AN ACOUSTIC STUDY ON MURMURED AND "TIGHT" PHONATION IN GUJARATI DIALECTS - A PRELIMINARY REPORT

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ABSTRACT

The purpose of our study was twofold: (i) to define "tight" phonation in acoustic terms and (ii) to examine the acoustic differences between murmured and "tight" phonation in Gujarati. The analysis was based on the parameters: Fo contour, overall intensity, amplitude of the 1st and 2nd harmonic, the frequency of F1 and F2, and the bandwidth of F1 and F2. The amplitude of the first two harmonics as well as the bandwidth of F1 and F2 turned out to serve best in distinguishing murmured from tight phonation.

INTRODUCTION

Gujarati -an Indo-Aryan language- is usually treated as a member of that group of languages which contrast murmur phonation and normal voicing. Both phonation types are used on the one side to separate murmured from clear vowels, on the other side they serve to distinguish murmured stops from voiceless, voiceless aspirated, and voiced ones. Acoustical analyses of murmur which have been carried out since the late fifties revealed several acoustic parameters by which murmur may be distinguished from normal voicing. Murmur is characterized by the following features: a lowering of fundamental frequency (Fischer-Jørgensen [2], Ohala [6], Schiefer [8]), an increase in the amplitude of the first harmonic in relation to the second one (Bickley [1], Ladefoged [4], Huffman [3]), broader formants [2], a later onset of higher formants [2], a lowering of the second formant (Pongweni, 7), an irregular intensity course [2], and a lowering of the overall intensity [8]. One of the most extensive acoustic studies on Gujarati, and a quite early one, is that of E. Fischer-Jørgensen [2], who examined the differences between murmured and clear vowels. It is apparent that the seven subjects used in her investigation showed great variability in producing murmured vowels. As Fischer-Jørgensen points out "all informants have murmured vowels in their natural speech, and this pronunciation seemed to be very constant for PvB, SK, and GU. In RD's and PBP's speech murmur is optional" [2, p. 74].

The differences between the subjects seem to reflect different dialects, as RD and PBP were born in Saurashtra (western part of Gujarat), whereas PvB (Baroda), SK (Surat), and GU (northern Gujarat, Ahmedabad) originate from the northern and eastern part of Gujarat. The dialectal differences of Gujarati have been subjected to an extensive study by one of us (Modi, 5), who employed the method of tomography in her analysis. It appeared that two dialect groups have to been treated separately according to the phonation types used. One group, which she calls "murmur", shows a low larynx position, whereas the other group ("tight") has a high larynx position in order to avoid murmur phonation. As the term "tight" for the non-murmur dialects was introduced impressionistically by Modi [5] it still lacks definition in terms of acoustic features. The aim of our present study was therefore to examine the influence of several acoustic parameters in murmur and tight phonation. The following parameters have been examined: (i) the course of the fundamental frequency (Fo), (ii) the overall intensity, (iii) the amount of energy in the first (H1) and second (H2) harmonic, and (iv) the frequency of F1, F2 as well as (v) their corresponding bandwidths B1 and B2.

MATERIAL AND INFORMANTS

Our analysis was based on a rather limited material, and the results should be taken as a preliminary report on the selectivity of the acoustic parameters for the separation between murmur and tight phonation. We based our analysis on murmured stops rather than vowels as we felt that the stops would provide the most stringent test for the saliency of the single acoustic parameters. Murmured stops occur in both dialects and are contrasted from the other stops by a distinctive release of the stop, which is characterized by an incomplete closure between the vocal folds during the phonatory cycle.
The material consisted of isolated words containing the murmured stops in five places of articulation (labial, dental, retroflex, palatal, and velar) followed by the vowel /a/ in word-initial position. Each CV syllable occurred five to 15 times

in the material. The material was recorded on tape in Baroda, India. One speaker (male) from Rajkot and one from Ahmedabad served as informants for tight and murmured phonation.

