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# A Comparison of Object Dropping and Echoic Vocalizing as Response Modes to Pure Tone Stimuli Among Mentally Retarded Children

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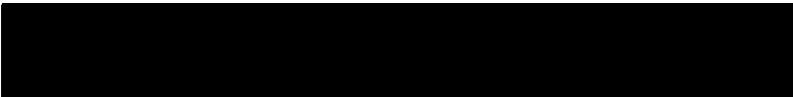
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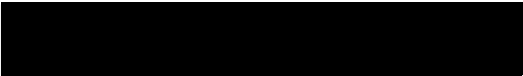
AN ABSTRACT OF THE THESIS OF ELLEN L. STANLEY for the Master of Science in Speech, With Emphasis in Speech Pathology/Audiology, presented April 29, 1970.

Title: A Comparison of Object Dropping and Echolic Vocalizing as Response Modes to Pure Tone Stimuli Among Mentally Retarded Children.

APPROVED BY MEMBERS OF THE THESIS COMMITTEE:

  
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Mentally retarded children demonstrate an abnormally high incidence of hearing impairment, and many, particularly those with IQ below 40, are difficult for audiologists to test. Consequently, there is great need among this population for investigating response modes and conditioning of responses to auditory stimuli. A review of the literature reveals no studies of echolic vocalization as a conditioned

response mode to pure tone stimuli among the retarded.

In this study, a heterogeneous sample of 13 moderately and severely retarded children ranging in age from 7 years 7 months to 16 years 3 months were compared on two response modes to suprathreshold pure tone signals of 500 and 4000 Hz: (1) dropping poker chips, and (2) echoic vocalization (EVR). All subjects received both treatments but were divided into Groups A and B, the former receiving Treatment One (object dropping) first, the latter receiving Treatment Two (EVR) first. Operant procedures combined social and tangible reinforcement in each treatment to achieve stimulus control without specific verbal instructions. EVR included two unusual stages: (1) conditioning of imitations to the experimenter's vocalizations, usually /a/, and (2) conditioning of response transfer from vocal to pure tone stimuli. Acquisition and extinction to first 500, then 4000 Hz proceeded sequentially within each treatment. Acquisition criterion for vocal and pure tone stimuli was eight consecutive responses. Extinction criterion was failure to respond to six out of eight tonal stimuli following withdrawal of reinforcement.

Eleven of the 13 children achieved acquisition criterion for both response modes, with only three of the older subjects encountering substantial difficulty in

response transfer in Treatment Two. Differences in acquisition data between treatments were not significant.

Three times as much extinction occurred with EVR in Treatment Two than with object dropping in Treatment One, but there was a tendency toward more false responses in the latter mode. Otherwise, data up to achievement of extinction criterion in the extinction phases did not differ significantly between treatments.

Order of presentation of treatment and frequency of the pure tone stimuli were not significant factors in the results.

It was concluded that despite substantially greater occurrence of extinction following withdrawal of reinforcement as compared with object dropping, echoic vocalization response has been shown to be an effective, practical response mode to suprathreshold pure tone stimuli among the children in this sample.

It was recommended that further investigation with EVR be directed toward: (1) the feasibility of eliminating response transfer by use of verbal assistance and direct conditioning of EVR to pure tones; (2) if response transfer is necessary, comparison of older and younger retardates on that procedure; (3) the possibility of increasing resistance

to extinction in EVR through visual reinforcement; (4) comparison of EVR and object dropping on threshold determination among MR children; (5) the practicability of pairing EVR and object dropping response modes; and (6) investigation of other forms of both breath expulsion and breath inspiration as response modes to pure tone stimuli among mentally retarded children.

A COMPARISON OF OBJECT DROPPING AND ECHOIC VOCALIZING  
AS RESPONSE MODES TO PURE TONE STIMULI  
AMONG MENTALLY RETARDED CHILDREN

by

ELTON L. STEWART

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

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## INTRODUCTION

The most reliable estimates of the number of individuals in this nation with measured intelligence quotients (IQs) below 70 indicate a population of between five and six million, most of them children (Weber, 1963; Gardner, 1967). In this study, they will be categorized according to the system adopted by the American Association for Mental Deficiency, from Heber (1959; revised 1961). (See Table I.)

TABLE I  
AAMD CLASSIFICATION OF MENTAL RETARDATION

Measured Intelligence (MI) Level of Deviation	Description	SD Range	IQ Range	
			Binet	Wechsler
I	Borderline	-1.01 to -2.00	68-83	70-84
II	Mild	-2.01 to -3.00	52-67	55-69
III	Moderate	-3.01 to -4.00	36-51	40-54
IV	Severe	-4.01 to -5.00	20-35	25-39
V	Profound	Below -5.00	Below 20	Below 25

This population is particularly challenging to the audiologist for at least four reasons, which cumulatively provided the impetus for the present investigation.

(1) As a requisite to accurate differential diagnosis, a valid, reliable audiologic assessment not only contributes vital information for appropriate medical and educational direction, but may challenge and even alter the validity of the "mentally retarded" (MR) label (Lillywhite and Bradley, 1969, p. 41).

(2) The amount of hearing impairment in an individual retardate may be disproportionately handicapping, making its identification that much more important (Frisina and Lloyd, 1965b, p. 273; Kimmich, 1965, pp. 129-30; Fisch, 1968, p. 123; Lillywhite and Bradley, p. 65 and p. 114). For example, a "moderate" loss may cause the MR child greater difficulty in learning language than would the same loss for a child of normal intelligence.

(3) Data on incidence of hearing impairment among MR children are remarkable in several respects. There is general agreement that the percentage is substantially higher than the 3 to 5 percent (O'Neill and Oyer, 1966, p. 293) of normal public school children reported with mild to severe losses, but in addition, the figures for MRs vary greatly. Birch and Matthews (1951) reported 2.5 to 18 times as much loss in 247 MRs 10 to 19 years of age as for normals. Lillywhite and Bradley (pp. 13-14) refer to an unpublished report on hearing testing in Oregon of 2,235 educable retardates in 1963-64 in which 17% had medically referable losses, a figure approximately five times the 3.3% found in that state's overall normal school population that year. Schlanger and Gottsleben (1956) cite studies reporting that from 13 to 55.5% of this handicapped group evidence hearing loss. A more recent survey by Lloyd and Frisina (1965b) reports a range of 8 to 56%. Incidence of hearing impairment among MR children also departs from the trend among normal school

populations in its apparent increase with chronological age (Schlanger and Gottsleben; Nudo, 1965; Webb et al., 1966)..

(4) Many retarded children are difficult to test, and a number of reports have stated that conventional hearing test procedures are not suitable for this population (Kodman et al., 1958; Meyerson, 1956 and 1965; Leach, 1965; Waldon, 1965; Fisch, 1968).



## CHAPTER I

### HISTORY OF THE PROBLEM

The essential concern of the audiologist faced with the task of assessing MR children is to obtain audiometric threshold data which is valid and reliable. According to Lloyd and Frisina (1965b, p. 9), the wide variations in reported incidence of hearing impairment among this population " . . . suggest a possible lack of inter- and intra-test agreement and/or other assessment problems." These problems have been associated with characteristics of the child under test as well as a number of other factors.

Intelligence of the subject has been suggested as a variable by Lloyd and Frisina (1965b, p. 10). A study by Bradley, Evans and Worthington (1955) reported somewhat more test-retest variation among 30 retardates with IQs between 30 and 50 than among an equal number with IQs between 50 and 79. Lloyd and Reid (1966), however, reported only a slight trend toward better test-retest agreement among retardates with IQs ranging from 40 to 75 as compared with lower levels. Lloyd, Reid and McMenis (1968) found no relationship between size of pure tone test-retest difference and IQ, and no significant difference between test-retest reliability on consecutive days in comparing children in MI Levels II, III, IV and V.

Atypical and diverse behaviors have been associated with variations in incidence data by Leach (1965) and Lloyd and Frisina (1965b),

and personality disorders have been referred to as influencing test results by Schlanger and Gottsleben.

Kopatic (1965, p. 135) made the following statement in regard to testing hearing among this population:

For purposes of validity, objectivity and reliability of pure tone audiometry with the mentally handicapped, it is necessary to obtain several audiograms before the retarded subject's hearing capacity can be ascertained.

This was later challenged by Lloyd and Melrose (1966, p. 138) on the basis of reliability data obtained in a study of four pure tone and two speech threshold measures:

When such tests are administered by a qualified audiologist, there appears to be no need to adopt routine repeat testing as a clinical procedure for mentally retarded children.

Frisina and Lloyd (1965b, p. 272) claim that audiometric testing can be accomplished at all levels of retardation and recognize criteria for testability as dependent upon the skill of the audiologist and his methods rather than on characteristics of the child. In another publication (Lloyd and Frisina, 1965b, p. 10), they state the following:

It is assumed that these children are testable when the appropriate methods are utilized and that the untestableness lies with the examiner and/or procedure and not necessarily with something inherent in the child.

Webb et al., (1966) examined data from 10 studies reporting on hearing loss among over 5000 institutionalized MRs and found that incidence increased as a direct function of stringency of pass-fail criteria of the examiners, a variable also mentioned by Lloyd and Frisina (1965b, p. 10). The latter authors also refer to characteristics of the testing environment as a possible variable. Still other factors which may influence incidence figures, although not exclusively among MRs, are variations in

audiometer performance up to 10 dB at particular frequencies (Eagles and Doerfler, 1961), and differences between reports employing audiometers calibrated to American Standards Association (ASA) reference levels of 1951 and the zero reference levels of the International Organization for Standardization (ISO) adopted in this country in 1964.

The prevailing impression is that variations in incidence figures on hearing impairment among retarded populations are indeed related in some degree to reliability and validity of test results, and that these, in turn, depend upon selection and skillful implementation of appropriate tests and procedures for each patient.

All hearing tests involve two major classes of variables: first, the delivery of precise, quantifiable auditory stimuli; second, the identification of the patient's responses to these stimuli. The first category presents relatively little difficulty for the audiologist, although a frequent problem with retardates and young children is their initial apprehension and rejection of the earphones. Generally, however, experienced clinicians will find conditioning procedures that will, in time, overcome this aversion.

