AN APPLICATION OF AUDITORY STIMULI AS FADING
PROMPTS IN DISCRIMINATION TRAINING

THESIS

Presented to the Graduate Council of the
North Texas State University in Partial
Fulfillment of the Requirements

For the Degree of

MASTER OF ARTS

By

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Denton, Texas
May, 1976

An experiment was conducted to examine the functionality of using auditory stimuli in isolation as fading stimuli. A review of the literature revealed very few reports regarding the usage of the auditory modality for fading purposes.

The study employed auditory prompts as fading stimuli in the transfer of stimulus control across stimulus modalities, specifically, the transfer of stimulus control from auditory to visual stimulus properties. A single subject was employed for the experiment.

The results were that the intensity of the auditory stimulus was an ineffective dimension to use for fading operations in the transfer of stimulus control across stimulus modalities. Further investigation is needed regarding the conditions that limit the transfer of stimulus control when auditory prompts are employed as fading stimuli.
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CHAPTER I

INTRODUCTION AND REVIEW OF THE LITERATURE

Any well conceived attempt to modify human behavior must consider the contributions of both phylogeny and ontogeny. "Phylogeny" refers to those structural aspects of the organism that are transmitted through inheritance. Behavior patterns that owe their manifestation to these variables are the result of many years of evolutionary development.

"Ontogeny" refers to those variables that have their influence during the lifetime of the individual--environmental variables, unique to the individual and common to all who inhabit our planet, and variables that are gross and specific. The interaction between organism and environment is one of ongoing interaction and behavioral change. Although phylogenetic and ontogenic variables are both important in determining an organism's development, at present only the ontogenic variables can be manipulated in any extensive manner to produce predictable changes in an organism's behavior. The most important behavioral change produced by this interaction between organismic and environmental events is called learning.

In ontogenetic development, the essentially undifferentiated behavior of the newborn gradually comes under the control of the external environment, as age and, therefore, experience
mounts. At birth, the human infant flails his limbs with little regard to what is happening around him. However, as a result of the effects his behavior has on his environment, certain responses become differentially associated with unique stimulus events. The infant learns to suck when a nipple is placed in his mouth, to orient toward moving things and human faces, to grasp objects placed in front of him, etc. These changes in behavior occur as a result of one of the most basic learning processes called discrimination learning.

Since so much of an organism's development involves discrimination learning, much of the experimental research in psychology has focused on the variables necessary to establish and maintain this form of behavior. Discrimination is, after all, the basic process involved in education. As a culture we place great emphasis on education and innovations in teaching-learning situations which increase the quality and quantity of material learned. As a result of this emphasis, several psychologists have developed creative techniques to increase the speed at which certain discriminations can be acquired. Omar Moore (25) taught very young pre-school children to read and do creative writing through precluding the occurrence of incorrect responses. Gattegno (8) taught children to discriminate letters more rapidly than usual with the selective use of color cues. Using a special procedure in which the subjects consumed the stimulus, Jarvik (13) taught rhesus monkeys a red-green discrimination in what was essentially one-trial
learning—traditional procedures typically required hundreds of trials.

A particularly interesting set of procedures designed to teach discriminations more effectively was developed by Terrace (40, 41). The primary technique involved in Terrace's training methods is called fading. Fading is similar to other types of programming in that its aim is to make learning more efficient. Programmed training involves an arrangement of the training conditions in such a way that the intermediate sequencing of training trials changes gradually from presentation to presentation. The method of successive approximation (shaping) is one type of programming wherein these gradual changes occur in some aspect of the response requirement. Progressively more elaborate response skills are called for—yet, the skills demanded fall within the range of the organism's capacity to succeed. As a result of this type of programming there is a high probability that the organism will make correct responses. The end result is that a completely new response, the terminal response, is established in the repertoire of the organism.

With fading, the stimulus component of the training conditions is the variable that is gradually changed. Initially, correct responding in the presence of the appropriate stimuli is insured through the use of effective auxiliary prompts. The supplemental stimuli or prompts are paired with the training stimuli. The ancillary stimuli are chosen because, prior to
training, they evoke the desired discriminative responding. When paired with the positive training stimulus, correct responses occur in the presence of the training stimulus as well. The auxiliary support that overdetermines the correct performance is gradually eliminated in progressive fashion until the auxiliary prompts are no longer present. The end result is that the response comes under discriminative control of the formerly neutral training stimuli. The purpose of using fading procedures is to establish new discriminations formerly not exhibited by the organism.

Terrace used fading techniques to teach pigeons to discriminate red from green and vertical from horizontal. Terrace's findings (40, 41) were significant in two ways. First, the fading procedure allowed him to teach a complex discrimination that formerly could not be taught in this species. Secondly, a product of using this procedure was that few or no errors occurred during the acquisition of the discrimination. The errorless learning phenomenon was a radical departure from prevailing attitudes. It was formerly presumed that errors were an integral part of the process by which discriminations are acquired. The fading procedure, and the resultant behavior it brings about, are also referred to as errorless discrimination procedure and errorless discrimination respectively.

Before examining errorless discrimination procedures, a few paragraphs characterizing discrimination learning and the traditional training procedures used to teach discriminations will follow.
Discrimination learning is a process whereby an organism learns to exhibit a specific set of behaviors under certain conditions and not under other conditions. The specific environmental stimuli that control appropriate behavior are called discriminative stimuli (48). A stimulus is a discriminative stimulus when an organism is more likely to make a specific response in the presence of that stimulus than another. Coming under the control of a discriminative stimulus exemplifies discrimination. When this occurs, it can be said that stimulus control has been obtained. With traffic lights, for example, a person is said to discriminate between red and green if the differential responses of braking and accelerating occurs in the presence of the two respective discriminative stimuli.

The procedure whereby a stimulus comes to acquire discriminative properties is called discrimination training. The traditional procedure for discrimination training typically proceeds in the following fashion. Two environmental stimulus conditions are chosen. In the presence of one set of environmental stimuli ($S^+$ or $S_+$) a given response is reinforced consistently. Responses to the negative stimulus condition ($S^-$ or $S_-$) are not reinforced. With repeated exposure of $S_+$ and $S_-$ stimuli, during which the response is only reinforced in $S_+$ the organism learns to respond only when the positive stimulus condition is present. When the negative stimulus condition is present, no responding occurs. When organism such as pigeons are
involved, the environment is arranged so that an animal is allowed access to grain when he pecks a response key in the presence of a red stimulus light and grain is not made available when key pecks are made in the presence of the green light. After training, the pigeon will peck the key if it is red and will not peck it if the key is green. The bird has learned to discriminate between red and green. A discrimination is formed as a result of the organism's experience with differential reinforcement in the presence of the two stimuli.

It was traditionally supposed that a discrimination could not be acquired unless the organism responded in the presence of the negative stimuli and failed to receive reinforcement. Responding to S- was accepted as a necessary condition for discrimination learning (11, 15, 16, 34, 37). More simply, error making was believed to be an integral part of the process of learning a discrimination.

