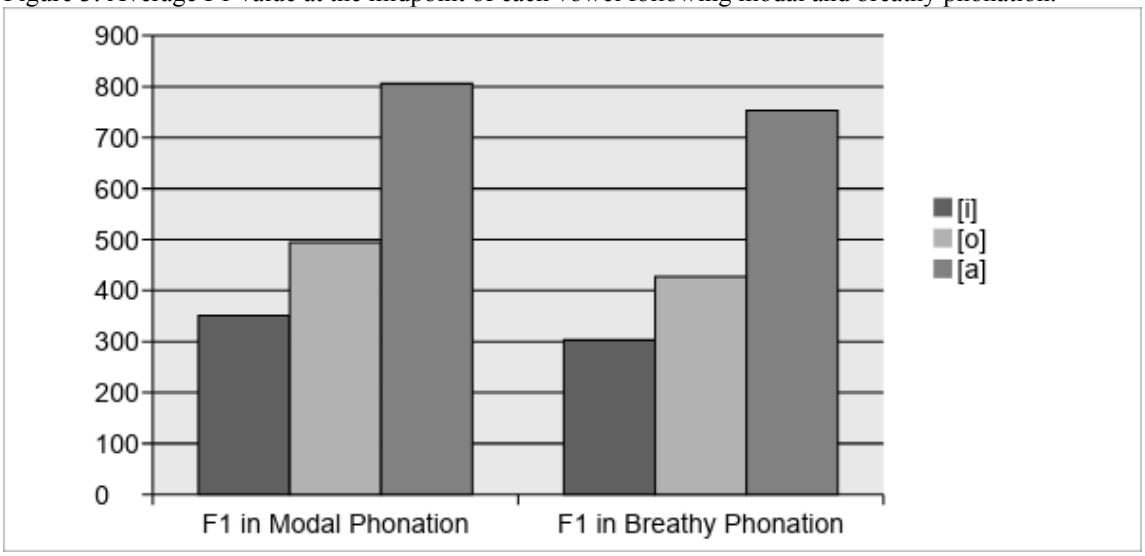
4.2 *Fundamental Frequency (F0)* Vowels following breathy voiced consonants show lower F0 values at the midpoint than those following modal voiced consonants; the F0 value at the midpoint of [i] following modal voiced consonants is 189.25 Hz while that following breathy voiced consonants is 171.02 Hz. Similarly, the F0 value at the midpoint of [o] following modal voiced consonants is 194.18 Hz while that following breathy voiced consonants is 165.39 Hz, and the F0 value at the midpoint of [a] following modal voiced consonants is 195.33 Hz while that following breathy voiced consonants is 168.56 Hz. Figure 2 represents this difference in F0.

Figure 2: Average F0 value at the midpoint of each vowel following modal and breathy phonations.



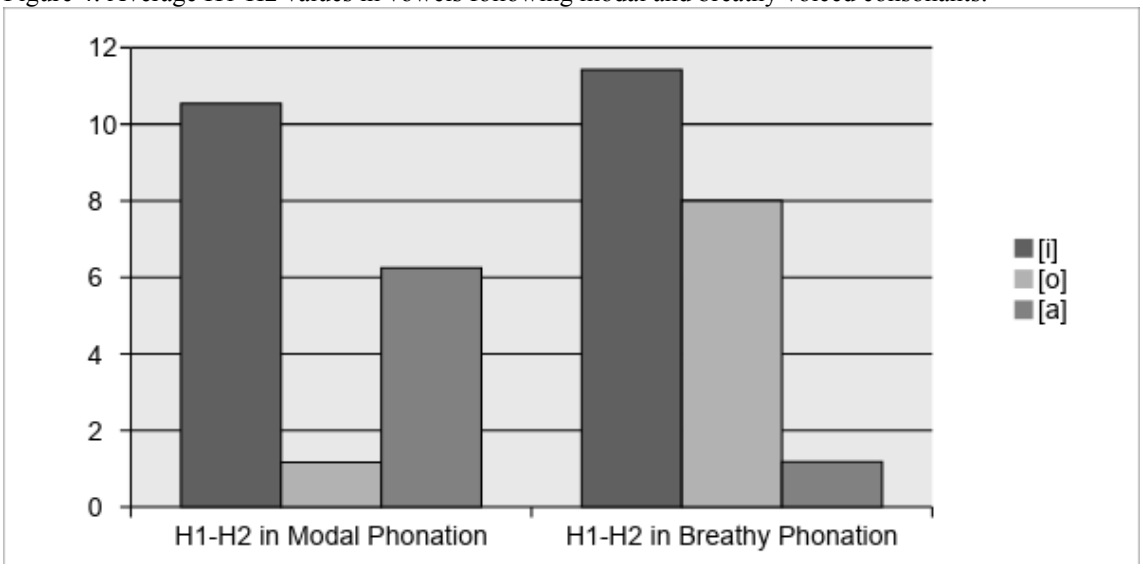
4.3 *The First Formant (F1)* The vowels following the breathy voiced consonants show slightly lower F1 values at the midpoint than those following modal voiced consonants; the F1 value at the midpoint of [i] following modal voiced consonants is 350.75 Hz while that following breathy voiced consonants is 303.06 Hz. In the same way, the F1 value at the midpoint of [o] following modal voiced consonants is 494.5 Hz while that following breathy voiced consonants is 426.98 Hz, and the F1 value at the midpoint of [a] following modal voiced consonants is 805.67 Hz, while that following breathy voiced consonants is 752.78 Hz. Figure 3 illustrates these measurements.

