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Lexical Tones in Sylheti

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Abstract

In this paper we examine the status of lexical tones in Sylheti. Sylheti is generally considered to be one of the varieties of Bangla (belonging to the Indo-Aryan language family). The consonant inventory of Sylheti has undergone significant reduction and restructuring, and lost all the aspirated stops due to obstruent weakening ([bʰai>**b**ai] 'brother', [lat̪ʰi> lat̪i] 'kick') and spirantization of the underlying voiceless bilabial stop (both aspirated and unaspirated) [p] and [pʰ] ([por] > [**ɸ**ɔr] 'read, [pʰul] > [**ɸ**ul] 'flower) and voiceless velar stop (both aspirated and unaspirated) [k] and [kʰ] ([kali] > [**x**ali] 'ink', [[kʰal > **x**al] 'drain/channel'). These processes gave birth to numerous homophones. Eight native speakers of Sylheti participated in a production experiment which recorded their utterances of 60 homophonous words (in a carrier sentence). However, in this paper we have concentrated only on the tonal properties of 24 monosyllabic words. The results show that the loss of breathy voice contrast and spirantization is compensated with a higher f_0 in the adjacent vowels. The result of one-way ANOVA shows a highly significant effect of tone on f_0 (measured at various points such as f_0 at vowel mid-point (measured in Mel) $p < 0.05$, [F (1, 414) = 67.06, p = 0.00)], max pitch (measured in Mel) $p < 0.05$, [F (1, 414) = 26.21, p = 0.00], min pitch (measured in Mel) $p < 0.05$, [F (1, 414) = 40.83, p = 0.00], average pitch (in Mel) $p < 0.05$, [F (1, 414) = 48.18, p = 0.00].

Index Terms: Sylheti, [+spread glottis], spirantization, homophone, tone, tonogenesis, production, perception.

1. Introduction

Sylheti is generally regarded as a variety of (Eastern) Bangla (Grierson 1928, Chatterjee 1971) (belonging to the Indo-Aryan language family). The language is spoken by approximately 10,300,000 people (7,000,000 in Bangladesh) (Lewis et al. 2013). The language is primarily spoken in Sylhet District (also known as Surma Valley comprising of districts like Sylhet, Habiganj, Maulvi Bazar, and Sunamganj) located in the north-eastern region of Bangladesh. In India, a considerable amount of Sylheti speakers inhabit the northeast state of Assam (the Barak Valley region comprising districts such as Cachar, Karimganj and Hailakandi) and Tripura (primarily the northern districts such as Dharmanagar, Kailasahar and Kumarghat)

No studies had been conducted on Sylheti at any (linguistic) level in general, and tone in particular. The distinct phonetic and phonological property distinguishes this variety from Standard Colloquial Bangla (henceforth SCB). One of the properties that distinguish Sylheti from SCB or other regional varieties is the significant application of obstruent weakening involving de-aspiration and spirantization. Consequently, the consonant inventory (especially the obstruents), of Sylheti exhibit a major reduction and restructuring compared to that of SCB. The loss of (underlying) breathiness contrast [+spread glottis] of the entire stop series due to the phonological process of obstruent weakening eventually led to deaspiration of voiced ([bʰai>bai] 'brother', [labʰ> lab] 'profit') and voiceless stops ([t̪ʰala>t̪ala] 'plate' [lat̪ʰi> lat̪i], 'kick'). Further, the process of spirantization targeting the underlying voiceless bilabial stop (both aspirated and unaspirated) [p] and [pʰ] ([por] > [**ɸ**ɔr] 'read, [pʰul] > [**ɸ**ul] 'flower) and voiceless velar stop (both aspirated and unaspirated) [k] and [kʰ] ([kali] > [**x**ali] 'ink', [[kʰal > **x**al] 'drain/channel') reduced and restructured the phoneme inventory of the language. These processes gave birth to numerous homophones. Considering the unique linguistic properties such as phoneme inventory, allophony, and inflectional morphology in particular and lexicon in general, Sylheti is often regarded as a separate language (Grierson 1928, Chatterjee 1939, Gordon 2005).