It is within the second class of variables that audiologists most frequently encounter serious difficulty in testing MR children; they often respond unpredictably and inconsistently if they respond at all, even at suprathreshold levels.

There are, of course, objective tests by which the examiner can circumvent some of the problems associated with subjective techniques. Chiefly, these consist of the use of electroencephalography (EEG), and psychogalvanic skin response or reflex (PGSR or GSR) audiometry, the

latter also referred to as either electrodermal audiometry (EDA) or electrodermal response (EDR).

EEG has been described as a promising technique for difficult-to-test patients (Miller, de Schweinitz and Goetzinger, 1963, p. 149; O'Neill and Oyer, 1966, p. 264), but it remains in a developmental stage and requires equipment and skills not readily available to the average clinician. Garwood (1965, p. 238) states that EEG studies among the mentally retarded are notably lacking in the literature, and Webb et al. (1964) describe the technique as "impractical" for that population.

GSR studies with the retarded are not yet conclusive. Fulton (1965, pp. 231-32) states that this technique ". . . can provide valid and reliable thresholds . . ." with severely retarded individuals in some cases, but other reports on its applicability to this population describe "complete failure" (Waldon, 1965, p. 189), and "limited value" (Lamb and Graham, 1968, p. 727). Webb et al. (1964) state that GSR is no more effective with the mentally retarded than standard audiometry, and Lloyd and Reid (1966) cite comparisons with a modified audiometric technique--conditioned orientation reflex or response (COR)--which found GSR the less reliable of the two.

All other audiometric test methods--both standard and modified--are essentially subjective tests and rely upon observation of the patient's responses to controlled sound stimuli. As such, they may be categorized as forms of behavioral audiometry. As defined by Goldstein (1962, p. 481), behavioral audiometry includes,

. . . any overt response, whether it is an intentional raising of the hand when the tone is heard, a repetition of a word in a speech test, or an involuntary startle response of a child.

Frisina (1963, p. 137) describes behavioral audiometry in terms of

reinforcement theory. From this standpoint, any subjective testing method can be viewed as an operant paradigm in which stimulus control is achieved by selective reinforcement of desired responses, leading to discriminative responsiveness by the subject to the auditory stimuli.

Most standard and modified pure tone tests with MR children require the child to respond with some type of identifiable motor behavior to each auditory stimulus. One exception is the use of "yes" responses as reported by Foale and Paterson (1954) with 100 boys in MI Levels I and II. Ordinarily, however, standard response modes consist of raising a hand or finger, or pressing a button in response to each discrete tonal stimulus. With higher level, cooperative retardates, verbal instructions may be sufficient to elicit the desired response behavior, but with lower level retardates, these may confuse more than they assist the subject. In these latter cases, experienced audiologists rely more on gestural demonstration or actual manipulation of the child's arm or hand at the start, with use of social reinforcement such as "Good" or "Fine" to sustain response behavior.

A summary by Lloyd and Frisina (1965a) of 63 audiometric studies among the retarded indicates that standard audiometry has often been the method of choice for testing. This summary also demonstrates that the percentage of "untestables" has been rather high, ranging from 7% for 30 MRs in MI Levels I to IV (Bradley, Evans and Worthington, 1955) to 45% for 20 children in MI Levels III and IV (Ryan and Stewart, 1965). Lillywhite and Bradley (1969, pp. 112-13) state that the majority of retarded children can be tested by standard methods if those appropriate to their mental development are chosen. Barr (1955) investigated use of pure tone audiometry among both normal and retarded pre-school children and

reported conventional test procedures generally applicable down to an MA of 3.0 years, with play audiometry successful for about two-thirds of the children in the MA range 2.5 to 3.0 years. He further reported that all pure tone examinations were unsuccessful for children with "grave general retardation and/or behavior problems" below a chronological age (CA) of 4.0 years.

Various modifications of standard procedures have been reported. Curry and Kurtzrock (1951) developed an ear-choice method requiring the child to point to the test ear as the signal was switched from side to side. Intensity of the signal was gradually lowered to threshold as the clinician swept from frequency to frequency. Lloyd and Melrose (1966) used a modified ear-choice technique in which threshold was determined for one frequency at a time instead of sweeping frequencies at each intensity level.

Play audiometry may include the more conventional hand-raising and ear-choice methods, but is more often thought of with reference to such motoric responses as dropping blocks, removing or inserting pegs on a pegboard, putting rings on a peg or removing them, striking an object such as a drum, etc. It has been hypothesized that repetition of such response modes has inherent reinforcing properties for the child (Lloyd, 1966, p. 131), but experienced clinicians generally use social reinforcement in addition in order to enhance this effect.

Visual reinforcements have been used by audiologists with difficult-to-test patients since 1930 (Ewing). Essentially, the method involves activation of a reinforcer such as a projected picture or mechanical toy by the patient pressing a button when the test signal is present. Pressing the button when no signal is present results in no reinforcement and

sometimes a delay in the next stimulus. The reinforcement schedule is typically 100%, and social reinforcement is usually paired with the visual. Lloyd (1965b) found his slide-show technique effective with many patients who were difficult to test by conventional methods, but described it as not universally applicable. Weaver (1965) described the slide-show method as of primary utility with normal young children, but applied the technique to two groups of retardates with respective mean IQs of 52 and 42 and found only one subject in the lower level group who could not be successfully conditioned and tested with that method.

Lloyd (1965) compared six threshold tests--hand raising, modified ear-choice, play (block-dropping), and slide show for pure tones, and two speech reception tests (point-to-the-picture, say-the-word)--among 40 MI Level II and III children averaging 12 years, 6 months of age and concluded that all of those methods were reliable if administered by a qualified audiologist. The play technique was slightly more reliable among the pure tone tests, and the two speech tests were reported slightly more reliable overall than the four pure tone methods.

Other techniques which have been found useful with the retarded include forms of behavioral observation audiometry (BOA) such as conditioned orientation response (COR) (Suzuki and Ogiba, 1961) and reflexive audiometry (Waldon, 1965). These are essentially outgrowths of infant screening procedures, relying on identification of reflexive localizing or searching responses to sound stimuli. Fulton and Graham (1966) reported the technique as an effective screening device for the severely retarded. Lloyd, Spradlin and Reid (1968, p. 237) state that it was found more successful with the moderately retarded than with lower levels.

Because pure tones are relatively inefficient stimuli for both mentally retarded and normal young children (Ewing and Ewing, 1944; Froeschels and Beebe, 1946; Waldon, 1965; Mendel, 1968), techniques have been devised with such diverse stimuli as animal sounds (Ryan and Stewart, 1965), baby cries (Waldon, 1965), exclamations such as, "I'm here," and "Watch out" and non-speech sounds such as made by a cow, horn, rattle, etc. (Beedle et al., 1966). Each of these reports claimed significant advantages over use of pure tone stimuli with MR children. At best, however, they are gross screening techniques which can not differentiate between a patient's two ears and do not generally provide precise, diagnostically important threshold data for specific frequencies.

Probably the most successful forms of behavioral audiometry with the mentally retarded are the techniques referred to as operant conditioning audiometry (OCA) or tangible reinforcement operant conditioning audiometry (TROCA) as reported by Spradlin and Lloyd (1965), Lloyd (1966), and Lloyd, Spradlin and Reid (1968). Other reports on this type of testing have been made by Meyerson and Michael (1960) and by La Crosse and Bidlake (1964). The most detailed descriptions and apparently the most successful applications to MR children, particularly those in the lower MI levels, are found in the reports authored or co-authored by Lloyd. According to Lloyd, Spradlin and Reid (p. 239), TROCA procedures consist of five inter-related phases: (1) determining the most effective reinforcer; (2) initial operant conditioning for pressing a large button in response to an intense (70 dB, ISO) warbled sound field tone; (3) stimulus generalization to both lower intensity levels and different frequencies; (4) sound field screening at 20 dB ISO; and (5) bilateral screening and threshold testing with earphones. The authors reported



(pp. 242-43) that they established stimulus control using this procedure with 42 of 50 profoundly retarded children, and that of these, pure tone data were obtained on 39 which " . . . seemed valid in terms of reasonable audiometric configurations and agreement with other data such as otologic findings." Masking was used with both air and bone conduction tests. They state that TROCA could be adapted to obtain Bekesy, SISI, tone decay, Stenger, DL, and other specific audiologic information. The chief disadvantages appear to be the clinical time and number of sessions demanded. The profoundly retarded children they tested required between 4 and 50 ten- to twenty-minute sessions.

It seems apparent, then, that no single technique for acquiring valid, reliable threshold data among MR children has yet met with universal acceptance among audiologists. Frisina and Lloyd (1965b, p. 274) recognize this in the following statement:

There is great need, especially in MI Levels IV and V, for systematically studying response modes and methods of conditioning for response to auditory stimuli.

It was with reference to this need that the following investigation was initiated.

## CHAPTER II

### DESCRIPTION OF THE PROBLEM

A review of the literature reveals no studies of echoic vocalization as a conditioned response to pure tone stimuli. Nearly all applications of pure tone audiometry to MR children have used some form of motoric response, such as hand-raising, pointing, pressing a button, dropping blocks, etc. Verbal responses, of course, are a standard response mode in speech audiometry, and gross screening techniques such as BOA have used increase, decrease, or cessation of vocal activity, as well as humming and echoing as gross measures of response to a variety of speech and non-speech sound stimuli (Frisina and Lloyd, 1965b, p. 277). But apparently there have been no reports of systematic use of echoic vocalizations, defined here as any discrete, laryngeally-phonated sounds, as a specific mode of response to pure tones which is conditioned and brought under stimulus control.

