EFFECTS OF REINFORCEMENT ON AUDITORY STIMULUS CONTROL AND THRESHOLD ASSESSMENT WITH RETARDED CHILDREN

by

MICHAEL JOHN REID

B.S., Little Rock University, 1963

A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF ARTS

Department of Speech

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1969

Approved by:

Robert T. Fulton

Major Professor

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Acknowledgments

Grateful appreciation is extended to all the members of my committee; but especially to Dr.'s Robert T. Fulton and Joseph E. Spradlin for their patience and suggestions during the initiation and completion of this study. Appreciation is also extended to the Speech and Hearing Staff, Parsons State Hospital and Training Center for their cooperation and assistance during the period of investigation. Special consideration is directed to Mrs. Gayle Wallingford, who graciously accepted the task of typing this manuscript.

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Chapter 1

Introduction

One of the audiologist's primary obligations is to provide reliable and valid audiometric data to facilitate medical and non-medical habilitation of the hearing impaired. However, it becomes difficult to carry out this obligation with patients who do not respond reliably to the auditory signals used in audiometric testing.

Incidence studies with mentally retarded populations have reported hearing impairments varying from seven to 55.5 percent (Lloyd & Reid, 1965). Investigators (Bradley, Evans, & Worthington, 1955; Schlanger & Gottsleben, 1956; Kodman, Powers, Philips, & Weller, 1958; Siegenthaler & Kryzwicki, 1959; Rigrodsky, Prunty, & Glovsky, 1961; Pantelokos, 1963; and Lloyd & Reid, 1967) have reported that six to 22.9 percent of the retarded populations tested were classified as "untestable," "non-testable," or "difficult-to-test" with clinical audiometric testing procedures. These findings indicate a need for audiometric techniques which are more applicable to severely and profoundly retarded patients.

Standard clinical audiometric procedures use pure tones as discriminative stimuli. Subjects usually respond by emitting a verbal response, raising a finger or hand, pointing to the ear where the stimulus is presented, dropping a block in a box, placing a ring on a peg, or pushing a button. These responses are often followed by verbal praise, a non-verbal nodding of the head, and/or patting or carressing from the experimenter. These events may be considered reinforcers for appropriate responses and often increase the probability that the subject will make the same response when the same discriminative stimulus is presented. However, these techniques are only effective for those subjects for whom these events are reinforcing. Many retardates, especially the severely and profoundly retarded, are not reinforced by such verbal and non-verbal events. Consequently they fail to respond to standard audiometric techniques.

More recently it has been possible to obtain audiometric data from severely and profoundly retarded patients using tangible forms of reinforcement. Tangible (edible) forms of reinforcement have been substituted for or paired with verbal and non-verbal approval. Such foods as candy, cereal, and popcorn are often more reinforcing for low-level retardates than social events.

In an audiometric testing situation, listening and attending behaviors are essential. It would appear that the use of food would result in incompatible behaviors such as mastication and the playing with food. These behaviors not only could distract the subject from the prescribed task, but could also create sufficient ambient noise to mask auditory signals, particularly when the discriminative signals are presented at near threshold intensities.

Although certain incompatible behaviors may result from using edible reinforcers, food has been found to be effective for the maintenance of stimulus control. The use of no reinforcement, or the withdrawal of food reinforcement, may reduce the occurrence of incompatible behaviors associated with reinforcement delivery; however, it may also result in a loss of stimulus control.

There is evidence (Lewis, 1960) that intermittent reinforcement (reinforcement delivered for a fixed or variable number of correct responses or following a fixed or variable period of time) maintains behavior.

Intermittent reinforcement has been found to lead to greater resistance to extinction than continuous reinforcement. Intermittent reinforcement, however, has not been systematically investigated during audiologic assessments with severely and profoundly retarded children.

Statement of the problem

The purpose of this two-fold investigation is:

1. to investigate the maintenance of auditory stimulus control with severely and profoundly retarded children under conditions of continuous (CRF) and fixed ratio (FR) reinforcement, and

2. to investigate the effects of non-reinforcement on the assessment of auditory thresholds after initial response maintenance by continuous and fixed ratio reinforcement.

Summary

This chapter demonstrates the need for additional research in the area of audiometric testing with severely and profoundly retarded children. The use of continuous and intermittent reinforcement schedules and their effects were presented. Questions were posed in an attempt to structure the direction of the planned investigations.

Chapter 2

Review of the Literature

The literature indicates that various investigators (Meyerson & Michael, 1960; LaCrosse & Bidlake, 1964; Spradlin, Lloyd, Hom, & Reid, 1968; Lloyd, Spradlin, & Reid, 1968; Fulton, Spradlin, & Lloyd, 1968; Fulton & Spradlin, 1967, 1968a, in press; and Bricker & Bricker, 1969) have used operant audiometric techniques with difficult-to-test retarded children.

Meyerson and Michael (1960) used a number of techniques and reinforcers to obtain audiometric data on retarded children. Their findings suggested that the most effective procedure consisted of a two-response-mode program. One response (button press) initiated a pure-tone stimulus, followed by reinforcement, while the second response terminated the pure-tone stimulus, followed by a second reinforcement. A bonus reinforcement was also provided for quick switching responses. Reinforcers consisted of candy, cigarettes, trinkets, and obsolete electronic parts.

Although details of their procedure were not included, LaCrosse and Bidlake (1964) reported on an operant technique used in evaluating 88 of 90 moderately retarded children. These children failed to respond reliably to standard audiometric techniques; however, 82 of the 90 children were found to have normal hearing, using the operant procedure. Six children were classified as having moderate to severe hearing losses. The results for two of the children were not presented.

Spradlin, et al., (1968) described a semi-automated operant procedure for assessing the hearing sensitivity of severely and profoundly retarded children. The procedure involved the presentation of pure tones as discriminative stimuli. The stimulus was presented on a variable-interval (VI) schedule.

When the subject responded (button press) in the presence of the stimulus, food reinforcement was delivered. If the subject failed to respond, the stimulus was terminated and no reinforcement was delivered. When the response was established and stimulus control was obtained, that is, when the subject repeatedly responded in the presence of the stimulus and failed to respond in the absence of the stimulus, thresholds were assessed. During screening or threshold assessment, the stimulus presentation and reinforcement delivery was electromechanically controlled with timers and relays. The frequency and intensity of the stimulus were controlled by the experimenter. Food reinforcers (candy, sugar coated cereal, marshmallows, and graham crackers) were delivered for correct responses. Social (verbal and non-verbal) reinforcement was paired with the food reinforcement for some subjects when the food reinforcement appeared insufficient.

Results with 41 severely retarded children revealed that stimulus control and bilateral hearing evaluations were obtained for 26 children. Of the 26 children evaluated, 15 had essentially normal hearing sensitivity, re: American Standards Association, (ASA), 1951, or International Standards Organization, (ISO), 1964, 2 had unilateral hearing impairments, and 9 had bilateral hearing impairments. Fifteen subjects failed to respond consistently to the stimulus or were still being evaluated at the time of writing.

Lloyd, et al., (1968) reported on 50 children on whom operant audiometric procedures were attempted. Tone (stimulus) control was established with 42 children. Twenty-three children had normal hearing, (re: ASA, 1951 or ISO, 1964 Standards), 1 had a profound unilateral loss, 8 had mild bilateral losses, 3 demonstrated moderate to severe bilateral losses, and 4 displayed profound bilateral impairments. Three of the 42 children were being assessed at the time of the writing. Eight children failed to respond consistently to the stimulus and were canceled from the program.

Fulton, et al., (1968) in a 16mm color film, illustrated an operant audiometric testing procedure similar to the procedure described by Spradlin, et al., (1968) and Lloyd, et al., (1968). The film sequentially presented steps necessary for:

1. determining effective food reinforcers,

2. establishing and maintaining response control, and

3. audiometric screening or determining auditory threshold with severely and profoundly retarded patients.

Fulton and Spradlin (1968a) in an attempt to systematize the above procedure, modified the program to include:

1. An alternating non-audible control period with the same temporal characteristics as the audible stimulus period. The control and stimulus periods were presented on a variable-interval (VI) schedule. A comparison of responses made during stimulus periods with responses made during control periods was used to determine response control. This procedure permitted the examiners to predetermine stimulus-control criteria.

2. Time-out (time out from opportunity to earn reinforcers) periods were inserted to reduce intertrial responses (responses occurring between stimulus periods). Each intertrial response (ITR) activated a time-out timer, delaying the onset of the next stimulus or control event by at least 5 seconds. As a result, high response rates during periods when the stimulus was absent were generally reduced. The time-out periods were initially activated by depression of the response key, but were later adapted to operate as a result of physical contact with either the response key or the immediate area surrounding the response key.

