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The Remediation of Rate and Rhythmic Stress Patterns with Deaf Children

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THE REMEDIATION OF RATE AND RHYTHMIC STRESS PATTERNS WITH DEAF CHILDREN

BY

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THESIS

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Introduction and Rationale

The fact that profound prelingual deafness prevents the normal acquisition of speech is well documented.

Few profound deaf children possess sufficient auditory capacity to learn speech utilizing only auditory cues. For the majority of these children, audition must be supplemented by visual and tactile cues. Many skilled teachers (such as Bell and Gallaudet) who have attempted to overcome this problem through intensive speech training have achieved only limited success. Reasons for failure differ, there is a general agreement that the quantity of highly skilled teaching is greatly required, and the prospectus for speech would be significantly improved if a more efficient means of speech training could be devised.

In recent years considerable attention has been given to the use of electronic devices to facilitate speech training by providing visual and tactile representations of speech sounds to compensate for the auditory feedback that the deaf child lacks.

Before the technology can be used with maximal effectiveness; however, more information is needed about the characteristics of the speech of deaf persons, specifically about the relationship between parameters of speech and its perceptual characteristics.

It is recognized that no two individuals, regardless of their hearing capacity, produce speech that is exactly the same. However, the speech and voice of the deaf child usually sound different from the speech and voice of a normal child. The teacher of the deaf attempts to develop "better sounding" speech in deaf children, often unaware of the difference she is attempting to identify and remediate.

Various deficiencies of deaf speech are not interdependent, they interrelate in many ways. Obviously, it would involve many hours of extensive research, for the experimenter to separate, control, and quantitatively measure all the aspects of "deaf voice." However, all these aspects affect intelligibility of the deaf speaker. Some of these deviant characteristics include: lack of pitch variation, improper velar control, poor timing and rhythm, inadequate breath control during phonation, a variety of types of articulation problems, and inappropriate loudness and intonation.

The characteristics that are assessed in this study are timing and rhythm. In normal hearing individuals established acceptable norms are determined by the listener's perception.

The duration of individual speech sounds may vary depending on such factors as the type of phoneme, the phonetic environment, the speaker, linguistic stress, and the overall speech rate.

Hudgins (1946) emphasizes that prosodic features suprasegmental timing and rhythm, are among the most resistant properties

of the speech waveform to the various types of natural distortion that can occur, and argues that this fact alone should give such cues special significance in the perception of speech.

Studies relating to this issue have had mixed results. John and Howarth (1965) attempted to improve the timing aspects of the speech of 29 deaf children, while ignoring other aspects of speech. Untrained observers listened to recorded before and after training samples. Intelligibility (number of words recognized) was about 19% pre and 30% post for the before and training examples, respectively. A second method for scoring was used that was sensitive to the listener's perception of the syntactic pattern of an utterance, performance was about 200% better with the after training utterances.

In contrast, some investigators have obtained improvement in timing accompanied either by no change or actual decreases in intelligibility (Stratton, 1974). Perhaps other aspects of speech were affected. Speech therapy with one specific feature may affect performance of others.

Timing and Rhythm

Many researchers and speech therapists have felt timing problems are significant contributors to the lack of intelligibility of the speech of the deaf. A few studies have produced results that are suggestive of some of the dimensions of the problems in deaf speech.

Deaf speakers tend to speak at a much slower rate than do normal hearing speakers (Boone, 1966; Colton & Cooker, 1968; Hood, 1966; John & Howarth, 1965; Martony, 1968; Nickerson, 1974). According to Nickerson, Voelker (1937) stated, " the average rates of speech sound production are 469 to 210 sounds per minute for the hearing and deaf speakers, respectively. The ranges (slowest to fastest speaker) for the two groups are 376 to 586 sounds per minute" (p. 280). Other researchers who have compared speech rates of normal hearing and deaf speakers have also found the rates to be considerably slower for deaf speakers (Colton & Cooker, 1968; Hood, 1966; Mason & Bright, 1937).

Deaf speakers tend to speak more slowly than the slowest hearing speaker. However, when the deaf and hearing speakers have been studied under similar conditions, the measured rate has often differed by a few factors (Hood, 1966; Mason & Bright, 1937; Voelker, 1938).

Closely related to the problem of slow rate is that of poor rhythm. Teachers and speech therapists for the hearing impaired have stressed the importance of emphasizing proper rhythm or phrasing as a therapy goal. Hood (1966) has noted that deaf speakers have a tendency to group syllables inappropriately. He had listeners rate the adequacy of the rhythm of speech and the deaf speakers consistently obtained lower ratings than the hearing speakers. DiCarlo (1964) who cites some evidence that deaf subjects speak with little or no rhythmic stress, infers

that the task of speech may inhibit the development of rhythmic speech but also a sense of rhythm in general.

Deaf speakers tend to insert more pauses and pauses of longer duration in continuous speech than do hearing speakers (Hood, 1966; Hudgins, 1946; John & Howarth, 1965; Nickerson, 1974). These pauses often are inserted at inappropriate places, such as within phrases (Nickerson, 1974).

The abnormally slow rate of utterance of deaf speakers is attributed to a combination of prolonged syllables and prolonged pauses between words (Hood, 1966). In Angelocci's study (1964) the deaf speakers typically "distorted the duration of the phoneme, first by extending duration several times than that of hearing speakers, and second, by not following the relative differences in duration as a function of voicing consonants or the effect of one sound upon another" (p. 404). Some examples are fricative consonants, closure periods, and plosive consonants (Angelocci, 1964; Calvert, 1962). In distorting their durations, deaf speakers destroy cues which may help in understanding their speech.

