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THE RELATIONSHIP BETWEEN DISCRIMINATION AND STIMULUS GENERALIZATION IN SEVERELY RETARDED CHILDREN

DISSERTATION

Presented in Partial Fulfillment of the Requirements for the Degree Doctor of Philosophy in the Graduate School of The Ohio State University

By

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The Ohio State University
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Approved by

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## CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACKNOWLEDGMENTS</td>
<td>ii</td>
</tr>
<tr>
<td>ILLUSTRATIONS</td>
<td>iv, v</td>
</tr>
<tr>
<td>BACKGROUND</td>
<td>1</td>
</tr>
<tr>
<td>Statement of the Problem</td>
<td>16</td>
</tr>
<tr>
<td>EXPERIMENT I</td>
<td>17</td>
</tr>
<tr>
<td>Introduction</td>
<td>17</td>
</tr>
<tr>
<td>Method</td>
<td>19</td>
</tr>
<tr>
<td>Subjects</td>
<td>19</td>
</tr>
<tr>
<td>Apparatus</td>
<td>20</td>
</tr>
<tr>
<td>Procedure</td>
<td>27</td>
</tr>
<tr>
<td>Results</td>
<td>37</td>
</tr>
<tr>
<td>Discussion</td>
<td>48</td>
</tr>
<tr>
<td>EXPERIMENT II</td>
<td>54</td>
</tr>
<tr>
<td>Introduction</td>
<td>54</td>
</tr>
<tr>
<td>Method</td>
<td>55</td>
</tr>
<tr>
<td>Subjects and apparatus</td>
<td>55</td>
</tr>
<tr>
<td>Procedure</td>
<td>55</td>
</tr>
<tr>
<td>Results</td>
<td>56</td>
</tr>
<tr>
<td>Discussion</td>
<td>61</td>
</tr>
<tr>
<td>SUMMARY</td>
<td>64</td>
</tr>
<tr>
<td>BIBLIOGRAPHY</td>
<td>66</td>
</tr>
<tr>
<td>AUTOBIOGRAPHY</td>
<td>72</td>
</tr>
</tbody>
</table>
ILLUSTRATIONS

Figure

1  Diagram of Laboratory and Apparatus......................... 22
2  Diagram of Stimulus Window, Stimulus Background Board, Auxiliary Lights, Plunger and Food Pan........ 24
3  Group Generalization Test Performance for the Five Conditions: Criterion, Overlearning, 2-SD Discrimination, Repeated SG and Normal, Plotted in Terms of Proportion of Total Responses........................................ 40
4  Group Generalization Test Performance for the Two Instructional Conditions: Conventional and Only, Plotted in Terms of Proportion of Total Responses........................................ 59

Table

1  Mean Individual Generalization Test Scores of Retarded Subjects Trained Under Criterion Condition........................................ 42
2  Mean Individual Generalization Test Scores of Retarded Subjects Trained Under Overlearning Condition...... 42
3  Mean Individual Generalization Test Scores of Retarded Subjects Trained under 2-SD Discrimination Condition........................................ 43
4  Mean Individual Generalization Test Scores of Retarded Subjects Trained Under Repeated SG Discrimination Condition on Generalization Test No. 5................................. 43
5  Mean Individual Generalization Test Scores of Normal Subjects Trained Under Criterion Condition........................................ 44
6  Summary of Subjects by Tests by Treatments Analysis of Variance of Stimulus Generalization Test Performance of Criterion, Overlearning, 2-SD Discrimination, Repeated SG and Normal Conditions.. 45
<table>
<thead>
<tr>
<th>Table</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>Summary of Subjects by Tests Analysis of Variance of Stimulus Generalization Test Performance of Criterion Condition</td>
</tr>
<tr>
<td>8</td>
<td>Summary of Subjects by Tests Analysis of Variance of Stimulus Generalization Test Performance of Overlearning Condition</td>
</tr>
<tr>
<td>9</td>
<td>Summary of Subjects by Tests Analysis of Variance of Stimulus Generalization Test Performance of 2-S^- Discrimination Condition</td>
</tr>
<tr>
<td>10</td>
<td>Summary of Subjects by Tests Analysis of Variance of Stimulus Generalization Test Performance of Repeated SG Conditions</td>
</tr>
<tr>
<td>11</td>
<td>Summary of Subjects by Tests Analysis of Variance of Stimulus Generalization Test Performance of Normal Condition</td>
</tr>
<tr>
<td>12</td>
<td>Mean Individual Generalization Test Scores of Normal Subjects Receiving Conventional Instructions</td>
</tr>
<tr>
<td>13</td>
<td>Mean Individual Generalization Test Scores of Normal Subjects Receiving Only Instructions</td>
</tr>
<tr>
<td>14</td>
<td>Summary of Subjects by Tests by Treatments Analysis of Variance of Stimulus Generalization Test Performance of Normal Subjects Receiving Conventional and Only Instructions</td>
</tr>
</tbody>
</table>
BACKGROUND

Stimulus generalization performance of severely retarded children has been the subject of very little research. The same condition exists for psychological research in general with this class of retardate. This scarcity of basic learning research is due primarily to the failure of psychologists to recognize the potential value of the severely retarded child for studying learning problems, particularly those related to the history of reinforcement or discrimination history. These retardates are characterized by a very limited behavioral repertory which presumably reflects an impoverished discrimination and reinforcement history. Because of this characteristic they should be ideally suited for learning studies that require "naive" subjects or are concerned with effects of history of reinforcement or discrimination on behavior.

Discrimination performance of mental retardates appears to be a function of learning, genetic, biochemical and of neurostructural variables (McCandless, 1964; Anderson, 1964; Waisman and Gerritsen, 1964; and Malamud, 1964, respectively). The variables of interest for this discussion are, of course, those classified under learning, specifically discrimination. Research related to the effects of discrimination and reinforcement history on the development of behavior suggests that the influence of these variables on development of a normal behavioral repertory may be quite extensive (Hunt, 1961; McCandless, 1964).

1The term severely mentally retarded refers to persons with IQ ranges from 20 to 35 as measured by the Revised Stanford-Binet Tests of Intelligence, Forms L and M (Heber, 1961).
1964; and Haywood and Tapp, 1966). Unfortunately this research either lacks adequate controls or does not deal directly with the development of mental retardation\(^2\) in humans. Therefore, few firm conclusions can be drawn concerning the specific learning variables that contribute to retarded development. Thus, the hypothesis being presented is somewhat speculative.

A concept of behavioral development based on a discrimination and reinforcement history assumption states that an individual's discrimination or behavioral repertory at any time in his life is primarily a function of his discrimination and reinforcement history (Ferster, 1961; and Bijou, 1966). From this point of view the mentally retarded person, as compared with the person of normal intelligence, is one with a deficient behavioral repertory which is the result of an inadequate discrimination and reinforcement history. Similarly, the severely retarded child has an even more impoverished behavioral repertory which reflects his very limited discrimination and reinforcement history. This is the basic formulation used by both Bijou and by Ferster to interpret the development of mental retardation and autistic behavior, respectively (Bijou, 1966; and Ferster, 1961).

\(^2\)The terms mental retardation and normal intelligence are used only in a descriptive sense to identify persons who have been classified on the basis of intelligence test scores. People labelled as mentally retarded are those with IQs of 84 or less and people identified as being of normal intelligence have IQs of 85 or above, as measured by the Revised Stanford-Binet Tests of Intelligence, Forms L and M (Heber, 1961). These terms do not refer to some hypothetical underlying mental process or intervening variable.
In conclusion, because of their limited discrimination repertoires severely retarded children should be quite useful for basic learning research concerned with the influence of history of reinforcement on discrimination. In addition, their extremely low rate of acquisition and very narrow discrimination repertory should make it possible to observe certain effects of stimulus control that may remain undetected when infrahuman organisms, such as pigeons, rats and monkeys are used as subjects (Watson and Sanders, 1966; and Ferster, 1961). Ross (1966) has also emphasized the application of results from research with retardates to knowledge of basic principles of learning.

Only two studies have been published that were concerned with stimulus generalization performance of severely mentally retarded children (Bialer, 1961; and Lane and Curran, 1963). Bialer gave severely retarded mongoloids a transfer of training test in a situation where transfer could occur on the basis of either primary or secondary generalization but not both. Subjects were trained to respond to stimuli in a simple simultaneous discrimination context on the basis of form cues and of verbal cues that had been associated with each form cue. The assumption underlying the procedure was that if, during the test of transfer, stimuli with forms identical to those used in discrimination training were selected this would be evidence for primary generalization. However, if stimuli with names identical to those used in discrimination training were selected this would indicate that transfer occurred by means of secondary generalization. All mongoloids transferred on the basis of form or primary generalization. Two other groups of subjects in this study were mildly
retarded\(^3\) and normal individuals. In contrast with the mongoloids
60 per cent of the mildly retarded subjects made verbal responses
during the transfer test and all normal subjects made verbal responses—
secondary generalization.

Tone intensity generalization was investigated by Lane and Curran
using a differential (two-stimulus) discrimination training procedure.
Three blind severely retarded males were trained to respond differentially to two tone intensities. They were then given a stimulus
generalization test using eleven different tone intensities intermediate
to the two training stimuli. Sloped, irregular, nonmonotonic generalization gradients were obtained that were similar to those found with
normal and infrahuman organisms.