3. A "pre-delay" in the response circuit controlled reinforcement for random responses which occurred simultaneously with the onset of auditory signals. The opening of the response circuit was delayed 300 milliseconds by the pre-delay. As a result, auditory signals were in effect 300 milliseconds before a response would result in reinforcement. Responses occurring during the first 300 milliseconds terminated the stimulus and provided no reinforcement. A "post-delay" of 300 milliseconds was also included to reduce non-reinforcement for responses occurring simultaneously with stimulus termination. Responses occurring during this 300 millisecond post-delay period were reinforced. Thus, both the response circuit and stimulus period were open the same length of time (2 seconds), but were shifted by 300 milliseconds.

Fulton and Spradlin (1967, 1968a, in press) also investigated ascending-descending threshold methods and the effects of different stimulus-control criteria on threshold variability. In the first of two experiments (Fulton & Spradlin, 1967), each subject was required to meet a stimulus-control criterion at each testing session. This criterion was defined as responding correctly to 90 percent of the stimuli presented at 20dB above a clinically determined threshold while not responding to more than 10 percent of the non-audible control periods, during ten consecutive and alternating pairs of stimulus and control periods. After each stimulus-control criterion was attained, alternating ascending-descending threshold techniques were used. Ascending techniques began at a point 10dB below a clinically-estimated threshold and ascended in 5dB increments to a point 10dB above the clinically estimated threshold. Descending techniques used a reverse procedure. Five ascents or descents (25 trials) were made daily for six sessions. Threshold was defined as the lowest intensity at which the subject responded to three of five stimuli for that level. The authors found that five of six subjects provided test-retest variability within ±5dB for five of six sessions. Subject variability did not exceed ±10dB. Ascending-descending techniques yielded similar results.

In the second experiment, three groups of subjects were assessed using three different stimulus control criteria. Group A was required to meet a control criterion (responding to 90 percent of the stimulus presentations and not responding to more than 10 percent of the control periods for 20 consecutive trials) prior to each experimental session; Group B was only required to meet the control criterion prior to the initial experimental session; and Group C was not required to meet any stimulus-control criterion prior to testing but was required to be familiar with the testing procedure. The ascending-descending threshold procedures followed the Carhart-Jerger and Hughson-Westlake methods. The results indicated that stimulus-control criteria affect threshold variability. Group A yielded less variability than Group B, followed by Group C which yielded the greatest variability.

The results of the two experiments indicated that reliable pure-tone data could be obtained from severely and profoundly retarded children and that stimulus control was a major variable in threshold variability. The findings again suggested that the ascending-descending threshold techniques were not a critical variable.

Fulton and Spradlin (1968b) also outlined a detailed procedure for obtaining audiometric thresholds with severely and profoundly retarded children, using a positive-reinforcement-discrimination program. Their procedure included sequential phases from initial training through threshold assessment, including contralateral masking. Although some phases appeared unnecessary, it was found that subjects progressed through each phase with minimal difficulty. Some phases may be excluded for clinical expediency; however, they were initially included to aid the subject in generalizing to other, more sophisticated tests.

Bricker and Bricker (1969) evaluated the establishment of auditory stimulus control with four groups of low-level children. Four different operant-training sequences were used: (a) initial response rate building; (b) light discrimination (white light versus no light); (c) transition (pairing a tone with a gradually fading white light versus no tone); and (d) tone discrimination (tone versus no tone). To determine the efficiency of the different sequences, 36 experimental subjects were divided into four treatment groups. Two groups started with rate building and progressed through sequences b, c, and d. One group started with light discrimination and progressed to sequences c and d, while a fourth treatment group started with tone discrimination and was not exposed to sequences a, b, or c.

The following results were obtained:

1. Operant audiometry techniques were effective in assessing hearing sensitivity levels of low-functioning retardates.

2. Substantial time saving was possible with subjects who began with tone discrimination, sequence d, as opposed to those in other treatment groups.

3. Reliable audiograms ($\pm$10dB for five of seven frequencies presented bilaterally during two evaluations by two experimenters) were obtained for 27 subjects. Six subjects provided reliable audiograms in one ear only while 3 subjects failed to provide reliable audiograms in either ear.

The review of the literature to this point has centered on the development and use of operant audiometric-testing techniques with retarded children. These operant procedures for the most part have used continuous food reinforcement following each correct response. Although reinforcement has been found to be effective in maintaining response control during audiological testing, the effect of frequency of reinforcement has not been examined.

The literature on the use of intermittent (partial) reinforcement in free-operant (lever-pulling) tasks has indicated that subject control can be maintained over time. Long, Hammack, May, and Campbell (1958) studied the effects of various schedules of reinforcement (fixed ratio, fixed interval, and variable interval) on free-operant, lever-pulling behavior. Approximately 200 "normal" children, varying in age from four to eight years, were used as subjects. Plastic trinkets, pennies, and 35mm Kodachrome transparencies were used as reinforcers. The younger children worked well for trinkets, while the older children required a combination of trinkets, pennies, and transparencies. The results support the notion that the behavior of children can be maintained over time using varying intermittent reinforcement schedules.

Ellis, Barnett, and Pryer (1960) reported free-operant, lever-pulling performances with 30 Negro male retardates, using a Lindsley manipulanda (Lindsley, 1956). The authors found that intermittent reinforcement (fixed ratio, fixed interval, and variable interval) schedules, using M&M candies and cigarettes as reinforcers, sustained behavior control for long periods of time.

Orlando and Bijou (1960) reported the use of intermittent (variable interval, fixed interval, variable ratio, and fixed ratio) reinforcement schedules with 46 retarded children ranging in age from nine to 21 years.

Reinforcers consisted of a mixture of edible candies. The results indicate that stimulus control, over time, was "fairly good." Effects of satiation, fatique, and boredom were minimal with candy reinforcers.

Free-operant research using intermittent food reinforcement with retarded children indicates that behavior control can be maintained for long periods of time. The results of these studies also suggest that intermittent reinforcement could be generalized to other situations where the maintenance of a similar behavior is necessary for long periods of time.

Summary

A review of the literature reveals that operant audiometric techniques currently used in assessing auditory sensitivity of severely and profoundly retarded have been successful, using continuous food and/or social reinforcement. Although the use of intermittent food reinforcement has not been applied to operant audiometric techniques, related research has demonstrated the usefulness of intermittent reinforcement in maintaining free-operant behavior over time. It would, therefore, appear that the use of intermittent reinforcement may be applicable to audiometric procedures.

Chapter 3

Procedure

Experimental Design

The experiment was designed to compare the effects of continuous and intermittent reinforcement on the maintenance of auditory stimulus control with severely and profoundly mentally retarded children. Two reinforcement schedules, continuous (CRF) and fixed ratio (FR-3), were used. An auditory pure-tone signal was used as the stimulus. Stimulus control was determined by an analysis of responses made in the presence of the stimulus and responses made during alternating (non-audible) control periods for each reinforcement schedule. Each reinforcement schedule was replicated on two occasions. Schedules were counterbalanced between two groups of subjects. Group and reinforcing schedule counterbalancing are shown in Figure 1.

Figure 1 About Here

The experiment was also designed to evaluate the effects of non-reinforcement on the assessment of auditory thresholds after initial maintenance on either CRF or FR-3 reinforcement schedules. Auditory thresholds were determined using a Hughson-Westlake descending procedure. Auditory threshold (four per subject) were assessed following each reinforcement condition.

Subjects

Ten severely and profoundly retarded children (four male and six female, residents of Parsons State Hospital and Training Center) were selected as subjects. Subject-selection criterion were based on: (a) prior operant audiometric experience with a two-year elapsed period since the initial, and

Figure 1

Counterbalance Design for Subject Groups

Group A	4 Sessions	1 Session	4 Sessions	1 Session	4 Sessions	1 Session	4 Sessions	1 Session
Condition [a]	Stimulus Control	Threshold Assessment	Stimulus Control	Threshold Assessment	Stimulus Control	Threshold Assessment	Stimulus Control	Threshold Assessment
Reinforcement [b]	CRF	None	FR-3	None	CRF	None	FR-3	None

Group B								
Condition	Stimulus Control	Threshold Assessment	Stimulus Control	Threshold Assessment	Stimulus Control	Threshold Assessment	Stimulus Control	Threshold Assessment
Reinforcement	FR-3	None	CRF	None	FR-3	None	CRF	None

Note.— a, Stimulus Control=Stimulus Control Maintenance, 15dB re: Estimated Threshold.
Threshold Assessment=Auditory Threshold Assessment, Hughson-Westlake Descending Technique.
b, CRF=Continuous Reinforcement.
FR-3=Fixed Ratio Reinforcement.
None=No Reinforcement.

most recent, operant audiometric test; and (b) normal auditory sensitivity (re: ISO, 1964) at the time of the last audiometric test. All subjects had previous training and had been assessed with operant audiometric testing procedures using continuous food reinforcement. Previous training included preliminary selection of reinforcers, earphone placement, and response training similar to that described in Appendix A.

