Computer-based System to Assess Efficacy of Stuttering Therapy Techniques

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Abstract— **This paper presents a computer-based system tool used to assess efficacy of stuttering therapy techniques. The software assists Speech-Language Pathologist (SLP) in determining suitable techniques for each client .The project implements Digital Signal Processing (DSP) techniques to analyze speech signals and incorporates standard speech fluency shaping techniques that can be used as part of fluency rehabilitation regimen. The software provides real-time visual and audio feedbacks for clients to be aware of their speech patterns. It provides self training aid for clients that motivates them to practice at home. The software runs under Windows XP on a computer equipped with multimedia capabilities. Real-time visual and audio displays enable the clients to compare their average magnitude profiles (AMPs) with clinician's and alter their speech to match clinician's AMP. The start and end alignment, maximum magnitude and duration of two AMPs are compared. A score is assigned to each category. The software is developed using Microsoft Visual C++ 6.0. Software is designed as graphic user interface (GUI), which makes therapy user friendly. Three techniques that are implemented in the project have been decided through the discussion with SLP in Hospital Sultanah Aminah (HSA). The techniques are Shadowing, using a Metronome (Taping) and Delayed Auditory Feedback (DAF). This project is done in collaboration with HSA where the hospital assists in the clinical trial.**

Keywords— **Stuttering, speech therapy, fluency shaping, therapy techniques, digital signal processing**

I. Introduction

Stuttering [1] is a disorder of fluency characterized by excessive amounts of dysfluencies, excessive durations of dysfluencies, and unusual amount of muscular effort in speaking. It is a disorder in the rhythm of speech in which the individual knows precisely what he wishes to say but at the time is unable to say because of an involuntary repetition, prolongation, or cessation of a sound.

The most commonly utilized techniques of facilitating fluency are fluency shaping and stuttering modification. Both techniques were considered by Person Who Stutters (PWS) to be better than those strategies that were intuitive on the part of the speaker such as forcing out the speech or avoidance [2]. Stuttering can be treated by fluency-shaping therapies [3] which effectively and durably replace the chronic stuttered speech pattern with a newly learned prolonged and rhythmic fluent speech. Stuttering Modification therapies [4] focus on changing individual moments of stuttering to make them smoother, shorter, less tense, and less penalizing.

The use of computer technology in speech therapy and assessment is still new in Malaysia. There are many clinical approaches to treat individuals who stutter, however, the treatment process may take months of repeated procedures that are costly and overly generalized. Normally, 2 to 3 months are required to determine suitable technique for each client. The maximum magnitudes of the clients and the clinicians, corresponding to the average magnitude profiles (AMPs), are determined and compared in our software. The maximum magnitude is determined where a total of 15 neighboring samples are summed to obtain a maximum value. Our hypothesis is by doing comparison between client's and clinician's AMPs for three therapy techniques (Shadowing, Metronome and Delayed Auditory Feedback), the computer analysis can help SLP to assess the efficacy of each technique, thus determining suitable technique for each client in faster and more accurate manner.

II. Stuttering treatment framework design

A. Problem Formulation

Speech therapy does not cure stuttering. Typically, clinical treatment for stuttering involves visiting a Speech-Language Pathologist (SLP) for a series of therapy sessions. Initially, the visits are once or twice a week, and between visits the PWS do various activities, exercises, and practice routines that will ultimately provide relief from stuttering. PWS can learn to control their speech fluency by shaping the tempo, loudness, effort or duration of their utterances. However, speech fluency treatment should not be limited to clinical sessions. Speech assessments should be obtained under multiple conditions and on various occasions [5]. This may not be feasible if particular equipment can be used only in laboratory settings or if parents are not able to bring a child to the clinic, necessitating clinicians to visit a child at home.

Stutterers must continue their practices at home so that it becomes their daily routines. The major problem [6] with

practicing outside the clinic is that clinicians cannot ensure that clients are practicing correctly and/or consistently. Clients may practice utterances at home regularly, but if they practice incorrectly, they will not see any progress in their rehabilitation. Lack of progress causes clients to practice less frequently, resulting in a cycle of poor practice where no improvement is achieved. The training process could be enhanced if clients have a surrogate clinician to assist them during daily home treatment sessions. In this system, the surrogate clinician will be a software package that clients use at homes. The software implements standard fluency shaping technique by providing immediate visual feedback to clients to let them know if they are practicing correctly. This motivates clients to practice at home and at the same time allows clinicians to assess the progress.

Studies [7] indicated that treatment was eventually helpful in reaching goals of successful management for PWS. Interestingly, however, there was no pattern regarding the approach or techniques that participants found helpful. Participants had difficulty identifying specific approaches or techniques to which they could attribute their success. Findings [8] suggest that a system that can identify suitable techniques is important because any rational and empirically informed procedure that enables the client to self-assess and systematically modify speech behaviors and the associated cognitive features may be likely to successfully facilitate fluency.