The languages of Indo-Aryan language family are not generally recognized for tone [Punjabi is known for two levels of tone; high and low (Bahl, 1957; Chatterji, 1969)]; however, the phonological processes of obstruent weakening and spirantization which eventually led to numerous homophones prompted us to investigate the tonal property of Sylheti. We conducted an acoustic experiment on 60 homophonous words with distinct lexical meanings (24 monosyllabic words, and 36 disyllabic words). Our findings confirm the presence of a two way tonal contrast in Sylheti. A high tone (marked) has emerged due to the loss of intended underlying feature [+spread glottis] which contrasts with a low tone (toneless or unmarked) occurring with every lexical entry. Statistical results suggest that the loss of [+spread glottis] among obstruents have been compensated with a significantly higher f_0 in the adjacent vowels.

2. Background

The literature on tonogenesis reveals that the loss of one or the other laryngeal features such as voicing contrast, aspiration or breathiness contrast (also called murmur voicing), glottalization, etc. of adjacent consonants are the usual sources of tonal contrast. Generally voiced obstruents are known to lower the pitch of adjacent vowels (Hombert 1978, Maddieson 1977), and voiceless obstruents may even raise the pitch of neighbouring vowels (Hombert et al. 1979, Yip 2002). Researchers also speculate that tone arises from a toneless state (Abramson 2004) - a language therefore, may acquire or lose (lexical) tone due to areal effect (Gussenhoven 2004). Among the indo-Aryan languages, tonal specification in Punjabi is rather well established. In Punjabi, breathy voiced consonants lost the breathy specification and the vowel following it acquired a low tone (/bʰa/→/pà/) (Hombert, Ohala & Ewan 1979, Vijayakrishnan 2009, Bhaskararao 1998, Bhatia 1975).

Presence of a high tone as a result of deaspiration in the syllable sequence of #BHV (initial breathy voiced consonant followed by a vowel), #HV, and VBH# (syllable containing a vowel and a breathy voiced consonant in the word boundary) was reported to be present in a few other Indo-Aryan languages such as Northern Haryanvi, Mandeli and so on (Bhaskararao 1998). However, the plausible phonetic reason related to the presence of a high tone in those languages seemed elusive.

The geographical distribution of Sylheti (the co-existence of other tonal languages such as Kok-Borok, Reang etc.) and the phoneme inventory where the obstruents have undergone drastic changes, make the linguistic scenario an interesting affair. Interestingly, the breathy voice contrast is also not present in many of the neighboring Tibeto-Burman languages. Thus, one could speculate that either any one of these reasons or both could have led to tonogenesis in Sylheti.

3. Acoustic measurements of Sylheti tones

3.1. Participants, Materials and Data collection procedure

Eight native speakers of Sylheti (six male, two female) from Dharmanagar district of north Tripura participated in the production experiment. The age of the participants ranged between 18 and 42 years. All the participants spoke Sylheti as their first language and were also fluent in English and Hindi. None of the speakers had any history of speech disorders.

The target words for the production experiment comprised a list of segmentally homophonous pairs of words gathered from two native speakers of Sylheti. The contrastive pairs were chosen in such a manner that historically one of the words had distinctive aspiration. There were also a few words those have undergone both the process of spirantization and deaspiration and thus appeared to be homophonous. Those words were compared with the words which already existed with their unaspirated counterparts. The dataset contained such 60 homophonous words. The monosyllabic words were of CV, CVV, and CVC syllable types and the disyllabic words were of V.CV, CV.CV, and CV.CVC syllable structure. However, as mentioned above, we have concentrated only on the monosyllabic words in this paper.

Table 1. *The dataset for the current experiment include the following target words-*

Sylheti words	**Gloss**	**Sylheti words with a history of underlying aspiration**	**Gloss**
ɸɔr	'read'	ɸɔr	'guard'
zao	'gruel'	zao	'tamarisk'
ga	'body'	ga	'wound'
gai	'cow'	gai	'stroke'
bat̪	'arthritis'	bat̪	'rice'
dax	'roaring of cloud'	dax	'drum'
ban	'tie'	ban	'pretend'
d̪an	'donate'	d̪an	'paddy'
xal	'skin'	xal	'channel/drain'
xua	'well'	xua	'jackfruit cell'
zal/ dʒal	'net'	zal	'chilly hot'
gail	'scold'	gail	'husking' 'device'

Target words were embedded in a fixed sentence frame of "I am saying **X**" [ami **X** xoiar], **X** being the target word. For the subjects to be able to maintain the tonal contrast between the words with distinct meanings, a method of priming was used, so that an example sentence where the meaning of the contrastive word would be best illustrated was first recorded. For example, in order to elicit the word [bat̪] 'rice', an example sentence 'I am eating **rice**' [ami **bat̪** xaiar] was recorded first, followed by the target word [bat̪] in the carrier frame. Each sentence containing the target word was displayed on a computer screen and the subjects were asked to produce those sentences in their mother tongue in a natural way. The meaning of each word was written along with the sentence frame. The target word was situated in the sentence medial position in order to ensure that the target word was not influenced by differing segmental properties of the adjacent words and that the intonational interference on the target words was uniform. Subjects were asked to repeat each sentence 4 times. However, only first three iterations were considered for the analysis. It was done in order to avoid the listing effect of intonations and pitch of the target words.