The speech sounds that require pause coordination of timing of different articulatory movements or the rapid transition from one position to another are often problematic for the deaf speaker. Some of the timing difficulties that deaf speakers have may stem from faulty breathing during speech. Some studies indicated that deaf speakers use about twice as many breaths as normal hearing speakers (Hudgins, 1937; Rawlings, 1935).

Hudgins summarizes speech breathing problems of deaf children with the following list "(a) short irregular breath groups often only one or two words in length with breath groups interrupting the speech flow at improper points; (b) excessive expenditure of breath on single syllables resulting in breathing speech; (c) false grouping of syllables resulting in the breaking up of natural groups and the misplacement of accents; (d) a slow methodical utterance resulting in a complete lack of grouping; and (e) a lack of proper coordination between breathing muscles and articulatory organs" (p. 642).

Several researchers have discussed specific problems that contribute to timing deficiencies (Hudgins, 1946; John & Howarth, 1965; Hood, 1966; Nickerson, 1974). Hypernasality is a problem resulting from breaking the velopharyngeal seal when their rate is reduced. Articulation depends upon proper timing at the level of individual speech sounds and the transition between them. Even the distinction between timing problems that apply to production of individual speech sounds and those that relate to suprasegmental, or prosodic aspects of speech cannot be maintained without qualification. For example, the results obtained by Hood (1966) suggest deaf children, who tend to make syllables of relatively long duration are likely to be judged to have poor rhythm.

Pitch and Intonation

Several investigators have noted that deaf speakers tend

to have a relatively high average fundamental frequency (F0), or to speak in a falsetto voice (Angelocci, Kopp and Holbrook, 1964; Boone, 1966; Martony, 1968). The results of the study by Angelocci, Kopp and Holbrook (1964) suggest that not only are the fundamental frequencies of the deaf speakers higher than those of hearing speakers on the average, but the average F0 for different speakers spans a wider range.

Deaf speakers often tend to vary the voice pitch much less than hearing speakers and the resulting speech has been described as flat or monotone (Calvert, 1962; Hood, 1966; Martony, 1968). A particular problem is that of inappropriate or insufficient pitch change at the end of a sentence. A terminal pitch rise may be even more difficult for a deaf child to produce than a terminal free (Phillips, Remillard, Bass & Pronovost, 1968). Deaf speakers who tend to produce each syllable with equal duration may also generate a similar pitch contour on each syllable. Such speakers may fail to indicate variations in stress either by changing the syllable durations or by modifying the pitch contour on the syllables. For example, a common error would be to fail to shorten an unstressed syllable and to lower the pitch on such a syllable.

Pitch problems vary considerably from speaker to speaker. Martony (1968) and Willemain and Lee (1971) have observed that deaf speakers sometimes begin a breath with an abnormally high

pitch and then lower the pitch to a more normal level. Willemain and Lee also noted that the average pitch of the deaf sometimes increases with the difficulty of the utterance. In as much as the production of high pitch requires increased vocal effort such as increased tension in the cricothyroid muscle and increased subglottal air pressure. They hypothesized the deaf speaker graduates high pitched tones as a way of providing kinesthetic cues concerning the onset and progress of voicing.

Pitch has been described as a particularly difficult property of speech for deaf children to learn to control (Boothroyd, 1971). One possible reason is that deaf children may lack conceptual appreciation of what pitch is (Martony, 1968). A lack of intuitive grasp of the concept may explain the reason deaf children often attempt to raise their pitch by increasing their vocal intensity (Phillips et al., 1968).

Loudness

Another problem, "loudness or volume" of speech has been noted by investigators (Carhart, 1970; Martony, 1968). The problem may take different forms: voicing may be too soft or too loud. Also the volume of a speaker's voice is affected by the nature of the impairment. An individual with a sensorineural loss may tend to speak in an abnormally loud voice because he does not receive feedback via bone conduction. An individual with a conductive loss may tend to speak very softly

because his own voice, which he may hear via bone conduction may appear very loud as compared with the speech of persons with whom he is talking. Carhart (1970) advocates that deaf people be trained to talk at each of four or five general levels of loudness and to shift to the other depending on kinesthetic cues and reactions from listeners to judge the appropriateness of the level at which they are talking at any given time.

Quality

The list of problems relating to speech quality is quite extensive. Calvert (1962) was able to find 52 different adjectives that have been used as descriptions of deaf speech in the literature. When 15 teachers of the deaf were asked to select from these 52 words those that they considered to be most accurate, the words most often chosen were "tense, flat, breathy, harsh and throaty."

Calvert (1962) also attempted to determine whether the speech of the deaf is distinguishable on the basis of quality from that of speakers with normal hearing. He had teachers of the deaf determine by listening whether recorded speech sounds (vowels and dipthongs in isolation, nonsense syllables, words and sentences) had been produced by profound deaf speakers, speakers imitating deaf speech, speakers simulating harsh and breathy voice or normally hearing speakers. Isolated vowels, from which onset and termination characteristics had been clipped, could not be distinguished as to source. However, the source of the sentences

was identified with 70% accuracy. Calvert (1962) concludes that deaf voice quality is not identified on the basis of relative intensity of the fundamental frequency and the harmonics alone, but on the dynamic factors of speech such as the transition gestures that change one articulatory position into another.

It has been stated that the level of suprasegmental development may be an important determinant of the intelligibility level achieved by profound hearing impaired children (Koike & Asp, 1977). Lieberman's (1970) study suggested that the prosodic aspects of the speech signal may be processed by listeners in a manner similar to the segmental aspects. Therefore, suprasegmental skill acquisition might serve to facilitate segmental development but also improve intelligibility during the therapeutic process and facilitate more natural sounding speech production at the conclusion of a therapy program.