Table 1 indicates the chronological age, sex, measured intelligence (MI) classification level (Heber, 1961), and previous operant data for each experimental subject.

Table 1 About Here

Two MI level V females who met the subject-selection criterion listed above were later rejected; therefore, Table 1 describes only eight subjects. One rejected subject was seen for 11 pretraining sessions. During these sessions, response consistency was insufficient to complete the pretraining sequence. The second rejected subject was seen for eight pretraining sessions. She completed the pretraining sequence; however, during the estimated threshold assessment, she ceased responding. Appropriate responding was not re-established with two additional sessions.

Equipment

All experiments were conducted in noise-controlled control (IAC, Model 800) and experimental rooms (IAC, Model 400). A pure-tone audiometer (Allison, Model 22) produced the auditory signals and controlled the signal intensity. A sound level meter (Bruel and Kjaer, Model 2203), condenser microphone (Model 4132), and artificial ear (Model 4152) were used to periodically check the calibration of the auditory signals.

Table 1

Subject Characteristics and Previous Operant Audiometric Data

for Initial Operant Audiometric Test

Subjects	Sex	CA (12-31-68)	Measured Intelligence	Previous Operant Audiometry Data[a]				
				Age	Sessions	Stimuli Presented	Stimuli Identified	Total Responses
Group A								
TB	M	9-10	IV	7-8	4	278	175	542
KD	F	8-8	IV	6-0	4	194	141	242
FK	M	13-1	V	10-11	4	179	144	255
RL	F	9-2	IV	6-5	6	258	176	146
Group B								
JM	M	11-9	V	8-10	10	367	349	1260
TP	F	10-0	IV	7-9	3	166	108	213
ER	M	11-0	V	8-7	8	443	265	79
JH	F	9-9	IV	7-2	6	333	174	418
Mean		10-4		8-0	5.62	264.7	191.5	394.4

Note.—a, Tabulations of age at time of examination, numbers of sessions, stimulus presentations, stimulus identifications, and total responses necessary to achieve stimulus control prior to pure-tone screening and/or threshold assessment.

The stimulus presentations and temporal parameters were controlled by electromechanical relay, behavioral-research components. The components were programmed with a MAC (Model 901) panel. (See Appendix B for program schematic.)

The experimental room was equipped with two speakers, a table and chair, earphones (TDH39 with MX41/AR cushions), and a response-reinforcement delivery apparatus consisting of a small response box attached to a larger reinforcement delivery box. (See Figure 2.)

Figure 2 About Here

The response box consisted of a two-inch diameter plexiglass button, inlayed with perforated stainless steel, mounted on a Foringer response key. The top of the response box was covered with a stainless steel plate. The stainless steel plate and response key were connected to a capacitance switch which was activated upon by physical contact during all intertrial periods.

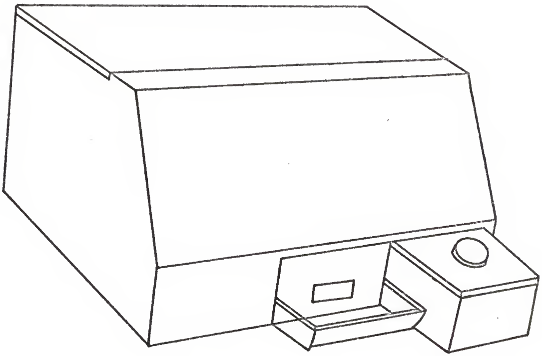
The reinforcement delivery box included a Davis (Model 310) universal feeder. A light, door chime, and goal box was also included. The goal box received the reinforcers, while the light and door chime provided immediate visual and auditory feedback (secondary reinforcers) when the subject made a reinforced response.

Experimental Programming

Auditory stimuli. Auditory stimuli, 1000 Hertz (Hz), were presented and temporally controlled by the relay apparatus. Auditory stimuli and control periods were presented on a variable-interval (VI) schedule of 6 seconds. Schedules, however, were dependent upon responses to tone or control periods and to intertrial responses which resulted in time-out delays.

Figure 2

Response-Reinforcement Delivery Apparatus



Stimulus durations were predetermined and controlled by an electronic timer. Durations ranged from 2 to 5 seconds during pretraining, but remained constant (2 seconds) during all experimental conditions.

Control periods. Control periods (non-audible periods) maintained the same temporal characteristics as the stimulus periods and were presented alternately with the stimulus periods. The interval between stimulus and control periods was VI-6 seconds if the subject made no intertrial responses. Control periods provided a systematic means of evaluating whether a subject's responses were discriminative or random.

Pre-post delays. Pre-post delays, as described by Fulton and Spradlin (1968a), were used to minimize inappropriate reinforcement for random responses made simultaneously with the onset and termination of the stimulus. The "pre-timer" delayed (300 milliseconds) the activation of the response circuit. Responses occurring during the first 300 milliseconds terminated the stimulus and provided no reinforcement. Responses occurring after the first 300 milliseconds terminated the stimulus and provided reinforcement. To control non-reinforcement for responses made simultaneously with the termination of the stimulus, a "post-delay" (300 milliseconds) was inserted in the response circuit. Responses made during the last 300 milliseconds following the termination of the stimulus were reinforced. The pre-post delays allowed the response circuit to remain open for the same time period (2 seconds) as the stimulus and control periods. Thus the response circuit opened and closed 300 milliseconds after the onset and termination, respectively, of the stimulus period.

The pre-post delays were also in effect for the recording and determination of responses made during the control periods. Figure 3 illustrates the stimulus (or control) period with an overlay of the response time period.

Figure 3 About Here

Responses. A response occurring during a stimulus period was reinforced and recorded as a correct response. A response occurring during a control period was recorded as a control response and was not reinforced. Responses other than correct or control responses were recorded and termed intertrial responses (ITR). These responses were not reinforced and resulted in a postponement (time-out) of the next stimulus and/or control event.

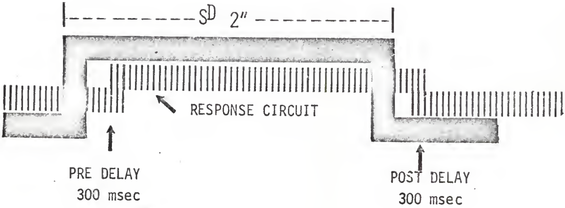
Time-out periods. Time-out (time out from opportunity to earn reinforcers) periods were a minimum of 5 seconds; however, continual responding or physical contact with the response apparatus would result in an indefinite time-out, during which time the automatic program was inoperative. The automatic program sequence would re-activate 5 seconds after physical contact or responding terminated. As a result, time-out periods reduced the probability that subjects would leave their hand on the response button or in the immediate environment. Physical contact other than actual button depression affected time-outs but was not recorded as an intertrial response.

Experimenter controlled time-out periods (20-40 seconds) were initiated during pretraining if the subject removed the earphones or moved about the experimental room. Time-out periods were also used when similar behavior was noted during experimental sessions. Programming was contingent upon appropriate earphone placement on the subject's head and the subject being seated in front of the response-reinforcement delivery apparatus.

Reinforcement. Reinforcement (food) delivery was programmed for each correct response during CRF conditions. The door chime and light were paired with reinforcement delivery. Reinforcers were delivered on every third

Figure 3

Pre-Post Delay



Note.— Reprinted from a paper by Fulton, R. T. & Spradlin, J. E., Parsons Demonstration Project Report Number 90, Parsons State Hospital & Training Center, Parsons, Kansas, 1968(a).

correct response during FR-3 conditions. Secondary reinforcers (door chime and light) were paired with food deliveries. No reinforcement occurred for the two correct interim responses. A schematic diagram of the automatic program wiring may be found in Appendix B.

Control criteria. Stimulus-control criterion was defined as responding correctly to five consecutive stimulus presentations with no responses during the five alternating control periods (5/0). Each subject was required to meet this criterion prior to progressing to the next pretraining step.

Subjects were also required to meet a stimulus-control criterion (5/0) within 36 alternating pairs of stimulus and control periods immediately preceding threshold assessment. When stimulus control was attained, auditory thresholds were assessed. If control was not attained within 36 alternating trial pairs, the session was terminated on the basis that insufficient control was maintained.

Auditory threshold assessment and criterion. All thresholds, estimated thresholds with continuous reinforcement and subsequent experimental thresholds (four) with no reinforcement, were assessed using a Hughson-Westlake descending procedure. In this procedure, the stimulus intensity was decreased in 10dB decrements for each correct response until the subject failed to respond. The stimulus was then increased 10dB and attenuated in 5dB increments after each correct response. This procedure was repeated until thresholds were obtained.

