

Roy Sarfati, August 2007

ADVANCED COMPUTERIZED APPLICATION OF THE FLUENCY SHAPING TECHNIQUE (S) IN A CONCENTRATED FORM.

The Apex Speech Care System project development 2003 - 2007. This research project's objective is multi-dimensional: First, to investigate the failure by existing stuttering treatments to maintain an adequate post treatment long term high retention levels. Second, to formulate a treatment protocol that combines several fluency shaping techniques that addresses all the relevant symptoms, physiological and psychological, related to stuttering. Finally, to develop and adapt an effective concentrated treatment method with the required application systems (hardware and software). Special consideration is given to integrating the most advanced computerized science and technology available to achieve and maintain a constant high post treatment retention level (80% +). The long term Study and Research group consisted of five individuals (all adults) with different levels of stuttering severity without any pre-existing medical conditions. Two of them had previous stuttering treatments with different methods. The Study group was segregated from the Focus group during the entire R&D phase. Three of the study participants were monitored post treatment for physiological regression during a period of 12 months. They showed retention levels between 83% and 94%. They reported a substantial reduction of their speech related psychological onsets to a comfortably manageable level.

KEY WORDS: Apex Speech Care System, Fluency Shaping Techniques(s), Concentrated Application, Retention Levels.

The guiding principle of the R&D Team (Research and Development Team) is to go beyond a theoretical research study limited to academic publications. The goal is to develop a practical, implemental, ground-breaking, effective treatment method with adequate application system(s). The foremost consideration in creating the Apex Speech Care System is to set the highest possible benchmark in the field of stuttering treatment. The set criteria included time measured, constant high retention levels, and a state-of-the-art application system.

Landmark: The Apex Speech Care System treatment protocol titled "Speech Therapy Method" was filed with U.S. Patent Office. All 16 claims related to the treatment method, filed in the patent application were granted In July 2007 (No: 7258660). This official confirmation corroborates that as late as July 2007, each component integrated into the treatment protocol of the Apex Speech Care System constituted an unprecedented innovation in the field of speech therapy. In this context, that system stands unequalled.

Development guidelines: During the research trials, the R&D Team consisted of a speech language pathologist, a neurologist (limited participation), a psychologist (limited participation) and a team of computer engineers educated in a wide range of disciplines (including a voice recognition expert [DSP engineer]). With respect to the expertise of the speech language pathologist, he continuously engaged in a variety of cutting-edge specialization courses related to the treatment of stuttering. It is significant to note that the speech language pathologist had a history of severe stuttering, as such he tested first hand all available treatment methods. This provided unique first-hand insight into the research and the formulation of the treatment protocol. The R&D Team tested fluency shaping techniques at all levels and methods of application in order to formulate the most effective combination and concentration ratios.

Focus Group:

A focus group composed of five adults (four males & one female) who had previous stuttering treatment was formed. Their retention levels from previous treatments ranged between 17% to 28%. Only the female was still using an online maintenance program. Four of the participants had a full time job, one was completing a graduate course.

The speech language pathologist supervised the focus group deliberations. The group met once a week for two hours during a three month period. In addition to their own topics, the group was asked to discuss the following issues:

a) Treatment expectations: the consensus among the participants was any treatment must be effective long term, short in duration, innovative in concept, with a progressive application system.

b) Post-treatment maintenance and support program: This part of the treatment program generated opinionated discussions within the focus group. The emerging consensus among the participants was that the post treatment maintenance and support program must be motivating, and multi-dimensional, or else it will not generate a constant level of interest to preserve regular usage to maintain a constant high retention level.

c) Program's Integration with a busy lifestyle: the group's expectations were constant availability, flexibility, and user-friendly.

Pre & Post Treatment Diagnostic Protocol

I. Diagnostic Equipment

All video/audio recordings were collected individually from the participants. A Panasonic VDR-300 was used to caption the recording during the evaluation. The video recorder was placed at the distance that provided a high definition picture of the participant's physical movements. The SLP sat directly from the participant allowing a clear view field for the video recording. The participant wore a high quality lapel microphone to ensure clear audio recording. A closed circuit TV was also used for remote monitoring when participants were asked to read and make phone calls, without the presence of the SLP.