B. Underlying Design Principles

The research evidence [9] showed that changes in stuttering treatment based on prolonged speech were needed and, as a result, corrective action is important and self-correction is the sine qua non of a scientific approach. Self-measurement serves as the basis for determining the clinical significance of a treatment change from the client's perspective. Our software is designed based on the facts that clients must be involved directly in the treatment process. Software provides real-time visual and audio bio-feedbacks where client's AMP is displayed as it is spoken and it is superimposed on the clinician's AMP. The display of AMP is intended to convey to the client those locations where the client's utterance differed from the clinician's in the aspect of start and end alignment, magnitude and duration. AMP of the spoken utterance is the primary source used to gauge the fluency and performance of the client.

Camperdown program outcomes [10] supported our project where it demonstrated that PWS could develop natural-sounding, nearly stutter-free speech without specific clinician instructions with regard to speech modifications although they do require consistent and reliable feedback concerning stuttering severity and speech naturalness. The success of the Lidcombe [11] and the Camperdown programs appear to suggest that many PWS are able to produce nearly stutter-free and natural-sounding speech by (1) developing a cognitive set to speak without stutters and (2) monitoring their speech, initially with the help of clinicians or family members, to verify that this goal is achieved. This inference has strong empirical foundation.

Many of the clinical therapy techniques require a conscious effort on the part of the clients [12]. Therefore, the element of motivation must be integrated into stuttering therapy. It is essential that the child enjoys the treatment and finds it to be a positive experience. Computer-based therapy displays speech waveforms and amplitude curve in graphical representation which can motivate and encourage child to practice their therapy for longer periods.

Rewards are important to motivate the clients. Research [12] supported that both tangible forms of rewards and verbal rewards were effective in reducing stuttering. Both forms of reward appeared to be successful, but their unique contributions could not be measured because treatment involved a number of therapy procedures. Therefore, in our software, we implemented rewards for the client whenever he or she manages to obtain scores of 80 and above.

Research [13] indicated that basically five steps are required in implementing clinical treatment system as follows.

1. Convert a clinical need into an answerable question.
2. Search for the best evidence to answer the question.
3. Critically evaluate the evidence for validity and applicability.
4. Apply the results to clinical practice.
5. Evaluate and audit performance

By performing the above tasks, the surrogate clinician helps minimize the problems associated with practice outside of clinic. This software tool enhances the treatment process by providing clients with the feedback necessary to identify speech properties while still allowing the clinician to have control of the treatment process. This combination of feedback, progress records, and customizable practice phrases would be a valuable asset to current treatment techniques. The clients themselves modify their speech in subtle and variable ways to gain control over stuttering and, in that, they appear to be similar to a well-known experimental technique for suppressing stutters known as response contingent stimulation.

Prolonged speech based stuttering treatment typically involves "shaping" speech systematically by requiring participants to meet specific criteria for rate and an assortment of related speech modifications such as gentle voice onset, continuous vocalization, and soft articulatory contact in small, incremental steps [14]. Thus, our project required significantly fewer clinician contacts compared to the traditional behavior therapies used in the past.

III. System design

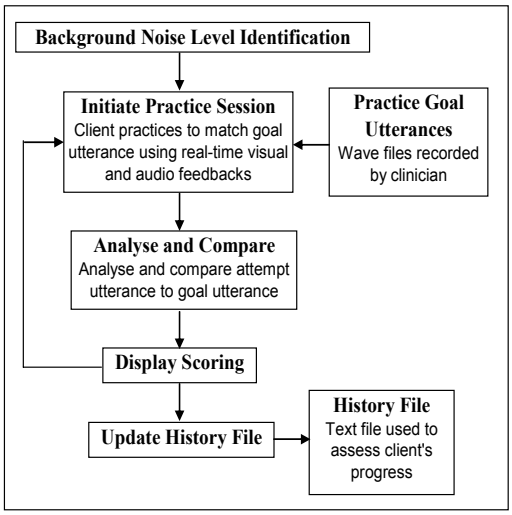

Fig. 1 System Design

Fig. 1 shows system design. Sound recording of 5 goal utterances is implemented where the software incorporates functions record, playback, open, close and save of standard WAVE file. In the speech pathology clinic, after the clinician has identified client's stuttering problem, the clinician verbally records 5 speech utterances, which the clients will later on practice at home. The 5 goal utterances are customized by the clinician for each client depending on the age and language level. Goal utterances are chosen based on their phonetic characteristics. Each goal utterance is stored in a separate WAVE file, which can be individually selected for practice. The duration for each target utterances is six seconds.