The comparative stimulus discrimination procedure used by Lane
and Curran prevents the investigation of a very interesting and
significant question. What are the characteristics of stimulus generalization gradients based on the severely retarded child's "natural"
discrimination history, i.e., the discrimination history of the child acquired in his environment outside the laboratory. Answers to this
question should furnish information about the effects of stimulus control exerted by different stimulus dimensions, particularly as related
to transfer. This type of problem can best be studied using a nondifferential or single-stimulus discrimination procedure. Single-stimulus

\(^3\)The term mildly mentally retarded refers to persons with
IQ ranges from 52 to 67 as measured by the Revised Stanford-Binet Tests of Intelligence, Forms L and M (Heber, 1961).
training presumably minimizes the effects of discrimination training in the test situation on generalization gradients and should reflect the subject's discrimination history acquired in the extralaboratory environment. Differential training, on the other hand, "builds in" the relevant discrimination history and obscures the effects of the subject's natural discrimination history.

Both sloped and flat generalization gradients have been obtained with the free-operant method using a single-stimulus training procedure when animals were used as subjects. Sloped gradients have been obtained following single-stimulus training with a wavelength of light, a size-brightness dimension, and angularity of a white line (Guttman and Kalish, 1956; Margoliou, 1963; and Butter, 1963; respectively). However, flat gradients have been obtained following training with light and tone, a black-white dimension, tone, light intensity and angularity of white line (Ferster, 1951; Rheinhold and Perkins, 1955; Jenkins and Harrison, 1960; Margoliou, 1963; and Newman, 1963; respectively).

Baron (1965) has formulated a hypothesis that accounts for the above inconsistency in results of single-stimulus generalization studies. He proposes that the slope of generalization gradients is a positive function of stimulus control, and that all stimulus dimensions do not maintain equivalent stimulus control over the behavior of different organisms, i.e., different organisms respond more readily or with greater sensitivity to some stimulus dimensions than to others. He suggests that, for any organism presented with a complex of stimuli, there is an "attending hierarchy," i.e., "an ordering of the degree to
which each element or dimension of the complex will come to control behavior." This hypothesis refers to a "natural" stimulus hierarchy that exists prior to formal stimulus discrimination training. Differential stimulus training is an example of formal discrimination training. Thus, if an organism receives single-stimulus training with a complex stimulus and is given a generalization test along a stimulus dimension high in his natural attending hierarchy, sloped gradients should be obtained. But if he is tested on a stimulus dimension low in the hierarchy, the resulting gradient should be relatively flat, the degree of slope being a function of the stimulus control properties of the stimulus.

A number of studies support Baron's concept of an attending stimulus hierarchy (Warren, 1953, 1954; Jones, 1954; and Newman, 1963). Warren (1953) found, in a discrimination study with monkeys, that color was the most effective stimulus dimension, with form next and size the least effective. In a cue-reduction study Warren (1954) found a combination of color-form to maintain the greatest stimulus control, followed by color-size, color, form-size, form and finally size. In a simple simultaneous discrimination study with pigeons where both color and form stimulus dimensions were presented, more pigeons responded to the color cue than to the form cue (Jones, 1954). Newman (1963) found that color maintained greater stimulus control over differential responding of pigeons than angular orientation. These four studies appear to support the concept of attending stimulus hierarchy.

In all of the studies color was the most effective stimulus dimension.

One study with retardates suggests that they also show differential
sensitivity to different stimulus dimensions. Zeaman (1963) found for retardates with an MA range from four to six years, that the number of trials required to reach criterion on a simultaneous discrimination problem was a function of the number of stimulus dimensions present as well as the specific dimensions themselves. Three-dimensional objects common to their living environment ("junk" stimuli) appeared to exert the greatest stimulus control as indicated by trials to criterion. Next in the hierarchy was color-form object or color-form three-dimensional stimuli; next was form, next was color-form on a two-dimensional background, and finally color alone was the least effective stimulus.

Newman's study (1963) also shows that attending stimulus hierarchies can be altered as a function of the discrimination history of the organism. One group of pigeons received differential training with line angularity while a second group was given single-stimulus training with this cue. When both groups were given a generalization test the differentially trained groups exhibited a steep gradient while the single-stimulus trained group showed a relatively flat gradient. This finding suggests that comparative stimulus training made line angularity an effective stimulus dimension for the pigeon.

Research with retardates also shows that stimulus hierarchies can be altered through training. Mankinen and Heal (1965) studied simultaneous discrimination performance of moderately\(^{\text{1}}\) and mildly retarded persons using stimuli containing both form and color cues, either of which was relevant. After subjects reached criterion the cues were

\(^{\text{1}}\)The term moderately mentally retarded refers to persons with IQ ranges from 36 to 51 as measured by the Revised Stanford-Binet Tests of Intelligence, Forms L and M (Heber, 1961).
split, and they were forced to discriminate on the basis of color or form but not both. In this way it was possible to determine which of the two cues had been relevant during discrimination training. The relevant cue was called the "preferred" dimension and the nonrelevant cue the "nonpreferred" dimension. A dimension preference was obtained, and it was maintained across several discrimination problems. In another experiment with retardates Heal, Bransky and Mankinen (1965) found that dimension preference had a significant influence on discrimination performance. Performance was superior with the preferred dimension relevant to that with the nonpreferred dimension relevant. Then subjects received additional training with the nonpreferred dimension relevant and the preferred dimension irrelevant. Errors on the nonpreferred dimension decreased as a function of training. Another test utilizing both dimensions showed that, as a result of training with the nonpreferred dimension, subjects could now solve problems in which either dimension was relevant with comparable facility. This last finding was replicated in another study by Mankinen and Lucker (1966). Thus, stimulus dimensions which formally were not utilized in discrimination situations became relevant as a function of discrimination training.

Two studies with infrahuman organisms bear more directly on the notion that the slope of generalization gradients are a function of the organism's natural discrimination history. Peterson (1962) raised four ducklings in white-walled cages that were illuminated by a monochromatic light of 589nm. Thus, they were exposed only to a narrow range of color. When given a generalization test along a hue dimension
flat gradients were obtained. However, two duckling raised under normal lighting conditions produced the usual sloped gradients.

Ganz and Riesen (1962) reared one group of infant monkeys in total darkness and another group in a normally illuminated and visually patterned environment. Initial stimulus generalization testing resulted in somewhat flatter gradients for the dark-reared group than for the light-reared group. It appeared that the effect of relative stimulus deprivation resulted in flatter gradients for the dark-reared group. But when generalization testing continued for six more days the gradients of the dark-reared group became steeper than those of the light-reared group. It is not clear why this latter finding occurred.

These two studies indicate that the slope of generalization gradients is a function of natural discrimination history. However, the second finding by Ganz and Riesen suggests that this relationship may be rather complex.

Research with moderately and mildly retarded subjects using a single-stimulus discrimination procedure has yielded sloping generalization gradients similar to those found with "normal" organisms. These studies employed a wavelength dimension (Zeaman, 1963) and a spatial dimension (Barnett, 1958; and Tempone, 1965).

Certain studies have shown that stimulus generalization gradients vary as a function of "intellectual" or developmental variables. Tempone found the slope of spatial generalization gradients to be a function of IQ and MA. Three groups of eight-year olds, with IQs of 75, 100, and 127, were tested on a spatial generalization task similar to the one used by Brown, Bilodeau and Baron (1951). Eleven lights were mounted,
9 degrees apart, in a horizontal row on a curved plywood panel. Subjects were instructed to depress a key when the center lamp was lit. Results of the generalization test showed the slopes of generalization gradients increased as a function of MA and IQ. Thus, the retardates "generalized more" than the two groups of normal children. However Barnett failed to find a relationship between the slope of generalization gradients and MA and IQ using the same type of spatial generalization task. His subjects were two groups of 18-year olds, one with an IQ of 50 and the other with an IQ of 100. Barnett's failure to find differences in generalization gradients may be due to the fact that he had older subjects than Tempone. These two groups of subjects may have had comparable discrimination histories with respect to a spatial dimension.

There were also certain methodological differences in the two studies which may have contributed to these different results. Tempone covered his lamps with a strip of milk-white plexiglas while Barnett's lamps were exposed. The plexiglas cover diffused the light sources and subsequently may have reduced cue properties of the lamps related to location. Tempone also used a procedure to eliminate anticipatory responses. Barnett told his subjects not to respond to peripheral lamps while Tempone gave no such instructions. Mednick and Freedman (1960) have pointed out the influence of instructions on spatial generalization gradients.

The relationship between MA, IQ and stimulus generalization found by Tempone has also been obtained with children of normal intelligence who differed on the basis of CA. Mednick and Lehtinen (1957) investi-
gated spatial generalization with children of normal IQ whose ages ranged from seven through twelve years. The 10-12 year group exhibited steeper gradients than the 7-9 year group. White and Spiker (1960) also found the same general relationship with normal children ranging in age from 42 to 61 months. The 42-54 month age group produced a flatter gradient than the 52-61 month age group.

These stimulus generalization studies showing a relationship among CA, MA, IQ and generalization suggest that the slope of a generalization gradient is a function of learning variables. One of these variables appears to be discrimination history of the organism. With respect to the child of normal intelligence, accumulated discrimination history appears to be positively related to CA, and in the case of retarded children, MA and IQ also appear to be positively related to discrimination history.