II. Diagnostic Assessment

The evaluator (SLP) administered the following assessments:

1. Stuttering Severity Instrument-3 (SSI-3)
2. Overall Assessment of the Speaker's Experience of Stuttering (OASES)

The Stuttering Severity Instrument-3 (SSI-3) was used to collect the following: Frequency of principal behaviors (i.e. repetitions, prolongations, and speech blocks), the average duration of the three longest stuttering utterances, and finally, the presence and frequency of secondary behaviors including but not limited to eye-blinking, tongue clicking, finger tapping, head, arm, and hand movements based on the prescribed ordinal scale. A speech sample between 500 and 1000 syllables was collected. The speech sample was gathered in various contexts: reading, conversation, and phone calls with and without disturbances. Stuttering events were calculated to obtain the percentage of stuttered syllables. This was done by counting all syllables and the stuttered syllables, then, the percentage value of the stuttered syllables was extracted. The thoracic and abdominal respiratory pattern was analyzed and monitored with Respiratory Displacement Sensors. In addition to the physiological assessment, the Overall Assessment of the Speaker's Experience of Stuttering, a perceptual diagnostic, was administered. It is composed of four sections: General Information, Reactions to Stuttering, Communication in Daily Situations, and Quality of Life. The General Information section was used to measure areas such as general understanding of

stuttering, treatments, and perception of their stuttering severity. The Reactions section targeted the emotions, behaviors, and self-perception analysis with regards to stuttering. The Communication in Daily Situations section focused on their experience in various social settings such as work and home. The Quality of Life section concentrated on the

impact of stuttering with regards to the individual's general state of being. Once the perceptual evaluation completed, a related psychological assessment was conducted on a need basis to further determine the impact of overt and latent psychological symptoms related to stuttering. Finally, a neurological examination was performed to rule out the presence of pre-existing neurological condition(s).

Rating procedure / reliability / effectiveness: To avoid misinterpretation, subjectivity, and inconsistency, the R&D Team opted to use instrumentation instead of individuals to rate and measure the participants during tests. To that effect the "Expert System" software program that was developed and integrated in the exercise phases of the treatment protocol was used for ratings and measures. This system provides a constant uniform rating and accurate measuring platform. In addition, a separate questionnaire was given to each participant for self-rating twice a day, after the first 4 hours of exercises and at the end of the practice day. The speech language pathologist reviewed the questionnaires for assessment daily.

Clinical program application: The treatment application consisted of 8 consecutive hours, divided into 20 minute exercise session, with a 10 minute break. The application was conducted inside individual soundproof booths. After each session, the group met in an adjacent conference room and engaged in an open discussion forum to express their opinions. Here, the group addressed experienced difficulties and/or ease attached to a particular set of exercises, related to a specific treatment phase, their interaction with the system's components and functions. Several of these discussions were videotaped for analysis. After 8 days (6 consecutive, 1 day break, and another 2 consecutive days) of treatment the retention levels were tested in a form of conversations (30 minutes), readings (10 minutes), and phone calls (15 minutes) with and without disturbances, all of which were videotaped for assessment. At completion the retention levels ranged between 91% and 97%. Each participant expressed reduced anxiety and withdrawal symptoms. The following day, participants in groups of three, visited a shopping mall with the SLP for a period of four hours each group. Each participant had to interact with a merchant in real life situations. Some ordered food, others inquired about an item to purchase. Initially participants demonstrated some apprehension, after an hour their newly acquired skills, and self confidence began to surface. At some point the various facets of their speech fluency reached their individual post-treatment retention levels.

Equipment / Systems & Technology: In order to coordinate, test, process and monitor the various components of speech production, a special computerized processing center (the Articulatory-Larigo-Lab) and complementing software were developed by our engineering team. Particular attention was given to precise voice recognition and respiratory pattern analysis systems. During the clinical application the treated individual is connected to, and interacts with the processing center unit. The Articulatory-Larigo-Lab incorporates the following systems:

Electroglottograph

This instrumentation is used to measure and analyze vocal cord activity during speech production. It provides the system with all data of the fluctuations of vocal cords activity. The procedure is non-invasive. Two electrodes attached to a velcro band are placed at the larynx level. The electroglottograph transduces transneck-impedance via an oscillator, specially designed with an amplitude-stable circuit. Technical settings: Its impedance

range is between 20 and 250 ohm with a signal to noise level of 48dB at 100 ohm electrode impedance. The frequency range was set between 3.5 Hz to 10,000 Hz to prevent frequency overshoot.