Speech data was captured with a *Shure* unidirectional head-worn microphone connected to a *Tascam* linear PCM recorder (ensuring a constant mike-to-mouth distance) via xlr jack.

3.2. Methods: Acoustic analysis of f_0

All the sentences were digitized at a sampling frequency of 44.1 KHz and 32 bit resolution in a quiet environment. Tokens distorted by background noise, hesitations or unusual pause, and micro-prosodic factors were excluded from the analysis. After each session, participants' data was transferred from the recorder to a portable PC using a USB cable. Each iteration of the target words was separated from the sentence using the wide band spectrograms and waveform displays and saved as individual sound file using Praat (version 5.3.04_win32) (Boersma and Weenink, 2012). Individual sound files of target words were manually segmented and three tier Praat Textgrid files were created- the first tier representing the tone bearing unit (TBU); individual phonemes of each word were marked in the second tier, and the third tier representing the whole word. The TBUs of all the target words were visually examined by observing the pitch of the onset (the point of initiation) and offset (the point of termination) in the region of the syllable nucleus or the entire rhyme, as all voiced codas in our data were only sonorants. Thus, each TBU consists of the vowel plus any voiced coda. A Praat script was written to measure the pitch contour at every 10% of the total duration of each TBU. Pitch was thus calculated at 11 consecutive points- starting from the onset ('start-pitch' [0%]) till the offset ('end-pitch [100%]) across the duration of each TBU; each point representing 10% of the total length of the pitch track. This was done with a pitch floor of 40 Hz and pitch ceiling of 600 Hz with a default time step of 100 milliseconds.

The percentage-wise pitch values were averaged across all the three iterations of each word produced by each speaker separately and was plotted as a line graph in order to observe the distinct pitch contours. We assumed that the loss of breathy voice contrast [+spread glottis] among the obstruents might cause a perturbation in the f_0 of the adjacent vowels. Pitch contours of those adjacent vowels (or the rhyme if the coda is a sonorant) would be considered as the indicator of lexical tone in Sylheti.

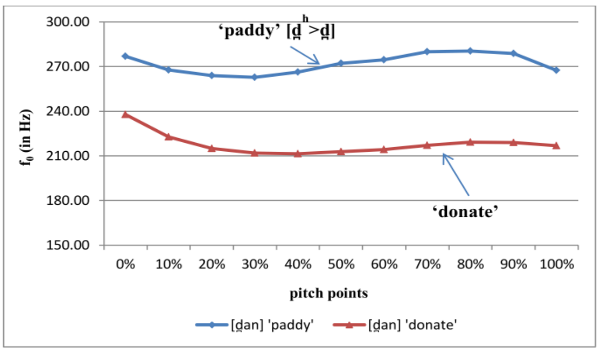

Figure 1: *Averaged pitch track for* [**d̪an**] (n=3) *is drawn using the percentage wise pitch values produced by a female speaker.*

The visual inspection of spectrograms of the homophonous words confirms the presence of tonal contrasts in Sylheti. Presence of a high tone is observed following the loss of historically unaspirated series. Using the same script (that was used to measure percentage-wise pitch values), values for duration, intensity, mean f_0, maximum f_0, minimum f_0, f_0 at vowel mid-point, were also measured. The Hertz values (for pitch) were transformed to Mel using Praat's inbuilt function HertzToMel in order to examine the range of contrastive tones at a perceptual level. The difference between the contrastive tones (mean f_0) is found to be around 30 Hz for male speakers and around 42 Hz for the female speakers. We conclude that the loss of underlying aspiration [+spread glottis] of stop consonants raise the f_0 of the adjacent vowels.