Another major variable which appears to influence the slope of generalization gradients following single-stimulus training when the free-operant method is used is the training stimulus presentation procedure. While Newman (1963) obtained flat gradients following single-stimulus training to a line angularity stimulus dimension, Butter (1963) found sloped gradients. The important methodological difference appeared to be the color of the discriminative stimulus. In contrast with Newman's white vertical line Butter used a green vertical line. Honig, Boneau, Burstein and Pennypacker (1963) also obtained steep gradients with this same stimulus dimension using a single-stimulus training procedure. They used fairly sharp contrasts of the stimulus elements on the key during training. A black vertical line on a white
key as the discriminative stimulus was contrasted with a plain white key as the nonreinforced stimulus. Newman concluded that it is important to have the relevant stimulus sharply contrasted during training.

Bialer's (1961) findings about primary and secondary generalization point out a possible problem that should be considered when a stimulus generalization study is undertaken with severely retarded children. In his study severely retarded persons transferred on the basis of primary generalization while those of normal IQ transferred by means of secondary generalization or verbal mediation. If subjects of normal intelligence are used to provide a baseline of "normality" for comparing the generalization performance of the retardates, the mediation factor may influence generalization performance in a way that results in a generalization gradient that differs from one that is a function of primary generalization alone. Thomas and De Capito (1966) have shown that verbal mediation will alter the slopes of generalization gradients. If this is a variable which has a significant differential effect on the generalization gradients of normal as compared as compared with retarded children, then the effects should be isolated so they can be taken into consideration when evaluating generalization performance differences between these two populations.

Because severely retarded children are generally unresponsive to training procedures employing only verbal instructions the free-operant conditioning method should be the most useful technique for developing differential responding prior to generalization testing. However, it poses a problem when normal humans are used as controls. It may be more difficult to control or assess mediation effects when an operant
conditioning procedure is used than when verbal instruction is used. Mediation should be more easily controlled through verbal instructions since the subject can be told to label or classify the stimuli or he can be given such specific instructions that all subjects have the same interpretation of the discrimination task at the time of testing. It should be possible to develop highly specific stimulus control with humans using an operant conditioning procedure, but to date, there are no published studies dealing with this problem that might provide guidelines for such a technique. This method has been used exclusively with rats, pigeons, and monkeys (Ferster, 1951; Guttman and Kalish, 1956; and Butter, Mishkin and Rosvold, 1965). Differential responding has typically been developed with humans using a verbal instructional technique (Brown, Bilodeau and Baron, 1951; and Kalish, 1958).

An additional variable that may influence the slopes of generalization gradients of severely retarded children following single-stimulus discrimination training is the condition of their central nervous system. The current prevailing attitude is that most of these retardates have brain damage (Robinson and Robinson, 1965). Generalization studies with brain-damaged organisms indicates that stimulus generalization gradients are changed as a function of brain lesions (Mednick, 1955; Mednick and Wild, 1961; Butter, Mishkin and Rosvold, 1965; and Randall, 1965). Mednick has found that brain-damaged adults and children show "less generalization" to test stimuli than nonbrain-damaged control subjects (Mednick, 1955; and Mednick and Wild, 1961). The obtained generalization gradients were less elevated and somewhat flatter than gradients produced by normal subjects. In
addition, generalization responsiveness was a function of both the locus and extent of the brain lesion. Adults with lesions either in the dominant cortical hemisphere or both hemispheres showed less responsiveness than those with lesions in the nondominant hemisphere (Mednick, 1955).

Studies with cats and monkeys have shown that experimentally produced brain lesions resulted in either broader or flatter gradients when lesions were made in cortical areas related to the modality through which stimuli were presented (Randall, 1965; and Butter, Mishkin and Rosvold, 1965). Randall found that bilateral ablation of the auditory cortices of cats produced broader auditory generalization gradients, both with respect to the number of test stimuli to which they responded and response frequency to these stimuli. Butter et al. found that inferotemporal lesions in monkeys resulted in flatter visual generalization gradients than those found in nonoperated and operated controls when a single-stimulus training procedure was used. But when a comparative stimulus discrimination procedure was used to make the two visual stimuli, wavelength and line angularity relevant, the obtained generalization gradients for the inferotemporal monkeys were comparable to those of the control subjects. Thus the "impaired" generalization gradients correlated with brain lesions were "normalized" by building in or conditioning the relevant discrimination history, i.e., through training with a comparative discrimination procedure.

These two animal studies not only show that generalization gradients are a function of brain lesions, but they also indicate that
the effect is specific to certain areas of the brain and not to others. Randall produced lesions in different areas of the midbrain in cats and found that there were no systematic differences in either auditory discrimination or generalization performance as a function of the lesions. Butter et al. found that the generalization gradients of monkeys with bilateral lateral striate lesions were not significantly different from unoperated controls.

These four studies show that generalization gradients can be influenced by brain damage, but the degree of the effect appears to be limited by both locus and extent of the lesions. All human subjects used in the two studies by Mednick had very clearcut neurological diagnoses, and the cats and monkeys had lesions in cortical areas correlated in function with the stimulus modality through which the generalization test was presented. Many severely retarded persons, on the other hand, have "minimal brain-damage," i.e., they do not have a clear-cut diagnosis of brain-damage, but instead carry a diagnosis of "chronic brain syndrome" which is a somewhat speculative diagnosis. In addition to their possibly having minimal brain-damage it is by no means clear where the locus of this damage is. In other words, although clear-cut cases of brain damage may influence generalization gradients if they are in an area that affects the stimulus modality in question, it is by no means clear that brain-damage in general will influence these gradients. At this point it is still a moot question.

In summary the slope of a stimulus generalization gradient to a given stimulus dimension appears to be a function of the organism's
discrimination history. Most of the recent generalization studies with animals have used a hue or line angularity stimulus dimension in conjunction with the free-operant conditioning method while most instrumental-type generalization studies with humans have employed a spatial stimulus dimension in combination with a verbal instructional discrimination procedure. Therefore, an investigation of the relationship between discrimination training procedures and stimulus generalization to a size dimension with severely retarded and normal children using the free-operant conditioning method should help clarify the relationship between stimulus generalization and discrimination history and possibly extend the generality of this finding.

Statement of the Problem

The purpose of this dissertation was to investigate stimulus generalization performance of severely retarded children to a size stimulus dimension in a free-operant conditioning situation following single (one-stimulus) and comparative (two-stimulus) discrimination training and to compare stimulus generalization gradients of these retardates with those of normal IQ children of an equivalent chronological age. Experiment I evaluates stimulus generalization performance of normal and severely retarded children as a function of discrimination training and Experiment II explores the influence of verbal mediation on stimulus generalization performance of normal children.
EXPERIMENT I

Introduction

The purpose of this experiment was to evaluate stimulus generalization performance following four discrimination training conditions with severely retarded children and to obtain a "normal" baseline generalization gradient from children of normal IQ with a CA equivalent to that of the retardates. Four discrimination training conditions were selected for the retardates: (1) one-stimulus discrimination training to criterion, (2) one-stimulus discrimination training to criterion plus over-learning, (3) repeated stimulus generalization testing following one-stimulus discrimination training to criterion, and (4) two-stimulus discrimination training to criterion.

The second and third discrimination procedures were included because of somewhat inconsistent results obtained from a pilot study with severely and profoundly retarded children. Four subjects were given single-stimulus discrimination training using a modified Guttman and Kalish (1956) type of free-operant technique. The discriminative stimulus ($S^D$) was a black disc and the stimulus that was never correlated with reinforcement ($S^A$) was the absence of the disc. Three retardates showed random responding on a test of size stimulus generalization, i.e., there was no differential responding during the generalization test on the basis of stimulus size. The
fourth subject, who received 30 more sessions of discrimination training than the other three, showed clear differential responding on the basis of size change during generalization testing. He received more discrimination training than the others because of a high rate of $S^\Delta$ responding, i.e., it required 30 sessions more for him to reach criterion than the other subjects.

One possible reason for differential responding during generalization testing to changing stimulus sizes may have been the additional sessions of training the subject received, even though his $S^\Delta$ rate was far above discrimination criterion level. So, one other subject was given 18 additional sessions of single-stimulus training and retested. This time he produced a relatively steep generalization gradient as opposed to the flat gradient obtained from him on the first test.

These results suggest that the two types of generalization gradients obtained from these four subjects may have been a result of the different amounts of discrimination training they received. It was also possible that the steep gradient obtained from the subject who was retested was a function of the two generalization tests, i.e., the extended exposure to the test stimuli under extinction conditions. Zeaman (1963) reported that retarded subjects in a hue generalization study did not show differential responding to changes in wavelength at the outset of generalization testing which utilized an extinction procedure. Instead differential responding appeared later in the test.
In order to assess the influence of number of discrimination training sessions and repeated stimulus generalization testing on generalization performance the second and third discrimination conditions were included. The single-stimulus discrimination procedure was used to assess discrimination history and/or determine whether these retardates would respond differentially to a size change during generalization testing following this type of training. The two-stimulus discrimination procedure was included to compare generalization gradients following two-stimulus discrimination with those following single-stimulus training. They have typically been steeper following two-stimulus training than single-stimulus training (Ferster, 1951; and Hearst, 1962).

The normal group received only single-stimulus training to the same criterion as the retardates. Its function was to serve as the normal frame of reference against which to compare retarded versus normal generalization performance following the same kind of training and to assess discrimination history effects.