Respiratory Displacement Sensors

These sensors are integrated into belts placed at the thoracic and abdominal level of the individual. Through the use of strain gauges they measure displacement of respiratory activities. The collected data is stored for analysis (The system calculates the mean and standard deviation of the signals). The resistance feedback provides thoracic and abdominal changes via custom dual channel 10 bit Analog to Digital converter. Measurements and analysis are conducted to identify the type of respiratory pattern during speech production: shallow, deep, or normal.

Simultaneous Voice and Respiratory Signals Processing

The signals from the voice and respiratory inputs are processed concurrently in a real time mode. Each of the two functions is processed by a separate multi-tasking software program running simultaneously. This provided constant data with each breathing and voice production.

Automated Digital Monitoring and Calibration systems

Speech is processed by Digital Signal Processing software program that receives a digitized input from voice sampling hardware and software. The DSP software program automatically calibrates itself for each monitored sound production within the set parameter(s) of the training time sample. This program determines the noise level of the signal, and detects the beginning and end of the speech segment in comparison with the parameter(s) of the training sample.

Performance tracking and auto-corrective “Expert System”

This computerized system provides simultaneous auto-corrective, biofeedback in real time. Its auto-diagnostic functions include articulatory muscle tension identification, respiratory pattern analysis, laryngeal activity/vocal monitoring, and voice stability analysis. Essential performance analysis & summary for each exercise are generated. The results of each sound category performed by the individual are stored in its data base. Concurrently it computes and compares the sound productions with the established parameters for a correct speech production. At the completion of each exercise session, customized adjustments are displayed in correlation with the targeted skills for each sound category. The recommendations are displayed in a user-friendly configuration and formulated based on the individual's performance. The results of the performance summary are stored for later review by the speech-language pathologist, and other clinical applications.

Methodology: Following In depth interviews with the participants, the focus group, and psychologists, it was determined by the R&D Team that the physiological symptoms were the primary cause and conveyor of the psychological symptoms. Therefore, priority was given to treating the physiological symptoms. This treatment strategy proved successful at the completion of the treatment. The below listed targeted areas of dysfluent speech production were measured for severity and frequency. Subsequently multi-directional monitored corrective measures were applied.

Physiological Sypmtoms/Rehabilitation

1. **Articulatory instability:** Articulatory stability is inducted/increased by synchronizing controlled respiratory patterns and coordinated vocal tract activities. The respiratory patterns are monitored via the system's displacement sensors. Coordination and stability of articulators and the vocal tract activity are monitored via acoustic, DSP algorithms,

and transneck impedance. Participants exercised timed applications of producing consonants and vowels in various combinations: consonant to consonant, consonant to vowel, and vowel to consonant per syllable, initially set at timed intervals of 2 to 3 seconds per set of 5 repetitions. Subsequently the sequences were gradually decreased

to ½ a second while increasing the number of syllables until its elimination at the Freestyle section of the program.

2. Articulatory incoordination: Articulatory coordination is induced/increased with the elimination of inappropriate articulation resulting in vocal spasms that occurs during stuttering resulting in musculature tension, negatively impacting smooth transition from sound to sound during co-articulation. Participants exercised timed applications in sound transitions. A decrease in the sound transition rate was effected at an interval of 2 to 3 seconds per set of 5 repetitions while gradually increasing the vocal amplitude and stabilizing articulatory transition from one sound to another. The practice was set at a single syllable level then progressed to multi-syllable utterances with systematic reduction of timed application to ½ second until its elimination, during the freestyle section of the program. Digital speech algorithms are used to calculate zero-crossing and amplitude at the 25 millisecond intervals, with repetitive analysis, while measuring the rise to maximum and from maximum to descent per syllable at the assigned timed-application.

3. Respiratory-phonatory coordination: Inconsistent vocal spasms and glottal closure disturbs the normal cycles and respiratory patterns. Consequently, the vocal cords vibratory cycle disrupt the flow of air during stuttering. People who stutter have the tendency to use a thoracic, or clavicular respiratory pattern, or a combination of both. The result is rapid inhalation or momentary cessation between inhalation and exhalation which increases articulatory pressure resulting in stuttering. To gain volitional control over the respiratory pattern, and coordinate the distension between the thoracic and the abdominal respiratory pattern, the participants exercised in timed application that was set at an interval rate of ½ second and gradually transitioning to a comfortable conversational rate per set of 5 repetitions during an exercise session. This allows the acquisition/control of optimal breathing pattern.

