A PSYCHOACOUSTIC BASIS FOR DISSIMILATION: EVIDENCE FROM TANGKHUL NAGA

Ryan K. Shosted

University of Illinois, Urbana-Champaign
rkshosted@uiuc.edu

ABSTRACT

The dissimilation of sequential aspirated obstruents is investigated in Tangkhul Naga. Acoustic, aerodynamic, and perceptual data were gathered to understand the alternation between aspirated and unaspirated prefixes in the verbal morphology of the language. Production data confirm that prefix onsets are aspirated only when the onset of the following syllable is sonorous. Two prefixes may occur in sequence. The traditional account predicts that the first of these will be unaspirated because it precedes an obstruent, not a sonorant. This is confirmed in the production data. However, perceptual data suggest that speakers of the language tend to hear an aspirated consonant in this position. This strengthens the claim that processing of repeated items is difficult and perhaps dispreferred—a psychoacoustic explanation for phenomena such as Grassmann's Law. This dissimilation pattern is still only perceptual in Tangkhul, but variation in production suggests dissimilation may be emerging at the production level also.

Keywords: dissimilation, aspiration, OCP, Grassmann's Law, Tangkhul Naga

1. INTRODUCTION

Tangkhul Naga (henceforth Tangkhul) belongs to a subgroup of Tibeto-Burman called Kuki-Chin-Naga. It is spoken mainly on the mountain slopes and plains of the Ukhrul District of Manipur state, India. There were 110,000 speakers in 1997 [5].

This paper uses evidence from Tangkhul to support a functional, language-processing-oriented explanation of dissimilatory processes. Some have argued that the difficulty of processing repeated items is the psychoacoustic basis of the Obligatory Contour Principle (OCP) [4]. For example, Frisch writes: "Similarity leads to mutual activation and competition that interferes with correct identification and serialization" [3].

An excellent historical example of a dissimilatory process is Grassmann's Law, the dissimilation of laryngeal features in the same word [6]. Celebrated in Sanskrit and Ancient Greek, forms of Grassmann's Law have been cited in only a few other languages [11, 13]. This paper shows that something like Grassmann's Law operates in Tangkhul Naga and appears to have a synchronic, functional, psychoacoustic basis.

1.1. The Tangkhul verb

The morphology of the Tangkhul verb is discussed by Arokianathan [1] and further elaborated by Mortensen [10]. In citation, the verb appears in the form: NOMINALIZING PREFIX + OPTIONAL LEXICAL PREFIX + ROOT, e.g. *kʰə-mə-ja* 'to accept'. The root has the shape CV or CVC (e.g. *-ja*). To the left of the root may be added any number of CV-shaped prefixes (e.g. *mə*), the majority of which are not morphologically productive, i.e. their removal or replacement does not produce any consistent semantic variation. One exception is the CV prefix /kʰə/ which acts as a nominalizer and always appears in the leftmost slot of the citation form of the verb.

The obstruent onsets of prefixes (both lexical and productive) surface as aspirated or unaspirated depending on the initial consonant of the verbal root. Arokianathan argues that voiceless obstruents lose aspiration when followed by an aspirated or unaspirated obstruent in the next syllable (shown in 1a) and remain aspirated before a sonorant (1b). Related patterns are attested in Angami [8] and Jingpho [9].

(1a)	kʰə +	pəm	→	kə-pəm	'sit.NOM'
	kʰə +	təm	→	kə-təm	'read.NOM'
(1b)	kʰə +	məŋ	→	kʰə-məŋ	'drink.NOM'
	kʰə +	rək	→	kʰə-rək	'weave.NOM'

One of the optional lexical prefixes is /kə/. Henceforth, the term 'lexical k-prefix' will apply to the second of two k-prefixes and 'nominalizing k-prefix' to the first. When verbs with the lexical k-prefix are nominalized, two k-prefixes occur sequentially, e.g. *kə-kə-tsà* 'be ill.NOM'. Henceforth, nominalized verbs with only one k-prefix will be called '1K verbs' and those with two k-prefixes will be called '2K verbs'.

