The Acquisition of Number Identification as a Function of the Type of Stimulus Presentation

Marco W. Salas Martinez

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Marco W. Salas Martinez
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INTRODUCTION

Many procedures and practical materials have been designed to deal with the problems of the establishment of complex responding, such as the reading repertoire. In most programs emphasis is placed on facilitating the discrimination of printed stimuli in order to obtain the vocal response which can be brought under the control of word, letter, and symbol stimuli. Since there have been relatively few studies concerned with evaluating which characteristics of printed stimuli determine the acquisition of a reading repertoire, the purpose of this study was to evaluate and measure differences in reading responses as a function of the different features of the printed stimuli presented.

The best presentation of the textual stimuli (the printed stimuli to be used) of any reading program is considered to be one in which programmed material is used. (Skinner, 1958) The general advantages of employing programmed material in the teaching of reading can be summarized as follows: first, techniques to facilitate learning are utilized in the presentation of the stimuli, e.g. segments of appropriate size, matching-to-sample arrangements, and fading; second, the material is presented in sequence proceeding from simple to complex discriminations; third, the subject is provided immediate feedback about his
performance; fourth, previously established criteria of acceptable performance assure that the subject will acquire necessary skills before proceeding to more complex discriminations; and fifth, a direct and observable measure of the stimuli presented, the responses emitted, and the number of reinforcers delivered is obtained.

There have been several attempts by researchers to isolate and analyze possible factors influencing the acquisition of a repertoire of reading behavior. Using two groups of non-reading, normal nursery school children, Corey and Chamow (1972) investigated the effects of two different stimulus-presentation techniques on the acquisition and retention of an oral repertoire. One technique utilized superimposition of pictorial stimuli correlated with printed stimuli, while the second involved the fading process in the presentation of the stimuli. Fewer errors in the children's performance were produced when the fading procedure was employed than with the use of the superimposition procedure, thus the fading procedure was found to facilitate the acquisition of a reading repertoire.

Working with two groups of normal, four year old children in training letter discrimination using a matching-to-sample task, Tawney (1972) investigated the effects of reinforcing discriminative responding to features of the stimuli thought relevant for discriminating letters versus the reinforcement of responding to features considered irrelevant.
He found the reinforcement of discriminative responding to the relevant features of stimuli produced a greater number of correct discriminations of letters than the reinforcement of discriminative responding to non-critical features of the same stimuli. In a similar study by Williams (1969), kindergarten children were assigned to one of three training conditions. In the first the subjects were trained using a matching-to-sample task and asked to identify comparison stimuli which differed from the standard. In the second the comparison stimuli presented were transformations (rotations and reversals of the standard stimuli). In the third group subjects were asked to trace and copy standard stimuli presented in an array, as in discrimination training. She found that the first discrimination training condition was most effective in establishing better discriminations of letter stimuli. Noelker and Schumsky (1973) investigated the relationship between the sequencing, form, and position of stimulus objects and the reading of nine year old retarded and normal children, all of whom were tested individually on all three conditions. Their main finding was that deficits in the position memory were the main distinguishing variable between normal and retarded children. Normal children made no errors discriminating on the basis of the position of the stimuli.

An analysis similar to Noelker and Schumsky's (1973) was done by Bryden (1972) by presenting nine different combinations
of stimuli patterned sequentially in both auditory and visual modalities, also, stimuli arranged spatially in visual dot patterns. Groups of children categorized as good or poor readers were asked to perform a matching task. Bryden's general finding was that the poor readers were inferior in the matching performance. Also, there was high correlation between reading skills and matching response. Of the matching tasks developed, the easiest discriminations were found in those in which a dot pattern was presented first. Brown and Perlmutter (1971), analyzing functional reading in trainable level retarded students, found that observing motor response to the printed stimuli was not a necessary condition for improving the reading repertoire.

Considering reading as a process of stimulus discrimination, several studies have attempted to analyze individually or as a group the different variables involved in the acquisition of discrimination behavior. Bond et al. (1973) investigated the importance of using color dimensions (previously preferred) and the angular rotation of geometric figures on discrimination learning in a matching-to-sample task with retarded children. The results of their experiment showed that retarded children learned tasks involving the color dimensions for which they had a predisposition more readily than those with the angular rotation dimension. Other dimensions of the stimuli used in the learning of discrimination tasks were analyzed by Ullman and Routh (1971).
Normal and retarded subjects were given trials in selecting the appropriate objects. The relevant dimensions manipulated were color, form, size, and depth of the object, and form, number of figures, size of the figures, and direction of lines on the face of the object. They found that increasing the number of relevant dimensions decreased the number of error of both non-retarded and retarded children in discrimination responding. Another variable affecting discrimination learning, number of trials provided, was studied by House (1973). He compared the affects of providing three versus ten trials per problem on the retarded children's discrimination performance. A superior performance was found when ten trials for discrimination problems were given.

Sidman and Stoddard (1967) emphasized the importance and the effectiveness of fading on programming form discrimination tasks (circles versus eclipses) when reinforcement and extinction were used. The findings of this experiment indicated that the stimulus shaping technique (fading) was more effective in teaching discrimination tasks to retarded children than using just reinforcement and extinction.

Moore and Goldiamond (1964) performed an experiment aimed at minimizing responding to the inappropriate comparison stimuli using pre-school children as subjects in a task involving form discrimination. Two different series of stimuli were used; in the first, full presentations where the sample, and comparison stimuli were illuminated at the same intensity,
varying only in the degree of rotation of the delta stimulus. In the second, a fading series, only the correctly matching stimulus was presented at the same intensity as the sample stimuli. They found that the use of the fading procedure permits the extension of the errorless establishment of discrimination in the matching-to-sample tasks.

