1998

The Effect of Diastema Closure on the Remediation of Lateral /S/: A Case Study

Reta Price
Portland State University

THESIS APPROVAL

The abstract and thesis of Reta Price for the Master of Science in Speech Communication: Speech and Hearing Science were presented July 15, 1998, and accepted by the thesis committee and the department.

COMMITTEE APPROVALS: [redacted]

John Tetnowski, Chair

[redacted]

Susan Rustvold

[redacted]

Candace Gordon

[redacted]

Carol Mack
Representative of the Office of Graduate Studies

DEPARTMENT APPROVAL: [redacted]

David Ritchie, Chair
Department of Speech Communication

ABSTRACT

An abstract of the thesis of Reta Price for the Master of Science in Speech communication: Speech and Hearing Science presented July 15, 1998.

Title: The effect of diastema closure on the remediation of lateral /s/: a case study.

An important morphological marker and one of the most frequently occurring speech sounds in English, the /s/ phoneme is also one of the sounds most often in need of remediation. Often, air emission during /s/ production, a particularly stubborn, often residual production error, is not remediated through traditional treatment methods, and yet the negative effect /s/ distortions have on listeners has been well-documented.

The subject of this investigation was a forty-eight-year-old male who received treatment for a lateralized /s/ during grade-school. It was hypothesized that his exerting high anterior pressure to prevent air from escaping from a diastema between his two maxillary incisors during /s/ production created lateral openings through which air was escaping. McGlone and Proffit (1973, 1974) found that subjects who had lateralized /s/

exerted a great deal of pressure on the anterior region of the palate. Closing the diastema might reduce anterior pressure and thus provide a means toward improved /s/ production.

Before having his diastema closed, the subject responded to items on the Photo Articulation test and the Dworkin-Culatta Oral Mechanism Examination. To establish a baseline of correct /s/ productions, a digital audio tape (DAT) recording was made of the subject reading words and sentences taken from Eugene T. McDonald's DEEP test of Articulation and the Rainbow passage. The subject's diastema was then closed using a common dental practice. Subsequent recordings were made four days after and then again one month after the procedure. Three graduate students rated the tapes for presence or absence of air emission during /s/ productions. A phonological context evaluation was also performed as well as a spectrographic analysis of selected productions.

While the data in this study do not support that closing the diastema remediated the subject's lateral /s/, the phonological context data do support that complex speech demands negatively impacted the subject's /s/ production, and that his best performance was in the context of speech sounds that do not require precise articulatory movement or breath control. A spectrographic evaluation revealed higher levels of spectral noise in the high frequencies when air emission was present.

THE EFFECT OF DIASTEMA CLOSURE ON THE REMEDIATION OF LATERAL /S/: A CASE STUDY

by
Reta Price

A thesis submitted in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE
in
SPEECH COMMUNICATION:
SPEECH AND HEARING SCIENCE

Portland State University
1998

Dedication

I would like to dedicate this work to my sister, Rhonda Ayling, whose love and support I felt at every turn.

Acknowledgments

I want to acknowledge the many people who have helped with this project. I want to thank my family for allowing me the time and space for its completion. I want to thank Rebecca and Nixi, the department secretaries for their patience and assistance with rules, regulations, forms and deadlines. I want to thank the people with whom I have had the privilege to work at the Oregon School of Dentistry, Dr. Jack Clinton, Dr. Peter Morita, Rose Russell, Sandee Valentine and Melissa Monner, who did the extra work that allowed me to be gone when I needed to be and encouraged me, always, to reach my goal. I would like to thank the members of my committee, Dr. Carla Dunn, Dr. Carol Mack, Candace Gordon, and particularly Dr. Susan Rustvold and Dr. John Tetnowski. Dr. Rustvold conducted the dental procedure in this study and never failed to have a kind and encouraging word when I needed it. Dr. Tetnowski served as chairman of my committee, and this project would never have been undertaken or completed without kindness and patience. Finally, I owe thanks to my husband, Mark Price, whose patience, support, and assistance were crucial, who often had more faith in my abilities than I did myself, and whose love I value above all else.

TABLE OF CONTENTS

LIST OF TABLES

PAGE

CHAPTER I

INTRODUCTION AND STATEMENT OF PURPOSE

Introduction

The /s/ phoneme is among the top three most frequently occurring phonemes in speech, an important morphological marker, and one of the sounds most frequently in need of remediation (Weiss, Gordon, Lillywhite, 1987). A particularly stubborn, often residual /s/ production error involves air emission. Air emission during /s/ production through either the opening between the tongue tip and the anterior maxillary teeth or between the lateral portion of the tongue blade and teeth or alveolar ridge results in a frontal or lateral lisp, also referred to as frontal and lateral /s/. Lisping can occur despite otherwise normal speech and language development, and seems to be particularly resistant to the effects of maturation (Gibon & Hardcastel, 1987). A number of studies have examined the articulatory features and gestures of the /s/ phoneme, resulting in implications for remediation (McGlone & Proffit, 1973,1974).

Temporal and electropalatographic studies support a strong speech-motor component to lisping. It follows then that the chances of effective remediation will be improved if treatment emphasizes articulatory positioning and motor practice. Traditional articulation treatments involve some sort of articulatory placement training. These methods typically include a component of auditory training that may or may not be helpful in the treatment of a client who lisps (Weiss, Gordon, Lillywhite, 1987). Speech appliances have been used to achieve phonetic placement (Gibon & Hardcastel, 1987). The speech appliance is designed to guide articulatory placement without relying on the client's interpretation of and ability to follow directions by the clinician. Speech appliances such as the r-stick (Clark, Schwarz, & Blakely, 1993) have been used successfully to remediate residual sound errors not resolved through traditional forms of therapy. A common criticism of speech appliances is that they cannot be used in treatment at the level of connected speech. Thus the client must generalize the new placement he has learned in order for treatment to be successful. This study proposes a semi-permanent alteration of the maxillary dentition that will spontaneously allow the client to redirect air flow during /s/ production to eliminate lateralizing. Research by McGlone and Proffit (1973, 1974) found that subjects who had lateralized /s/ exerted a great deal of pressure on the anterior region of the palate. If that pressure is exerted to prevent ambient air from escaping from a diastema during /s/ production, then closing the diastema should spontaneously redirect air flow forward rather than laterally during /s/ production.

Statement of Purpose

The purpose of this study is to investigate the effects of closing a diastema between the two maxillary central incisors on lateral air emission during /s/ phoneme production. The diastema will be closed semi-permanently through the application of acrylic material to the two central incisors. The question under investigation is whether closing the diastema facilitates remediation of lateral air emission during /s/ production. This question will be addressed by measuring a single subject's /s/ productions before and after the dental procedure. Results will be measured perceptually and acoustically. The research hypothesis is that the subject's lateral air emission will be eliminated by closure of the diastema. The null hypothesis is that the subject's lateral air emission will not be affected by closure of the diastema.

Definitions

Speech appliance: A removable or semi-permanent devise placed interorally to facilitate articulatory placement.

R-stick: A speech appliance developed by Robert Blakely to facilitate /r/ production.

Electropalatograph(EPG): speech appliances consisting of a palatal stent imbedded with electrodes that when contacted provide real-time visual feed back of articulatory placement to the user.

Diastema: A space occurring between two naturally adjacent teeth.

Lateral air emission: Air escape during /s/ production between the lateral portion of the tongue blade and the teeth or alveolar ridge.

Frontal air emission: Air escape during /s/ production between the tongue tip and anterior maxillary teeth.

CHAPTER II

REVIEW OF THE LITERATURE

Phonological and Articulatory Development and Error Patterns

Phonological development is the process by which children incorporate the ability to produce the sounds of their native language with an understanding of the rules governing the combination of those sounds. Children typically acquire the sounds of their language and a cursory understanding of phonotactics by age four, although refinement of sound production continues through age seven or eight. Some children encounter delays and manifest disorders during this process of development. Often speech and language disorders co-occur; however, some individuals demonstrate residual sound errors despite otherwise normal speech and language development. Research supports that children who have multiple sound errors very often have concomitant language delays, while children with only a few residual sound errors do not seem to show this tendency. However, residual sound errors do appear to be resistant to the effects of maturation and remediation and do draw negative attention to the speaker (Gibbon, & Hardcastle, 1987; Silverman, 1976). One of the most common residual sound errors occurs on the phoneme /s/, and one of the most common types of errors on this particular phoneme is air emission.

The frequently occurring /s/ serves as a morphological marker, and is also one of the sounds most frequently in need of remediation (Weiss, Gordon, Lillywhite, 1987). A common residual /s/ production error involves air emission. Typically in English, an /s/ is produced by raising the lateral margins of the tongue bilaterally, resulting in a groove created by the blade of the tongue. A sustained flow of air must then be maintained and allowed to escape only between the tip of the tongue and the maxillary anterior teeth. Air emission, either through the opening between the tongue tip and the front teeth or between the lateral portion of the tongue blade and teeth or alveolar ridge, results in a frontal or lateral lisp, also referred to as frontal and lateral /s/. Thus, correct /s/ production requires precise control of the articulators in combination with the respiratory system. The /s/ phoneme is a late-developing sound that requires both precise articulatory movement and placement. In the literature, the accepted age of mastery for the /s/ phoneme ranges from three years of age to six to seven years of age (Templin 1957;

Prather, Hedrick, Kern, 1975; Maurer, Sundstrom, 1988; Kenney, Prather, 1986). Despite disagreement on the age of mastery of the /s/ phoneme, errors during /s/ production that persist beyond age six should be considered for remediation.

In the Portland Public Schools, misarticulation of the /s/ phoneme is considered for remediation if the errors draw attention to the child's speech and/or impede academic progress in some way and the child is at least seven years old (Portland Public Schools, Speech-Language Severity Index, 1988). Residual sound errors do draw negative attention to an individual's speech (Silverman, 1976; Mower, Whale, & Dollar 1978) and thus may impede academic progress due to a reduced willingness to engage in classroom activities that involve speaking; however, research supports that residual errors do not correlate with language delays in the same way multiple phonological errors appear to do.

A study conducted by Gross, St. Louis, Ruscello and Hull (1985) found language development in children who have only a few residual articulation errors (mean of five errors) to be within normal limits. This study compared three groups of children on measures of mean length of utterance and syntactic structures: those with a mean of five residual articulation errors, those with a mean of fifteen articulation errors, and those with no articulation errors. The researchers concluded that the children with a high number of articulation disorders had concomitant language delays, while those children with only a few residual errors scored within normal limits in language development (Gross, St. Louis, Ruscello, Hull, 1985). It does seem clear that something significantly different is occurring between a child who has multiple phonological errors and one who is unable to refine a certain sound production beyond the age of mastery and even into adulthood. This difference may be important in terms of treatment.

Methods of Remediation

Not all researchers have classified lisping as simply one among other sound production errors. The treatment approach offered by Scripture (1914) pairs lateral and frontal /s/ with stuttering.

In his monograph, Stuttering and Lisping (1914), Scripture describes an approach to the treatment of lisping that closely parallels treatment for stuttering. Scripture suggests that remediation of lisping include the regulation of breathing during various activities including sentence repetition and singing, linking (continuous phonation), speaking with sticks (using sticks to tap out a rhythm for speaking), use of a metronome, slowness (prolongation), and speaking together (choral reading). Many of the treatments he suggests for the remediation of lisping echo current fluency induction treatment for stuttering. Regardless of the underlying causes (language, speech-motor, or both), it is clear that individuals who have lateral or frontal air emission during /s/ production have an obstinate error to remediate.