Electronic devices are alternate approaches to therapy in the development and teaching of suprasegmental features of speech, specifically timing and rhythm. When hearing impairments are too severe to be adequately treated with hearing aids, other visual display and vibrotactile devices and procedures may prove useful in helping the child overcome the lack of suprasegmental features in his speech.

Training devices and techniques are used in speech training. For example, repetitive productions of selected speech features (voicing, intonation, rhythm) with some type of feedback to show

the user his response in relation to the acceptable target response. Speech training for production, according to Strong (1975) should be based on two premises. The first premise is that selected deficiencies can be isolated and appropriate feedback provided to a subject so he can overcome the deficiencies. The second premise being that those specific features which are drilled on in the training sessions will have substantial carry over into every day speech usage.

Speech training devices must be capable of extracting appropriate speech parameters from the speech of normally hearing and impaired subjects and presenting them in a meaningful way to the hearing impaired subject. In essence, a speech code needs to carry information on vocal tract configurations, articulations, and manner of production. Correct prosodic information carried in the acoustical variables of intensity, duration, and fundamental frequency is also necessary to produce normal sounding intelligible speech.

Once a speech code has been selected there are several options in terms of sense modality to which it will be presented. The two alternate kinethestic cues that deaf speakers use are visual and tactile. An instrument for each modality can be utilized.

The tactile and aural modes of reception are probably more closely related to each other than is either with the visual. However, most of the speech training devices to be enumerated are visual, which may imply that visual devices are particularly

useful as training devices (Strong, 1975). With visual aids, standard acceptable patterns can be stored and compared to those produced by the child.

The developments of visual display devices have ranged from simple single feature displays such as the "s" meter (Risberg, 1968) to very complex systems which present a selection of phonetic characteristics. In addition, there are systems which display the speech signal in a relatively unprocessed form as a spectrographic display. A review of early instruments was presented by Pronovost (1967a) and a comprehensive relatively current survey is presented by Strong (1975).

One of the theoretical basis for appropriate use of visual feedback for the hearing impaired child is so the child can evaluate his own speech. This ensures a high level of active involvement, and, theoretically, enhances learning.

Closely related to the concept of active participation is the principle associated with cognitive learning which stresses learning with understanding. This is especially useful when the verbal explanation of an articulatory concept is abstract and non-meaningful, visual display instruments clearly distinguish appropriate and inappropriate production features. These devices have the potential for increasing the student's understanding of articulation. Secondly, visual displays permit the teacher to assess the student's concepts of speech production by questioning the student concerning interpretation of visual patterns.

Another important factor in the learning process is related to the provision of accurate and consistent feedback. Providing feedback from both instructor and instrument increases the likelihood of accurate feedback to the students.

A final consideration relates to frequency of repetition. With a distinctive visual pattern for a target and a method by which teachers can monitor student performance, instrumentation may be used to provide necessary feedback during repetitive practice.

Visual and vibrotactile aids are primarily intended for use in speech training. Several approaches are possible to give speech information to the deaf through the tactile sense. One approach is using a vibrator that is excited directly by the amplified speech signal which may be felt by the fingers. However, the sensitive frequency range of the skin is limited to frequencies below about 800 Hz. A second approach is the tactile speech spectrum indicator developed at the Speech Transmission Laboratory in Stockholm (Pickett, 1963). It is in principle a channel vocoder with vibrotactile presentation of the speech patterns indicating the energy in frequency bands covering the frequency range of speech. The next approach was tried by Guelke and Huyssen (1959). Here the frequency components in bandpass filters were transposed down to the range of maximum tactile sensitivity, 100-400 Hz, where they were further analyzed mechanically by small steel reeds with resonant frequency

separation of only 15 Hz. Finally, it is possible to utilize the information in the zero crossings of the speech signal. Use of the zero crossings restricts the distance between speaker and microphone. This is to assure the elimination of the influence of the background noise in the room.

Although the skin cannot resolve temporal events above 800 Hz, the much slower rates on which articulatory events succeed one another are well within the range. Much of Gault's (1928) single vibrator was the result of the skin's capacity to perceive the rhythms of speech amplitude. Fraisse (1963) also remarked on the skin's ability to organize rhythmic patterns.

Rhythmic prosodic patterns of pitch and amplitude, in addition to providing specific syntactic cues, serve to segment the speech stream into various units. They also provide a temporal framework for the integration and ordering of integral components within such units. Neisser (1967) remarked that rhythmic pattern is a structure which serves as a support, an integrator, and a series of cues. The role of such patterns is increasingly emphasized in the study of auditory speech perception (Martin, 1972), and given the skin's ability to perceive rhythms, an optimal tactile display of speech should incorporate them effectively.

In addition to the rhythm of speech amplitude, the patterns of intonations indicated by rising and falling voice pitch may

be directly perceived by the skin's vibratory sense as these frequencies are within the range of the skin's capacity to discriminate.

Tactile displays can utilize most effectively spatiotemporal integration as well as rhythmic temporal. If successive spatial patterns presented to the skin's surface are close enough together in time and coherently related to one another configurationally, they are integrated into durable perceptual objects underlying apparent movement. Since the acoustic speech signal is derived from organized, continuous movements of the articulators; It is possible to devise an auditory-tactile transformation that preserves these valuable integrating characteristics in a form used by the skin. Some researchers emphasize the relevance of vibratory sense. Ling (1976) found a common error in perception of speech by the deaf children was an inability to perceive many unstressed and even some stressed syllables. One of the acoustic features of speech that seems to be available even to profoundly hearing impaired children through the vibratory sense is the number of syllables in a word, phrase, or sentence (Zeisser & Erber, 1977). In a recent study by Krinlebotn (1968) the results indicated better articulation of the order of 50 to 100% for two of three deaf subjects. Kringlebotn used single and multi-syllable word lists. These words were selected on the basis of familiarity. Their pronounciation of the words was recorded before and after one, two, and three hours of vibrotactile training in which the deaf

child compared the vibration patterns resulting from his own pronounciation with that of the teacher. The recordings were used in articulation tests with normal hearing listeners.