It is well established that infants and young children's vocal behavior can be brought under stimulus control. Rheingold, Gewirtz and Ross (1959) demonstrated that vocal behavior could be very quickly modified in normal infants as young as three months. Horowitz (1963) has reported on effective reinforcements and schedules for sustaining vocal behavior of MR children. Many other studies (e.g., Kerr, Meyerson and Michael, 1965; Salzinger et al., 1965), have demonstrated success in shaping both vocal and verbal behaviors in children diagnosed as mentally retarded through use of response-contingent reinforcement programming. There appears to be no limit to the applicability of such procedures in terms of MI levels,

but reports by Bradley, Evans and Worthington (1955), Das (1961), and Fulton and Graham (1966) indicate that conditioning time is inversely related to MI level; i.e., lower level retardates are slower to condition.

The primary purpose of this investigation was to compare motor and echoic vocal responses (EVR) to pure tone stimuli among MR children. Acquisition and extinction data for 500 and 1000 Hz suprathreshold signals were compared between motor and echoic vocal responses.

The motor response used in this study was the dropping of poker chips into a pail. This is a type of response common to play audiometry and is very similar to the block-dropping method which Lloyd (1965a) reported as slightly more reliable for test-retest consistency than standard, ear-choice and slide-show techniques.

The echoic vocal response (EVR) included any discrete, laryngeally-phonated utterance which could be temporally identified as a response to the tonal stimulus. This response category was defined broadly to include practically any non-vegetative vocal activity, since the specific type used by a child might depend upon (1) his repertoire of vocal behaviors, (2) the particular vocalization brought under stimulus control in the operant paradigm, and (3) variability among vocal responses from event to event. Thus, for one child, guttural, vowel-like grunts might be acceptable; for another, a particular word or phrase or a variety of verbal utterances might serve equally well. The variability of possible responses within this class was not deemed critical, since it was primarily the temporal relationship of the response to the stimulus which would determine validity.

It was felt that the essential criteria for identification and acceptance of classes of responses, whether motor or vocal, were, (1)

that the auditory stimulus become discriminative for responding, i.e., become a discriminative stimulus ( $S^D$ ); and (2) that absence of the tonal stimulus become a neutral stimulus ( $S^\Delta$ ). Assuming an effective reinforcer for each child, these criteria were felt to be both achievable and compatible with established reinforcement principles.

The problem to be investigated is stated in the following two hypotheses:

(1) A heterogenous sample of moderately and severely mentally retarded children will demonstrate significant differences in acquisition data obtained for echoic vocal responses to suprathreshold pure tone stimuli as compared with similar data for motor responses (object dropping) to the same stimuli.

(2) A heterogenous sample of moderately and severely mentally retarded children will demonstrate significant differences in extinction data obtained for echoic vocal responses to suprathreshold pure tone stimuli as compared with similar data for motor responses (object dropping) to the same stimuli.

In addition, the following questions were felt to be of interest:

(1) Is echoic vocalization a practical response mode to pure tone signals for mentally retarded children? Is this a modification which might be used alternatively and more or less equally well as compared with standard and play response modes?

(2) What are the specific advantages or disadvantages which might be expected in application of this response mode to mentally retarded subjects?

(3) What are the implications for further research?

## CHAPTER III

### METHOD

#### I. SUBJECTS

Fourteen children, 6 boys and 8 girls, were initially selected from an enrollment of 24 at the Retarded Children's Center in Aloha, Oregon. Of the original 14, one 9-year-old boy failed to achieve criterion for either the motor or echoic vocal response (EVR) modes and was dropped from the study. Another boy, 15-years old, achieved criterion on the motor tasks but failed to reach the criterion on tasks involving EVR. In addition, one 13-year-old girl reached criterion on all tests except those involving motor responses to 4000 Hz signals. Thus, the total N for different statistical treatments ranged from 13 to 11. Criteria for those subjects included in the study (Table II) encompassed the following:

#### Mental Age

MAs between 2.0 and 5.0 were sought for the following reasons: (1) Children with MAs above 5.0 years are not considered generally difficult to test; standard hand-raising, ear-choice or play techniques are usually effective. (2) Children below an MA level of 2.0 years are most often quite difficult to test by any conventional methods and require greater clinical time to condition. The limited scope of this investigation did not justify inclusion of subjects with extremely low MAs.

Unfortunately, as is often the case with trainable MRs, precise, recent psychometric data were not available for all subjects. MAs based

TABLE II  
SUBJECT DATA

Subject	Group	Sex	CA Yr. Mo.	MA Yr. Mo.	SB IQ	MI Level	Diagnostic Label
DB	A	F	10 - 10	2 - 9	35	IV	
LH	A	F	13 - 5	3 - 9	38	III	
CB	A	M	14 - 4	---	34	IV	
DM	A	M	15 - 0	---	37	III	
MD	A	M	11 - 4	---	--	--	"Mod." MR
DS	A	M	7 - 7	---	--	--	"Sev." MR
CB	A	F	7 - 7	2 - 11	--	--	"Mod." MR
LK	B	M	12 - 10	---	31	IV	
LL	B	F	12 - 3	2 - 2	30	IV	
EH	B	F	8 - 5	3 - 8	48	III	
LD	B	F	7 - 3	2 - 10	43	III	
SH	B	F	16 - 3	3 - 8	49	III	
CC	B	F	11 - 3	---	--	--	"Sev." MR

on the Stanford-Binet Intelligence Scale were available on seven of the subjects and ranged from 2 years, 2 months to 3 years, 9 months, with a mean of 3 years, 1 month. No specific MA data were available on the remaining six children. However, three of the latter had been assigned Binet IQs which were within the "moderate" and "severe" categories of the AAMD (Table 1) and the remaining three had been medically diagnosed as either "moderately severe retardation" (one case) or "severe retardation" (two cases). Thus, Group A contained three subjects whose mean MA was 3 years, 2 months, and four whose MAs were unspecified. Group B consisted of four subjects whose mean MA was 3 years, 1 month and two whose MAs were not specified.

#### Intelligence

So far as possible, children were selected from the IQ range 20 to 51 on the Revised Stanford-Binet. This range encompasses MI Levels III and IV, "moderate" to "severe" retardation. Spradlin (1967) has stated that qualified audiologists have been able to accomplish pure tone testing on most children with IQs of 40 or above, corresponding roughly with the lower limits of the moderate range of retardation, and Frisina and Lloyd (1965a) recognize the levels below this as most challenging for the clinical audiologist. Thus the range selected permits comparison of the two response modes among some children in MI Level III who may be relatively easy to condition and those individuals in MI Level IV who may be difficult to test.

Recorded IQs available for nine subjects ranged from 30 to 49, with a mean of 38. The remaining four were unrecorded except in terms of general range or medical diagnosis. Thus, Group A consisted of four subjects

with measured scores ranging from 34 to 38 and a mean of 36. Two of the remaining three in Group A had a medical diagnosis of "moderate" retardation; the third had been diagnosed as "severe" retardation. Group B was made up of five individuals ranging from 30 to 49 in Binet IQs, with a mean of 40, and one subject with an unspecified IQ who had been diagnosed as "severe" in retardation.

### Chronological Age

CA is not of particular importance in a study comparing the same subjects on two different measures. An age range from 7 to 18 years was arbitrarily selected to allow greater generalization of projected results to school-age MR populations. In addition, it was felt that comparison of response behaviors between children with similar MAs but differing in CAs would be of interest.

The 13 subjects included in this study ranged from 7.25 years to 16.25 years with a mean CA of 11.38 years. The six Group A subjects ranged from 7.6 to 15.0 years, with a mean CA of 10.8 years. The six subjects in Group B ranged in age from 7.25 to 16.25 years with a mean CA of 11.4 years.

### Physiologic and Sensory Factors

Children with handicapping neuromuscular involvement, specific brain damage, or gross sensory impairment were excluded from consideration because of the likelihood of special difficulties in responding to the testing procedures. This study particularly required that each child have auditory acuity in his test ear which would permit responses to 500 and 4000 Hz air-conducted pure tones delivered by earphone at 70 dB HL. Therefore, as a precautionary measure, a screening criterion of 20 dB



below this level was established so that only children with pure tone thresholds of 50 dB or better in the test ear at those frequencies were selected.

## II. TEST ROOM, APPARATUS, AND MATERIALS

The experimental program was conducted in a special education room of a public elementary school during a summer period when classes were not in session. This provided an environment which was relatively free from distractions. Included were three chairs (one for the experimenter, one for an assistant recording data, and one for the subject), an experimental control booth (Figure 1), a recently calibrated Maico MA-16 portable audiometer, 100 plastic poker chips in a plastic pail, a tin pail, and supplies of five different nutrient reinforcers.

Ambient noise level in this environment was periodically monitored with a General Radio Company Type 2203 sound level meter and found to vary within a range of 42 to 58 dB SPL on the C scale (ASA, 1951). According to Hirsh (1952, p. 164) the typical earphone cushion attenuates about 20 dB of externally produced noise. The same source (p. 163) defines audiometric "quiet" as an environment in which the overall SPL of a flat-spectrum noise does not exceed 30 dB (ASA). This accounts for his conclusion that 40 to 50 dB of such noise is permissible for pure tone threshold testing. Since air-conducted test signals of 500 and 4000 Hz in this experiment were delivered by earphone at suprathreshold levels only (70 dB HL), the possibilities of ambient noise in the 42 to 58 dB range effectively masking these tones were remote.