Typically, there are two approaches in the treatment of speech sound disorders: traditional and phonological processing. The traditional approach addresses one sound at a time from production in isolation through syllables, words, phrases, sentences and finally in connected speech. This approach emphasizes motor learning through drill activities in articulatory placement. Traditional treatment approaches also commonly involve some sort of auditory discrimination activity.

Phonological processing treatment also has an auditory component; however, this type of treatment does not focus on drill and practice of articulatory placement, but rather addresses sound productions in the context of processes that are in error. Which treatment approach is appropriate depends on what kind of and in what quantity sound errors occur. A child who produces errors or distortions on a few sounds or just one sound consistently across position in words (initial, medial, or final) but who is intelligible and whose language development is otherwise within normal limits might benefit from traditional treatment that focused on the refinement of one sound at a time. On the other hand, a child who is highly unintelligible due to multiple phonological processing errors, such as consonant cluster reduction or final consonant deletion, would likely benefit more from a phonological processing approach. A child or adult unable to refine his/her articulation of one specific sound but who otherwise appears to have no difficulty with the underlying rules that govern sound combination might benefit more from a program that stressed correct articulatory placement. All traditional approach treatments have a component of articulatory placement.

The canon of traditional treatment of articulation disorders includes Scripture and Jackson's (1927) phonetic placement approach, Hawk and Young's (1938) moto-kinesthetic approach, Van Riper's (1939) stimulus approach, Milison's (1954) integral stimulation, and

McDonald's (1964) sensory-motor approach. Traditional articulation treatments all involve some kind of articulatory placement training, either through direct manipulation of the articulators by the clinician as that found in moto-kinesthetic treatment, or through a combination of direct manipulation and instruction for placement to the client by the clinician as in phonetic placement and shaping treatments.

Also included in the traditional treatment of articulation disorders is a component of auditory discrimination training. The client is asked to produce the target sound in isolation, then in single syllables, multi-syllables, phrases, sentences and finally in connected speech. However, it has been observed that certain sounds, such as stops, can not truly be produced in isolation. In addition, practice on the phonetic placement for an /s/ produced in isolation may not benefit the client attempting /s/ in connected speech. Nonetheless, because they emphasize motor movement, traditional treatment approaches may benefit clients who have isolated, seemingly motorically-based sound errors, such as lateral /s/.

Residual sound errors which have not been resolved through traditional forms of therapy have been successfully remediated through the use of speech appliances, which facilitate articulatory placement. Speech appliances such as electropalatographic stents and Blakely's r-stick (1993) aid in articulatory placement and provide visual and proprioceptive feedback respectively. Electropalatography (EPG) has been used successfully under research conditions to treat phonological disorders. Subjects are fitted with a palatal stent and asked to produce phonemes in ascending linguistic context from syllables to connected speech. This progression from syllable to connected speech mirrors one aspect of Van Riper's stimulus treatment approach. The difference is that subjects undergoing electropalatographical treatment are not given auditory discrimination training. The r-stick initiated by Blakely (1993) has been used successfully to remediate residual sound errors not resolved through traditional forms of therapy.

In an article reviewing the use of speech appliances, Ruscello (1995) speculates on why speech appliances are successful when traditional treatment fails. He believes that speech appliances create sensory feedback that aids the client in learning correct placement for specific productions. This sensory feedback provides the client with a proprioceptive model for correct production of a phoneme; however, since speech appliances to date have been removable, he adds that this form of feedback must be replaced with other forms after the appliance is removed. Thus, speech appliances are used to establish motor learning in the production of a sound and then are faded. One of the criticisms of the use of speech appliances is that training can occur at the phoneme-, syllable- and word-level, but not at the level of connected speech. Nonetheless, appliances have proven effective in the treatment of clients who are unable to correct sound production from traditional treatment.

Dagenais (1995) summarized treatment of articulatory and phonological disorders using EPG. In electropalatographic treatment, clients are fitted with a custom palatal stent with sensors. During treatment the client watches a computer screen that displays squares corresponding to the placement of the sensors. The squares are usually demarcated by color. Typically the green represents target squares in placement for a specific phoneme. Red squares are areas clients are not to contact during production. Touching sensors on the stent with the tongue causes either the desired or undesired squares to be enlarged or darkened. The client, using this real time feedback, attempts to approximate correct placement. Clients progress in production from sounds in isolation, through single syllables, multi-syllables, phrases, sentences, and connected speech. Clients are asked to spend a portion of the treatment session practicing sound production without the stent in place. Time practicing without the stent in place is gradually increased as the client gains proficiency. Included in this summary was a study conducted by Dagenais, Critz-Crosby, and Adams (1994) who treated two eight-year-old female clients using EPG.

The subjects in the Dagenais, Critz-Crosby and Adams (1994) study were referred for treatment of lateralized sibilants. During the EPG assessment of the first subject, it was found that palatal contact made during velar stop in addition to sibilant production--while acoustically acceptable--was unusual. This deviation in velar stop productions might be explained as an individual difference within normal limits or as an apparently isolated residual sound error that in fact represents a more generalized sound production disorder. Assessment of the second subject also indicated atypical contacts for both sibilants and stops. Based on their assessments, researchers provided treatment for velar stops as well as sibilants. Subject One was able to approximate appropriate productions during treatment, but had difficulty generalizing these productions outside the clinic room. Subject Two made slight improvements on sibilant production during treatment and was able to generalize this improvement, but did not retain the improvement when tested six months post treatment. Other investigations have yielded more favorable results.

Gibbon and Hardcastle (1987) used EPG with a twelve-year-old boy for treatment of lateral /s/. The subject was presented with normal phonology except in the production of /s/ and /z/, both of which he lateralized. The subject was able to discriminate between /s/ productions with and without lateral air emission. Traditional treatment was first attempted, but no improvement was achieved. The client was then fitted with a palatal stent containing 62 sensors, provided with a visual model for correct /s/ production, and real-time visual feedback of his own productions. At the end of the first session, the client was able to produce /s/ without lateralizing when asked to read a list of ten single-syllable words. At the end of the fourth session, he was able to read full sentences and either produce /s/

and /z/ correctly on the first trial or immediately self-correct. A reevaluation at six months post treatment revealed that the client had retained correct productions across linguistic context. The difference in performance between the subjects in the Dagenais, Critz-Crosby and Adams (1994) study and this one may have been maturity. The Dagenais, Critz-Crosby and Adams (1994) subjects were eight years old as compared to the twelve-year-old in this study.

Treatment with EPG provided the client visual feedback in phonetic placement. A client is not reliant upon mirroring an acoustical model made by the clinician. Nor is he/she reliant on following directions for placement by the clinician. EPG also provides a means of tracking the client's number of productions and progress through each session, as the computer counts and scores each response as appropriate or inappropriate. However, because the EPG is a removable device, the client must first be tolerant of wearing it; cognitively capable of understanding the pattern-matching task at hand; and able to stabilize, generalize and maintain production of a newly acquired sound without the stent in place.

The most common criticisms of speech appliances are based on their removable nature. Sounds can often be taught only in isolation, as with the r-stick, and clients often fail to retain correct placement once the appliance is withdrawn, as with both the r-stick and palatal stent. If a semi-permanent modification of the structure of the dental arch, such as that under investigation in this study, remediates lateral /s/ production, then establishment, stabilization, generalization and maintenance will take place simultaneously. In addition to utilizing EPG for treatment, the results of these studies assist in defining the physical characteristics of /s/ production. Other studies have looked at /s/ production acoustically.

Evaluation of Phoneme Production

Attempts to describe the variability in /s/ production among individuals who misarticulate this frequently occurring phoneme have been ongoing and taken several different tacks. Descriptions have arisen from acoustical and non-acoustical direct observations, palatographic studies, and cineradiographic studies (Weismer and Elbert, 1982). Based on his observations, Charles Van Riper concluded that individuals who had lateral or frontal air emission during /s/ production--lateral and frontal /s/--were committing a substitution error. Most commonly /θ/ and /ð/ were substituted for /s/ and /z/. However, recent research has found that while this may be the case with frontal /s/, it may not explain lateral /s/. Two studies conducted by McGlone and Proffit (1973, 1974) tested previous descriptions of articulatory gestures during /s/ production by comparing speakers who produced lateral and frontal /s/ with speakers whose productions were within normal limits. An impression was made of the subjects' palate, and a stent was constructed. After the subjects adapted to wearing the stent, pressure transducers were embedded in the stent to measure tongue placement and pressure during speech and swallowing activities. An analog signal was recorded and a graphic representation was produced. Based on Van Riper's conclusions regarding phoneme substitution, subjects were asked to produce syllables beginning and ending with /θ/ and /ð/ as well as /s/ and /z/. Articulatory gestures during /θ/ and /ð/ productions of subjects who produced lateral /s/ were found to differ distinctly from those produced during /s/ and /z/ attempts. The subjects who produced lateral /s/ had much higher pressure readings in the central incisor region than did normals and subjects who had frontal air emission during /s/ and /z/ production; however, they produced lower central incisor pressure than normals during /θ/ and /ð/ productions. Those subjects who had lateral /s/ were not simply substituting /θ/ and /ð/ for /s/ and /z/. Therefore, treatment that simply addresses lateral or frontal /s/ as sound substitutions may not remediate the errors.

Kent and Forner (1978) used spectrograms to compare the temporal nature of articulation in adults and children whose articulation was within normal limits. There were ten subjects in each of the following categories: adults, twelve-year-old children, six-year-old children, and four-year-old children. Based on the results of previous research, the hypothesis was that the four- and six-year-old subjects would show longer speech segment duration than either the twelve-year-old subjects or the adults. Each subject was asked to repeat sentences modeled by one of the researchers. Three sentences where repeated four times, and a wideband spectrogram was obtained. The researchers found that there was greater duration in the speech segments of the two younger groups. Based on these results and other research, the conclusion was that speech segment duration is an indication of neuromuscular maturation.

Given this conclusion, Weismer's and Elbert's 1982 study on the temporal characteristics of children who misarticulate /s/ has important implications in the treatment of these individuals. They compared the temporal characteristics of three subject groups: adults with normal articulation, children between the ages of 4:3 and 6:0 with normal articulation, and children of the same age who misarticulated /s/. All of the subjects in this study were determined to have hearing, intelligence, and speech mechanism structures and functions within normal limits. The subjects were segregated into the normal articulating or misarticulating groups based on performance on the Goldman-Fristoe test of articulation. A speech sample using a set of 45 nonsense sequences with /s/ represented in several positions and phonetic contexts was collected from each subject. Based on previous research such as that of Kent and Forner (1978), it was expected that differences in temporal duration would be found between the adult and child subjects. However, an additional difference in duration was found between the two groups of children. If, as Kent and Forner (1978) concluded, the difference in duration between adults and children with normal articulation is due to neuromuscular maturation, then the even greater latency shown in children who misarticulate /s/ indicates unusually immature speech-motor control. This finding supports that remediation programs for /s/ production that include speech-motor training or provide some sort of compensation may be most effective.

Whatever the element in speech motor development inhibiting refinement of /s/ production, it appears to be highly resistant to the effects of maturation and should be considered a high priority of remediation.