4. Vocal cords hyperadduction: To reverse the effects of vocal cords hyperadduction, the initial step is the stabilization of the vocal cord movements. The presence and degree of the vocal cord hyperadduction (open and closed duration of the vocal cord vibratory cycle), are detected and calculated by the electroglottograph. To establish an efficient vocal cord vibratory pattern, it is necessary to gradually increase and decrease the vibrations relating the voice onset and termination amplitude at single syllable utterances at the rate of timed application of 2 to 3 seconds per set of 5 repetitions during an exercise session. As the number of syllable utterances increases, the rate of timed application decreases to ½ second until its elimination for a long-lasting control over the vocal cord vibrations.

Psychological symptoms

Communicative anxiety and other psychological symptoms, listed hereunder, were addressed first on individual basis, then in a group setting. The participants reported alleviation in certain symptoms as speech control began evident.

1. Social Interactions/Withdrawal
2. Academic Regression
3. Family dynamics
4. Latent or overt anxiety symptoms
5. How to address Negative Reaction of others

Speech Sounds:

The speech sounds are categorized based on their distinctive features and acoustic characteristic to facilitate co-articulation and eventually, promote fluent speech production. Therefore, the vowels and consonants are sequenced from least to most

demanding (from an articulatory stand point), based on the individual ease of achieving articulatory and vocal tract stability. In addition, the degree of articulatory pressure (low to high) was factored in for each sound during speech production.

Syllable Extension: This technique is used to achieve initial and final sound articulatory stability at various complexities of utterances. Results revealed that a set of 5 for 20 minutes yielded the highest retention level of 93%. Whereas, set of 3 for 10 minutes yielded the lowest retention level of 33%. A balance of set and time is critical for high retention level (Refer to Table 1).

Sets	Practice Time (min)	Retention (%)	Testing Time (Hours)
3	10	33	100
4	10	41	100
5	10	53	100
5	20	93	100
10	30	73	100

Table 1

Gradual Voice Initiation: This technique is used to gain/increase articulatory coordination and adaptation of low-impact vocal cord vibration. Results indicated that a set of 5 for 20 minutes yielded the highest retention level of 95%. In contrast, a set of 3 for 10 minutes yielded the lowest retention level of 23%. A balanced coordination between the sets and duration was achieved for optimal level of retention (Refer to Table 2).

Sets	Practice Time (min)	Retention (%)	Testing Time (Hours)
3	10	23	100
4	10	37	100
5	10	49	100
5	20	95	100
10	30	80	100

Table 2

Optimal Breathing Pattern: This technique is used to adjust incorrect respiratory-phonatory pattern focusing on thoracic and abdominal movements during speech. Results indicate that a set of 5 during a 20 minute practice session was most effective in achieving a correct thoracic-abdominal respiratory pattern, a requirement for fluent speech production (Refer to Tables 3 & 4).

Component	Set	Level of Involvement	Practice Time(min)	Retention (%)	Testing Time (Hours)
Thorax	3	high	10	35	100
Thorax	4	high	10	41	100
Thorax	5	high	10	49	100

Thorax	5	low	20	93	100
Thorax	10	High & Low	30	75	100

Table 3

Component	Sets	Level of Involvement	Practice Time(min)	Retention (%)	Testing Time (Hours)
Abdomen	3	low/ high	10	25	100
Abdomen	4	low/high	10	43	100
Abdomen	5	low/high	10	51	100
Abdomen	5	balanced	20	95	100
Abdomen	10	low, high, or balanced	30	71	100

Table 4

The Maintenance & Support: This phase is a critical component for a long lasting high retention level of fluency. For the post treatment maintenance and support program, the participants were provided with an audio/video CD containing a complete computerized maintenance program, and another audio CD with few exercises for use in the event a computer program session is missed. The participants were evaluated for post-treatment retention levels. The results are as shown in Table 5.

Post-Treatment Retention Level (%)	Immediate	3 Months	6 Months	9 Months	12 Months
	100	97-99	91-99	87-95	83-94

Table 5

Results & Post-treatment monitoring procedure: In order to obtain reliable data as for the efficiency of the new treatment method and the retention levels, 3 of the treated participants were selected for monitoring for a period of over 12 months. The monitoring included unscheduled phone calls, and visits to the clinic for assessment with the following instruments, electroglottograph, respiratory displacement sensors, and a computerized processing center with biofeedback in real time. After a 12 month monitoring period the retention level maintained was between 83% and 94%. The speech language pathologist placed random phone calls once or twice a month to each participant. The participants were also invited separately to the clinic once a month for a 30 minute interview and assessment. The participants reported good feeling, self confidence, and great progress in their personal life.

