F0 PERTURBATION OF STOPS IN NEPALI AND MEITEI

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The present article accounts for the fundamental frequency (F0) perturbation of stop-types in Nepali spoken in the Maram region of Manipur, India. Experiments were performed on the speech of the native speakers of Nepali in order to investigate if the F0 perturbation following the stop-types would be affected due to contact with a tonal language, Meitei.

Keywords: F0, stop-types, tonal, Meitei

1. Introduction

Fundamental frequency (F0) is directly related to the pitch of the voice and is the effect of the consonants in the following vowel's F0 or pitch. It has been considered to serve as a key marker for a number of paralinguistic and extra-linguistic functions. Studies on F0 perturbations have been well established across languages featuring in tonal and non-tonal languages alike.

Established work related to F0 perturbation draws on two distinctive theories governing F0 perturbation. Cross-linguistically, voiced obstruents have been found to lower F0 in the following vowel (House and Fairbanks, 1953), (Hombert, 1978) and (Christovich, 1971)**.** This lowering has been attributed to physiological and phonetic factors by few (Stevens, 2000), (Honda, 1983) and (Atkinson, 1978), while some argue that F0 lowering following voiced obstruents serves to maintain a phonological contrast between voiced and voiceless obstruents, (Ohde, 1984), (Kingston and Diehl, 1994). Nepali exhibits a four way stop contrast like Hindi: voiceless stops (VLS), voiceless aspirated stops (VLAS), voiced stops (VS), and voiced aspirated stops (VAS). The latter are also referred to in the literature as *breathy* or *murmured* stop. Several studies by (Poon & Mateer, 1985), (Pokhrel, 1989) and (Khatiwada, 2008) have contributed a great deal towards the experimental analysis of the sound system in Nepali. For instance, (Poon and Mateer, 1985) focus on VOT (voice onset time) of Nepali stops as a cue to distinguish them in the voiced-voiceless and unaspirated-aspirated dimension. They, quite like other researchers working on four-way laryngeal contrasts, found that VOT is not a sufficient cue to distinguish the so called voiced-aspirates or breathy voiced stops from their voiced counterparts. In another related study, (Pokharel, 1989) provides an extensive acoustic description of the sound system of Nepali as spoken in Nepal. Clements and Khatiwada (2007) found that the aspirated affricates [tsʰ] and [dzʰ] are distinguished from their unaspirated counterparts [ts] and [dz] by means of muffled or breathy voice and lowered F0 of the following vowel. Earlier studies on voiced aspiration (Dutta, 2007) established this lowering of F0 appearing to be the most consistent cue to the feature [+ spread glottis] in Nepali. In our study, we intend to examine if Nepali also exhibits voicing related F0 perturbation similar to Hindi. In addition, we investigate the impact of knowledge of tonal excursions, due to extensive contact with Meitei especially on voicing related F0 perturbation. Meitei is a Tibeto-Burman language spoken exclusively in the Indian state of Manipur that is bordered by Myanmar to the East, Nagaland to the North, Mizoram to the South and Assam to the West and Northwest. The Meiteis are mainly located in Manipur apart from other places such as Nagaland, Peren, Dimapur, Koima, Phek; Assam, Cachar and Dima Hasao; Mizoram, Aizawl etc.

In this study, we hypothesize that long term contact with a tonal language, i.e. Meitei in our case, would affect the F0 perturbation related to certain stop-types. Hence, we will pay particular attention to voiced stops (VS) and voiced aspirated stops (VAS) in order to examine if the F0 following the two stop-types is consistent in maintaining the perturbatory effect despite being in contact with a tone language for a long time. However, we have also considered and analyzed

in our experiment the voiceless stops (VLS) and voiceless aspirated stop (VLAS) in order to exemplify that like Hindi and other Indic languages, Nepali too maintains a four way laryngeal contrasts. The study presented here looks at social factors: age, gender, level of proficiency (LOP), ethnicity, intra/inter-lingual contact and change at the phonetic level and also seeks to understand the ways in which social identities and beliefs shape and influence speakers' ability to identify, comprehend and as well as socially evaluate varieties.

2. Method

2.1 Note task

The recorded materials for the present research were elicited from native speakers of Nepali, born and brought up in Maram. A brief sociolinguistic profile was taken from each participant in order to keep in record their language background and social profile, age, qualification, gender etc. The recorded materials included stops (labials, dentals, velars and retroflex) and the sentences were written in Devanagari script (Appendix A). Three repetitions of each sentence were recorded and were used in two different contexts, namely phrase initial (focus) and phrase medial (non-focus) to maintain consistency in their recordings. The recordings were made using a head mounted AKG C420 III *pp* microphone. After the completion, the recorded data were then digitized at 22050 Hz. This process was followed by segmentation and annotation of the data starting from zero crossing, and this involved identifying the beginning and end of segmental features. Several acoustic cues were taken into consideration, for instance: closure duration, burst, period of vowel duration, aspiration, stop-type and place of articulation. Twenty distractors or filler sentences were also added and randomized in order to mask the intention of the study. Next, analysis involved running Prosody Pro, a *praat script* (Boersma and Weenink, 2014) that gives systematic prosodic analysis for accurate pitch tracking of the F0, including F0 maximum and F0 minimum values. Statistical measurements were obtained from R studio for systematic values for the assigned labels using the Linear Mixed effect model.