Method

Subjects

Twelve institutionalized severely retarded children and six children of normal IQ were used in this experiment. The retardates were selected from two wards of children with IQs of 35 or less and with a CA range from seven through fifteen years. They had a mean CA of eleven years with a range from eight years, four months to fourteen years, nine months and a mean SQ of 25 with a range from 17
to 36 as measured by the Vineland Social Maturity Scale. Normal
subjects were selected from a local children's home and were matched
with the retardates on the basis of CA. They had a mean CA of eleven
years, four months with a range from nine years to thirteen years,
eight months and a mean Vineland SQ of 98.33 with a range from 87
to 111. Normal subjects were selected from an institution in order
to keep deprivation conditions as similar as possible between the
two IQ groups. All subjects were ambulatory, and none had any obvious
visual defects that would presumably result in marked impairment to
visual acuity.

Apparatus

The experiment was conducted in a 21 by 21 foot room (Figure 1). In one corner of this room was an 8-foot square cubicle. The exper­
menter and the programming equipment were located inside the cubicle
while the subject remained outside in the larger room. On one wall
of the cubicle (as seen from the subject's side) was a 12" X 15 1/2"
plexiglas window and behind it, within the cubicle was a 15" X 18"
plywood board painted flat white that served as a background upon which
the discriminative stimulus and test stimuli were mounted during dis­
crimination training and generalization testing (Figure 2). A small
disc magnet, approximately 3/4" in diameter, was attached to the center
of this board and was used to attach the different stimuli. The board
was hinged so that it could be opened to attach and remove stimuli.
Figure 1. Diagram of laboratory and apparatus.
Figure 2. Diagram of stimulus window, stimulus background board, auxiliary lights, plunger and food pan.
Three inches beneath this window was a Lindsley manipulandum (plunger). Beside the plunger to the subject's left was a food pan. Two 7-watt fluorescent lights, one on each side of the stimulus window, illuminated the white background as did three clear and two blue 7 1/2-watt incandescent lights located on each side of the stimulus window beside the fluorescent lights. An Eico Model 377 tone generator was mounted above the stimulus window inside the cubicle and connected to a 4-inch speaker that channeled the tone out into the larger room.

Schedules of reinforcement were programmed by commercially manufactured equipment obtained from Foringer and Company. Both programming and recording equipment were housed in a 4-foot square by 8-foot high relatively soundproof booth. Four 3/8" thick plywood discs painted flat black were used as training and test stimuli. They were 1", 2", 4" and 7", respectively in diameter. Six 7" black plywood discs with 28, 17, 8, 5, 3, and one pieces of candy, respectively, mounted on them were also used in early discrimination training. Another 7" black disc with a shallow cup, 3" in diameter, filled with candy, recessed in the center of the disc and a second 3" shallow cup filled with candy also were used as S_D's. Reinforcements consisted of poker chips that were used to operate candy, snack and entertainment-type vending machines or were exchanged for money.

The four dispensing machines, each approximately 72" long X 67" high X 24" deep, were constructed of heavy guage sheets of aluminum, and mounted on 6" casters which locked. Two machines dispensed "edible" reinforcements, i.e., candy and snacks. One dispenser contained five kinds of candy: m & m's, minature malted milk balls, candy corn, mints
and "sweet and sour" candies. The other dispenser contained five kinds of snacks: fritos, pretzels, graham crackers, corn cheez and potato chips. From the front an edible dispenser had five small parallel windows; behind each window a different candy or snack was displayed. There were five adjacent slots for poker chips and beneath each window were open receptacles. Inside were mounted five Gerbrands universal feeders which contained the reinforcements.

The two "manipulatable" machines "dispensed" either movies, played music, or showed electrical-mechanical toys or live animals. One machine was divided into seven compartments; five of these held electrical-mechanical toys that moved, one a movie projector, and the seventh, a tape recorder for music. The five toy compartments could be viewed through one-way windows protected by plexiglas; the movie on a small, protected screen, and the music was channeled through a five-inch speaker. Each compartment had an indicator light and slot for poker chips. The chip "triggered" programming equipment and operated the compartment to which it was connected, either turning on compartment lights in the toy compartments or operating a projector or tape recorder. The second manipulatable machine contained six compartments and held live animals: a monkey, a kitten, a guinea pig, a rat, a barpressing rat, turtles, fish, parakeets and a canary. Different sets of animals were used on alternate days as were toys and movies.

A second type of reinforcing stimulus was a shocking device. It consisted of a 3½" X 42" 3/4" plywood board laced with 18 swg. tinned
copper bus bar wire spaced one-inch apart. It was connected by one electrode to a Sprague .05 mfd. at 600 working volts DC capacitor in connection with an Echlin model IC-7 6-volt ignition coil powered by three 1 1/2 volt dry cell batteries. The other electrode was connected to the Lindsley manipulandum.

Procedure

Retarded subjects were divided into two groups, and both normal and retarded children received single-stimulus discrimination training using a multiple variable interval (S\textsuperscript{D})—drl or time out from reinforcement (time out) or time out-vocal "NO"-electric shock (S\textsuperscript{A}) schedule. After one retarded and the normal group met discrimination criterion they were given a generalization test. Once the other retarded group reached criterion it was given overlearning discrimination training and then received a generalization test. Following generalization testing both retarded groups were split into two subgroups and each half was assigned to one of two new groups. One was given two-stimulus discrimination training followed by a generalization test while the other received repeated generalization testing.

The twelve retarded subjects were rank-ordered on the basis of CA, adjacent members were divided into pairs, and one member of each pair was randomly assigned to one of two groups, hereafter referred to as Group MR I and Group MR II. The two groups were given training and testing in the following manner. Group MR I received single-stimulus discrimination training to a rate criterion of 6 S\textsuperscript{D}/ 1 S\textsuperscript{A} responses for five successive sessions with a 7" black disc serving as the final
The final $S^D$ was the absence of the black disc. Retardates were then given a generalization test of the type used by Guttman and Kalish (1956). This training condition was called the criterion condition. Group MR II was given single-stimulus discrimination training with the same stimuli to the same criterion, and in addition, received 25 more sessions of over-learning discrimination training. They too were given a generalization test the session following the termination of discrimination training. This training condition was called the overlearning condition.

After both MR groups completed generalization testing they were each divided into two equal sized subgroups and one subgroup from each MR group was assigned to one of two new training conditions. One subgroup from each larger group received repeated stimulus generalization testing while the other subgroup from each MR group was given two-stimulus discrimination training. Repeated generalization testing was presented in the following manner. Subjects were given a session of the same single-stimulus discrimination training they had received previously followed by a session of generalization testing. This cycle was repeated until subjects had completed four more generalization tests, making a total of five tests when the initial generalization test following discrimination criterion was included. This training condition was known as the repeated SG condition.

With regard to the subgroups receiving two-stimulus discrimination training, the same 7" disc used as an $S^D$ in single-stimulus training again served as the discriminative stimulus while a 1" black disc was used as an $S^Δ$. Subjects were again trained to the same
discrimination rate criterion of $6 S^D/1 S^A$ responses for five successive sessions and were then given the same type of generalization test used previously. This training condition was referred to as the $2-S^D$ discrimination condition.

The normal group received the same kind of single-stimulus training, were trained to the same discrimination criterion, and were given the same generalization test as the MR criterion group with some slight variations during early discrimination training (to be discussed under shaping procedure).

The two groups of retardates were run simultaneously in two replications. First, two subjects from each group were trained and tested. When all of their training and testing was completed a second replication, consisting of four subjects from each group, was conducted. After all retardates completed training and testing the normal group was trained and tested.

**Shaping differential responding in retardates under single-stimulus training conditions.** All retarded subjects first received approximately five sessions of poker chip training. They were given 30 chips each session and shaped to drop them in the dispensing machines. The purpose of chip training was to condition the chips as generalized reinforcements. Then single-stimulus discrimination training was introduced. Subjects first received five sessions of magazine training with a 3" shallow cup filled with candy ("candy pan" $S^D$) attached to the magnet in the center of the white background board. A pan of candy was used as the initial $S^D$ because it has been found that moderately retarded children acquire a discrimination in fewer trials when
common objects (junk stimuli) are used as $S^D$'s than when three-dimensional geometric form stimuli are used (Zeaman, 1963). Candy seemed to be a logical $S^D$ for obtaining candy among other reinforcements. During magazine training the plunger was removed, and the basic contingency for reinforcement was that the subject take the chip he had just received in the presence of the candy pan $S^D$, spend it in a dispensing machine, and return to the stimulus window. Each time he received a chip the $S^D$ was removed, and when he returned to the stimulus window after spending a chip the $S^D$ was re-presented, and a chip was dispensed. The main reason for shaping subjects to spend a chip each time they received one was to condition a behavior that was incompatible with plunger pulling during $S^A$. In early phases of the discrimination shaping procedure each chip presentation was followed by an $S^A$ interval. If the subject immediately took his chip and spent it, most of the $S^A$ interval was over by the time he returned to the stimulus window, and the remaining period of time he was required to not respond was much less than if he had stayed at the stimulus window throughout the entire $S^A$ period. Auxiliary stimuli were also presented during the $S^D$ and $S^A$ conditions to provide increased feedback. The three incandescent lights on each side of the stimulus background were illuminated during $S^D$ while the two blue lights on each side were illuminated during $S^A$ along with the presentation of a 45 cps square wave tone. A session was terminated when the subject had received 30 reinforcements.

