

## Overview of a Computer-based Stuttering Therapy

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### Abstract

*The purpose of this paper is to introduce the reader to a variety of anti-stuttering devices that have been used to treat stuttering. The use of devices to cure, or at least control, stuttering is not new. A variety of devices have been utilized, with a variety of purposes. A few examples of each of the different classes of devices are discussed. Reviews on these various electronic devices are presented where there is no one best treatment for stuttering for every client. It is suggested that choosing different types of stuttering managements is a personal decision based on the unique values and treatment objectives of each individual person who stutters. This leads to the implementation of our computer-based Malay stuttering therapy to help Speech-Language Pathologist (SLP) to determine suitable technique for each client. The project implements Digital Signal Processing (DSP) techniques to analyze speech signals and incorporates fluency shaping techniques. Our hypothesis is by doing comparison between client's and clinician's Average Magnitude Profiles (AMPs) for different techniques, the computer analysis can help SLP to determine suitable techniques in faster and more accurate manner. This will reduce cost and time for therapy. We believe our software tool will improve the effectiveness and availability of stuttering therapy in Malaysia. We hope that our software tool will provide insights into the implementation of computer-based Malay stuttering therapy in Malaysia.*

### Keywords:

Stuttering, Speech Fluency, Computer-Based, Therapy Techniques, Electronic Devices

### 1. Introduction

Stuttering is one of the serious problems in speech pathology. It occurs in 1% of populations and has found to affect four times as many males as females. Stuttering [1] is the disorders in the rhythm of speech in which the individual knows precisely what he wishes to say, but at the time is unable to say it because of an involuntary, repetitive prolongations or cessation of a sound.

There are basically four classes of computer-based stuttering devices available on the market. Some devices are aimed at forcing the person who stutters to change the manner in which they speak. Others are utilized to provide the client with more easily observable feedback of their current physiologic status or production pattern, often to assist them in achieving speech production targets utilized in therapy. Still others alter the natural feedback the client receives in an attempt to prevent stuttering. We will discuss one by one in the following sections.

### 2. Devices that Alter Auditory Feedback (AAF)

There are four types of AAF [2]. They are Masked Auditory Feedback (MAF), Delayed Auditory Feedback (DAF), Frequency Altered Feedback (FAF) and Combined/multiple feedback (DAF, FAF, MAF). The effectiveness and value of auditory feedback has been documented in the professional literature [3]. Indeed, portable devices are available for implementing auditory feedback. Most of these devices are single purpose especially DAF devices. Some of the feedback devices are intended to disrupt feedback (DAF and MAF), and others are intended to enhance normal auditory feedback. MAF refers to the use of sound, generally a noise of some sort, of sufficient intensity to block the auditory feedback of the speaker's own voice to his or her ears. With DAF [4], we hear what we say a short period of time after we say it. The stutterer talks into a microphone and his or her speech is recorded and played back through speakers or headphones at a delay of 250 milliseconds [5]. Some stutterers stutter less severely when they experience DAF while they speak [6]. The most recent of the AAF modes to be introduced is

frequency altered feedback, also known as frequency shifted feedback (FSF). The effects of FAF in stutterers have been examined in a variety of paradigms, including frequency shifting in either direction, at various speaking rates [7, 8].

Pocket DAF/FAF Assistant [9] is a software application that implements DAF and FAF techniques on handheld computers running Windows Mobile 2003 for Pocket PC and Windows Mobile 5.0 operating system. The application can be used by people having stuttering problem to control their speech fluency, increase their confidence level and develop the carryover fluency when the techniques are used on a regular basis. Pocket DAF/FAF Assistant delays the voice to ears a fraction of a second later. The application provides delay ranged from 50 to 250 milliseconds. The delay increment step is 10 milliseconds. A short delay (50-80 milliseconds) almost instantly reduces stuttering without changing the speech speaking rate. A longer delay (90-250 milliseconds) enables stutters to stretch vowels and talk slower. It can help with even severe stuttering, but requires training, and mental effort. FAF shifts the pitch of voice and provides the pitch shift in the range from one-half octave down to one-half octave up. The FAF enhances the effectiveness of the application when it is used simultaneously with DAF [10].

The SpeechEasy [11] is digitally programmable with special computer software for a wide range of settings of DAF and FAF. SpeechEasy fluency devices are based on a natural phenomenon called the "choral effect." The "choral effect" occurs when people who stutter speak or sing in unison with others and their stuttering is dramatically reduced or even eliminated. SpeechEasy employs AAF in the form of auditory delays and frequency shifts to provide maximum long-term benefit to individuals who stutter. They are adjusted to fit in or behind the ear, and are to be worn like traditional hearing aids. Initial clinical trials of SpeechEasy have been conducted at the Stuttering Research Laboratory, East Carolina University. This device has demonstrated a 80-90% success rate in the treatment of over 200 patients of all ages who suffer from fluency disorders, with levels of fluency enhancement varying from 50% improvement up to 95% improvement [11].