Remediation of /s/ production errors should also be considered a high priority based on what research has revealed regarding listeners' perceptions of people who lisp. Silverman (1976) conducted a study to evaluate listener response to a female speaker who lisped. College students majoring in Communications and in Business Administration were asked to rate video-taped speakers. Half of the participants viewed a video tape of a woman reading a passage with normal articulation, while the other half viewed a tape of the same woman reading the same passage but with a simulated lateral lisp. The subjects were asked to rate the speaker using a semantic differential scale containing 49 contrasting attributes, such as brave/cowardly, direct/circuitous, serious/humorous, happy/sad, non-handicapped/handicapped.

The subjects who viewed the tape of the speaker lisping gave consistently more negative ratings than those who viewed the tape of the speaker using normal articulation. Perhaps most importantly, the subjects who viewed the tape of the speaker lisping consistently rated her as handicapped. Thus, one speech-sound error was regarded in the minds of the listeners as indicative that the speaker was disabled. In light of these results, it is important for those individuals who have not been able to resolve production errors through traditional treatment delivered during school age intervention that alternative forms of intervention be established.

The findings of this study were duplicated in 1978 by Mower, Whale, and Dollar with male speakers. In this study, businessmen from a southwestern community were asked to rate five male speakers, using a one-to five-point scale in five categories: speaking ability, intelligence, education, masculinity and friendship. Initially subjects based their judgments on viewing passport-like photos of each of the men, they then viewed video tapes of the subjects reading a passage. Two of the men read the passage with a simulated frontal lisp. The initial ratings of these two men shifted negatively after subjects viewed the video tapes. The researchers in this study concluded that lisping calls adverse attention to the speaker. They further state that these negative ratings were based on first impressions that might ameliorate as persons become more familiar with the individual who lisps. However, first impressions are important impressions, particularly in the area of employment. The decision whether or not to offer someone employment is very often made on the basis of a brief interview. Clearly, this speech disorder calls for remediation.

Summary

Research to date indicates people who lisp are among that group of clients who do not necessarily benefit from traditional forms of intervention. Distortions on /s/ production may continue to adulthood. Treatment approaches like EPG and speech appliances may benefit this population because they bypass the routes relied upon by traditional treatment. Individuals with otherwise normal speech and language development are hearing the /s/ phoneme and are not likely to have phonological processing errors. They do, however, appear to lack the speech motor development necessary to refine production. Treatment that bypasses the auditory channel and provides a proprioceptive and motor model for production seems to best address the problem of residual sound errors. It is also possible that a simple change in the dental anatomy, as is proposed in this study, may have an effect in remediating lateral air emission. According to data from the McGlone and Proffit studies cited earlier, subjects who have lateral air emission during /s/ production exert higher pressure on the maxillary central incisor region of the palate than do subjects with normal /s/ articulation. It is possible that the subject in this study is exerting that pressure to prevent air from escaping from between his two front teeth. Once the anterior opening is closed he will no longer need this compensatory gesture. Whether or not closing a diastema between the two central anterior maxillary teeth will facilitate remediation of lateral /s/ is the question posed in this study.

CHAPTER III

METHODS

Study Plan

This single-subject study was designed to investigate the effects of diastema closure on lateral air emission during /s/ production.

Subject

One adult subject who produced lateral /s/ participated in this study. The subject, a forty-eight-year-old male, had previously received treatment while in grade school for lateralized /s/ as well as for fluency. He was not currently participating in individual fluency treatment but did attend a monthly stuttering support meeting. He was referred for this study by his fluency clinician.

Procedures

Assessment and Treatment

The subject received an articulatory assessment to establish baseline function. He then underwent closure of his diastema and was subsequently re-evaluated for articulation.

Assessment included a Dworkin-Culatta oral mechanism examination and the Photo Articulation test.

Three digital audio tape (DAT) recordings were made of the subject reading words and sentences from Eugene T. McDonald's DEEP test of Articulation as well as the Rainbow passage. Materials from the DEEP test of Articulation were used so the effects, if any, of phonetic context could be evaluated. Within 48 hours of the first recording, the subject's diastema was to have been closed by Dr. Susan Rustvold, using a common dental procedure. No anesthetic was required for this procedure. A rubber dam was placed to isolate the two maxillary central incisors. The teeth were then dried and an acid etching material placed on the mesial-facial surfaces of both teeth. Acrylic material was then placed on the mesial surfaces to close the space between the two teeth. A near-ultraviolet-blue light was then used for approximately thirty seconds to cure the acrylic. The rubber dam was then removed, and the acrylic material was smoothed and shaped.

A DAT recording of the subject reading the same words, sentences and passages as in the first recording was to have been made within two days of diastema closure. (Scheduling conflicts delayed the second recording two extra days.) A final DAT recording of the same readings was made one month after closure.

Narrowband spectral analyses of selected productions were then performed. Three second-year graduate students in speech-language pathology listened to each DAT recording and evaluated productions for the presence of lateral air emission. Listeners were provided with an oral model of lateral air emission by the investigator. Listeners' hearing was screened at 500, 1000, 2000, and 4000 Hz at 20dB. They were provided with four scripts of the words, sentences, and passage read by the subject. Each transcript had instructions at the top of the first page describing how the script should be marked. Evaluators then were asked to listen to each of the three sessions and record instances of air emission. The first recording was presented a second time labeled as Session Number Four as a check for reliability. The presence of air emission during /s/ productions was established by the agreement of at least two of the three listeners.

Data Analysis

A descriptive evaluation was made by the investigator on lateral /s/ before, immediately after, and one month after treatment.

CHAPTER IV

RESULTS AND DISCUSSION

Results

The purpose of this study was to investigate the effects of diastema closure on the remediation of lateral /s/. In the original design of this study, the subject was to have been recorded before diastema closure and again within 48 hours of closure and finally one month after closure. Due to scheduling conflicts, however, the second recording took place four days after the subject's diastema was closed. The final recording was made one month after closure.

The subject's performance on all areas of the Dworkin-Culatta oral mechanism examination was within normal limits. (Please see Appendix A, "Dworkin-Culatta Oral Mechanism Examination," for areas evaluated.) His performance on the Photo Articulation test revealed distortions ranging from 1-3 in severity in the initial, medial and final positions on words with the /s/ phoneme as well as /s/ blends, /ʃ/, /tʃ/ and /dʒ/.

Listeners One and Two passed the hearing screening at 500, 1000, 2000, and 4000 Hz at 20dB. Listener Three passed the hearing screening at 1000, 2000 and 4000 Hz, and at 25dB at 500 Hz. Each listener was given four scripts and instructed to listen to each of four tapes and put a red hash mark above a given /s/ each time they heard air emission during production. Instructions were printed at the top of every script. (See Appendix B, "Subject's Reading Tasks and Listener's Instructions.") The examiner read a portion of each script, imitating lateral air emission to provide a model.

Evaluation of the data provided by the listeners revealed that the subjects correct productions of /s/ at the word level declined, but improved slightly at the sentence and passage reading levels. (See Table 1, "Percentage of Correct /s/ Production of Three Reading Tasks Across Three Sessions," below.)

Table 1

Percentage of Correct /s/ Production of Three Reading Tasks Across Three Sessions

Reading Tasks	Pretest session 1	Four Days after Closure session 2	One month after closure session 3
Words from the DEEP test of Articulation	60%	0%	30%
Sentences from the DEEP test of Articulation	22%	50%	42%
The Rainbow Passage	48%	70%	78%

As a measure of each listener's reliability, he/she was given the same tape (session three) to rate twice. The results of the intra-rater reliability testing were as follows: The first listener marked thirty-four percent of the occurrences of air emission the same from the first to the second transcript, the second listener forty percent, and the third sixty-four percent.

The results of the phonetic context evaluation revealed that the following combinations proved to be most difficult for the subject at the word level: "house flag," where /s/ is preceded by the rising diphthong /au/ and followed by the voiceless fricative /f/ blended with the voiced lateral /l/; "star thumb," where /s/ is in the releasing position blended with the voiceless stop /t/, followed by /ɑ/, a lax back vowel; and "sled sheep," where /s/ is again in the releasing position blended with a voiced lateral followed by /ɛ/, a lax front vowel. There were no phonetic contexts at the word level in which the subject consistently produced /s/ without air emission.

Air emission occurred on all but five of the forty-nine sentences the subject was asked to read. A phonological context evaluation was thus conducted on those sentences with correct productions rather than on those in error. No air emission was detected across all three sessions in the following sentences:

The pup sat down.
Ice water is cold
Guess how I do it?
Guess it now!
Is ice ever hot?

There were also limited contexts in which the subject appeared to show improvement after the diastema was closed. Air emission was detected during the first session but not during sessions two or three on the following sentences:

Mother will sew your dress.
We saw a boy.
He is a nice boy.
I ride the bus to school.
This game is fun.

Thus the subject evinced lateral air emission in the presence of fricatives, both voiced and voiceless, as in "Is your face very cold?" and "bus fish," with the exception of /h/, as in "Guess how I do it?". Air emission was also present in the context of stops, either voiced or voiceless and either bilabial, alveolar or velar, as in "Bob saw the cat," "I play on a nice day," and "You may take some," excepting /p/ and /g/, as in "The pup sat down" and "This game is fun." No air emission was present when /s/ was proceeded by /ɛ/ and followed by the voiceless fricative /h/, as in "Guess how I do it," but was present when /s/ was proceeded by /ɛ/ and followed by /m/, a bilabial nasal, as in "The dress made her look funny" and /tʃ/, a voiceless affricate, as in "I guess children can come." The subject's productions of /s/ appeared to improve after the procedure in the context of /l/, /i/, /^/, and /I/, as in "Mother will sew your dress," "We saw a boy," "I ride the bus to school," and "This game is fun." His production improved in the context of /aI/ when /s/ was followed by /b/, as in "He is a nice boy," but not when followed by /d/, as in "I play on a nice day." In general, the subject's productions were best in the context of vowels and early developing consonants that required little articulatory precision or interruption of air flow.

A narrowband spectrographic analysis was conducted comparing /s/ productions where air emission was heard with those where air emission was not heard. Spectrographs of words where air emission was detected revealed greater amounts of noise in the higher frequencies when compared with spectrograms where emission was not heard. (See Appendix D, "Spectrographic Analysis.")

Discussion

The question under investigation in this study was whether closing the diastema facilitates remediation of lateral air emission during /s/ production. According to the data, the subject did improve /s/ productions at the sentence and passage reading levels, though only to seventy-eight percent, which falls below eighty percent typically set as a minimum clinical goal. However, given the low intra-rater reliability, these findings are questionable. When transcripts of the session played twice for listeners were evaluated, agreement was low, which brings into question the reliability of their evaluations of the other sessions, as well as the validity of their judgements as to when air emission was and was not present. One possible reason for the low level of reliability among listeners is a lack of adequate training, but it is also possible that because the listeners were graduate students in speech-language pathology they were highly sensitized to and thus overly critical of /s/ productions. (Perhaps naïve listeners should be asked to rate the same productions and those results compared with the listeners in this study.) The listeners may also have had trouble separating stridency from air emission, and thus indicated air emission where there was naturally occurring friction.

The listeners scored the subject as having the lowest air emission present throughout all three sessions in the context of the Rainbow passage. There are several possibilities for this as well. The listeners were all familiar with the Rainbow passage and thus may have been able to focus their attention more on the air emission and less on the script than at the word or sentence level. It may also be that the listeners were simply more tolerant of air emission in the context of connected speech than in isolated words, and sentences. There is also the possibility that because this subject has been treated in the past for a fluency disorder he was also familiar with the Rainbow passage and may have applied fluency induction techniques to his reading. As Scripture (1914) suggested perhaps the same techniques used to treat stuttering improve /s/ productions as well. Another reason listener reliability was so low is that they were also allowed to listen to and rate all four tapes in one sitting. It is possible the listeners became fatigued.

