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Voice Onset Time across Gender and Different Vowel Contexts in Telugu

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Abstract

This study was aimed at measuring voice onset time across vowel contexts and gender in Telugu (one of the south Indian languages) speaking young adults. *Considering* twelve participants, group I consisted of six adult males in the age range of 19–26 years and Group II consisted of six adult females in the age range of 19-25 years. A set of 18 CV syllables with plosives /p/,/ʈ/,/k/ and their voiced cognates /b/ /ɖ/,/g/ in different vowel contexts /a/,/i/,/u/ were considered. VOT measurements were made using PRAAT (version 5.3.17) software program. Considering vowel context, the current study results showed least VOT in the context of /a/ when compared to /i/ or /u/ vowel context. Another observation on comparison of VOT across gender revealed *no significant difference.* This finding augments our understanding on the physiology of speech production and also variation in sub phonemic features of plosives such as VOT with varying vowel contexts in Telugu.

Key words: Voice onset time (VOT), Vowel context, Gender, Telugu language, Voiced and voiceless plosives.

1. Introduction

Speech is a system of verbal communication and is distinct to human beings. Stetson (1928) believed that "speech is movement made audible". Simple, audible sounds are produced by the effort of vocal folds which is further altered by the articulators (tongue, lips) to generate speech. The analysis of speech sounds in terms of temporal and spectral aspects is called acoustic analysis. It allows the speech pathologists to infer a great deal about the movement and

placement of the articulators during the production of both normal and abnormal speech. Speech sounds comprise of vowels and consonants. Among consonants, Stops are abundantly represented in all the world's languages and are produced by the complete occlusion of the oral cavity by articulators. Acoustic characteristics of stops include closure duration, voice onset time (VOT), release burst and formant transition. Voice onset time (VOT) is measured as the time interval between the release burst and the first quasi periodicity in the acoustic signal (Lisker & Abramson, 1964; Keating, 1984; Klatt, 1975). VOT is a strong cue to voicing differences between stops (Lisker & Abramson 1964, 1970).

Studies in English have revealed that voiceless plosives /p/, /t/, /k/ have longer positive VOT in the range of 30 to 100 milliseconds and voiced plosives /b/, /d/, /g/ showed shorter positive VOT in the range of 0-25 milliseconds or negative VOT in the range of -100 to 0 milliseconds (Docherty, 1992; Klatt, 1975; Lisker & Abramson, 1964, 1967). VOT values differ according to the place of articulation and voicing. For example, velar plosives show the longest VOT among the three primary (bilabial, alveolar, velar) places of articulation, and VOT is longer in a high vowel context than in a low vowel context (Smith, 1978). Docherty (1992) reported in the language of British English that, the VOTs of the voiceless plosives were shorter for the bilabial plosive /p/ than the alveolar plosive /t/ and velar plosive /k/, with no significant differences among /t/ and /k/ VOTs. He also found that /k/ had longer VOTs in the context of high vowel /i/ and /t/ in some of the back vowel contexts.

Morris, McCrea, and Herring (2008) studied VOT with respect to gender in isolated syllable utterances. They found no significant difference between the VOTs across gender, but significant VOT differences occurred across vowel contexts, with shorter VOTs in /a/ context than /i/ or /u/. In addition, they also stated that VOT varies with the place of production with longer VOT values for alveolar and velar plosives than bilabial plosives. Some of the earlier findings on VOT in American English and British English (Higgins, Netsell & Schulte, 1998; Klatt, 1975; Smith, 1978; Docherty, 1992) stated that VOT was shorter in the context of vowel /a/. Klatt (1975) said that voiceless plosives typically had longer VOTs when followed by high, close vowels and had shorter VOTs when followed by low, open vowels.

Morris, McCrea, and Herring (2008) studied the effect of gender on VOT measurement and they concluded that, no significant difference between the VOTs of males and females in either of the voiced or voiceless syllables. But a slightly longer VOT values were observed among females than males for voiceless plosives. A maximum difference of approximately 10 milliseconds was observed for dental stop /t̪/ while the other stops had a lesser variation of around 5 milliseconds. Allen, Millerand and DeSteno (2003) observed no gender difference in VOT when they adjusted the speech tempo/rate. In isolated words, individual differences in VOTs were observed even after speaking rate was controlled with females showing longer VOTs and reduction in rate of speech.VOT differences across gender in English speaking individuals had mixed results. Most of these studies point out that, females produce longer VOTs than males for voiceless consonants (Koenig, 2000; Swartz, 1992; Robb, Gilbert & Lerman, 2005;Whiteside & Irving, 1997; Whiteside & Marshall, 2001).