However, the non-normalized data showed a significant difference of f_0 among the male and female speakers ($p < 0.05$, F [1, 414] = 357.15, p = 0.01). It was observed that on average, Sylheti female speakers average fundamental frequency was almost 65 Hz higher than the male speakers. In order to avoid inter/intra-speaker and token variations, we adopted the z-score normalization procedure following Disner (1980) and Rose (1987, 1991) that uses the formula in (1).

(1) $z = (f_0 i - x)/SD$,

where $f_0 i$ is the sampling point (such as 'startpitch' calculated at the onset of the TBUs (0%), 10^{th}, 20^{th}, ... 90^{th}, 100^{th} point) (in Hertz), x is the average f_0 (in Hertz) of all the sampling points, and SD represents the standard deviation of all the sampling points. Following this method, the percentage-wise pitch values (measured in Hz) of each token produced by each speaker were normalized into Z score values. The Z score values were averaged across all the tokens and all the speakers (for all the 11 points) and plotted on a graph to reconstruct the pitch track. The normalized pitch tracks clearly demonstrate the presence of a high tone following the loss of historically breathy voice contrast [+spread glottis].

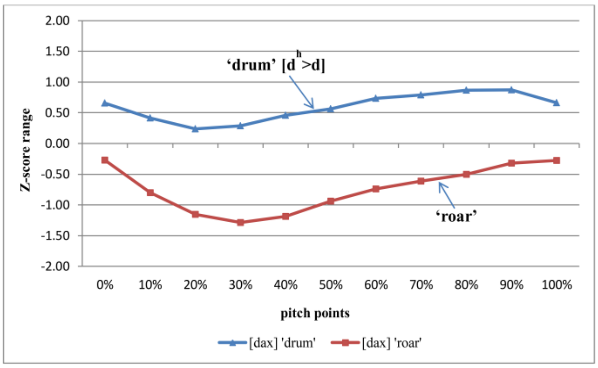

Figure 2: *normalized pitch tracks for* [**dax**], (n=27, {9 speakers * 3 iterations each})

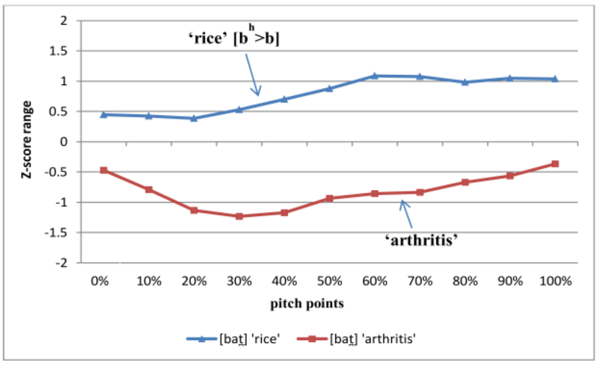

Figure 3: *normalized pitch tracks for* [**bat̪**], (n=27, {9 speakers * 3 iterations each})

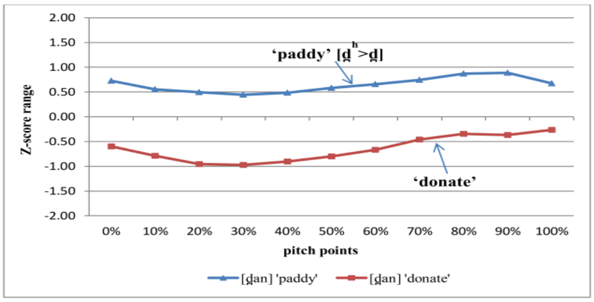

Figure 4: *normalized pitch tracks for* [**d̪an**], (n=27, {9 speakers * 3 iterations each})

In order to confirm whether the differences between the tonal categories are significantly different or not, a one way ANOVA test was conducted on normalized pitch points for the 24 monosyllabic words collected from 8 speakers.