Figure 3: Average F1 value at the midpoint of each vowel following modal and breathy phonation.



4.4 *H1-H2* Figure 4 shows average H1-H2 values in different vowel types. Unlike the average durations, F0 and F1 values did not show a consistent pattern. As shown in Figure 4, the average H1-H2 value of [i] following modal voiced consonants is 10.54 Hz while that following breathy voiced consonants is 11.42 Hz. Similarly, the average H1-H2 value of [o] following modal voiced consonants is 1.169 Hz while that following breathy voiced consonants is 8.001 Hz, and the average H1-H2 value of [a] following modal voiced consonants is 6.248 Hz while that following breathy voiced consonants is 1.175 Hz.

Figure 4: Average H1-H2 values in vowels following modal and breathy voiced consonants.



5 Discussions

5.1 *Duration* Comparing the durations for F0 and F1 values at the midpoint of each vowel following modal voiced consonants and breathy voiced consonants, it seems that there is a coarticulatory effect of breathy voiced consonants on the following vowels. It is observed that vowels following breathy voiced consonants show longer durations than those following modal voiced consonants. This result correlates with the previous study that breathy voiced vowels show longer durations than modal voiced vowels in Kedang and Jalapa Mazatec (Gordon, 2001, p.18). I found that breathy voiced consonants have an influence on the

following vowels in terms of the duration.

5.2 *Fundamental Frequency (F0)* Considering the F0 value at the midpoint of vowels following the modal voiced consonants and breathy voiced consonants, coarticulatory effects of breathy voiced consonants on the following vowel can be seen. The vowels following breathy voiced consonants show lower F0 values than those following modal voiced consonants. As the previous study states that breathy phonation types often exhibit a lowered F0 value compared with modal phonation F0 in some languages (Gordon, 2001, p.17-18), this result indicates that there is a coarticulatory effect of breathy voiced consonants on the following vowels regarding the F0 value.

5.3 *The First Formant (F1)* Although vowels following breathy voiced consonants show slightly lower F1 values at the midpoint than those following modal voiced consonants, the difference in F1 values is minimal compared with the difference in F0 values. Yet, the result of this paper still corresponds to the previous research, which states breathy voiced sound shows a lower F1 value compared with the modal voiced sound in some languages (Gordon, 2001, p.17-18). However, the difference in the F0 values between breathy voiced consonants and modal voiced consonants is too small to conclude that the F1 values at the midpoint of vowels following modal voiced consonants and breathy voiced consonants support the coarticulatory effect of breathy voiced consonants on the following vowels. Thus, the result did not provide sufficient evidence to state that there is a coarticulatory effect of breathy voiced consonants on the following vowels regarding F1 values.

5.4 *H1-H2* The average H1-H2 values in both vowels following modal voiced consonants and breathy voiced consonants did not correspond to the result of the previous study mentioned in Section 2. According to the previous study, breathy voiced vowels show high H1-H2 values than that of modal voiced vowels. However, in this study, the vowels following breathy voiced consonants did not show consistent higher H1-H2 values than those following modal voiced consonants. One of the possible reasons of this result is the inconsistency of preceding consonants in terms of the place of articulation. It is possible that the difference in the place of articulation affects the phonation of the following vowels.

6 Conclusion

This paper investigates the coarticulatory effects on vowels in environments that follow breathy voiced consonants and modal voiced consonants in Shona. The hypothesis in this study is that breathy voiced consonants have coarticulatory effects on the following vowels. From the result, coarticulatory effects could be observed in the differences in F0 values and the duration. On the other hand, the difference in F1 values was too small to support the coarticulatory effects on the following vowels. Moreover, coarticulatory effects on the following vowels could not be verified in H1-H2 values. As for the enhancement of reliability of this study, preceding consonants of the vowels of the selected words should be unified in terms of the place of articulation, since the difference of the place of articulation might have affected the result of values for H1-H2, F0, and F1, and the duration.