However, Terrace found that discriminations could be established without the necessity of responding in the presence of the negative stimulus. He employed the fading technique—a method that involves gradual stimulus change. It is the essential element in errorless discrimination training as established by Terrace (40, 41). Fading procedures allow the experimenter or teacher to gradually change the stimulus conditions under which a behavior is exhibited so that repeated extinction trials with the negative stimulus and consequent errors are unnecessary. The procedure involves pairing an established discriminative stimulus (effective stimulus) with a
novel stimulus and then gradually changing the effective stimulus so that it becomes identical to the novel stimulus. In this way, an already established behavior may be errorlessly brought under the control of new discriminative stimuli. These fading procedures have several advantages over traditional discrimination training procedures. They may be used to program, rapidly and with few errors, the learning of new stimulus discriminations (26, 40). In contrast, standard discrimination procedures result in errors and longer acquisition times (26, 40, 41). Also complex discriminations that organisms have not acquired in many trials have been taught using fading procedures (26, 41, 45). Another advantage of fading procedures is that certain emotional by-products characteristic of traditional techniques do not occur when fading procedures are used (44). Furthermore, the efficiency of subsequent performances has been positively related to the absence of errors in training (43). Although these reasons provide the rationale for using errorless procedures, further application and assessment in certain sets of circumstances is necessary in order to determine the relative value of errorless procedures.

The following review of the literature relevant to this study will be divided into four sections. The first section will be a summary of the historical precedents leading to errorless learning. The second section will deal with the laboratory studies of Terrace (40, 41), classical studies in which errorless discrimination was first demonstrated. The
third section will deal with subsequent investigations and applications of errorless discrimination procedures. The final section will be a discussion of the studies that relate directly to the current study.

Historical Precedents

The experimental literature contains several incidental accounts which discuss the fact that fewer errors occur in learning when the initial training involves widely divergent stimuli that gradually become more similar on subsequent trials. In his studies on conditioned salivation with the dog, Pavlov (27) observed that he could more effectively teach a fine discrimination if he began training with two very different stimuli and then gradually reduced this difference along a continuum. He was not successful in teaching the discrimination when the two stimuli he began with differed only slightly.

In a discussion of discrimination and psychophysics, William James (12) recognized the value of slowly reducing the distance between two tactile stimuli. He pointed out that much smaller two-point limens could be obtained if training began with a widely separated pair of points and proceeded with the gradual reduction in the difference between the two points. Schlosberg and Solomon (29) made use of a series of graduated progressions in the establishment of a discriminated jumping response with the Lashley jumping stand. They demonstrated that discriminations could be learned without error when the training was gradual. The rats learned a simultaneous
discrimination between two narrowly separated gray cards when
the discriminative stimuli were gradually changed from a pair
of white and black cards to the final pair of gray cards.
Lawrence (18) showed that rats learned a simultaneous bright-
ness discrimination between two narrowly separated grays with
fewer errors when a progressive series of graduated steps was
used than when the two most similar grays were used throughout.
Baker and Osgood (4) demonstrated that humans can learn to
discriminate pitch more effectively when a series of progres-
sively graduated transition steps were employed than when a
standard method of training was used.

Skinner (34) pointed out that the time at which the nega-
tive stimulus was introduced could affect the error rate. In
a study on brightness discrimination, he found that if the S-
was introduced on the first few bar presses, then the rats made
only a few S- responses. If the rats were allowed to receive
many reinforcements for responding in the presence of S+ before
the introduction of S-, they made many more responses to the
negative stimulus when it was introduced.

In a discussion of programmed learning and teaching ma-
chines, Skinner (35, 36) mentioned a technique whereby stimulus
control could be gradually transferred from one set of stimuli
to another set. He called this technique a "vanishing" tech-
nique. He suggested that vanishing procedures might be used
in teaching anatomy, geography, poetry, and other types of ver-
bal behavior. Basically, this technique involved the use of
auxillary stimuli which already functioned as discriminative stimuli. These stimuli were employed along with a novel set of stimuli so as to insure that the organism would make the response in the presence of the new set of stimuli. The auxillary stimuli were then gradually withdrawn so that at the end of the learning sequence the new set of stimuli controlled the response. In a discussion concerning the principles involved in a behavioral technology of teaching, Holland (10) briefly mentions a form of gradual progression whereby the paired stimulus support of an effective stimulus is gradually withdrawn as a new stimulus dimension assumes control of the response. He illustrated the point with an example of a text of neuroanatomy material in which written words accompanied pictorial displays and in subsequent frames the textual prompts were gradually eliminated. He added that fading could be applied in the construction of programmed instruction verbal programs that did not involve pictorial displays or diagrams.

Although several references were made to the procedure of fading in the years before 1963, it was Terrace who analyzed this available information and placed it in a consistent and systematic framework. He was also the first psychologist to empirically demonstrate and isolate the necessary conditions for errorless discrimination learning.

Terrace's Classical Laboratory Studies Involving Fading

The procedures involved in errorless discrimination training are based on Terrace's first two experiments (40, 41). In his
initial experiment, Terrace examined the role that non-reinforced responding played in the acquisition of a discrimination. When establishing discriminative performances with most differential procedures, there is generally abundant responding to $S_-$. Since the non-reinforced occurrence of responses to $S_-$ precedes establishment of the discriminative behavior, it was presumed that this part of the learning process was essential to the development of discriminative responding. The focus of Terrace's experimental examination was on the validity of the notion that responding to $S_-$ is a necessary condition for discriminative learning to occur.

The focus of these experiments was on how and when the negative stimulus was introduced in discrimination training procedure. He investigated four methods of introduction. In one experiment (40), he assessed these effects on the acquisition of a color discrimination with pigeons. Terrace examined two basic variables that he referred to as "time" and "method" variables. The two time variables involved the "early" and "late" introduction of $S_-$. In the early condition, the $S_-$ was introduced during the first conditioning session; in the late condition, it was introduced after considerable training with $S_+$. The two parameters of the method variable of introducing $S_-$ were called "constant" and "progressive". With the constant method of $S_-$ introduction, the $S_-$ was of the same brightness and duration as the $S_-$, and differed from it only in wavelength--the necessary difference for color discrimination.
The progressive (fading) method of S- introduction differed from the constant method in that in addition to the wavelength difference, the S- initially had lower brightness and shorter duration values. These lower values were gradually increased during training until they were of the same brightness and duration as the S+. Combining the time and method variables, Terrace had four groups of subjects. These four groups represented all combinations of the two parameters of the two independent variables. The resultant groups involved early-progressive, early-constant, late-progressive, and late-constant introduction of S-.

Discrimination training began for the pigeons in the early-progressive and early-constant groups during the first experimental session. S- was introduced immediately after the response was conditioned to the S+. For the early-constant group the S- was initially presented at full intensity and duration. For the early-progressive group, the intensity and duration were increased in three phases. During Phase 1, the intensity of S- was held constant, at its minimal level, and the duration of S- was increased progressively until the duration of the S- equaled the duration of the S+ (30 seconds). During Phase 2, the duration of S- was reduced to one second and held constant at this value while the intensity of S- was increased gradually until it was equal to the intensity of the S+. During Phase 3, the duration of the fully intense S- was increased progressively until the duration of S- equaled the duration of S+.
During the next two sessions the durations of S+ and S- were increased progressively until they each had a duration of three minutes.

"Late" discrimination training was started in both the late-progressive and late-constant conditions after the subjects had been exposed to only the S+ for 14 sessions. Late-progressive training followed the same progressive procedure previously described for the early-progressive group. The late-constant group also followed the same constant procedures used for the early-constant group.

