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Stuttered Speech: An Acoustic Study

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Abstract- The purpose of this study is to compare the duration characteristic of individual words and entire Passage in the speech of adults who stutter (S=10) recorded near the onset of their stuttering to those of controlled nonstuttering adults (C=10). Stuttered speech was identified in digital recordings of the clients read speech. The digitized signals were analyzed by means of Cool Edit Pro software. Using visual displays of sound spectrograms, the durations of individual words (including repeated words) in the passage and entire passage duration were analyzed. In this work 80% of data were used for training and remaining 20% for testing over all accuracy.

Keywords: *Adult; Assessment; Dysfluency; Objective; Stuttering.*

1 Introduction

Stuttering also known as Stammering is a problem with the timing of speech. People who stutter have difficulty in moving from one sound to the next in a word, or have difficulty in getting sound started after it has stopped. The late Charles Van Riper defined stuttering as "when the forward flow of speech is interrupted by a metrically disrupted sound, syllable, or word, or by the speaker's reactions thereto".

The term *Stuttering* is most commonly associated with involuntary sound repetition, but it also encompasses the abnormal hesitation or pausing before speech.

One of the challenging problems in the domain of communication disorder is an objective and an automatic way of classification of stuttering events, which is considered as difficult and complex problem [1].

Stuttering is conceptualized by various theories and hence its definition, causes and features are delimited differently. Yairi and Ambrose (2005) team differentiated Stuttering like Disfluencies (SLD) from Other Disfluencies (OD) [7]. SLD are part-word repetitions, single-syllable word repetitions and disrhythmic phonation [2]. OD comprised interjections, multiple-syllable words and phrase repetitions, revisions or abandoned utterances. It is reported that the SLD occurs at the onset of the disorder. Clinicians use diagnosis to rate a patients stuttering severity along with distinguishing stutterers and nonstutterers [3]. By tracking the stuttering severity over time, a clinician can measure a patient's progress through a treatment program, as well as the efficiency of a treatment program.

To measure a stuttering severity rating for a patient, there are number of diagnosis methods. These methods require samples of the patient's speech, which might be gathered in real time through direct interaction with the subject, or on videotape. Every individual's speech can vary greatly with the speaking context, for which a variety of samples are usually collected, using transcript of the speech for analysis. To take the advantage of the techniques, Yaruss et al., (1998) provided facts that the different techniques produce similar results for rating the stuttering severity and concluded that the best strategy is to use both techniques to take the advantage of the different strengths of each [8].

Most methods require a count of the disfluencies in a patient's speech for assessment of stuttering.. The presence covert behavior such as avoiding saying certain words or sounds [3] is another measurement of stuttering. Speaker's reactions to his own stuttering are also one of the measurements [9]. Most of these features are subjective and are not as well-defined as the more objective disfluency count.

Stuttering Severity Instrument 3 (SSI 3) [6] has been standardized on 28 adults. The instrument attempted to meet the criteria of simplicity, objectivity, sensitivity to fluency changes of clinical significance, reliability, validity, and usability with adults provide an objective method for stuttering diagnosis. Clinicians use this instrument to count the stuttering events per 100 syllables in samples of both spontaneous and read speech. The presence of physical signs of stuttering can be computed by SSI 3 using the average duration of the three longest stuttering events. The Systematic Disfluencies Analysis (SDA) [3] which is transcript based methods provides more comprehensive method that combines objective and subjective features. Both subjective and objective features can be documented by using SDA.

Our work is the extension of work done by Rebecca and Ehud, 1994, where it is considered that silent interval between the units can be one of the factors for identifying the stuttering [5]. Here we measure the duration characteristic sounds along with silent intervals between sounds of the stutterers and nonstutterers, which can be used as one of the parameter for objective assessment of early stuttering.

2 Methods

2.1 Subjects and Materials

Ten clients who stutter and 10 nonstuttering adults participated. Most of the client resided in small and medium size urban area. Recording procedure was same as the procedure described in the report by Ravikumar, et al [4].

From the reference of speech-language pathologist and the observation of authors of this paper all the subjects revealed no gross speech, hearing or language problems with the exception, of course, of within-word disfluencies produced by the stutterers. The speech was recorded digitally by cool edit Pro version 1.2 which is a multitrack hard disk editing system, using Philips multimedia headset (SHM3300). The recorded speech was processed using MATLAB Version 7 Release 14.