Arokianthan's rule predicts that the nominalizing k-prefix in 2K verbs will be unaspirated because it precedes a non-sonorant syllable onset. However, production data show that there is some low-level

variation in this regard: the prefix is sometimes aspirated. Moreover, the prefix is perceived as an aspirate under certain conditions. Experiments show that Tangkhul speakers disprefer sequences of two identical unaspirated k-prefixes and sometimes modulate aspiration to differentiate them. Even though speakers usually categorize the nominalizing k-prefix as aspirated when it precedes an unaspirated lexical k-prefix, they are relatively less likely to do so when it precedes an aspirated lexical k-prefix (i.e. when the verbal root has a sonorant onset). These results suggest that it is difficult for speakers to process identical prefixes in sequence. Laryngeal gestures may be modified to increase the perceptual distance between the two.

2. Methods

2.1. Production

One female speaker of Tangkhul participated in the production phase of the experiment which took place in the UC Berkeley Phonology Laboratory.

Aerodynamics Oral air flow was recorded using a Rothenberg split-flow air mask [12], a Glottal Enterprises pressure transducer, and PCQuirer software to digitize and measure the signal. The air flow signal was calibrated using a pneumotach calibration unit.

The subject was asked to insert tokens into the carrier phrase *əya i nə* ___ *hang è* 'I said ___ yesterday.' Tokens were nominalized verbs of either the 1K or 2K type. The corpus of 50 verbs was recorded on three separate occasions. Peak airflow was measured during the consonant release of the k-prefixes.

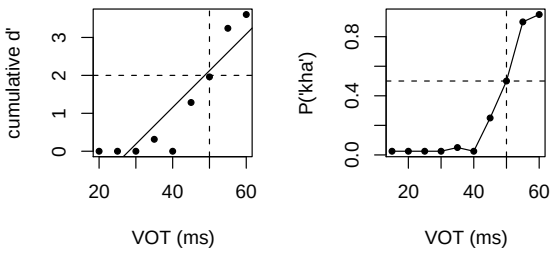
Acoustics Audio was recorded separately from the aerodynamic phase because the split-flow mask attenuates high frequencies in the audio signal. A Marantz solid-state recorder and head-mounted microphone were used in a sound-attenuated booth. Tokens of 1K and 2K verbs were recorded with every possible consonant in verbal root onset. The corpus of 193 verbs was recorded on three separate occasions, bringing the total number of stimuli to 579. Though the speaker knew that her pronunciation was being studied, she was never made aware that the experiment had to do with aspiration of the prefixes. Using Praat, VOT was measured in both k-prefixes of 2K verbs and in the single k-prefix of 1K verbs.

2.2. Perception

Three speakers of Tangkhul participated in the perception phase of the experiment, which took place in the UC Berkeley Phonology Laboratory, as well. The goal of the main perception experiment was to answer the question: How do speakers categorize the first of two k-prefixes when the aspiration of the second k-prefix is variable? Speakers were presented with nonce 2K verbs and asked to judge whether they heard 'ka' or 'kha'. Nonce 2K stimuli were created by using natural 1K verbs from the acoustic experiment and splicing in an 'ambiguously' aspirated k-prefix at the leftmost edge of the 1K verb.

