F_0 PERTURBATION EFFECTS OF PREVOCALIC STOPS ON PUNJABI TONES

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ABSTRACT. The perturbation effects of the prevocalic stop consonants on the F0 contours of the following Punjabi tones on a vowel [aa] are investigated. As is the case with the languages already studied the unvoiced stops perturbate the F0 onset values to a higher start while the voiced stops perturbate them down for each Punjabi tone. This tone-splitting, however, has been found to remain consistent in Punjabi for first 100 ms, unlike in other languages which show a fast or slow convergence of the F_0 tracks for the corresponding voiced and unvoiced stops. It is suspected that tone-splitting in Punjabi extends over a much longer period unlike in other tone languages as Yaruba and Thai. The level-falling tone of Punjabi, which has the highest frequency register, split by 30 Hz, while the low register tones, the level and dipping tones split by 14 and 12 Hz respectively on the average, for the first twelve periods of vocal cords vibrations.

INTRODUCTION

The standard dialect of Punjabi was investigated to determine the perturbatory effects of prevocalic stop consonants on the following Punjabi tones. It has been known for some other languages that the stops , voiceless aspirated, voiceless unaspirated and voiced, characteristically perturbate the initial F_0 values of the following vowels. The voiced series generally give lower tonal reflexes than the voiceless series [House and Fairbanks 1953, Lehiste and Peterson 1961, Mohr 1968, Lea 1973 and Löfqvist 1975). These studies were limited to non-tone languages, but the same effect has been observed in tone languages as well [Hombert 1977, Gandour 1974].

The two voiceless series of stops, generally tend to have similar perturbation effects. There were ,however, claims made for some languages as Korean (Han 1967, Kim 1965), Thai (Ewan 1976) and Danish (Jeel 1975) that voiceless aspirated stops gave higher F_0 onset values compared to their voiceless unaspiarted counterparts. But conflicting data were also found from the same as well as other languages. For instance Fischer-Jorgensen (1968) could not discover any noticeable dependence of F0 onset value on the aspirated/unaspirated contrast of the precedeing stop consonant in Danish. In Thai (Gandour 1974, Erickson 1975), Korean (Kagaya 1974) and Hindi (Kagaya and Hirose 1975) rather opposite effect was noticed; that is unvoiced unaspirated stops gave higher F_0 onset values compared

to their aspirated counterparts. Hombert (1978) made a detailed study on the two series of voiceless stops in English and French and observed no direct correlation between the duration of aspiration after a voiceless consonant and the onset F_0 values of the following vowel.

To explain this lack of correlation between aspiration and F0 onset value of the following vowel, the explanations were sought from various physiological [Hirose 1975, Hirose and Gay 1972] and aerodynamic parameters [Ladefoged 1967,1968,1974; Lieberman 1967, Murray and Brown 1975, Ohala and Ohala 1972] that might affect F_0 under the condition of aspirated/unaspirated distinction.

DATA COLLECTION

To study the perturbatory effect of prevocalic stops on the Punjabi tones a single male speaker was selected. An adult male, 48 years old, with Punjabi as his mother tongue, was chosen for data collection. Six words of CV type, [paa, taa, kaa, baa, daa, and gaa] were spoken with three Punjabi tones in random order, in a carrier sentence "CV keh" ("say CV"). It can be noticed from the carrier sentence that the prevocalic stops used in this study were word-initial as well as utterance-initial. Each sentence was spoken 10 times; thus there were 6x3x10=180 tokens, altogether, of the test words for analysis. Of the eighteen words (6 CV words x 3 tones) twelve were non-sense. The recordings were made in a sound treated room using professional audio equipment, in one session. The ILS software (Signal Technology Inc. 1987) was used for speech input, digital processing thereof and its display on the monitor. The input was lowpass filtered upto 4.8 kHz before its digitization at 10 kHz/sec. Since our interest was confined to only the fundamental frequency of the waveform, the digitized waveform was further lowpass filtered upto 1000 Hz/sec by an ILS digital Butterworth filter of 10th order to filter off kinks in the speech wave. The smoothed waveform was manually monitored to determine each period which in turn yielded the fundamental frequency value.