Allowing for the moment that the results provided by the listeners were valid and reliable, phonetic context then appears to have an effect on productions. For instance, the subject performed best when /s/ was preceded and followed by vowels or when preceded by a vowel and followed by /p/,/h/, or /g/. Vowel production requires very little articulatory precision. The phoneme /h/, a voiceless fricative, requires simple exhalation of the breath stream with no articulatory placement. The /g/, a voiced stop, is made simply by raising the back of the tongue to the soft palate and momentarily stopping air flow. However, when /ɛ/ proceeded /s/ and was followed by /m/ or /tʃ/, both of which require constriction of air flow and precise lip or tongue movement, air emission was present. The phonetic contexts in which the subject evinced improvement were /l/, /i/, /u/, and /aI/. In the case /i/, /s/ was followed by / / which is a lax back vowel. In the context of /aI/, air emission was not present when /s/ was followed by /b/, a bilabial stop, but was present when /s/ was followed by a /d/, an alveolar stop. Bilabial sounds require less oral motor precision than alveolar sounds. In all other phonetic contexts including fricatives, affricates, stops, nasals and velars, air emission was present. Thus, in general, the contexts in which the subject performed /s/ without distortion were very limited and generally characterized by phonetic context requiring little articulatory precision. These data combined with the information obtained from the oral motor examination appear to indicate that the subject's difficulty is related to oral motor planning for speech.

The subject scored within normal limits on all of the components of the Dworkin-Calluta oral mechanism exam. This exam included several subcategories for the evaluation of the all of the following areas: facies, circumoral musculature, masticatory musurlature, dentition and gingiva, hard palate, veloharyngeal mechanism, the tongue, and laryngeal mechanism. This was a very thorough oral mechanism exam broken up into subcategories designed to expose anomalies that implicate specific etiologies. For instance, in the general survey of the facies, facial flaccidity would implicate damage to the facial nerve, whereas a mask-like facies is associated with Parkinson's. Each area was assessed for symmetry, synergistic movement, strength, and coordination during speech tasks. The subject scored within normal limits in all areas. Thus, because no problems were found motorically during vegetative functions, the lateral air emission appears to be an artifact connected to oral motor planning for speech.

Spectral analysis comparing productions reported by listeners to have air emission with those that did not have air emission revealed higher levels of spectral noise in the high frequencies when air emission was present. These acoustic results support the perceptual results recorded by listeners.

Chapter V

Summary and Implications

Summary

The /s/ phoneme is among the most frequently occurring phonemes in speech and is an important morphological marker. However, errors with the /s/ phoneme are difficult to remediate. Many researchers have investigated the placement and feature characteristic of the /s/ phoneme while others have investigated nontraditional treatment methods. Based on the findings of McGlone and Proffit (1973, 1974), subjects who lateralized /s/ exert high pressure on the anterior portion of the palate. It was hypothesized that a subject with a diastema between the two maxillary anterior teeth might be exerting that pressure as a compensatory gesture to prevent ambient air from escaping between the two front teeth during /s/ production. It was further hypothesized that closing that diastema might relieve the subjects need to block frontal air escape resulting in spontaneous redirection of lateralized airflow during /s/ production.

The present study investigated whether closing a diastema would remediate lateral air emission during /s/

production. While the data do not support the conclusion that remediation was successful, evaluating /s/ productions in phonetic context do suggest that correct production of /s/ is diminished in the context of sounds with complex features.

Implications

Although closure of the diastema failed to bring about remediation of the subject's lateral /s/, this study raised several important questions. The most serious raised arises from the discovery of low intra-rater reliability. Speech-language pathologists routinely make subjective judgments, such as those made by the listeners in this study, regarding the presence or absence of errors in clients' sound productions. The results obtained in this study cast doubt on the accuracy of such judgements. Studies examining intra-rater reliability have been conducted in area of stuttering, and perhaps the results of this study indicate a need for such comparisons in the area of articulation disorders as well.

The data from this investigation do not support that closure of a diastema alone remediates lateralization of /s/ within the time frame of this investigation, but perhaps this procedure in combination with clinical intervention, or this procedure alone given more time, would remediate the /s/. It was hypothesized that this client was using a compensatory gesture to close off air flow from between his two front teeth during /s/ productions, creating a lateral opening. With the diastema closed, it was hoped spontaneous correction of this unnecessary gesture would occur. It did not, but perhaps in combination with traditional articulation intervention, it might. In addition, having a dental procedure very often temporarily disrupts speech, and in fact the percentages of this subject's correct productions dipped at the fourth-day post-procedure session; however, they improved at the thirtieth-day session. Perhaps given more time, the subject would have shown more improvement. Given that the subject's vegetative oral motor functions were all within normal limits, the difficulty, it seems clear, occurs in the context of motor planning for speech. The subject's correct productions in the context of vowels and bilabials would provide a place for intervention to begin.

The question is also raised by this investigation of whether or not other individuals with residual sound errors would show the same tendency to perform better on problem sounds in the context of vowels and consonants with simple placement as did the subject in this study. It seems reasonable that sounds requiring high levels of articulatory precision and breath control would be more difficult for individuals with residual sound errors than sounds that do not require precision and breath control. It would require the support of several additional studies to be able to generalize which phonetic contexts, if any, are consistently beneficial or troubling to clients who have lateral air emission during /s/ productions. However, this kind of evaluation could prove very helpful in establishing where intervention should begin and the course it should take. When providing traditional intervention, it is typical to begin by placing the problem sound in the initial, final, or medial position and in the linguistic context of single syllable words through connected speech. If future research supports the effects of phonological context found in this study, then a new consideration for intervention will have been identified. Evaluation could determine where along the continuum of sound development productions begin to break down. A context for intervention could then be established starting with the phonological context in which the subject was able to produce the sound correctly. Intervention could then proceed along the continuum, advancing from contexts with early developing sounds like vowels and bilabials to contexts with later developing sounds like fricatives and affricates.

Although closure of the diastema failed to bring about remediation of the lateral /s/ in this subject, the acoustical and phonological context data may have implications in the identification and treatment of /s/ distortions. If future researchers are able to control intra-rater reliability through the suggestions made here or with other strategies, a reliable evaluation of the effect of phonetic context on production might be made.

References

Clark, C.E., Schwarz, I.E., & Blakeley, R.W. (1993). The removable r-appliance as a practice device to facilitate correct production of /r/. American Journal of Speech-Language Pathology, 2, 84-92.

Dagenais, P.A., (1995). Electropalatography in the treatment of articulation/phonological disorders. Journal of Communication Disorders, 28, 303-329.

Dworkin, J.P. & Culatta, R.A., (1980). Dworkin-Culatta Oral Mechanism Examination. Nicholasville, KY: Edgewood Press, Inc.

Gibbon, F. & Hardcastle, W., (1987). Articulatory description and treatment of "lateral /s/" using electropalatography: a case study. British Journal of Disorders of Communication, 22, 203-217.

Gross, G.H., St. Louis, K.O., Ruscello, D.M., & Hull, F.M., (1985). Language abilities of articulatiory-diordered school children with multiple or residual errors. Language, Speech, and Hearing Services in Schools, 16, 171-186.

Hodson, B.W., & Paden, E.P., (1991). A phonological approach to remediation targeting intelligible speech. Austin TX: Proed.

Karlin, H.E., & Trachman, M.K., (1986). Dental auxiliary's encyclopedic dictionary. Englewood Cliffs, New Jersey: Prentice-Hall, Inc.

Keith, R.L., Thomas, J.E., (1989). Speech Practice manual for dysarthria, apraxia and other disorders of articulation. Philadelphia, PA: B.C. Decker Inc.

Kenney, K., & Prather, E.M., (1986). Articulation development in preschool children: consistency of productions. Journal of Speech and Hearing Research, 29, 29-36.

Kent, R.D., & Forner, L.L., (1978). Speech segment durations in sentence recitations by children and adults. Journal of Phonetics, 8, 157-168.

McDonald, E., (1964). Articulation testing and treatment: A sensory-motor approach. Pittsburgh, PA: Stanwix House.

McGlone, R.E., & Proffit, W.R., (1973). Patterns of tongue contact in normal and lisping speakers. Journal of Speech and Hearing Research, 16, 456-473.

McGlone, R.E., & Proffit, W.R., (1974). Comparison of lingual pressure patterns in lisping and normal speech. Folia Phoniat, 26, 389-397.

Mowrer, D.E., Wahl, P., & Doolan, S.J. (1978). Effect of lisping on audience evaluation of male speakers. Journal of Speech and Hearing Disorders, 43, 140-148.

Mowrer D.E., & Sundstrom, P., (1988). Acquisition of /s/ among kindergarten children who misarticulate /s/ as measured by the deep test of articulation. Journal of Communication Disorders, 21, 177-187.

Pendergast, K., Dickey, S., Selmar, J., & Soder, A., (1968). Photo articulation test. Danville, IL.: Interstate Publishers.

Prather, E.M., Hedrick, D.L., & Kern, C.A., (1975). Articulation development in children aged two to four years. Journal of Speech and Hearing Disorders, 40, 179-191

Portland Public School. (1986). The Speech and Language Severity Rating Scale Manual. Portland, OR: Portland Public Schools.

Ruscello, D.M., St.Louis, K.O., & Mason, N., (1991). School-aged children with phonological disorders: coexistence with other speech-language disorders. Journal of Speech and Hearing Research, 34, 236-242.

Ruscello, D.M., (1995). Speech appliances in the treatment of phonological disorders. Journal of Communication Disorders, 28, 331-353.

Scripture, E.G.W., (1914). Stuttering and Lisping. New York, NY: The Macmillan Company.

Scripture M., & Jackson, E., (1927). A manual of exercises for the correction of speech disorders. Philadelphia, PA: F.A. Davis.

Sliverman, E.M., (1976). Listeners' impressions of speakers with lateral lisps. Journal of Speech and Hearing Disorders, 41, 547-552.

Templin, M., (1957). Certain Language Skills in Children: Their development and interrelationships. Institute of Child Welfard, Monograph 26. Minneapolis: University of Minnesota Press.

Van Riper, C., (1978). Speech correction: principles and methods. Englewood Cliffs, NJ: Prentice-Hall.

Weismer, G., & Elbert, M., (1982). Temporal characteristics of "functionally" misarticulated /s/ in 4 to 6-year-old children. Journal of Speech and Hearing Research, 25, 275-287.

Weiss, C., Gordon, M., & Lillywhite, H., (1987). Clinical management of articulatory and phonlogic disorders. Boltimore, OH: Williams & Wilkins.

Young, E., & Hawk, S., (1938). Moto-kinesthetic speech training. Standord, CA: Stanford University Press.

EVALUATION MATERIAL

References for oral examination and articulation testing.

Dworkin, J.P. & Culatta, R.A., (1980). Dwarkin-Culatta Oral Mechanism Examination. Nicholasville, KY: Edgewood Press, Inc.

Pendergast, K., Dickey, S., Selmar, J., & Soder, A., (1968). Photo articulation test. Danville, IL.: Interstate Publishers.

APPENDIX A

DWORKIN-CULATTA ORAL MECHANISM EXAMINATION

DWORKIN-CULATTA ORAL MECHANISM EXAMINATION

By James P. Dworkin, Ph. D. and Richard A. Culotta, Ph.D.