The above literature suggests that studies on VOT are by and large in English. Voice onset time varies with gender, vowel context, utterance type and also with languages. There are no well documented literature in Telugu language (a south Indian Dravidian language) reporting the effect of vowel context and gender on VOT. Hence, the present study aimed at measuring voice onset time across three vowel contexts (/a/, /i/ and /u/) and across gender in Telugu speaking young adults.

2. Method

2.1. Participants

A total of 12 participants were considered in the study divided into two groups. Group I consisted of six adult males in the age range of 19–26 years with a mean age of 22.83 years and Group II consisted of seven adult females in the age range of 19-25 years with a mean age of 21.85 years. All the participants were native speakers of Telugu and had no history of any structural and functional abnormalities of the oral mechanism and had no speech, language or any neurological impairment.

Telugu is one of the Dravidian languages (Krishnamurti, Bh. 2003) and is the second most widely spoken language in India (Hussain, Durrani & Gul, 2005). Telugu language is one

of the 22 official languages in India as recognized by Indian Constitution in Article 343 (Wikimedia Foundation, 2008a). It is widely spoken in the states of Andhra Pradesh and Telangana, India.

2.2. Material

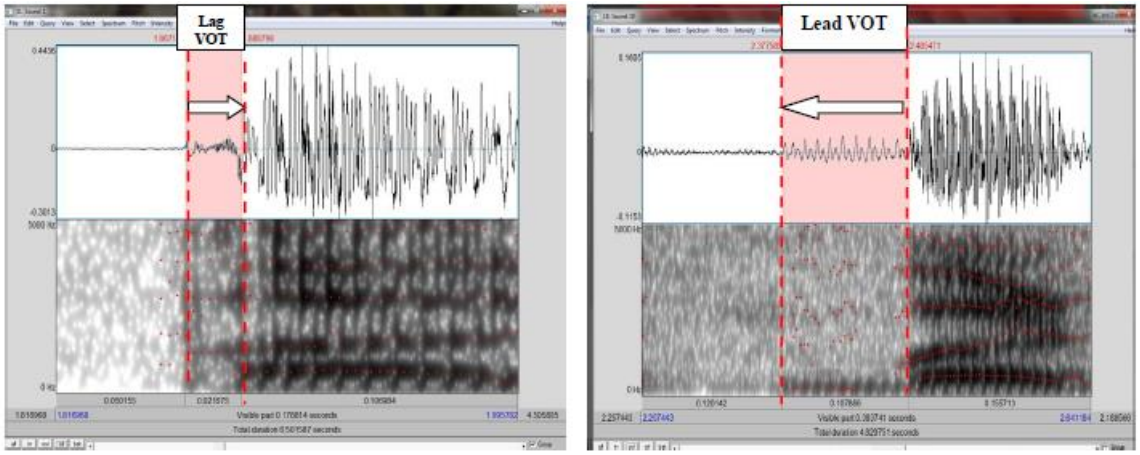
A set of 18 CV syllables with plosives /p/,/ṭ/,/k/ and their voiced cognates /b/,/ḍ/,/g/ in different vowel contexts /a/,/i/,/u/ were considered (e.g. /pa/, /pi/, /pu/, /ba/, /bi/,/ bu/ etc) as the material. Thus, each participant was made to produce a these 18 CV syllables. A total of 216 tokens were recorded from the 12 participants.

2.3. Recording Procedure

Initially the participants were familiarized with the test stimuli and were instructed to utter the stimuli CV tokens at a comfortable loudness level and pitch. Participants were seated comfortably and the recordings were carried out in a quiet room using a high-quality Microphone (iBall i342MV). The microphone was kept at a constant distance of 10 cm from the mouth of the speaker.

2.4. Data analysis

The recorded samples were fed to a SAMSUNG RVS509 laptop loaded with PRAAT (version 5.3.17) software program for acoustic analysis of the stimuli recorded. VOT measurements were made directly from the spectrograms by measuring the distance between the release of the plosive to the onset of voicing of the following vowel in each syllable. Figure 1 shows the screen display of the analyzed VOT in the token /pa/ and /ba/. Voiceless plosive /pa/ was measured as the interval between articulatory release and onset of voicing. Here voicing lags the articulatory release. Hence, lag VOT or positive VOT. Voiced plosive /ba/ was measured as the interval between the burst of noise signaling articulatory release to the onset of voicing. Here voicing leads the articulatory release. Hence, lead VOT or negative VOT.



3. Statistical Analysis

Statistical Package for Social Sciences (SPSS) version 20.0 (SPSS Inc., Chicago, IL) was implemented to perform the statistical analysis. Mean and standard deviation (SD) of VOT values for all the syllables were obtained from the descriptive statistics. Level of significance was set to 0.05. Gender served as the independent variable and the stimuli including syllables in varied vowel context served as the dependent variable. Independent sample t-test was carried out to assess the gender effect. Mixed ANOVA was also performed.