Each of the problems that have been discussed are related in some way to each of the others. In the past, training techniques have produced disappointing results. Methods which involve use of electronic devices will provide the deaf child with a constant visual or tactual representation of his own and other people's speech.

Statement of the Problem

It is documented in the literature that deaf speakers possess many distinct and deviant characteristics when compared to normal hearing speakers. Among the parameters of speech considered deviant are rate and rhythmic stress patterns. This study was designed to evaluate results of therapy on rate and stress patterns in the speech of severely, profoundly hearing impaired children. Seven other suprasegmental features were measured before and after therapy to determine change without therapy directed toward them. Two treatment procedures were used, one involving vibrotactile feedback and the other involving visual feedback.

Methodology

Subjects

The subjects were randomly selected from Kaley Elementary School in Orange County. Each subject's criteria for profound hearing loss was greater than 60 dB SPL and all subjects were presently enrolled in an oral program. The children's ages ranged from 7 to 13 years. Fourteen subjects were given therapy utilizing a visual display instrument, The Speech Vocal II. Another group of fourteen subjects were given the exact same therapy utilizing a vibrotactile instrument, The Fonator. There were 12 female and 16 male subjects. The onset of hearing losses were from birth wever, some were not diagnosed until two years or later. Subjects were fitted with their first hearing aid from two years to eight years. Academic levels ranged from first through sixth grade. Intelligent quotient scores ranged from 84 to 116.

Design

The design of this study is a simple pre-post treatment. The design involved the intelligibility of deaf subjects. Rate and stress patterns were evaluated and comparisons were made before and after therapy. The dependent variables of this study are rate and stress patterns. The two therapeutic programs administered are the independent variables. The comparison of the first therapeutic

program utilized a vibrotactile instrument, The Siemens Fonator. The other therapeutic program utilized The Speech Vocal II, a visual display instrument. The therapeutic program primarily relied on these instruments to teach and reinforce the deaf subjects The same materials for drill work on syllable, word, phrase, sentence, reading level were used with both groups. Criterion of 90% accuracy was established for each level of speech.

The suprasegmental features of rate and stress patterns affect the intelligibility of the listener's perception. As a speaker talks, he can say the same sentence several times, each time with a stress on a different word and convey numerous meanings. As mentioned, electronic devices are effective in assisting the teacher in speech training of these features of speech.

It is imperative that profoundly deaf children learn these suprasegmental features correctly. Suprasegmental parameters in the study are defined as stress and rate. Stress is defined relative to this study as vibratory patterns of the vocal chords which include change in frequency, intensity, and duration of voicing. Speech rate means the number of syllables spoken per unit of time. The goal of the therapy was to help these children recognize these aspects of acoustic vibratory patterns that were common to different situations. The exercises provided developed and taught characteristics of speech which could be generalized to different contexts.

Pre-Post Testing

Each subject was placed in a group according to random number table.

Quality tape recordings of each subject were obtained. Three to five minute conversation samples were recorded while student and teacher interacted. The second part of the pre and post test was a sentence level test. A set of twenty sentences and pictures were shown to the subject on videotape. The speech clinician who presented the stimulus pictures was a graduate student in Speech Pathology at the University of Central Florida. A pilot study indicated that a sequence of two stimulus sentences were appropriate. It appeared that the subjects were not capable of remembering more than two sentences. Two model sentences were shown, then the subjects were asked to say the required sentence for each corresponding cartoon picture card until all twenty sentences were given. The Multiple Phoneme Articulation Test cards were advantageous for the reason that most children easily associate the correct sentence with the picture. This particular method of presentation controlled for immediate imitative behavior. The examiner used ten of the most frequent sentences remembered as the actual sentences for baseline data.

The third part of the pre-test assessed suprasegmental features of rate and stress while reading. Each subject was given a 100 word word passage on his or her current reading level from their text. The text was provided by each classroom teacher. A pre-school picture book was used for the non-readers. The examiner showed the

pictures to the child and told the story. The examiner then asked the child to retell part of the story. A three to five minute tape recorded the reading passage.

Therapy and Materials

After the pre-test was administered, therapy was given to each group for two 15-minute sessions individually for a six week period. The therapy methods were approached from Daniel Ling's view and his text, Speech for the Hearing Impaired (1976). In addition, The Appletree Curriculum was used. The children were accustomed to using this material.

Observation was made of classroom presentation of The Appletree Curriculum. The classroom teacher instructed the children regarding linguistic application only. No attention or emphasis was given to speech, specifically to timing. The Appletree Curriculum is a patterned program of linguistic expansion. This sequential system provided the sentence level from simple noun+verb+ adjective to higher sentence constructs. Each subject had to achieve criterion of the material before preceding to the next level of the hierarchy. Criterion for the nonsense syllables, words, phrases, sentences, and reading level was 90% accuracy. A record of the number of responses for each session was recorded. For example, the correct response on the phrase level for two accented stress words (more milk mommy) was spoken on the second and third syllables. The goal of all levels was to practice

appropriate rhythm and timing of speech but also to encourage carry over to outside the therapy situation.

The pre and post test tapes were judged by a panel of five listeners, who were graduate speech student clinicians at the University of Central Florida. The pre and post tapes were judged on a seven-point evaluation scale for nine suprasegmentals. The evaluation scale included characteristics previously mentioned that are common to deaf speakers (see Appendix A for complete details).