Fifty stimulus presentations were presented to each subject during each threshold assessment session. Threshold was defined as the lowest intensity level at which a minimum of four stimulus presentations were presented and correctly identified 50 percent of the time. During threshold testing, responses occurring during control period presentations were recorded.

Thresholds were judged invalid if control responses exceeded 20 percent of those control periods presented.

Experimental Procedure

Pretraining. Because the subjects had had previous experience with similar procedures, preliminary steps such as selection of reinforcers, experimental room adjustment, earphone placement, and response training, were omitted. (See Appendix A for total program.)

If the subjects failed to respond within the first 36 stimulus presentations, hand-shaping techniques were used until an appropriate response was established. Automatic programming (Step 2) was then initiated.

Step 1 The experimenter took the subject into the experimental room, seated him in front of the response-reinforcement delivery apparatus, and placed the earphones on his head. The experimenter then left the experimental room to activate the automatic program.

Step 2 Test Frequency: 1000 Hz at 30dB Sensation Level (SL) or 60dB (ISO, 1964) if the SL was unknown.

Stimulus Duration: 5 seconds with .3 second pre-post delays.

Stimulus and control period presentation interval: VI-6 seconds.

Stimulus Presentation: Bilateral.

Response: Button press.

Time-out: 5 seconds subsequent to termination of physical contact.

Stimulus-Control Criterion: 5/0.

Reinforcement: CRF.

Step 3 Reduce stimulus and control period duration from 5 to 3 seconds.

Stimulus-Control Criterion: 5/0.

All other contingencies remain unchanged.

Step 4 Reduce stimulus and control period duration from 3 to 2 seconds.
Stimulus-Control Criterion: 5/0.
All other contingencies remain unchanged.

Step 5 Change stimulus presentation from bilateral to unilateral (test ear).
Stimulus-Control Criterion: 5/0.
All other contingencies remain unchanged.

Step 6 Threshold assessment: Determine estimated threshold (ET).
All other contingencies remain unchanged.

Experimental. To determine the maintenance of auditory-stimulus control, subjects were presented a 2-second, 1000 Hz stimulus at 15dB re: estimated threshold, with alternating control periods. Fifty alternating stimulus and control periods were presented to each subject during each session. This schedule was presented for four consecutive sessions. Two alternating reinforcement schedules (Figure 1) were utilized with two groups of subjects. One subject group started with CRF and alternated FR-3, CRF, FR-3, while the second group started with FR-3 and alternated CRF, FR-3, CRF.

Auditory thresholds, with no reinforcement, (Figure 1) were obtained on every fifth session with each subject to determine the effects of continuous and intermittent reinforcement on subsequent non-reinforced auditory thresholds. Prior to actual threshold assessment, each subject met a stimulus-control criterion (5/0) with reinforcement. Reinforcement delivery during pre-threshold stimulus control criterion testing was based on the current reinforcement schedule. That is, subjects receiving CRF or FR-3 reinforcement during auditory stimulus control maintenance were reinforced with that schedule during pre-threshold stimulus control criterion testing. Auditory thresholds with no reinforcement were assessed for each subject meeting the stimulus-control criterion. Subjects failing to meet the necessary control criterion were terminated and no auditory threshold was obtained. Thresholds were determined for 50 alternating stimulus and control period trials.

Chapter 4

Results

The results are presented and discussed according to: pretraining, auditory stimulus-control maintenance, and auditory threshold variability. Descriptive statistics (means) and graphic plots are used to present the results.

Pretraining

Pretraining was not a primary area of investigation. An examination of the initial pretraining session performance data, however, provided an indication of the subjects' ability to retain the response task (there was a two-year interval between initial training and this experiment).

Three subjects (TB, FK, and JM) responded appropriately within the first 36 stimulus presentations. These subjects required no response re-training. Five subjects (KD, RL, TP, ER, and JH) failed to respond appropriately during the first 36 stimulus presentations; therefore, hand-shaping techniques were used to re-train an appropriate button pressing response. Four of the five subjects established the desired response with minimal experimenter assistance during the first session. One subject required six additional sessions to establish the response.

Pretraining performances (number of sessions, stimulus presentations, stimulus identifications, control responses, total responses, and total pretraining time) for each subject are provided in Table 2.

Table 2 About Here

Tables 1 (initial training) and 2 (current pretraining) indicate the total number of sessions, stimulus presentations, stimulus identifications,

Table 2

Pretraining Results

Subjects	No. of Sessions Required	Stimuli [a] Presented	Stimuli [b] Identified	Control Responses	Total [c] Responses	Total Time (Minutes)
TB	3	200	98	49	849	92.10
KD	2	74	38	6	99	28.35
FK	2	23	23	0	154	38.10
RL	13	618	183	23	884	289.48
JM	3	147	116	53	1519	80.68
TP	3	186	78	15	279	70.52
ER	3	75	82	0	78	43.00
JH	2	106	59	12	485	57.23
Mean	3.87	178.6	84.6	19.2	543.4	87.45

Note:—a, An equal number of control periods were presented.
b, Number of stimuli correctly identified and reinforced.
c, The difference between total responses and stimulus responses plus control responses are intertrial responses.

and total responses required to establish stimulus control for pure-tone screening and/or threshold assessments. A comparison of the data on Table 1 and 2 indicates that most subjects required fewer sessions, stimulus presentations and stimulus identifications for the experimental pretraining phase than were initially required for previous operant audiometric sessions. Total responses, however, were generally higher for the experimental pretraining sessions than for the initial operant sessions.

No test times were available from the initial records; therefore, time comparisons could not be made. The total time (minutes) required for each subject to complete the experimental pretraining phase is presented in Table 2. Pretraining times ranged from 28.35 to 289.48 minutes, with a mean of 87.45 minutes. With the exception of one subject (RL), pretraining was completed in an average time of 58.59 minutes.

These data support the notion that the re-establishment of auditory stimulus control is less difficult once stimulus control has previously been established. A large percentage of the subjects (seven of eight subjects) quickly re-established the response pattern with minimal or no assistance from the experimenter.

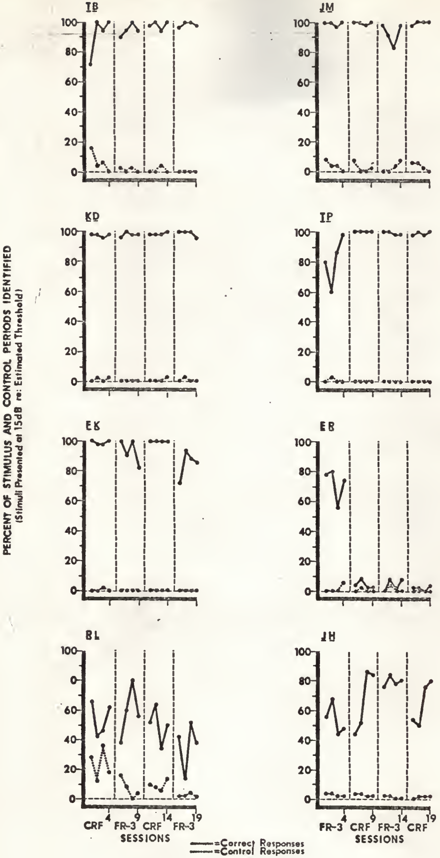
Auditory stimulus control maintenance

Subject performances during auditory stimulus control maintenance are presented in Figure 4. The data indicate the percentage of stimulus and control responses for each subject during each session for both reinforcement conditions (CRF and FR-3).

Figure 4 About Here

Figure 4

AUDITORY STIMULUS CONTROL MAINTENANCE



The strength of stimulus control was determined by the relationship between stimulus and control responses. Generally, the greater the difference between stimulus and control responses, the greater the degree of auditory stimulus control. For example: one subject (KD) responded appropriately to almost 100 percent of the stimulus presentations while not responding to more than 4 percent of the control presentations. This subject was considered to be under good auditory stimulus control. Subject (RL) generally responded to less than 70 percent of the stimulus presentations and to as much as 36 percent of the control presentations. This subject, therefore, was considered to be under less adequate auditory stimulus control.

One subject (ER) identified 60 to 80 percent of the stimulus presentations during the first reinforcement condition (FR-3), but failed to respond to more than 10 percent of the stimulus and control presentations during subsequent conditions. During these latter conditions, this subject indicated essentially no auditory stimulus control.

Five subjects (TB, KD, FK, JM, and TP) consistently maintained good auditory stimulus control. They responded correctly to 80 percent or more of the stimulus presentations during a majority of the sessions. The subjects generally responded to less than 6 percent of the control presentations during most sessions.

