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Ted Madden

The purpose of this study was to determine whether one ear of a profoundly deaf student could duplicate a response rate similar to the response rate achieved by the opposite ear on an auditory training program. The formal hypothesis of this study was: a student that reaches criterion level of acceptable performance in the right ear on one presentation of Auditory Training Program No. V will achieve the same criterion level of acceptable performance during the first presentation of the last twenty test slides of Auditory Training Program No. V to the left ear.

In observation of clinical performance of hearing impaired patients, it was reported that often the discrimination score of

one ear improves or remains the same after a hearing aid is fitted to that ear for a length of time. At the same time, the contralateral ear, i.e., the ear not fitted with a hearing aid, fails to maintain or improve its ability to respond to speech discrimination tests. Since a review of the literature failed to reveal any existing research explaining this observation, an investigation into this problem appeared warranted.

Three subjects were selected for the purpose of this investigation, two males and one female. Each subject was a student in high school at the Oregon State School for the Deaf. Of the three subjects, two were juniors, and one was a senior. All three subjects possessed hearing levels below 110dB (ISO 1964 standards).

To evaluate the hypothesis, each subject was first given a pretest trial to determine the discrimination ability of each ear when presented with Auditory Program No. V. Then the right ear of all three subjects was trained to a predetermined criterion level of acceptable performance. For each day that a treatment phase was presented to a subject, the remaining successive subject(s) was/were given the twenty test slide sequence of the auditory training program. A post-test of the left ear followed the training of the right ear, and this was compared to the pretest score achieved by the left ear at the beginning of the treatment period. To support the hypothesis of this study, the left ear would have to demonstrate a response rate comparable to the trained right ear on one presentation of the training program.

Results of the study indicate that the left ears of two of the subjects tested, obtained response rates comparable to the response rates achieved by their right ears. However, the results also showed that the left ear on the third subject tested failed to compare with the response rate obtained by his trained right ear. It was suggested that this gave added support to the reported clinical observations, since out of the three treatment subjects tested, one subject was found who could not respond with the left ear. It was concluded that a more intense investigation of the research problem be considered.

Suggestions were also given in regards to improving the multiple-base-line design utilized in this study.

# The Effect of Auditory Training On the Auditory Discrimination Ability of the Contralateral Ear

by

Roy Bruce Anderson

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APPROVED:

Redacted for Privacy

Associate Professor of Speech
in charge of major

Redacted for Privacy

Assistant Professor of Education
in charge of Counseling

Redacted for Privacy
Redacted for Privacy

Associate Professor of Psychology
in charge of Psychology

Redacted for Privacy

Chairman, Department of General Studies

Redacted for Privacy

Dean of Graduate School

Date thesis is presented Aug 10 - 1971

Typed by Mary Lee Olson for ROY BRUCE ANDERSON

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# THE EFFECT OF AUDITORY TRAINING ON THE AUDITORY DISCRIMINATION ABILITY OF THE CONTRALATERAL EAR

## CHAPTER I

## INTRODUCTION

### Statement of the Problem

This study was concerned with investigating behavior characteristics pertaining to the hearing performance of profoundly deaf children. In this study, an attempt was made to determine whether or not the left ear of a profoundly deaf subject could respond accurately to an auditory training program which was presented to the right ear. In a study by Grove, Conkey, and McDonell (1971) a profoundly deaf student was presented with a teaching program designed to teach the auditory discrimination task of distinguishing the difference between a male voice and a female voice. One question asked by these authors was that if this program was presented to the subject's right ear, until that ear could make the required discrimination, what would happen to the untrained left ear when it was presented with the same program which had previously been presented only to the right ear. Would the left ear be able to achieve a similar level of performance as that achieved by the right ear; or would the left ear be unable to respond to the auditory program?

In terms of this study, the hypothesis read: a student that reaches criterion level of acceptable performance in the right ear on one presentation of Auditory Training Program No. V (the male and female discrimination program) will achieve criterion level of acceptable performance in the left ear on one presentation of the last twenty test slides of Auditory Training Program No. V to the left ear. (The test slide sequence was a test of the left ear's ability to respond to the program.)

## The Purpose of the Study

Several reports by audiologists and hearing aid consultants have reported instances where discrimination scores of hearing impaired people have changed or remained constant in the ear to which a hearing aid was fitted, as opposed to the contralateral ear which was not fit with a hearing aid (Conkey, 1971; Willoughby, 1971; Briggs, 1971; Schueier, 1971). An example of this phenomena is recorded by a series of audiological evaluations conducted on a nine year old boy who was referred to the Western Oregon Cooperative Speech and Hearing Center in Monmouth, Oregon. This boy was seen at this center on May 4, 1967, and his hearing was assessed in the left ear at 47dB, average pure tone responses, and in the right ear at 45dB, average pure tone responses. Speech discrimination scores were 80 percent in the right ear, and 82 percent in the left ear with speech reception threshold scores of 50dB and 40dB respectively. It was recommended by the audiologist that this young man be fitted with a hearing aid, and on May 11, 1967, a hearing aid evaluation was performed. As a result of this evaluation, this subject was fitted with a Zenith Delegate B hearing aid in the left ear, and in this aided situation, he demonstrated that between various speech sounds he could achieve 88 percent discrimination as compared to 82 percent discrimination. This boy was again seen on May 6, 1968, ten months later, for a re-evaluation of his hearing ability. At this time, his hearing was again assessed and his average pure tone responses were found to be 48dB in the right ear and 37dB in the left ear. His speech discrimination score was 48 percent in the right ear and 82 percent in the left ear, with an aided discrimination score between various speech sounds at 84 percent. His speech reception threshold was assessed at 47dB in the right ear, and 40dB in the left ear. In retrospect, these two hearing evaluations reveal that although responses remained similar for pure tone, speech reception threshold, and aided discrimination scores, the unaided right ear showed a loss in speech discrimination ability from 80 percent to 48 percent. One observation of the results of this subject would indicate that the loss in discrimination ability of the right ear was a direct result of fitting a hearing aid to the left ear while leaving the right ear unaided. One could speculate that if each ear were to have been fitted with an aid, the discrimination scores would have remained at their original or comparable speech discrimination levels.

In summary then, because of this one subject and in regarding reports of similar subjects, (Conkey, 1971; Willoughby, 1971; Briggs, 1971; Schueier, 1971) it seems appropriate to question the behavioral response characteristics of the two ears, and ask if it is appropriate, as is reported, to assume that one ear can duplicate the discrimination ability of the opposite ear. The purpose of this study was to determine if this behavioral phenomena could be found in other hearing impaired individuals.

