Nepalese retroflex stops: a static palatography study of inter- and intra-speaker variability

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Abstract

Retroflex sounds are classically defined as produced with the tongue tip curled backward and often in contact behind the alveolar ridge ([1], [2], [3]). The sounds, however, present a great inter-language, inter- and intra-speaker articulatory variation. Retroflex stops in Nepali, an Indo-Aryan language spoken in Nepal, are produced with the tongue tip with no backward curling movement at the alveolar ridge ([4],[5]). For Pokharel [5], this is not a real type of retroflexion, but rather is apico-alveolar with no backward curling of the tongue tip.

The aim of this study is to experimentally verify Pokharel's statement and the originality is to go beyond this claim. We wish to verify whether there is any co-articulation effect while producing the retroflex in different vocalic contexts. We use the direct palatography method to determine the place of articulation. Our articulatory data reveal an important articulatory inter and intra speaker variability. The majority of the retroflex stops realized in our study are sub-apico-post-alveolar in the case of back vowels and apico-alveolar in the case of the front vowels.

Index terms: retroflex, retraction, Nepali, apical, alveolar, palatograms, linguograms.

1. Introduction

Retroflex sounds are described as being produced with the tip of the tongue curled backward behind the alveolar ridge ([1], [2], [7], [8]). Laver [1] states *« A retroflex stop segment is one where the tip of the tongue is curled upwards and backward, such that either the tip or the under surface of the tip makes an airtight seal at the post-alveolar or palato-alveolar place of articulation. By definition, retroflexion also involves a degree of displacement of articulation»*. By definition, this implies the contribution of some sub-lingual activity [7].

Beside the tongue tip curling backward, Bhat [3] mentions the "Retraction" of the tongue body during the production of the sound, though according to the author, this is not an obligatory defining feature. For Bhat, the retraction is necessary for a retroflex but is not unique to these sounds. He claims that the apical alveolar also presents a tongue body retraction. Different studies have shown that the class of retroflex sounds displays considerable articulatory variation ([3], [7], [8]). In particular, the actual gesture of bending the tongue tip backward is, in fact, not a defining property of this class as it can not be observed for all sounds traditionally described as retroflex [9].

Nepali**,** an Indo-Aryan language principally spoken in Nepal and in some regions of India and Bhutan, has a set of 20 obstruents. The phonological inventory of the Nepalese obstruents is as follows; 1. voiceless unaspirated : [p, t, ʈ, ts, k] 2. voiced unaspirated: [b, d, ɖ, dz, g], 3. voiceless aspirated: [p^h, t^h, $ʈ^h$, ts^h, k^h], and 4. voiced aspirated: [b^h, d^h, $ɖ^h$, dz^h, g^h]. The digraph Cs or Cz represents the affricates and ʈ or ɖ represents the retroflex.

Pokharel [5] claimed that the production of Nepalese retroflex stops is 'apico-alveolar', that is, there is no curling backward movement of the tongue and the segment is articulated directly at the alveolar ridge, rather than further back in the vocal tract as is the case with most Indo-Aryan retroflex stops like those of Hindi [10] and Gujarati [6]. However, to date there is no quantitative experimental study to support this description.

The aim of this study is twofold: first, we want to verify experimentally Pokharel's classification by means of classic static palatography. Secondly, we want to evaluate patterns of inter- and intra-speaker variability in the production of Nepalese retroflexes and thereby extend Ladefoged and Bhaskararao's [7] approach based on Hindi and other Indian languages.

2. Method

2.1. Corpus

In order to determine the articulatory configurations of Nepalese retroflex sounds, two different corpora were investigated.

2.1.1. Corpus 1

Table 1. *List of first corpus.*

baʈa	'*vessel*'	Voiceless unaspirated
paʈ^{h}a	'*lambs*'	Voiceless aspirated
gaɖa	'*cart*'	Voiced unaspirated
gaɖ^{h}a	'*deep (of color)*'	Voiced aspirated

Corpus 1 focuses on differences in the place of articulation in the production of the following Nepalese retroflex stops: voiceless unaspirated, voiceless aspirated, voiced unaspirated and voiced aspirated. The following vowel context was restricted to [a]. The four different target words were embedded in the carrier phrase "babako _____" (Father's_____).