7 Appendix

The values for H1-H2, F0, and F1, and the duration at the midpoint of vowels of each token.

phonation	word	vowel	H1-H2	duration	f0_midpoint	F1_midpoint
modal	[pinda]	[i]	17.108	0.1581	179.91	362.5
modal	[pinda]	[i]	13.893	0.1895	174.18	358.01
modal	[pinda]	[i]	14.965	0.1864	180.51	345.55
modal	[pikata]	[i]	7.0768	0.1033	209.31	307.51
modal	[pikata]	[i]	10.365	0.1027	202.43	370.3

modal	[pikata]	[i]	13.1	0.0926	199.57	373.12
modal	[mupimbira]	[i]	4.5604	0.0865	190.72	326.91
modal	[mupimbira]	[i]	6.4505	0.1187	182.51	364.39
modal	[mupimbira]	[i]	7.345	0.1076	184.19	348.51
modal	[tonora]	[o]	3.91	0.1689	238.77	539.91
modal	[tonora]	[o]	4.053	0.2165	230.65	583.84
modal	[tonora]	[o]	5.2131	0.2511	236.99	499.39
modal	[doroba]	[o]	3.1787	0.1812	161.25	449.77
modal	[doroba]	[o]	1.0234	0.1853	162.97	437.96
modal	[doroba]	[o]	-0.5015	0.1713	167.65	461.24
modal	[kora]	[o]	-2.525	0.3452	186.89	471.42
modal	[kora]	[o]	-2.0284	0.3763	179.09	506.35
modal	[kora]	[o]	-1.7941	0.3935	183.36	500.65
modal	[katsi]	[a]	11.011	0.197	185.37	726.49
modal	[katsi]	[a]	2.5268	0.2317	180.17	820.66
modal	[katsi]	[a]	1.2091	0.2273	177.36	764.99
modal	[kapi]	[a]	6.3902	0.1507	207.3	844.88
modal	[kapi]	[a]	7.933	0.2065	200.23	771.68
modal	[kapi]	[a]	14.206	0.1961	201.92	800.7
modal	[ipa]	[a]	2.6529	0.1407	199.49	862.96
modal	[ipa]	[a]	2.9108	0.1801	207.86	840.22
modal	[ipa]	[a]	7.3937	0.2102	198.27	818.52
breathy	[d̤ibi]	[i]	6.9341	0.2523	200.41	301.5
breathy	[d̤ibi]	[i]	9.9184	0.2699	201.82	340.44
breathy	[d̤ibi]	[i]	6.9322	0.2581	200.17	350.02
breathy	[d̤inda]	[i]	14.102	0.2161	152.52	279.04
breathy	[d̤inda]	[i]	16.57	0.2316	149.19	277.64
breathy	[d̤inda]	[i]	15.146	0.2411	149.94	298.43
breathy	[d̤irtza]	[i]	12.288	0.1689	166.18	286.45
breathy	[d̤irtza]	[i]	9.8791	0.1745	161.07	294.39
breathy	[d̤irtza]	[i]	11.016	0.1725	157.93	299.65
breathy	[d̤ora]	[o]	-1.0159	0.3386	170.22	438.11
breathy	[d̤ora]	[o]	1.2245	0.3662	175.36	465.08

breathy	[d̤ora]	[o]	3.6526	0.3648	173.49	411.3
breathy	[g̤ora]	[o]	17.541	0.3231	169.12	437.08
breathy	[g̤ora]	[o]	13.674	0.3328	167.14	427.99
breathy	[g̤ora]	[o]	11.68	0.3167	175.82	441.67
breathy	[d̤onza]	[o]	7.0255	0.2536	155.8	418.44
breathy	[d̤onza]	[o]	3.7361	0.2721	148.99	409.28
breathy	[d̤onza]	[o]	14.494	0.266	152.62	393.89
breathy	[d̤akisa]	[a]	5.4533	0.1676	160.77	739.74
breathy	[d̤akisa]	[a]	-3.0735	0.1543	154.18	704.34
breathy	[d̤akisa]	[a]	-2.2822	0.1691	162.17	704.48
breathy	[d̤ara]	[a]	unidentified	0.332	179.08	853.8
breathy	[d̤ara]	[a]	-0.5347	0.3464	178.06	819.98
breathy	[d̤ara]	[a]	0.7354	0.3412	176.59	836.08
breathy	[d̤amba]	[a]	0.437	0.1749	169.11	457.38
breathy	[d̤amba]	[a]	-0.2567	0.2479	170.79	827.53
breathy	[d̤amba]	[a]	9.8013	0.2521	166.36	831.71

References

Gordon, Matthew. & Ladefoged, Peter. (2001). Phonation types: A cross linguistic overview. Journal of Phonetics, 29(4), 17-18