# CHAPTER II

## SURVEY OF RELATED LITERATURE

In surveying the literature it becomes clear that a depth of information exists on the neurophysiological factors related to speech perception in a normal individual (Kimura, 1961; Bryden, 1963; Rosenzweig, 1954; Broadbent, 1954) as well as auditory tests designed to detect central auditory dysfunctions (Jerger, 1960; Matzker, 1959; Brocca, 1958; Katz, 1962; Calearo, 1957). Literature has also been appearing on binaural versus monaural hearing (Hirsh, 1950; Chappell, Kavanagh, and Zerlin, 1963; Jerger, 1961; Dirks, 1961; Cherry, 1953), but little research evidence exists on the behavioral aspects of learning to discriminate an auditory signal presented to one ear and determining if this learned behavior can be duplicated when the same auditory signal is presented to the contralateral ear.

The question of differences existing in the auditory ability of the right and left ears of an individual has been asked but not resolved. In a listening experiment conducted by Bryden (1963), it was possible to establish that the perception of verbal material was better organized when presented to the right ear. His results indicated that of 32 normal adult subjects tested, most adults identified numbers presented to the right ear more accurately than numbers presented to the left ear. He also demonstrated that the subjects preferred to report the material from the right ear first. The author felt that this evidence seemed to indicate that the encoded speech signals were more readily decoded in the left-hemisphere than in the right. Kimura (1961) also indicates that the left-hemisphere was more dominant than the right-hemisphere for people with language dominant left-hemispheres, and attributed this to the fact that perhaps the crossed auditory pathways in man were stronger and more numerous than the uncrossed pathways.

In regards to these results, some theories were proposed as explanations for the ability of the human organism to preceive speech. Liberman et al. (1967) suggests that the encoded speech signals are more readily decoded in the left-hemisphere than in the right. He indicates that there may be a special left-hemisphere mechanism for the perception of sounds, and questioned whether or not encoded vowels and unencoded steady-state vowels were processed unequally by the two hemispheres. Shankweiler and Studdert-Kennedy (1967) investigated this problem and determined that a significantly greater right ear advantage was found for the unencoded steady-state vowels. They suggest that the steady-state vowels are less strongly lateralized in the dominant (speech) hemisphere, and that this may be taken to mean that these sounds, being unencoded, can be, and sometimes are, processed as if they were nonspeech. Liberman et al. (1967) indicates that a similar study was again reported by Shankweiler and Studdert-Kennedy, which demonstrated a similar set of results for consonant vowel comparisons, with the same right ear advantage being found in stop consonants, and with no difference existing for vowels.

Abbs and Sussman (1971) take a more general approach to speech perception theories and develop a neurophysiological oriented approach. Their theory suggests that the phonological attributes of human speech may be decoded by neurosensory receptive fields, innately structured to detect, and respond to, the various distinguishing parameters of the acoustic sound stream. They suggest that the physical attributes of speech, such as the format structures, and the greater intensity of lower formats, could very easily be recognized by a spatial array of receptive fields similar to the kind found in the visual system in the detection of color shades and other contrasting surfaces. In addition to the physical attributes of sound, they mention that the acoustic characteristics of continuant and interrupted, compact and diffuse, grave and acute, and sharp, flat, and plain also could be recognized by similar or identical types of receptive fields. The receptive fields or "feature detectors", were defined as "organizational configurations of the sensory nervous system that were highly sensitive to certain parameters of complex stimuli."

## Summary

This chapter has indicated that information exists concerning neuro-pathways of the hearing mechanism, and that some questions have been asked concerning a dominant ear with respect to hearing ability. The author was unable to gather evidence which would answer the clinical observation concerning disproportional discrimination scores. Instead, the purpose of this survey has been to bring to the reader's attention some articles which deal with the problems of hemisphere dominance and speech perception. This information is presented as examples of the types of literature now available, and is not intended in any way to suggest an answer to the problem of this study. It is suggested that although the literature does not support the hypothesis that an ear cannot duplicate responses of the contralateral ear, the fact still remains that clinical reports occasionally exist on cases of mismatched discrimination scores after periods of wearing one hearing aid. Therefore, this study was an attempt to investigate this phenomena and determine if duplication of mismatched discrimination ability could be obtained on a profoundly deaf subject by means of an auditory training task.

# CHAPTER III

## RESEARCH METHODS

### Hypothesis

A student that reaches the criterion level of acceptable performance in the right ear on presentation of Auditory Training Program No. V (See Appendix A) will achieve criterion level of acceptable performance during the first presentation of the last twenty test slides of Auditory Training Program No. V to the left ear.[1]

### Selection of Subjects

Three subjects were selected from students currently enrolled in high school classes at the Oregon State School for the Deaf.

The following criterion were used to select the subjects:

1. Had not previously been exposed to the auditory training programs utilized in this study.
2. Have a measured bilateral hearing level of less than 110dB (ISO 1964 standard) through the speech range (500-2000 Hz) as measured by two previous pure-tone audiometric evaluations.

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[1]The program used in this study was developed through the efforts of Dave Grove, Harlan Conkey, and John McDonell as a result of a grant, contract # OEC-70-0049, provided by the U. S. Department of Health, Education, and Welfare. Criterion level of acceptance performance for completion of Program V is two consecutive trials with no more than four errors on the last twenty test slides.

3. Be able to achieve more than 50 percent but less than 75 percent correct response rate on one presentation of the last twenty test slides of Auditory Training Program No. V.

Two boys and one girl were selected to participate in this project. Of these three subjects, two were in their third year of high school and one was in his fourth and final year. Ages of the subjects were 18, 29, and 21, and all three subjects had measured I.Q. scores between 100 and 125 as measured by the Wechsler Intelligence Tests (WAIS or WISC). Hearing levels for the students were taken from the school's evaluation files, and each student had hearing levels below 110dB, ISO 1964 level (See Appendix B). Subjects were not matched according to similar I.Q. or hearing levels because this project was interested in behavior changes within each individual and not in comparing the behavior changes of these three subjects to other similar groups. None of the subjects had been exposed to any of the teaching programs prior to this study.