EDGEWOOD PRESS, Nicholosville, Ky 40356

I. EXAMINATION OF FACIES

1. GENERAL SURVEY
   a. normal symmetry
      asymmetry
   b. flaccidity (R/L)
   c. spasticity (R/L)
   d. ptosis (R/L)
   e. lip corner droop (R/L)
   f. mouth breathing
   g. drooling
   h. contortions
      tics
      grimaces
   i. mask-like facies

II. EXAMINATION OF CIRCUMOITAL MUSCULATURE

1. LIP PUCKERING
   a. normal range of protrusion
      reduced range of protrusion
   b. normal symmetry of protrusion
      asymmetry of protrusion

2. SMILING
   a. normal hp excursion
      reduced range of lip excursion
   b. synunetry of lip corners
      asymmetry of lip corners (R/L)

2. LIP SMACKING
   a. normal force
   b. reduced force

4. STRENGTH
   a. normal
   b. weak

5. LABIAL DIADOCHOKINETICS

   /pʌ/ /bʌ/

   a. normal syll. production
      imprecise syll. production
   b. normal rate
      slow, labored rate
   c. normal timing
      irreg. timing

III. EXAMINATION OF MASTICATORY MUSCULATURE

1. MANDIBULAR MOVEMENT
   a. normal depression
      deviate dep. (R/L)
   b. normal elevation
      deviate elev. (R/L)
   c. jerks, writhing or dystonic movements
   d. TMJ noises
      bulging
      activity

2. MANDIBULAR RANGE
   a. normal
      reduced

IV. EXAMINATION OF DENTITION AND GINGIVA

1. OCCLUSAL RELATIONSHIP
   a. normal
      class I Malo.
      class 11 Malo.
      class III Malo.

2. GINGIVA
   a. normal color
      abnormal color
   b. swelling
   c. bleeding
   b. missing teeth

V. EXAMINATION OF HARD PALATE

1. GENERAL SURVEY
   a. normal arch
      high-narrow arch
   b. growths
   c. well defined rugae
   d. submucous clefting

VI. EXAMINATION OF VELOPHARYNGEAL MECHANISM

1. GENERAL SURVEY
   a. normal velar height
      low velum (R/L)
   b. bifid uvula
   c. normal tonsil size
      hypertrophied tonsils
      absent tonsils
   d. rhythmic pulses or spasms

2. VELAR ACTIVITY
   a. mid-line symm.
      deviation (R/L)
   b. normal range
      limited range, bilaterally
   c. nasal air emission
   d. hypernasal resonance
      hyponasal resonance
      nasal snorting

3. CHEEK PUFFING
   a. nasal emission
   b. oral emission

4. BLOWING (INTRA-ORAL)
   a. nasal emission
      oral emission

5. BLOWING (EXTRA-ORAL)
   a. normal breath prolongation
      reduced prolongation
      jerky prolongation
      explosive prolong
   b.nasal air emission

6. GAG REFLEX
   a.normal
      hypoactive
      hyperactive

VII. EXAMINATION OF TONGUE

1. GENERAL SURVIEY
STRENGTH
- a. normal appearance
  atrophy (R/L)
- b. fasciculations
- c. microglossia
  macroglossia
- d. growths
  lesions

2. PASSIVE TONGUE MOBILITY
- a. normal
  resistive

3. TONGUE PROTRUSION
- a. normal
  resistive

4. ACTIVE TONGUE MOBILITY
- a. normal speed
  reduced speed
- b. normal range
  reduced range
- c. fluid movement
  jerky, writhing or

  dystonic movement

5. TONGUE ELEVATION
- a. normal
  limited range
- b. normal frenum
  short frenum

6. ANTERIOR TONGUE STRENGTH
- a. normal
  weak

7. LATERAL TONGUE
- a. normal
  weak

8. LINGUAL DOKINETICS
/tʌ/ /kʌ/
- a. normal syll. production
  imprecise syll production
- b. normal rate
  slow, labored rate
- c. normal timing
  irreg. timing

9. SEQUENTIAL SYLLABLE
- a. normal syll. production
  imprecise syll production
- b. normal rate
  slow, labored rate
- c. normal timing
  irreg. timing

VIII. EXAMINATION OF LARYNGEAL MECHANISM

1. VOCAL QUALITY, PITCH, LOUDNESS
- a. normal quality
  hoarseness
  breathiness
  harshness
  strained-strangled

2. PITCH/LOUDNESS/ MATCHING
- a. normal pitch variability
  monopitch
- b. normal loud variability
  monoloudness

3. COUGHING

a. normal
   hoarse-breathy
   strained-strangled

b. normal pitch
   abnormally high
   abnormally low

c. normal loudness
   abnormally loud
   abnormally soft

c. inhalatory stridor

APPENDIX B

SUBJECT'S READING TASK

SUBJECT'S READING TASK

Instructions to listeners

Please listen to recordings 1 through 4, and indicate those places where you hear lateral air emission during /s/ production by placing a red hash mark over the corresponding /s/ on the transcript. Please feel free to stop and rewind the tape if you would like to review a production.

SUBJECT'S READING TASK

1. Words

Bus fish,	house flag,	chair sun,	star thumb,
horse key,	knife spoon,	sled sheep,	fish house,
thumb saw,	saw teeth		

2. Sentences

The pup sat down.	Bob saw a cat.
I ate some cake.	I could see you.
You may take some.	The dog saw me.
Can you come soon?	I can see you.
He will laugh soon.	I have seen a zebra.
Both saw the doll.	A mouse sat by the door.
Come as soon as you can.	I wish someone could play.
Which seat is mine?	Turn the page soon.

Mother will sew your dress. Your city is far away.

We like to sing songs. We saw a boy.

You said I could go. We saw sand in the

box.

I like this pie. He is a nice boy.

I ride the bus to school. I play on a nice day.

I like this coat. This game is fun.

The dress made her look funny. Go to the house near the road.

He took us far away. Is your face very cold?

This thing is mine. Give us that car.

This zoo is big. This shoe is red.

I guess children can come. Can you watch us jump

today?

The nice lady had a dog. Can you watch us run today?

I will race you to school. Ice water is cold.

Guess how I do it. Can you guess each one?

Guess it now! Is ice ever hot?

Get ice at the store. Draw a house up there.

Take the dress off my chair.

3. Rainbow passage

When the sunlight strikes raindrops in the air they act like a prism and form a rainbow. This rainbow is a division of white light into many beautiful colors. These take the shape of a long round arch, with its path high above, and its two ends apparently beyond the horizon. There is, according to legend, a boiling pot of gold at the end of the rainbow.

Throughout the centuries men have explained the rainbow in various ways. Some have accepted it as a miracle without physical explanation. To the Hebrews it was a token that there would be no more universal floods. The Greeks used to imagine that it was a sign from the gods to foretell war or heavy rain. The Norsemen considered the rainbow as a bridge over which the gods passed from earth to their home in the sky. Other men have tried to explain the phenomenon physically. Aristotle thought that the rainbow was caused by reflection of the sun's rays by the rain. Since then physicists have found that it is not reflection, but refraction by the raindrops which causes the rainbow. Many complicated ideas about the rainbow have been formed. The difference in the rainbow depends considerably upon the size of the water drops, and the width of the colored band increases as the size of the drops increases. The actual primary rainbow observed is said to be the effect of superposition of a number of bows. If the second bow falls upon the green of the first, the result is to give a bow with an abnormally wide yellow band, since red and green lights when mixed form yellow. This is a very common type of bow, one showing mainly red yellow, with little or no green or blue.

Appendix C

Production Evaluation

Production Evaluation

Words from the DEEP test of Articulation	Pre-test session 1	Four days after closure session 2	One month after closure session 3	Phonetic Context
bus fish,	+	-	-	b ʌ s f I ʃ
house flag,	-	-	-	h a u s f l æ g
chair sun	+	-	-	tʃ ɛ r s ʌ n
star thumb	-	-	-	s t ɑ r θ ʌ m
horse key,	+	-	+	h ɔ r s k i
knife spoon,	+	-	+	n aI f s p u n
sled sheep,	-	-	-	s l ɛ d ʃ i p
fish house,	-	-	+	f I ʃ h au s
thumb saw,	+	-	-	θ ʌ m s ɔ
saw teeth	+	-	-	s ɔ t i θ

Sentences from the DEEP Test of Articulation	Pre-test session 1	Four days after closure session 2	One month after closure session 3	Phonetic Context
The pup sat down.	+	+	+	p s æ
Bob saw a cat.	-	-	-	b s ɔ
I ate some cake	-	+	-	t s ʌ
I could see you.	-	-	-	d s I
You may take some.	-	-	-	k s ʌ
The dog saw me.	-	+	-	g s ɔ
Can you come soon?	-	-	-	m s u
I can see you.	-	-	+	n s i
He will laugh soon.	-	-	-	f s u
I have seen a zebra.	-	-	+	v s i
Both saw the doll.	-	-	-	θ s ɔ
A mouse sat by the door.	-	-	-	s s æ
Come as soon as you can.	-	-	-	z s u
I wish someone could play.	-	+	+	ʃ s ʌ