The hypothesis consisted of two parts: (1) the subject's speech rate and stress patterns will demonstrate a positive change simply from exposure of a therapy program and the practice of these features; (2) the subject's speech will exhibit a difference in the results of the two treatment groups.

Description of the Instruments

The Siemens Fonator is a vibrotactile speech training tool. The purposes are to (1) create awareness of speech characteristics, (2) provide information about the production of speech sounds, (3) offer feedback to the student on his/her own speech production, (4) provide information during auditory training and speech reading practice.

The Fonator consists of an amplifier, microphone, single vibrator, and a set of headphones. A table stand for the microphone and a wrist strap for the vibrator are included.

The amplifier is a transistor stabilized power pack. Eleven transistors, two diodes, printed circuitry, and a pre-amplifier with three transistor stages are the primary amplification system. An intermediate amplifier with tone control for high frequency and low frequency intensity adjustments is provided. There are separate output amplifiers for the vibrator and the headset, with each having independent volume control using a driver stage and complimentary push-pull output circuit.

The microphone is a dynamic, directional (cardioid) microphone The vibrator is of a strong electromagnetic type, and the headset consists of dynamic headphones and an adjustable head band.

The volume controls for both vibrator and headset. The tone controls for the vibrator, and the power switch are located on the front panel. The microphone, headset, vibrator, and power cable sockets are located on the rear panel.

Specifications:

(1) Amplifier:
(with DT 96 headphone) Maximum Output: 1k Hz 132 dB SPL

Frequency Response: 15Hz to 16k Hz Peak: 40 dB

Gain: 1.0k Hz 35 dB

(2) Microphone:
Dynamic type with cardioid characteristics
Frequency Response: 40 Hz to 18k Hz

(3) Dimensions:
Width: 31cm
Depth: 17.5cm
Height: 10.3cm

(4) Vibrator:
Electromagnetic type; 60 dB SPL input and full-on gain:
vibromotive force is 0.1N at 1k Hz
Tone control: ± 20 dB at 50 Hz
± 20 dB at 16k Hz

(5) Fuses for 11o volt/60 Power Supply:
Primary: 0.25A, Slow-blow
Secondary: 0.25A, Fast-blow

Weight: 3kg

The gain of the headphones at 1.0k Hz is 35 dB, and the peak is 40 dB. These figures appear to be low for gain levels to be used with profoundly hearing impaired students. However, the microphone is held at the lips, resulting in a high intensity input level (approx. 70 - 90 dB SPL). Siemens utilizes this gain because the combination of this input level and the gain of the instrument results in an output level that is more than adequate to meet the needs of profoundly hearing impaired children.

The basic procedure for therapy with the Fonator was the following: (1) The vibrator was placed in the hand of each subject; (2) The examiner spoke into the microphone, giving short examples of the desired speech skill; (3) The student felt the vibrator and listened to the therapist; (4) The examiner asked the student to attempt imitation, matching the production of the therapist's vibratory and auditory pattern; (5) The examiner contrasted the student's production with the correct target skill; (6) The examiner asked the student to make the production again; (7) These steps were continued until the criterion was achieved for that specific target skill.

The Vocal II Visible Speech Training System consists of two instruments. Vocal II Control Unit Model VC-78 contains the electronic control circuitry and digital memory storage for the system. The control unit generates video signals which are cabled into Model VM-78 video monitor. The Vocal II Control Unit VC-78 and Monitor VM-78 thus combine into one system to provide visualization of processed speech information.

The Vocal II system is a two channel acoustic processing instrument that converts sound (speech spectrum) into electronically processed digital storage (memory). The system then displays this "stored" information on the screen of a video monitor. The display is continually updated as new information is processed in the memory bank. The system permits two segment presentation on the video screen. One segment is used for "instruction" purposes and for presentation of visual goals to the student. The second segment is used for student practice.

Processing of the voice sounds may take two forms, these being Amplitude vs. Time and Frequency vs. Time. When in the Amplitude vs. Time mode the (vertical) amplitude display is on a logarithm scale. The input signal is adjustable over a 50 dB range speech envelope being 40 dB. In Frequency vs. Time modes the vertical amplitude of the display represents the frequency characteristics produced during vocalization. In either mode the use of movable cursors allows specific objectives to be set and measurements to be made. In the Amplitude vs. Time mode, one

vertical cursor is available and may be used by the instructor to introduce a latency objective into the student practice. In the Frequency vs. Time mode two horizontal cursors are available. One cursor is electronically coupled to a digital frequency counter and may be used to establish frequency objectives for student practice. It also permits specific frequency measurements of the displayed vocalization characteristics. The introduction of the second horizontal cursor allows the instructor to establish frequency bandwidth objectives into the student practice.

Three Frequency bands are available for Fundamental Frequency vs. Time use. They are: F1 (70-140 Hz) F2 (140-280 Hz); F3 (280-560 Hz). Proper use of the various bands is dictated by the requirements of the teacher but may be guided according to the age and sex of the student. Children will normally vocalize within the bandwidth of F3, adult females within band F2 and adult males within band F1. One frequency band has been designated for specific practice by the student to allow visualization of fricative formation. This is designated S1 and has a bandwidth of 4k-8k Hz.

The controls and indicators are as follows:

(1) Microphone:	Special purpose microphone for sound (speech) pick up into VC-78.
(2) Frequency Display:	Provides digital readout of frequency, derived from position of horizontal cursor, which is controlled by push button #4.