## Instrumentation

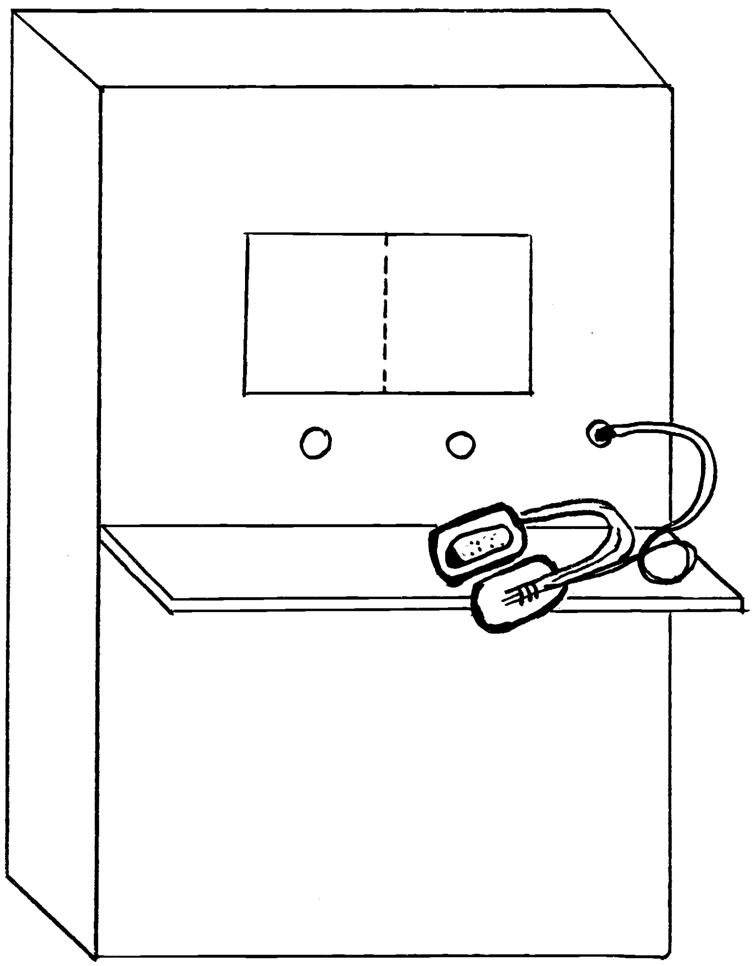
The apparatus used in this project was the Automated Reading Monitor System, i.e., the ARMS Machine. This instrument was developed by Kay Rigg and J. A. Boehm at the New Mexico State University Communications Research Laboratory.

Two units separated the instrumentation system: 1) a teaching machine unit which consisted of a control logic system, stimulus presentation system, and a data instrumentation system; and 2) an analysis and program preparation unit composed of a data reduction system and a code generator system.

A rectangular console measuring four feet by two feet by three feet (4'x2'x3') housed the teaching machine, and this console was designed so as to present both a visual and auditory stimuli. A tape recorder and master control panel were located on the back of the unit, and an optic system and slide projector were located inside the unit above the control logic and data instrumentation module. These two components were accessible by means of a locking door situated on the back of the console. The front of the unit consisted of a fold-down chair where each student sat facing a rear projection screen. This rear projection screen measured six and three quarter inches by ten inches and two response push-buttons were in a lower central position to the screen. An audio output jack was placed in the lower right hand corner complete with two TDH 39 earphones (See Figure 1).

This teaching machine was designed to present programmed instruction in a corrective mode. This required that the machine present information continuously until a response was made. If the response was incorrect, the machine presented the frame until the student made a correct response. When the subject made a correct response, the machine would advance to the next frame. Accuracy of the response was confirmed by automatically flooding the screen with a green light when a correct response was made or by automatically turning off the projection lamp when an incorrect response was made. Presentation of auditory information was repetitive, and depending on the response rate of each subject, at a pace varying between two and 30 seconds.

FIGURE 1. Front View of ARMS Machine Console.



The auditory system was designed in such a way that the presentation of an auditory signal to each earphone could be made independent of the contralateral earphone. An attenuator, calibrated in ten decibel steps, was placed in series between the amplifier and the earphone which allowed the operator to select a signal presentation level from 110dB to 80dB, i.e., a 40dB range. This system had an optimum output of 120dB above .0002 dyne per square centimeter.

The data instrumentation system of the teaching machine provided coded information about the student's performance. The information consisted of the following: 1) the number of times an auditory and visual stimulus was presented before the learner made a response, 2) response definition (which button was pushed), 3) response latency, and 4) response accuracy.

The teaching machine tape recorder had a dual purpose in that it provided the coded information acting as the input to the control logic, and provided the auditory stimulus. The control logic unit identified pulses which when fed into the control logic, defined the correct response for the frame, advanced the slide projector, and controlled the direction of tape travel.

The design criteria for the teaching machine control logic unit was as follows: 1) to present visual, auditory, and audio-visual frames in a corrective manner; 2) to present continuous visual information and repetitive auditory information until a response was made; 3) to confirm responses with an appropriate reinforcer; and 4) to allow only one response per presentation.

The ARMS Machine was equipped with two TDH 39 headphones with 400 grams of pressure. The right earphone was used in this study, with the left ear being disconnected.

The right earphone was adjusted to fit the left ear when programs were presented to this ear.

## Test Procedures

Subjects were first selected by examining audiograms obtained from the school's evaluation center. From this reservoir of possible subjects, 13 students were given the test slide sequence of Auditory Program No. V. This sequence was presented to the right ear.[2]

The following set of written directions were presented to all candidates that participated in the screening project:

> I am doing a research project, and would like you to participate. I want you to listen to some male and female voices and see if you can match the right voice to the correct picture. You will see two pictures (man and woman), and hear a voice. Push the button that lies under the picture which matches the voice. Guess if you must.

Three subjects were found who met selection criteria. These three students were then given the following set of written directions:

> Of the students tested, you were one of the few that met my screening demands. I would like you to work with me for about 20 minutes a day for approximately one week. During this time, you will learn to make the discrimination between a male and female voice, and I will be able to help perfect training programs for teaching discrimination skills to other students with hearing problems.

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[2]This score was recorded and utilized as a measurement in the pretest phase for each subject selected to participate, and it is recorded as the first percentage score plotted for the right ear on each of the three graphs (See Figures 3, 4, and 5).

> The procedure will be the same as when you were first tested. Push the button that lies under the picture which matches the voice. On some programs you will not be told whether you are correct or incorrect.[3] On others, a green light will appear when you are correct and the screen will be dark when you are wrong. Do not be concerned about making wrong answers. Do not be afraid to guess. Thank you.

After reading the directions each subject was seated in front of the rear projection screen, fitted with the right earphone to the appropriate ear, and proceeded according to the following plan (See Figure 2 for an outline of the research design):

Subject One

1. Pretest: One presentation of the last 20 test slides of Auditory Program No. V was presented to the left ear.[4]

2. Treatment I: Auditory Program No. V was presented to the right ear until the subject achieved criterion demands.

3. Post-test I: The left ear was presented with the last 20 test slides of Auditory Program No. V.

4. Treatment II: The right ear was presented with two trials of Auditory Program No. V.

5. Post-test II: Four trials of the last 20 test slides of Auditory Program No. V were presented to the left ear.

6. Treatment III: Two trials of Auditory Program No. V were presented to the right ear.

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[3] The intent was to remove feedback information concerning correct or incorrect responses. However, because of instrumentation inadequacies, it was not possible to remove feedback as to whether a response was correct or incorrect.