Table 2: *Statistical analysis of variance among Sylheti tones-*

ANOVA						
		Sum of Squares	df	Mean Square	F	Sig.
Z start	Between Groups	140.72	1	140.72	204.85	
	Within Groups	284.39	414	.69		**.00**
	Total	425.12	415			
Z 10%	Between Groups	191.86	1	191.86	401.64	
	Within Groups	197.76	414	.48		**.00**
	Total	389.62	415			
Z 20%	Between Groups	242.36	1	242.36	622.58	
	Within Groups	161.16	414	.39		**.00**
	Total	403.53	415			
Z 30%	Between Groups	269.58	1	269.58	792.18	
	Within Groups	140.89	414	.34		**.00**
	Total	410.47	415			
Z 40%	Between Groups	282.51	1	282.51	887.37	
	Within Groups	131.81	414	.32		**.00**
	Total	414.32	415			
Z 50%	Between Groups	265.46	1	265.46	847.29	
	Within Groups	129.71	414	.31		**.00**
	Total	395.17	415			
Z 60%	Between Groups	245.77	1	245.77	737.11	
	Within Groups	138.04	414	.33		**.00**
	Total	383.81	415			
Z 70%	Between Groups	211.91	1	211.91	501.32	
	Within Groups	175.00	414	.423		**.00**
	Total	386.91	415			
Z 80%	Between Groups	153.38	1	153.38	316.29	
	Within Groups	200.76	414	.49		**.00**
	Total	354.14	415			
Z 90%	Between Groups	113.55	1	113.55	190.43	
	Within Groups	246.87	414	.59		**.00**
	Total	360.42	415			
Z end	Between Groups	74.44	1	74.44	111.56	
	Within Groups	276.22	414	.67		**.00**
	Total	350.66	415			

The results of an ANOVA test where tone-types were the categorical variables (Independent factor, with two levels, viz. high and low) and normalized f_0 measured at 11 consecutive points (such as start pitch [Z start = 0%], Z 10%, … Z end = end pitch), across the total length (duration) of each TBU confirms the significance of group effects between Sylheti tones.

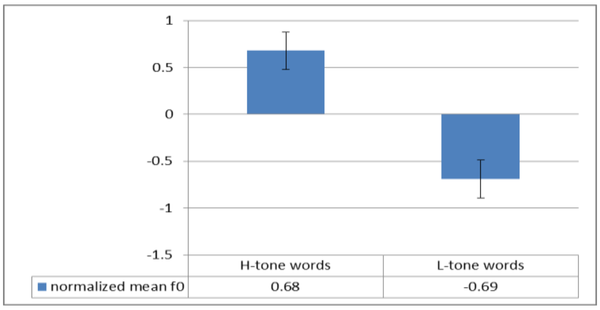

Figure 5: *Means of normalized pitch tracks with standard error bars.*

Similar one-way ANOVA test was also conducted on the f_0 calculated at various points in Mel. The results show a highly significant effect of tone on f_0 (such as f_0 at vowel mid-point (measured in Mel) $p < 0.05$, [F (1, 414) = 67.06, p = 0.00)], max pitch (measured in Mel) $p < 0.05$, [F (1, 414) = 26.21, p = 0.00], min pitch (measured in Mel) $p < 0.05$, [F (1, 414) = 40.83, p = 0.00], average pitch (in Mel) $p < 0.05$, [F (1, 414) = 48.18, p = 0.00]. A similar pattern was also observed for the remaining 36 disyllabic words (not reported in this paper).

4. Perception Test

As statistical results of the instrumental experiment established the presence of lexical tones in Sylheti, we conducted another experiment to verify if the native Sylheti speakers use differences in f_0 to perceive the differences between contrastive tones or not. 14 native speakers (7 male, 7 female, aged between 18 and 75 years) participated in the perception test. 7 of the 14 subjects also took part in the production experiment. The dataset for the perception experiment comprised of real speech data in the consistent sentence frame [ami **X** xoiar], 'I am saying **X**' (**X** being the target word) which were recorded during the production experiment. 40 homophonous words (in the fixed sentence frame) with contrastive tones were chosen for this experiment. The target words with contrastive tones in the fixed sentence frame did not differ in terms of their length/duration ($p > 0.05$, [F (1, 414) = 1.21, p = 0.27) and/or intensity ($p > 0.05$, [F = (1, 414) = 2.19, p = 0.14). Thus, the only differentiating cues distinguishing the lexical meaning of the target words was the difference in f_0. Each of those words with contrastive meaning was repeated 5 times and randomized. Each sound file was embedded with three options (meaning) (the real meaning, the contrastive meaning, and the third option being *"NOT SURE"*). All the (randomized) sound files and the options attached with the sound files were displayed on a computer screen. Subjects were asked to listen to real speech data in the fixed sentence frame and choose one of the three options displayed on the computer screen that best represents the meaning of the target word that they have heard. Subjects were allowed to listen to each word up to three times (if required).

The results of the perception test revealed that all the participants could appropriately categorize all the iterations of the 40 words (100% correct guess) (22 monosyllables, 18 disyllables) except the pair [xal] 'skin' and [xal] 'drain' where the successful correct guess was 70% and 60% respectively (few tokens were left with "NOT SURE" option). The result of the perception test further fortifies our initial conjecture about the presence of lexical tone in Sylheti.