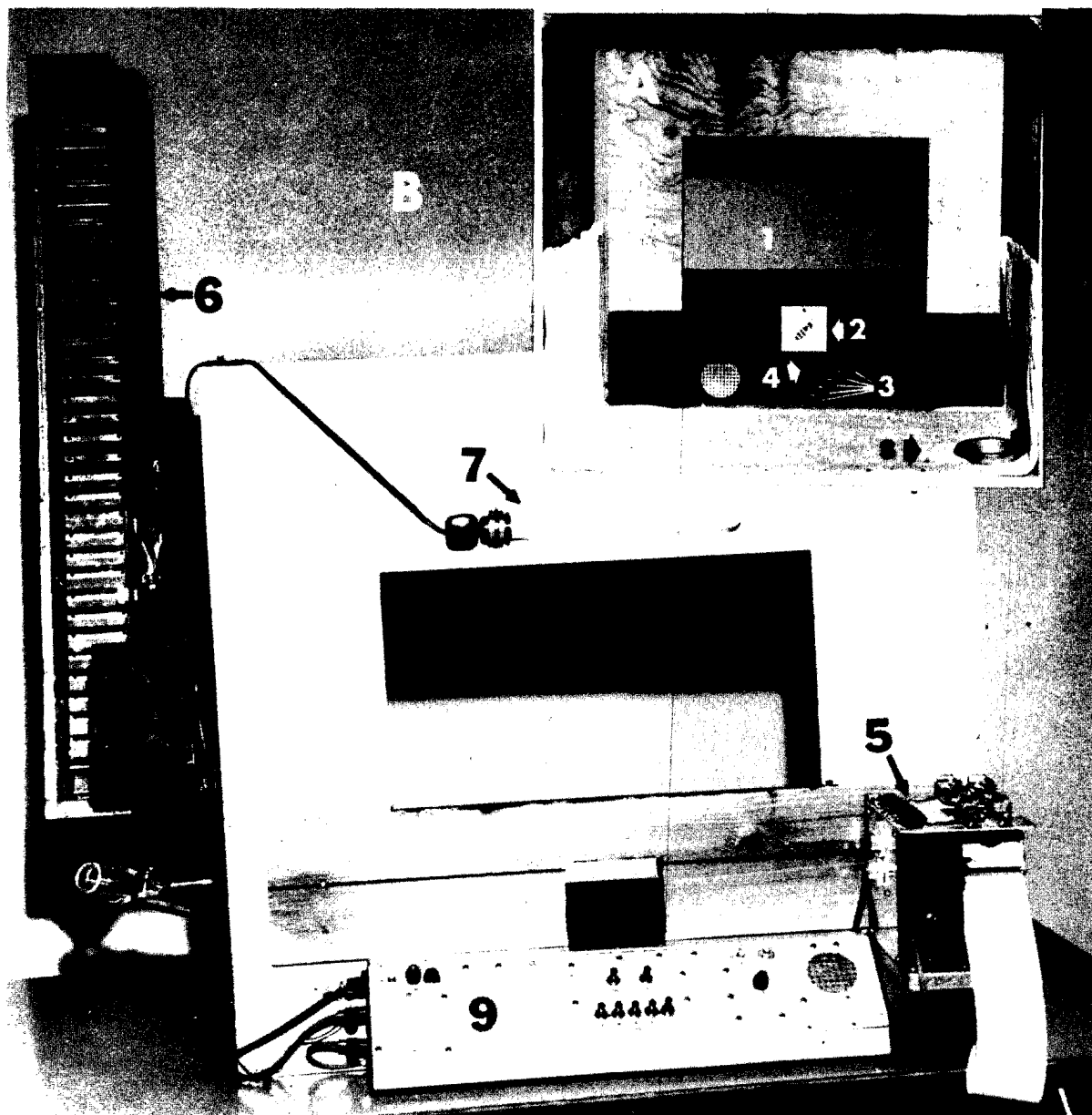
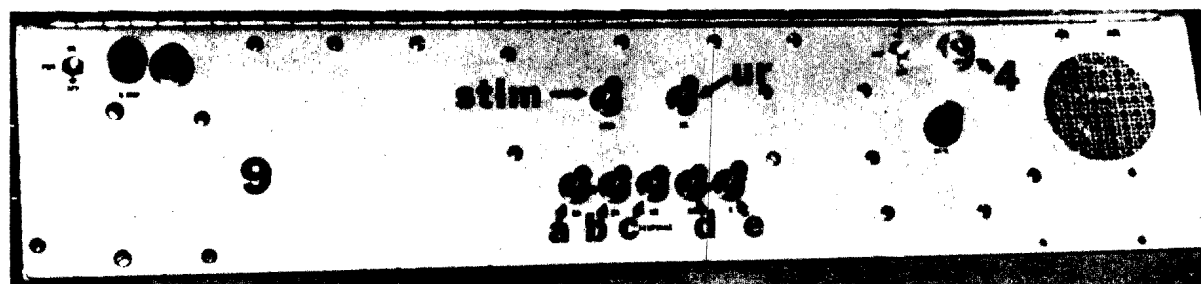


Figure 1. A. The interior of the booth, as viewed from the child's position. B. The booth as viewed from the experimenter's position. C. The control console.

- |                                  |                                |                     |
|----------------------------------|--------------------------------|---------------------|
| 1. Open window for experimenter. | 4. Voice-activated neon tubes. | 7. Overhead light.  |
| 2. Window for picture stimuli.   | 5. Event recorder.             | 8. Dispenser tray.  |
| 3. Bank of five lights.          | 6. Nutrient dispenser.         | 9. Control console. |



The experimental control booth<sup>1</sup> (Maurer, 1968) incorporated the following features (Figure 1): (1) an open window for the experimenter; (2) a small window for the subject; (3) a red light activated by the reinforcement switch and visible to the subject; (4) a Universal 70-bucket dispenser for nutrient reinforcements; (5) a dispensing tube assembly with receptacle tray; and (6) a console with reinforcement toggle switch.

### III. SELECTION OF STIMULI

Stimuli for this investigation consisted of discrete two-second 500 and 4000 Hz pure tones delivered by earphone to the test ear at 70 dB HL. These frequencies were selected because they represent low and high frequencies normally included in both screening and threshold testing, thereby permitting greater generalization of results to certain aspects of standard audiometry.

A signal duration of two seconds was selected after consulting research reports on effect of duration of pure tone signals upon perceived threshold. Goldstein and Kramer (1960) noted that most studies to that time had indicated that threshold would not be affected beyond approximately 150 msec. Wright (1960) summarized many studies and placed the reported limit at 200 msec. The comprehensive investigation carried out by Goldstein and Kramer reported diminishing effects by duration even beyond this, but indicated that threshold values for pure tones

<sup>1</sup>This booth was originally constructed for operant research under Public Health Research Grant 70-4382 by Research Instrument Service, University of Oregon Medical School, Portland, Oregon.

should not be expected to decrease significantly for signals of 2000 msec (two seconds) or longer.

#### IV. SELECTION OF REINFORCEMENTS

Both social and tangible (nutrient) reinforcements were used on a 100% schedule. This was based on a study of 72 retarded children by Horowitz (1963), who reported that combined candy and verbal (social) reinforcement for vocal responses resulted in the greatest resistance to extinction, and that continuous reinforcement was much more effective than partial (50%) reinforcement in achieving stimulus control.

Selection of an appropriate nutrient reinforcer for each child was accomplished in the following manner prior to actual experimental procedures. Each child was allowed to choose just one of five nutrient bits, each in a separate cup, which were offered on a tray. The specific nutrients were halved M & M candies, Cocoa Puffs, halved Crispy Critters, halved Froot Loops, and Trix. The item selected was then replenished and a second offering made. This procedure continued until one edible item had been chosen twice. That nutrient was then used as a tangible reinforcer with that particular child. Social reinforcement consisted of the experimenter's exclamations of "Fine," "Good," "Excellent," etc., accompanied with a smile and/or nod. For purposes of this study, the term "reinforcement" will hereafter refer to combined social and tangible reinforcement.

#### V. PROCEDURES

Each child was subjected to two experimental treatments. In order to negate effects of presentation order, the children were randomly

assigned to two groups: Group A children received Treatment One first; Group B children received Treatment Two first. Each subject was allowed a brief rest period between treatments. During this time, he was taken from the test room by an assistant, this period allowing the experimenter to replenish the dispenser buckets with reinforcers.

Prior to exposure to either treatment, each subject was preconditioned to a task-readiness stage, defined as (1) being seated before the experimental booth, and (2) having accepted placement of the earphone over his test ear. The contralateral, non-test ear remained uncovered, that earphone resting anteriorly to the ear. This stage was achieved either directly or by operant procedures employing successive approximations.

Response modes for each treatment were conditioned without the use of specific verbal instructions.

#### Treatment One

The child was conditioned to drop a poker chip into a pail immediately following presentation by earphone of a 70 dB 500 Hz pure tone signal of two seconds duration. Latency of each stimulus tone following the child's response, (or, if he did not respond, following the antecedent signal), was randomized within one to ten seconds to avoid rhythming. Acquisition of stimulus control arbitrarily was considered complete when eight consecutive responses to the pure tones had occurred. A response without antecedent signal presentation resulted in no reinforcement and a delay of from 10 to 15 seconds before presentation of the next stimulus tone.

Following acquisition of response criterion, reinforcement terminated, but randomized stimuli presentations continued either until extinction of responses was complete or until 25 cumulative unreinforced stimuli had been delivered. Extinction criterion was arbitrarily defined as failure to respond to six out of eight tonal stimuli. Identical procedures followed for acquisition and extinction of motor responses to the 4000 Hz signals, completing Treatment One.

### Treatment Two

The child initially was conditioned to echo the experimenter's vocalizations in the following manner: If the child vocalized spontaneously during the initial two minutes following achievement of task readiness, the last syllable of his utterance was echoed by the experimenter. This sequence of child vocalization followed by experimenter echoing was reinforced and continued until eight consecutive sequences had been completed. The next reinforcement was then withheld, allowing the experimenter to initiate the subsequent sequence and to be echoed by the child. This reversed contingency was, thereafter, the only one reinforced through acquisition of criterion.

If no vocalizations were spontaneously emitted by the child during this brief initial period, the experimenter vocalized /a/ and simply waited for the child to imitate him. This contingency was reinforced until the criterion of eight consecutive responses by the subject was achieved.

Following acquisition to vocal stimuli, transfer to 500 Hz pure tone stimuli was achieved in the following manner: A continuous 500 Hz pure tone at 70 dB HL was introduced into the subject's test ear by

earphone four seconds prior to each of the experimenter's stimulus vocalizations, and was continued through the superimposed vocalization for another two seconds, both stimuli then terminating simultaneously. This contingency was repeated as necessary to achieve transfer of the S<sup>D</sup> properties of the experimenter's vocalizations to the pure tones. Randomized latencies for presentation were continued as before. The experimenter's vocalization was omitted from this contingency just as soon as the child responded to the pure tone; when the subject transferred his responses to the pure tone stimulus, pairing of the vocalization was terminated. In those cases in which transfer was more difficult, the experimenter gradually faded his vocalizations in intensity until only the pure tone stimulus remained. In a few instances, it was necessary to reinstate these vocalizations one or more times in order to effect transfer. Acquisition was considered complete when the subject had made eight consecutive vocalization responses to pure tone stimuli.