[4] Program V will always be presented at an intensity level of 110dB above .0002 dyne per square centimeter.

FIGURE 2. A diagram of the research design employed in this study. Note that this design follows a multipe-baseline approach wherein the treatment I program is completed for each subject before a treatment I program is started for the next successive subject.

| Subject One<br>Pretest | Treatment I | Post-test I | Treatment II | Post-test II | Treatment III |
|---|---|---|---|---|---|
| May 13 | 17, 18, 19, 20, 21, 24, 25 | 25 | 31 | 31, 1 | 1, 2 |

| Subject Two<br>Pretest<br>(For each day that Subject One was given Treatment I program, one trial of the pretest program was presented to the right ear of subject two.) | Treatment I | Post-test I | Treatment II | Post-test II | Treatment III |
|---|---|---|---|---|---|
| May 12,18,21 | 25, 26, 27 | 27 | 31 | 31, 1 | 1 |

| Subject Three<br>Pretest<br>(For each day that Subject Two was given the Treatment I program, one trial of the pretest program was presented to the right ear of subject three.) | Treatment I | Post-test I |
|---|---|---|
| May 11, 19, 20, 21, 24, 25, 26, 27 | 28, 31, 1, 2 | 2, 3 |

Subject Two

1. Pretest:

   A. One presentation of the last 20 test slides of Auditory Program No. V was presented to the left ear.

   B. For each day that Subject One was presented the treatment I trials, one presentation of the last 20 test slides of Auditory Program No. V was presented to the right ear.

2. Treatment I: When Subject One reached criterion on treatment I trials, Auditory Program No. V was presented to the right ear until Subject Two reached criterion demands.

3. Post-test I: The left ear was presented with one trial of the last 20 test slides of Auditory Program No. V.

4. Treatment II: Two trials of Auditory Program No. V were presented to the right ear.

5. Post-test II: The left ear was presented with four trials of Auditory Program No. V.

6. Treatment III: Two trials of Auditory Program No. V were presented to the right ear.

Subject Three

1. Pretest:

   A. One presentation of the last 20 test slides of Auditory Program No. V was presented to the left ear.

   B. For each day that Subject Two was presented the treatment I trials, one presentation of the last 20 test slides of Auditory Program No. V was presented to the right ear.

2. Treatment I: When Subject Two reached criterion on treatment I trials, Auditory Program No. V was presented to the right ear until the subject achieved criterion demands.

3. Post-test I: Four trials of the last 20 test slides of Auditory Program No. V were presented to the left ear.

## Design

This study utilized a multiple-baseline approach in that while Subject One was receiving a treatment program,Subject Two and Three were being given pretest trials. Like-wise, while Subject Two was receiving the treatment program, Subject Three was continuing with the pretest trials. When a subject reached criterion level of acceptable performance on a treatment program,the next successive subject would then begin his Treatment I procedure. This procedure was utilized as a control whereby it could be determined that a behavior change was a result of presentation of the auditory program rather than some other external stimuli.

As a result of the repeated exposure to Auditory Program No. V, it was felt that a subject might memorize the program rather than learn to attend to the auditory stimulus. Consequently, when a subject began to achieve an 80 percent correct response rate on the treatment I phase, the auditory stimulus would be intermittently turned off. If the subject, unaware that no auditory signal was being presented, continued to respond correctly, it would be an indication that he had memorized the presentation order of Auditory Program No. V.

The original design did not call for added treatment and post-test trials for Subjects Two and Three. During the investigation it was felt that the pretest trials of these subjects might not be reliable. As a result, two more treatment and two more post-test trials were presented to these two subjects. It was felt that this change would increase the reliability of the results when the left and right ear of each of these subjects were compared.

In addition, subjects were often presented with several program trials during a one day session. During subject availability, of approximately 30 minutes per day, as many pretest, treatment, and post-test trials were presented as time would allow. Periodically, a subject achieved criterion level in the right ear during a particular treatment session, if time allowed, post-test trials were run during this same session.

## Data Collection and Analysis

Data was collected on every presentation of Auditory Program No. V and on every presentation of the test slide sequence of said program. A separate data sheet was kept on each subject (See Appendix C), and data was recorded in terms of percentage of correct responses. Percentage scores were always figured from the last 20 test slides of Auditory Program No. V even though the complete program of 60 slides was presented.

Data was analyzed by comparing post-test scores to pretest scores and determining whether a significant difference existed between the two different scores. A difference was considered significant if the post-test results for the left ear equalled or approximated the level of performance attained by the right ear during treatment phases.

# CHAPTER IV

# RESULTS

The hypothesis was:

A student that reaches the criterion level of acceptable performance in the right ear on presentation of Auditory Training Program No. V will achieve criterion level of acceptable performance during the first presentation of the last 20 test slides of Auditory Training Program No. V to the left ear.