Three subjects (JH, RL, and ER) demonstrated lesser degrees of auditory stimulus control than did the five previously mentioned subjects. One subject (JH) responded to more than 50 percent of the stimulus presentations and to less than 5 percent of the control presentations. A second subject (RL) tended to respond to less than 70 percent of the stimulus presentations and to less than 20 percent of the control presentations. The third subject (ER) maintained auditory stimulus control during the first reinforcement condition (FR-3) and then ceased to respond. This subject responded to less than 10 percent of the stimulus and control presentations during subsequent reinforcement conditions.

The data reveal that auditory stimulus control was maintained for most subjects using both schedules of reinforcement. However, auditory stimulus control generally appeared more variable when FR-3 reinforcement was used.

During auditory stimulus control maintenance, intertrial response rates for all subjects were recorded (Figure 5). High intra- and inter-subject variability of ITR rates required that the data be plotted on a logrithemic scale.

There was no indication that either reinforcement condition resulted in significantly higher or lower ITR rates. It was noted, however, that subjects demonstrating greater auditory stimulus control generally indicated less variable or lower ITR rates than those subjects demonstrating lesser degrees of auditory stimulus control.

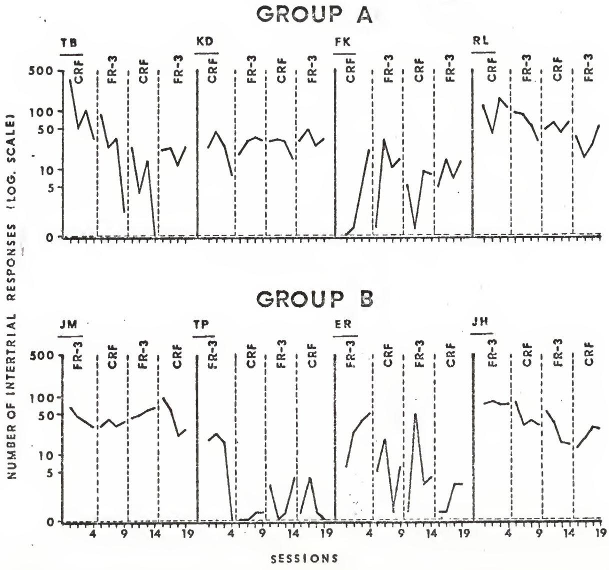
Figure 5 About Here

Auditory threshold variability

Auditory thresholds, both estimated and experimental, were obtained on all experimental subjects. Thresholds were obtained using a Hughson-Westlake descending procedure. Experimental thresholds were based on 50 stimulus presentations, and the experimental auditory threshold was defined as the lowest intensity level at which at least a 50 percent correct response rate occurred with a minimum of four trials for that level.

Figure 5

Intertrial Responses



The estimated threshold (initial threshold) was obtained with continuous reinforcement. Subsequent experimental thresholds (four) using no reinforcement were obtained on the fifth session of each reinforcement condition. These threshold values are plotted for each subject in Figure 6.

Figure 6 About Here

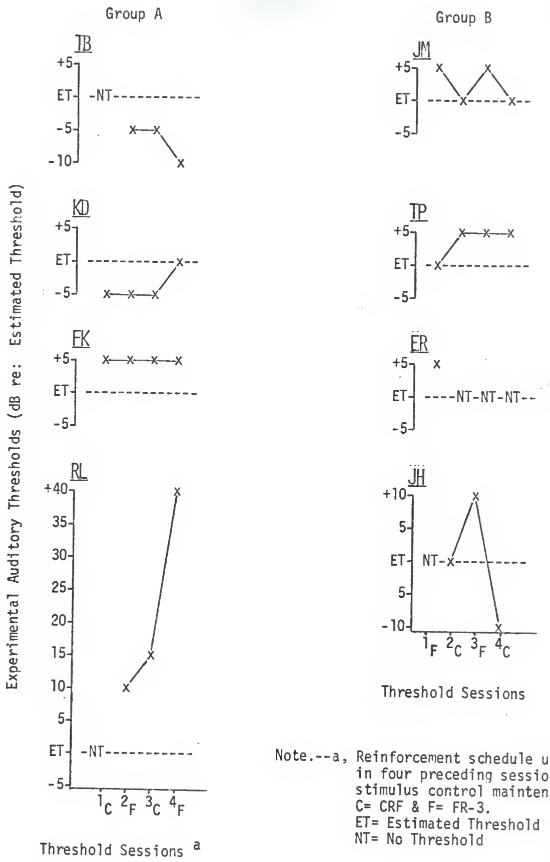
Auditory thresholds were obtained from four subjects (KD, FK, JM, and TP) for all experimental sessions. Thresholds were obtained from three subjects (TB, RL, and JH) for three sessions, while a threshold for only the first experimental session was obtained from one subject (ER).

Subjects TB and RL met the pre-threshold stimulus-control criterion for the first experimental threshold session, but failed to meet the auditory threshold criterion. JH failed to meet the pre-threshold stimulus-control criterion during the first experimental threshold session; therefore, the subject was excused and a threshold was not obtained. A threshold measurement was obtained from ER during the first experimental threshold session, but the subject failed to meet the pre-threshold stimulus control-criterion during subsequent threshold sessions.

Experimental thresholds did not significantly differ from the estimated threshold; 14 thresholds were higher (poorer) and 12 were equal to or lower (better) than the estimated threshold. Experimental thresholds for 5 subjects (TB, KD, FK, JM, and TP) tended to be within ±5dB of the estimated threshold. Thresholds for subjects RL and JH generally exceeded ±5dB.

Although threshold variability was within ±10dB for most subjects, responses made during threshold sessions varied. Stimulus responses at the

Figure 6



Note.--a, Reinforcement schedule used in four preceding sessions of stimulus control maintenance, C= CRF & F= FR-3.
ET= Estimated Threshold
NT= No Threshold

lowest intensity level followed three different patterns. These patterns were plotted from the lowest stimulus response levels for each threshold descent (Hughson-Westlake descending procedure) and are shown in Figure 7.

Figure 7 About Here

The three patterns (patterns on Figure 7 are coded with description below, i.e., a, b, and c) reveal: (a) consistent responses at or near the same intensity level for all threshold descents with an equal consistency in the absence of responses at or near the next lower intensity level; (b) consistent responses at or near the same intensity level for most threshold descents with a gradual increase in the intensity level and deviation from the previous lowest response level during the latter threshold descents; and (c) responses at or near the same intensity level during the first four or five threshold descents, followed by a greater increase in the intensity level and deviation from the previous lowest response level for all remaining threshold descents.

A comparison of the threshold response patterns with auditory stimulus control maintenance data (Figure 4) reveals that subjects who demonstrated good auditory stimulus control generally provided threshold response patterns more closely resembling patterns a or b. Subjects demonstrating lesser degrees of auditory stimulus control generally provided threshold response patterns resembling b or c. It therefore appeared that threshold response variability was influenced by intra-subject stimulus control.

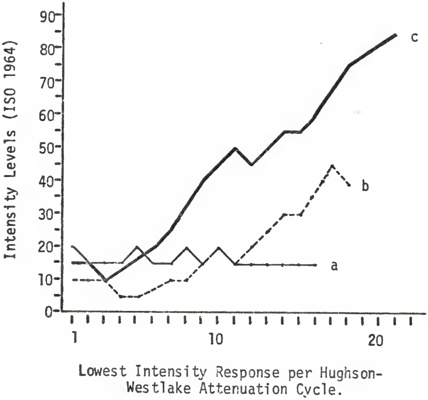
Summary

The following results were obtained:

1. Response re-training was generally less difficult than initial response training.

Figure 7

Auditory Threshold Patterns



Note.--See text (p.34) for a, b, and c definition.

2. Auditory stimulus control was maintained with most subjects using either continuous or intermittent reinforcement schedules.

3. Non-reinforced auditory thresholds generally fell within ±5dB of the estimated threshold during most experimental threshold sessions; subjects demonstrating good auditory stimulus control generally provided less variable thresholds than did subjects demonstrating poorer auditory stimulus control.

4. Response variability during threshold testing tended to be related to the degree of auditory stimulus control maintained prior to threshold testing.

Chapter 5

Summary

Various studies have provided pertinent information on the use of operant audiometric testing techniques with severely and profoundly retarded children. These studies, for the most part, have used continuous (food and/or social) reinforcement. It was speculated that continuous food reinforcement may result in various incompatible behaviors which affect the assessment of auditory thresholds. It was felt that incompatible behaviors associated with food reinforcement delivery may be reduced or eliminated by using intermittent or no reinforcement. Intermittent reinforcement conditions, however, have not been systematically investigated with respect to the audiometric testing of severely and profoundly retarded children.

