LARYNGEAL DYNAMICS IN STUTTERING

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ABSTRACT
The present study investigated laryngeal behavior during the dysfluent word production in persons with stuttering. Five adult stutterers served as subjects. Subject's tasks were conversation and reading. The materials were recorded and analyzed acoustically using spectrogram of CSL 4300B (Kay Elemetrics). Laryngeal errors such as voiced/voiceless, voiceless/voiced, partially voiced/voiced, partially voiced/voiceless, voiced/partially voiced, unvoiced/partially voiced were identified by the wide band spectrogram and the results are discussed.

INTRODUCTION
VanRiper (1982) defined stuttering as the breakdown in forward flow of speech in terms of hesitation, stoppages, repetitions and prolongations of speech. Fluency is interrupted by contractions, tremors or abnormalities of phonation and respiration. A number of authors (Adams, 1974; Agnello, 1975; Wingeate, 1976) have suggested that the failure to coordinate respiratory actions and adjustment of laryngeal musculature in preparation for phonation is related with stuttering dysfluencies. Starkweather (1982) even said that laryngeal stuttering is primary and oral articulatory stuttering is secondary. The primariness of laryngeal stuttering is because, it occurs first and perhaps causative in the sequence of stuttering behaviors or it occurs first and is perhaps causative in the development. Number of studies have been done involving phonation in fluent and dysfluent speech of stutterers and showed aberrant muscle activity including the lack of reciprocity between abductor and adductor muscle groups (Freeman, Ushijima, 1978; Freeman, 1979; Shapiro, 1980). Chevrie - Muller (1963) used EGG and acoustic data and reported irregularities in terms of hard glottal attack, delayed transitions and clonic fluttering of vocal folds. Rashida (2001) compared EGG in stuttering and nonstuttering children and found significant difference pertaining to parameters of EGG. The initiation of phonation is a complex process involving adduction of vocal folds, adjustment of vocal folds muscles and increase in sub glottal pressure. Though several studies have attempted to explain laryngeal mechanism in stuttering the processes involved are not clearly understood. The present study aims at investigating laryngeal behaviors during the moment of stuttering. Specifically spectrographic analysis of laryngeal behaviors will be investigated.

METHOD
Subjects: Six persons with stuttering (four males two females) with a mean age of 20 years participated in the study. None of the subjects had complaint of hearing impairment, mental retardation, neurological problem or language delay. All the subjects had moderate to severe degree of stuttering. All exhibited, repetitions, prolongations, filled and unfilled pauses and had slow rate of speech. None of the subjects attended speech therapy.
Material: Bisyllabic meaningful Kannada words with stop consonants (/k/, /g/, /n/, /l/, /l/, /l/, /l/, /l/) in the initial position, phrases, reading passage and conversation were used.
Procedure: Subjects were instructed to read the material on to the microphone kept at a distance of 10 cm from the mouth of the speaker. Reading and conversation with the experimenter was recorded, digitized at 16 kHz sampling rates using the external module of CSL 4300B and were stored onto the computer memory.
Analysis: Wide-band bar type spectrograms of repetitions were obtained. Abnormal laryngeal behaviors were described based on observations from spectrograms.
RESULTS AND DISCUSSION

In general, seven abnormal laryngeal behaviors during the moment of stuttering were identified as follows:

1. Partially voiced / voiced (PV/V): Normal voiced phoneme is characterized by voice bars/formant structure (if the phoneme is a vowel) on the baseline of the spectrograms and by closing and opening laryngeal gesture (Figure 1). PV/V was characterized by fills and voice bars on the base line indicating opening between two vocal folds (Figure 2). The right side of all the figures represent the position of vocal folds.

   ![Figure 1(a): Normal spectrogram of the word /avana/ (b) Glottal gesture indicating closure.]

   ![Figure 2(a): Pv/V in the word /avana/ (stuttering) (b) Glottal gesture indicating opening.]

2. Partially voiced / unvoiced (PV/U): Normal unvoiced phoneme is characterized by silence and the glottis is completely open (Figure 3). PV/U was characterized by fills and voice bars on the baseline and comparatively lesser opening of glottis (Figure 4).

   ![Figure 3 (a): Normal spectrogram of the syllable /tʃa/. (b) Glottal gesture indicating opening.]

   ![Figure 4 (a): Spectrogram of the syllable /tʃa/ uttered as /ha/. (b) Open glottal gesture.]