Terrace found that the manner in which the S- was introduced clearly affected the number of responses that occurred to S- during the acquisition of the discrimination. Late-constant training resulted in the most errors. Early-constant and late-progressive training resulted in an intermediate number of errors. An "error" was considered as the failure to respond to the stimulus correlated with reinforcement (S+) or a response to the stimulus correlated with nonreinforcement. In all cases, the subjects of the early-progressive group learned the discrimination with virtually no responses to S-; in other words, with almost no errors. Later variations of the early-progressive training procedure reliably demonstrated that pigeons could learn this discrimination with absolutely no errors. Thus, this discrimination training procedure was called "errorless". The results demonstrated that responses to S- (errors) are not a necessary condition for the acquisition
of a discrimination. In establishing the discriminative performance the progressive method of training was shown to be clearly superior to the constant method of training.

To summarize Terrace's findings, the necessary conditions for the acquisition of errorless discrimination are:

1. the introduction of S- immediately after conditioning the response to the stimulus correlated with reinforcement (S+), and,

2. an initially large difference between S+ and S- that is progressively reduced to a smaller and constant S+ - S- difference.

In his second series of experiments, Terrace (41) examined different procedures for transferring stimulus control from one set of stimuli to another set of stimuli, specifically from a red-green dimension to a vertical-horizontal dimension. The subjects in three of the four groups were trained to acquire a red-green discrimination by the errorless procedures previously demonstrated effective. They were then shifted to the vertical-horizontal discrimination in one of three manners. For the "abrupt" group, there was an abrupt shift from the red-green to the vertical-horizontal discrimination following the fifteenth red-green discrimination session. For two superimposition groups a vertical line was superimposed on a red background and a horizontal line was superimposed on a green background during sessions 11-15. For one superimposition group, a "superimposition only" group, the vertical and horizontal stimuli appeared without any colored backgrounds from
the start of the sixteenth session. For the other superimposition group, a "superimposition and fading" group, the sixteenth session began with the same conditions as in session 11—the horizontal and vertical stimuli were superimposed on the red and green backgrounds. During the course of the sixteenth session the red and green backgrounds were slowly faded out until only the vertical and horizontal lines remained.

The subjects in the fourth group were trained with only vertical and horizontal stimuli. Traditional discrimination training procedures were used for this group. All experimental groups were trained to a criterion of four successive sessions in which no responses to S- occurred. The birds who had superimposition and fading training acquired the vertical-horizontal discrimination with no errors while the superimposition-only, the abrupt and the vertical-horizontal only, groups made many more errors.

The essential procedure central to Terrace's success at establishing errorless discrimination is a fading procedure. In the first experiment fading was first used to establish a red-green discrimination. The auxiliary cue was brightness, which, as fading progressed, was gradually eliminated. In the second experiment fading procedures transferred stimulus control from color stimuli to form cues, resulting in a vertical-horizontal discrimination. Essentially, discriminative stimulus control was shifted or transferred from one set of stimulus properties to a different set of stimulus properties.
From some incidental observations, Terrace made some predictions as to possible instances in which errorless discrimination learning may fail to occur. In the second experiment, when existing color discrimination was transferred to form vertical-horizontal cues, Terrace observed that only small amounts of fading could be tolerated in the final fading stages. If these fading units were too great, stimulus control disintegrated abruptly. When Terrace attempted to train a new group of pigeons to discriminate between a vertical and horizontal line using an intensity fading dimension, he encountered another limiting condition of fading. In this training procedure, the intensity of S- was progressively increased. The discriminative performance was perfect until the last few increments in intensity. At this point the discriminative performance disintegrated. The intensity difference, rather than the difference in orientation of lines, appeared to have been the controlling factor in this discriminative performance. To summarize, it appears that if an inappropriate fading dimension is used, the errorless discrimination training procedures may not be successful. This suggests that certain stimulus dimensions are more suited for fading purposes, depending on what particular stimuli are involved.

According to Terrace (44), unfavorable by-products of discrimination learning resulting from traditional procedures are not observed when the discrimination is trained in an errorless fashion. A well documented by-product of traditional discrimination procedures is the emotional responses occurring
along with non-reinforcement when $S-$ is presented. Such emotional behavior can be thought of as "frustration" produced, a result of errors and non-reinforcement. With pigeons, these responses include such things as wing-flapping, striking the response key, and jerking head movements (44). These responses do not occur when errorless procedures are employed. Aggression, often seen within traditional discrimination training methodology when errors occur and a suitable target is present, is likewise not observed in successful errorless training. Although often only transitory, these by-products can prove to be disruptive to ongoing training. Since these emotional components of error-making are also observed in human discrimination performance, this suggests further justification for the examination of errorless training procedures as a viable alternative to traditional techniques.

Subsequent Investigations With Fading

Since Terrace's initial work, the effectiveness of fading procedures has been demonstrated in a variety of situations and with a variety of subjects. A survey of the relevant literature with lower organisms will be presented first, followed by a review of studies employing retarded and other abnormal populations. Finally, studies with normal human populations will be cited.
Animal Studies

The effects of drugs on discriminative performance trained errorlessly were studied by Terrace (42). In the experiment, one group of pigeons learned a discrimination between a vertical and horizontal line without any errors by the fading-transfer procedure previously described.

Intensity of the wavelength was the fading dimension employed. Another group of pigeons made many errors when standard reinforcement-extinction procedures were used. The drugs were injected in both groups following conditioning. When the discrimination was conditioned without errors, the imipramine and chlorpromazine produced no disruptive effects on discriminative performance. However, both imipramine and chlorpromazine had significant disruptive effects on the previously exact performance in the group that learned the discrimination with errors.

Using pigeons as subjects, Westbrook and Miles (47) conducted a fading experiment that involved both auditory and visual stimuli. They sought to determine whether non-reinforced responding in the absence of a tone was a necessary condition for the tone to acquire stimulus control. Different training conditions were compared. In the conditions involving fading, the $S_+$ was a tone and a light, and the $S_-$ was a light and a noise. The $S_-$, which at first was a dark key, was gradually made the same as the fully lighted key by gradually increasing the intensity that transilluminated the key. In another training
condition, abrupt introduction of the tone was employed and assessed. Another training condition was included in which reinforcement trials differed from non-reinforcement trials on the basis of both visual and auditory features. In this training condition, responding was based on both auditory and visual features and the tone exerted little control over responding when tested by itself. In the condition where reinforcement differed from non-reinforcement trials solely on the basis of the auditory features, an abrupt and a gradual introduction of the negative stimulus, a light, were compared for their effect upon control in the compounds. The tone acquired strong control in both cases. The finding relevant to fading is that the tone acquired control in the gradual condition with the occurrence of very few errors (responses to the negative stimulus).

Results obtained by Schusterman (30) lend support to the use of fading procedures as an effective errorless training method with the California sea lion. The researcher obtained a series of form discrimination reversals--virtually without error. The stimulus was faded along a size dimension. Once this auxiliary cue was gradually eliminated stimulus control had successfully transferred to form, the desired dimension.

Ray (28) investigated different discrimination training procedures in an effort to find the most efficacious among them. Using four groups of rhesus monkeys, the experimenter constructed an experimental situation in which line tilt was
the controlling stimulus dimension to be established. A vertical line was the S+ condition. The fading dimensions employed consisted of intensity and/or form of the visual stimulus. In basic agreement with Terrace's analysis, she found that the transfer to line tilt as a controlling dimension was facilitated when lines varying in tilt were paired with progressively darkening background intensities.