## Subject One

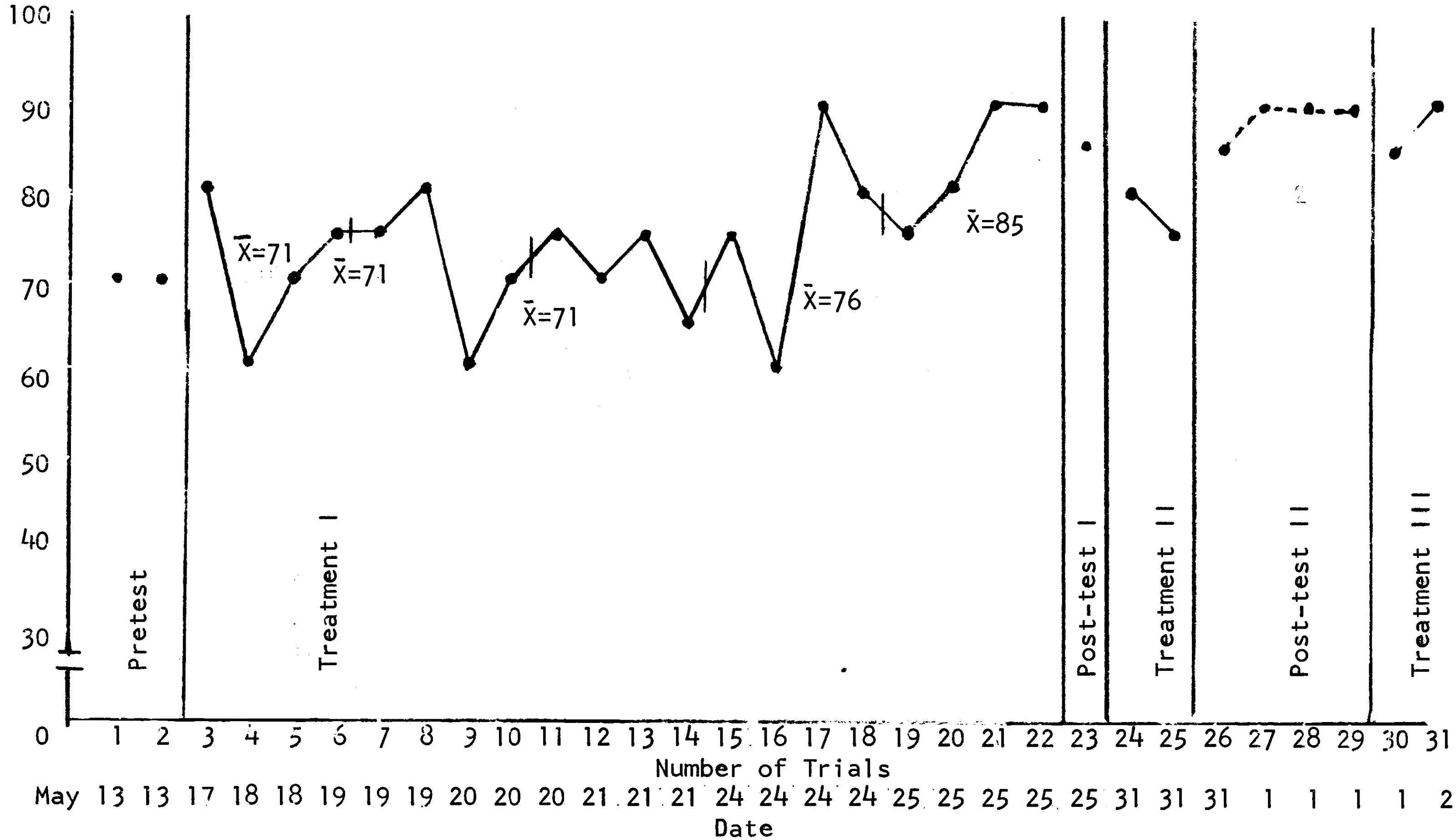
A total of 31 trials were presented to Subject One from May 13 to June 2, 1971. Of these 31 trials, 24 treatment trials were given to the right ear, six test trials were presented to the left ear, and one test trial was given to the right ear during the pretest phase of the design.

Subject One obtained a score of 70 percent in both ears during the first screening trials presented on May 13, falling within the 50 to 75 percent range required by the population selection standards of this investigation.

When given the test to determine whether memorization of the auditory stimulus was occurring, this subject failed to respond correctly to the auditory program.

The results obtained for Subject One are shown in Figure 3 and did not support the hypothesis as stated. By dividing the 20 treatment I scores into sets of four and computing averages for each set, mean scores were 71, 71, 71, 76, and 85 percent. These results indicated

FIGURE 3. Percentage scores attained by Subject one during Pretest, Treatment I, Post-test I, Treatment II, Post-test II, and Treatment III phases of the research procedure. Solid lines connecting points together indicate obtained scores for the right ear, and dashed lines or points not connected with lines indicate scores obtained for the left ear.



an improvement for the right ear during the treatment phase. The score obtained for the left ear during the first presentation of the last twenty test slides of Auditory Program No. V was five percent below the criterion level score, 90 percent on two trials, reached by the right ear in the treatment I phase.

A time span of five days followed the completion of post-test I phase and the beginning of treatment II phase. The representation of the complete program to the right ear, after a five day time lapse shows a decline of scores down to 80 and 75 percent respectively. The post-test II results demonstrated that the left ear achieved a criterion level of 90 percent in three out of four trials, and treatment III phase shows the right ear again attaining 90 percent on the last trial.

The general trend of the data revealed that scores moved from a pretest score of 70 percent, in both ears, to a post-test mean score of 82 percent for the left ear, and 88 percent for the right ear. These mean scores are reported as arithmetic means and are computed by dividing the sum of the last five scores obtained for either the right or left ears by five. The range of scores for the left ear were from 70 to 90 percent, and the range of scores for the right ear were from 70 to 90 percent.

## Subject Two

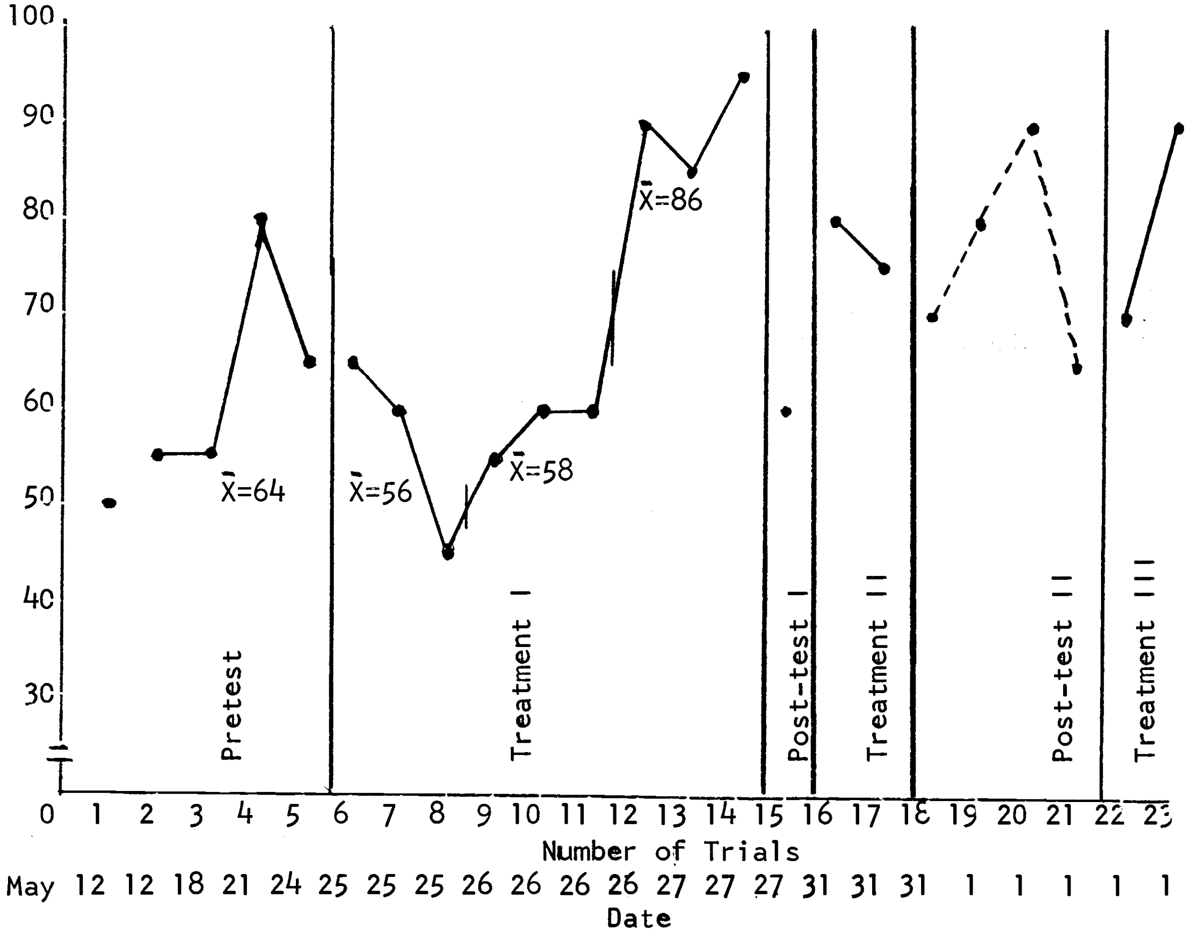
Subject Two was presented a total of 23 trials between May 12 and June 1, 1971. Of these 23 trials, 13 were treatment trials presented to the right ear, four were test trials presented to the right ear, and six were test trials presented to the left ear.