2.2 Analysis

For our analysis the entire data samples are divided into double unit, multiple units and entire passage. Table 1. and Table 2. shows the details of stutterers and control with respect to absolute duration in milliseconds for double unit and multiple unit sounds. Fig. 1. and Fig. 2. show the relationship between stutterers and control for double unit and multiple units respectively in terms of absolute durations. The sound spectrogram for one of the sound Gra-Gra-Gra-Gra is shown in Fig. 4. With the help of sound spectrogram the different sounds are recognized and segmented. Fig. 4 indicates the producer do measure the absolute duration of sounds

Table 1. Double Unit Sound Repetition (co-co-coat)

Group/ ANOVA	1st spoken unit	2nd spoken unit	Total
Stuttering	0.106	0.028	0.134
Control	0.215	0.431	0.646

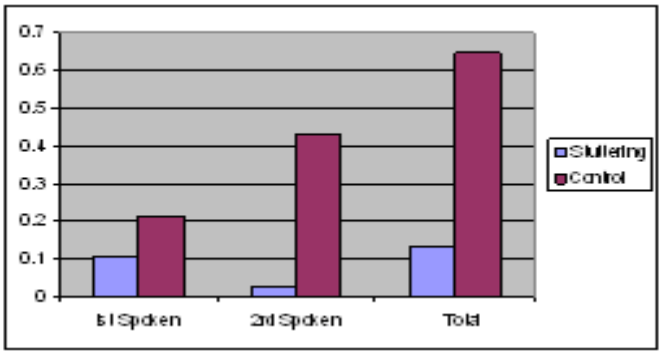


Fig. 1. Relationship between stutterers and control client for Sound co-co.

Table 2. Multiple Unit Sound Repetation (gra-gra-gra-gra)

Group/ ANOVA	1st spoken unit	2rdspoken unit	3rdspoken unit	4thspoken unit	Total
Stuttering	0.106	0.028	0.028	0.082	0.244
Control	0.215	0.431	0.323	0.539	1.508

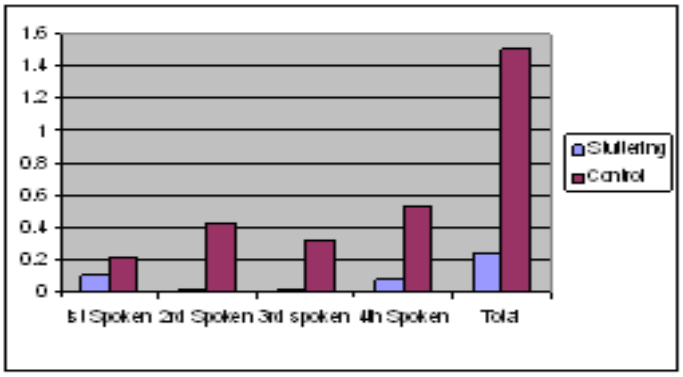


Fig. 2. Relationship between stutterers and control client for sound gra-gra-gra-gra.

3 Results

The duration in milliseconds for various segments of sounds with respect to stutterers and nonstuttered clients are measured.

$$\text{Confusion Matrix (In terms of \%)} = \begin{pmatrix} 62.5 & 37.5 \\ 7.7 & 92.3 \end{pmatrix}$$

Average Percentage = 77.4%

The confusion matrix shows the percentage accuracy in separating the stutterers and nonstutterers in terms of duration characteristics of sounds. This Parameter can be used as one the parameters for objective assessment of early stuttering. The overall accuracy of this work is 77.4%. Fig. 3. shows how these parameters are separated with respect to duration characteristics.

From our analysis it is clear that the sound duration produced by the stuttered speech is very less compared to the control subjects, where as when compared to the entire passage, the overall duration or time taken to produce sound is more for a stutters than the control subject. This duration comparison is shown in Fig. 5.