Conclusion: The data proved that the multi directional fluency shaping techniques applied in a concentrated form were successful in achieving a reduction of stuttering between 91% and 97% at completion. The application period consisted of 6 consecutive days for 8 hours, 1 day off, and another 2 consecutive days. Each day was divided into 20 minutes sessions with a 10 minutes recess for discussion. The maintenance and support program given to the participants for home application showed that after 12 months the participants who used it on daily basis for a 20 minutes session had a consistent retention level of 83% to 94%.

Technical System Overview

This paper details the process and functionality of the software and hardware. It is intended to illustrate how the protocol is used and the various functions incorporated in the software and hardware.

Sound production:

1. Syllable Extension
2. Gradual Voice Initiation
3. Optimal Breathing Pattern

For a single syllable sound the prescribed duration is 2 seconds. For a 2 syllable word the duration would be 1 second for each syllable with a distinct break between each syllable.

For Gradual Voice Initiation the sound is produced by increasing the amplitude of the sound production to a certain level then decreasing the sound level.

Optimal Breathing Pattern technique emphasizes breathing from the diaphragm and keeping the upper thorax breathing under control. The patient uses the abdominal breathing to intake air for the sound production then exhales as the sound is produced.

The patient is connected to a microphone, an ElectroGlottograph (EGG), and breathing sensors to interface with the processing center.

The sound production is analyzed for tension as well as correctness of the technique being used. The EGG measures the changes in resistance across the vocal cord. During speech the vocal cords vibrate and this causes the change in resistance. The vocal cords cycle of opening and closing are monitored for tension. Breathing sensors are placed around the abdomen and thorax. The software monitors the displacement during the sound production and determines if there is proper abdominal breathing and low thoracic movement.

The process starts by selecting a sound group exercise from the exercise menu. In addition the patient selects the technique to use and the number of syllables to use in the practice exercise. Once the session starts the patient is presented with information screens that explain the sounds in the sound group. The patient can play audio examples of the sound group and also play animated drawings depicting the correct and incorrect articulation mechanisms such as the lips and tongue. The patient will proceed through all the information screens till they reach the exercise screen.

At the exercise screen the patient clicks a button to select a random word from the selected sound group. The word is displayed to the patient along with instructions on how to properly produce the sounds in the sound group. There is a timer button that begins an animated stopwatch the patient will use to time the duration of the sound production. Once the patient is ready the start button is clicked and the sound production can begin. After the practice sound is completed the patient clicks the stop button and the results are analyzed and presented to the patient. The patient receives feedback on the tension in the voice and vocal cords, tension in breathing, and proper or improper usage of the practice technique.

The practice exercise is scored as a pass or fail and indicated in the score board on the exercise screen. Each practice sound is exercised 5 times. After the fifth exercise a new word will be retrieved in a random manner. The exercise session is 20 minutes in length. At the end of the session a performance summary screen is presented to the patient. This screen has the results of all the practice exercises performed during the session. In addition, there are recommendations on how to improve performance. At the end of the exercise session the patient meets with the Speech Language Pathologist to discuss the results.

System Architecture

The basic components of the system consist of the monitoring equipment, Apex Speech Care System software, the Apex database, and the Apex configuration tool.

The Articulatory Laryngeal Lab (ALL) is a specially designed processing center that analyses all the data collected during patient interaction and provides biofeedback in real time. The three main areas that are analyzed are:

1. Voice tension and speech patterns.
2. Vocal cord tension during exercises.
3. Breathing patterns.

The system's software is a custom designed analysis and biofeedback program that is used to analyze the voice, vocal cord, and breathing activities of the patient during exercise sessions.

The system's database consists of configuration data as well as a collection of inputs used by the software during the exercise sessions. The database is standalone and each treatment unit has an independent copy of the database.

The system's configuration tool is used to read and set the configuration parameters that are associated with the voice, EGG, and breathing analysis on individual basis.