PROCEDURE

The acoustic analysis of the data was run in Munich, where the words were digitized (using a sample rate of 20 kHz) filtered with a cut off frequency of 8 kHz and stored on a PDP11/50. The periodic portions of the initial CV syllables of all words were segmented into single pitch periods by the help of a segmentation routine (for further detail cf. [8]) and stored for further analysis. The fundamental frequency was calculated from the segmented material and measured for the first 14 pitch periods after the burst of the stop. The intensity was measured for the same vowel portion. The same (segmented) material was used to calculate the contribution of H1 and H2 to the overall intensity of all pitch periods of the vowel. A second analysis was run on the unsegmented data in order to gain F1, F2 data and their corresponding bandwidths by the use of a LPC procedure. The following adjustments were made: frame size = 512 samples (this is equivalent to a segment duration of 25.6 ms), window shift size = 128 samples, filter degree = 22, Hamming window size = 512 samples, preemphasis factor = 0.7. There was a limitation for bandwidth of the formants, which could not exceed 2/3 of the formant's value. Greater bandwidth led to a rejection of the formant proposed by the routine. As great problems were involved in the calculation of F1 in murmur (for detail see below) this preliminary analysis was run on the velar stops only. Separate multivariate two factorial analysis of variance were run for (i) FO, (ii) intensity, (iii) H1 and H2, (iv) F1, (v) F2, (vi) B1, and (vii) B2.

RESULTS

Fundamental frequency. The results are given in Figs. 1 to 3 and in Table 1. The differences in Fo between both speakers are small. Fo at vowel onset is low in both speakers and increases towards P14. In the murmured dialect a Fo fall from P1 to P3 can be observed, which is obviously not produced by the other speaker. Concerning the influence of the stop's place of articulation great differences between the dialects can be observed. The murmured speaker shows a quite regular pattern as for all stops a fall from P1 to P2/P3 can be found and a quasi-linear rising towards P14. The Fo differences at vowel onset are smaller than at the end of the contour. At the end of the (measured) vowel portion higher Fo values are assigned to the [+ant] (/dh bh ḍh/), lower values to the [-ant] stops (/ǰh gh/). The tight-phonation speaker shows somewhat greater Fo differences at vowel onset, a rising Fo after /bh jh/ and a falling-rising pattern (from P1 to P4) after /gh dh ḍh/. The difference

Table 1: Statistical results for Fo, intensity, and harmonics H1 and H2 D=dialect, P=place of articulation, H=harmonics.

	Fo	intensity	H1/H2
INTERACTIONS			
D-P-H	---	---	n.s.
H-P	---	---	n.s.
D-H	---	---	<.001
D-P	<.001	<.001	n.s.
H1/H2	---	---	<.001
DIALECT	<.01	<.001	<.001
PLACE-OF-ARTIC	n.s.	<.001	<.001

between the stops at P14 is greater and Fo seems to depend on the apicality of the stop rather than on its position: [-apic] stops show slightly higher, [+apic] stops lower values.

Intensity. Fig. 4 displays the results for the intensity averaged over all places of articulation for both speakers, whereas the influences of the place of articulation are plotted separately for murmur and tight in Figs. 5 and 6, respectively. The statistical results are given in Table 1. The intensity is lower in tight than in murmur phonation. In both dialects the intensity is lowest at vowel onset, increases rapidly towards P3/P4, and increases slowly towards the end of the contour in murmur, whereas in tight phonation the amount of increase is greater from P8 to P14, which indicates a change in the underlying phonation process. In murmur the influence of the place of articulation on the intensity is small, smallest at vowel onset and increases slightly towards the end of the contour. The increase in intensity over the contour is nearly the same for all stops. At P14 [+ant] stops show a somewhat greater intensity than do [-ant] stops. In tight phonation the influence of the stop's place of articulation is greater at vowel onset as well as at the end of the contour. The intensity is greater in [+ant] stops and less in [-ant] ones. The intensity course after /gh/ differs significantly from the other ones as there is an abrupt increase in intensity after P9. This again can be explained by a change in the underlying phonation type, as we believe that murmur can be sustained after /gh/ only if it is accompanied by a low larynx position.