3. Cessation of voicing(C): Normal voiced phoneme, most of the time is characterized by voice bars on the base line and closing and opening vocal folds (Figure 1). Cessation was characterized by complete cessation of voicing or pause on the spectrogram and an open glottal gesture (Figure 5).
Figure 5 (a): Spectrogram of the word /jaru/ with (b) Glottal gesture indicating opening. Cessation of voicing after /a/.

4. Unvoiced aspirated for voiced (UA/V): Normal voiced phoneme is characterized by voice bars on the baseline of the spectrogram and a closing and opening glottal gesture (Figure 6). UA/V was characterized by fills in low frequency region with an open glottal gesture (Figure 7).

Figure 6: Spectrogram for word /beta/ Figure 7: spectrogram of the word /beta/ uttered as /pheta/.

5. Murmured for voiced (M/V): Voiced plosives are characterized by voice bars during closure (Figure 8) and a murmured plosive was characterized by fills in low frequency and a partially open glottal gesture (Figure 9).

Figure 8: Spectrogram for the word /dodda/. Figure 9: Spectrogram of the word /dodda/ uttered as /dhodda/.

6. Unvoiced / voiced (U/V): Voiced phonemes were characterized by silence, instead of voice bars, indicating open glottal gesture (Figure 10).

Figure 10: Spectrogram of the word /jeevitha/ in normal and stutterer. In normal (a), spectrogram of /j/ is characterized by voice bars and in stutterer (b) by silence.
Voiced / partially voiced (V/Pv): Partially voiced phonemes had voice bars, instead of fills and voice bars, on the baselines indicating a closing and opening laryngeal gesture. (Figure 11).

Figure 11: Spectrogram of the word /hotel/ in normal (a) and in a stutterer. (b).

Table 1 shows the different laryngeal behaviors exhibited by six subjects. The results indicated that all subjects had U/V or used open vocal folds instead of closed vocal folds. 50% had and Pw/V and UA/V indicating partially open and extremely open folds instead of closed vocal folds. 10% of the subjects had PV/V and cessation of voicing indicating partially open vocal folds instead of closed vocal folds. It appeared that these subjects had problem positioning the vocal folds in closed position.

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Table 1: abnormal laryngeal gestures in stutters.

The results on abnormal laryngeal behaviors were interesting and can be explained in three ways. First of all, most of the time, a stutterer tried to open his vocal folds when closure was required and this happened often on plosives. Plosives are produced by building air pressure in the oral tract. Schwartz (1976) explained "Air way Dilatation Reflex" and he observed that the reflex was inhibited in stutterers resulting in laryngospasms. It appears that a passive airflow keeps the vocal fold open, which is a relaxed laryngeal posture prior to speaking enabling a stutterer to continue speech.

Second, the phenomenon of abnormal laryngeal behavior can be explained by MacKay & McDonald's (1984) concept of temporal miscoordination. According to them, a fluent utterance will be possible only if the neural impulses reach the respiratory, laryngeal and articulatory systems at the correct time and if these systems coordinate with each other in time. In instances of abnormal laryngeal gestures as found in this study, there is incoordination of the laryngeal system resulting in a feedback and another attempt to utter the phoneme. Repeated attempts (repetitions) are done till the target laryngeal gesture is reached.

Third, in some instances, cessation of voicing was observed. Voicing involves vocal fold vibrations. This can continue till there is a difference in the subglottic (P_{sub}) and supra glottic (P_{supr}) air pressure. When P_{sub} = P_{supr}, vocal folds cease vibrating. This is a normal phenomenon occurring in the production of stop consonants. However, in the example given in this study, the cessation longer than normal indicating an articulatory fixation resulting in no pressure difference between subglottic and supra glottic regions.

The results of the present study throw light on various abnormal laryngeal gestures used by a stutterer. However, not all stutterers, and not stutterers always, exhibit these abnormal laryngeal gestures. Knowledge of such abnormal laryngeal gestures helps the speech pathologist to understand the abnormal physiological mechanism involved in stuttering and thus to correct these abnormal gestures. For example, a stutterer can be taught the difference between a voiced and an unvoiced...
speech sound, he can be made aware of the abnormal laryngeal gesture he is using and taught to use a correct laryngeal gesture.

To conclude, some stutterers exhibit abnormal laryngeal gestures during the moment of stuttering and understanding the physiological mechanisms underlying these gestures will definitely enhance the diagnosis and treatment of stuttering.

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