Subject Two obtained a score of 55 percent for the right ear and 50 percent for the left ear during the first screening trials presented on May 12 with these scores also falling within the 50 to 75 percent range required by the population selection criteria of this investigation.

When given the test to determine whether memorization of the auditory stimulus was occurring, this subject also failed to respond correctly to the auditory program.

This subject showed the same general trend that was shown by Subject One (See Figure 4) in that the right ear produced increased scores as the number of trials in the treatment I phase increased. Mean scores, figured by dividing the nine scores of the treatment I phase into sets of three and then figuring the average for each set, are 56, 58, and 86 percent respectively. Increased scores were also apparent for the right ear in the pretest phase where the percentage scores moved from 55 to 65 percent with a range between 55 and 80 percent, and a mean score of 64 percent. However, the post-test I score was significantly lower with a ten percent increase over the pretest score (50 percent to 60 percent), and did not support the hypothesis. The mean score for the left ear on the post-test I and II was 72 percent with a range from 60 to 90 percent. These results demonstrated a criterion level score of 90 percent by the left ear on one out of five trials, but the mean score of 72 percent was still 18 percentage points below the criterion level of acceptable performance, 90 percent on two trials, attained by the right ear during treatment I phase. In contrast, the mean score achieved by the right ear on treatment II and III phases was 76 percent, only four mean

FIGURE 4. Percentage scores attained by Subject two during Pretest, Treatment I, Post-test I, Treatment II, Post-test II, and Treatment III phases of the research procedure. Solid lines connecting points together indicate obtained scores for the right ear, and dashed lines or points not connected with lines indicate scores obtained for the left ear.



percentage points above the mean score demonstrated by the left ear. These mean scores are again arithmetic means and are therefore averages of the obtained scores being discussed.

A time span of three days followed post-test I phase and the beginning of treatment II phase. The trials of treatment II phase indicate a decline of 10 to 15 percentage points (80 percent and 75 percent) from that attained by the right ear in the treatment I phase. Scores during the post-test II phase for this subject increased steadily from 70 to 90 percent, then declined rapidly to 65 percent. The final scores attained during treatment II phase increased, in two trials, from 70 to 90 percent.

## Subject Three

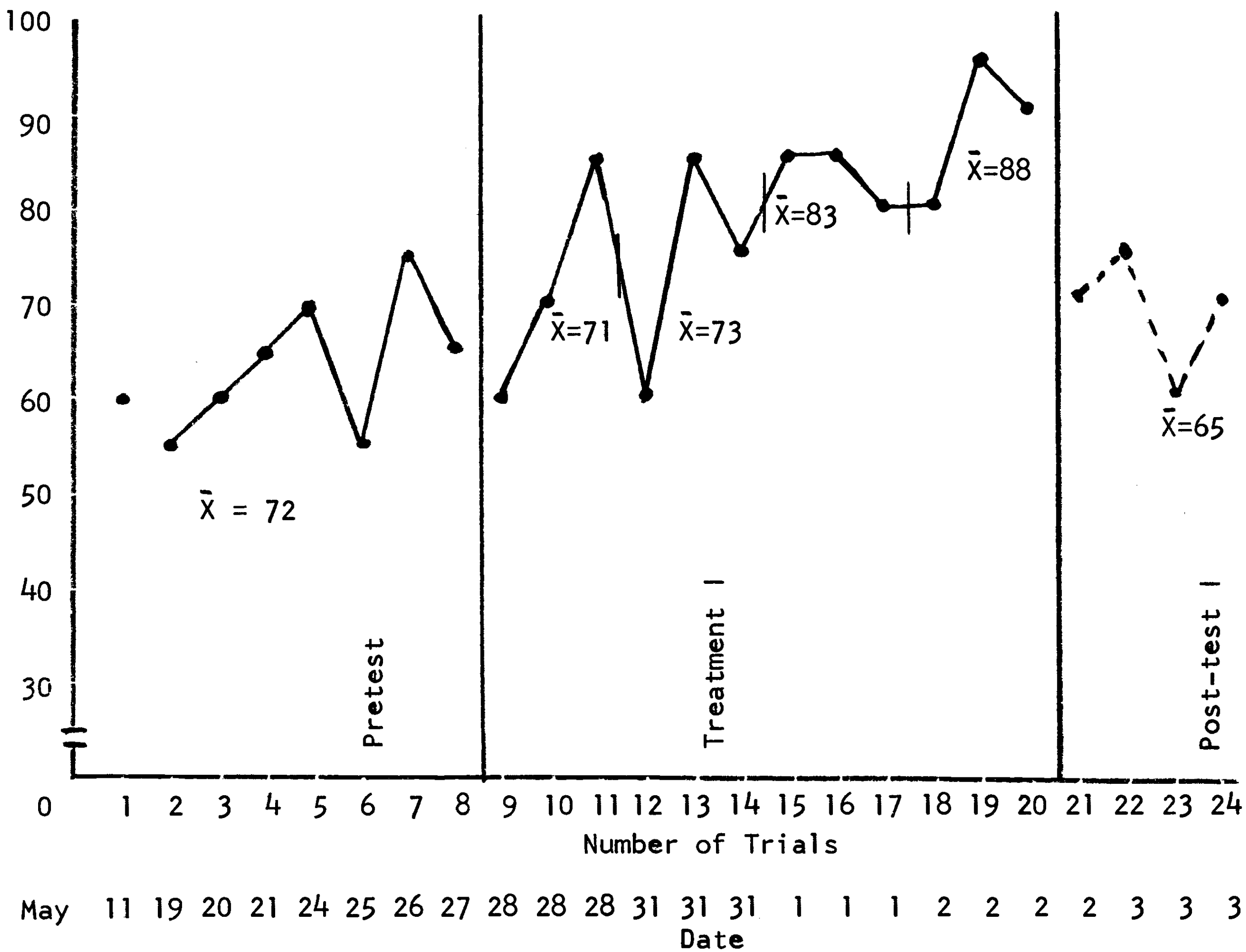
Between May 11 and June 6, 1971, 24 trials were given to Subject Three. Of these trials, 12 were treatment trials given to the right ear, five were test trials given to the left ear, and seven were test trials given to the right ear during the pretest phase.