5. Discussion

Many researchers have discussed the relationship between tonogenesis and consonant types (Hombert 1978, Ladefoged 1971, Thurgod 2002, Gordon and Ladefoged 2002, Gordon 2002, Svantesson and House 2006, Kingston 2011, and so on). In this regard, Hombert (1978) argued that an intended feature of a sound may have intrinsic effects on neighbouring sounds. Thus, in course of the historical development of a language when a particular feature of a particular sound is lost, the speakers tend to reinterpret (or rather compensate) the lost feature (or the original intended feature) as intrinsic feature in the neighbouring sound. When the intrinsic features are reinterpreted as the main features and the original feature is lost, the result is likely to be the usual source of tonogenesis (Hombert 1978, Bhaskararao 1998).

In this context, let us recall the process of tonal development in Punjabi from breathy voiced consonants. In Punjabi, the BHV sequence became voiceless unaspirated leaving a low tone on the vowel. Notice, a two-way loss of the breathy voiced consonants is compensated in the neighbouring vowels, resulting in a low tone. Other studies have also shown that breathy voiced consonants are stronger f_0 depressor (Ladefoged 1971, Kingston 2011 and so on). However the depression of f_0 following the loss of breathy voiced consonant is hardly common let alone a universal phenomenon.

In case of Sylheti, we observed two way tonal contrasts: the emergence of high tone in the vowels following the loss of aspiration, and a low tone elsewhere.

To account for a similar kind of tonal phenomena i.e. the emergence of high tone following the feature [+spread glottis] in Nakhorn Sithammarat Thai, Kingston (2009) drew a distinction between the features [spread glottis] and [constricted glottis]. He reported that it is the reflexes after [spread glottis] consonants that are higher in Nakhorn Sithammarat Thai and termed this feature as "Spread high" and distinguished it from "Constricted high". He has argued that the [spread glottis] or [constricted glottis] consonants first induced higher tones reflexes in the three way splits (as found in languages such as Yung-chiang Kam, Nakhorn Sithammarat and Szu ta chai), and the higher reflexes later exchanged values with the lower tones (as explained in Kingston 2011). Since both [spread glottis] and [constricted glottis] consonants are capable of either raising or lowering f_0, then, it is left with the choice of the native speakers of the individual language which feature to retain. The development of high tone as a reflexion of glottal constriction (or due to a process of glottalization) is reported in many Athabaskan languages (Kingston 2011, Gordon and Ladefoged 2002).

The justification behind the emergence of high tone in Sylheti could be two fold- first, the historical development of the loss of intended feature [+spread glottis] associated with aspirated obstruents is indeed reinterpreted and readjusted with a perturbed f_0 in the following vowels (in order to maintain the lexical distinctions among the likely homophonous words); secondly, due to the idiosyncratic human nature of hypo-correction (as suggested by Ohala 1993), where the listeners probably fail to normalize the coarticulatory effects such as the effects of [+spread glottis] on f_0, the vowels following the aspirated obstruent consonants might have been compensated with a perturbed f_0. Since the [+spread glottis] quality of the consonants was reinterpreted on the adjacent vowels, the vowels might have acquired a property similar to creakiness (as could be heard in few speakers' tokens at least) in order to maintain the lexical distinction of homophonous words, with an increased f_0 (since the conditioning environment wasn't completely lost that resulted in hypo-correction). Once the conditioning environment (the feature [+spread glottis]) was lost, the f_0 patterns were phonologized for the homophonous words with contrastive lexical tones. Sylheti thus offers another example of a language that is in the process of undergoing tonogenesis triggered by the systematic deletion of the feature [+spread glottis] and partially due to the process of spirantization. As mentioned before Sylheti continues to have a long history of coexisting with other Tibeto-Burman languages (such as various dialects of Kok-Borok, Reang which are tonal in nature). Even though there is no clear evidence of direct borrowing of lexical items from those tonal languages into Sylheti, there is still a narrow-window of possibility that the emergence of Sylheti tones is due to an areal feature as the indigenous speakers of Tibeto-Burman group of languages by and large use Sylheti as a common medium for interaction. It would be an interesting study to look into f_0 properties of these languages and bilinguals who speak Sylheti along with other Tibeto-Burman languages.

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