In comparing different methods for establishing serial position sequences with monkeys, Sidman and Rosenberger (32) noted that fading was a viable technique in facilitating the acquisition of this discrimination. The animals learned a longer serial position sequence when brightness cues for the correct serial responses were faded out gradually rather than eliminated suddenly. The fading procedures were found to be clearly superior in establishing longer serial chains than were procedures employing no fading procedures in training the performance.

Boren (6) also found that with monkeys, acquisition of serial position sequences was effectively facilitated employing a progressive fading program. The dimension used for the fading was visual. Compared with fading procedures, trial and error training resulted in poor acquisition of the discrimination.

In another experiment, Mackay and Brown (21) investigated the use of a delayed matching-to-sample procedure in teaching serial position sequences to monkeys. Brightness cues were employed as the auxillary stimuli that were gradually eliminated.
The fading procedure was more effective than a non-fading procedure in the development of the sequence discriminations.

**Exceptional Human Populations**

In a study evaluating the usefulness of fading programs for teaching retarded children form discriminations, Sidman and Stoddard (33) concluded that fading techniques can teach retarded children much more effectively than a teaching technology which depends only on reinforcement and extinction processes.

A group of retarded children was taught to discriminate a circle from an ellipse by use of a fading technique. Control subjects were exposed to the training program without the fading technique. More subjects in the fading group learned the discrimination than did subjects in the non-fading group. Subjects in the fading group also tended to make fewer errors on series after criterion performance had been established in both groups.

The dimension used for transferring stimulus control was visual. Stimulus control was transferred from "bright versus dark" to "form versus no-form" and then finally to "circle versus ellipse". Although the fading program did not completely eliminate errors, it greatly reduced the number of errors involved in learning the discrimination.

Touchette (45) conducted a study to determine the effectiveness of a fading program in training a position discrimination to severely retarded subjects. The same subjects had previously demonstrated no learning under standard differential reinforcement conditions. Brightness and color dimensions were
employed as the dimensions along which fading occurred. Touchette also employed the fading program to successfully teach the discrimination to subjects who had no previous experience with the discriminative response. In comparing subjects with and without histories of trial and error training, he suggested that a history of trial and error training may interfere with the acquisition and retention of a discrimination.

In another study, Touchette (46) used a stimulus control transfer procedure to train simple form discriminations to three severely retarded boys. Discriminative control was shifted from a color to a form dimension without errors. Touchette developed a time delay procedure for measuring the point at which transfer of stimulus control occurred—that point at which subjects began responding on the basis of the new stimulus dimension and no longer relied on the old one. Touchette’s data showed that the transfer point differs widely among subjects. This measurement procedure has great potential in studies involving fading because it allows more precise feedback and subsequent effective manipulation of the fading progression in the errorless acquisition of a discrimination.

A discriminative performance of matching stimuli to a sample in terms of rotation of a form was established by Bijou (5) with fading procedures. Subjects were drawn from a population of retarded youngsters. Bijou noted that the task was more efficiently learned when fading of auxiliary visual stimuli were included as part of the training conditions.
An innovative approach to testing the hearing of moderately retarded children was developed by Meyerson and Michael (24). The principal aspect of their methodology was the use of fading procedures in transferring discriminative control from visual to auditory stimuli. The procedure involved many phases. Initially, subjects were trained to press either of two separate levers for rewards. Above each lever was a light that could be energized by the experimenters. Discrimination training at this point involved rewarding the subject for pressing on the lever above which the light was illuminated. The presence of the light was then alternated between the two levers until near perfect control with the light was established, i.e., subjects tracked the light-on condition. After discriminative responding based on the presence of the light was well established, a sound from the midpoint of the frequency sensitivity of the normal range of hearing was selected to be paired with one of the light-on levers. Whenever the light above the tone lever was illuminated, the sound was presented concurrently. However, no sound was present whenever the light came on above the other lever. In this manner "sound-on" and "sound-off" were consistently paired with their respective levers. At this point the children were trained to wear earphones. The intensity of the light was gradually faded out on subsequent trials. Control of the discriminative responding was transferred from the visual dimension to the auditory dimension. When the sound was presented the subjects responded on one
lever and when the sound was withheld the subjects responded on the other lever. Finally, the investigators utilized the obtained auditory stimulus control to assess the child's auditory sensitivity by varying the frequency and volume of the auditory stimulus.

Lloyd, Spradlin, and Reid (19) also found that an application of fading procedures made it possible to obtain accurate pure-tone threshold data with difficult-to-test populations. The design of their audiometric procedure was somewhat different from the previous investigation. With profoundly retarded children, the authors first established a button-pressing response. Next, reinforcers for button-pressing were made dependent on the presence of two stimuli, a light and a tone. A discrimination based on the presence versus absence of light-tone stimuli was formed as a result of alternating light-tone periods with no-light-tone periods. Reinforcers were delivered when responses were made in the presence of the light-tone combination. In the absence of the light-tone combination, responding was not reinforced. After exact discriminative control was established, the initiation of the fading program began. The intensity of the light was progressively faded out in a systematic way until responding was under control of the tone only. Variations of the frequency and volume of the auditory stimulus were made and pure tone sensitivity was determined for the individual. Discriminative tone control was established and precise audiometric measurements were attainable with forty-two
profoundly retarded children. Similar results were also obtained with three normal infants.

Komechak (17) used essentially the same set of procedures as did Lloyd and his associates (19) to test the hearing of a single non-verbal child. In this case the fading procedure permitted diagnosis of his hearing where the usual audiometric procedures had previously been unsuccessful.

Lovass, Berberich, Perloff, and Schaeffer (20) integrated fading procedures with other reinforcement principles in an overall program designed to build imitative speech with two schizophrenic children. Two children learned to imitate a verbal model by being trained with a series of increasingly fine discriminations. A portion of the program relied on fading procedures for the development of the imitative vocal discriminations. An example of prompting will be illustrated with the sound "b". The fading involved manual prompting of the mouth and lips while simultaneously presenting the model sound "b". When the child made the sound the physical prompting was stopped for that trial. In the next stages the prompting was gradually faded by the adult moving his fingers away from the child's mouth, to his cheek, and finally gently touching the jaw. In the final stage, the adult gave the model sound "b" and without the aid of the manual prompt the child imitated the sound. The rate at which the fading progressed was determined by the child's performance. In summary, imitative control of the vocal behavior was established with the aid of physical prompts that were subsequently faded out.
Baer, Peterson, and Sherman (3) produced highly developed motor imitation with three retarded children by using a combination of shaping and fading procedures. Before the experiment the subjects were without imitative behavior, either vocal or motor. The fading procedures were only used in the initial training sequences. The experimenter would say "do this" and would then demonstrate a motor response such as raising his arm. Since none of the subjects was imitative, none of the initial cues were followed by any behavior which resembled that demonstrated by the experimenter. In the ensuing trials the experimenter repeated the demonstration and accompanied it with manual prompting that insured corresponding behavior on the part of the subject. Reinforcers were delivered immediately following the behavior. After several trials, the experimenter began gradually to fade out his prompting assistance. For example, in the beginning, the subject's arm was raised by the experimenter to full length following the experimenter's motor prompt. In the next stage the arm was only partially raised. Then, the arm was only touched. The prompts were faded until the subject made an unassisted response in the presence of the experimenter motor demonstration. The auxiliary stimuli (manual prompting) were used to insure the occurrence of the response in the presence of the discriminative stimulus (the experimenter demonstration). Gradually, the auxiliary tactile stimuli were eliminated and control of the response was transferred to the imitative stimuli. The fading
procedures were effective in minimizing errors in the initial training sequence. In addition, the fading procedures permitted imitative behaviors to be acquired more expediently than by using shaping procedures alone.