(3) Cursor Control: (Vertical)	Position controls for the vertical cursor (17). Top button moves cursor to right, bottom button moves cursor to the left.
(4) Cursor Control: (Horizontal #1)	Position controls for one of the two horizontal cursors. Frequency readout (2) displays frequency corresponding to the position of the cursor.
(5) Cursor Control: (Horizontal #2)	Position controls for the second horizontal cursor. This cursor does not have a corresponding frequency readout. Horizontal cursor move upward when the top button is pushed and downward when the bottom button is pushed.
(6) Sweep Selector:	Two position switch selects either single or multiple sweep. In single position the video monitor display will sweep once then remain on the screen. In multiple position, the sweep will continually repeat itself and erase all stored information on the monitor at the beginning of each sweep.
(7) Trace Selector:	Two position switch that selects either the upper or lower segment of the monitor for display of processed speech information.
(8) Sweep Trigger:	Two pushbutton switch that control sweep initiation and termination. Depressing the start button begins sweep of the video display. Depressing the stop button will terminate the sweep instantaneously. A hand held push button is also supplied with the instrument and may be used to start the sweep.
(9) Model Selector:	A five position switch that selects the speech processing function as follows: A - Amplitude vs. Time F1- Frequency vs. Time 70-140 Hz F2- Frequency vs. Time 140-280 Hz F3- Frequency vs. Time 280-560 Hz S1- Fricative formation 4k-8k

(10) Time Base:	Selects the Time required for the video display to complete one sweep. Time may be selected at 2, 4 or 8 seconds.
(11) Gain:	Adjusts microphone amplifier gain.
(12) Power Indicator:	Power is on when this light is illuminated.
(13) Power Switch:	Turns power to the instrumenr on or off.
(14) Practice Segment:	The lower of the two segments available for display.
(15) Instruction Segment:	The upper of the two segments available for display.
(16) Power Switch:	Turns power to the monitor on or off.
(17) Vertical Cursor:	Movable Vertical Cursor used to indicate latency.
(18) Vertical Hold:	Provides horizontal stabilization of the monitor trace.
(19) Horizontal Hold:	Provides horizontal stabilization of the monitor trace.
(20) Brightness:	Adjust brightness of the display trace.
(21) Contrast:	Adjusts contrast of the monitor display.

Statistical Analysis

After the six weeks of therapy had been given consisting of fifteen minute sessions twice weekly. The subjects were administered the post test which was the same as the pre test.

The scores from the five judges were fed into the computer for computation of t and f tests. The results of the t test reflected the difference between pre and post therapy ratings The analysis of variance demonstrated the differences between

the three speaking conditions on the nine variables for the two treatment groups. Judges mean scores of ratings for each variable and for treatments were also computed. The pre and post tests consisted of three parts. A non-imitative spontaneous sample of conversational speech was taped for three to five minutes between teacher and subject. Another sample included a videotaped presentation of twenty stimulus sentences. The most frequently remembered stimulus sentences by all subjects were utilized in the sample. A 100-word sample was also obtained from each of the subject's current reading text.

Results

A panel of five graduate student clinicians evaluated recorded speech samples of reading, sentences, imitation and conversation for 28 deaf subjects made before and after therapy. These speech samples were randomized and identified by number only, so judges did not know if the sample being judged was pre or post therapy - the listening judgments were completed in one hour segments for a total of three hours. Tapes were played on a Wollensak 3m model 2851 type recorder. Each speech sample was one minute in length and each subject had six samples. After listening to each one minute sample, the evaluation scale was completed by the judge. Mean scores from the five judges for each subject on each variable in all three conditions were used in analysis of data.

Visual inspection of ratings provided by judges revealed consistency among these five judges. However, since the mean of all five was being used, no computations of interjudge reliability were made.

A t test was computed for pre and post conditions on all subjects using the mean rating of the five judges. A significant

difference between pre and post scores was shown at or beyond the .05 level of confidence for the following conditions and variables (a) reading; stress, and intelligibility. (b) conversation; intelligibility, and loudness. (c) sentences; tension. There was positive movement toward the normal rating of four for the variable tension in sentence initation. The differences in scores for the other conditions and variables did not represent movement toward normal.

After comparing mean scores and pre and post treatment, analysis of variance was computed to analyze treatment effects on each variable.

At the conversation level rate moved in the postive direction 3.4 to 4.0 for Treatment 1 which was using the vibro tactile instrument. However, negative movement was indicated in Treatment 2 which was therapy using the visual display instrument. Breath support ratings reflected slight improvement for treatment 1, but movement toward inadequacy with Treatment 2. Resonance overall pre and post scores indicated no change (2.9); however, when examined more closely improvement was made in Treatment 1 and decreased in Treatment 2. Stress indicated a postive effect for Treatment 1 and Treatment 2 showed no change.

At the reading level results indicated rate improvement for Treatment 1 and a slight decrease for Treatment 2. Loudness increased slightly with both treatments. Breath support showed a small positive movement for Treatment 1 while remaining the

same for Treatment 2. Pitch became higher with Treatment 1, while it moved from high toward normal with Treatment 2.

Sentence imitation revealed improvement for tension with both treatments. The intelligibility level was increased by Treatment 1, but not for Treatment 2.

All other variables appear in Tables 1, 2 and 3, show no change or a slight change in a negative direction.

It may be concluded from these results that little change occurred that was observable to judges following six weeks of therapy which consisted of 15 minutes, twice weekly for either treatment condition. The stability of the judges' ratings have not been verified empirically; therefore, the changes reported cannot be viewed as absolute.