Amplitude of H1 and H2. Figs. 7 and 8 display the results for H1 and H2 for both dialects, whereas the statistical results are again given in Table 1. We have measured the amount by which the single harmonics contribute to the overall intensity of the single pitch periods. In tight phonation the amount of energy is slightly higher in H1 than in H2. This feature is associated, as mentioned above, with murmur phonation. The difference remains relatively constant throughout the vowel. In murmur on the other hand the difference between H1 and H2 is much greater. Whereas the course of H1 and H2 is nearly level in tight phonation, the amount of energy in H1 increases in murmur from P1 to P14. H2, on

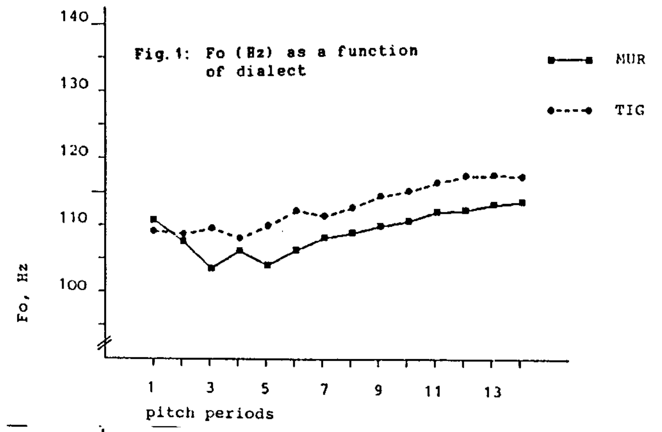

Fig. 1: Fo (Hz) as a function of dialect

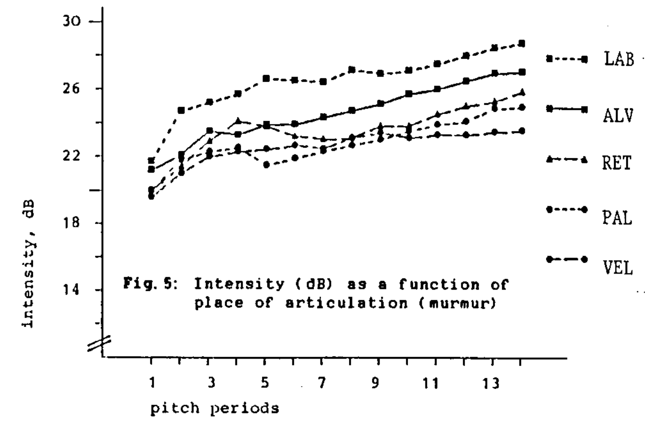

Fig. 5: Intensity (dB) as a function of place of articulation (murmur)

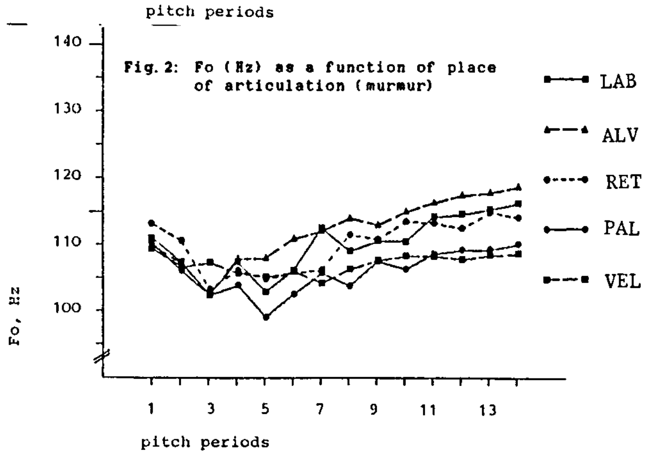

Fig. 2: Fo (Hz) as a function of place of articulation (murmur)

