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# Temporal Dynamics of Repetitions during the Early Stage of Stuttering: An Acoustic Study

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----------**ABSTRACT**----------

**The purpose of this study is to compare the duration characteristic of sound repetitions in the speech of adults who stutter (S=10) recorded near the onset of their stuttering to those of controlled nonstuttering adults (C=10). Dysfluent episodes are identified in digital recordings of the clients read speech. The digitized signals are analyzed by means of Cool Edit Pro software. Using visual displays of sound spectrograms, the durations of the spoken repetition units, the silent intervals between the units and the total dysfluency are measured. The stutterers exhibit shorter silent intervals between spoken repetitions units, which is used as one of the parameter for objective assessment of early stuttering. The total duration of the stutterer's dysfluency is significantly shorter because of their shorter silent intervals when compared to dysfluency of equal repetition units produced by control subjects. Analysis reveal that silent interval duration is capable of differentiating stuttering from control client with 77.4 - 95 % accuracy. In this work 80% of data are used for training and remaining 20% for testing.**

Keywords**: Adult, Assessment, Dysfluency, Objective, Stuttering**

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## 1. INTRODUCTION

Stuttering, also known as stammering is an interdisciplinary field of science, which is of interest for researchers from many areas like speech analysis, speech physiology & pathology, psychology, acoustics, etc. 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) [2]. SLD are part-word repetitions, single-syllable word repetitions and disrhythmic phonation [3]. 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 [4]. 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. For analyzing the speech samples some methods advocate the use of real-time investigation where the clinician analyzes the speech while the subject is talking. Other methods perform on non-real-time using transcript of the speech for analysis. To take the advantage of both the techniques, Yaruss et al., (1998) provided facts that the two 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 [5].

Most methods require a count of the disfluencies in a patient's speech for assessment of stuttering. Overall tenseness, hyperarticulation, and inappropriate word stress, which contribute to an unclear sense of unnaturalness of the stuttered speech, are the features of stuttering that are more subjective in nature. The presence covert behavior such as avoiding saying certain words or sounds [4] is another measurement of stuttering. Speaker's reactions to his own stuttering are also one of the measurements [6]. Most of these features

are subjective and are not as well-defined as the more objective disfluency count.

Stuttering Severity Instrument 3 (SSI 3) [7] provide an objective method for stuttering diagnosis. Clinicians use this tool 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) [4] which is transcript based methods provides more comprehensive method that combines objective and subjective features. A fine-grained analysis of verbatim transcriptions of the subject's speech is required for these methods. Based on repeated viewing of the videotape, clinicians mark and classify disfluencies on the transcript for the SDA. For audible and visible aspects of stuttering additional markings are also made along with duration of the stuttering event. Both subjective and objective features can be documented by using SDA.

Our work is the extension of work done by Rebecca and Ehud in 1994, where it is considered that silent interval between the units can be one of the factors for identifying the stuttering [8]. Here we measure the duration characteristic of sounds along with silent intervals between sounds of the stutterers and nonstutterers, which can be used as one of the parameters for objective assessment of early stuttering.

## 2. Method

### 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 is same as the procedure described in the report by Ravikumar, et al [9].

From the reference of speech-language pathologist and the observation of authors of all the subjects revealed no gross speech, hearing or language problems with the exception of course, within-word disfluencies produced by the stutterers. The speech is 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 is processed using MATLAB Version 7 Release 14.

### 2.2 Analysis

For our analysis the entire data samples are divided into single unit, double unit and multiple units. In our study we have considered only double unit and multiple unit for analysis, as their were very few samples of the single unit sounds of stutterers and control. 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 shows 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. 5. With the help of sound spectrogram the different sounds are recognized and segmented. Fig. 5 indicates the procedure to measure the absolute duration of sounds and silent intervals between the sounds.