Subject Three obtained a score of 55 percent for the right ear and 60 percent for the left ear during the first screening trials presented on May 11. Again this score fell within the 50 to 75 percent range required by the population selection standards of this study.

This subject also failed to respond correctly to the auditory program when given the test to determine memorization of the auditory stimulus.

The results obtained for Subject Three did not support the hypothesis and are depicted in Figure 5. Scores for the left ear

FIGURE 5. Percentage scores attained by Subject Three during Pretest, Treatment I, and Post-test I phases of the research procedure. Solid lines connecting points together indicate obtained scores for the right ear, and dashed lines or points not connected with lines indicate scores obtained for the left ear.



move from 60 percent in the pretest procedure to a mean score of 65 percent achieved by the post-test I procedure. These post-test I scores demonstrated a range from 60 to 75 percent. The mean score for the post-test results of the left ear was five percent above the pretest score for the same ear (60 to 65 percent). Once again arithmetic means of the obtained scores for each phase are utilized.

Variance of scores was again demonstrated during the right ear's exposure to Program V with jumps and declines as high as 25 percentage points. Mean scores, figured by dividing the 12 scores of the treatment I phases into sets of three and then figuring the average for each set, were 71, 73, 83, and 88 percent respectively. These percentage scores demonstrated an increased performance for the right ear as the treatment I phase progressed. Increased scores were also apparent for the right ear in the pretest phase where the percentage scores moved from 55 to 65 percent with a range from 55 to 75 percent, and a mean score of 72 percent.

# CHAPTER V

## SUMMARY AND CONCLUSIONS

The purpose of this study was to determine whether one ear of a profoundly deaf student could duplicate a response rate similar to the response rate achieved by the opposite ear on an auditory training program. The formal hypothesis of this study was: a student that reaches criterion level of acceptable performance in the right ear on presentation of Auditory Training Program No. V will achieve the same criterion level of acceptable performance during the first presentation of the last twenty test slides of Auditory Training Program No. V to the left ear.

In observations of clinical performance of hearing imparied patients, it was reported that often the discrimination score of one ear improves or remains the same after a hearing aid is fit to that ear for a length of time. At the same time, the contralateral ear, i.e., the ear not fitted with an aid, fails to maintain or improve its ability to respond to speech discrimination tests. Since a review of the literature failed to reveal any existing research explaining this observation, an investigation into this problem appeared warranted.

Three subjects were selected for the purpose of this investigation, two males and one female. Each subject was a student in high school at the Oregon State School for the Deaf. Of the three subjects, two were juniors, and one was a senior. All three subjects possessed hearing levels below 110dB (ISO 1964 standards).

To evaluate the hypothesis, each subject was first given a pretest trial to determine the discrimination ability of each ear when presented with Auditory Program No. V. Then the right ear of all three subjects was trained to a predetermined criterion level of acceptable performance. For each day that a treatment phase was presented to a subject, the remaining successive subject(s) was/were given the twenty test slide sequence of the auditory training program. This procedure acted as an experimental control, and increased performance by these subjects during presentation of the test slide sequence would indicate influence from some external casual factor. A post-test of the left ear followed the training of the right ear, and this was compared to the pretest score achieved by the left ear at the beginning of the treatment period. If the left ear could demonstrate a performance rate comparable with the right ear, then it would be indicative of a duplicated response rate and support the hypothesis of this study.

Two of the three subjects showed improved performance when the auditory program was first presented to the left ear. This evidence indicates that the left ear of these subjects was able to respond, without training, to the auditory cues of this program. In examining the data of these two subjects, it is indicated by post-test I scores,* that neither of the two subject's left ears were able to respond at the predetermined criterion level of 90 percent. However, this does not seem indicative of an inability to respond, but it is suggested that this lower response rate for the left ear may be a result of a decreased motivation to perform well on the program. In support of this suggestion, it is necessary to examine the remaining post-test and treatment results

*See Figures 3, 4, and 5.

of these two subjects. These results indicate that both ears performed at comparable response rates (Subject One: 88% vs. 82%, and Subject Two: 76% vs. 72%). In addition, since the variability of all responses was so great, it is suggested that the 85 percent score achieved by Subject One on the post-test I phase may be a poor evaluation of the subject's true score at that time, and that a different test score could possibly indicate a higher response rate.

Subject three was the only subject of the three, who failed to approach criterion levels in the left ear during the post-test period, and this finding suggests that the clinical observations referred to earlier may be accurate. A hypothesis suggesting an explanation for the poor response rate demonstrated by this subject is not within the limits of this paper. The important implication is that this subject did not perform as would be expected by examining the results of the two previous subjects. In other words, he did not show an improved ability to respond to an auditory discrimination task when that program was presented to the untrained ear. It is the opinion of this investigator, that since these results were found, a more intense investigation of the research problem be considered. This implies that further investigations may find additional subjects with an inability to respond, and therefore support the clinical evidence cited in this study.

If additional evidence can be gathered which supports a hypothesis suggesting that a hearing impaired student cannot duplicate in one ear a response rate similar to the response rate in the opposite ear, then this would have important implications in auditory training procedures, and in underlying philosophies which guide the education of deaf children. For example, often in teaching hard of hearing children auditory training tasks, emphasis is not directed to binaural amplification of teaching programs. If the evidence could be found supporting the above hypothesis, then this could indicate a new emphasis pertaining to presenting the auditory stimulus to both ears. Finding support for such an hypothesis would also have important implications for the audiologist and the hearing aid consultant in the fitting of hearing aids. For instance, if it is demonstrated that duplication of responses between ears is not a function of the hearing system, then it may be well worth the money for a patient to invest in the cost of fitting a hearing aid to each ear. In this way, amplification to both ears would provide an equal advantage in the attainment of the auditory cues related to speech perception. However, if only one ear was fit with a hearing aid, that ear alone would benefit from the amplification, and not the opposite ear. This pattern may also indicate that, prior to fitting a hearing aid, a prospective candidate should be taught an auditory discrimination task to one ear. The subject could then be tested to determine if the opposite ear could acquire the task. If it was determined that the opposite ear could not make the required discrimination, then it would indicate that auditory training of both ears should be considered.