The tests are listed in Table 1.

2.1.2. Corpus 2

Corpus 2 focuses on the influence of vocalic context on the place of articulation and on the amount of lingual contact. Here we restricted the analysis to the production of the voiceless unaspirated retroflex stop [ʈ]. Table 2 contains the words to be uttered by the speakers.

Table 2. *List of second corpus.*

baʈa	'*vessel*'
miʈi	'*logatom*'
muʈu	'*heart*'

The three different target items were embedded in the same carrier phrase as in Experiment 1.

2.2. Subjects

Eight native speakers of Nepali with no articulatory defects volunteered as subjects for the articulatory experiments.

2.2.1. Experiment 1

Four male speakers (M1, M2, M3 and M4) aged between 25 and 57, and two female speakers (F1 and F2), aged 39 and 58, participated in this study. All speakers currently live in France and use Nepali within the family and frequently in their day-to-day social life.

2.2.2. Experiment 2

The second corpus was built with the help of a couple of a 38-year old male and his 35-year old wife, both native speakers of Nepali visiting Paris for the first time. Neither of them had ever left Nepal for a long period and neither of them had any noticeable articulatory idiosyncrasies.

2.3. General technique

Information on place of articulation was determined by direct static palatography ([6], [11], [12]). Both palatograms (showing the area of the palate with which the tongue has made contact) and linguograms (showing the area of the tongue that has made contact with the palate) were obtained for all test items with the aid of a digital camera. The term 'palatography' is used as a cover term for both experimental methods. Place of articulation was identified with reference to the anatomical distinctions proposed by Catford [2] (Figure 1) and the dentition plan proposed by Firth [11] with a slight modification on my part (Figure2).

2.4. Articulatory parameters

The anatomical figure of the tongue shown in Figure 1 and the dentition plan shown in Figure 2 are used to determine the place of articulation.

In our discussion of the place of articulation of the retroflex sounds, we will use the following terms, based on the dentition plan suggested by Firth [11] (Figure 2): dental, denti-alveolar, alveolar, post-alveolar and pre-palatal.

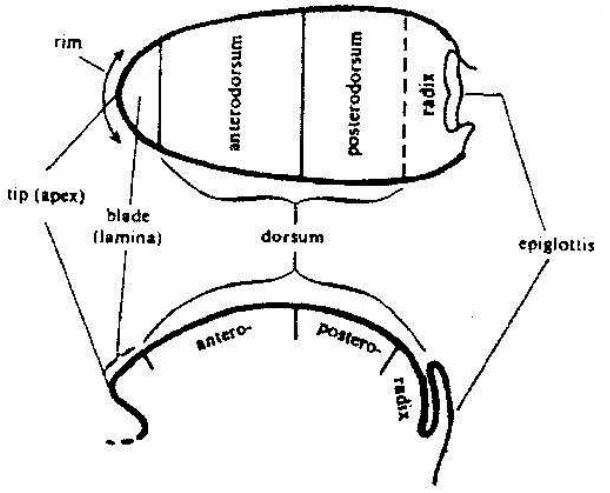

Figure 1. *The subdivisions of the tongue (Catford [2]).*

Though it is not always easy to delimit the boundary of the apex and the blade of the tongue, we consider that the fronter part that involves the tongue tip is apical. A sound is produced within a region up to 10 to 15 mm behind the apex is considered laminal [2] (see Figure 1). In this study, the apical articulation will be considered as the involving active participation of both apex and rim of the tongue (Figure 1). Just as tongue subdivision indicates the role of the active articulator, the dentition plan gives us the places of articulation.