4. Results

The study was aimed to analyze the VOT of plosives across different vowel contexts and gender in 12 adult speakers of Telugu. The mean and standard deviation of VOT of the stop consonants in different vowel contexts /a/, /i/ and /u/ are presented in Table 1.

Table 1 *Shows the Mean and Standard deviation of VOT values for stops in syllables across vowel contexts*

Gender	Plosives	/a/	/i/	/u/	
		Mean	Mean	Mean	Combined mean
Males	/p/	18.58 (8.74)	19.63 (4.34)	26.80 (13.52)	21.67 (8.87)
	/t̪/	20.2 (6.31)	34.68 (8.40)	30.56 (8.86)	28.48 (7.86)
	/k/	41.50 (8.65)	58.45 (18.02)	65.33 (24.26)	55.09 (16.98)
Females	/p/	17.23 (5.11)	14.93 (4.43)	28.46 (6.02)	20.20 (5.19)
	/t̪/	18.70 (1.68)	22.13 (4.38)	21.66 (4.02)	20.83 (3.36)
	/k/	31.98 (2.49)	58.96 (6.51)	52.35 (15.07)	47.76 (8.02)
Males	/b/	126.33 (27.80)	143.40 (34.93)	123.91 (25.09)	131.21 (29.27)
	/d̪/	101.81 (19.71)	134.76 (19.21)	107.13 (25.24)	114.56 (21.39)
	/g/	101.51 (35.13)	113.71 (26.78)	116.30 (39.14)	110.50 (33.68)
Females	/b/	113.18 (27.40)	122.70 (24.19)	117.16 (26.74)	117.68 (26.11)
	/d̪/	104.40 (15.33)	116.71 (33.75)	110.61 (23.01)	110.57 (24.03)
	/g/	90.55 (15.86)	107.01 (20.86)	114.31 (19.10)	103.95 (18.61)

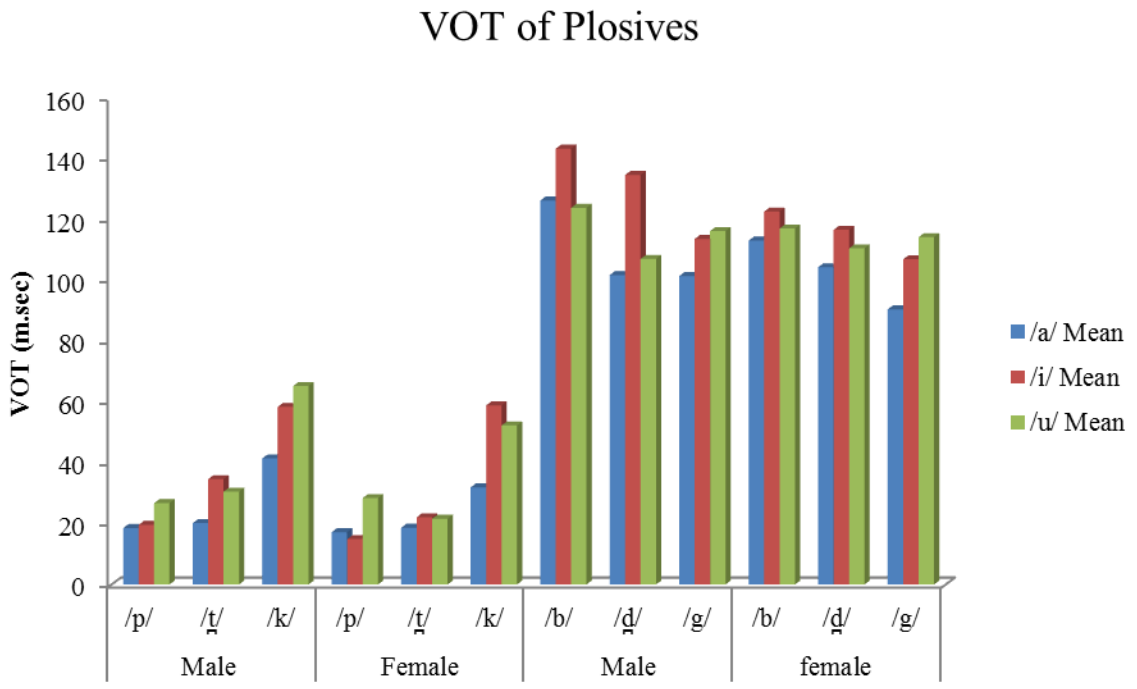


Figure 2. Shows the Mean VOT values for plosives across gender and across different vowel contexts

