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On the Properties of Velar /k/ in Kannada

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INTRODUCTION

The stop consonants are produced by occluding the oral cavity by an articulator, behind which air is held for sometime and released. Acoustic analysis of stop consonants has showed five distinct segments namely occlusion, burst, frication, aspiration, and voiced format transitions. Stop consonants are unique in that they represent the nonlinearity of the speech production and perceptual system. They demonstrate the redundancy of acoustic cues available to distinguish speech sounds. They provide the best example of listner use of acoustic overlapping of phonemes in the speech stream. They have consistently produced evidence of phonetic level processing. They appear to be the most highly encoded speech sounds. In word initial position, they provide the most important and reliable phonetic information about a word's identity in fluent speech. Also, they are the most information bearing elements of speech.

Our the past few decades, several investigators (Fisher-Jorgensen, 1954; Fujimura, 1961; Raphael, 1972; Keating, 1979; Lahiri, 1980; Stevens, 1975) have studied stop consonants in various languages of the world and have attempted at explaining the manner, place and voicing using acoustic parameters. This study aims at extracting various temporal and spectral parameters of the velar unvoiced, unaspirated stop consonant /k/ in Kannada language.

METHODOLOGY:

Stimulus: Meaningful Kannada words with */k /* in various positions and in various phonetic contexts were selected for this study. They were so selected to study the effect of (1) preceding vowel (2) following vowel (3) following consonant (4) clustering and (5) embedding in a sentence on the temporal and spectral aspects of *Ik/.*

Short vowels /a/, /i/, */ul, Id* and *lot* and their long counterparts /a:/, /i:/ */w.l,* /e:/ and o:/ were selected. Also, among the consonants, the affricates /e/, */j/* (palatal), the stops /i/ */dl* (retroflexes),/t/, *Id/* (dentals). *Ipl, Ibl* (bilabials), the nasals *In/* (retroflex), *In!* (dental), *Inl* (palatal), */ml* (bilabial) and /r/, */l/, /v/, /s/, Is/, /h/* and /l/ were selected. All the combinations selected were in meaningful Kannada words. The carrier phrase /i:ga na:n he:l ti:ni/ was used for embedding in sentences. Totally there were 56 words.

Subject: One yOUng male adult Kannada speaker aged 26 years served as a subject. He was a trained speech pathologist with normal hearing and Speech.

Method: The subject was familarized with the material which was visually presented with the words/sentences, one at a time. He was instructed to speak the words/ sentences into a microphone which was placed at a distance Of lOcmS from the mouth. All the utterances were recorded on a high fidelity magnetic tape and these were recorded on a high fidelity magnetic tape and these were subjected to spectrographic analysis. Wide band bar and section type of spectrograms, were obtained for all the stimuli. From the Spectrograms 17 temporal parameters, namely, closure duration, burst duration of Fl, F2 and F3 of the preceding and following vowel, Speed of transistion of F1, F2 and F3 of the preceding and following vowel and 18 spectral parameters namely Terminal Fl, F2 and F3 of the preceding vowel, steady FO of the preceding and the following vowel, terminal FO of the preceding vowel, initial FO of the following vowel, burst amplitude, amplitude Of the Consonant, preceding and following vowel Fl, F2, F3, Bl, B2, B3, LI, L2 and L3 of the consonant were extracted. The signal was fed in to the Visipitch to obtain FO measurements.

RESULTS

The data was tabulated and a principal component analysis was performed. The results of these are in Table 1 and 2.

In general, the duration of/k/ was longest in the geminate-cluster condition and shortest in singleton condition. The transition durations and speed of transitions of F1, F2 and F3 of the preceding vowel decreased successively. FO patterns of the preceding

Table 1: Average duration of temporal parameters of *IV]* in

	None luster condition	Geminate cluster condition	Non-geminate cluster condition
Consonant duration	164	309	215
Closure duration	137	281	185
VOT	16	14	21
Burst duration	9		
Transition duration			
Preceding vowel			
Fl	27		
F2	25		
F3	13		
Speed of transition			
Preceding vowel		•	
(Hz/ms) Fl	5		
F2	3		
F3	3		
Transition duration			
Following			
vowel Fl	14		
F2	19		
F3	8		
Speed of transition			
Following vowel			
(Hz/ms) Fl	8		
F2	5		
F3	-		
Preceding vowel			
duration-short	72	74	70
long	160		

	Preceding vowel	Following vowel
Steady FO (Hz)	117	119
Terminal/initial FO (hz)	109	116
FO dip (Hz)	8.89	3.1
Burst amplitude (dBR)	10	
Fl (Hz)		
F2(Hz)		
F3 (Hz)		
Bl (Hz)	364	
B2(Hz)	341	
LI	57	
L2	50	
Terminal Fl (Hz)		
Terminal F3 (Hz)		

vowels were falling and that of the vowel following was either falling or raising. The bandwidths and the intensities of the Fl and F2 declined respectively. The principal component analysis depicted the effects of various conditions on the temporal and spectral properties of *Ikl.*

Effect of preceding vowel on /k/:- It seemed that the closure duration of *Ikl* increased when preceded by the long vowels *la:/, /i:/* and /e:/ and VOT increased when preceded by /a/. The transition durations were longer for the vowel /a/ and /i/ and maximum speed of transition was achieved in vowels /a/ and /a:/. Fl and F2 of */kl* was lowered when preceded by high back vowels /u/ and *lot* respectively. F2 was raised when preceded by front vowels and lowered when preceded by back vowels. The amplitude of the burst was maximum when */kl* was preceded by /i/ and minimum when preceded by /e/.