System Software

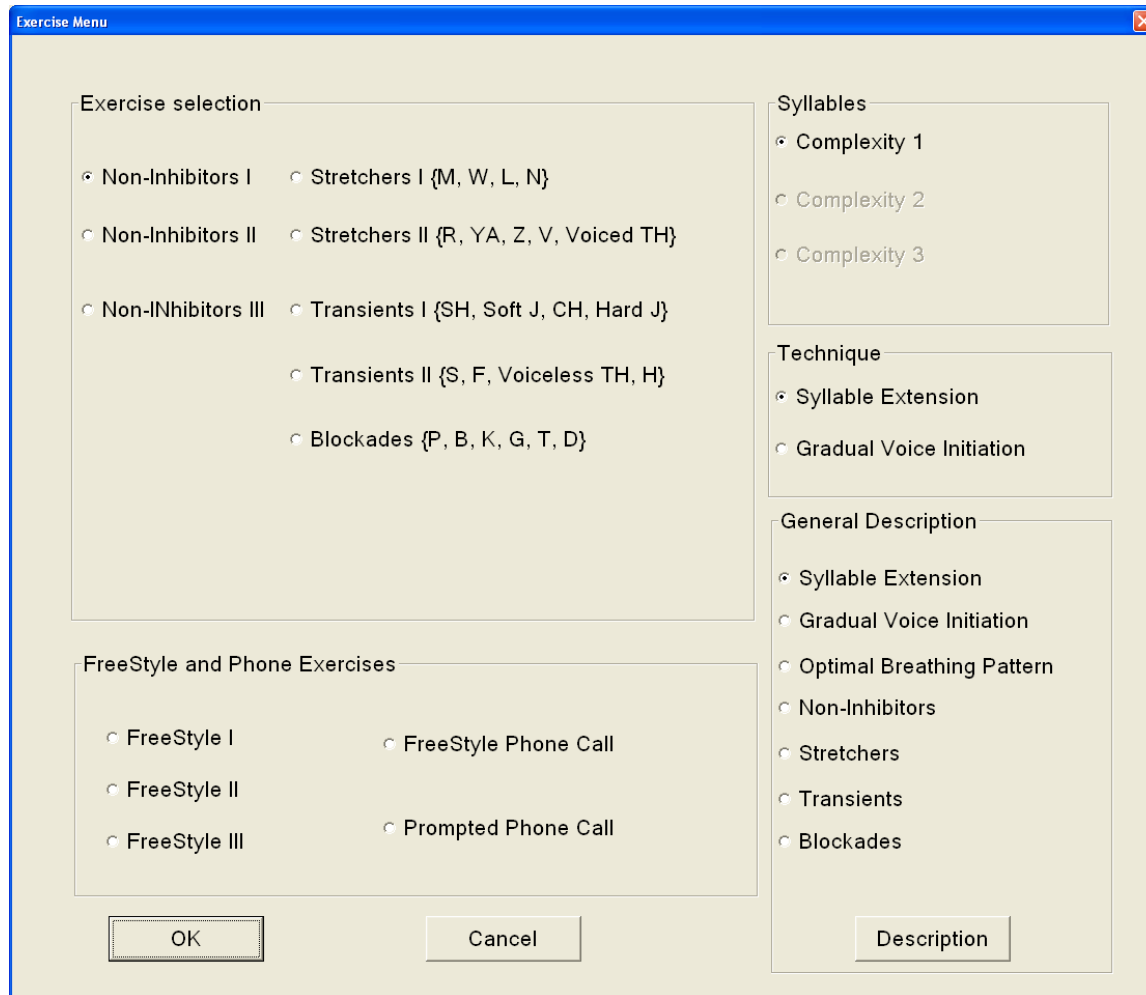
Start of Program

The choices are English or Spanish.

Once the patient clicks on the language button the program presents the patient with a Logon screen in the chosen language. The interaction can be individualized by way of a username.

Exercise Menu

The program presents the patient with the Exercise Menu screen. From the Exercise Menu screen the patient can select which exercise to work on. The Exercise Menu has several sections and components to select from. The main sets of exercises are the major sound groups. These groups are Non-Inhibitors 1, 2, and 3, Stretchers 1 and 2, Transients 1 and 2, and Blockades.



When selecting a sound group to exercise with the patient must also chose the complexity level to associate with the sound group. Complexity level corresponds to the number of syllables in the word or phrase that will be exercised. There are three complexity levels: level 1 single syllable, level 2 two syllables, and level 3 for three syllables.