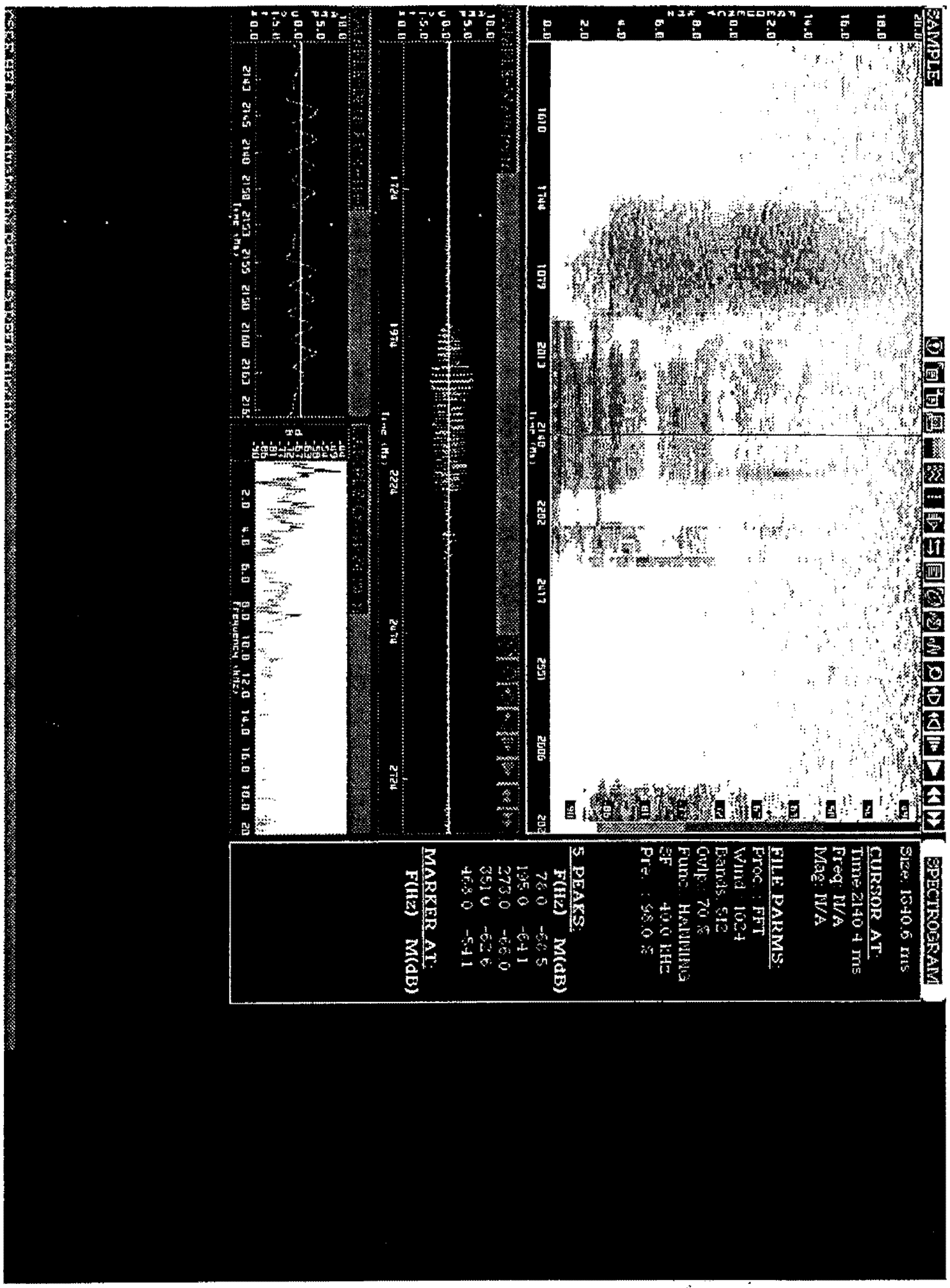
Which seat is mine?	-	-	+	tʃ s I
Turn the page soon.	-	-	+	d s u
Mother will sew your dress	-	+	+	l s o
Your city is far away.	-	-	-	r s I
We like to sing songs.	-	-	-	u s I
We saw a boy.	-	+	+	i s ɑ
You said I could go.	-	-	-	u s ɛ
We saw sand in the box.	-	-	+	i s ɑ
I like this pie.	+	-	-	I s p
He is a nice boy.	-	+	+	aI s b
I ride the bus to school.	-	+	+	ʌ s t
I play on a nice day.	+	-	-	aI s d
I like this coat.	+	+	-	I s k
This game is fun.	-	+	+	I s g
The dress made her look funny.	-	+	-	ɛ s m
Go to the house near the road.	-	-	-	au s n
He took us far away.	-	-	-	ə s f
Is your face very cold?	-	+	+	eI s v
This thing is mine.	+	+	-	I s θ
Give us that car.	-	+	-	ʌ s ð
This zoo is big.	+	+	-	I s z
This shoe is red.	-	_	-	I s ʃ
I guess children can come.	-	+	-	ɛ s tʃ
Can you watch us jump today?	+	+	+	ə s d
The nice lady had a dog.	-	-	-	aI s l
Can you watch us run today?	-	-	-	ə s r
I will race you to school.	-	-	-	eI s j

Ice water is cold.	+	+	+	aI s w
Guess how I do it.	+	+	+	ɛ s h
Can you guess each one?	-	-	+	ɛ s i
Guess it now!	+	+	+	ɛ s I
Is ice ever hot?	+	+	+	aI s
Get ice at the store.	- -	- +	+ -	aI s æ
Draw a house up there.	-	_	+	au s ə
Take the dress off my chair.	-	+	_	ɛ s ɑ

