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An Acoustic Study of the Vowels in Goalparia

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The study presents an acoustic examination of the five monophthongs in Goalparia language, detailing the fundamental frequency (F0) and durational characteristics of these vowels produced in CVC context by 10 male native speakers in Dhubri District of Assam. It entails a rigorous acoustic analysis using the speech processing software Praat which provides a detailed view of the characteristics of these vowels. Previous studies of the vowels in Goalparia has been based mainly on auditory impression and thus stopped short of providing information regarding the exact nature of these vowel sounds. The results in the present study provide objective evidence for detailing the features of the vowels that the native speakers perceive and produce in their speech.

1. Introduction

Goalparia, a member of the Indo-Aryan family of languages, had its origin in the west part of old Kamrupa district of Assam, the geographical region now comprising North Bengal, the Western part of Assam and the north east part of Bangladesh. However, the term Goalparia has been an issue of continuous debate in the last few decades as some of the scholars believe that it is better to describe the language as Rajbangsi language. The first significant statement about this language is made by Grierson (1963). While talking about the geographical domain of this language he said:

“It is spoken in the following district ---- Rangpur, Jalpaiguri, the Tarai of Darjeeling district, the native state of Coochbihar, together with the portion of Goalpara in Assam.... The dialect is usually known as Rajbangsi from the tribe of that name....The dialect of Western and South-Western Goalpara is purely Rajbangsi.” (Grierson, 1963, Vol-v, Part-I:163)

On the other hand, Goswami (1991), in his study of the language makes the following comment: “The use of the language is not limited to the tribe called Rajbangsi....It is used by every community.” (Goswami, 1991)

There are also others who tried to avoid this debate and wanted to define the language in their own manner. Dutta (1982) was of the opinion that the language is better known as ‘desi bhasa’. Das (1990b) says that the language should be called the Kamatai language. Kakati (1962), in his pioneering study of the formation and development of Assamese, recognizes the main factor which gives rise to the problem of naming the language:

“The spoken dialect of Goalpara district seems to have greatly contaminated with admixtures of the Rajbangsi dialect--- the dialect that was evolved under the dominance of the Koch Kings of Koch-bihar, whose descendents ruled over Goalpara and contiguous portion of Kamrup...” (Kakati, 1962:18). The existence of numerous studies describing the language reveals the special character of itself and the term Goalparia is adopted here only for the sake of simplicity and to avoid the large socio-political and cultural discourse associated with the term Rajbangsi. Census

(2001)¹ mentions about the presence of 82570 speakers of Rajbangsi language and the language is not included in the list of 22 scheduled languages.

1.1 Previous studies

The earliest mention of the Goalparia language was made by Grierson (1963) when he described it as Rajbangsi language. There have been few more studies which have looked into the properties of the language in detail and Goswami (1991) is perhaps the most widely accepted among these. This study gives a detailed account of all the vowel and consonant sounds in the language. For the purpose of his description, Goswami (1991) uses Assamese alphabets to represent the sounds instead of using IPA symbols. The study presents a five vowel inventory for Goalparia: [a, e, i, o, u]. Das (1990a) describes three dialects of the language: Ghullia, Carua and Jharua. However, this study presents a six-vowel system for all the three dialects of Goalparia. It describes an additional vowel – a mid front vowel. Bhakat (2000), while describing the language as Rajbangsi, presents a phonological, morphological and syntactic analysis of the language. Prodhani (2010) also looks at the phonological, morphological and syntactic aspects of Goalparia language. This study also gives evidence for the presence of an additional mid front vowel. All the studies mentioned above describe the presence of same vowels in Goalparia. Another common factor in all these studies is that the analysis presented is based purely on auditory impression of the investigators. It has also been found during the present investigation that the additional mid front vowel is only a variant of [e] occurring in those positions where the Goalparia speakers do not use [e]. It is felt that an acoustic study of the main five vowels would reveal more characteristics of the vowels in Goalparia and the present study aims at providing such a description.

2. Methodology

This study aims at looking at the acoustic properties of the monophthongs in Goalparia by focusing on their durational and F0 (fundamental frequency) properties. Monosyllabic target words containing the vowels in Goalparia were selected for this experiment. It has also been made sure that the target words have identical sounds on both sides of the vowels. Also, the study avoided the occurrence of the vowels in the word initial and final positions. Thus, the following monosyllabic Goalparia words with CVC structure (consonant + vowel + consonant) were selected for the present study:

[kin]	‘buy’
[kun]	‘which’
[kan]	‘ear’
[ken]	‘why’
[kon]	‘which’

Ten male speakers of Goalparia language were asked to pronounce the target words by placing them in the blank position of the sentence frame given in (1). Placing the target words in the sentence medial position helps in minimizing any kind of iterative pattern which might otherwise colour the pronunciation of the same if recorded in isolation.