Auditory Feedback Tools (AFT) [12] is a program option which provides five different auditory feedback tools in a software package for therapy and feedback applications. The AFT program provides DAF, as a form of disruptive feedback, which has proven to be effective in fluency therapy. The DAF in AFT has a range of feedback from 150-500 milliseconds, adjustable in 10-millisecond increments. In masking mode, a speech-band noise signal is played through headphones so that patients cannot hear their own speech production. This deliberately degraded feedback has been shown, in some cases, to improve speech [12]. In many patients, it can enhance the proprioception of speech or voice behaviors such as easy onset and eliminating hard glottal attack.

Transcutaneous Electrical Nerve Stimulation (TENS) consists of the pocket sized processing unit, a lapel microphone, self-adhesive gel pad TENS electrodes, and a set of headphones which can be used to provide an optional DAF. Speech is picked up by the lapel microphone, delayed

from 15ms to 150ms, amplified, and delivered to the TENS electrodes. The electrodes provide a mild electrical shock to the skin, in the form of a "tingling" sensation, whose strength can be adjusted. According to Dr. Shames [13], the use of TENS feedback results in less adaptation and hence greater awareness of the use of sustained phonation.

### 3. Devices that Provides Feedback on Physiological Status or Production Patterns

Several therapy programs utilize electronic analyses and feedback of acoustic speech characteristics. These devices provide immediate feedback of voice onset patterns, duration, and amplitude/loudness. As each speech production target is introduced to the clients, they receive training on the type of feedback from the voice monitor that indicates the correct achievement of the target. Once the clinician has confirmed that the clients know what to look for on the voice monitor, the clients could practice without the clinician's presence, freeing up the clinician while the clients engage in intensive practice on their targets.

FluencyNet [14] uses personal computer-based hardware and software to replace the voice monitor. The software program also presents the stimuli (sounds, words, and longer utterances) to practice for each target, data on performance over time, and an opportunity for the client to self-judge the accuracy of their production before feedback is given. FluencyNet is based upon the physical analysis of speech sounds as they are being uttered. FluencyNet provides real-time measures of sounds, evaluate the sounds against standards for their production, and immediately signal the results of the evaluation in graphs plotted on the computer screen. When the onscreen graph shows an accumulation of many green bars and few red bars, the speech signals are judged to be mostly correct. On the other hand, when the onscreen graph shows an accumulation of many red bars and few green bars, the speech signals are judged to be outside the limits necessary for the maintenance of fluent speech.

Digital Speech Aid (DSA) [15] is designed based on an advanced DSdP (Digital Sound Processing) of speech signal in the auditory feedback loop. The device uses the most modern DSP circuitry and it is designed according to the algorithms developed to elicit the desired response characteristics of the feedback signal. All known and many new algorithms can be easily implemented in the existing hardware, due to the fact that DSdP software is stored in EPROM, which could be easily changed and reprogrammed. With DSA, a person can speak in any fashion and at any rate. DSA is most effective in the case of "Classical Stutterers" who consist about 80% - 90% of the stuttering population. Significant improvement or total fluency is observed in about 40% - 60% of "Classical Stutterers".

### 4. Devices that Alter Speech Motor Production Patterns

Fluency Master [16] is a miniature, wearable, electronic stuttering control device that looks like a hearing

aid. Research [16] has shown that the speech muscles of stutterers do not perform the correct sequence of movements necessary to produce fluent speech. The Fluency Master reduces stuttering by modifying physical factors that affect speech, giving the brain the ability to more effectively control the movement of speech muscles. Fluency Master fosters better hearing of the natural vocal tone associated with speaking. Vocal tone provides information for the brain to use in guiding speech muscle movements. Vocal tone consists of a "buzz" that is generated by vibrations of the vocal folds in the larynx, and is transferred to the ears through the soft tissues, cartilage, and bones of the throat and skull. Vocal tone is a natural, internal component of speech, and provides a "background" sound that is always present inside our bodies when we talk.

Stuttering controlled by Fluency Master involves the use of a miniature microphone to detect vocal tone vibrations. The vocal signal is amplified and processed by electronic circuitry housed in a small hearing aid case. A tiny plastic tube carries the sound to a custom-fitted ear-piece.

## 5. Pacing/Metronome

Many stutterers stutter less frequently when they pace their speech while reading aloud or doing a spontaneous speech task with the beats of a metronome [17]. Doing so will cause stutterers to concentrate on how they are speaking and thus reduce their speaking rates. This technique has been used clinically for several centuries. The metronome beat can be delivered auditorily, visually, tactilely, or by some combination of these senses. The client is told to pace his or her speech while reading aloud or doing a spontaneous speech task with the beats of a metronome which is one word per beat.