Creating the stimuli The ambiguously aspirated prefix was selected with the help of a separate perception experiment. A natural, aspirated k-prefix was spliced out of a verb and the aspiration was reduced in 5 ms intervals, creating a series of stimuli along a VOT continuum from 20 to 60 ms. The adulterated prefixes were then played back to one of the speakers while wearing headphones and seated at a quiet computer terminal. Onscreen instructions reminded her to strike a certain key on the keyboard if she heard 'ka' and another if she heard 'kha'. When the listener struck a key, the next token was played. No feedback was delivered. All results were gathered using E-Prime. The cycle of nine tokens was repeated five times on four different days for a total of 180 individual responses. Hence, the listener was given 20 chances to categorize each of the nine digitally-altered prefixes. Figure 1 shows that the stimulus with 50 ms of aspiration was categorized as 'kha' 50% of the time and that it corresponds to a cumulative d' of approximately 2. Because of its perceptual ambiguity, the 50-ms k-prefix was spliced onto 1K verbs to form the nonce 2K verb corpus.

Figure 1: Cumulative d' and identification function for stimulus series 'ka' ↔ 'kha'.



Main experiment The three speakers of Tangkhul listened to a nonce 2K verb corpus. The corpus was based on 51 1K verbs: 17 where the root onset was an unaspirated obstruent, 17 with an aspirated obstruent, and 17 with a sonorant. To these 51 base forms three different classes of k-prefix were added: unaspirated (30 ms VOT), ambiguously aspirated (50 ms VOT), and aspirated (70 ms VOT). This

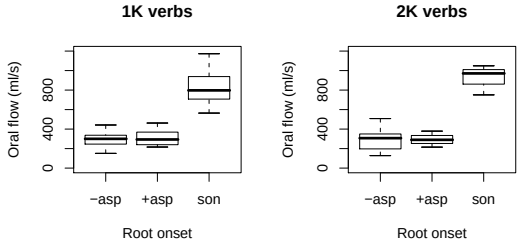
brought the total in the corpus to 153. All tokens were played four times in computer-randomized order and the listener was asked to choose whether the first sound was 'ka' or 'kha'. No third option was allowed. Because the ambiguously aspirated prefix was identified as aspirated 50% of the time in isolation, it was presumed that any change in identification rate of the test prefix would be conditioned by the variation in verbal root onset (hence, by the aspiration of the second k-prefix).

3. RESULTS

3.1. Production

Aerodynamics Figure 2 illustrates production differences in k-prefixes adjacent to verbal roots for both 1K and 2K verbs.

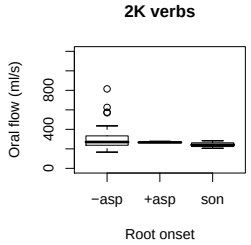
Figure 2: Oral flow in k-prefixes adjacent to verbal roots.



Prefixes before sonorants are more aspirated than prefixes before aspirated and unaspirated obstruents. Analysis of variance (ANOVA) indicates that these differences are significant for 1K verbs [$F(2,101) = 267.92$, $p<0.001$] and 2K verbs [$F(2,42) = 55.31$, $p<0.001$].

Figure 3 shows that differences in peak oral flow are not as great in the first of two k-prefixes. While there is a measurable tendency for the first of two k-prefixes to aspirate if the root onset is unaspirated, the effect is not likely to be significant. It should be noted, however, that the variation is greater in this condition.

Figure 3: Oral flow in the first of two k-prefixes, non-adjacent to the verbal root.



Acoustics The results of the acoustic experiment are similar to those of the aerodynamic experiment: VOT is greatest in k-prefixes immediately preceding sonorants (Figure 4). This effect is significant for 1K verbs [$F(2,336) = 1276.5$, $p<0.001$] and 2K verbs [$F(2,232) = 1229.5$, $p<0.001$]. However, in the first of two k-prefixes, there is little VOT distinction between verbs with different verbal root onset (Figure 5). Any empirical differences that exist are not likely be significant.

Figure 4: VOT in k-prefixes adjacent to verbal roots.