2.2 Participant speakers

Initially, before the final recording task was undertaken, a pilot study was conducted wherein forty native speakers were chosen at random and were asked to furnish their details in a language background questionnaire (LBQ) format, where they were asked to mark on a continuous scale their level of proficiency (LOP) in languages such as Meitei, Hindi and Maram. After the pilot study was reviewed, only twelve speakers' data were recorded comprising of six male and six female speakers considering age, level of proficiency and occupation. This procedure was carried out by taking an average of each factor on an excel sheet and then normalized. Thus, while *subject, items* and *age* functioned as random variables, *gender, level of proficiency (LOP)* and *stop-type* functioned as fixed variables.

Twelve native Nepali speakers (6 male and 6 female) were chosen for the recording task. All participants were between the age group of 30 and 55.

2.3 Acoustic parameters

The experiment involved segmentation and annotation of the data in *Praat* starting from zero crossing, and this involved identifying the beginning and end of segmental features. Variability of F0 was calculated with the standard deviation (SD) of each task. A *z-score* F0 value in addition to normalizing the gender effect also allows us to represent each F0 value in terms of number of standard deviations the value is away from the mean. Intra/Inter-speaker and token variation in F0 contours were normalized by taking 10 measures of F0 starting at 10 percent and ending at 100 percent of the vowel. The sorted data were fed in R Studio for statistical analyses and with the following variables listed: ZF01, ZF02, ZF03 (referring to the z-score normalized values of 10%, 20% and 30% of the initial portion of the vowel), stop-type, subject, level of proficiency (LOP).

2.4. Nepali stops

Place and manner of articulation:

Table 1 displays the four way stop contrasts in Nepali, VLS (voiceless stop), VLAS (Voiceless aspirated stop), VS (Voiced stop) and VAS (Voiced aspirated stop), occurring at four places of articulation (PoA) as displayed in the table.

Table 1: Nepali stops-place and manner of articulation

PoA	VLS	VLAS	VS	VAS
Labial	p	p^h	b	$b^ɦ$
Dental	t	t^h	d	$d^ɦ$
Velar	k	k^h	g	$g^ɦ$
Retroflex	ʈ	ʈʰ	ɖ	$ɖ^ɦ$

3. Results

3.1 General observations

We have designed four level of proficiency (LOP) scale for Meitei: very high (VH), high (H), medium (M) and low (L), corresponding to LOP in Meitei with two stop-type: VS and VAS. The plots displayed give the ZF0 normalized value in relation to the two stop-type: voiced stop (VS) and voiced aspirated stop (VAS). The ZF0 labelled as ZF01, refers to the normalized value of initial 10%, ZF02 to 20% and ZF03 to 30% of the vowel portion that show lower mean, following the two stop-type considered for the study.

We found that speakers were able to maintain the voiced and voiced aspirated distinction of stop-types despite their very high LOP in Meitei. The F0 following the VAS production was significantly lower compared to VS in all the three experiments performed.

Thus, from the three statistical experiments conducted on the subjects' LOP in Meitei, the observation and result confirm that despite the subjects' knowledge of a tonal language Meitei ranging from very high, high, medium to low, the subjects still maintain the voiced and voiced aspirated stop contrast but showed no significant interaction within any of the four LOP generated. As evident in all the three experiments, the median line for VAS is significantly lower than VS in all the four LOPs.

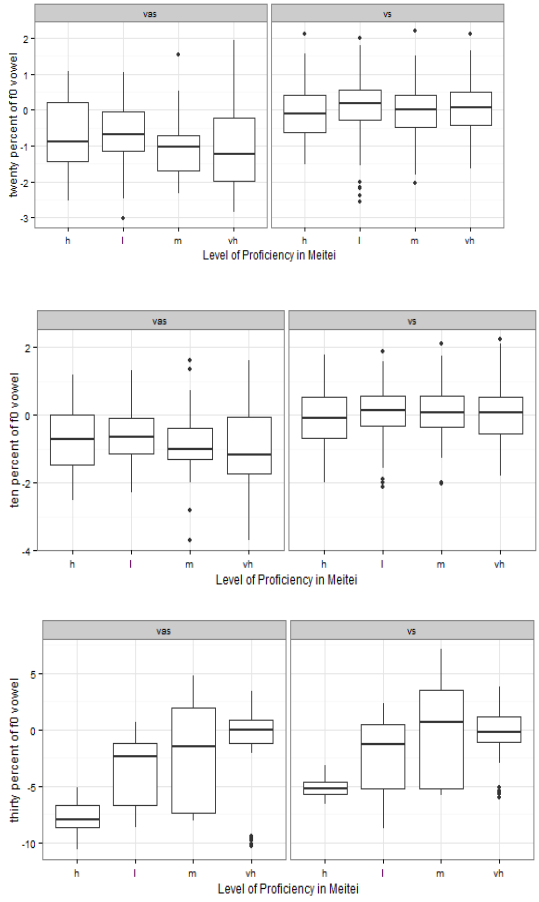

Figure 1: Effect of LOPs on VS and VAS (ZF01, ZF02, ZF03) in Meitei.