¹ Source: <http://www.censusindia.gov.in>, retrieved on January 10, 2014.

- (1) mui _____ ko-lung
 I _____ say-Perfective
 I _____ have said.

2.1 Participants and Recording Procedure

The speakers were between 22-28 years of age and they were born and brought up in their native villages where the recording was conducted. All of them were from the same socio-economic and educational background. The experiment was carried out in a quiet environment in Balajan, Agomoni and Golakganj in Dhubri district of lower Assam. Four of the participants were from Balajan area, and three each were from Agomoni and Golakganj area. All the speakers were graduates and they could also speak Assamese. None of the speakers had any previous record of problem in hearing or listening impairment. Each of the speakers was paid a small fee for their participation in the production experiment.

The speakers produced 5 iterations of each of the words in the sentence frame mentioned in (1) with sufficient pause in between. The subjects were asked to read the sentences aloud written in Assamese script which is the script used for Goalparia language. The speakers were explicitly told the meaning intended by the sentence they were about to pronounce. An Edirol Roland R-09HR with its inbuilt microphone was used for the recordings. The recordings were digitized at a sampling frequency of 44.1 kHz and 32 bit resolution. The process of recording continued for four days due to cancellation of several wave files as they are found to accompany the sound of strong wind. Out of the 5 iterations of each of the words in the sentence frame only the first three were considered for the present experiment. This amounted to a total number of 30 tokens (10 speakers x 3 iterations) for each of the target words.

2.2 Measurement Criteria and Statistical Analysis

The recordings of the total number of 150 tokens of the target words were then analyzed in Praat at 44.1 kHz and 32 bit resolution. The sounds were first labeled at the level of phonemes.

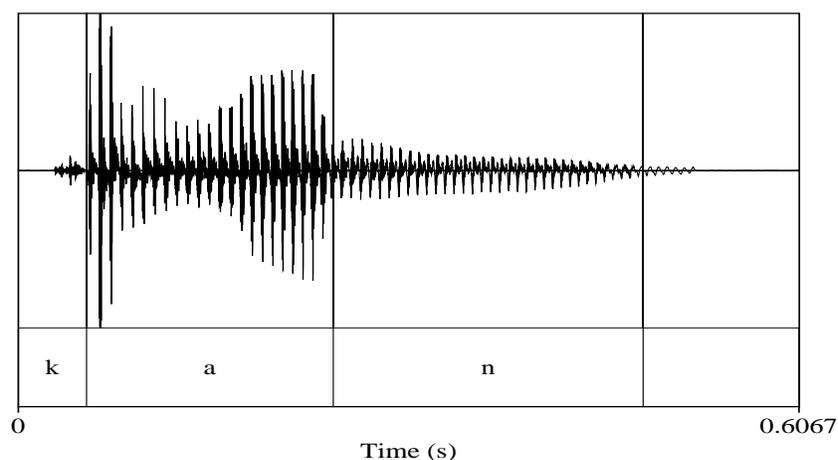


Figure 1: Spectrogram showing the process of segmenting the vowel sound in [kan]

Labeling in Praat was done using a see-listen-label method, visually evaluating the spectrogram of the sound files and listening. Figure 1 presents a view of the spectrogram for [kan] ‘ear’. For all the words, the duration of each of the phonemes, hertz value in the three formant frequencies, their bark value in first and second formants, and the mel values in first and second formants were extracted in an MS-Excel sheet using a Praat script. A statistical analysis was done using ANOVA Test in *R* to examine difference of duration values of vowels. A *p*-value smaller than 0.05 indicates significant difference in durational values. The perceptual distance between various combinations of vowels in Goalparia was calculated using the first formant frequency (M1) and second formant frequency (M2) in mel scale to measure distance between vowel (i) and vowel (j) in the well known Dij formula:

$$D_{ij} = \sqrt{((M1_i - M1_j)^2 + (M2_i - M2_j)^2)}$$

3 Results

A detailed consideration of the pronunciation of all the 150 words revealed the following acoustic information about the vowels in Goalparia language. There can be found significant difference in duration (in millisecond) in the pronunciation of the 5 vowels in Goalparia. Also the F0 (fundamental frequency) of the vowels are also found to be significantly different from each other. In addition to these, the acoustic analysis of the vowels also showed that the vowels in Goalparia are significantly different from each other.