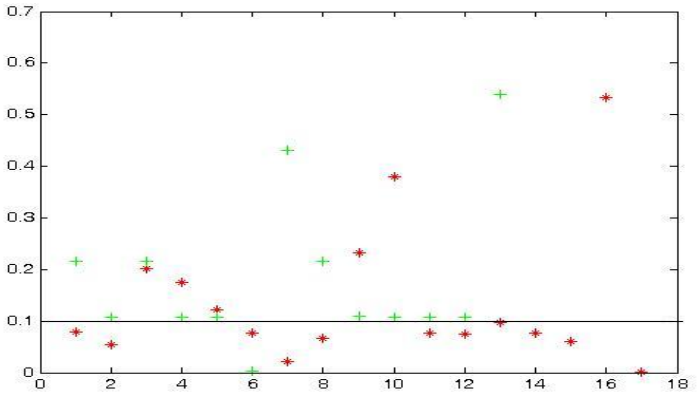


Fig. 3. Comparison of time duration of sounds between stutterers and control clients.

Table 3. Test data for Stutters and control

	Stutters		Control	
	Test Data 1	Test Data 2	Test Data 3	Test Data 4
1st Spell (minute)	1.14	1.18	1.09	1.07
2nd Spell	1.04	1.05	0.58	0.72

From our analysis it is clear that, when a stutter or a control subject reproduces the same passage second time, the time required reduces. It is also observed that the time taken decreases only for few seconds with respect to stutters, where as for control subject, it is more and is shown in Table 3.

4 Discussion

The purpose of our study was to compare duration characteristics of double unit, multiple units and entire Passage in speech of Adults who stutter recorded near the onset of their stuttering to those of nonstuttering Adults. This may be used in future for objective assessments of early detection of stuttering artifacts. Repetitions may reprint reflexive responses in attempting to correct various spatial and temporal articulatory relations. The faster rate of repetitions units exhibited by the stuttering adults may indicate a heavier reflexologic role than in disfluencies of normally speaking adults. To this general notion we add that in normal speakers, the system

allows sufficient time to make necessary adjustments. In stutters however corrective responses may be reflexively rigid, allowing only brief intervals for readjusting.

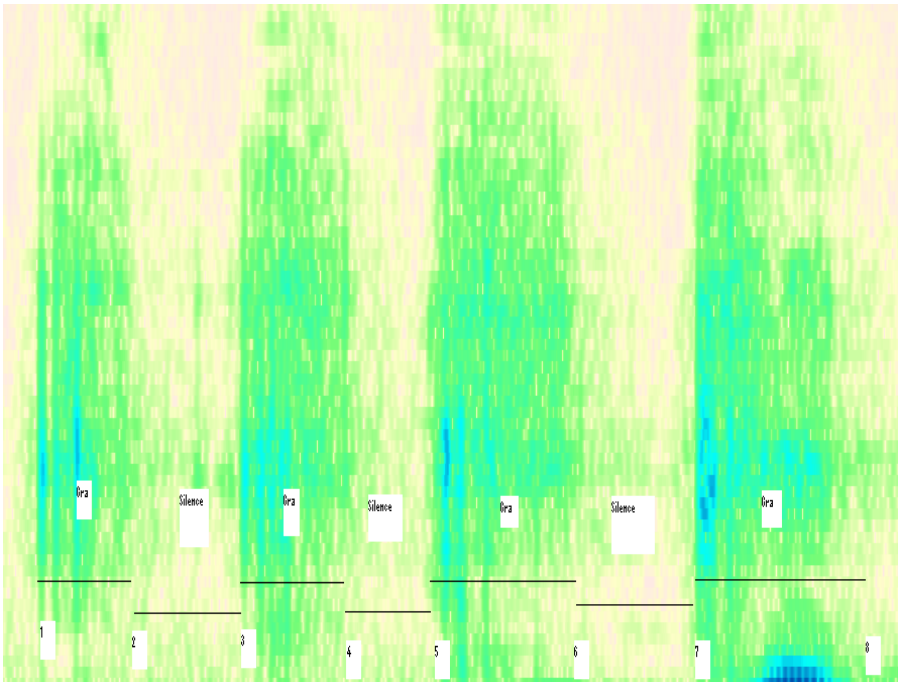


Fig. 4. Sound Spectrogram for Gra-Gra-Gra-Gra.

Thus the chance is greater for an unsatisfactory outcome that requires additional repetitive corrective attempts. This may account for the fact that the stuttering adults exhibited considerably larger number of disfluent episodes of two or more repetitions units.