APPENDIX D

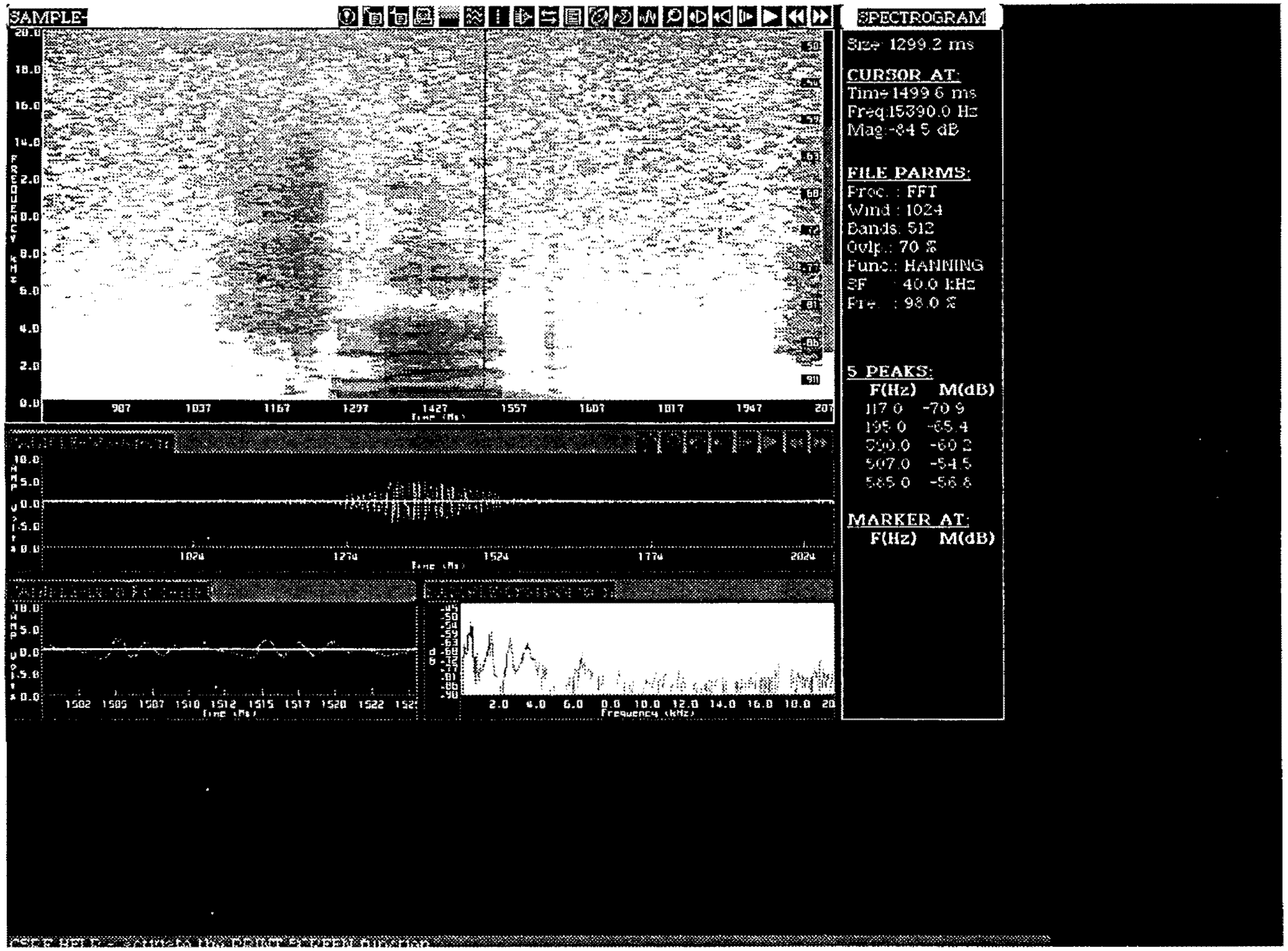
SPECTROGRAPHIC ANALYSIS

sled Pretest

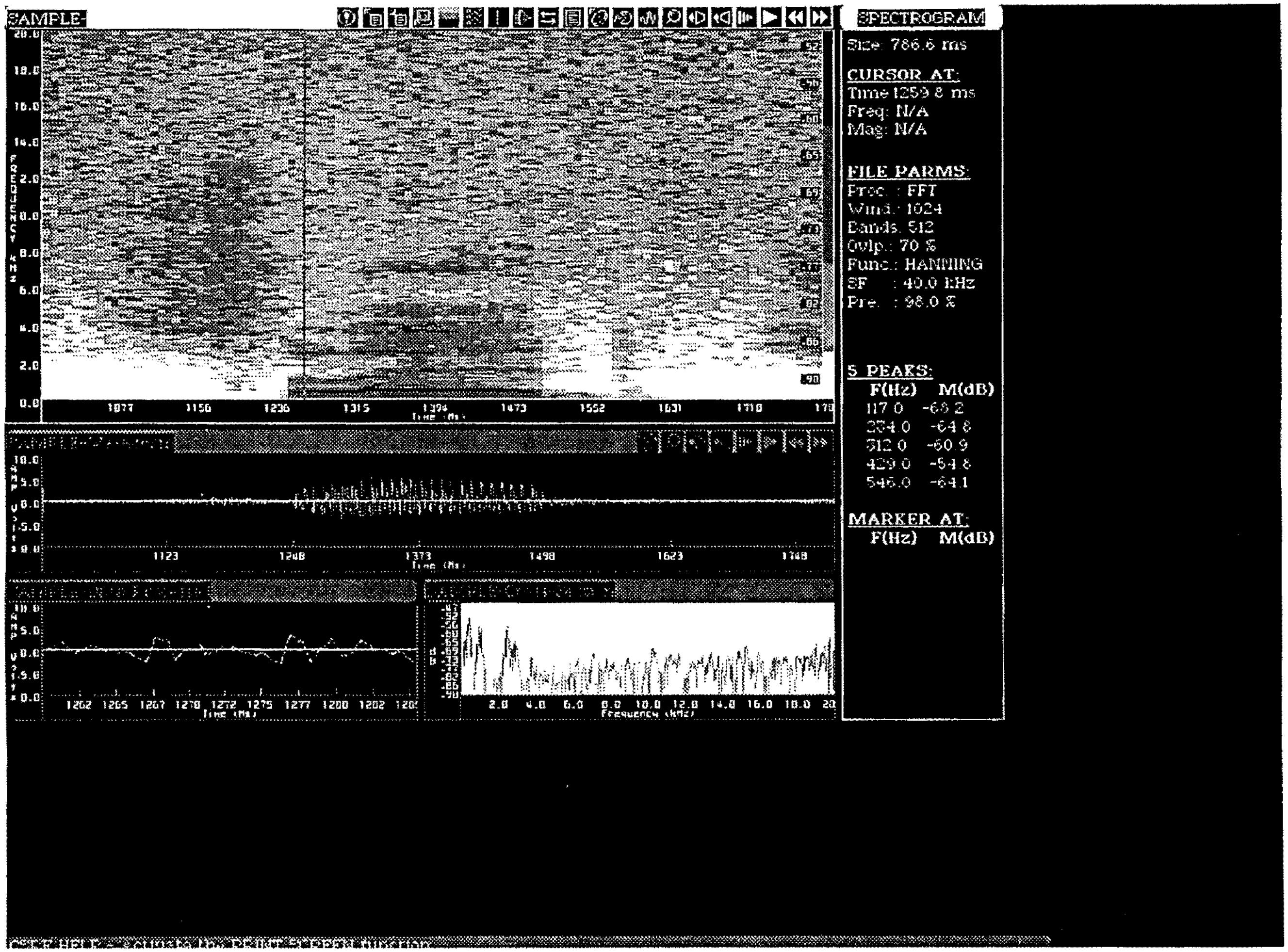


Always marked

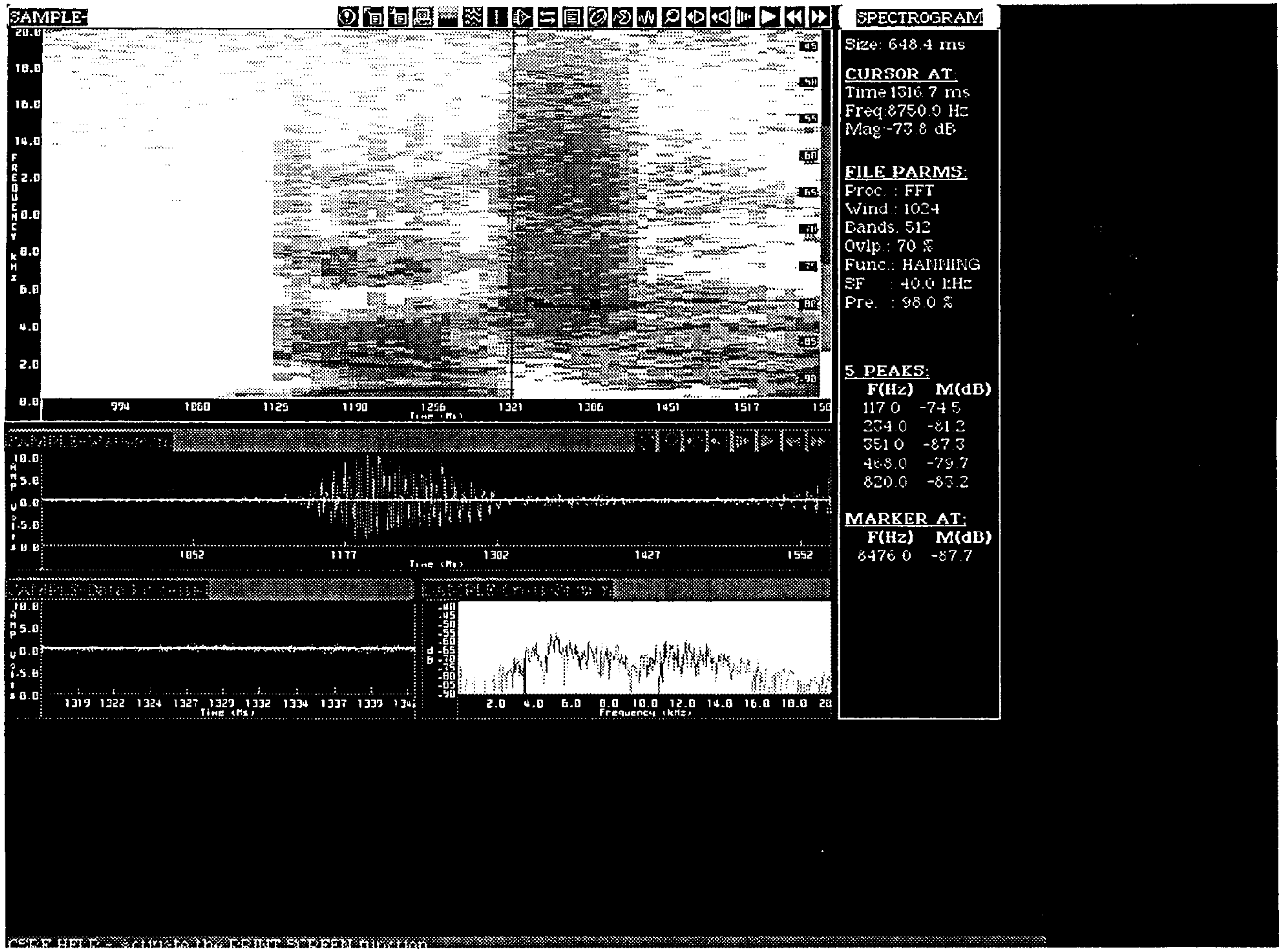
sled Session 2



sled Session 3

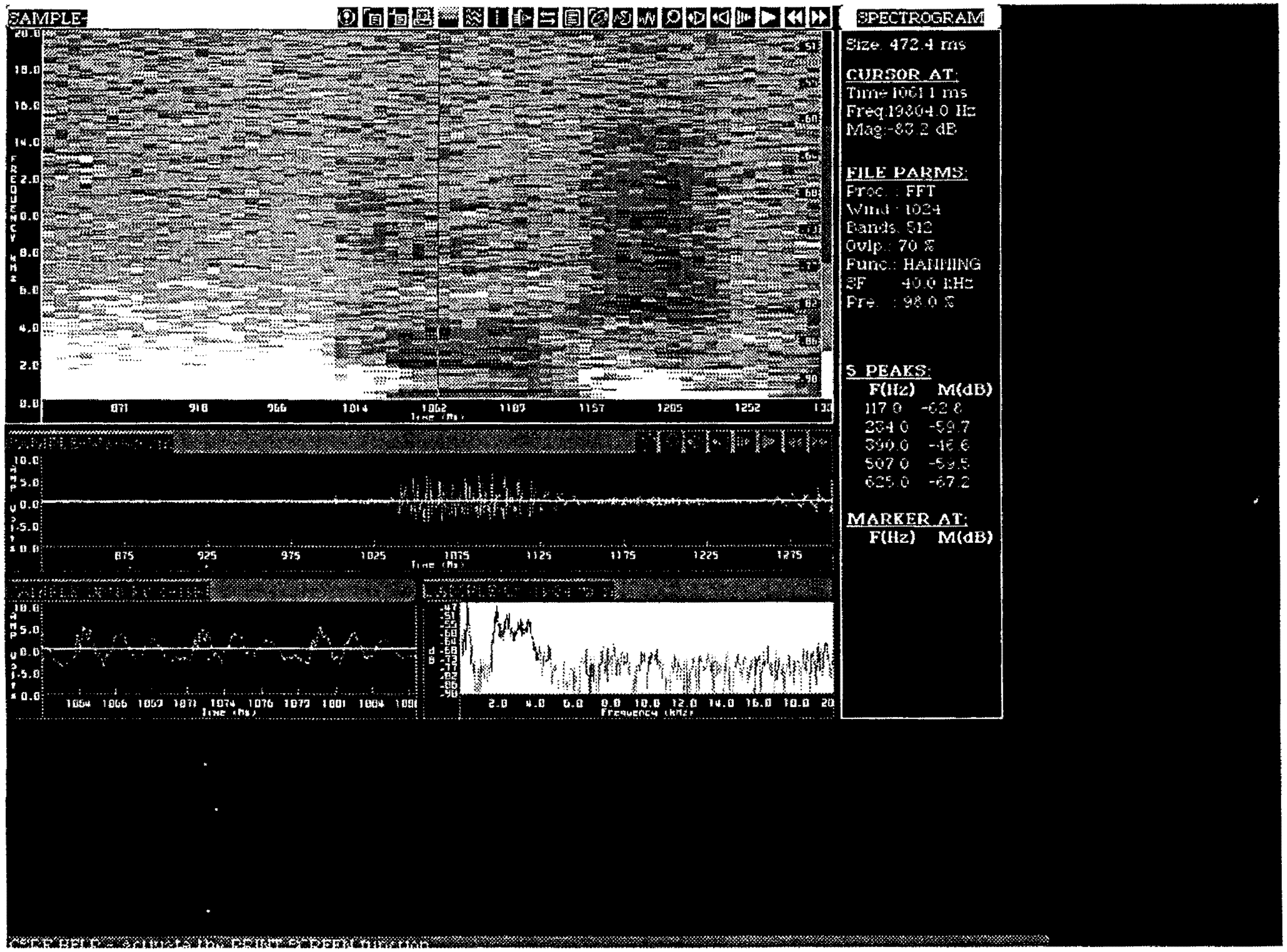


Guess how I do it? Pretest

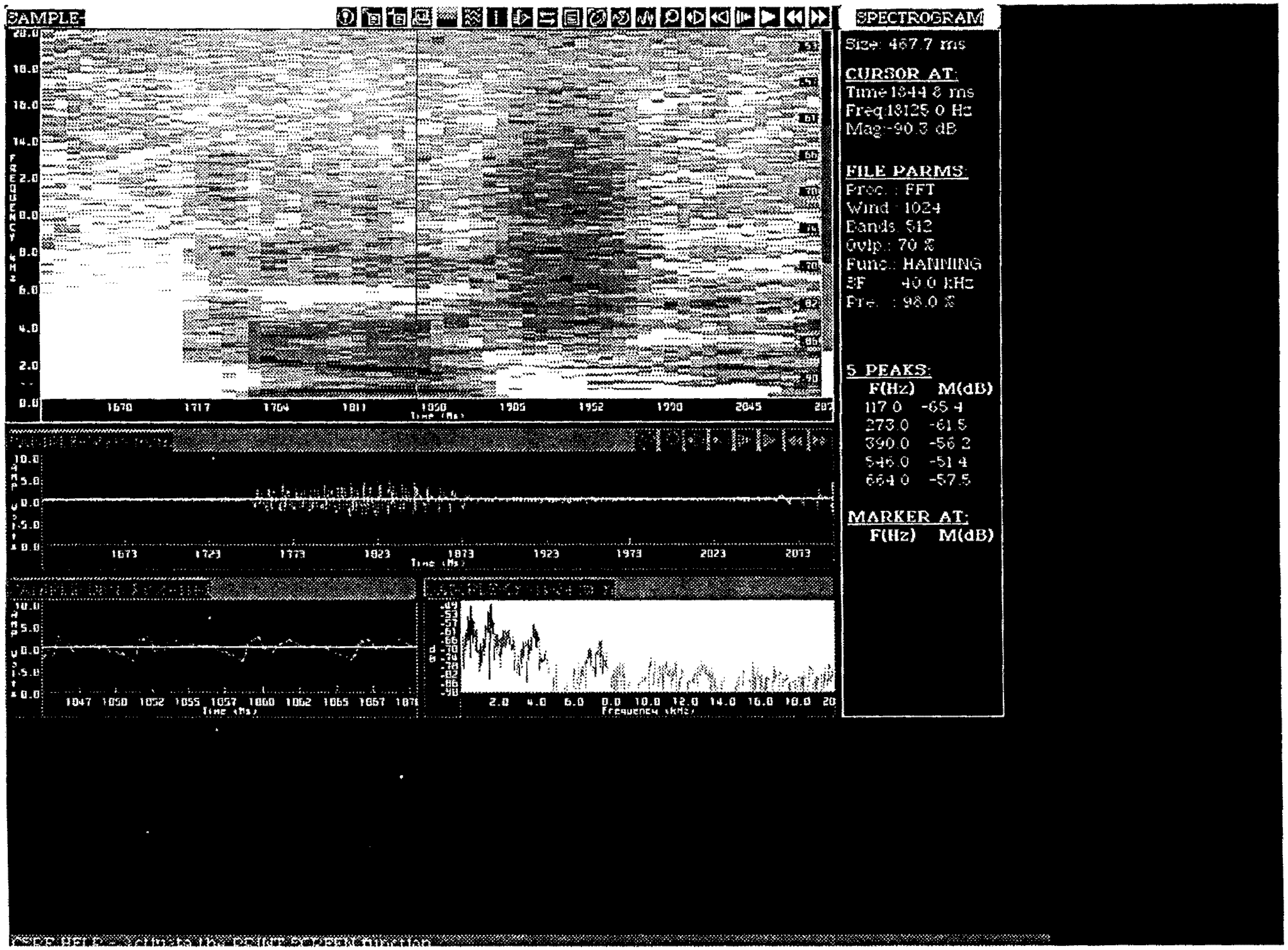