4.1. Vowel Context

From Table 1, it can be said that, VOTs are higher in the context of /i/ and /u/ when compared to /a/. Considering the place of articulation, the mean VOTs were longer for the dental plosive /t̪/ and velar plosive /k/ than bilabial plosive /p/. In the context of /a/ and /i/, VOT of voiceless plosives show an increasing pattern as the place of articulation moves backwards (from bilabial to velar), whereas, VOT of voiced plosives showed a decreasing pattern as the place of articulation moves backwards (from bilabial to velar) . Present results are in consistent to the views of Docherty (1992) who stated that voiceless plosive /k/ had longer VOTs in the context of /i/. Further, all voiceless plosives /p/, /t̪/, /k/ and voiced plosives /d̪/, /g/ showed significant difference ($p<0.05$) across vowel contexts except for voiced bilabial plosive /b/. Pair wise comparison of plosives in different vowel contexts showed that voiceless bilabial plosive /p/ and /k/ showed significant difference ($p<0.05$) from /a/ to /i/ and /i/ to /u/ contexts. But, for dental plosives /t̪/and /d̪/ significant difference was present for only across /a/ and /i/ contexts. A significant difference of $p<0.05$ was also observed for voiced velar plosive /g/ from /a/ to /u/ contexts.

4.2. Gender Difference

Combined mean values of voiced and voiceless plosives are shown in Table 1. It is apparent from Table 1 that, although males had higher mean VOT than and females in both voiceless and voiced plosives, there was no significant difference ($p>0.05$) observed across gender. Only the voiceless dental plosive /t̪/ [$F(1, 10) = 18.68$, $p<0.05$] showed significant difference across gender, which was higher in males. Using Independent sample t-test to assess the effect of vowel context across gender, results revealed that, there was no significant difference between vowel contexts and gender except for plosives /t̪/and /k/. Voiceless dental plosive /t̪/ in the context of /i/ [$t(1, 10) = 3.24$, $p<0.05$] and /u/ [$t(1, 10) = 2.23$, $p<0.05$] exhibited the gender difference. Likewise, the voiceless velar plosive /k/ in the context of /a/ showed a statistical difference [$t(1, 10) = 2.58$, $p<0.05$] across gender.

5. Discussion

The present study was aimed to find the effect of vowel context and gender on VOT in Telugu. Considering vowel context, the current study showed least VOT in the context of /a/

when compared to /i/ or /u/ vowel context. This is consistent with the results of Morris et al (2008) that VOT was least in the context of /a/ compared to /i/ or /u/ contexts in English. Other earlier findings for American English syllables (Higgins et al., 1998; Klatt, 1975; Smith, 1978) and British English syllables (Docherty, 1992) also stated that VOT was shorter in the vowel context of /a/. Higgins, Netsell, and Schulte, (1998) reasoned out the differences in VOT across /a/ and other vowel contexts. They opined that high vowels have lower peak oral airflows and as a result, the pressure drop in the supra glottal space will take place slowly and lengthen the VOT. The other reason is an anterior, upright pull on the vocal folds that would enhance glottal resistance preceding high vowel production. Thus, the phonation threshold pressure will be more and need additional sub glottal pressure to be developed for the onset of voicing. These justifications were consistent with Docherty's (1992) discussion of aerodynamic factors in the variability of VOT. Klatt (1975) also stated that voiceless plosives typically had longer VOTs when followed by high, close vowels and had shorter VOTs when followed by low, open vowels.

In the present study, pair wise comparison of syllables showed there was a significant difference from /a/ to /u/ contexts in voiceless plosives. Similar results were noticed by Morris et,al (2008) for voiceless plosives that mean VOT of plosives /p/ and /ʈ/ were shortest in the context of /a/ and longest in the context of /u/. However, for /k/ the mean VOT was longest in /i/ context. Likewise, in voiced plosives the present study showed there was no significant difference in terms of vowel contexts for voiced bilabial plosive. This finding is contradicting to the view of Morris et. al (2008) that VOTs of voiced bilabials /ba/ and /bi/ were similar; with the mean VOT for /bu/ being longer compared to /ba/ and /bi/. Voiced dental plosives and velar plosives /ɖa / and /ga/ showed shorter VOT than /di/ and /gi/. On gender viewpoint, the present study revealed no significant difference for VOT across gender except for plosives /ʈ/and /k/. These results are consistent with the view of Morris et. al (2008) stating that there was no significant difference in voiced or voiceless plosives across gender. To conclude, it can be said that VOT varies with vowel contexts, and not across gender in Telugu language. This finding augments our understanding on the physiology of speech production and also variation in sub phonemic features of plosives such as VOT with varying vowel contexts.

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Appendix 1

List of stimuli words used in the study

/pəllI/	/pIllI/	/pulI/
/ ʈəttə/	/ ʈIttu/	/ ʈummu/
/kəkku/	/kIkku/	/kukkə/
/bədi/	/bIddə/	/buddI/
/ ɖəggu/	/ ɖIttə/	/ ɖuddu/
/gəddI/	/gudI/	/gIrI/

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