Marshall and Hegrenes (22) used fading in conjunction with operant reinforcement principles to improve the communication skills of four autistic children. The authors taught the children to answer questions "What is this?" and "What do you have?" by initially pairing the questions with auxiliary imitative prompting stimuli and then gradually fading out these imitative vocal prompts.

Striefel, Bryan, and Aikins (38) established instruction following behavior with three profoundly retarded adolescents with a stimulus control transfer program. The teaching of a series of specific motor responses to specific verbal instructions was accomplished in the following stages. First, imitative control of the different motor responses was established whereby the adolescents reliably imitated the motor behavior of the model. In the next stage, a verbal instruction was presented immediately before the behavior was modeled and imitated. A time delay was inserted between the verbal instruction and the modeling of the behavior each time a correct response occurred. The length of the delay changed in an increasing manner if the subject continued to respond correctly. The transfer of stimulus control was evident when the subject correctly responded for a consecutive number of trials without the aid of the modeling.
Thus, discriminative control was transferred from visual stimuli (motor modeling) to verbal stimuli (instructions). Touchette's time delay procedure might be considered a fading procedure if sequential time delays are to be considered as fading steps. The fact that the values of the fading stimuli themselves were not gradually eliminated suggests that in some particular situations, fading stimuli can be abruptly dropped out if the experimenter knows the proper time. The time delay procedure allows subjects to respond in the absence of the prompting stimulus and as such, it provides the experimenter with an index of the degree that the stimulus control transfer has occurred. The application of the delay procedure was a successful test of the viability of the technique as a worthwhile measurement method in studies that involve fading.

A fading technique was used by Sherman (31) in conjunction with imitation and reinforcement procedures to reinstate verbal behavior in the repertoire of two long-term, mute psychotics. After imitative vocal behavior was established, imitative vocal prompts were employed to induce the subjects to respond properly to questions presented by the experimenter (such as "What is this?" while holding up a picture). Gradually the imitative prompting dimension was eliminated. Eventually, the responding was regularly controlled by the questions themselves and not by the supplementary imitative prompts used in training. Control of responding was transferred from one set of words to a different set of words.
In an extensive research on an experimental motivational system for therapy and rehabilitation with mental patients, Allyon and Azrin (2) report that fading procedures involving verbal imitative prompts made discrimination training efficient. Applications of prompting-fading in conjunction with shaping procedures were made in training patients to perform certain tasks in the cafeteria and laundry. Initially, in both situations, the amount of time and skills required was very small. Gradually, more time was required. Verbal prompting was used to insure appropriate response occurrences in the training of the discrimination tasks associated with performance in the respective situations. Throughout the training progression the prompting and supervision required to maintain the proper performance of duties was gradually reduced. The results showed that the behavioral progression made up of shaping and fading was very effective in establishing the discriminative performance. The time required for the training of the discriminations was greatly abbreviated as a result of the fading procedure. In another instance, the process of restoring normal eating with a patient was accomplished by a graduated series of steps in which consumption of drinks was progressively changed to consumption of food. The gradual change of stimulus conditions was noted as necessary to modify the eating habits of the patient.
Studies With Normal Populations

In an exploratory program, Taber and Glaser (39) developed a learning program designed to teach the reading of color words to beginning first grade students. Their program was the result of suggestions made by Skinner (36), regarding the use of color as an ancillary cue. By pairing the actual color with the color name, and gradually vanishing the color prompt, the author hypothesized that the verbal response would transfer from the color and come under control of the printed word—in this case, the name of the color. They reported that the discriminative transfer program was successful as a teaching device when the original controlling stimulus had good discriminative control. In this case, it involved the ability to name the colors correctly when a colored object was shown. The children who did make the original discrimination learned the word discrimination in an expedient fashion. Discriminative control was transferred from color stimuli to printed stimuli with no difficulty.

Moore and Goldiamond (26) employed pre-school subjects in the training of a visual discrimination task that was successfully executed with fading procedures. With a delayed matching to sample procedure, in effect, matches were made according to the degree of rotation shared by the sample and the alternatives. The brightness of the different alternatives was the aspect of the stimulus presentation that was faded. The discrimination, first controlled by brightness cues, was
maintained by rotation cues after completely fading out the auxiliary brightness cues. The discriminative stimulus control had been transferred from brightness to degree of rotation in an almost errorless fashion. Without the aid of the fading procedure, the discrimination of rotation proved to be very difficult for the children and performance was no better than chance. However, the authors note that the children's accuracy with the discrimination was good under the same conditions when a fading program was employed in training and then removed.

One aspect of the procedural operations that merits comment is that the length of time spent on each fading step was directly related to the subjects' performance. A correct response advanced the subject to the next fading step. An incorrect response changed the intensity of the fading stimulus to the previous value at which the subject had responded correctly. Furthermore, the authors note that the steps within the fading progression have a definite effect on the discriminative control transfer. With certain individuals, a disruption of performance occurred when some of the intermediate fading steps were not used in the training sequence. This suggests that the fading progression should always be a consideration in the planning and implementation of a discrimination training program that involves fading procedures.

In an experiment by Hively (9), pre-school and first grade children profited from a high density of reinforcement associated with an "errorless" performance. He found that success on
early, simple discriminations facilitated later performance on related complex discriminations. Training with a series of progressively difficult form discrimination tasks was much more efficient than training in the final discrimination only.

With 22 kindergarten children, McDowell (23) investigated the use of fading in teaching the reading of fourteen words. With three different groups correct reading responses were insured in the beginning of training by using supplementary echoic, pictorial, and spoken stimuli. The supplementary stimuli which overdetermined the response were gradually faded out and the reading responses came under control of the textual stimuli only. Pictorial stimuli were gradually faded out by placing tracing paper over the drawings. The degree of opaqueness was gradually increased until the pictures were not visible. With spoken stimuli (a recording), the sound intensity was attenuated in progressive steps. In all three groups the children completed the program and showed a significant improvement in their ability to read the words.

Karraker and Doke (14) reported an application of errorless discrimination procedures to the training of alphabet letters with kindergarten children. Transfer of stimulus control from pictures to letters was effected. As with Terrace's (40, 41) original studies in fading, early-late and progressive-constant dimensions of the method of S- introduction were employed. For progressive groups S- fading occurred along four dimensions: verbal prompt, color, size, and stimulus duration.
A comparison of error-making was made while paying attention to the relation between errors made and the method of S- introduction used. Although an exact replication of errorless discrimination learning was not obtained, some aspects of the results were noteworthy. The progressive method of introduction of S- was more effective in minimizing errors than the constant method. Fewer errors were made under the early S- presentation condition as opposed to a late presentation. Again, the results obtained are congruent with Terrace's laboratory findings. The authors also suggested that the functionality of fading along different stimulus dimensions should be contrasted in future experiments.