TABLE 1

Double unit sound repetition (CO-CO-COAT)

| Group/ ANOVA | 1st spoken unit | Silent Interval | 2nd spoken unit | Total disfluency |
|---|---|---|---|---|
| Stuttering N=4 | 0.106 | 0.215 | 0.028 | 0.134 |
| Control N=4 | 0.215 | 0.315 | 0.431 | 0.646 |

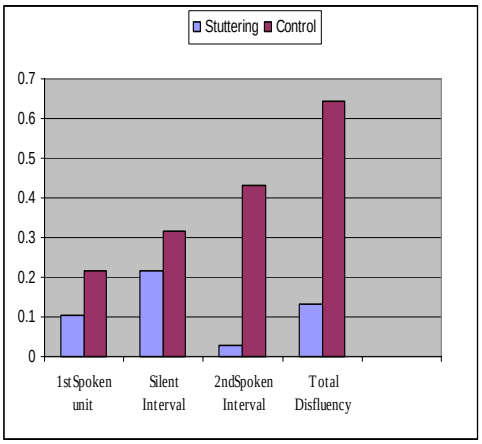


Fig. 1. relationship between stutterers and control client for sound co-co.

TABLE 2

| Group/ ANOVA | 1st spoken unit | 1st silent Interval | 2nd spoken unit | 2nd silent Interval | 3rd spoken unit | 3rd silence Interval | 4th Spoken unit | Total Disfluency |
|---|---|---|---|---|---|---|---|---|
| Stuttering N=28 | 0.106 | 0.215 | 0.028 | 0.081 | 0.028 | 0.107 | 0.082 | 0.244 |
| Control N=28 | 0.215 | 0.315 | 0.431 | 0.107 | 0.323 | 0.108 | 0.539 | 1.508 |

multiple unit sound repetition (GRA-GRA-GRA-GRA)

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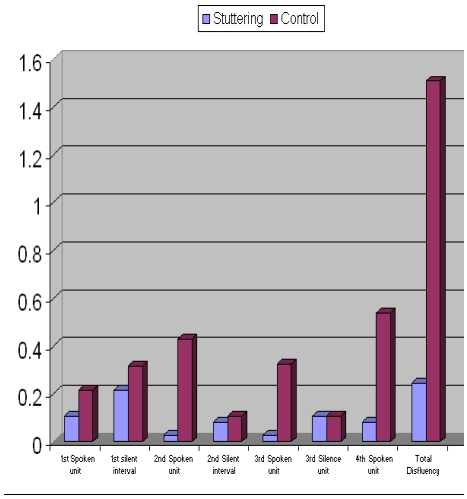


Fig. 2. relationship between stutterers and control client for sound gra-gra-gra-gra.

## 3. Results

The duration in milliseconds for various segments of sounds with respect to stutterers and nonstuttered clients are measured. The confusion matrix 1 shows the percentage of accuracy in identifying the stutterers and nonstuttering in terms of silent intervals between the sounds. The overall accuracy is 95%. Figure 3 show the detailed comparison of stutterers (*) and nonstutterers (+) in terms of silent intervals. From the Fig. 3 it is clear that the dysfluent silent interval of stutters is smaller than that of nonstutterers.

Confusion Matrix 1

$$\text{(In terms of \%)} = \begin{pmatrix} 90 & 10 \\ 00 & 100 \end{pmatrix}$$

Average Percentage = 95%

Confusion Matrix 2

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

Average Percentage = 77.4%

The confusion matrix 2 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. 4 shows how these parameters are separated with respect to duration characteristics.

It is also observed that total duration of the stutterer's dysfluency is significantly shorter because of their shorter silent intervals when compared to dysfluency of equal repetition units produced by control subjects.