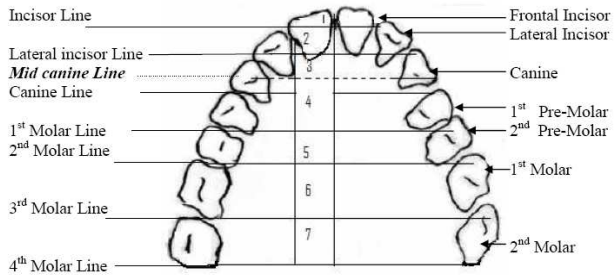

Figure 2. *Reference lines and articulatory zones: a slight modification of Firth's [11] dentition plan, with a new mid canine line.*

Figure 2 depicts a slightly modified version of Firth's [11] dentition plan. We introduced a new mid canine line between the lateral incisor line and the canine line. Whilst, in Firth's proposal [11], the alveolar region ends with the canine line, we suggest that it ends with the mid-canine line. As a result, as in Ladefoged and Maddieson [12], "alveolar" denotes contact on or on the front part of the alveolar ridge (Region 3 in Figure 2). The dental region is located in front of the incisor line (Region 1 in Figure 2). The denti-alveolar is identified with region 2 (lateral incisor) and sometimes with region 3 (mid canine). The region behind the alveolar ridge, i.e. between the mid canine line and the first molar line, is the post-alveolar region (Region 4 in Figure 2). The pre-palatal region is around the second molar line (Region 5 in figure 2). The palatal region is behind the second molar region (Region 6 in Figure 2).

3. Results

3.1. Experiment 1

Experiment 1 did not reveal any particular differences with respect to the place of articulation between the four different stops categories, i.e. voiceless, voiced, aspirated and unaspirated. However, sometimes the marks left by aspirated productions were clearer than those left by non-aspirated ones, and the marks left by voiced productions were, in turn, clearer than those left by voiceless productions.

The results of Experiment 1 are summarized in Table 3.

Table 3. *Results of Experiment 1: Sub= Subject; PoA= Place of articulation; LC= lingual contact; PAl= post alveolar; Ap= apical; SAp= sub apical.*

	ʈ		ʈʰ		ɖ		ɖʰ	
Sub	PoA	LC	PoA	LC	PoA	LC	PoA	LC
F1	PAl.	Ap	PAl	Ap	PAl	Ap	PAl	Ap
F2	PAl.	Ap	PAl.	Ap	PAl	Ap	PAl	Ap
M1	PAl.	Ap	PAl.	Ap	PAl	SAp.	PAl	SAp.
M2	PAl	Ap	PAl	SAp	PAl	SAp	PAl	SAp
M3	PAl	SAp	PAl	SAp	PAl	SAp	PAl	SAp
M4	PAl	SAp	PAl	SAp	PAl	SAp	PAl	SAp

The results of Experiment 1 clearly indicate that the place of articulation of Nepalese retroflex stop productions is realized as post-alveolar. Some speakers (F1, M1) however, produced more fronter type of the retroflex than others, but they are always behind the alveolar ridge. Figure 3 gives an example of the more fronter retroflex stops than the retroflex stop articulated by the speaker M5 in Figure 5.

In a nutshell, all retroflex realizations in our experiment were clearly produced behind the alveolar ridge, which presents a considerable difference from the data provided by Pokharel [5]. No subject has produced retroflex stops as apico-alveolar as claimed by Pokharel [5].

Furthermore, some variation among speakers can be observed, as a single speaker may vary with respect to the place of articulation. The voiceless retroflex of speaker M1 is more fronter whereas his voiced retroflex is more posterior, they are however produced behind the alveolar ridge. The articulation is usually (sub) apical and post-alveolar. However, some of our examples of retroflex sounds were produced only with the tip and the rim of the tongue, suggesting that the sub-lingual activity may not be necessary to produce retroflex stops in Nepali. Nevertheless, all subjects reported having had the impression of curling back the tongue tip. As the dynamic aspects of the sound production cannot be visualized via static palatography, we are not able to verify this impression.

Figure 3 presents an example of an apical retroflex. Speaker F1 produces a voiceless unaspirated retroflex [ʈ] Contact is made exclusively by the apex and rim of the tongue. The sound is articulated as post-alveolar.