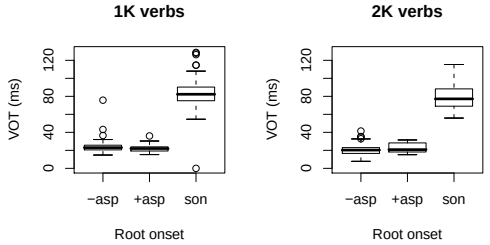
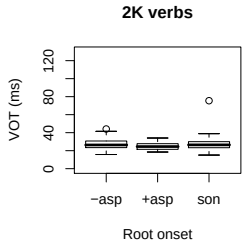


Figure 5: VOT in the first of two k-prefixes (non-adjacent to the verbal root).



3.2. Perception

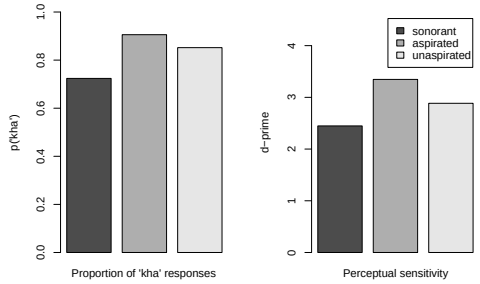
The repsonses of all three listeners were pooled together. Next, the proportion of 'kha' responses and d' were calculated for reponses to the ambiguously aspirated k-prefix [7]. As shown in Figure 6, listeners categorized the test-prefix as aspirated on more than 70% of the trials (a d' of greater than 2), regardless of verbal root onset. Also, listeners were least likely to identify the first k-prefix as aspirated before a sonorant verbal root onset. Thus, a sequence of two aspirated k-prefixes was dispreferred.

Response bias (c), or the listener's tendency to respond 'kha' regardless of the stimulus, was relatively low and comparable across test conditions: sonorant = 1.30, aspirated obstruent = 1.47, unaspirated obstruent = 1.34 (c ranges from -2.33 to 2.33; 0 indicates no bias towards either response) [7].

4. DISCUSSION & CONCLUSION

Production results confirm Arokianathan's generalization: prefixes adjacent to verbal roots are aspi-

Figure 6: Perceptual measures: proportion of 'kha' responses and perceptual sensitivity (d').



rated when the verbal root begins in a sonorant. An additional finding of the present study concerns two k-prefixes in sequence. The traditional account predicts that the first of two k-prefixes will be unaspirated, resulting in two serialized unaspirated prefixes when the verbal root begins in an unaspirated or aspirated obstruent. The same holds true if the verbal root begins in a sonorant and the adjacent k-prefix is aspirated. Contrary to this prediction, the current study shows that when two k-prefixes appear in sequence, the first of these sometimes aspirates if the verbal root is an unaspirated obstruent. Recall that when the verbal root is unaspirated, this implies an unaspirated k-prefix adjacent to the verbal root. Thus, sequences of three unaspirated consonants are somewhat dispreferred in the production data. While this effect has not yet achieved significance, the perception results may suggest that the trend is gathering strength.

The perception experiment confirms the psychoacoustic reality of this dissimilation. The aspiration of the k-prefix adjacent to the verbal root is determined by the character of the root's onset. Thus, when two k-prefixes appear in sequence, the aspiration of the non-adjacent prefix is modulated. When the second (rightmost) k-prefix is unaspirated, the first (leftmost) k-prefix tends to be perceived as an aspirate. For example, the form *kʰə-kə̀-tsà* is preferred over *kə̀-kə̀-tsà* 'be ill.NOM'. Moreover, sequences of two aspirated prefixes are relatively dispreferred, but are more commonly heard than sequences of two unaspirated prefixes.

These results support the argument that identical sequences are difficult to process and so are dispreferred, perhaps in order to increase the perceptual salience of repeated morphemes. It has been demonstrated that speech error-rates are more common in sequences with repeated segments [2, 14]. Segmental OCP effects are attested in a wide variety of languages including the Semitic languages, English, and Ngabaka. To these we might add Tangkhul, where sequences of aspirated or unaspirated consonants are dispreferred in a specific morphological context.

5. REFERENCES

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