In conducting a new study, this writer recommends that the following changes or additions be made in this research design:

1. More than one pretest and post-test trial be given to each subject to insure approximately a true score

2. That base-line data (pretest trials) be obtained on the left ear as well as the right ear for the subjects who are waiting to receive treatment.

3. That each day the right ear of a subject receives the treatment program, the left ear receives a test slide sequence

4. That all feedback concerning response accuracy during the test phases be eliminated

5. That a minimum of six subjects be used in the study, with two subjects receiving treatment while four subjects are given test trials sequences, then two more subjects receiving treatment while two subjects are given test trial sequences, and finally the two remaining subjects receive treatment on the program.

These additional procedures would provide a level of experimental control not achieved by the previous investigation. It is further recommended that following the post-test phase for each subject, the treatment programs be given to the left ear. This information would give an investigator a look at the difference in the number of trials it took for the left ear to achieve criterion level as compared to the number of trials for the right ear to achieve criterion level. If duplication of the response rate of one ear is comparable to the opposite ear, then the number of trials needed by the left ear to achieve criterion level should be less.

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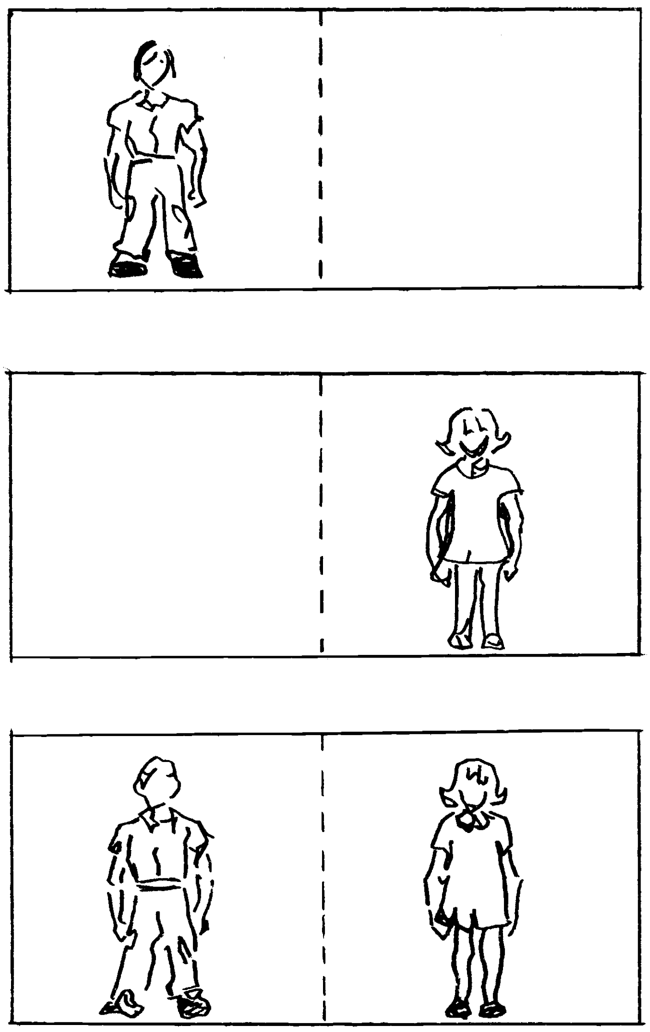
# APPENDICES

# APPENDIX A

## Auditory Program V

Objective: Given a visual stimulus (picture of a male or female) and an auditory stimulus (male voice or female voice saying a novel sentence each time) the child is to respond by pressing the appropriate manipulandum which matches the appropriate picture to the voice 90% of the time.

Auditory Program V is a 60 frame program which presents forty frames with a picture of a boy on the left side of the screen and a picture of a girl on the right side of the screen. (See Figure below) Concurrent with this visual stimulus, a boy's voice or a girl's voice is presented. The child is to respond by pressing the appropriate manipulandum on the ARMS Machine. This is following by twenty test slides where the boy and girl's picture is presented concurrently with either a male or female voice.



# APPENDIX B

Hearing level thresholds for each subject as measured by two pure-tone audiometric evaluations. Evaluations were made utilizing a Beltone 15C Audiometer and was conducted in a IAC 1200 two room testing suite.

| Hertz | 125 | 250 | 500 | 1000 | 2000 | APT |
|---|---|---|---|---|---|---|
| Subject One | | | | | | |
| right ear | 70dB | 90dB | 95dB | 105dB | 110dB | 103dB |
| left ear | 70dB | 90dB | 95dB | 105dB | NR | 103dB |
| right ear | NR | 90dB | 90dB | 105dB | NR | 103dB |
| left ear | NR | 90dB | 85dB | 105dB | NR | 102dB |
| Subject Two | | | | | | |
| right ear | NR | 70dB | 95dB | NR | NR | 105dB |
| left ear | 65dB | 75dB | 100dB | NR | NR | 106dB |
| right ear | NR | 90dB | 85dB | 100dB | NR | 98dB |
| left ear | NR | 85dB | 85dB | 105dB | NR | 100dB |
| Subject Three | | | | | | |
| right ear | 60dB | 65dB | 85dB | 90dB | 95dB | 83dB |
| left ear | 55dB | 65dB | 85dB | 90dB | 95dB | 83dB |
| right ear | NR | 70dB | 90dB | 105dB | 105dB | 100dB |
| left ear | NR | 70dB | 80dB | 80dB | 100dB | 86dB |

(ISO 1964 Standards)

NR = No response

dB = decibel

APT= Average Pure-Tone Threshold

APPENDIX C. Data Collection Sheet - Auditory Training Project

| DATE | Program | dB | Hz | Stimulus | Print Out Correct | Counter Wrong | % of Correct Responses | Last 20 Responses | % of Correct Responses | Reinforcer |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. | | | | | | | | | | |
| 2. | | | | | | | | | | |
| 3. | | | | | | | | | | |
| 4. | | | | | | | | | | |
| 5. | | | | | | | | | | |
| 6. | | | | | | | | | | |
| 7. | | | | | | | | | | |
| 8. | | | | | | | | | | |
| 9. | | | | | | | | | | |
| 10. | | | | | | | | | | |
| 11. | | | | | | | | | | |
| 12. | | | | | | | | | | |
| 13. | | | | | | | | | | |
| 14. | | | | | | | | | | |
| 15. | | | | | | | | | | |
| 16. | | | | | | | | | | |
| 17. | | | | | | | | | | |