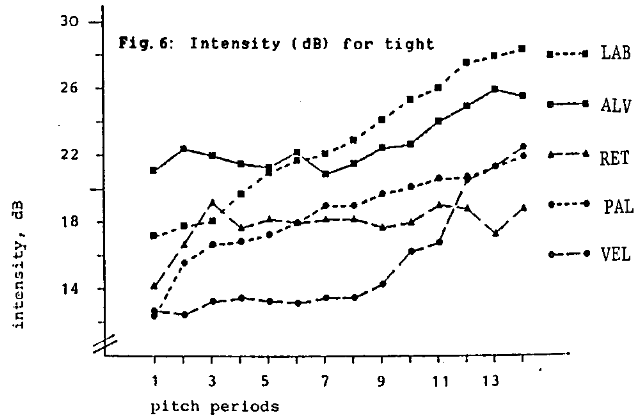

Fig. 6: Intensity (dB) for tight

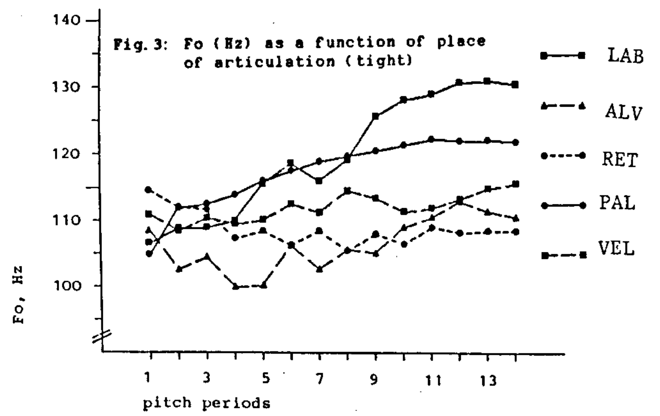

Fig. 3: Fo (Hz) as a function of place of articulation (tight)