Once criterion for pure tones was achieved, reinforcement was then withheld, with the temporally randomized presentations of pure tone stimuli continuing again until either extinction, (failure to respond to six out of eight stimuli) or delivery of 25 cumulative unreinforced stimuli. Acquisition and extinction procedures then followed immediately with 4000 Hz tones. In those few cases in which vocal responses to 4000 Hz signals were not immediately acquired, the experimenter returned to vocal stimuli, achieved criterion, then paired the 4000 Hz signals with the vocal stimuli as necessary to effect transfer.

## CHAPTER IV

### RESULTS

#### I. GENERAL

Eleven of the originally selected 14 subjects achieved the acquisition criteria for both treatments. One boy (DM) failed to achieve criterion for either 500 or 4000 Hz in Treatment Two, and one girl (LH) failed to achieve criterion on 4000 Hz only in Treatment One. One boy could not be adequately conditioned to the response tasks for either treatment and was dropped from the study. The latter was a 9-year 1-month-old boy with a Binet IQ of 42 and an MA of 2 years, 7 months. He had shown strong aversion to wearing earphones in previous attempts at audiologic assessment at Portland State University. In this investigation, extensive conditioning procedures were effective in bringing him to hold one phone to his ear, and he responded appropriately to some signals. Because of the great amount of time required for conditioning, however, it was decided to exclude him from the study.

Treatment Two incorporates a conditioning procedure unusual to audiologic assessment of MR children: response transfer from vocal to pure tone stimuli. The degree of difficulty in effecting response transfer with these subjects may be seen in Table III. Twelve of the 13 children succeeded in achieving the transfer criterion of eight consecutive responses to pure tone signals. One boy (MD) transferred to pure tones immediately, achieving criterion without need for any superimposed



TABLE III  
 DIFFICULTY IN RESPONSE TRANSFER FOLLOWING  
 ACQUISITION TO VOCAL STIMULUS

Subjects	No. Combined Stimuli Before 1st Response to Tonal Stimulus	No. Tonal Stimuli Not Responded to Before Acquisition
Group A		
DB	1	1
LH	9	27
CB (M)	1	5
DM	7	(43) <sup>a</sup>
MD	0	0
DS	2	0
CB (F)	3	0
Group B		
LK	4	0
LL	1	0
EH	1	0
LD	2	0
SH	20	19
CC	1	0

<sup>a</sup>Did not achieve criterion; did not achieve transfer.

vocalizations by the experimenter. Five subjects (DB, CB-M, LL, EH and CC) required only one pairing of pure tone and vocal stimuli before they responded to the pure tone alone; two (DS and LD) required two pairings, another (CB-F) three, while EH and SH needed 9 and 20, respectively. The mean number of paired stimuli among the 12 children who achieved transfer was 4.0; the range was 0 to 20. A t-test (see Appendix B) of the difference between the Group A mean, 3.385, and the Group B mean, 4.833, was not significant at the .05 level.

Among the 12 children achieving transfer, 8 responded to all consecutive pure tone stimuli following reinforcement of the first correct

contingency. One girl (DB) failed to respond to just one tone, and one boy (CB-M) failed to respond to a total of 5 signals. Two girls (LH and SH) achieved transfer with substantial difficulty, failing to respond to 27 and 19 cumulative pure tones, respectively.

The subject who failed to achieve transfer was a 15-year-old boy with a recorded Binet IQ of 37, a score that falls just below the mean for the 9 children for whom such data were available. This boy (DM) required 7 pairings of stimuli before his first response to an unpaired pure tone, and thereafter was unable to approach the transfer-acquisition criterion of 8 consecutive responses, with 43 cumulative failures to respond to pure tone signals.

It is of interest to note that LH, SH and DM were among the oldest children in the sample, with the two girls representing the highest MA and IQ scores, respectively, (see Table II) and that all three were very cooperative subjects.

Table IV reports on the subjects who did or did not extinguish for each frequency within the two treatments. It may be seen that only two subjects (DB and MD) did not extinguish in either treatment, and that only one subject (EH) extinguished at both frequencies in both treatments. Of the 12 subjects who achieved criterion at both 500 and 4000 Hz in Treatment One, involving object dropping, 9 did not extinguish at either frequency. Two subjects (LH and LL) extinguished on 500 Hz only, one (LH) failing to achieve criterion at 4000 Hz.

In contrast, among the 12 subjects who achieved criterion at both 500 and 4000 Hz in Treatment Two, involving EVR, only two did not extinguish on both frequencies. These were the same two subjects who did not extinguish at either frequency in Treatment One. All remaining subjects

TABLE IV  
 SUBJECTS WHO EXTINGUISHED VS SUBJECTS  
 WHO DID NOT EXTINGUISH

Subjects	Treatment One		Treatment Two	
	500 Hz	4000 Hz	500 Hz	4000 Hz
Group A				
DB	DNE <sup>a</sup>	DNE	DNE	DNE
LH	X <sup>b</sup>	(DNAC) <sup>c</sup>	X	X
CB (M)	DNE	DNE	X	X
DM	DNE	DNE	(DNAC)	(DNAC)
MD	DNE	DNE	DNE	DNE
DS	DNE	DNE	X	DNE
CB (F)	DNE	DNE	X	X
Group B				
LK	DNE	DNE	X	X
LL	X	DNE	X	X
EH	X	X	X	X
LD	X	X	X	DNE
SH	DNE	DNE	X	X
CC	DNE	DNE	X	X

<sup>a</sup>Did not extinguish.

<sup>b</sup>Extinguished.

<sup>c</sup>Did not achieve criterion.

except DS and LD, who failed to extinguish at just 4000 Hz, extinguished for both frequencies in Treatment Two. For the total group, there were 24 extinctions in 49 separate tests; i.e., extinction occurred in approximately 49% of the total number of tests making up this study. Six of the 24 extinctions occurred in Treatment One; the remaining 18 were in Treatment Two. Thus, Treatment One had a rate of extinction of 24%, contributing 25% of the total number of extinctions, while Treatment Two

had an extinction rate of 75% and accounted for 75% of the total number of extinctions.

## II. ANALYSIS OF THE DATA

### Order of Treatment

In order to determine whether order of presentation of treatments was a significant factor in the findings, data were analyzed to determine whether the differences between means of first and second presentations were statistically significant. For this purpose, t-tests (see Appendix B) were applied to those differences among the following data: (1) acquisition time to criterion; (2) number of tonal stimuli required to achieve criterion; (3) rates of correct response during extinction phase; and (4) rates of false response during the extinction phase. Examination of these data in Table V shows that none of the t-tests reached the .05 level of significance. In terms of these data, order of presentation of treatments was not a significant factor in this study. It is of interest, however, that Group A, which received Treatments One and Two in that order and included 25 tests, accounted for 8 extinctions, 1/3 of the total, while Group B, which received the treatments in the reverse order and had 24 tests, accounted for 16 extinctions, or 2/3 of the total.

### 500 Hz vs 4000 Hz

There would appear to be no basis for expecting substantial differences between means for 500 and 4000 Hz, although procedures did adhere to a fixed order involving acquisition and extinction, with the low frequency signals first within each treatment. It was felt, however,

TABLE V  
COMPARISON OF MEANS FOR ORDER OF PRESENTATION

Type of Data	Order	Treatment One				Treatment Two			
		500 Hz	N	4000 Hz	N	500 Hz	N	4000 Hz	N
Mean acquisition time to criterion in seconds	1st	440.833	6	110.60	5	489.333	6	189.667	6
	2nd	225.333	6	195.50	6	446.667	6	192.0	5
		t = 0.825 <sup>a</sup>		t = 1.991 <sup>b</sup>		t = 0.197		t = 0.028	
Mean number of tonal stimuli to achieve criterion	1st	16.50	6	9.20	5	14.0	6	13.0	6
	2nd	11.333	6	10.167	6	19.167	6	11.60	5
		t = 1.162		t = 0.423		t = 0.407		t = 0.382	
Mean rate of correct response <sup>c</sup> during extinction	1st	4.289	6	4.363	5	2.144	6	2.285	6
	2nd	2.803	6	3.424	6	4.252	6	4.163	6
		t = 1.622		t = 0.806		t = 1.719		t = 1.679	
Mean rate of false response <sup>d</sup> during extinction	1st	0.835	6	1.735	5	0.417	6	0.737	6
	2nd	0.424	6	1.037	6	0.024	6	0.447	6
		t = 0.765		t = 0.549		t = 0.942		t = 0.373	

<sup>a</sup>Levels of significance when both Ns equal 6 are 2.228 at .05 and 3.169 at .01.

<sup>b</sup>Levels of significance when Ns are 5 and 6 are 2.262 at .05 and 3.250 at .01.

<sup>c</sup>Number of correct responses divided by time in seconds and multiplied by 60 equals rate of correct response per minute.

<sup>d</sup>Number of false responses (responses without antecedent signal tones) divided by time in seconds and multiplied by 60 equals rate of false response per minute.

that this expectation of non-significance ought to be tested. Therefore, t-tests (see Appendix B) were applied to the differences between means for these two frequencies. Examination of Table VI shows that all t-scores are below the .05 level of significance. Thus, neither the results for echoic nor motoric response modes appears to have been influenced by the frequency of the pure tone stimuli.