After magazine training was completed the plunger was replaced and subjects were shown how to operate it to obtain poker chips. A modi-
fied version of the quick-shaping technique developed by Bijou and Orlando (1961) to condition multiple schedule performance with retardates was used. Subjects were shaped toward responding differentially to the presence and absence of a 7" black disc on a multiple variable interval 15 second—drl 20 second schedule of reinforcement, i.e., they were eventually reinforced for plunger pulling during $S^D$ on a variable interval (VI) 15 second schedule of reinforcement and required to not respond for a minimum of 20 seconds during $S^A$ in order for the $S^D$ to be re-presented. The symbol drl is an abbreviation for differential reinforcement for low rates of responding. At first a response in the presence of the $S^D$ produced a chip on a continuous reinforcement (crf) schedule. Each time a subject received a chip the $S^D$ was removed and was not re-presented for a minimum of 3-5 seconds. During this time a 3-5 second drl contingency was in effect also. When they had made no responses during $S^A$ for five successive $S^A$ intervals the $S^A$ and drl intervals were increased slightly, perhaps 1-2 seconds, depending on the particular child. In this way pausing (not responding) was shaped. Since most children spent a chip as soon as they received it, it was a simple matter to shape up pausing to ten seconds. This was about the average time required by a child to spend a chip and return to the stimulus window. However, when the $S^A$ interval was greater than ten seconds, and $S^A$ was still in effect when they returned to the stimulus window, several subjects would begin to pull the plunger regardless of whether or not the $S^D$ was present. For those subjects an additional 5 second drl was introduced, beginning at the moment they returned to the stimulus
window, and it was gradually increased until subjects would not respond during $S^A$ for a total period of 20 seconds, the final drl contingency.

Once pausing during $S^A$ was shaped the schedule of reinforcement was changed from crf to fixed ratio (FR) 5. If after a couple of sessions on FR 5 they were still not responding or were responding very little during $S^A$, the schedule of reinforcement was changed to variable ratio (VR) 5-10-5-10--etc. If pausing was still maintained for several sessions, e.g., four or five, the $S^D$ interval was changed from one reinforcement to 60 seconds. Then the schedule of reinforcement was changed from VR 5-10-5-10--etc. to VI 15 seconds. At this point the final multiple schedule contingency had been reached. Since some subjects exhibited rather long postreinforcement pauses, they were actually being reinforced for plunger pulling on a crf schedule much of the time, even though the programmed schedule was VI 15 seconds. For this reason a reinforcement "hold" contingency was added to the VI 15 second contingency. Under this new condition the timer motor controlling the reinforcement contingency remained stopped after the subject received a reinforcement and did not begin again until a response was made.

Subjects were usually trained on the final multiple schedule with the candy pan $S^D$ until they had reached the discrimination rate criterion of 6 $S^D/1 S^A$ responses for five successive sessions. Then the stimulus fading procedure began. First, the candy pan $S^D$ was replaced by a 7" black disc with eight pieces of candy attached to the center of the front. If stimulus control did not deteriorate it
was replaced in one or two sessions by the 5-candy disc. In a similar manner the 5-candy disc was replaced by a 3-candy disc which was replaced by a 1-candy disc which was finally replaced by a 7" black disc with no candy on it. Next, the two florescent lights were introduced. After one or two sessions, if stimulus control had not deteriorated, the incandescent lights were left off during $S^D$ and $S^A$, and finally the tone was no longer presented during $S^A$, leaving only the black disc as the significant $S^D$. Each session terminated when subjects had received 30 chips.

By the time three subjects completed training it had become obvious that this procedure would have to be modified in order to maintain stimulus control during the fading of the auxiliary stimuli and after they were all removed, leaving only the black disc $S^D$. Stimulus control was deteriorating during fading of these stimuli for several subjects and did not fully recover. Because of this factor some subjects were not meeting the discrimination criterion. So more steps were added to the fading procedure. A 3" candy pan filled with candy was recessed within a black 7" disc; a black 7" disc with 28 pieces of candy that covered the same area on the disc covered by the candy pan was added as well as a black disc with 17 pieces of candy on the front. These three stimuli followed removal of the candy pan and preceded the 7-candy black disc. A variac was now used with the auxiliary light stimuli, and light and tone changes were made very gradually in a manner similar to the shaping procedure developed by Sidman (1966). In addition a rather aversive $S^4$ punishment condition was added. This was a chain of aversive events consisting of: (1) time
out from reinforcement, (2) vocal "NO" and (3) electric shock. The first response during $S^\Delta$ produced a 15 second time out, the second response a relatively loud and "firm" vocal "NO" and the third and all subsequent responses during that $S^\Delta$ interval a brief electric shock. This punishment schedule evidently worked on a principle of higher order conditioning. All subjects came into the laboratory barefooted and stood on a wire grid as they pulled the plunger. Since one electrode was attached to the grid and the other to the plunger, the third response during $S^\Delta$ was followed by a split-second shock discharging through the child's body. For those subjects for whom the shock did not appear to be sufficiently aversive to stop plunger pulling, a large puddle of water was poured on the laboratory floor around the grid, and they walked through it to spend their chips, thus keeping the soles of their feet moist. Now the shock appeared to be sufficiently aversive to all subjects to terminate plunger pulling during $S^\Delta$. All of these stimulus and aversive events resulted in a marked reduction in $S^\Delta$ responding, and the remaining nine retardates were trained under these new conditions.

Two procedures were instituted to insure that only the black disc was the effective $S^D$ and its absence the effective $S^\Delta$. The $S^\Delta$ interval was varied each session during the last five sessions of discrimination training from 20 to 45 seconds. Four 30 and four 45 second $S^\Delta$ intervals were presented each session on an aperiodic basis. This procedure was designed to test and control for temporal discrimination. In addition, the white background board, which had to be opened to attach and remove the $S^D$, was opened and closed without attaching an $S^D$, a
minimum of four times each session for the last five sessions of
discrimination training. After 15 seconds it was again opened and
the $S^D$ presented. This procedure was included to test and control for
any cue effects that might develop from opening and closing the back-
ground board. Discrimination training continued for each subject
following the completion of all fading procedures until he had reached
the discrimination criterion.

Shaping differential responding in retarded children under two-
stimulus training conditions. Retardates trained under the two-stimu-
lus discrimination condition first received training with a 7" black
disc serving as the $S^D$ and a 1" black disc as the $S^A$. Once subjects
met the 6 $S^D$/1 $S^A$ rate criterion for one session a 20 second interval
with no disc at all was interspersed between each 7" disc and each 1"
disc presentation interval. Now subjects were presented with the
following stimulus cycle: a 7" disc for 60 seconds ($S^D$), no disc for
20 seconds ($S^A$), a 1" disc for 30 seconds ($S^A$) and no disc for 20
seconds. The 1" disc was presented for only 30 seconds because, even
with this interval, the total time between presentations of the $S^D$
was now 70 seconds, and this long an $S^A$ interval appeared to be
aversive to some subjects. The response rate became more "grainy"
and pauses increased in frequency and were longer.

Shaping differential responding in children of normal IQ under
single-stimulus training conditions. A somewhat simplified version
of the single-stimulus training procedure used for retardates was
used for normal children. They were brought into the laboratory and
told that if they pulled the plunger they would obtain chips which
could be exchanged for money at the end of each session at the rate of four cents per chip. They were also instructed to watch the 7" black disc which was used as the $D$ at the beginning of training but its function was not specified. First pausing was shaped in the same way it was for retardates except that auxiliary incandescent lights and tone stimuli and candy stimuli were not used. Then the $D$ interval was increased from one reinforcement in length to 60 seconds and the reinforcement schedule was gradually changed from crf to FR 5 to VR 5-10-5-10-etc. to VI 15 seconds. The same 60 second $D$-20 second $A$ intervals were used and the aversive stimulus used to eliminate $A$ responding was time out for the first $A$ response and a vocal "NO" for the second and all subsequent responses during that $A$ period. No shock was used. Subjects usually obtained approximately 40 chips each session.

**Stimulus generalization testing.** All subjects received the same kind of generalization testing. Four discs were used as test stimuli and were arranged in eight blocks of four stimuli per block. This arrangement consisted of randomly ordering one 7", one 4", one 2" and one 1" stimulus in each block with the restriction that the first stimulus in each block could not be identical with the last stimulus in the preceding block. Each stimulus presentation interval was 60 seconds long and was followed by a 20 second $A$ interval, during which response scores were recorded and test stimuli changed. The test period began by reinforcing subjects as usual on a VI 15 second reinforcement schedule for two to three $D$ intervals or until they had received five poker chips. Then the feeder was disconnected, i.e.,
extinction was put into effect, and the generalization test began the following S^D interval. It lasted for approximately 43 minutes or until a subject stopped responding for ten successive stimulus presentation intervals.

Results

Discrimination performance of both retarded and normal subjects surpassed by a wide margin the pre-established discrimination criterion during the last five training sessions prior to generalization testing. While the discrimination rate criterion was set at 6 S^D / 1 S^A responses for the last five sessions of training, retarded subjects had a mean rate ratio of 77 S^D / 1 S^A responses for the last five sessions and normal subjects had a ratio of 117 S^D / 1 S^A responses. These extreme differences in S^D and S^A responding clearly indicate that stimulus control was established by the time generalization testing was introduced. In addition, responding to opening of the S^D door was extinguished by the end of discrimination training in those few retardates that showed such responding. No subjects appeared to have developed a temporal discrimination to the 20 second S^A interval during training.