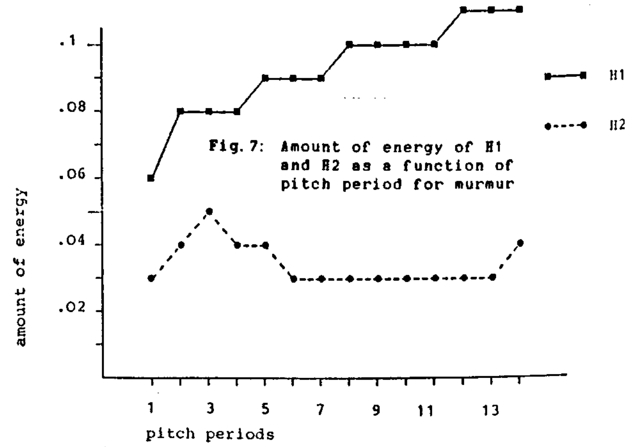

Fig. 7: Amount of energy of H1 and H2 as a function of pitch period for murmur

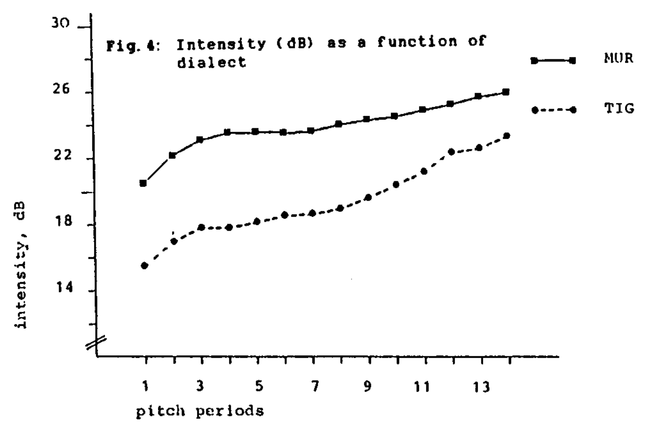

Fig. 4: Intensity (dB) as a function of dialect

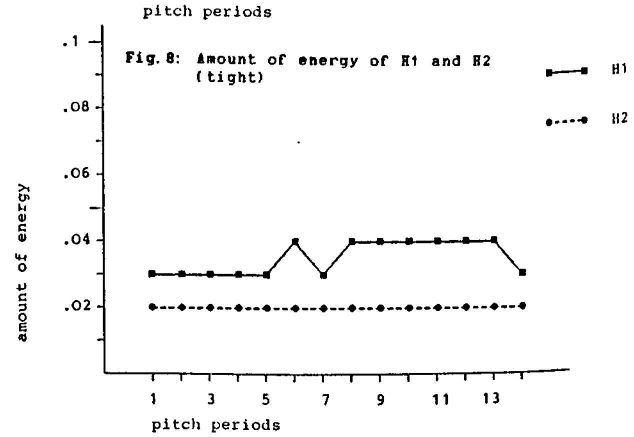

Fig. 8: Amount of energy of H1 and H2 (tight)

the other hand, shows a rising-falling-level pattern. The influence of the stop's place of articulation is significant in both dialects, where [+ant] stops again have somewhat higher values than [-ant] stops.

F1, F2, B1 and B2. As the LPC failed to calculate F1 precisely for about 250 ms of the vowel after the stop's release, F1 and B1 are measured for the steady vowel portion only. The results for F1 differ extremely between the murmured and tight speaker: F1, averaged over 368 ms is 660.0 Hz in murmur and 906.5 Hz in tight phonation (for details cf. Table 2). The corresponding bandwidth is 370.9 Hz in murmur and 203.3 in tight phonation. The bandwidth decreases slowly in murmur (427.4 Hz at the beginning and 347.0 Hz at the end of the contour) and in tight phonation, where B1 is 257.8 Hz at the beginning and 149.8 Hz at the end of the contour. The frequencies of F2 are rather comparable: F2 = 1373.7 Hz in murmur and 1383.9 Hz in tight phonation, whereas the mean of B2 of tight phonation (152.0 Hz) is higher than that of murmur (125.1 Hz).

Table 2: Averaged formant- and bandwidth values and standard deviations for the murmured and tight dialect in Hz; minimum and maximum values of the formants and bandwidth; level of significance from the analysis of variance for F1, F2, B1, and B2.

	F1	F2	B1	B2
murmur				
x	660.0	1373.7	370.9	125.1
sd	86.1	60.5	130.5	76.4
MIN	622.0	1331.3	294.0	91.3
MAX	708.0	1450.3	495.2	183.5
tight				
x	906.5	1383.9	203.3	152.0
sd	57.3	111.9	76.1	84.4
MIN	872.0	1293.2	150.1	80.4
MAX	1002.0	1485.0	265.0	254.8
p	< .001	< .001	< .001	< .01

DISCUSSION

The acoustic parameters involved in this study contribute in different degree to the separation between murmur and tight phonation. The overall Fo cannot be used to distinguish between murmur and tight as it is rather a feature of the speakers voice than of the underlying phonation type. On the other hand, there are great differences in respect to the influence of the stop's place of articulation, which is small in murmur, great in tight phonation. The same is true for the overall intensity, which first of all reflects differences in the recording level, more than differences due to the underlying phonation type. But again, the place of articulation of the stop influences the intensity course more in tight than in murmur phonation. Taking both parameters together, we argue that they reflect different degrees of variability in the phonation, showing greater variability in tight phonation (with a high larynx position) and less variability in murmur, where the larynx position is low.

The results of the analysis of H1 and H2 show that in both dialects "murmur" occurs. Whereas the degree of murmur is high in murmured it is low in tight dialects. This difference in the degree of murmur is reflected by the results from bandwidths B1 and B2. In both dialects the bandwidth of F1 is much more greater than found in other languages, a fact that accounts for less sharp boundaries in the spectrum. On the other hand B1 remains great throughout the contour in murmur, but decreases in tight phonation. The results from B2 again reflect a higher degree of murmur in the murmured speaker, as the bandwidth is smaller compared to the 'tight' speaker.

In summary, the murmured stops are produced with a murmur release in both dialects. But there are differences in the degree and duration of murmur between the speakers. The amplitude of the first and second harmonics, as well as the bandwidths of F1 and F2 are the most efficient acoustic parameters to distinguish between tight and murmur phonation in Gujarati.

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