4. Conclusion

We identified several acoustic and non-acoustic cues of F0 perturbation in Nepali. The results stay consistent with established works in Hindi (Dutta, 2007) and Marathi (Patil and Rao, 2008). We found that the Nepali speakers maintained four way stop contrast: voiceless stop (VLS), voiceless aspirated stop (VLAS), voiced stop (VS) and voiced aspirated stop (VAS) despite being in contact with Meitei for a very long time. These findings lend support to the claim that physiological and phonetic factors determine F0

perturbation in the following vowel but socio-phonetic conditions such as high level of proficiency fail to impact the regular F0 pattern following the stops. There are no clear answers directly linked to such socio-phonetic constraints because there are multiple layers embedded in the speakers' mind both physiologically and socially. Additionally, it is also difficult for us to separate the phonetic and social entities. As research from similar studies suggests, phonetic factors are automatically correlated with social factors from the early period a child begins to speak. It then becomes difficult to segregate one factor from another. Some of the social and psychological factors such as identity and attitudes, are therefore confirmed to be strong factors in the speakers' phonetic performances.

Our results indicate that F0 perturbation patterns follow universal claims, in that VAS lowers F0 more than VS. However, high level of proficiency with a tonal language fail to impact the speakers F0 following certain stops. We had hypothesized that long term contact with a tonal language will impact the F0 of the following vowel in VS and VAS production. However, the experiments failed in establishing the same. One primary reason could be because Meitei is heavily influenced by Indic languages which have led to borrowings from several languages it has come into contact with and thus maintains a four-way contrast in stops similar to Nepali and Hindi. Following this, another reason could be due to minimal level of interaction in Meitei despite their high level of proficiency both in written and spoken form. Our experiment showed that despite the subjects' LOP in Meitei ranged from very high, high, medium and low, the Nepali speakers followed the regular F0 pattern in their production of VS and VAS. Thus, there was no significant effect on the F0 perturbation of stop voicing with regard to the two stop-types.

Studies that establish the effect of consonant voicing on onset F0 in English rests partly on what Kingston and Diehl (1994) call a *controlled process*; one that is intentionally manipulated by speakers to produce a desired perceptual effect, and in part from an intrinsic effect of the laryngeal gestures involved in voicing which is automatic and physiological (Stevens, 2000). It is observed that co*gnitive phonetic* processes manipulate phonetic objects and it was noted that the precision of controlled physical processes varies enormously not solely of intrinsic factors but also due to deliberate tightening or relaxing of the precision of articulation. Utterances contain a wealth of detail beyond the underlying utterance plan. Some of this is a function of the mechanism itself (e.g. co-articulation) and some are the result of carefully supervised speech production. Thus, the cognitive phonetic agent "bridges the gap between the physical and cognitive processes in phonetics by controlling the way phonologically determined utterance plans are phonetically rendered in detail" (Tatham and Morton, 2003:17).

Considering both the theoretical and practical aspects related to F0 perturbations across languages, a further understanding with controlled experimental designs is required, in order to understand the complex patterns that seem to govern speakers' speech production and perception. Further research based on acoustic study of some of the Tibeto-Burman languages is required, since adequate data is still lacking from this language family. This would in turn help contribute towards not only on understanding of the linguistic aspects of these languages but also towards language documentation (as most of the tonal languages from these regions are drawn towards extinction (Driem, 2001). Further, it would help in our understanding of the F0 excursions associated in tonal languages. Results obtained from such perspectives would invoke to better our understanding of the complex multi-layered pattern that languages are governed by and hence provide explanations as to how "bottom-up" process manifest. Foulkes and Hay (2015) suggests "as speakers, we tend to intricate control to tailor speech appropriately, since acts of speaking is governed by complex interaction of many force operating at multiple layers of structure, choosing from alternatives ranging from personal, identity, attitude, emotion." It further claims that phonetic output is constrained by biological factors as well as social ones, in terms of the physical constraints imposed by the vocal

tract and limitations of memory and by cognitive factors resulting in such changes.

These claims widely parallels the results obtained from our present study as the subjects in our study widely adhered to the linguistic norms of the language in terms of their cognition and performance based requirements.

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APPENDIX A

Phrase initial (focus) and phrase medial (non-focus) sentences.

उले खा भन्यो गास हाईना
उले हास भन्यो ताक हाईना
उले थाक भन्यो बात हाईना
उले सात भन्यो खाट हाईना
उले चाट भन्यो बाजी हाईना
उले धार भन्यो बाली हाईना
उले छाता भन्यो कि बाजे
उले काल भन्यो झार हाईना
उले दाथ भन्यो दादा हाईना
उले फास भन्यो लास हाईना
उले भात भन्यो रोटी हाईना
उले कालो भनी कि सेत्तो
उले झार भन्यो काल हाईना

उले टाप्के भन्यो बाटी हाईना
उले गारी भन्यो कि भारी
उले आली भन्यो पाप हाईना
उले ठारो भन्यो भात हाईना