This study was designed to investigate the maintenance of auditory stimulus control under conditions of continuous and intermittent reinforcement using edible reinforcers. The study was also designed to investigate the effects of no reinforcement on audiometric thresholds following sessions of stimulus control maintenance using continuous and intermittent reinforcement.

To compare the effects of continuous and intermittent reinforcement on auditory stimulus control maintenance, two reinforcement schedules (continuous and fixed ratio-3) were used. Each reinforcement schedule was counterbalanced between two groups (four subjects each) and was presented on two occasions.

Stimulus and alternating (non-audible) control presentations (50 each) were presented to each subject during each session. Subjects were maintained on a given reinforcement schedule for four consecutive sessions prior to being exposed to the alternate reinforcement schedule.

Stimulus control was determined by an analysis of responses made in the presence of the auditory stimulus and responses made during the alternating control (non-audible) periods.

The results revealed that auditory stimulus control was maintained with most subjects using both schedules of reinforcement. Stimulus control was, however, slightly more variable when intermittent (FR-3) reinforcement was used.

To investigate the effects of no reinforcement on threshold variability, non-reinforced thresholds were obtained following each auditory stimulus control condition. Prior to threshold testing, each subject was required to meet stimulus-control criteria with the current reinforcement schedule. Subjects failing to meet the criteria were excused and no threshold was obtained. Thresholds were obtained with subjects meeting the criteria using alternating stimulus and control presentations (50 each).

The results showed the acceptable auditory threshold can be obtained using no reinforcement with most subjects. Thresholds generally fell within $\pm$10dB variability. Response variability during threshold testing tended to be related to the amount of auditory stimulus control maintained with reinforcement prior to threshold testing.

Recommendations

Further research on the use of intermittent reinforcement for the maintenance of auditory stimulus control prior to threshold testing and during threshold testing is indicated. Such research may provide additional information to the question of minimizing incompatible behaviors, associated with edible reinforcers, during audiometric testing. Further exploration of the variables involved in the use of various intermittent reinforcement schedules are recommended.

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APPENDIXES

APPENDIX A

Detailed Procedure for Obtaining
Audiometric Thresholds Via the Positive
Reinforcement Discrimination Program.

PARSONS DEMONSTRATION PROJECT

REPORT NO. 91

NOVEMBER, 1968

Detailed Procedures for Obtaining Audiometric Thresholds Via the Positive Reinforcement Discrimination Program

Robert T. Fulton

and

Joseph E. Spradlin

These papers essentially represent a series of reports involving all aspects of the Demonstration Project. As such, they may range from reports on clinical activities to more formal research papers intended for publication. Circulation of these reports is limited to Parsons State Hospital and Bureau of Child Research staff. Distribution to other interested persons will be made at the discretion of the authors.

The following audiologic test procedures (positive reinforcement discrimination) are employed with mentally retarded difficult-to-test persons in the Speech and Hearing Clinic, Parsons State Hospital and Training Center.

These procedures have been designed to be operative with the Allison 22 audiometer and the electro-mechanical relay programming system described by Worthy, Fulton, and Hurt (Parsons Demonstration Project Report No. 85 - Rev.).

Reinforcer:

The examiner should select an effective reinforcer prior to the beginning of training. The subject will tell the examiner, in a variety of ways, what is a good reinforcer. If the reinforcing event is nutritive, the child may make such responses as opening his mouth or sticking out his tongue if the nutritive is placed near his mouth. If the reinforcing event is social, the subject may smile or laugh or attempt to hold the E's hand. A reinforcing event is anything which a specific child "will work to obtain."

Earphone Placement:

After the child is seated in the experimental room, the earphones are put in place. Many severely retarded children will allow the earphones to be placed in position and will not attempt to remove them. In this case, the examiner should place the earphones in position and proceed directly to the training program.

If the child refuses the earphones initially, several techniques can be used to train the child to wear them. The examiner may choose to deliver reinforcement contingent on the child allowing the earphones to be brought closer and closer to position. Such successive approximation training is usually effective but is often slow.

A second procedure is to simply place the earphones in position and hold them in place applying pressure with the thumbs behind the child's ears as long as the child struggles. When the child relaxes, pressure is removed. If the child begins to struggle again, pressure is reinstated. The procedure is not elegant, but it is usually effective. During this procedure the examiner may choose to deliver positive reinforcement to the child when he is not resisting. This may speed up the training process for two reasons: first, reaching for reinforcement is somewhat incompatible with resisting earphones and secondly, ceasing to resist is reinforced by release of pressure and by positive reinforcers.

Once the child is wearing the earphones, the experimenter trains the subject to make the response by presenting the tone and demonstrating the response. After each demonstration, the child is reinforced. After a couple of demonstrations, the examiner takes the child's hand and moves it through the response pattern while the tone is present. The child is reinforced. After two or three such aided responses, the child can often perform the response himself. If the child does not respond independently after 10 or 12 aided trials, it may be necessary to go to a shaping procedure.

Response Button:

The response button (Foringer) requires a downward pressure for activation. A light, controlled by a dimmer, is mounted under the plexiglass and perforated steel response button. The light may be used as a visual cue (lights up during S^D period) during the initial training phases. As the subject comes under control the light is gradually dimmed until the auditory signal is the only clue to the S^D. The light may be left on continuously as a cue to the physical location of the response button. Most subjects, however, do not require the use of the light; and the absence of a light does not prolong training.

Once the child is making the response independently, the following automatic training program is instituted.

Initial Program (Automatic) for Training

Training is aimed toward establishing a response to a change in the auditory signal as a discriminative stimulus (S^D), rather than establishing a response to the simple presence of a tone. This technique is used because later stages of hearing testing oftentimes require the child to respond to a change in tone intensity or to a tone superimposed on a background signal (i.e. masking or pedestal tone).

Ambient Noise:

A background of controlled ambient noise is used. The subject is trained to respond to discriminative stimuli which differ in intensity and/or frequency. These discriminations are often later needed in the masking of unilateral air conduction losses or bone conduction thresholds. Intensity discrimination in the presence of a pedestal tone is required for the Short Increment Sensitivity Index (SISI). Training the subject to respond to ambient noise from the "outset" is easier than "fading in" the necessary background signals at a later date. Once the subject has been trained to respond differentially, the background signal can be eliminated, with no adverse effects, for threshold measurements.

Narrow band masking (750 Hz) is initially used as a background signal. The masking signal is presented at an intensity above threshold and approximately 20-30 dB below the peak intensity of the S^D. (Narrow band filters reduce the mean power of white noise by approximately 20 dB. A system for obtaining appropriate masking levels with the Allison 22 audiometer and Model 25 Filter is as follows: Insert white noise into Channel 2, calibrating the signal with the filter in the "out" position, on the VU meter. Adjust the Channel 2 attenuator to the same level as the test signal (Channel 1) and then turn the filter to "in". The masking level will be approximately 20 dB below the peak intensity for the S^D.) The ambient noise background is presented bilaterally until later phases in the training program.

Test Signal (S^D):

A 500 Hz tone of five seconds (5") duration is used as the initial S^D. The S^D is presented at 30 dB above the subject's estimated threshold or at 70 dB re audiometric zero. A more intense tone may be required if the subject is thought to have a significant hearing loss. A 500 Hz signal has been found to be pleasant and sensitive to most subjects. (In the automated program, the test signal is presented through Channel 1.)

Test Signal (S^D) Parameters:

The S^D duration (5") is controlled by a timer. A reinforcer is delivered if the subject responds during the S^D period. In order to control against reinforcement of 'chance' responses made simultaneously with the onset of the S^D (the S^D would not be audible to the subject) a "pre-timer" delays (300 milliseconds) the activation of the response circuit. Also to control against the non-reinforcement of responses made simultaneously with the termination of the S^D (the termination of the S^D would not be apparent) a "post-timer" delays (300 milliseconds) the termination of the response circuit. That is to say that the response circuit remains open the same duration as the S^D but is shifted 300 milliseconds later in time. The test signal is presented bilaterally until later in the training program.

Control Periods:

Non-audible periods with the same temporal characteristics as the S^D are alternated (50% duty cycle) with the S^D. The use of control periods provides a systematic check on whether the subject's responses are discriminative or due to chance.

Presentation of S^D and Control Periods:

The alternating S^D and control periods are presented on a variable interval of six seconds (VI-6"). That is, the periods are initiated on the average of one each six seconds with variable intervals between presentations. VI schedules help control the S from responding to a fixed interval of time.

Inter-trial Interval and Responses:

The intervals between S^D and control periods are called the inter-trial intervals (ITI). Responses made during an ITI result in a five second (5") "time-out". The "time-out" is a period during which the program is inoperative and consequently a period during which reinforcement cannot be earned.