Table 1

t Test for Pre and Post for
Suprasegmentals at the Sentence Level

Suprasegmentals	M Pre Measure	SD	M Post Measure	SD	t
Rate	3.62	1.10	3.46	.924	.139
Loudness	3.74	.924	3.35	.914	.000
Breath Support	3.16	.831	3.35	.892	.063
Pitch	4.24	1.06	4.25	1.18	.950
Resonance	2.82	.988	2.83	1.19	.952
Tension	4.53	1.07	4.19	1.07	.002*
Stress	3.15	1.02	2.94	1.04	.069
Intelligibility	3.16	1.85	3.35	2.06	.400
Articulation	2.11	.701	2.03	.719	.324

* $p < .05$

Table 2

t Test for Pre and Post for
Suprasegmentals at the Reading Level

Suprasegmentals	M Pre Measure	SD	M Post Measure	SD	t
Rate	3.23	1.04	3.25	.933	.876
Loudness	3.68	.948	3.75	.850	.431
Breath Support	3.01	1.00	3.07	.819	.595
Pitch	4.40	1.12	4.31	1.21	.392
Resonance	2.89	1.12	2.79	.971	.338
Tension	4.52	1.24	4.35	1.08	.193
Stress	3.31	1.38	2.91	1.09	.006*
Intelligibility	3.10	1.95	2.61	1.77	.040*
Articulation	2.16	.782	2.14	.912	.816

* $p < .05$

Table 3

t Test for Pre and Post for
Suprasegmentals at the Conversation Level

Suprasegmentals	M Pre Measure	SD	M Post Measure	SD	t
Rate	3.52	1.33	3.71	1.25	.184
Loudness	3.67	1.13	3.34	.973	.004
Breath Support	3.26	.991	3.21	.942	.663
Pitch	4.17	1.20	4.30	1.19	.249
Resonance	2.90	1.21	2.90	1.05	.952
Tension	4.18	1.08	4.25	1.05	.552
Stress	2.95	.916	3.07	1.00	.243
Intelligibility	3.54	2.02	2.94	1.80	.011*
Articulation	2.19	.778	2.16	.857	.757

* $\underline{p}$ = < .05

Table 4

Judges' Mean Scores at the Sentence Level

	All Subject's Mean		Vibro-tactile #1		Visual Display #2	
	Pre	Post	Pre	Post	Pre	Post
Rate	3.6	3.4	3.6	3.4	3.6	3.4
Loudness	3.7	3.3	3.8	3.4	3.6	3.2
Breath Support	3.1	3.3	3.3	3.3	3.0	3.3
Pitch	4.2	4.2	4.2	4.2	4.2	4.2
Resonance	2.8	2.8	2.9	2.8	2.6	2.7
Tension	4.5	4.1	4.5	4.2	4.4	4.1
Stress	3.1	2.9	3.2	3.0	3.0	2.8
Intelligibility	3.1	3.3	3.1	3.5	3.2	3.1
Articulation	2.1	2.0	2.1	1.9	2.0	2.1

Table 5

Judges' Mean Scores at the Reading Level

	All Subject's Mean		Vibro-tactile #1		Visual Display #2	
	Pre	Post	Pre	Post	Pre	Post
Rate	3.2	3.2	3.0	3.2	3.4	3.2
Loudness	3.6	3.7	3.7	3.8	3.6	3.7
Breath Support	3.0	3.0	2.9	3.0	3.0	3.0
Pitch	4.4	4.3	4.1	4.3	4.6	4.2
Resonance	2.8	2.7	2.8	2.9	2.9	2.6
Tension	4.5	4.3	4.4	4.1	4.6	4.5
Stress	3.3	2.9	3.6	2.8	3.0	2.9
Intelligibility	3.0	2.6	3.4	2.8	2.7	2.4
Articulation	2.1	2.1	2.1	2.0	2.1	2.2

Table 6

Judges' Mean Scores at the Conversational Level

	All Subject's Mean		Vibro-tactile #1		Visual Display #2	
	Pre	Post	Pre	Post	Pre	Post
Rate	3.5	3.7	3.4	4.0	3.6	3.3
Loudness	3.6	3.3	3.6	3.4	3.6	3.2
Breath Support	3.2	3.2	3.3	3.5	3.6	2.9
Pitch	4.1	4.3	4.2	4.2	3.1	4.3
Resonance	2.9	2.9	2.8	3.0	4.0	2.7
Tension	4.1	4.2	4.0	4.3	2.9	4.1
Stress	2.9	3.0	2.9	3.2	4.2	2.9
Intelligibility	3.5	2.9	3.3	2.9	2.9	2.9
Articulation	2.1	2.1	2.2	2.2	3.8	2.1

Discussion

The results of this study indicate interaction of the variables, treatment and listener judgments. Improvement was indicated for rate at the conversational level with Treatment 1. Treatment 1 showed a positive effect whereas Treatment 2 adversely affected rate. Treatment was designed to move from syllables, to phrases, to sentences, to reading, to conversation. After six weeks, ten subjects in the Treatment 1 group, were working at the conversational level of speech. Generally, the conversational level is considered the most difficult and resistant to change. However, the conversational task may have been easier for these profoundly deaf children since reading skills and auditory recall are made so difficult by the hearing impairment. Performance of the sentence imitation task was hindered during pre, post and therapy situations by poor auditory memory skills. Attempts to minimize this difficulty included presentation by videotape. Two sentences were presented and then subjects were asked to respond only to the stimulus pictures used on the videotape mode. Each subject's response was recorded. It was necessary to present in this way

to administer all twenty sentences. For those subjects whose hearing losses were severe to profound, their only sources of sentence reception were cues of lip reading and reading the stimulus cards. If these subjects had difficulty in recognizing or reading the actual stimulus words, they could not be expected to repeat them. No visual cues were provided for rate or stress in the pre and post test conditions. This difficulty in speech reception was reflected by pausing, rephrasing, and imitation attempts.