Researchers, clinicians, and people who stutter have long been aware that speaking to a superimposed rhythm can facilitate a noticeably more fluent speaking pattern in many individuals who stutter. AFT [12] provides metronomic pacing in the form of an audible click to help assist patients with the timing/rhythm aspects of speech production. Among these are stutterers and patients with motor speech disorders such as cerebellar ataxia and Parkinson's disease. The pacer rate is adjustable from 50 to 150 beats per minute adjustable in 5 beat increments.

## 6. Computer-Based Malay Stuttering Therapy

The use of computer technology in speech therapy and assessment is still new in Malaysia. The general approaches used for stuttering therapy in Malaysia are prolongation of speech, airflow management, regulation of breathing, gentle phonatory onset, shadowing, taping and speech rate reduction. The process of determining suitable therapy techniques may take months of repeated procedures that are costly and overly generalized. These techniques work to certain degree and the results depend very much on the particular case. Therefore, we implement a computer-based Malay stuttering therapy with the combination of different stuttering therapy techniques to help SLP in determining suitable techniques for each client. There are differences of

tense and lax vowels in pronunciation between Malay and English Language where Malay Language has only 6 vowel sounds, with no long-short distinction.

Our project implements 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 runs under Windows XP on a computer equipped with multimedia capabilities. The software is developed using the Microsoft Visual C++ 6.0 Integrated Development Environment (IDE). The system software is developed as graphic user interface (GUI), which makes therapy user friendly. Our hypothesis is by doing comparison between client's and clinician's AMPs, the computer can help SLP to determine suitable technique. This will reduce cost and time for therapy. The example of AMPs is showed in Figure 1.

This software tool is similar to speech therapy tools only found in the speech pathology clinic in some countries and provides the added advantage of being available for home use by clients that own a personal computer. Three techniques implemented in our project are Shadowing [18, 19, 20], Metronome (Taping) and Delayed Auditory Feedback.

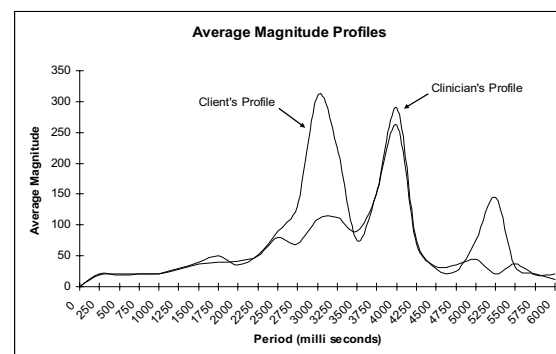


Figure 1. Examples of Average Magnitude Profiles of Client and Clinician

## 7. Reviews

The published literature on the clinical use and effectiveness of the computer-based devices described above consists of a few reports with small numbers of patients in uncontrolled case series. The results are somewhat mixed, but suggest a decrease in stuttering in some individuals performing reading tasks more so than monologue.

There is no one best treatment for stuttering for every client. Therefore, it is suggested that choosing different types of stuttering managements is a personal decision based on the unique values and treatment objectives of each individual person who stutters. Without a definitive treatment for developmental stuttering, the field of speech-language pathology continues to serve the stuttering population by offering as many valid and reliable treatments as possible; however, it is ultimately the client's responsibility to become informed of the various approaches towards stuttering management, and pick specific treatments

that best meets their needs. With this in light, the inclusion of a prosthetic computer-based device into a stuttering management program becomes a private choice that is determined by the personal values and treatment objectives of each individual client.

Normally, 2 to 3 months are required to determine suitable therapy technique for each client. These techniques work to certain degree and the results depend very much on the particular case. The treatment process may take months of repeated procedures that are costly and overly generalized. Therefore, implementation of a computer-based Malay stuttering therapy with combination of different stuttering therapy techniques is required to help SLP in determining suitable techniques for each client.

## 8. Conclusion

There are four classes of assistive and anti-stuttering computer-based devices available that have been employed in treating stuttering. Alter Auditory Feedback (AAF) and Speech Motor Production Patterns Alteration are the most commonly used principals in designing computer-based stuttering devices.

Our software is designed to help SLP in determining suitable techniques for clients in faster and more accurate manner. This will reduce cost and time for therapy session. We believe our software tool will improve the effectiveness and availability of stuttering therapy in Malaysia. We hope that our software tool will provide insights into the implementation of computer-based Malay stuttering therapy in Malaysia.

Our system is currently being tested clinically at Speech Pathology Centre of Hospital Sultanah Aminah. The effectiveness of the software is currently under evaluation. A report of the effectiveness of the software will be available after the tool has been thoroughly evaluated.

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