TABLE VI  
COMPARISON OF MEANS FOR 500 AND 4000 Hz PURE TONES

Frequency of Supra-Threshold Pure Tone Stimuli	Acq. Time to Criterion in Sec.	No. Tonal Stimuli to Achieve Criterion	Rate of Correct Response During Extinc.	Rate of False Response During Extinc.
Treatment One				
500 Hz	307.909	13.545	3.743	0.687
4000 Hz	156.909	9.727	3.851	1.354
	t = 1.416 <sup>a</sup>	t = 1.274	t = 0.171	t = 1.557
Treatment Two				
500 Hz	401.454	11.272	3.198 <sup>c</sup>	0.220 <sup>c</sup>
4000 Hz	190.727	12.363	3.224 <sup>c</sup>	0.592 <sup>c</sup>
	t = 2.195	t = 0.368	t = 0.061 <sup>b</sup>	t = 2.025 <sup>b</sup>

<sup>a</sup>Levels of significance for Ns of 11 are 2.228 at .05 and 3.169 at .01.

<sup>b</sup>Levels of significance for Ns of 12 are 2.201 at .05 and 3.106 at .01.

<sup>c</sup>N equals 12. All other Ns are 11.

#### Treatment One vs Treatment Two

T-tests were then applied to differences between means for Treatment One and Treatment Two on the same data. Inspection of Table VII

TABLE VII

## COMPARISON OF MEANS OF TREATMENT ONE AND TREATMENT TWO

	Acq. Time to Criterion in Sec.	No. Tonal Stimuli to Achieve Criterion	Rate of Correct Response During Extinc.	Rate of False Response During Extinc.
500 Hz (N = 12)				
Treatment I	333.083	13.917	3.546	0.629
Treatment II	468.0	16.583	3.198	0.220
	t = 0.922 <sup>a</sup>	t = 0.414	t = 0.517	t = 1.227
4000 Hz (N = 11)				
Treatment I	156.909	9.727	3.851	1.354
Treatment II	190.727	12.363	3.292	0.646
	t = 0.703 <sup>b</sup>	t = 1.113	t = 0.829	t = 0.935

<sup>a</sup>Levels of significance when Ns are 12 are 2.201 at .05 and 3.106 at .01.

<sup>b</sup>Levels of significance when Ns are 11 are 2.228 at .05 and 3.169 at .01.

reveals that all t-scores are well below the .05 level of significance. It should be noted that acquisition times for Treatment Two include the response transfer from vocal to tonal stimuli, and that despite slightly greater means in Treatment Two for both acquisition time and number of tonal stimuli to criterion, the differences are still not significant. In other words, in this heterogenous sample of MR children, with verbal instructions ruled out in each treatment, it did not require significantly more time to condition echoic vocal responses, despite the response transfer stage, than it did to condition standard motor responses.

Although t-scores for the differences between means of acquisition and extinction data for the two treatments did not achieve a level of

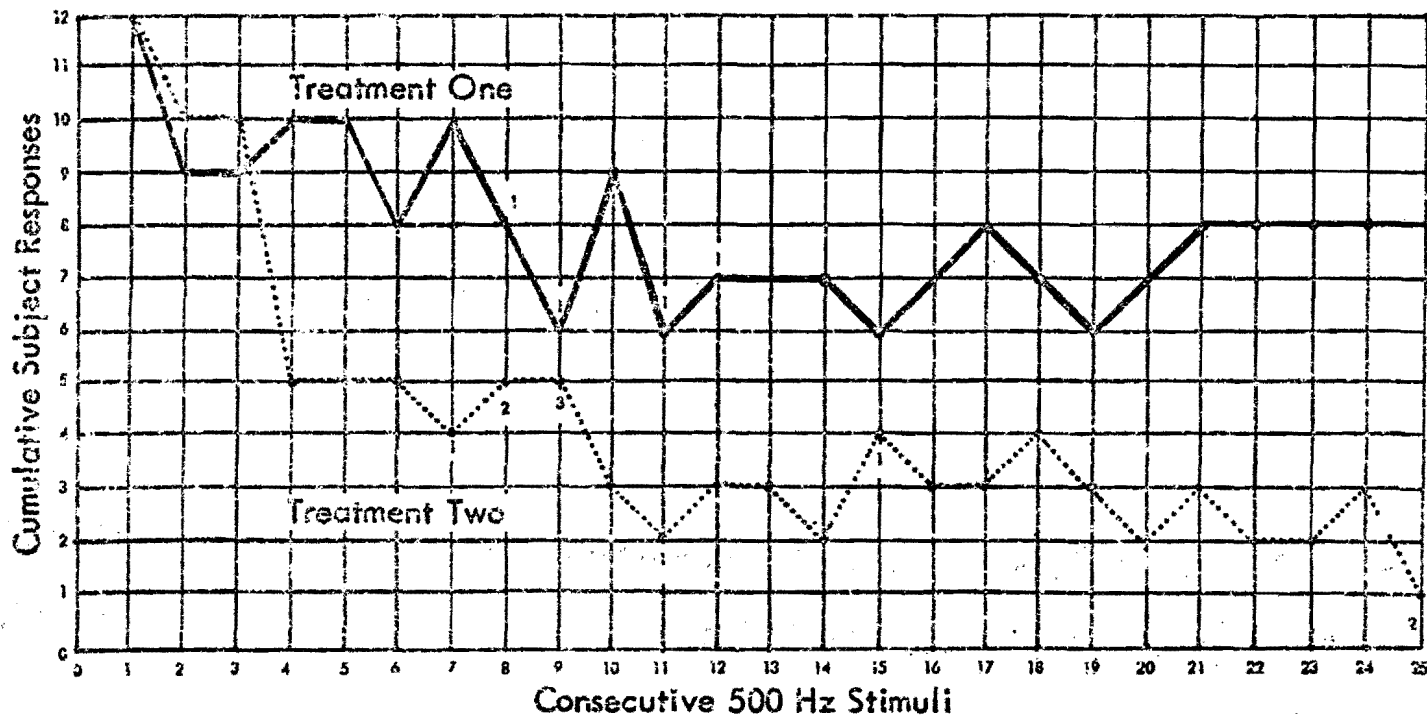
statistical significance (see Table VII), two trends are apparent in the extinction phase. One is that somewhat more false responses (responses without an antecedent signal tone) occurred in Treatment One than in Treatment Two. Although there was considerable disparity in the distribution of the sample, the mean number of false responses for object dropping (Treatment One, both frequencies) during the extinction phase was 8.75, while the mean number of false responses for EVR (Treatment Two, both frequencies) was only 1.636. Despite this trend, a t-test of the difference between these means, as for previously reported extinction data, did not achieve the .05 level of significance.

The second trend has previously been referred to: there was three times as much extinction in Treatment Two (EVR) as in Treatment One (object dropping). Although the extinction data did not achieve a statistical level of significance, this trend is most apparent in Figures 2 and 3, comparing cumulative response curves for the two treatments.

#### MI Level III vs MI Level IV

Although the number of subjects who could clearly be differentiated by psychometric data was limited, t-tests were applied to differences between means of subjects in MI Level III (moderate retardation) and MI Level IV (severe retardation). Results of these statistical treatments are seen in Table VIII. The only significant difference occurred at 500 Hz in Treatment One on number of tonal stimuli to achieve criterion, and this was at the .05 level only. In this instance, the number of stimuli was greater for 4 severely retarded children than for 5 moderately retarded subjects. No significant differences were found between MI III and MI IV children in any other frequency-treatment combination.





**Figure 2.** Comparison of cumulative response curves for Treatment One (object dropping) and Treatment Two (EVR) during extinction phase for 500 Hz stimuli following withdrawal of reinforcement. (Numbers refer to subjects achieving extinction criterion).

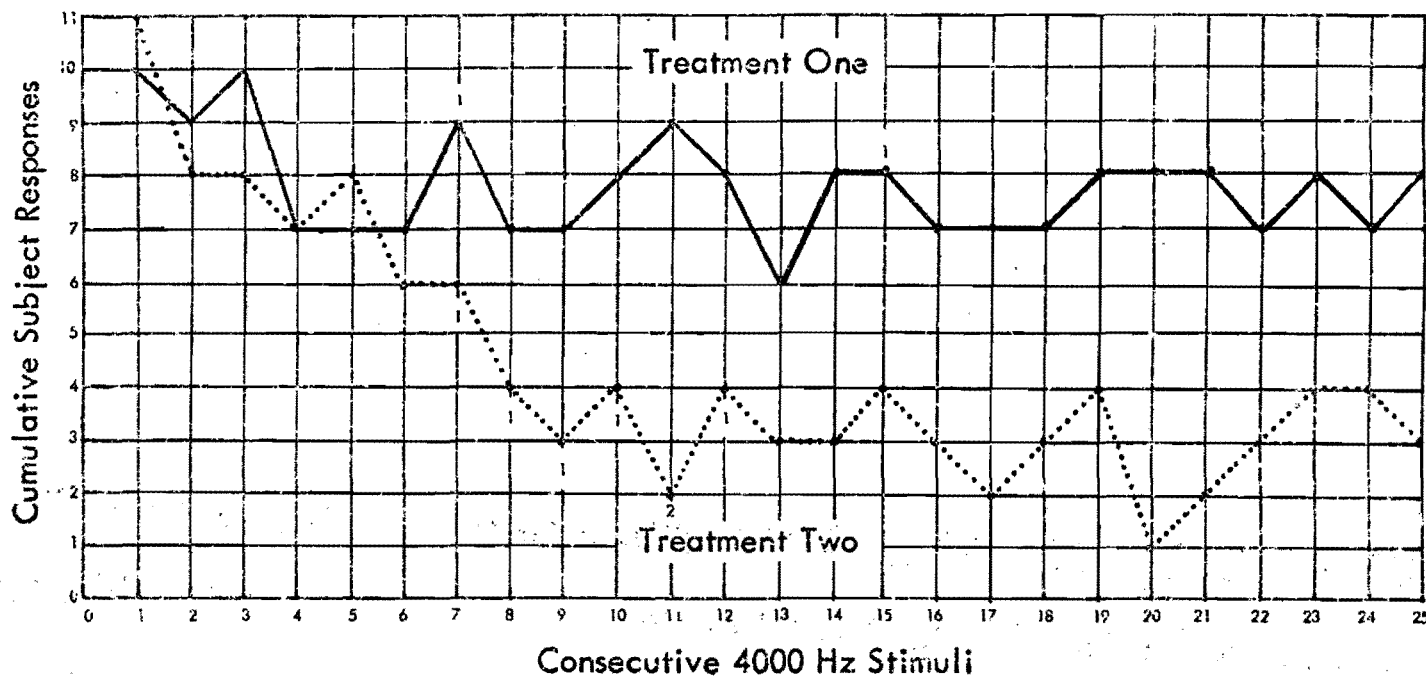


Figure 3. Comparison of cumulative response curves for Treatment One (object dropping) and Treatment Two (EVR) during extinction phase for 4000 Hz stimuli following withdrawal of reinforcement. (Numbers refer to subjects achieving extinction criterion).<sup>a</sup>

<sup>a</sup>Note that Figures 2 and 3 account for only 17 of the 18 extinctions occurring in Treatment Two. Since subject LH did not achieve criterion at 4000 Hz in Treatment One (see Table IV), her responses for both treatments at that frequency, and her extinction at that frequency in Treatment Two, were excluded from Figure 3.