At the reading level, rate made positive change with Treatment 1. This involved a vibro tactile instrument whose primary feature conveys tactile pulsations of speech while Treatment 2 provides visual signs of rate. Reading material used in the study was familiar to the subjects and it was at the instructional level. Their regular reading textbook was used. Reading proficiency levels might have influenced their use of stress and rate.

One possible explanation for increase in loudness levels for both treatments may be due to criteria performance for the skill in the classroom situation. The teacher usually requires and gives verbal cues for loudness in a reading group environment.

At the conversational and reading levels breath support improved with Treatment 1, and on sentences for Treatment 2.

Assuming a subject was using appropriate rate and stress, breath support would also be appropriately utilized. The visual display device did not overtly convey to the subject when he was using inadequate breath support or making too many pauses. However, many subjects would exhaust their air supply before they could finish the phrase or sentence. The visual representation would indicate the length of an utterance and displayed gaps for inappropriate pauses or inhalations. These were mentioned by the experimenter to correct the stress of the model sentence.

Pitch, a most obvious deviant characteristic of deaf persons, stayed the same at the sentence level. A small positive change was noted at the reading level attributed to Treatment 2. The visual contour on the screen represented the pitch level of the sentence. The Speech Vocal II, the visual instrument for Treatment 2, can be specifically set for pitch control. However, since pitch was not being specifically treated the dial was set on amplitude versus time. The subjects may have received positive reinforcement from producing more of a visual contour by raising the pitch level.

Resonance did not show changes with all subjects between pre and post ratings. When viewed separately, both treatments showed slight improvements; on the reading level, for Treatment 1, and on the sentence level for Treatment 2. Subjects that exhibited

characteristics of inadequate velopharyngeal closure consistently used resonance incorrectly throughout conversation. However, these subjects changed resonance in the sentence imitation or reading tasks. Practice in rate and stress may be facilitated more adequate velopharyngeal closure.

Tension moved toward the direction of the normal rating of four for both treatments at the sentence level. This may have been due to the familiarity of the testing situation, and the examiner. The other two pre and post conditions were conducted in the presence of the teacher, and responses were elicited by the teacher. The subjects may have been more relaxed in the post testing situation with the examiner.

Intelligibility scores showed negative movement due to incorrect design of this variable. Judges expressed difficulty in evaluating the scale for intelligibility. Since all other scales were bi-polar, the intelligibility was also designed bi-polar to maintain consistency. However, for this particular variable a bi-polar scale is not feasible.

Intelligibility showed improvement only on the sentence level. The judges may have understood more words because the sentences were short discreet units. Obviously, intelligibility would not improve if articulation skills were poor. Articulation showed no change for either treatment on any level. The idea

that suprasegmental features are important in comprehension and production of speech is demonstrated in this study. Unless these skills are developed, improvement in articulation might be more difficult to obtain.

In conclusion, the speech pathologist needs to use extreme care in choosing therapy methods. Other related factors may be influencing the assumed positive effects of therapy. Additional studies are needed to evaluate procedures and materials used in therapy for effectiveness and efficiency.

Summary

The literature on the speech of hearing impaired indicates that problems exist in the suprasegmental features of speech production which include rate, loudness, breath support, pitch, resonance, stress, tension, intelligibility and articulation. Little information has been reported regarding the interdependency of these variables on each other.

In recent years numerous instruments have been made available commercially with claims that they aid the development of speech skills. This study was designed to evaluate nine suprasegmental features before and after a short period of therapy. Therapy was directed at changing two of the suprasegmental features, rate and stress. Data consisted of listener judgments made from tape recorded speech samples, in three speaking conditions, before and after therapy were analyzed. Results revealed significant differences in pre and post therapy ratings for the suprasegmental features of intelligibility, tension and stress. Analysis of pre and post scores by treatment groups indicated improvement with both treatments for the variables

tension and loudness. Movement away from the direction of normal was noted for the following variables: rate, loudness, stress, articulation, pitch, intelligibility, for Treatment 1. Variables for Treatment 2 that moved away from normal were: rate, loudness, intelligibility, articulation, resonance and breath support. Some of the suprasegmental features that did not change were: breath support, pitch, articulation, and stress. Rate and stress were the only two suprasegmental factors receiving attention in therapy. Others showed change in pre and post conditions.

This study emphasizes the need to evaluate the techniques and methods utilized in therapy procedures.

Appendix A

Panel Evaluation Scale

(Circle the number which most appropriately describes this student's voice).

1. The rate of this student speech is:

1	2	3	4	5	6	7
very slow			normal			very fast

2. This student talks:

1	2	3	4	5	6	7
very soft			normal loudness			very loud

3. This student uses breath support:

1	2	3	4	5	6	7
too short			normally			too long

4. The pitch of this student's voice is:

1	2	3	4	5	6	7
too low			normal			too high

5. The resonance of this speaker's voice is:

1	2	3	4	5	6	7
denasal			normal balance			hypernasal

6. The tension of this voice is:

1	2	3	4	5	6	7
too lax			normal			too often

7. The speaker uses stress:

1	2	3	4	5	6	7
too seldom			normally			too often

8. The intelligibility of this speech pattern is:

1	2	3	4	5	6	7
difficult			easy			impossible

9. Articulation accuracy is:

1	2	3	4	5	6	7
inaccurate			normal			too precise

Appendix B

Multiple Phoneme Articulation Stimulus Cards

1. What is the number?
2. What books do you want?
3. Let's visit the zoo.
4. We need more paint.
5. He looks like his father.
6. When will we finish?
7. March is a windy month.
8. Give me the ball.
9. Here is something for you.
10. That man is my father.
11. Here is my picture.
12. Feed the dog.
13. Do you like jello?
14. My bird can talk.
15. What did you find?
16. What do you have?
17. I will go.
18. Do a good job.
19. They came to visit.
20. This is my lunch.

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