In conclusion, we harmonize with Rebecca and Ehud, 1994 statement given for child characteristic which hold even for adults during onset. Compare to individual unit comparison of stuttered speech and control subject, the time duration taken for entire passage is dual in nature.

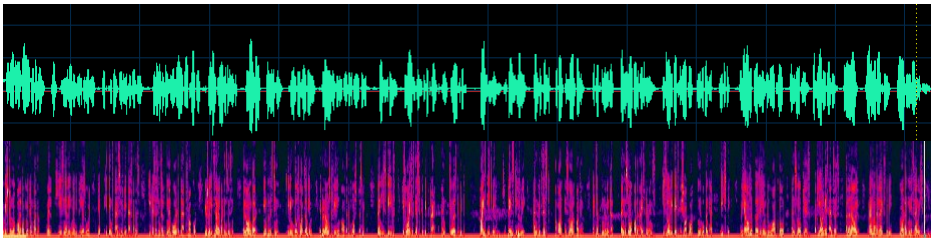
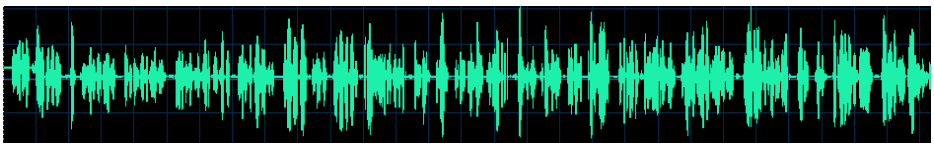


Fig. 5(a). Waveform and Spectrogram for Test Data 1



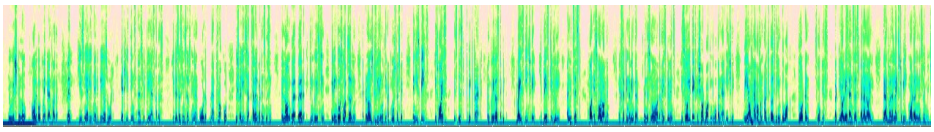


Fig. 5(b). Waveform and Spectrogram for Test Data 2

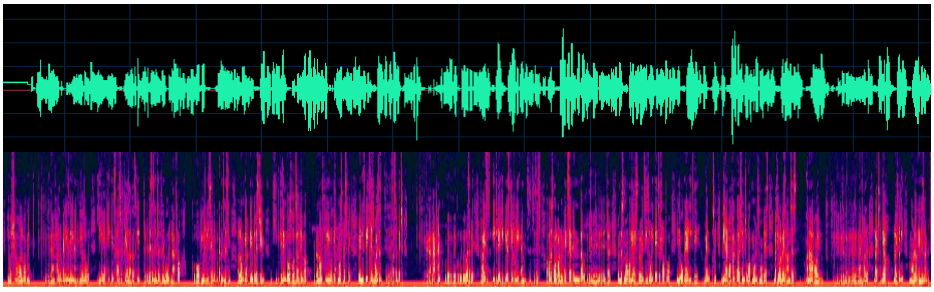


Fig. 5(c). Waveform and Spectrogram for Test Data 3

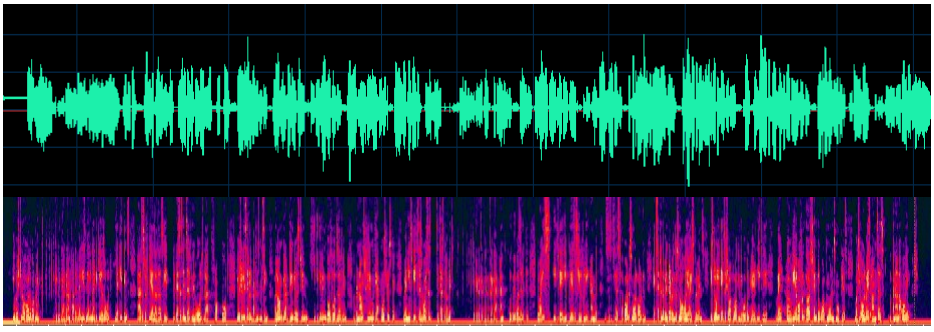


Fig. 5(d). Waveform and Spectrogram for test Data 4

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