Corey and Shamow (7) conducted a study with nursery school children in which they compared fading and superimposition procedures in terms of their efficacy in the acquisition and retention of oral reading. In this study, pictorial stimuli were superimposed on printed stimuli and then gradually faded out. Their findings suggested that fading procedures facilitated the acquisition of reading and produced better retention with fewer errors as compared to the superimposition or "sight" method of teaching reading.

In a previously mentioned study conducted by Lloyd, Spradlin and Reid (19), fading procedures allowed the authors to provide accurate audiometric measurements with three normal infants. The fading operations were necessary in order to establish a means by which to test the hearing of this usually difficult-to-test population.
Acker (1) proposed an economical and effective apparatus for fading use in teaching normal children in educational settings. Presumably its usage could be extended to other populations as well. The apparatus for presenting prompting stimulus materials involves two Kodak Carousel .35 mm projectors with remote control. The proposed system would utilize a focus difference between two stimuli (S+ and S-) as the fading dimension. This technical aspect precludes preparation of many series of stimuli which progress through the prompting dimension in a wide variety of steps and step sizes. While keeping S+ in focus, presenting a series of S-s which progress from extremely out-of-focus to in-focus over trials is the general strategy suggested. The number and size of steps in such a progression is immediately adjustable by altering projector focus. This obviates making more than one set of slides for discrimination training. Acker also suggested that a brightness difference as a prompting dimension could be obtained by connecting a rheostat in series with the S- projector bulb. As with focus difference the changes in the prompting progression could be made independent of the discriminative stimuli and, thus, provide an immediate and effective means of adjusting the prompting progression in accordance with performance.

Studies Directly Related To The Present Experiment

The preceding studies have extended the generality of the efficacy of errorless discrimination training and transfer
procedures. Further consideration will now be given to the objective of the present experiment.

The studies which share common ground with the present experiment are those wherein the fading dimension and the training dimension are of different sensory modalities. The result is that transfer of stimulus control has to be effected across stimulus modalities as opposed to transfer within the same stimulus modality.

Transfer of stimulus control can take place along the same stimulus modality but between different dimensional properties as in the transfer of stimulus control from one set of visual discriminative stimuli to another set of visual discriminative stimuli (5, 6, 7, 21, 26, 28, 30, 32, 33, 39, 40, 41, 42, 45, 46). Sherman's study (31) was somewhat unlike the above in that control was transferred from one set of words to another set.

Stimulus control has been effectively transferred across stimulus modalities in very few studies. Using fading procedures, Meyerson and Michael (24) and Lloyd and his associates (19) transferred stimulus control from visual to auditory features. Lovas and his associates (20) transferred stimulus control from tactual to auditory stimuli while Baer, Peterson and Sherman (3) used fading to transfer stimulus control from tactual to visual stimuli. Striefel, Bryan and Aikins (38) transferred stimulus control from visual stimuli to verbal stimuli.
The objective of the present study is to determine the functionality of using auditory prompts as the fading stimuli in the errorless transfer of control from an auditory stimulus dimension to a visual stimulus dimension. The three reports in the literature that did employ an auditory basis for fading purposes were Allyon and Azrin (2), McDowell (23) and Karraker and Doke (14). Allyon and Azrin (2) employed fading procedures to transfer discriminative control from verbal and imitative stimuli to visual-auditory stimuli. The McDowell and Karraker studies (23, 14) transferred control from visual and auditory stimuli to other visual stimuli. Since all three studies used auditory prompts in conjunction with other prompts, conclusive statements could not be made regarding the efficacy of the auditory mode as a dimension along which to face as it was part of a multiple compound. Assessment of the functional value of the auditory mode as a fading dimension, it is suggested, should be studied in a situation where its effects can be viewed in isolation.

As there are only a few studies that directly bear on stimulus control transfer across stimulus modalities, specifically, a transfer from an auditory to a visual basis of responding, this study is a worthwhile pursuit as it might extend our understanding regarding the value of using the auditory modality as a fading dimension. The current study will employ a fading procedure in which the fading dimension will involve auditory prompts in the establishment of receptive
verbal behavior, with printed words serving as the discriminative stimuli. The purpose of the study will be to investigate the shifting of stimulus control from auditory stimulus properties to visual stimulus properties.


CHAPTER II

METHOD

Subject

The subject involved in the present experiment was a twenty-eight year old male. Deviations from normal development were observed in early childhood. Inadequate development of communicative and social skills constituted the basic evidence of abnormality. Accompanying these deficits were stereotyped and self-stimulative behavior patterns. The subject, from two to five years of age, was seen by a variety of professionals for diagnosis and assessment in an effort to determine the nature of the problem. When five years old, the subject began attending his first of numerous residential therapy programs, all of which emphasized speech therapy. Only minimal progress was evidenced at the end of a ten year period—he never developed functional language. When the subject was age fifteen, the parents were advised to place him in an institution in which general caretaking rather than remediation was the primary consideration. The subject lived in a number of such institutions until the age of twenty-seven. At that time, he began living at home with his parents. At the time of the experiment he was enrolled in a program at the Center for Behavioral Studies which is located at North Texas State
University, Denton, Texas. He exhibited no expresssive verbal behavior, and control by the speech or gestures of others was only slight.

Apparatus

The apparatus used in the present experiment consisted of the following items:

1. a Bell and Howell Language Master player-recorder, and four pre-recorded Language Master cards;
2. a shoe, a gear, a cup, and a ball;
3. two sets of four 6 inch by 4 inch white index cards with the words "shoe", "ball", "cup", and "gear" stenciled on separate cards;
4. a wooden response bin, 12 inch by 12 inch by 2 inch;
5. a variety of food and liquid reinforcers.

All phases of the experiment were conducted in a room measuring approximately twelve feet by twenty feet. Figure 1 illustrates the position of the desk, table, and chairs in the experimental room.

Procedure

Preliminary Assessment

A preliminary assessment was made to determine if the subject would differentially respond to the different printed word cards. These printed word cards were the stimuli that served as the training stimuli in the subsequent fading phase of the experiment. A match-to-sample procedure was employed
for the assessment. Figure 2 illustrates how the match-to-sample materials were arranged on the desk. The subject was seated facing the desk. The response bin on the desk was directly in front of the subject. Two sets of word cards, a match set and a sample set were used. Each set consisted of the words "ball", "cup", "gear", and "shoe". The match set, as illustrated in Figure 2, was positioned on the right side of the desk. These cards were the alternatives from which the match was selected. A light was stationed at the rear of the desk on the right side. The experimenter sat to the left of the subject. The reinforcers and sample set of word cards were situated on a table to the left of the experimenter.

The match-to-sample procedure was initiated by presenting the subject with a sample word card. Immediately after presenting the sample card, the experimenter would energize the light. The light was used to cue the subject to respond. The correct response consisted of the subject selecting the matching word card from the array of alternatives and placing it in the response bin. Correct responses were reinforced with food or liquid and incorrect responses were extinguished. No special training to establish match-to-sample responding was necessary as a match-to-sample repertoire had been previously established.