Figure 3 summarizes group generalization test performance for the five conditions—criterion, overlearning, 2-S^D discrimination, repeated SG and normal. Group test scores are plotted as proportions. These proportions are the mean number of responses to a test stimulus divided by the mean number of responses that occurred to all test stimuli throughout the generalization test. This type of score was used in order to minimize the effects of response variability resulting from
extinction during generalization testing. Only the 2 $S^D$ discrimination and the repeated stimulus generalization conditions resulted in sloped gradients. While the 2-$S^D$ discrimination gradient was moderately steep, at least between the 7" and 4" stimuli, the repeated SG gradient was rather flat. No other conditions yielded differential response patterns that could be interpreted as generalization gradients except for the normal condition. The response pattern for the normal group showed a very slight gradient which decreased in slope as a function of distance from the $S^D$.

The greatest difference in responding between test stimuli for the 2-$S^D$ discrimination and the repeated SG condition was between the 7" and the 4" test stimuli. It is not possible, with this data, to determine whether or not this response pattern was the result of a greater perceived difference between the 7" and 4" stimuli as compared to the differences between the 4" and 2" and the 2" and 1" stimuli. Thomas\(^5\) noted, however, that when test stimuli are not very similar along the relevant dimension differential responding usually occurs between the $S^D$ and the other stimuli rather than smooth, sloped gradients, i.e., the greatest differential responding will occur between the $S^D$ and the next closest stimuli and be relatively minimal thereafter.

An inspection of individual response patterns during testing indicates that some subjects exhibited sloped gradients similar to the group gradients (see Tables 1 through 5). The greatest number of individual sloped gradients were obtained under the 2 $S^D$ discrimination condition as would be expected, followed by the repeated SG

\(^5\)Personal communication with David Thomas.
Figure 3. Group generalization test performance for the five conditions: criterion, overlearning, 2-SD discrimination, repeated SG and normal, plotted in terms of proportion of total responses. These proportions are the mean number of responses to a test stimulus divided by the mean number of responses that occurred to all test stimuli throughout the generalization test.
Thus these gradients were not simply a function of group scores but were also represented by individual performance as well.

A simple analysis of variance, comparing the CA's of the three groups, MR I, MR II, and Normal, yielded an F of 1.44 which was not significant. Since the CA effect was controlled through group matching a repeated Subjects by Tests by Treatments analysis of variance (McNemar, 1963) was used to analyze the generalization test data. Table 6 summarizes the results of this analysis. Both a significant Tests main effect and a Treatment X Tests interaction were obtained (.001 level for both), indicating that differential responding to the four test stimuli did occur, and test performance varied as a function of training or IQ as well. Individual analyses of variance for the five conditions resulted in only two significant test effects (see Tables 7 through 11). These were the 2-S^D discrimination condition and the normal condition (.001 and .05 levels respectively). Thus the repeated SG gradient was not significant. Although the gradient obtained under the normal condition looked almost flat, there was a very slight gradient. The fact that this test condition was significant is probably due to the very uniform and stable rates exhibited by the normal subjects, resulting in a small error term.

In order to determine what effect verbal mediation could have had on the response patterns obtained during generalization testing, normal subjects were asked to tell what they "thought they should do" during generalization testing. All said they thought they should keep pulling the plunger. When asked why they thought this they replied
### TABLE 1

**MEAN INDIVIDUAL GENERALIZATION TEST SCORES OF RETARDED SUBJECTS TRAINED UNDER CRITERION CONDITION**

<table>
<thead>
<tr>
<th>Subject</th>
<th>7&quot;</th>
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<th>2&quot;</th>
<th>1&quot;</th>
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<td>MR-2</td>
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<td>.087</td>
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### TABLE 2

**MEAN INDIVIDUAL GENERALIZATION TEST SCORES OF RETARDED SUBJECTS TRAINED UNDER OVERLEARNING CONDITION**

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**TABLE 4**

MEAN INDIVIDUAL GENERALIZATION TEST SCORES OF RETARDED SUBJECTS TRAINED UNDER REPEATED SG DISCRIMINATION CONDITION ON GENERALIZATION TEST NO. 5

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<tr>
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TABLE 5
MEAN INDIVIDUAL GENERALIZATION TEST SCORES OF NORMAL SUBJECTS TRAINED UNDER CRITERION CONDITION

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<td>.273</td>
<td>.228</td>
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either that they wanted more chips and thought they would get them or they thought they were supposed to pull the plunger when discs were displayed on the background board, and that these were all discs. In addition all normal subjects reported that they saw the stimulus sizes changing during the generalization test, so lack of differential responding was not a function of failure to detect changes in stimulus sizes.

Resistance to extinction during stimulus generalization testing appeared to vary both as a function of IQ and previous generalization tests. All normal subjects but one responded throughout the entire 32 presentation of test stimuli. The one exception stopped responding at the 24th test period. Six out of the twelve retardates responded throughout the test; two stopped responding at the 29th and 30th test periods, respectively, while the other four stopped responding around
TABLE 6

SUMMARY OF SUBJECTS BY TESTS BY TREATMENTS ANALYSIS OF VARIANCE OF STIMULUS GENERALIZATION TEST PERFORMANCE OF CRITERION, OVER-LEARNING, 2-S^D DISCRIMINATION, REPEATED SG AND NORMAL CONDITIONS

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<tr>
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<td>3</td>
<td>204,197.433</td>
<td>10.843**</td>
</tr>
<tr>
<td>Subjects</td>
<td>.566</td>
<td>5</td>
<td>.113</td>
<td></td>
</tr>
<tr>
<td>Interaction: Treatments X Tests</td>
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<td>12</td>
<td>85,477.072</td>
<td>7.144**</td>
</tr>
<tr>
<td>Interaction: Subjects X Treatments</td>
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<td>.096</td>
<td>&lt;1.00</td>
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<td>15</td>
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<td>717,879.133</td>
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<td>11,964.652</td>
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<tr>
<td>Total</td>
<td>2,638,673,966</td>
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<td></td>
</tr>
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</table>

**.001 level

TABLE 7

SUMMARY OF SUBJECTS BY TESTS ANALYSIS OF VARIANCE OF STIMULUS GENERALIZATION TEST PERFORMANCE OF CRITERION CONDITION

<table>
<thead>
<tr>
<th>Source</th>
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<th>Mean Square</th>
<th>F</th>
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</thead>
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<tr>
<td>Tests</td>
<td>42,481,458</td>
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<td>14,160,486</td>
<td>1.30 NS</td>
</tr>
<tr>
<td>Subjects</td>
<td>.208</td>
<td>5</td>
<td>.041</td>
<td></td>
</tr>
<tr>
<td>Remainder</td>
<td>163,313,292</td>
<td>15</td>
<td>10,887.552</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>205,794,958</td>
<td>23</td>
<td></td>
<td></td>
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### TABLE 8

SUMMARY OF SUBJECTS BY TESTS ANALYSIS OF VARIANCE OF STIMULUS GENERALIZATION TEST PERFORMANCE OF OVERLEARNING CONDITION

<table>
<thead>
<tr>
<th>Source</th>
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<tr>
<td>Tests</td>
<td>15,520.458</td>
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<td>5,173.486</td>
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<tr>
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<td>.175</td>
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</tr>
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<td>Remainder</td>
<td>114,191.292</td>
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<td>7,612.752</td>
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<tr>
<td>Total</td>
<td>129,712.625</td>
<td>23</td>
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<td></td>
</tr>
</tbody>
</table>

### TABLE 9

SUMMARY OF SUBJECTS BY TESTS ANALYSIS OF VARIANCE OF STIMULUS GENERALIZATION TEST PERFORMANCE OF 2-S D DISCRIMINATION CONDITION

<table>
<thead>
<tr>
<th>Source</th>
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<th>df</th>
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<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tests</td>
<td>1,471,287.125</td>
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<td>490,429.041</td>
<td>19.113**</td>
</tr>
<tr>
<td>Subjects</td>
<td>.708</td>
<td>5</td>
<td>.141</td>
<td></td>
</tr>
<tr>
<td>Remainder</td>
<td>384,891.125</td>
<td>15</td>
<td>25,659.408</td>
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</tr>
<tr>
<td>Total</td>
<td>1,856,178.958</td>
<td>23</td>
<td></td>
<td>.001 level</td>
</tr>
</tbody>
</table>

### TABLE 10

SUMMARY OF SUBJECTS BY TESTS ANALYSIS OF VARIANCE OF STIMULUS GENERALIZATION TEST PERFORMANCE OF REPEATED SG CONDITION

<table>
<thead>
<tr>
<th>Source</th>
<th>Sums of Squares</th>
<th>df</th>
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<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tests</td>
<td>100,670.458</td>
<td>3</td>
<td>33,556.819</td>
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<td>Subjects</td>
<td>.708</td>
<td>5</td>
<td>.141</td>
<td></td>
</tr>
<tr>
<td>Remainder</td>
<td>329,453.792</td>
<td>15</td>
<td>21,963.586</td>
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</tr>
<tr>
<td>Total</td>
<td>430,124.958</td>
<td>23</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### TABLE 11

**SUMMARY OF SUBJECTS BY TESTS ANALYSIS OF VARIANCE OF STIMULUS GENERALIZATION TEST PERFORMANCE OF NORMAL CONDITION**

<table>
<thead>
<tr>
<th>Source</th>
<th>Sums of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tests</td>
<td>7,941.000</td>
<td>3</td>
<td>2,647.000</td>
<td>4.45*</td>
</tr>
<tr>
<td>Subjects</td>
<td>000.000</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Remainder</td>
<td>8,921.000</td>
<td>15</td>
<td>594.733</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>16,862.000</td>
<td>23</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* .05 level

the 21st test period. Retarded subjects who received repeated (up to five) generalization tests generally stopped responding after fewer test periods on later tests than they did on the first generalization test and resistance to extinction decreased as a function of number of tests.
Discussion