A stainless steel plate surrounds the response button and a perferated steel plate is embedded in the response button ("touch plates"). Bodily contact with these metal plates triggers a capacitance device which in turn initiates a "time-out" (time-out begins when contact is broken). The "touch plates" control against the subject fumbling or playing with the response mechanism when a trial is about to be presented. With the use of "touch plates", a trial cannot be presented until five seconds after the last contact. Trained responses, thereby, become discrete responses and are seldom associated with accidental touching or random playing with the response button.

Response Control Criteria:

The determination of whether a subject is under stimulus response control is determined by recording his responses to S^D and control periods. If the subject responds randomly, a significant percentage of the responses will occur during the control periods. If, however, he responds discriminatively, he will respond during S^D periods and refrain from responding during control periods. Subjects are required to meet response control criteria for each phase before moving to the next phase. Response criteria is defined as responding to all S^D periods with no responses during control periods for five consecutive and alternating pairs of presentations (5/0), unless otherwise specified.

The 'program' is programmed as described above and remains in effect until changes are specified in the detailed "phases" stated below:

Phase 1. Initiate initial program

Criteria: Obtain response topography (subjective evaluation of response control--disregard responses to control periods until the subject appears to be under control).

Phase 2. Response Control

Continue with the same program as Phase 1, but now evaluate responses to control periods (50%, alternating duty cycle for S^D and controls).

Criteria: Response control criteria (5/0)

(a) Response light (if used): Decrease light intensity by 20% for each two consecutive correct responses, and increase by 20% for each two consecutive S^D 'misses' Continue sequence until light is no longer visible.

Criteria: Response control criteria (5/0) without light

Phase 3. S^D Duration--I

Reduce S^D interval to 3"

Criteria: Response control criteria (5/0)

Phase 4. S^D Duration--II

Reduce S^D interval to 2"

Criteria: Response control criteria (5/0)

Phase 5. Ambient Noise Generalization--I

Generalize the narrow band ambient noise to adjacent noise bands (1K and 500 Hz) maintaining intensity at above threshold levels and 20-30 dB below the S^D intensity, or intensities as described in the initial program.

Phase 5. (cont'd)

Criteria: Response control criteria (5/0) for each band (return to successful bands as required to assist in generalization)

Phase 6. Ambient Noise Generalization--II

Generalize from noise bands to pedestal puretone frequencies (order 1K, 750, 500 Hz) maintaining pedestal intensity at 10 dB re estimated threshold

Criteria: Response control criteria (5/0) for each pedestal frequency (return to successful pedestals as required to assist in generalization)

Phase 7. "Fading-out" Background signal

Fade out 500 Hz background signal (last background signal used in Phase 6) in 10 dB increments for each two consecutive, correct responses.

Maintain S^D at 30 dB re estimated threshold.

Criteria: Response control criteria (5/0) after ambient noise level has been faded out

Phase 8. Stimulus Generalization

Generalize S^D to other frequencies (order 500, 1K, 2K, 4K, 8K, 2K, 500, and 250 Hz)

Phase 8. (cont'd)

Criteria: Two consecutive responses (2/0) at each frequency before moving to next frequency. If the S misses two consecutive responses return to a previously successful frequency for two responses, then try generalization again.

Phase 9. Intensity Generalization

Reduce S^D (500 Hz) intensity in 10 dB increments until control is lost or intensity has been reduced to near screening levels. Repeat at 1000 Hz.

Criteria: Two consecutive responses at each intensity level.

Phase 10. Unilateral Generalization

Unilaterally present 500 Hz S^D at 20-30 dB re estimated threshold.

Criteria: Response control criteria (5/0) for each ear

Phase 11. Threshold (or screening) Assessment

Criteria before assessment: The subject must meet response control each session before any threshold or screening measures are taken. Criteria (5/0)

Phase II. (cont'd)

Screening Program: The S is assessed for octave frequencies (250-8K Hz bilaterally) at 1964 ISO levels (equivalent to 15 dB ASA levels). If the S fails two or more frequencies for either ear he fails screening criteria and all frequencies are assessed per threshold program.

Threshold Program: Assess thresholds using the Hughson-Westlake descending schedule. Threshold is defined as the lowest intensity level at which the S maintains a 50% response rate for a minimum of at least six trials for that level. Assess bone conduction thresholds in a similar manner to that for air conduction thresholds. If air conduction thresholds differ by 40 dB or more between ears and/or bone conduction thresholds vary more than 10 dB between ears, masking should be applied. (See masking procedure.)

Masking Procedure

Phases 12-14 are intended only as pretraining and adaptation phases and should not be interpreted as correct masking procedures.

Phase 12. Present 500 Hz S^D (automatic, 2", with controls, VI-6) at 30 dB re SL bilaterally (i.e., 30 dB re better ear) with ambient narrow band masking level (500 Hz) at 30 dB re SL (masking should be calibrated with filter in the "out" position).

Criteria: Response control criteria (5/0)

Phase 13. Increase masking level 10 dB

Criteria: Response control criteria (5/0)

Phase 14. Masking and S^D Generalization.

Generalize to other frequencies (order 1K, 2K, 1K, and 250 Hz) with appropriate narrow band masking at 20 dB below S^D and S^D at 30 dB re SL for each frequency.

Criteria: Two consecutive responses (2/0) at each frequency before moving to next frequency. If the S misses two consecutive responses, return to the previously successful frequency. (If still unsuccessful, use a greater differential between masking and S^D.)

Phase 15. It is now assumed that the subject has completed pretraining masking procedures and is ready for masked auditory thresholds ('plateau style' masking procedures for bone conduction measures and 80 dB [re audiometric zero] narrow band masking for air conduction measures). Assess thresholds using standard procedures and the Hughson-Westlake descending threshold technique.

APPENDIX B

Audiometric Positive Reinforcement Program.

PARSONS DEMONSTRATION PROJECT

Report No. 85 (Revised) January, 1969

AUDIOMETRIC POSITIVE REINFORCEMENT PROGRAM

Riley C. Worthy, Robert T. Fulton, and Dennie D. Hurt

These papers essentially represent a series of reports involving all aspects of the Demonstration Project. As such, they may range from reports on clinical activities to more formal research papers intended for publication. Circulation of these reports is limited to Parsons State Hospital and Bureau of Child Research staff. Distribution to other interested persons will be made at the discretion of the authors.

Audiometric Positive Reinforcement Program

Riley C. Worthy, Robert T. Fulton, and Dennie D. Hurt

The Audiometric Positive Reinforcement Program herein described is used clinically and in applied audiologic research (Fulton & Spradlin, 1967 and 1968) in the Parsons State Hospital and Training Center Speech and Hearing Department and is a modification of the program employed by Lloyd, Spradlin, and Reid (1968) and Spradlin, Lloyd, Hom, and Reid (1968). The accompanying response and reinforcement delivery apparatus are basically the same as that described by Lloyd et al. (1968); however, other response and delivery apparatus would be applicable to this program. The auditory stimulus may be generated and the stimulus intensity controlled by instrumentation of the examiner's choice

In the Audiometric Positive Reinforcement Program, trials are presented on a variable interval (VI) schedule and reinforcement is made contingent upon a response in the presence of a tone. Through a switching arrangement, tones may be presented on every trial or, as a control feature, on alternate trials only

A trial begins with the onset of a tone. After the tone has been on for .3 seconds, the subject may respond and be reinforced. The delay at the onset of tone is the Pre-Tone Delay and insures that, in the event of short latency responses, the tone will not be turned off before it has had time to impinge upon the subject. If the subject fails to respond, the tone terminates after a predetermined interval and is followed by a .3 second Post-Tone period during which the subject may respond and be reinforced before the trial ends and the inter-trial interval (ITI) begins. Should the subject respond during the tone period, a reinforcer is delivered, the trial ends, and the ITI begins. Control trials are identical except that tone presentation and reinforcement are omitted. Responses which occur during the ITI produce a 5 second time-out (TO) during which a trial may not be initiated.

Circuit Description

For descriptive purposes, the circuit may be broken down into five functional networks: (a) The tape programmer system consisting of the Program Control (G-S E1100A which is labeled "Tape Programmer" in the schematic), a Gerbrand Model IA Variable Interval Timer (the "Tape Programmer" which is not shown on the schematic since its operation is controlled through the E1100A Program Control), relays (Ry) 6 and 7, and the time-out (TO) timer; (b) the intra-trial timing system which consists of the tone timer, pre-tone timer, and post-tone timer; (c) the reinforcement system consisting of pre-determining counter, Delay Relay #2, and Ry's 8 and 9; (d) a relay "flip-flop" consisting of Ry's 1 through 5 and Ry 10; and (e) a flip-flop delay system consisting of Delay Relay #1 and Ry 11.