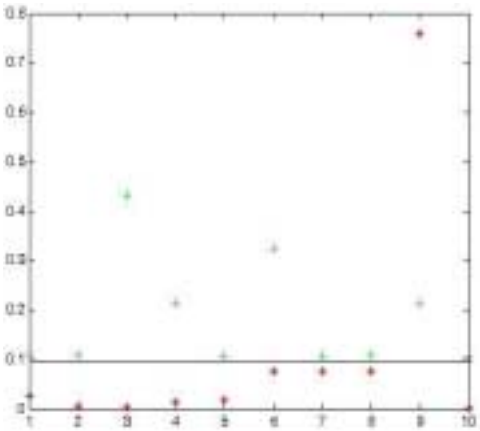

Fig. 3. comparison of silent intervals between stutterers and control clients

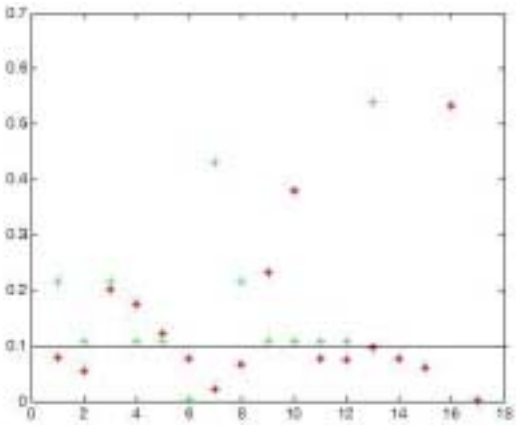

Fig. 4. comparison of time duration of sounds between stutterers and control clients.

## 4. Discussion

The purpose of our study is to compare duration characteristics of sound 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.

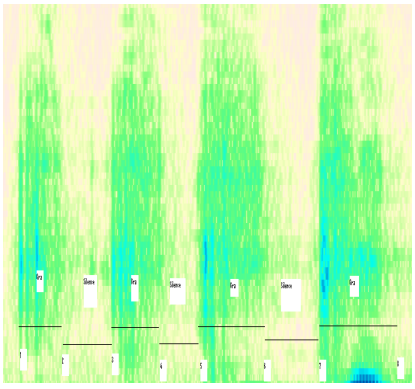

Fig. 5. sound spectrogram for gra-gra-gra-gra.

Specifically our results substantiate the trend reported by the Rebecca and Ehud, 1994, that the stutterers exhibited shorter silent intervals between spoken repetition units, when compared to nonstutterers [8]. The total duration of stutterer's disfluency is significantly shorter because of their shorter silent intervals when compared to disfluency of equal repetition units produced by the control subjects .The occurrence of this trend is reflected in all recorded data that we have analyzed.

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. 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 dysfluency 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.

## 5. Acknowledgment

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## References

[1] Andrezej Czyzewski and Andrzej Kaczmarek, "Intelligent Processing of Stuttered Speech", Journal of Intelligent Information Systems, Vol. 21, No. 2, 2003, pp. 143-171

[2] E. Yairi and N. Ambrose, "Early Childhood Stuttering", Austin, TX: PRO-ED; 2005.

[3] Ambrose. N. G and Yairi. E, "Early Childhood Stuttering I: Persistence and Recovery rates", Journal of Speech, Language and Hearing Research, Vol. 42, 1999, pp. 1097-1112.

[4] Conture. E, Rothenber. M and Molitor. R, "Electro-glotto-graphic Observation of Young Stutterers Fluency", Journal of speech and Hearing Research, Vol. 29, 1986, pp. 384-393.

[5] Yaruss. J. S, Max. M. S, Neuman. R and Campbell J.H, "Comparing Real-Time and Transcript – Based Techniques for Measuring Stuttering", Journal of Fluency Disorders, Vol. 23, No. 2, 1998, pp. 137-151.

[6] Yaruss. J. S, "Evaluating Treatment Outcomes for Adults who Stutter", Journal of Communication Disorders, Vol. 34, 2001, pp. 163-182.

[7] G. Riley, "Stuttering Severity Instrument for Children and Adults", Third. Austin, TX, Pro-Ed, 1994.

[8] Rebecca Niermann Throneburg and Ehud Yairi, "Temporal Dynamics of Repetitions during the Early Stage of Childhood Stuttering: An Acoustic Study", Journal of Speech and Hearing Research, Vol. 37, October 1994, pp. 1067-1075.

[9] Ravikumar. K. M, Rajagopal. R and Nagaraj. H. C, "An Approach for Objective Assessment of Stuttered Speech Using MFCC Features", ICGST International Journal on Digital Signal Processing, Vol. 9, June 2009, Issue. 1, pp. 19-24.

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