Spectrographic Analysis of Syllable Repetition in Childhood Stuttering and Normal Non-Fluency

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ABSTRACT

Stuttering is a disorder of fluency, characterized by repetitions, hesitations, prolongations and audible pauses. Stuttering usually develops in the early years of childhood, and it tends to undergo many changes in the course of time. Many children stutter transiently before developing normal fluent speech. There is no clear agreement to regard transient period of dis-fluency as stuttering. Therefore, the present study was designed to investigate the efficacy of acoustic parameters for differentially diagnosis of childhood stuttering from normal non-fluency. Five Kannada speaking stuttering children (age range of 3 - 12 years) and eight normal children participated in the study. Speech was elicited using picture, picture depicting stories and repetitions of words. All these were audio-recorded and transferred to multi-speech software. Using wide-band spectrogram, F1, transition duration (F1,TD), onset and offset of F2, pattern of F2, extent and speed of F2, transition were extracted. These parameters between groups were compared. Results indicated shorter F1,TD, higher onset and offset of F2 in children with stuttering compared to normal children. Absent and discrepant transition patterns were more in children with stuttering compared to normal children.

INTRODUCTION

Stuttering is a temporal disruption of the simultaneous and successive programming of muscular movements required to produce a speech sound or its link to the next sound (Van Riper, 1982). This disruption is characterized by repetitions, hesitations, prolongations and audible pauses. Many children stutter transiently before developing normal fluent speech. The rate of development of non-fluencies within the context of normally fluent speech in the early years appears to be a very dynamic phenomenon and one, which probably occurs on a highly individual basis. Disfluencies have also assumed a central role in descriptions of the development of stuttering and in subgroup differentiation. Time-related variations in disfluency from easy repetitions to tense sound prolongations, blocks and broken words have been a core feature in developmental models of stuttering (Bloodstein, 1960a). Most studies on early
childhood non-fluencies examine the following characteristics: interjections, part-ward repetitions, word repetitions, phrase repetitions, revision of incomplete phrases, dys-rhythmic phonation (phonation that disturbs the rhythm of a word, such as prolongation, improper stress, a break in the word), and tense pause (barely audible manifestations of muscle tension occurring between words and within words). Howell & Vause (1986, among others) have set a few indicators that show that the fluent and disfluent speech of stutterers and non-stutterers, though perceptually identical, differ acoustically. However, the results of acoustic analysis of the speech of normally non-fluent and stuttering children are equivocal. $F_2$, $F_4$ transition, voice onset time, duration of vowels and consonants, F0 perturbation have been investigated as possible differential diagnostic indicators. The second formant transitions in dysfluent speech of normal children and children with stuttering indicate a variable pattern. The $F_2$ transitions are sometimes absent or atypical (Howell & Vause, 1986, among others) and when they are appropriate, they tend to be shorter in duration (Yaruss & Conture, 1993). However, it is yet not possible to get acoustic correlates that differentiate stuttering from normal non-fluency.

In this context, a project has been undertaken to differentially diagnose stuttering from normal non-fluency. The present study is a part of the project funded by Indian Council of Medical Research (ICMR) and it investigated the efficacy of acoustic parameters as indicators of differential diagnosis of stuttering and normal non-fluency.

**METHOD**

**Subject**

Two groups of subjects were involved in the study. Group I consisted of five Kannada speaking children (age range of 3-12 years) diagnosed as having stuttering and group II consisted of eight age matched normal Kannada speaking children. None of the subjects had any complaint of hearing impairment, mental retardation, neurological problem or language delay. All of them had normal orofacial structure and function.

**Material**

It consisted of disyllabic words with stop consonants. Ten C1V1C2V2 Kannada meaningful words with the unvoiced consonants [k, c, t, t, p] and their cognates [g, j, d, d, b] in the initial position followed by a long mid vowel /a:/ a trill and vowel /u/ or vowel /i/ in the final position formed the material. Also, general conversation and picture description were recorded.

**Procedure**

Children were tested individually. They were instructed to repeat the words after the experimenter in a microphone kept at a distance of 10 cm from the mouth and these utterances, conversations and picture descriptions were audio recorded on to a using high quality MZ-
R30 digital Sony recorder and stored onto the computer for spectrographic analysis. General conversation and picture description were transcribed verbatim and sound syllable repetition (SSR) were identified and analyzed.

**Acoustic Analysis**

Acoustic analyses were performed using multi speech software, which permitted to store the tokens. The tokens was fed from the cassette deck on to the computer digitized at 16 kHz sampling rate using a 16-bit quantization and stored on to the memory of the computer. Each token was analyzed using ‘spectrogram’ and ‘formant frequency’ program (Multispeech) and the following parameters were extracted.