The sample words were presented, one at a time, in a random order for three blocks per word, thirty trials per block. Between trials the arrangement of the matching word card array was changed.
The subject demonstrated proficiency at correctly matching the match cards to the sample cards. Thus, it was established that the subject could discriminate between the different stenciled word cards. The subject was also tested in order to assess his abilities for pairing the appropriate objects to the printed word cards. The assessment procedure was basically the same as described above with the exception of the objects occupying the space previously designated for the match word cards. The correct response consisted of the subject picking up the appropriate object and placing it in the response bin when the experimenter presented that particular printed word card. The level of accuracy with this task was at chance values. A high level of accuracy with the pairing of the appropriate objects to the printed word cards was the goal of the fading phase.

**Preliminary Training**

A preliminary training phase preceded the basic experiment. The objective of the preliminary conditioning phase was to train the subject to respond discriminatively to the four objects via auditory stimuli. In the fading phase of the experiment these four auditory stimuli functioned as the auxiliary fading stimuli. Figure 3 depicts the positioning of the materials during this training phase.

As before, the subject was seated facing the desk and the response bin was directly in front of him. An array of
four different objects (ball, cup, gear, shoe) was on the right side of the desk. These objects were the alternatives from which the object selection was to be made. The light was stationed directly behind the array of objects. The Language Master, pre-recorded Language Master cards, and reinforcers were stationed on the table to the left of the experimenter.

The words "shoe" and "ball", and the sounds of a bell and a buzzer were the four different auditory stimuli on which differential responding was based. The words "shoe" and "ball" were used to occasion responding to the objects shoe and ball respectively. The sounds of the bell and the buzzer were used for the objects cup and gear respectively. Each of the individual words and sounds were recorded on Language Master cards in order to keep auditory presentations consistent across trials. The correct response consisted of the subject picking up the appropriate object and placing it in the response bin when the experimenter presented that particular auditory cue. When the word "shoe" was presented, the object shoe was the correct choice. When the buzzer sound was presented, the object gear was the proper selection. First, the experimenter presented the auditory stimulus by running one of the pre-recorded cards through the Language Master. As the auditory stimulus presentation ended, the light was energized to cue the subject to respond. Second, the subject picked one of the objects from the array on his right and placed it in the response bin. If correct, the experimenter delivered the food or liquid reward.
Incorrect responses were extinguished, i.e., no reward was given. Initially the subject was prompted by manual guidance to make a choice from the array. The manual prompting was employed to signal the subject when to respond, but it did not cue him as to the proper selection. After some initial exposure to the conditions, the subject began to respond in the presence of the auditory cue and the light. At this point, manual prompting was discontinued. The arrangement of the objects was randomized after each trial. Training proceeded in blocks of trials in which the four auditory cues were presented thirty times each. Within each block of trials, the auditory stimuli were randomly ordered.

Mastery of performance in the preliminary training phase was defined as 95 per cent correct on each word and each sound for three consecutive blocks of trials.

Training

Phase 1.--The subject was seated facing a desk. The response bin was positioned directly in front of the subject on the desk. The choice objects (shoe, cup, gear, ball) were positioned to the right of the response bin. A light was stationed behind the array of objects. The experimenter sat to the left of the subject. The Language Master, four pre-recorded Language Master cards, and reinforcers were situated on a table stationed to the left of the experimenter. On the pre-recorded Language Master cards were the words and sounds which had
previously been conditioned as discriminative stimuli during the preliminary training phase.

During Phase 1 only auditory cues were presented to the subject. The four auditory cues were presented for three blocks of trials. Within a block of trials each of the four auditory stimuli was presented thirty times. The order presentation of the words and sounds within each block of trials was random. Thirty trials for each auditory cue was completed before proceeding to the next block of trials. When the subject was ready, the experimenter ran the pre-recorded Language Master card through the Language Master. For example, the recorded card would say "cup, cup". The light was then illuminated to signal the subject to select an object. The correct response for the subject was selecting the appropriate object and placing it in the response bin. Food and liquid reinforcers were used for correct responses. Incorrect responses were extinguished.

This phase was designed to provide an index of the degree of discriminative stimulus control which existed for the subject's selection responses as related to each of the four auditory stimuli. These four auditory stimuli were later used in Phase 2 as the fading stimuli.

Phase 2.—During this phase, transferring stimulus control from auditory to visual stimuli was attempted. Specifically, the goal was to transfer stimulus control from recorded words
or sounds to printed stimuli using fading procedures. The four auditory discriminative stimuli were employed as the fading stimuli. The intensity of the auditory stimulus was the dimension of the fading stimulus that was progressively faded out. The transfer of stimulus control training procedures consisted of initially pairing the training stimuli (printed words) with the already effective discriminative stimuli (recorded words and sounds), and then gradually eliminating the ancillary auditory cues in a progressive fashion.

Training occurred during hourly sessions, twice a day, five times per week. The subject was seated facing a desk. Directly in front of the subject was a response bin, and the objects to be chosen (ball, cup, gear, shoe) were located to the right of the response bin. A light was positioned behind the array of objects. On the lower right hand side of the desk were four individual index cards with the words "ball", "cup", "gear", and "shoe" stenciled on their respective cards. The experimenter had four matching stenciled cards in his hand. The experimenter was seated to the left of the subject. The Language Master, pre-recorded Language Master cards and reinforcers were stationed on a table to the left of the experimenter.

Initially, the auditory and printed stimuli were presented conjunctively. A discrete trial procedure was employed. A complete trial was defined by the following cycle. First, the experimenter placed one of the printed word cards in the response bin. The subject picked up the corresponding printed
word card from the array of cards on his right and placed it directly on top of the experimenter card in the response bin. This initial sequence minimally insured that the subject had attended to the particular features of the printed card which was presented. Whenever the subject incorrectly matched the printed cards, the trial was stopped and the next trial was initiated after a thirty second delay. Next, after the subject had matched the appropriate printed card, the experimenter ran the corresponding pre-recorded Language Master card through the Language Master. After the auditory stimulus was presented the light was illuminated in order to signal the subject to make a selection. The light was used to signal the subject to respond but it did not specifically indicate the correct choice. At this point, one of three different things occurred that terminated the trial cycle. The subject could place the correct object in the response bin and be reinforced with liquid or food. If the subject placed an incorrect object in the response bin or failed to respond within ten seconds, the trial was stopped and no delivery of either consumable reward or verbal praise occurred. After each trial the printed cards and the object were returned to their original positions, and the arrangement of the four objects was randomized.

Throughout the fading phase the visual and auditory stimuli were presented in the above manner. Since intensity was the fading dimension employed, it was the volume of the auditory prompt that was gradually attenuated throughout the fading
phase. The volume control on the Language Master recorder allowed twenty-eight different variations of the intensity of each auditory cue.

In the beginning the auditory stimuli were presented at full intensity. The rate at which the fading out of the intensity progressed was directly dependent on performance. Five consecutive correct responses with one of the words or sounds lowered the intensity of the subsequent presentations of that word or sound by one unit. The next five consecutive responses with the same word or sound further reduced the intensity of that particular auditory stimulus by one more unit. However, the intensity of the auditory presentation was increased on subsequent trials whenever an incorrect response was made. In other words, when the subject made an error the fading progression was backed up to the previous step at which he had responded correctly.