TABLE VIII  
COMPARISON OF MEANS OF MI LEVEL III AND MI LEVEL IV

	Acq. Time to Criterion in Sec.	No. Tonal Stimuli to Achieve Criterion	Rate of Correct Response During "Extinc."	Rate of False Response During "Extinc."
Treatment One				
500 Hz:				
MI III	210.0 <sup>a</sup>	10.0 <sup>a</sup>	3.518 <sup>a</sup>	0.109 <sup>a</sup>
MI IV	602.5	22.25	4.090	0.138
	t = 1.845 <sup>b</sup>	t = 3.082	t = 0.370	t = 0.185
4000 Hz:				
MI III	177.0	44.0	4.115	0.0
MI IV	121.25	32.0	5.406	0.294
	t = 0.981 <sup>c</sup>	t = 1.0	t = 0.793	t = 0.390
Treatment Two				
500 Hz:				
MI III	790.0	33.75	3.007	0.625
MI IV	271.25	8.0	3.736	0.0
	t = 2.115	t = 1.594	t = 0.463	t = 1.0
4000 Hz:				
MI III	150.75	13.0	2.922	1.105
MI IV	168.75	12.5	3.579	0.688
	t = 0.275	t = 0.123	t = 0.454	t = 0.917

<sup>a</sup>N equals 5. All other Ns are 4.

<sup>b</sup>Levels of significance when Ns are 4 and 5 are 2.365 at .05 and 3.499 at .01.

<sup>c</sup>Levels of significance when both Ns are 4 are 2.447 at .05 and 3.707 at .01.

Relation of IQ, MA and CA to Acquisition and Extinction Data

Product-moment correlations (see Appendix B) were computed between IQ, MA and CA data and (1) acquisition time, (2) number of tonal stimuli to acquisition, (3) rate of correct response during extinction phase,

and (4) rate of false response during extinction phase. Computations for each frequency-treatment combination resulted in a total of 48 coefficients of correlation. Table IX illustrates that these  $r$ 's were quite inconsistent. Overall, correlations were equally divided between positive and negative. Approximately 69% of these were either negligible or slight, 27% were substantive, with only about 4% showing a high degree of

TABLE IX  
FREQUENCY OF POSITIVE AND NEGATIVE CORRELATIONS BETWEEN  
IQs, MAs, CAs AND ACQUISITION-EXTINCTION DATA

Range of $r$	Parameters Correlated						Totals
	IQ		MA		CA		
	Acq. <sup>a</sup>	Ext. <sup>b</sup>	Acq.	Ext.	Acq.	Ext.	
.00 to .20	+ 0 - 1	+ 0 - 3	+ 2 - 1	+ 1 - 4	+ 1 - 1	+ 0 - 2	+ 4 - 12
.20 to .40	+ 4 - 1	+ 1 - 0	+ 1 - 1	+ 1 - 0	+ 2 - 1	+ 1 - 4	+ 10 - 7
.40 to .70	+ 1 - 1	+ 2 - 2	+ 2 - 0	+ 1 - 0	+ 2 - 1	+ 1 - 0	+ 9 - 4
.70 to 1.0	+ 0 - 0	+ 0 - 0	+ 1 - 0	+ 0 - 1	+ 0 - 0	+ 0 - 0	+ 1 - 1
Totals	+ 5 - 3	+ 3 - 5	+ 6 - 2	+ 3 - 5	+ 5 - 3	+ 2 - 6	+ 24 - 24

<sup>a</sup>"Acquisition" here refers to both acquisition time and number of stimuli to criterion.

<sup>b</sup>"Extinction" here refers to both rate of correct response and rate of false response during extinction as defined in this study.

relationship. There was no instance in which a substantial (.40 to .70) or high (above .70) correlation was clearly supported by similar frequency-treatment pairings, and in many cases there was direct contradiction in terms of positive versus negative relationship. It is clear that in this small, heterogenous sample of retarded children, in which IQ and MA ranges varied only 19 points and 1 year, 7 months, respectively, and in which Ns for psychometrically-measured subjects were only 7 and 9, that there was no consistent relationship between IQ, MA or CA on the one hand, and acquisition and extinction data on the other.

#### IV. SUMMARY OF RESULTS

##### Acquisition

(1) Eleven of the original 14 mentally retarded subjects achieved acquisition criteria for both treatments, i.e., for both EVR and motor response modes.

(2) Response transfer from vocal to pure tone stimuli was accomplished with little difficulty with 10 of the 13 subjects exposed to it. Two girls achieved transfer with substantial difficulty, and one boy failed to achieve transfer.

(3) Acquisition data did not differ significantly between treatments for the retarded children in this study.

##### Extinction

(1) Extinction following withdrawal of reinforcement occurred in 24 of the 49 separate tests comprising this study.

(2) Three times as much extinction occurred with EVR in Treatment Two than with object dropping in Treatment One. Six extinctions occurred

in Treatment One; 18 extinctions occurred in Treatment Two. Nine of the 12 subjects in Treatment One did not extinguish at either frequency; only 2 of the 12 subjects in Treatment Two did not extinguish at either frequency.

(3) There was a trend toward more false responses in Treatment One (object dropping) as compared with Treatment Two (EVR).

(4) Differences in extinction data between the two treatments were not statistically significant in terms of rate of correct response, rate of false response, and number of false responses up to the point of achievement of extinction criterion.

#### Order of Treatments

(1) Order of presentation of treatments was not a significant factor in terms of acquisition time, number of tonal stimuli to acquisition, rate of correct response during the extinction phase, or rate of false response during extinction phase.

(2) Eight extinctions among 25 tests occurred in Group A, which received Treatment One first. Sixteen extinctions occurred among the 24 tests of Group B, which received Treatment Two first. Thus, Group A accounted for  $1/3$  of the extinctions, while Group B accounted for  $2/3$ .

#### Additional Results

(1) Frequency of the pure tone stimuli (500 vs 4000 Hz) was not a significant factor in the results.

(2) Among the small numbers of subjects who could be categorized on the basis of psychometric data, no clear and consistent differences were found in statistical analysis of acquisition and extinction data

between MI Level III (moderately retarded) and MI Level IV (severely retarded) children.

(3) The small numbers of subjects on whom specific MA and IQ scores were available, and the relatively small numerical ranges encompassed, did not permit consistent, meaningful correlations of psychometric data with acquisition and extinction data.

## CHAPTER V

### DISCUSSION

Results reported in the preceding chapter demonstrate no significant differences in acquisition data between object dropping and EVR. Thus, the first hypothesis of this study is not supported by the results. However, it is interesting that the additional procedures of vocal conditioning and response transfer in Treatment Two did not require a significantly greater amount of time than the simpler procedures of Treatment One. Since verbal instructions were not used in conditioning either response mode, this raises the question as to whether EVR could be effected in less time with such assistance. If the subject could be directly conditioned to EVR for pure tones with the help of verbal instruction, then it is conceivable that this response mode might be acquired significantly faster than object dropping. This, however, remains to be established.

The difficulty in response transfer encountered by three subjects, (two finally achieving it and one failing after many stimuli pairings), and their general characteristics, (cooperative, among the oldest, one near the IQ mean, the other two at the top of the respective MA and IQ ranges), is interesting. The boy (DM) who failed to achieve transfer was in Group A, in which Treatment One was presented first. He had easily acquired criterion for object dropping responses with the minimum number of tonal stimuli and had not extinguished at either frequency. LH was also in Group A, but had been relatively slow to achieve object



dropping criterion for 500 Hz, subsequently extinguishing, and had failed to achieve criterion at 4000 Hz. SH, however, was a Group B subject who went on to achieve criterion at both frequencies in Treatment One rather quickly without extinguishing for either. These three subjects do not appear to share any characteristics which would distinguish them from their peers except age and the psychometric data referred to. Consequently, the question arises as to whether age is an influencing factor in response transfer among retardates. This should be the object of further study.

The second hypothesis of this study tends to be supported in terms of the substantially greater number of extinctions occurring in association with EVR as compared to object dropping, a ratio of three to one. Evidently, for the retarded children in this sample, resistance to extinction was greater for object dropping than for echoic vocalizing. This raises the question as to whether EVR might be made more resistant to extinction in some manner. One possibility involves utilization of the voice-activated neon tube in the experimental control booth (see Figure 1). This was not in operation for this study. A future application in which activation of this light by a vocal response is made contingent upon an antecedent test tone should be investigated.

The trend toward occurrence of fewer false responses for EVR than object dropping also deserves some future consideration. There appeared to be more dispersal of this phenomenon among the subjects engaged in object dropping than when they responded vocally. The false responses associated with EVR, while sometimes numerous, were limited to fewer children. If this is a trend which is sustained in future studies, then

EVR might offer a decided advantage in audiometric testing of MR children prone to demonstrate a high frequency of false positive motor responses.

The greater frequency of extinction among Group B subjects--16 in 24 tests--as compared with Group A subjects, who had only 8 in 25 tests, is felt to be a chance occurrence rather than a function of order of treatments. There is no evidence that order of presentation was a significant factor in the obtained results, and there is no rationale which would seem to support a relationship between that factor and extinction.