1. Onset and Offset of \( F_2 \): The onset and offset of \( F_2 \) in Hz was estimated from the audio-visually apparent center of the \( F_2 \) energy bands on the spectrogram display at the onset and offset of \( F_2 \) transition.

2. \( F_2 \) Transition duration (\( F_2 \)TD): It was measured as the time difference (ms) between the onsets of \( F_2 \) transition at the beginning of the vowel till the steady state. The beginning of the steady state portion of the following vowel was defined as the time when the formant, paralleled the time axis. This measure of \( F_2 \) transition duration is believed to approximate the amount of time the articulators spend moving from one position to other. (Yaruss & contour, 1993).

3. Extent of \( F_2 \) transition: It was estimated by calculating the difference between the onset and offset frequency of \( F_2 \) (in a syllable). This is believed to represent the overall movement of the articulators during the transition.

4. Extent of \( F_2 \) transition: = Onset frequency of \( F_2 \) - Offset frequency of \( F_2 \)

5. Speed of \( F_2 \) transition: The speed with which the second formant frequency (\( F_2 \)) changes during the transition was measured by using the following formula.

\[
\text{Speed of } F_2 \text{ transition} = \frac{\text{Extent of } F_2 \text{ transition (Hz)}}{F_2 \text{ transition duration (ms)}}
\]

This is believed to approximate the speed with which the speech articulation moves from one location to the next.

6. Pattern of \( F_2 \) transition: The manner, in which movement of articulators shifted from one phoneme to another phoneme, was visually inspected. This was classified as rising, falling and absent.

**Statistical Analysis**

The Mean and Standard deviation (SD) of these parameters were computed using SPSS
software (version 10). Independent t-test was used to find out the significant difference between groups.

RESULTS AND DISCUSSION

The results indicated shorter F₂ transition duration (p<0.01), higher onset (p<0.001) and offset F₂ transition (p<0.01), slightly lower speed and extent of F₂ transition (not statistically significant) in children with stuttering when compared to normal children. Absent or discrepant F₂ transition were found more in children with stuttering when compared to normal non-fluency (NNF) children. Table 1 shows the Mean, Standard deviation (SD) and significant differences of all parameters in both groups.

Table 1: Mean values, standard deviation (SD) and significance differences of F₁ onset and offset (Hz), F₂ transition duration (ms), extent of F₂ transition (Hz), speed of F₂ transition (Hz/ms) in both groups were depicted

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Stuttering</th>
<th>NNF</th>
<th>Significances (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>S.D</td>
<td>Mean</td>
</tr>
<tr>
<td>Onset of F₂ transition</td>
<td>2290</td>
<td>518</td>
<td>1640</td>
</tr>
<tr>
<td>Offset of F₂ transition</td>
<td>2342</td>
<td>575</td>
<td>1877</td>
</tr>
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<td>F₂ Transition duration</td>
<td>38.41</td>
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<td>52.13</td>
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<tr>
<td>Extent of F₂ transition</td>
<td>228.34</td>
<td>144.23</td>
<td>310.13</td>
</tr>
<tr>
<td>Speed of F₂ transition</td>
<td>6.24</td>
<td>3.49</td>
<td>7.01</td>
</tr>
<tr>
<td>Pattern of F₂ transition (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Discrepant</td>
<td>27.6</td>
<td></td>
<td>22.7</td>
</tr>
<tr>
<td>Non discrepant</td>
<td>24.1</td>
<td></td>
<td>36.4</td>
</tr>
<tr>
<td>Absent</td>
<td>48.3</td>
<td></td>
<td>40.9</td>
</tr>
</tbody>
</table>

Note: * p<0.01, ** p<0.001

The results show several points of interest. Onset and offset frequency of F₂ transition were significantly higher in group I compared to group II. This indicates that positioning of articulators while producing stuttered sounds were different from normal disfluent sound. On the other hand, shorter transition duration was found in group I compared to group II. Shorter transition duration indicates faster articulatory movement in stuttering. Similarly, extent and speed of F₂ transition was lower in group I which implies abrupt articulatory movements from one articulatory position to another, although these differences were not statistically significant. Absent or discrepant F₂ transition were found more in group I compared to group II. This finding is in consonance with Stromsta (1986), Montgomery & Cooke (1976), Howell et al (1986) & Yaruss et al (1993). This may be because stutterers truncate their production of some phonemes during some sound syllable repetitions. The articulatory path may be incorrect in such productions.
To conclude, $F_2$ transition duration was significantly shorter and onset and offset of $F_2$ transition were significantly higher in children with stuttering compared to normal children. Thus, it implies that acoustic parameters can be used for differential diagnosis of children with stuttering and normal non fluency.

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REFERENCES