Effect of following vowel oh */k/:-* The following vowel seemed to affect the VOT of */kl.* VOT increased when */kl* was followed by /a/ and /u:.*l.* Transition durations of Fl and F2 were longer when the following vowel was /a/. Speed of transitions of Fl and F2 were maximum for the vowels / . a/, /i/ and /u/ respectively. The burst was weak when followed by the front vowel *Id* and absent when followed by /i/. Bursts at regions of F2 of the vowels /a/, /u/ and */ol* were observed. Burst amplitude was maximum when */kl* was followed by *lol.*

Effect of following consonant (kvc condition) on *Ikl:-* The following consonat mainly seemed to affect die burst duration. Burst duration, VOT and transition duration of F1 were maximum when the following consonant was the dental aspirated /th/. Longer VOT in this condition might be attributed to the aspiration in *Ikl* which though unaspirated was uttered as aspirated, the amplitude of the burst increased when followed by palatals and decreased when followed by nasals. Initial FO of the following vowels was high (128 Hz) when */kl* was followed by *Id* and low (98 Hz) when */k/* was followed by */ml.* The following vowels exhibited two FO patterns-raising when the following consonant was **ñ,ṇ,ṅ,n,m,p,r,l** and s and falling for the others.

Effect of clustering on /k/:- The following consonant affected closure duration and VOT. Closure duration was lengthened when followed by /s/ (220 ms) and shortened when followed by retroflexes /r/ and / s/ (160 ms), when compared to singleton */kl.* The intrinsic duration of */kl* in non-cluster non-geminate condition appears to be 150.5 msecs and in geminate condition 345 msecs. VOT increased when *Ikl* was followed by /r/ and /l/. The following consonant did not seem to affect the spectral aspects of */kl.*

Effect of embedding in a sentence:- there was no significant effect on either temporal or spectral parameters of */kl* when they were embedded in sentence.

It appeared that the preceding vowel, following vowel, following consonant and cluster mainly affected the temporal parameters-closure duration and VOT and the spectral parameters -Fl, F2 and burst amplitide of *Ikl.*

DISCUSSION

The result of the present study on *Ikl* duration is in consonance with that of Zue (1976) who reported singleton */kl* duration as 148 msecs. Liberman et al (1952), on the basis of speech production and perception data postulated that VOTs greater than 20 msecs tend to be perceived as voiceless whereas VOTs lesser that 20 msecs will be perceived as voiced. In contrast, Klatt

(1975) reported VOT range of 12-39 msecs for voiceless unaspirated plosives. Also, Klatt (1975) and Lisker and Abramson (1967) reported shorter VOTs for /p, t, k/ in post-vocalic and pre-unstressed position. In the present study, the average VOT value for /k/ was found to be 17msee which is in contrast with the notion of Liberman *et al.*, (1952). This might be attributed to language differences. Whereas Liberman *et al.*, report it for English, the present data is from Kannada language.

According to Klatt (1975), the average burst duration of /k/ was 37 msecs. However, Fisher-Jorgensen (1954), Halle, Hughes and Radley (1957) opine that the burst or the transient explosion produced by the shock excitation of the vocal tract upon the release of occlusion is usually less than 20 msecs. The average burst duration of /k/ in this study was 9 msecs which is in agreement with Fisher-Jorgensen (1954) and Halle, Hughes and Radley (1957). Also, the double/multiple bursts reported to be the characteristic of velar place of articulation were noticed in this study.

Klatt (1975) and Raphael (1972) found an average duration of the vowel preceding a singleton voiceless stop in English to be 164 msecs. The results of the present study which indicates 160 msecs duration for the long vowel preceding /k/ is in par with the above findings.

Fundamental frequency dip (pitch fall) pattern has been found to differentiate voiced from voiceless stops. Voiced stops are reported to have a rising pitch pattern (Kohler, 1985; Ohde, 1984). In this study, the preceding vowels exhibited a falling F0 pattern and the following either a falling or rising F0 pattern. Also, the bandwidth is reported to increase with formants which was not observed. Instead, the bandwidth reduced with the formants.

The greater duration and speed of Fl transition in /a/ can be explained on the basis of the extent of movement the articulator need to perform: /a/ has a much higher Fl than /i/ or *Inl* and hence the articulator can be presumed to take longer time in traniting from an open tract to complete clousure as in the stop consonant.

Many of the spectral and temporal parameters seem to be affected by the preceding and the following phonemes and some results seem to be specific to kannada language. This warrants research on the other speech sounds in kannada for possible application in perception of the hearing handicaped.

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