There is also a technique that has to be chosen for the exercise. There are two techniques, Syllable Extension and Gradual Voice Initiation. Syllable extension refers to a technique in which the syllables of the word are prolonged at set amplitude. Gradual Voice Initiation refers to a technique were each syllable is produced with a gradual increase and decrease in amplitude. Each syllable is produced for a specific duration depending on the complexity chose.

The Exercise Menu screen also has a section for Free Style speech exercises and phone call exercises. Free Style speech is exercises that consist of three or four syllable phrases. When using Free Style speech the patient also must select the technique to use. Free Style speech is done in what is referred to as Slow Normal Rate (SNR). The patient speaks normally but slows down the speech production to maintain control of the articulation process.

Phone Call exercises are of two types, Free Style calls and Prompted calls. In Free Style phone calls are made without prompting. With Prompted calls the system will present the patient with specific phrases to use. Phone calls can be done with or without disturbances. Disturbances are sounds that are played in the background to serve as a source of distraction. The performance is rated on a summary screen.

The Exercise Menu screen also has a section for general descriptions of following:

- Syllable Extension
- Gradual Voice Initiation
- Optimal Breathing Pattern
- Non-Inhibitors
- Stretchers
- Transients
- Blockades

Any of these categories can be selected and then clicking the Description button to view a corresponding set of screens. Once the patient has selected the exercise to perform the OK button is clicked and the software determines the starting point of the sound group to be done. At that point the sound group information screens are displayed.

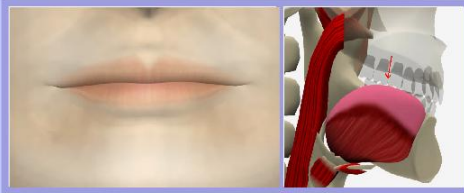
Sound Group Information Screens

Each sound group consists of various sounds organized by their acoustical characteristics. The sound groups are as follows:

1. Non-Inhibitors 1 (AY, Short Flat AH, EE, EH, Short I)
2. Non-Inhibitors 2 (AH, O, OO, AU, Short back AH, ER)
3. Non-Inhibitors 3 (I, OI, OW, YOO)
4. Stretchers 1 (M, W, L, N)
5. Stretchers 2 (R, YA, Z, V, Voiced TH)
6. Transients 1 (SH, Soft J, CH, Hard J)
7. Transients 2 (S, F, Voiceless TH, H)
8. Blockades (P, B, K, G, T, D)

Each sound group has a set of associated information screens for each of the sounds in the group. Each information screen consists of a description of the sound and how to produce it. There are also graphic animations showing the correct and stressed productions of the sound. These animations are controlled by a PLAY button. Clicking the PLAY button starts the animations. There is also a button for an Audio example of the specific sound. When the button is clicked the patient will hear the example using the technique that is currently selected. This would be Syllable Extension or Gradual Voice Initiation.

CORRECT



STRESSED APEX™
Speech Care System



INSTRUCTIONS FOR PRODUCING

“AY” Sound (BAY)

First, slowly lower the bottom lip to create an adequate opening for producing the sound. As the bottom lip drops, the tongue is raised to contact gently the sides of the upper teeth. (These are concurrent activities). Refer to the Animation.

END SE 1

PLAY

AUDIO

MENU

NEXT

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Once the patient has viewed the information about the sound the NEXT button is clicked to bring up the next sound description. Each time the NEXT button is pressed the software compares the current information screen identifier and selects the next screen in the sequence. This process continues till all the information screens have been viewed. Once all the information screens for a sound group have been presented the program opens the Exercise screen.

Exercise Screen

The Exercise Screen consists of the following components:

1. Voice graph
2. Vocal cord graph
3. Exercise timer
4. Breathing meters
5. Tension meters
6. Word display
7. Message display
8. Score board
9. Control buttons
10. Menu bar

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File Help Meters Disturbances Analysis Messages AnalysisType Reports

Voice

Vocal Cords

Breathing Meter

Abdomen Chest

Deep High

Shallow

Balanced Low

Tension Meter

Vocal Cords Voice

High

Moderate

Mild

None

Use Syllable Extension

Score

1 2 3 4 5 6 7 8 9 10

CLOSE SKIP WORD CLOCK START STOP

Voice graph

The graph provides visual feedback on the application of the speech technique being used. The graph will show the extension of the syllable during Syllable Extension technique and the incremental rise and fall during Gradual Voice Initiation.