Within a block of trials two auditory cues were presented in an interspersed order. The two recorded words were always presented within the same block, and the two recorded sounds were also presented consistently within the same block. The sequencing within each block was randomized. A block of trials consisted of 30 separate presentations of each of the two auditory cues. In the beginning of the fading phase, only blocks involving the two words were used. Training with the sounds would begin after training with the words was completed.
The criterion for evidence of transfer of stimulus control was when the subject made ten consecutive correct responses in the presence of only the printed word. A series of probe trials was employed for one of the words and one of the sounds, during which all conditions were the same as Phase 2 except that the fading stimulus was not present. The preliminary assessment served as a baseline against which to compare the probes. Each probe, a block of ten trials, occurred after blocks 10, 20 and 30. The probes served to assess whether or not the subject made the discrimination in the absence of the auxiliary stimuli.

Maximum limits on the length of the experiment were predetermined. Training on 35 blocks of trials without obtaining transfer was considered the point at which it could be concluded that transfer would not take place without modifying some aspect of the experimental arrangement.
CHAPTER REFERENCES


CHAPTER III

RESULTS AND DISCUSSION

Results

Figures 4, 5, 6, 7 and 8 of the appendix present the data that illustrate the training segment. Figure 4 presents the performance data for the different objects during the two phases of training. One graph for each object is presented in this figure. The percentage of correct responses is presented on the ordinate of the graphs and blocks of trials are shown on the abscissas. During Phase 1 only auditory discriminative stimuli were employed. This phase provided an index of the discriminative stimulus control that existed for each of the different auditory stimuli. It can be seen that the discriminative selection of objects was highly accurate for all four objects during this phase.

In the initial stages of Phase 2, the fading phase, high levels of accuracy with the discrimination task continued. During this phase the printed stimuli and the auditory prompts were paired together; the aim was to progressively fade out the auditory prompts. During this phase the rate at which the fading progression proceeded was governed by two basic rules that stated that five consecutive correct responses advanced the progression and one incorrect response reversed the
progression. With Figures 5, 6, 7 and 8 the intensity level of the fading stimulus is presented on the ordinate of the graphs and trials are shown on the abscissa. As can be seen on Figures 5, 6, 7 and 8 the fading progression for each auditory prompt changed in a consistently accelerating fashion between trial 1 and trial 60. It can be seen that the accuracy of the discriminative responding for each word was high during the first and second block of trials (Figure 4) corresponding to the progressive attenuation of the intensities of the different auditory stimuli from trial 1 to trial 60.

In Figures 5, 6, 7 and 8 it can be seen that the intensity of each of the auditory prompts was adjusted during the fading phase in accordance with performance. Such adjustments were necessary between trial 61 and trial 120 for each of the auditory stimuli. As depicted by Figures 5, 6, 7 and 8, the fading progression advanced, regressed and advanced in direct relation to performance between these trials. As represented by Figure 4, blocks 3 and 4 corresponding to trials 61 - 120 show a decrease in the percentage of correct responses.

In Figures 5, 6, 7 and 8 it can be seen that the intensity of each auditory stimulus oscillated back and forth between two fading steps from trial 121 to trial 1,050. An accompanying decrease in the percentage of correct responses corresponding to these trials is found in Figure 4, blocks 5 - 35. As depicted by Figures 5, 6, 7 and 8 the oscillation continued and the progressive elimination of the different auditory stimuli
(the fading prompt) was not completed. The visual discriminative control necessary for transfer to occur did not develop. The expected shifting of stimulus control from auditory stimuli to visual stimuli did not occur. The auditory intensity level at which the repetitive oscillating over trials occurred was comparable for all of the words and sounds.

The probes, Figure 9, show that the accuracy of the performance based solely on the visual stimuli did not improve significantly over the chance levels of the preliminary assessment.

Discussion

The present study employed auditory prompts as fading stimuli in the transfer of stimulus control across stimulus modalities, specifically, the transfer of stimulus control from auditory to visual stimulus properties. The purpose was to examine the functionality of using auditory stimuli in isolation as fading stimuli. The dimension of the auditory stimulus employed for fading usage was stimulus intensity.

As mentioned previously, the outcome of the current study was that the shifting of stimulus control from auditory stimulus properties to visual stimulus properties was not accomplished. The failure of transfer of stimulus control to occur can be accounted for in a variety of ways. Several investigators have offered a variety of possible reasons, explanations, and hypotheses regarding unsuccessful attempts at shifting stimulus control.
Ray (2) and Terrace (5) have both made the obvious point that it is crucial to the fading-transfer procedure that control by the new stimulus dimension develops before all other cues to the appropriate response are eliminated.

Terrace has also made other observations regarding fading. The stimulus control transfer procedures used by Terrace (5) commenced training with both sets of stimuli presented at their maximum value. The stimuli that initially controlled the subject's behavior were then gradually "faded out". Terrace noted that this approach allows the subject to continue under the control of the gradually disappearing stimuli.

Terrace (6) noted that during repeated failures of a procedure to transfer stimulus control from brightness to line orientation, errors typically occurred only in the final few steps of fading. This observation further suggests that subjects may continue to be controlled by the dimension being removed, rather than coming under the control of the desired dimension. The results of the present experiment are congruent with the preceding statements in that the subject in the present experiment continued to be controlled by the dimension being removed rather than coming under the control of the training stimulus.

An alternative explanation of the negative results can be taken from the results obtained in two experiments with autistic and retarded children. Lovas and his associates (1, 4) provided evidence that the probability of a particular stimulus coming to control a response depended on the context
in which it appeared. They found that autistic and retarded children characteristically respond to only one component of a complex stimulus. The results of the two experiments indicated that prompts interfered with learning in autistic and retarded children when the prompts required response to simultaneous multiple cues. However, when prompting within the relevant dimension of a training stimulus was employed, fading procedures were successful. The subjects always failed to acquire a previously unlearned discrimination when the extra-stimulus prompt was employed, although they usually did learn a previously unlearned discrimination when the within-stimulus prompt was employed. The findings were obtained independent of which modality (auditory or visual) was required for the discrimination. The results of the present experiment can be viewed as similar in the results obtained by Lovass and his associates when the "extra-stimulus" prompt was employed.

Ray and Sidman (3) made a point that could be used to account for the unsuccessful transfer of stimulus control in the current study. They point out that failing to obtain stimulus control transfer may indicate that fading has taken place along an inappropriate dimension.

Exact information is not available but it seems that certain dimensions of a stimulus are more suitable for fading purposes with some stimulus modalities, but not with other stimulus modalities. The suitability of certain dimensions for fading purposes appear to depend on the nature of the task, the
nature of the organism, and the stimulus modality employed. One stimulus modality may be more functional as a fading stimulus than another stimulus modality. Additional studies should be conducted to shed light on these preceding considerations.

The results indicated that intensity of the auditory stimulus was an ineffective dimension to use for fading purposes in the transfer of stimulus control across stimulus modalities. Further investigation is needed regarding the conditions that limit the transfer of stimulus control.
CHAPTER BIBLIOGRAPHY


APPENDIX
Figure 1--Room Arrangement
Space for sample stimulus presentation

Sample word cards
Reinforcers

Response bin

Match word cards array

Light

Figure 2--Material positions during Preliminary Assessment
Figure 3--Material positions during Preliminary Training
Figure 4--Percentage of correct responses: Phase 1 and Phase 2.
Figure 6--Fading progression

Intensity level

Trials

5 consecutive correct
one incorrect
Figure 7: Fading progressions

- 5 consecutive correct
- one incorrect
Figure 8--Fading progression: bell
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