3.1 Duration

The average duration (in millisecond) of 30 iterations of each of the vowels in Goalparia is presented in Figure 2. It can be found that there exists significant difference in duration among the vowels in this language. Figure 2 shows that the mid front vowel [e] is longer than the high front vowel [i]. Among the back vowels it is found that the mid back vowel [o] is the longest and the low back vowel [a] is the shortest. An ANOVA test is done with the help of *R* 2.14.1 on the

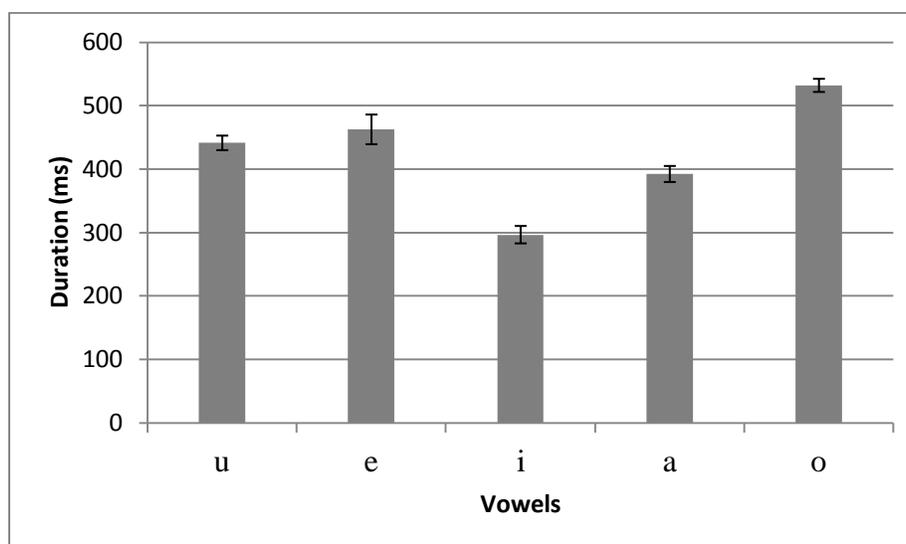


Figure 2: Durational difference in millisecond among the vowels in Goalparia. (n=30) durational values of all the tokens of the 5 vowels in Goalparia to check whether there are any significant difference among the various vowels in Goalparia. This comparison has revealed that

the vowels in Goalparia are (statistically) significantly different from each other in term of duration ($F [4,145] = 143.6, p < 0.05$).

A post hoc test using TukeyHSD is performed to see the exact nature of durational differences among various combinations of vowels in Goalparia. Table 1 presents the result of this analysis. The results in Table 1 show that the back vowel [u] and the front vowel [e] have the maximum durational difference between them. The least durational difference can be noticed between the front high vowel [i] and the back high vowel [u]. Table 1 shows that there is no significant statistical difference between the duration of [o] and [a], and between the duration of [u] and [i]. Result presented in Table 1 reveals significant durational difference between other combinations of vowels.

Label	diff	lwr	upr	p adj
e-a	42.12504	30.336556	53.913524	0.0000000
i-a	-41.41460	-53.203084	-29.626116	0.0000000
o-a	4.21796	-7.570524	16.006444	0.8589297
u-a	-44.90308	-56.691564	-33.114596	0.0000000
i-e	-83.53964	-95.328124	-71.751156	0.0000000
o-e	-37.90708	-49.695564	-26.118596	0.0000000
u-e	-87.02812	-98.816604	-75.239636	0.0000000
o-i	45.63256	33.844076	57.421044	0.0000000
u-i	-3.48848	-15.276964	8.300004	0.9241273
u-o	-49.12104	-60.909524	37.332556	0.0000000

Table 1: Result of post hoc test showing durational difference between vowels

3.2 F0 of Goalparia vowels

F0 values at the mid points of each of the iterations of the vowels were extracted by using a Praat Script to see the nature of difference among them in terms of their F0 values. An ANOVA test was done in R to see the nature of difference in F0 values of the vowels in Goalparia. The ANOVA test showed that the vowels in Goalparia have statistically significant difference from each other in terms of F0, ($F [4, 145] = 686.4, p < 0.05$). Although the statistical analysis confirmed the existence of significant difference, an attempt was also made to measure the nature of difference between various combinations of vowels. To look into this kind of difference, a post hoc test is performed on the F0 values on vowel midpoint of all of the 150 tokens using TukeyHSD. The result of the post hoc test shows that the greatest difference in F0 mid values lies between the back high vowel [u] and the back low vowel [a]. The vowels which differ least in terms of F0 mid values are the back high vowel [u] and the front high vowel [i].