Figure 3: *An apical post-alveolar* [ʈ] in [*baʈa*]*: Palatogram (left) and linguograms for Speaker F1. Palatal contact is behind the alveolar ridge. The tongue tip and the rim are used.*

Figure 4. [*gaɖʰa*]*: Palatogram (left) and linguogram for Speaker M2. Palatal contact is behind the alveolar ridge. We notice a lesser degree of subapical contact.*

This sound can be interpreted as involving tongue retraction without really curling back the tongue tip. A more sophisticated method is needed to verify this interpretation.

The voiced aspirated retroflex [ɖʰ] produced by speaker M2 (Figure 4) is sub-apical but his retroflexion is not as important as in the sound found in other Indian languages like Hindi or Tamil [6, 7, 8].

3.2. Experiment 2

Experiment 2 differed from Experiment 1 by the use of three different vocalic contexts. As Experiment 1 showed no difference in the place of articulation between voiced and voiceless retroflex or between aspirated and non-aspirated retroflexes, we only used the simple voiceless unaspirated retroflex [ʈ] for Experiment 2.

The results of Experiment 2 are summarized in Table 4.

Table 4. *Results of Experiment 2.*

Subject	Vocalic context	ʈ	
		PoA	LC
F3	a	Post-alveolar	Sub apical
	i	Alveolar	Apical
	u	Post-alveolar	Sub-apical
M5	a	Post-alveolar	Sub-apical
	i	Alveolar	Apical
	u	Post-alveolar	Sub-apical

Experiment 2 clearly demonstrates that there is intra-speaker variation for Nepalese retroflexion.

Both speakers produce their retroflex segments at the post-alveolar region with the underside of their tongue in the case of the back vowels [a] and [u], and against the alveolar ridge in the case of the high vowel [i]. These results show that there is articulatory variation.

The place of articulation differed according to the different vocalic contexts. The retroflex stops tended to be produced at the anterior part of the vocal tract with the tip and rim of the tongue when they were flanked by the high front vowel [i]. In this case, the retroflex articulation can be defined as apico-alveolar. The segment is produced with the tongue tip

curling back behind the alveolar region with the underside of the tongue when it is preceded and followed by back or and low vowels, i.e. [u] or [a].

Figure 5. *Palatograms (first row) and linguograms (second row) of Corpus 2 test words as produced by the speaker M5 in different vocalic contexts: [a] (first column), [i] (second column), [u] (third column). Place of articulation as well as lingual contact vary according to different vocalic contexts. The high front vowel is realized further forward and with only the tip and the rim of the tongue without subapical contact.*

These co-articulation effects are clearly seen for speaker M5 via his three occurrences. In Figure 5, we can observe that the place of articulation and the lingual contact are not the same throughout the three different vocalic contexts. The retroflexion is more retracted in the context of [a] and [u], whilst it is more anterior in the front vowel environment.

We observe in Experiment 2 that there is variability not only among the different speakers but also within the same speaker depending on the vocalic context. This co-articulation effect was expected, but it is proven experimentally in this second experiment.

4. Conclusion

The retroflex stop productions investigated in this study showed a considerable degree of articulatory variation - inter-speaker as well as intra-speaker. All retroflex stops uttered in the vocalic context [a] during Experiment 1 have been produced as post-alveolar. We notice that the realization of retroflex consonants is influenced by the different vocalic contexts. The retroflex sounds are produced as alveolar in the context of high front vowel like [i], as the vowels are more anterior, but as post-alveolar in the context of back vowels like [a] and [u], which are more posterior.

This study raises another important question. Retroflexion was very prominent for the two subjects of Experiment 2, who both live in Nepal. This could imply that Nepalese speakers who live abroad for a longer period and speak other foreign languages might lose their subapical retroflexion. However, some of the subjects in Experiment 1 also had subapical articulation in spite of residence abroad. Our data are not sufficiently exhaustive to verify this claim and further studies are needed.

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