These results show that only the two-stimulus discrimination procedure consistently resulted in sloped gradients when a size dimension was varied during generalization testing. None of the single-stimulus techniques produced sloped gradients, although two retarded subjects trained under the repeated generalization condition yielded clear-cut sloped gradients and a sloped but non-significant group gradient was obtained. In addition, the gradient obtained from the normal group was significant but was almost horizontal. The flat gradient obtained for the overlearning condition suggests that a sloped size generalization gradient following single-stimulus discrimination training is not a function of amount of training per se once subjects have reached discrimination criterion. It cannot be effectively argued, on the basis of these results, that sloped gradients would have been obtained from severely retarded children under single-stimulus training conditions if they simply had received more training. It is not clear why sloped gradients were obtained from two subjects in the earlier exploratory research and not in this study. It may be that size was already a relevant dimension for the retardate who showed differential responding the first time he was tested, and that the effects of the first generalization test using an extinction procedure resulted in size becoming a relevant dimension for the second subject who produced a sloped gradient the second time he was given a generalization test but not
the first time. Since the normal control group also produced flat gradients, the flat gradients obtained for retarded subjects under the single-stimulus method do not appear to be primarily a function of discrimination history, MA or IQ.

The only two training conditions that produced sloped gradients were the $2-S^D$ discrimination and the repeated SG condition, and only two subjects in the repeated SG condition had clearly sloped gradients. Both training conditions employed a comparative stimulus procedure and only one, the $2-S^D$ condition, utilized a differential reinforcement technique. Thus, it appears that these two training procedures, comparison of different stimuli along a dimension and differential reinforcement, contributed to the development of a relevant discrimination history with severely retarded subjects resulting in the size dimension acquiring stimulus control properties. These findings also suggest that sloped generalization gradients obtained from severely retarded subjects under an extinction procedure may be a function of the test itself as well as a result of discrimination training and history. Zeaman (1963) reported a similar finding for retardates on a hue generalization test utilizing an extinction procedure.

It would appear from these results that a size stimulus dimension is low in the attending hierarchies of both normal and severely retarded children of the age represented by subjects in this experiment. On the basis of the verbal reports given by the normal subjects form was probably the dominant stimulus dimension for normal subjects. Other studies with normal children support this hypothesis (Colby and Richardson, 1942; Corah, 1964; and Suchman and Trabasso,
1966) and suggest that size is below form and color in the stimulus hierarchies of normal children (Suchman and Trabasso). The dominant stimulus dimension for retardates could have been either form or color. If the hypothesis that development of form as a dominant stimulus dimension is correlated with the development of verbal mediation is valid, then color would probably be the dominant stimulus dimension (Kagan and Lemkin, 1961). The MA concept also suggests that color would be the dominant stimulus dimension for the retarded subjects. Young children tend to be color dominant and usually shift to form dominance between the ages of four to six years (Corah and Suchman and Trabasso). Retarded subjects in this experiment had a mean SA of two years, nine months.

A discrimination history interpretation of these severely retarded children's stimulus hierarchy would also suggest that color was the dominant stimulus dimension. Lee (1965) has suggested that reinforcement for form discrimination in learning to read and other school activities probably contributes significantly to the shift from color to form dominance, and also is the main reason for differences in learning color and form concepts between preschool- and school-age children. Suchman and Trabasso reported that African children showed no shift from color to form dominance by adolescence which is in contrast to findings for American children. This last finding is most likely a function of discrimination history.

An alternative interpretation of the results obtained in this experiment is that sloped gradients were obtained under the two-stimulus training condition and not under the single-stimulus condition
primarily because subjects were not permitted to compare different stimuli along the relevant dimension under the single-stimulus condition as they were under the two-stimulus condition (Lashley and Wade, 1946; and Ferster, 1951). This interpretation appears to be relevant to the extent that a two-stimulus discrimination procedure results in a sloped generalization gradient even when no such gradient is obtained for the same stimulus dimension following single-stimulus training. However, the differential procedure is not a necessary condition for obtaining sloped gradients in normal organisms. As pointed out in the background section of this dissertation both the specific stimulus dimension and the stimulus presentation method are also significant variables related to obtaining sloped gradients. Hue generalization studies employing the Guttman and Kalish procedure provide ample evidence that changes along the relevant stimulus dimension in conjunction with differential reinforcement are not necessary in order to produce steep gradients (Guttman and Kalish, 1956; Hanson, 1957; Honig, Thomas and Guttman, 1959; and Newman, 1963). This type of procedure provides little opportunity for stimulus comparison unless the intermittent blackout periods could be interpreted as providing an opportunity for comparison of presence of the stimulus dimension with its absence. Newman, however, conducted a hue generalization study in which the wave length stimulus was present continuously, i.e., no blackout periods were used at all, and found that the absence of blackout periods had little effect on the wave length generalization gradients of pigeons.

With respect to the problem of mediation in normal control subjects,
it appears from the consistent way all normal IQ children in this experiment classified all test stimuli as belonging to the $S^D$ class, that a single-stimulus discrimination procedure results in all test stimuli of the same form and color, but different in size, being classified by normal subjects as falling into the $S^D$ class. Since the test performance of normal and retarded children trained under the same single-stimulus conditions was quite similar, it would appear that the mediation factor did not produce a response pattern in the normal children that differed from the pattern in retardates. Another experiment is needed to determine the conditions under which test stimuli that differ from the $S^D$ only on the basis of size will be classified by normal children of the age represented in this study as belonging to the $S^D$ class, and on the other hand, will also be classified as falling into an $S^A$ class.

Considering the reduction in resistance to extinction by retarded subjects following a single-stimulus generalization test, it might be advisable to use a separate severely retarded group for each training condition studied in generalization studies that use an extinction test technique and compare several training conditions, rather than evaluate any single group of subjects with more than one generalization test. This would enable the experimenter to obtain a larger number of test trials with each subject, i.e., increase the sample size per subject, and also decrease the effects of a generalization-extinction test method which might contribute to the slope of gradients independently of the training and discrimination history effects themselves.

In conclusion only the two-stimulus discrimination method resulted
in clear-cut sloped generalization gradients. None of the single-stimulus training procedures produced consistently sloped gradients in either severely retarded or normal subjects. Thus, it appears that size stimulus dimension is not ordinarily a relevant dimension for retardates or normals of the age and IQ represented in this experiment. However, size can become a relevant dimension through using a two-stimulus discrimination training technique. With respect to the problem of mediation, since normal and retarded subjects trained under single-stimulus conditions yielded similar generalization gradients it would appear that the mediation factor had little effect on the gradients of normal subjects. However, it is not clear, from these results, just what effect mediation does have in a free-operant conditioning situation.
EXPERIMENT II

Introduction

This experiment was undertaken to determine the conditions under which verbal mediation produces sloped and flat generalization gradients. An instructional technique was used to directly manipulate verbal mediation. Two groups of normal subjects of an age comparable to that of children in Experiment I were given two different sets of instructions and then tested for size generalization. Group I was instructed to "pull the lever when you see this disc and you will get poker chips." Group II was instructed to "pull the lever only when you see this disc and you will get poker chips." The first set of instructions were intended to be somewhat ambiguous in order to obtain both sloped and flat gradients. By obtaining both types of gradients and then asking the subjects how they "thought" they should respond during the generalization test, the relationship between verbal mediation and generalization performance could be evaluated. The second group was included to insure that sloped gradients would be obtained. It seemed that the addition of the word "only" to the instructions would clearly result in sloped gradients whereas the first set of instructions might produce very few sloped gradients. In addition to assessing mediation effects this experiment should also provide a basis for comparing generalization performance following an instructional procedure with such performance following
a free-operant conditioning method. This last objective would be accomplished by comparing the results of this experiment with those of Experiment I.

Method

Subjects and apparatus

Subjects were 18 noninstitutionalized children of normal IQ with a mean CA of eleven years, three months and a CA range from eight years, two months to thirteen years. They had no obvious visual defects that would possibly interfere with visual acuity. The same laboratory and apparatus used in Experiment I with normal subjects were used in this experiment with the exception that none of the auxiliary incandescent light stimuli were used.

Procedure

Subjects were brought individually to the laboratory, shown the plain black 7" disc, the stimulus window and the plunger. The stimulus background board was illuminated by the two florescent lights. Subjects in one group (Conventional Instructions) were told, "If you pull this plunger when you see this disc you will get poker chips." Subjects in the other group (Only Instructions) were told, "If you pull the plunger only when you see this disc you will get poker chips." Subjects were then asked to repeat the instructions to see if they understood them. They were also told that the chips would be exchanged for money at the end of the session at the rate of four cents for each chip.

Subjects were differentially reinforced on a multiple VI 15 second
(SD) -- drl 15 second (S\textsuperscript{A}) schedule of reinforcement. The SD interval was 30 seconds and the S\textsuperscript{A} interval 15 seconds. They received their first five or six reinforcements on a crf schedule and then were shifted to FR 5, to VR 5-10-5-10-etc. and then to VI 15 seconds. After they had received 50 reinforcements a stimulus generalization test was introduced. The same test procedure and test stimuli used in Experiment I were used in this experiment with the exception that each generalization test consisted of only three blocks of test stimuli.