3.3 Goalparia Vowels in Bark Chart

Although it has been found in section 3.1 that there exists statistically significant durational difference among the vowels in Goalparia, there difference in terms of their Formant frequencies can reveal further information regarding the height of the vowels, their roundedness and their backness. The F1 and F2 values in bark provide information regarding the placement of the vowels in the vowel chart. Formant 1 values are inversely associated to the heights of the vowels and Formant 2 values are positively associated with front or back characteristics of the vowels in

the vowel space of the speakers of a language. F1 and F2 (bark) values of the vowels in the target words were extracted by using a Praat script. The averaged F1 and F2 bark values of all the 30 tokens of each of the vowels are plotted in the vowel chart in Figure 3. It can be seen that the back vowel [a] in Goalparia occupies a considerably higher position, even higher than the front vowel [e].

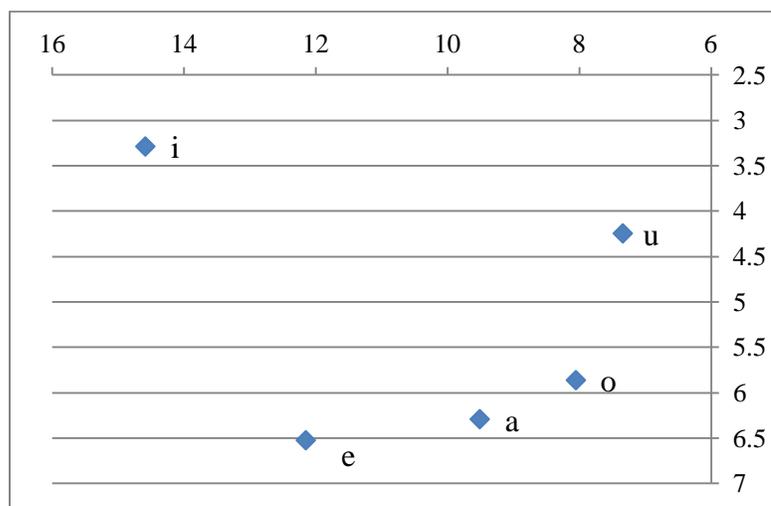


Figure 3: Vowel plot showing the 5 monophthongs in Goalparia.

The perceptual difference among vowels in Goalparia is presented in Table 2 by transforming the F1 and F2 values of the vowels to mel scale in order to examine the perceptual vowel quality. The difference in mel scale indicates the difference which a human being senses in sound pitch. Dij value in Table 2 shows the perceptual difference values of each vowel from others vowels in the phonemic inventory of Goalparia. It can be seen from Table 2 that the perceptual distance is maximum in Goalparia between [o] and [e], one of which is a front vowel and the other is a back vowel. This difference is measured as 303.67. On the other hand the perceptual difference is minimum between the back vowels [o] and [u] which is 79.72.

	e	a	i	o	u
e		192.09	137.59	303.67	
a			225.1	154.35	195.99
i				231.65	
u	126.38		179.94	79.72	

Table 2: Perceptual distance among vowels in Goalparia in Mel scale.

4. Conclusion

The discussion presented above enumerates the acoustic properties of the five vowel sounds in Goalparia language. Results of the present experiment have revealed some of the yet not described properties of these sounds. The bark chart presented in Figure 3 shows that the back vowel [u] in Goalparia is considerably lower than the front high vowel [i]. Similarly the front vowel [e] is found to be quite low in Figure 3. Also the back vowel [a] occupies a quite high position. Previous studies of Goalparia could not bring out these properties of these vowels as they described the vowels based only on auditory impression. It has also been found that the

vowels in Goalparia differ from each other in terms of duration and their fundamental frequency (F0). The study also reveals that the perceptual difference among the vowels in Goalparia is more between [o] and [e], and it is minimum between [o] and [u]. Further studies involving disyllabic words would throw light on other phonetic properties of Goalparia vowels like stress, pitch change etc.

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