Never marked

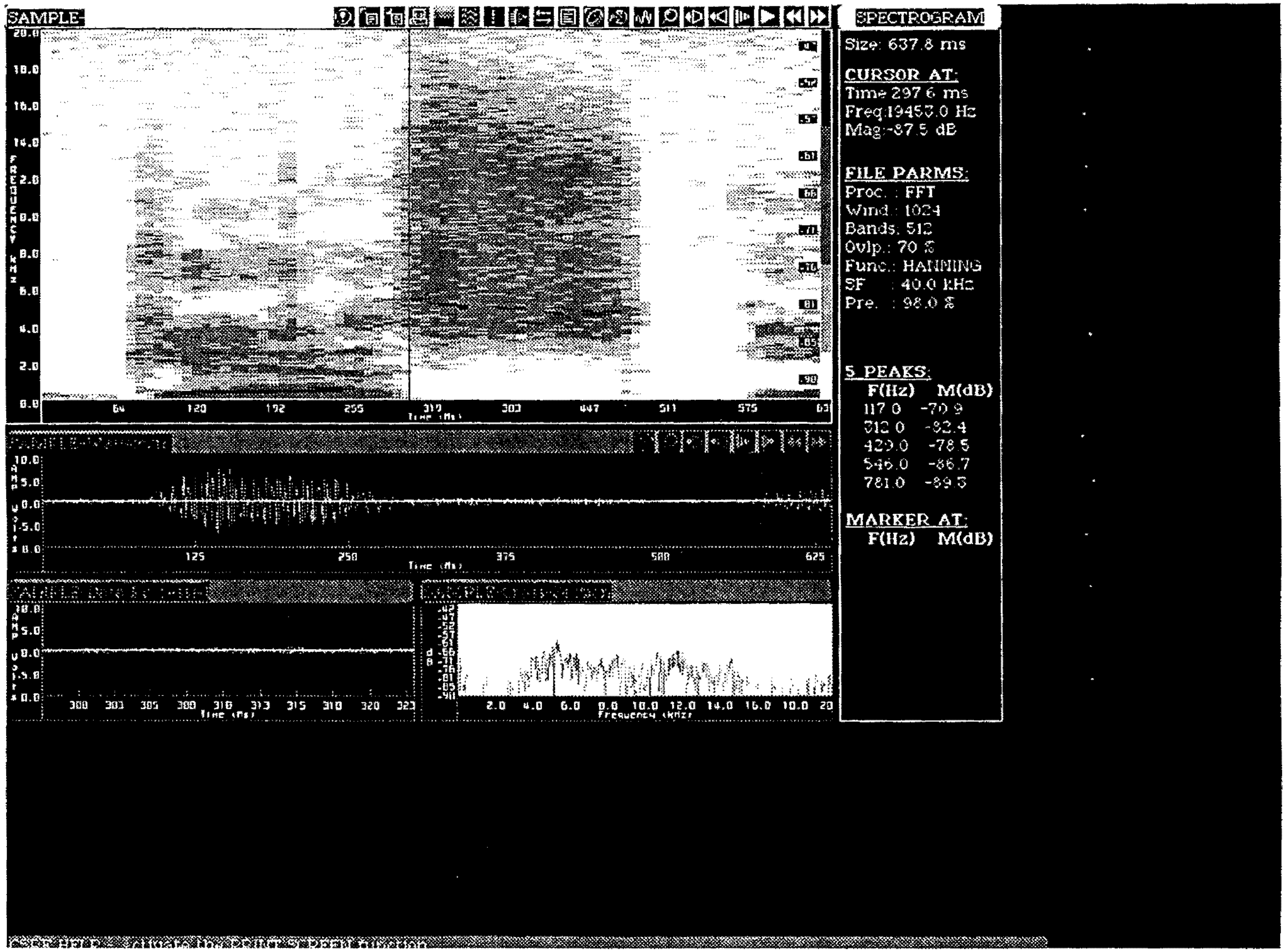
Guess how I do it? Session 2



Guess how I do it? Session 3

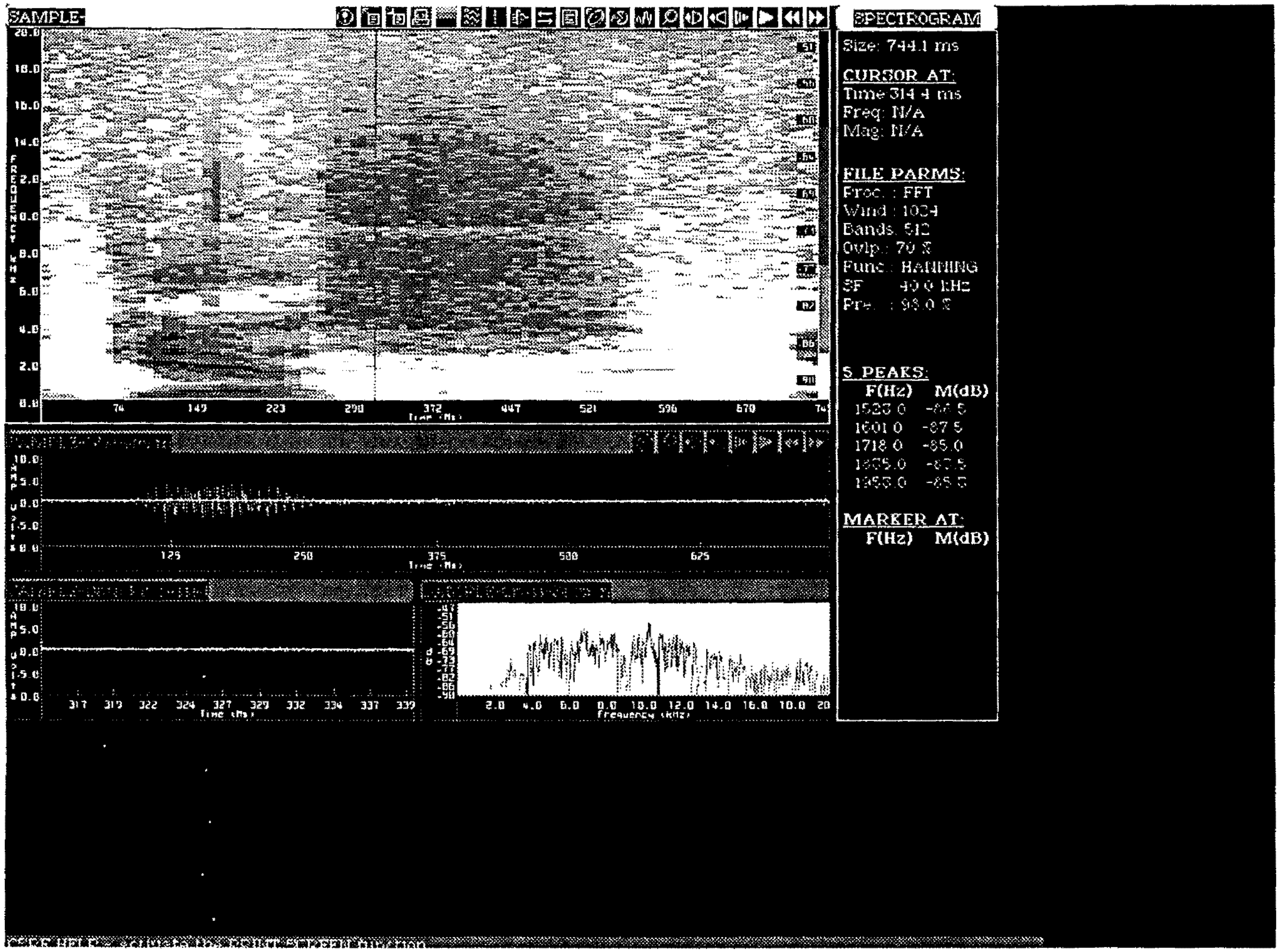


Can you guess each one?   Pretest



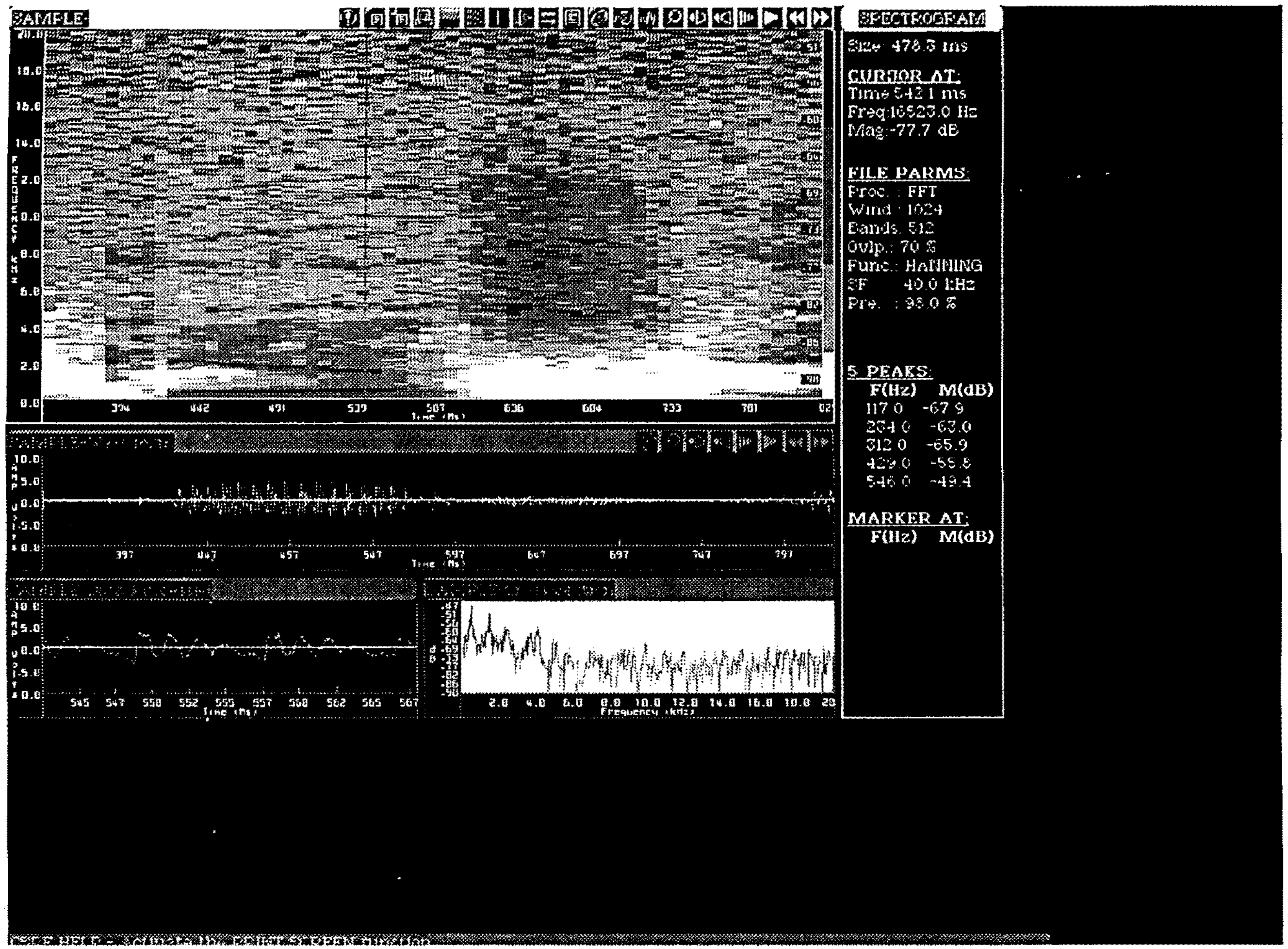
Improved

Can you guess each one? Session 2



Improved

Can you guess each one? Session 3



Improved