The software is able to calculate and display the AMP of the client as it is spoken as shown in Fig. 2. The speech processing is done in real-time. This provides immediate feedbacks to the client, which give clients the opportunity to alter their speech. A text history file is generated after completing a treatment session as shown in. A separate history file is created for each client. The history file summarizes the client attempts. Clinician can use this information to assess or monitor client progress and observe how much time client spends to practice. This information can be used as reference for clinician to determine suitable techniques for each client.

The selection of scoring parameters is important because the parameters will influence in our clinically significant outcome for behavioral treatments for stuttering within an evidence-based framework [15]. Moreover, it is important to make sure that a framework might lead towards outcomes that are meaningful for the clinician or clinical researcher, the client and relevant others such as parents of a child who stutters. The stuttering measures also enable the SLP and the parent to communicate effectively about the severity of the child's stuttering throughout the treatment process. Any departure from the criterion speech performance, as specified with the stuttering measures above, results in more frequent clinic visits and possibly an increase in parental contingencies. Client's AMP is compared with clinician's AMP in four categories. They are start location identification, end location identification, maximum magnitude comparison and duration comparison.

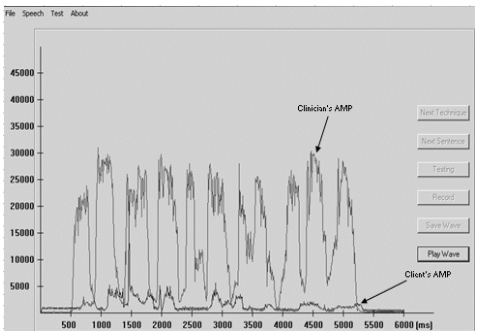

Fig. 2 Average Magnitude Profiles of Clinician and Client

IV. Results and discussions

Test subjects were selected from 6 primary schools located in Skudai, Malaysia. A total of 11 subjects participated, 10 males and 1 female. 10 of the test subjects had been diagnosed by a SLP as having stuttering and had been stuttering for at least six months. One of whom have been omitted from analysis because the subject in question was identified to be not a stuttering client. The age span was between 8 and 12 years old. They were not familiar with speech technology in any way. The participants were tested in a quiet setting in one session which required approximately 5–10 minutes.

The data collection process began by engaging each participant in a short conversation regarding their favorite sports or interests to obtain data on participants' language level so that the author knows precisely which set of sentences to be used for that subject's oral-reading task. The test was presented on a computer monitor positioned at a comfortable reading level for each participant. At the beginning of the recording session, participants were given a short practice for each sentence before the actual recording.

Each subject carried out three tasks. Of the data collected, a total of 281 subject utterances have been analyzed

in the present work. In time, this amounts to 1686 seconds or 28.1 minutes of speech. The speech sample was presented to the SLP in both the audiovisual and audio-only mode. SLP judged each sample individually.

Measures of %SS (Percent Stuttered Syllables) for three techniques were made by SLP from HSA as shown in Table 1. From Table 1, it was certified that two subjects (Subjects G and H) were identified as having mild stuttering, two subjects (Subjects C and E) were identified as having mild-to-moderate stuttering, three subjects (Subjects B, D, and F) as moderate, two subjects (Subject A and I) as moderate-to-severe, and one subject (Subject J) was identified as having severe stuttering. Out of ten subjects, only one subject had a history of receiving traditional speech therapy for remediation of dysfluency through their school systems. The measure of %SS provides additional references for determining suitable therapy techniques for each client other than the scoring generated by the software.

Table 1 %SS for Each Technique

Test Subject	Percentage of Stuttered Syllables (%SS)		
	Technique 1	Technique 2	Technique 3
A	15.23	20.97	9.62
B	11.11	13.46	14.86
C	5.77	5.77	11.54
D	16.00	7.84	7.14
E	8.62	4.76	11.90
F	17.46	7.69	13.51
G	5.77	5.77	3.85
H	7.69	9.62	11.54
I	22.41	16.42	12.77
J	20.24	23.08	35.87

V. Conclusions

Currently, we implemented three stuttering therapy techniques in our software. The project can be extended by implementing more stuttering therapy techniques in order to increase the accuracy. We hope that the current outcomes will be re-examined with larger and diverse samples and that the proposed topics will be investigated through innovative methodologies in efforts to inform treatment directions in stuttering. Due to the well-documented variability of stuttering within subjects, speech samples should ideally be obtained under multiple conditions and on multiple occasions. This can be particularly important for young children, as stuttering has been reported to fluctuate greatly over time and sometimes cease entirely. Our current software aimed at determining suitable therapy techniques for each client by looking at the scoring generated automatically by the software and the %SS measured from speech samples. This personal computer-based system is intuitive to use, cost-effective, and easily integrated into current speech rehabilitation regimens. We believe our software tool will improve the effectiveness and availability of stuttering treatment.

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