The voice graph displays the voice signal in real-time. The data is processed to fit on the screen. Approximately 10 seconds of signal can be processed during the exercise.

The processing algorithm starts with the first data point and begins to scan the input to determine each set of zero crossings that demarcate a single cycle. Within that cycle the minimum and maximum point values are determined. The difference between the minimum and maximum is calculated as the displacement of the signal. The displacement is then drawn on the graph centered on the mid-line. The technique graphs the shape of the sound production.

The voice graph used three colors to indicate the amplitude of the signal. Green indicates normal voice amplitude within about 70% of maximum. Yellow is used for 70%-90% of maximum amplitude. Red is used for amplitudes of 90% or greater.

Vocal Cord Graph

The vocal cord graph displays the activity of the vocal cords during the sound production. The graph is drawn in real-time. The graph will indicate activity only during the sound production. The signal for the graph comes from an EGG (ElectroGlottoGraph) device connected to the patient. The EGG device is read by the monitoring software. The data is collected then displayed as a line graph.

Exercise Timer

The exercise timer is a 10 second clock that can be started and stopped, and used by the patient to time the duration of each syllable. The overall time to do the actual sound production is 2 seconds. As the sound is produced the timer is monitored by the patient to complete the exercise within the time constraint.

Breathing Meters

There are two meters for monitoring the tension of the breathing technique. There is one meter to measure the abdominal breathing and another to measure the thoracic movement. As the patient performs the practice exercise the breathing displacement sensors are monitored by the software. The data is collected and saved for analysis at the end of the exercise. The abdominal measurements can indicate a balanced, shallow, or deep movement. Balanced breathing is the target. The thoracic measurements can be high or low. High thoracic movement indicates that the patient was breathing too much from the thorax. A measure of low thoracic movement is an indication that the breathing is being done correctly. The goal is to maintain balanced abdominal breathing with low thoracic movement.

Tension Meters

There are two meters that display the tension in the voice and vocal cords obtained from the microphone and EGG devices. Voice tension is measured by analyzing the voice jitter, shimmer, and harmonic to noise ratio. For the vocal cord tension is measure by vocal cord jitter and contact quotient. Tension is categorized as none, mild, moderate, and high. Each parameter is checked against a database containing the limits for each level. In order to pass the voice tension test two out of the three parameters for voice are required to be within limits. For the vocal cord parameters passing ranges must be achieved for one of the two parameters. The tension level for each parameter is determined by comparing the calculated values of the parameters with the ranges in the database so that a weight is assigned to each parameter. The final tension level is determined by the averaging of the individual parameter tension values.

Word Display

The word display is where the practice exercise word or phrase is presented to the patient. For the first five practice words in an exercise session the word is augmented with a phonetic hint showing how the word or phrase should to produced using the speech technique that is chosen. For example, the word will be separated by syllables and show which syllables are going to be extended. After the first five practice words there are no hints for syllable parsing. Words for the exercise display are extracted from a database in a random manner. When the word button is clicked the program reads all the words for the sound group in effect and then generates a random number that is used to select the word from the set.

Message Display

The message display has two functions. The first function is to indicate which of the two techniques correspond to the current exercise session. If the practice session is for syllable extension then the first line in the message display will say to use the syllable extension technique, likewise for gradual voice initiation. Also, at the same time instruction for the production of the current sound group are displayed. The second function of the message display is to provide feedback on the practice exercise.

If the practice exercises fails then there will be a break down of each measurement. A message will be presented for each of the following; vocal cord tension, voice tension, abdominal breathing, thoracic breathing, and a message for each syllable in the exercise. The syllables are evaluated against the technique in use. If it is a two syllable word there will be a reference to each syllable indicating proper or incorrect usage.

Syllable 2 may have been too short and that would be indicated separately from syllable 1 which may have been correct.

Score Board

The score board is used to indicate the results of each exercise practice. Words are practiced in sets of 5. There is a pass fail indication for each word attempted. A pass is indicated with a green check mark while a fail is marked with a red x. The basic function of the scored board is to provide some feedback on the progress of the individual practice exercises. When the set of 5 words is completed the score board is reset.

The research and development of the Apex Speech Care System including but not limited to software and hardware, was conducted in-house and funded with own funds.

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