Results

All subjects but one appeared to clearly understand the instructions and responded differentially to the presence and absence of the 7" disc. When the one exception, subject N-19, continued to pull the plunger during S\textsuperscript{A} she was reminded that she was to pull only to the SD and then her S\textsuperscript{A} response rate decreased markedly. The mean SD/S\textsuperscript{A} rate ratio obtained for all 16 subjects was 49 SD/ 1 S\textsuperscript{A} responses.

Figure 4 summarizes the generalization test performance of the two groups. Scores are again plotted in the form of proportions. As this figure shows the main group performance differences were between responding to the 7" and 4" stimuli. The difference was greater for the Only Instructions group than the Conventional Instructions group yielding what could loosely be called a steeper gradient for the Only group. Again, as Thomas pointed out, the differential response patterns obtained, as opposed to sloped gradients, may be a function of the large differences in the size of the test stimuli.

Tables 12 and 13 summarize individual performance of the two groups.
Five subjects in the Only group showed differential responding, one produced a somewhat sloped gradient and two produced relatively flat gradients. Five subjects in the Conventional group produced relatively flat gradients, two showed differential responding and one produced a somewhat sloped gradient. Thus, more differential responding was obtained under the Only Instructions conditions while more flat gradients were obtained under the Conventional Instructions condition.

Questioning of subjects following the test revealed that all subjects were aware that stimulus sizes were changing during the generalization test. However, their manner of responding to this change was apparently controlled by their interpretation of the instructions they received. All subjects who showed differential responding, i.e., responded to the $S^D$ but not at all or very little to the three test stimuli, said that they were supposed to respond only to the "big one" or the one shown to them before the experiment itself began. Subjects who produced flat gradients either said that they were supposed to respond whenever a disc was presented or that they kept responding to all stimuli during the generalization test because they thought they would get more chips. The two subjects who produced somewhat sloped gradients during testing said that they were not sure what they should do when the other three test stimuli were presented but thought that they should not respond to them.

CA scores for the two groups were statistically evaluated with a simple analysis of variance, and a nonsignificant $F$ of 1.611 was
Figure 4. Group generalization test performance for the two instructional conditions: conventional and only, plotted in terms of proportion of total responses.
TABLE 12
MEAN INDIVIDUAL GENERALIZATION TEST SCORES OF NORMAL
SUBJECTS RECEIVING CONVENTIONAL INSTRUCTIONS

<table>
<thead>
<tr>
<th>Subject</th>
<th>7&quot;</th>
<th>4&quot;</th>
<th>2&quot;</th>
<th>1&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>N-7</td>
<td>.247</td>
<td>.226</td>
<td>.270</td>
<td>.257</td>
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<td>N-8</td>
<td>.265</td>
<td>.274</td>
<td>.240</td>
<td>.221</td>
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<td>N-9</td>
<td>.326</td>
<td>.240</td>
<td>.221</td>
<td>.212</td>
</tr>
<tr>
<td>N-10</td>
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<td>.000</td>
<td>.000</td>
<td>.000</td>
</tr>
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<td>.897</td>
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<tr>
<td>N-13</td>
<td>1.000</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
</tr>
</tbody>
</table>

TABLE 13
MEAN INDIVIDUAL GENERALIZATION TEST SCORES OF NORMAL
SUBJECTS RECEIVING ONLY INSTRUCTIONS

<table>
<thead>
<tr>
<th>Subject</th>
<th>7&quot;</th>
<th>4&quot;</th>
<th>2&quot;</th>
<th>1&quot;</th>
</tr>
</thead>
<tbody>
<tr>
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<td>.171</td>
<td>.032</td>
</tr>
<tr>
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<td>.252</td>
<td>.254</td>
<td>.245</td>
</tr>
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<td>N-17</td>
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<td>.015</td>
<td>.000</td>
<td>.000</td>
</tr>
<tr>
<td>N-18</td>
<td>.991</td>
<td>.000</td>
<td>.000</td>
<td>.009</td>
</tr>
<tr>
<td>N-19</td>
<td>.286</td>
<td>.296</td>
<td>.228</td>
<td>.190</td>
</tr>
<tr>
<td>N-20</td>
<td>1.000</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
</tr>
<tr>
<td>N-21</td>
<td>1.000</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
</tr>
<tr>
<td>N-22</td>
<td>1.000</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
</tr>
</tbody>
</table>
obtained. Then a repeated Subjects by Tests by Treatments analysis of variance was calculated to assess possible test and interaction effects between the two groups (Table 14). A significant test main effect was obtained (.001 level) but the interaction was not significant indicating that the slope of the two group gradients was significant but performance differences of the two groups on the generalization test were not significantly different from each other.

Discussion

These results indicate that the response patterns obtained during the generalization test were a function of the way normal subjects classified the test stimuli. If all three test stimuli, the 4", 2" and 1" discs, were classified as not belonging to the same class as the $S^D$, i.e., were not "that one", then differential responding resulted. If both the $S^D$ and test stimuli were classified together as discs or simply were not separated into two classes, such as "$S^D$" and "not $S^D$", flat gradients were obtained. For those subjects who vacilated between the two classification systems, sloped gradients were obtained. Every single subject in this study responded to the test stimuli in accordance with the way he classified them.

Similar findings have been obtained by Landau with young normal children and adults. Both sloped and flat gradients were obtained on a line angularity generalization test that utilized an instructional procedure. There was a close correspondence between the way subjects responded to the test stimuli and the way they classified them.

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6 Personal communication with Jeffrey Landau.
### TABLE 14

**SUMMARY OF SUBJECTS BY TESTS BY TREATMENTS ANALYSIS OF VARIANCE OF STIMULUS GENERALIZATION TEST PERFORMANCE OF NORMAL SUBJECTS RECEIVING CONVENTIONAL AND ONLY INSTRUCTIONS**

<table>
<thead>
<tr>
<th>Source</th>
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<th>Mean Square</th>
<th>F</th>
</tr>
</thead>
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<td>.001</td>
<td>1</td>
<td>.001</td>
<td></td>
</tr>
<tr>
<td>Tests</td>
<td>3,504,448.671</td>
<td>3</td>
<td>1,168,149.557</td>
<td>21.423**</td>
</tr>
<tr>
<td>Subjects</td>
<td>.109</td>
<td>7</td>
<td>.015</td>
<td></td>
</tr>
<tr>
<td>Interaction: Treatments X Tests</td>
<td>340,286.687</td>
<td>3</td>
<td>113,428.895</td>
<td>2.114 NS</td>
</tr>
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<td>Interaction: Subjects X Treatments</td>
<td>.124</td>
<td>7</td>
<td>.017</td>
<td></td>
</tr>
<tr>
<td>Interaction: Subjects X Tests</td>
<td>1,145,031.704</td>
<td>21</td>
<td>54,525.319</td>
<td></td>
</tr>
<tr>
<td>Interaction: Subjects X Treatments X Tests</td>
<td>1,126,703.688</td>
<td>21</td>
<td>53,652.520</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>6,116,470.984</td>
<td>63</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

¹ **001 level
classified the test stimuli and the response patterns obtained from them on the generalization test. Thomas\textsuperscript{7} also obtained similar results with college students.

With respect to the flat gradients obtained for normal subjects in Experiment I it would appear that this type of conditioning procedure results in test stimuli being classified as falling into the $S^D$ class of discs. With regard to the sloped gradients obtained using the two-stimulus discrimination method, a comparison of the group gradients for the $2 S^D$ discrimination condition in Figure 3 of Experiment I with the Only Instructions condition in Figure 4 of this experiment suggests that the analogue to the mediation or instructional method in the conditioning procedure is the two-stimulus discrimination method.

\textsuperscript{7} Personal communication with David Thomas.
SUMMARY

Two experiments were undertaken to evaluate size stimulus generalization performance of severely retarded and normal children. In the first experiment severely retarded children were given four kinds of discrimination training using a free-operant conditioning method: (1) single-stimulus training to a criterion, (2) single-stimulus training to a criterion plus overlearning training, (3) two-stimulus training to a criterion and (4) repeated stimulus generalization testing. A normal group, included to serve as a normal discrimination baseline for comparing retarded performance, received single-stimulus discrimination training to a criterion. Results of this experiment indicated that only the two-stimulus discrimination condition produced sloped generalization gradients to a size dimension. None of the single-stimulus conditions resulted in sloped gradients with either normal or retarded subjects. Results indicated that size is not ordinarily a relevant stimulus dimension for either retarded or normal children of the age and IQs represented in this study. It was suggested that the two-stimulus condition resulted in size becoming a relevant dimension for the retardates trained with a two-stimulus discrimination technique. It was also suggested that verbal mediation did not alter the gradients of the normal group as compared with those of the retarded group receiving similar training.

The second experiment was conducted to determine the influence of
verbal mediation on stimulus generalization performance of normal IQ children. Two groups of normal children were given single-stimulus discrimination training using an instructional method and then were tested for size generalization. One group was instructed to pull a plunger when they saw "this black disc" while the other group was told to pull the plunger "only" when they saw "this black disc." The "only this" instructions produced greater differential responding than the "this" instructions. Verbal reports from subjects who showed flat gradients indicated that they classified all test stimuli as being the same as the $S^D$, i.e., discs, while reports from subjects who responded differentially to the $S^D$ and test stimuli indicated that test stimuli were classified as not falling into the $S^D$ class.
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