Tape Programmer

Trial presentation is initiated by the tape programmer which provides a maintained ground level output from its BAB connections on a variable interval schedule. When a ground pulse is applied to the operate point of the programmer, it "recycles" the tape causing the maintained output from BAB to be removed. A trial is thus ended and the inter-trial-interval (ITI) defined.

Raw responses are shaped by the E783F Pulse Former and are connected to the "common" (C) studs of Ry's 6 and 7. Both relays are off during the ITI and on during a trial. Counters connected to normally closed (NC) and normally open (NO) of Ry 6 record responses which occur during the ITI and trials, respectively. Ry 7 is redundant; it routes responses to the time-out (TO) timer during ITI's and to the pre-tone timer during trials. In its Operate Reset-Normal mode, the TO timer is always timed out unless an ITI response resets it. If it is timing when the tape programmer produces an output, the onset of the trial is delayed.

Intra-Trial Timing System

The pre- and post-tone timers are set for .3 second timing cycles and the tone timer for the required tone duration. A maintained, ground level signal from the tape programmer is routed through the AAB connections of the TO timer to the operate studs of both the tone timer and the pre-tone timer. The post-tone timer is operated from AAB of the tone timer. Thus connected, the pre-tone and tone timers begin operation simultaneously. The pre-tone timer times out after .3 seconds; the tone timer after the interval for which it was set, and both remain in their timed out state until the post-tone timer, which began when the tone timer timed out, completes its .3 second cycle, operating the tape programmer causing it to recycle to the ITI removing power from all three timers. With this timing sequence, response from the NO of Ry 7 may pass through the pre-tone timer and be reinforced at any time from .3 seconds after tone onset to .3 seconds after tone cessation.

Reinforcement

During "tone on," relay 5 is in its quiescent state and "correct" responses appear on its right N.C. contact. They are then routed to the tape programmer through a diode (causing the program to recycle to ITI) and to common of Switch B. When the switch is in its normally closed position, responses are routed to the predetermining counter which delivers reinforcement at the appropriate ratio. With Switch B open, no reinforcment is delivered.

Flip-Flop

Alternation of control periods with tone periods is accomplished through the flip-flop circuit of Ry 1 through 4. A pulse at the junction of the diodes from C of Ry's 1 and 4 causes the flip-flop to change states and to remain so until the next input. Maintained ground is available from the NC of Ry 3 during tone periods and from the NO during control periods. Ry 10 is thus operated from the NC and delivers ground, derived from the ABA connections of the tone timer, to a tone source. Ry 5 is operated from the NO of Ry 3. The left C of Ry 5 receives maintained ground from the tone timer and delivers it to an indicator light during control periods.

A response from the right NO of Ry 5 recycles the apparatus during control and from the NC during a tone period. Both routes are through diodes which serve as back-path eliminators.

Flip-Flop Delay System

The flip-flop configuration is operated by any pulse which recycles the tape programmer. The flip-flop, however, changes states so rapidly that it is possible for a single response to be recorded in both control and tone periods; therefore, Ry 11 and delay relay #1 have been inserted to delay the flip-flop operation for about .5 to 1.0 seconds, or enough time for all apparatus to reset to the ITI state. Input to the flip-flop is the operate stud of Ry 11. A diode is connected between the programmer recycle line and Ry 11 to prevent back-paths. Switch A disables the flip-flop causing it to remain in one state or the other should it be so desired.

Touch Switch

The external metal frame of the response key is connected to the input of a solid state capacitance switch. When the subject makes physical contact with the response key, e.g. rests his hand on the key or "holds" the key between responses, the capacitance switch operates. The output of the capacitance switch is connected through Ry 6 to the operate point of the time-out timer, hence any contact with the response key during an inter-trial-interval produces a time-out as would a response.

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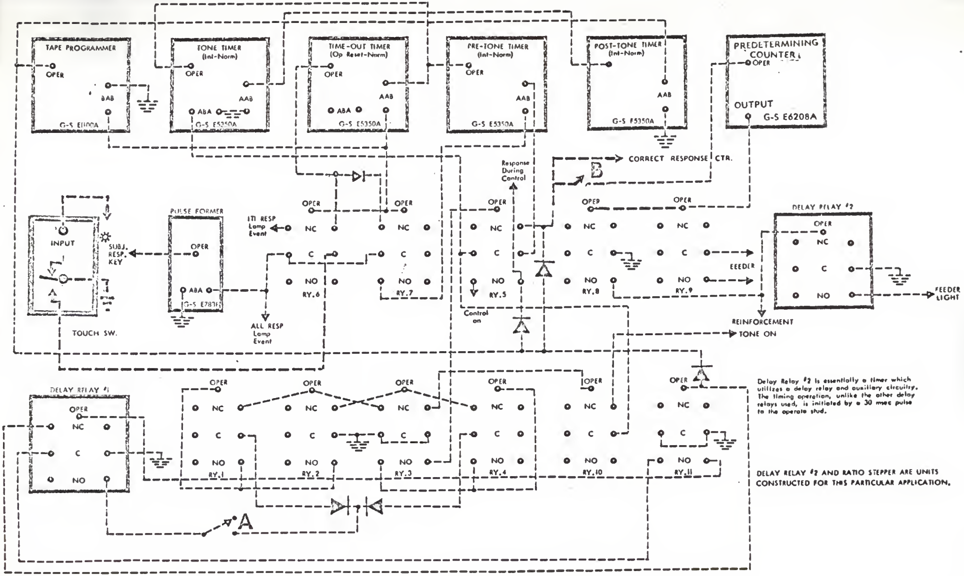

Delay Relay #2 is essentially a timer which utilizes a delay relay and auxiliary circuitry. The timing operation, unlike the other delay relays used, is initiated by a 30 msec pulse to the operate stud.

DELAY RELAY #2 AND RATIO STEPPER ARE UNITS CONSTRUCTED FOR THIS PARTICULAR APPLICATION.

SUBJECT RESPONSE KEY

A OPEN = TONE PRESENTED EACH INTERVAL
CLOSED = TONE AND CONTROL INTERVALS ALTERNATE

B OPEN = NO REINFORCER OR FEEDER LIGHT
CLOSED = REINFORCER & FEEDER LIGHT

AUDIOMETRIC POSITIVE REINFORCEMENT PROGRAM

EFFECTS OF REINFORCEMENT ON AUDITORY STIMULUS CONTROL AND THRESHOLD ASSESSMENT WITH RETARDED CHILDREN

by

MICHAEL JOHN REID

B.S., Little Rock University, 1963

AN ABSTRACT OF A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF ARTS

Department of Speech

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1969

Abstract

Various studies have provided pertinent information on the use of operant audiometric testing techniques with severely and profoundly retarded children. These studies, for the most part, have used continuous (food and/or social) reinforcement. It was speculated that continuous food reinforcement may result in various incompatible behaviors which affect the assessment of auditory thresholds. It was felt that incompatible behaviors associated with food reinforcement delivery may be reduced or eliminated by using intermittent or no reinforcement. Intermittent reinforcement conditions, however, have not been systematically investigated with respect to the audiometric testing of severely and profoundly retarded children.

This study was designed to investigate the maintenance of auditory stimulus control under conditions of continuous and intermittent reinforcement using edible reinforcers. The study was also designed to investigate the effects of no reinforcement on audiometric thresholds following sessions of stimulus control maintenance using continuous and intermittent reinforcement.

To compare the effects of continuous and intermittent reinforcement on auditory stimulus control maintenance, two reinforcement schedules (continuous and fixed ratio-3) were used. Each reinforcement schedule was counterbalanced between two groups (four subjects each) and was presented on two occasions.

Stimulus and alternating (non-audible) control presentations (50 each) were presented to each subject during each session. Subjects were maintained on a given reinforcement schedule for four consecutive sessions prior to being exposed to the alternate reinforcement schedule.

Stimulus control was determined by an analysis of responses made in the presence of the auditory stimulus and responses made during the alternating control (non-audible) periods.

The results revealed that auditory stimulus control was maintained with most subjects using both schedules of reinforcement. Stimulus control was, however, slightly more variable when intermittent (FR-3) reinforcement was used.

To investigate the effects of no reinforcement on threshold variability, non-reinforced thresholds were obtained following each auditory stimulus control condition. Prior to threshold testing, each subject was required to meet stimulus-control criteria with the current reinforcement schedule. Subjects failing to meet the criteria were excused and no threshold was obtained. Thresholds were obtained with subjects meeting the criteria using alternating stimulus and control presentations (50 each).

The results showed the acceptable auditory threshold can be obtained using no reinforcement with most subjects. Thresholds generally fell within $\pm$10dB variability. Response variability during threshold testing tended to be related to the amount of auditory stimulus control maintained with reinforcement prior to threshold testing.