RESULTS

The results of F_0 contours for the three Punjabi tones for six stop consonants are shown in Fig. 1. These are the averaged F_0 contours of [p,t,k] and [b,d,g] for each tone. Twelve periods from the onset of voicing in the case of voiceless stops and twelve from the moment of release of closure in the case of voiced stops were examined manually . It was hoped that 12 periods would constitute enough time (approximately 100 msec) to show any initial rise or fall in F_0 contour at the onset, directional trend of the contour and any confluence, if any, of the F_0 tracks of the corresponding voiced and voiceless stops e.g. [p] and [b] etc, as has been observed in the case of tone

Table I. The VOTS of the voiceless stops [p,t,k] and the voiced closure durations for the voiced stops [b,d,g] for the three Punjabi tones are given.

	stop	Punjabi tones			
		level-falling tone	level tone	dipping tone	average
VOTS(ms)	p	5.92	5.91	5.36	5.73
	t	5.93	6.94	6.63	6.5
	k	21.96	18.9	21.53	20.8
Voiced Closure duration (ms)	b	63.0	102.6	73.0	79.5
	d	86.4	91.7	86.0	88.03
	g	79.3	98.9	97.5	91.9

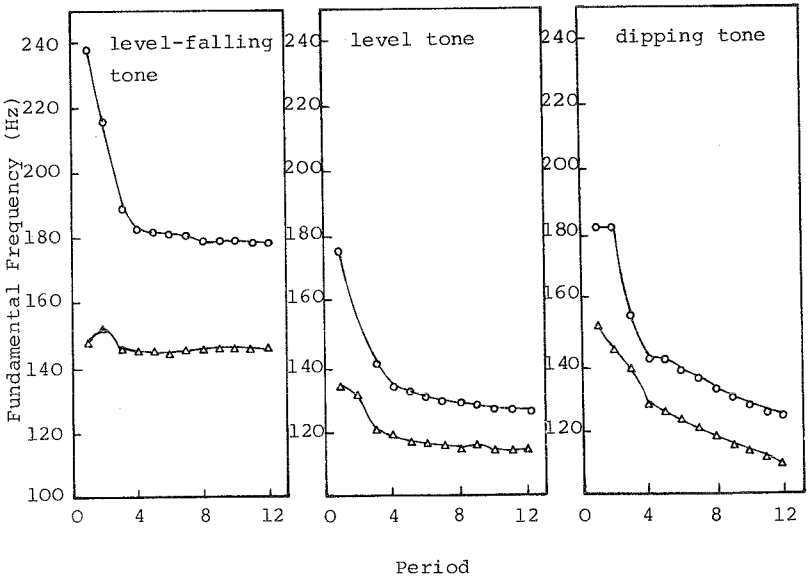

Fig 1. The top graph in each panel represents averaged F_o for [p,t,k] and the bottom one is for [b,d,g].

language, Yaruba [Hombert 1977].

Besides computing F_0 values, the voicing onset times for the voiceless stops and the closure durations for the voiced stops were also measured. These informations are important to determine whether the voiceless stops studied are aspirated or unaspirated, and their voiced counterparts, fully voiced or partially voiced. The VOTs for the voiceless stops [p,t,k] turned out to be quite small indicating their unaspirated nature, and the closure durations for the voiced stops quite long indicating their fully voiced nature. The table 1 gives data on VOTs and closure durations for each tone and for each of the six stops studied, averaged over 10 tokens of each test word.

DISCUSSION AND CONCLUSIONS

The perturbatory effects of the utterance-initial prevocalic stop consonants on the fundamental frequency F_0 of the following vowel spoken with three Punjabi tones were studied. The study was confined to a single low vowel [aa] and to a single speaker and covered most frequently used [Feroze-ud-din 1983] six stop consonants of Punjabi. These stops are voiceless unaspirated and voiced in bilabial [P, b], velar [k, g] and retroflex [t, d] articulations.

One thing which is conspicuously noticeable from the graphs in Fig. 1 is near parallelism of the average F0 tracks for the voiced and unvoiced series for the whole 12 periods for each tone. This is in sharp contrast to Yaruba tones in which the F0 tracks of the voiced and voiceless series show a regular fast merging and do merge in about first 100 msec of voicing [Hombert 1977]. It is thus obvious that in the case of Punjabi, the tone splitting is quite extended over a much longer period unlike the case for Yaruba tones (Hombert 77). In the case of non-tone languages such as American English and French, the F0 tracks clearly show a tendency of convergence in the first 12 periods or 100 msec [Hombert 1978]. In fact our choice of restricting the F0 calculation to first 100 ms of voicing was influenced by the results on Yaruba, American English and French, which show a merging or near-merging of the corresponding F_0 tracks in the first 100 ms.

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