Similarly, it would seem that little or no weight ought to be attached to the one significant t-score (at the .05 level) found between means for number of tonal stimuli to criterion at 500 Hz in Treatment One between MI Level III and MI Level IV children. The Ns of 5, the absence of significant t-scores for any other frequency-treatment acquisition data, the limited ranges for psychometric data, and the subsequent inconsistent  $r$ s between psychometric and acquisition-extinction data lend support to this position.

The results provide no initial evidence to suggest that echoic vocalization would be impractical as a response mode for routine audiologic assessment of certain mentally retarded or other subjects. Indeed, the findings tend to support the position that it may be a useful adjunct to the audiologist's options. Certainly, one can think of some physically handicapped patients, retarded and otherwise, for whom a response mode other than object dropping or hand raising might be desirable. The applicability of EVR to clinical threshold determination, however, remains to be established.

It is clear that additional research employing EVR with mentally retarded children is needed. It is felt that the following questions and

proposals merit serious consideration:

(1) Can verbal instruction be used in conjunction with operant techniques to effectively bypass the vocal conditioning and response transfer stages used in this study to achieve EVR? This would entail verbally directing the subject to vocalize a syllable such as /a/ immediately following perception of each pure tone signal and reinforcing this contingency to achieve stimulus control. Certainly, an investigation of this question should be initiated. If it is established that EVR can be directly conditioned among MRs, then this modification should be compared with a similarly verbal-assisted object dropping response mode.

(2) If response transfer is shown to be essential to EVR among MR children, then an investigation limited to that procedure should compare older and younger retardates sharing similar MAs in order to determine whether the older children tend to be more resistant to transfer.

(3) The possibility of increasing the resistance to extinction for EVR among MR children by use of a voice-activated light should be explored.

(4) Frequency of false positive response in EVR as compared to object dropping should be an integral part of any further research.

(5) EVR and object dropping should be compared for effectiveness in threshold determination among MR children. This is an essential step toward clinical application of this response mode.

(6) Pairing of motor and EVR modes in testing MR or other difficult-to-test patients should be investigated. Of particular interest are (a) whether a combination of the two response modes would result in greater resistance to extinction than either one alone, and (b) whether

valid responses might be separable from false positive responses on the basis of pairing vs absence of pairing.

(7) Other applications of breath expulsion or inspiration as response modes should be explored. It is conceivable that blowing a whistle or horn might prove to be practical and less resistant to extinction than phonation. Audible inspiration of breath might also be an effective response mode for some children if it could be brought under stimulus control. This phenomenon has been observed to sometimes precede a motor response to a sound stimulus among young children.

## CHAPTER VI

### SUMMARY AND CONCLUSIONS

#### I. PROBLEM

Mentally retarded children demonstrate an abnormally high incidence of hearing impairment, and many, particularly those with IQs below 40, are difficult for audiologists to test. Consequently, there is great need among this population for investigating response modes and conditioning of responses to auditory stimuli. A review of the literature reveals no studies of echoic vocalization as a conditioned response mode to pure tone stimuli among the retarded.

#### II. METHOD

A heterogenous sample of 13 moderately and severely mentally retarded children ranging in age from 7 years, 7 months to 16 years, 3 months were compared on two response modes to suprathreshold pure tone signals of 500 and 4000 Hz: (1) dropping poker chips, and (2) echoic vocalization (EVR). All subjects received both treatments, but were divided into Groups A and B, the former receiving Treatment One (object dropping) first, the latter receiving Treatment Two (EVR) first. Operant procedures combined social and tangible reinforcement in each treatment to achieve stimulus control without specific verbal instructions. EVR in Treatment Two included two unusual stages: (1) conditioning of imitations to the experimenter's single-syllable vocalizations, usually /a/, and (2)

conditioning of response transfer from vocal to pure tone stimuli. Acquisition and extinction to first 500 and then 4000 Hz proceeded sequentially within each treatment. Acquisition criterion for both vocal and pure tone stimuli was arbitrarily defined as eight consecutive responses. Extinction was arbitrarily defined as failure to respond to six out of eight tonal stimuli following withdrawal of reinforcement.

### III. RESULTS

- (1) Eleven of the 13 children achieved acquisition criterion for both response modes.
- (2) Three of the 13 children encountered substantial difficulty in response transfer.
- (3) Acquisition data for the two treatments did not differ significantly.
- (4) Extinction occurred among slightly less than half of the subjects. EVR in Treatment One accounted for three times as much extinction as object dropping in Treatment One.
- (5) There was a trend toward greater occurrence of false responses in Treatment One (object dropping) as compared with Treatment Two (EVR).
- (6) Up to achievement of extinction criterion, differences in extinction phase data between treatments were not statistically significant.
- (7) Order of presentation of treatments was not a significant factor in the results.
- (8) More extinction occurred in Group B than in Group A. This was attributed to a chance occurrence.

(9) Frequency of the pure tone stimuli was not a significant factor in the results.

(10) No clear, consistent differences were found between moderately retarded and severely retarded subjects, but Ns for those with valid psychometric data were small and ranges of scores were limited.

(11) No consistent relationship between MA, IQ, and CA data on the one hand, and acquisition-extinction data on the other was evident in the results.

#### IV. CONCLUSIONS

Despite substantially greater frequency of extinction following withdrawal of reinforcement as compared with object dropping, echoic vocalization response (EVR) has been shown to be an effective and practical response mode to suprathreshold pure tone stimuli among a small, heterogeneous sample of moderately and severely mentally retarded children.

Further investigations in clinical and experimental settings are recommended and described.

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## APPENDIX A

### DEFINITION OF TECHNICAL TERMS AND ABBREVIATIONS

#### I. AUDIOLOGIC TERMS

- dB: The abbreviation for the term decibel, which is 1/10 of a bel. The decibel expresses the ratio of two values of power. It is a useful measure for comparing the power of two sounds.
- HL: The abbreviation for the term hearing level or hearing loss, which is the deviation from the established threshold level represented by a zero reading on the hearing loss dial of the audiometer.
- Hz: The abbreviation for the term Hertz, from the German physicist, Heinrich Hertz, about 1886. It is equivalent to cycles per second (cps), referring to the number of double sine waves or complete cycles occurring in a vibrating body each second.
- Masking: The amount by which the threshold of audibility of a sound is raised by the presence of another (masking) sound. The unit customarily used is the decibel (dB).
- Pure tone: A simple tone or sound wave, the instantaneous sound pressure of which is a simple sinusoidal function of the time.
- Screening (audiometric): A method or group of methods designed to separate individuals whose thresholds lie above the normal from those whose thresholds lie at or below the normal threshold. Both speech and pure tones are used as test signals.
- Sound field: A region containing sound waves. Sound field audiometric testing introduces either pure tone or speech signals to the subject by means of air conducted sound waves without the use of earphones or bone oscillator, usually within a confined room especially designed for that purpose.
- SPL: The abbreviation for the term sound pressure level, which is, in decibels, 20 times the logarithm to the base 10 of the ratio of the pressure of this sound to the reference pressure, usually stated as .0002 dynes per cm<sup>2</sup>.
- Suprathreshold: Above threshold; i.e., a sound stimulus which is above the threshold for hearing.

Threshold testing: Determination of the lowest intensity of a stimulus required to produce a sensation in a subject or elicit a response from him.

## II. OPERANT TERMS

Discriminative stimulus ( $S^D$ ): A stimulus in whose presence a particular bit of operant behavior is highly probable, because the behavior has previously been reinforced in the presence of that stimulus.

Neutral stimulus ( $S^\Delta$ ): Any environmental event which at any particular time brings about no change at all in behavior, whether it precedes, accompanies, or follows a response.

Operant conditioning: The science of behavior in which the frequency of occurrence of bits of behavior is modified by the consequences of the behavior.

Paradigm: A model or pattern.

Reinforcement theory: Operant conditioning theory.

Stimulus control: The stage in operant conditioning at which an  $S^D$  will, with a high degree of probability, control a particular operant (response). The high frequency of the operant in the presence of the  $S^D$  is achieved through the frequent accompaniment of the  $S^D$  with the occurrence of the operant and subsequent reinforcement of this contingency.

Stimulus generalization: The tendency to respond to other stimuli in addition to the one stimulus in the presence of which the response was first reinforced. An organism or behavior is said to generalize to all those stimuli in whose presence the rate of responding increases after the response has been reinforced in the presence of one other stimulus.

## APPENDIX B

### FORMULAE USED FOR STATISTICAL COMPUTATIONS

#### I. T-TESTS

When the number of scores was the same for both groups:

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{\Sigma X_1^2 - (\Sigma X_1)^2/N + \Sigma X_2^2 - (\Sigma X_2)^2/N}{N(N-1)}}$$

When the number of scores for each group was not equal:

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{\Sigma X_1^2 - (\Sigma X_1)^2/N_1 + \Sigma X_2^2 - (\Sigma X_2)^2/N_2}{[N_1 + N_2 - 2]} \left[ \frac{1}{N_1} \quad \frac{1}{N_2} \right]}}$$

N refers to the number of subjects;  $\bar{X}$  represents the scores for each parameter; and  $\bar{X}$  equals the respective sample means. (Thompson, 1965).



When comparison of means for two measures was made on the same subjects for both treatments:

$$t = \frac{\bar{X}_2 - \bar{X}_1}{\sqrt{\frac{\sum D^2 - (\sum D)^2 / N}{N(N-1)}}$$

$\bar{X}$  represents the respective mean; D refers to deviations of each subject on the two parameters; and N is the number of pairs of scores (Thompson, p. 33).

## II. COEFFICIENTS OF CORRELATION

Product-moment formula:

$$r = \frac{N\sum XY - \sum X\sum Y}{\sqrt{[N\sum X^2 - (\sum X)^2][N\sum Y^2 - (\sum Y)^2]}}$$

N refers to the number of subjects; and X and Y represent the scores or values, respectively, whose linear relationship was investigated (Thompson).