There is little evidence demonstrating the importance of the use of fading and the training in generalization of printed stimuli presented in a matching sample arrangement. Based on the consideration that such printed stimuli are variables closely related to the establishment of a reading repertoire, the present study investigated how manipulations or variations in the textual stimuli affect the learning. If so, of what importance to the establishment of textual stimuli is the operation of gradually changing a stimulus that is easy to discriminate or that already has control over the behavior to another stimulus with a complex dimension, i.e. fading? A second purpose was to evaluate the effect of varying the dimension (size, form, color) of the stimuli during the process of the learning on subsequent generalization responses. For the purpose of this study, generalization is arbitrarily considered to be the vocal and motor discriminations of the printed stimuli when some of its dimensions (color, form, size) have been changed.

To summarize, the major purpose of this study involved evaluating and measuring differences in the reading responses
of retarded children which could occur as a function of the different features of the printed stimuli.
METHOD

SUBJECTS:

The subjects for this study were two retarded adults from the Day Training Center, Kalamazoo, Michigan where they were enrolled in a training program which taught social skills, basic languages, reading, and arithmetic skills.

Both subjects, Evelyn, who was 21 years old, with an I.Q. of 40, and Mariane, who was 23 years old with an I.Q. below 30, were characterized by a limited academic background, specifically with deficiencies in the reading responses mentioned above and their possession of the repertoire of prerequisite behaviors necessary to the development of the program, i.e. instructional, imitative, discriminative, and attentive behavior.

SETTING:

Each subject was seated in a 2 by 1.5 meter experimental room in front of a .74 meter high table, on which was placed a programmed teaching machine, model MTA-S-A 400 Scholar, with a cumulative record for correct and incorrect responses. A box containing a red bulb and a buzzer was located on top of the machine.

MATERIALS:

The printed stimuli were presented on paper strips in
a match-to-sample arrangement on the programmed teaching machine. In addition, twenty cards (ten number-symbols, ten number-words) containing numbers and words were used to test the subjects daily. The approximate size of each letter and symbol was 1.5 cm. (except for those stimuli used for generating and evaluating generalization responses).

Two series of printed material were programmed: one series for teaching nine number-symbols, and the other for teaching nine number-words. Each set of numbers was classified into three different categories, depending on the presence or absence of certain dimensions of the textual stimuli. These categories were 1) "fading and generalization"; 2) "no fading"; and 3) "fading without generalization". The characteristics of the printed stimuli for the programs categorized as "fading and generalization" were a) all the stimuli were presented in a matching-to-sample arrangement; one stimulus was the sample and four stimuli placed below it were the comparison stimuli; b) at the beginning of the program, the sample stimulus and the comparison stimuli had the same color, which was faded gradually; c) three of the twenty items of the program contained stimuli that had dimensions different from the standard ones presented originally (color, size, width, form, etc.).

The characteristics of the stimuli for the "fading-without-generalization" program were the same as those for the "fading-and-generalization" program except that the
third c) characteristic was absent; i.e. there were no stimuli with different dimensions. All of them had the same color, size, form, etc.

In the third program called "no fading" only the first characteristic a) remained for the stimuli; the other two b) and c) were excluded. Here all the stimuli were printed in black and presented in a match-to-sample arrangement.

PROCEDURE:

Before beginning this experiment, a pilot study was run with two other retarded youths in order to evaluate the number of items that each program should include, the number of sessions of the experimental conditions, possible failures, and other factors that could affect the program.

Each subject was trained to operate the machine. The subject in the experimental room, seated in front of the programmed teaching machine, received instructions and was asked to imitate the machine responses of the experimenter. All the verbal and motor prompts used were faded out until the subject could reliably match the sample stimuli without assistance. Each trial included the presentation of one sample stimulus in the top of the machine and four comparison stimuli placed below. During this procedure, the entire matching response consisted of a) indicating with her finger (motor response) and reading (verbal response); b) the sample stimulus; and c) reading and pressing the window containing the word or symbol that had the same shape (in some items the
same color) as the word or symbol presented in the long window. When this window was pressed, the microswitch placed behind the panel activated the cumulative recorder, moving the paper strip and exposing a new item to the subject. The comparison stimulus that matched the sample was considered a discriminative stimulus, since it was correlated with the reinforcement. The other stimulus having different characteristics than the sample functioned as a delta stimulus.

The behavior that was measured and recorded was a textual, or reading response. A reading response was defined as a discrete and observable vocal and motor response to the printed stimuli presented as both a word and symbol. The subject's responses were categorized into two classes: a) correct: when the vocal and motor response corresponded to the printed stimulus presented, and b) incorrect: when the textual response did not correspond to the stimulus presented.

Three different records were kept on the behavior of the subjects in each experimental condition; a) the record of the responses was taken by the experimenter; b) the record of the responses was recorded by another recorder; and c) the record of the responses recorded by a tape recorder. In order to assure the independence of the observation, the behavior to be recorded was explained in detail to the second observer, who was located in one corner of the experimental room during the recording time, at a distance from which he could not...
see the recording of the observer, but could easily see and listen to the subject's responses.

After each session, the three recordings were compared, response by response, to each item presented. In order to obtain reliability, the number of agreements (when the observers recorded the same behavior under the same category) were divided by the number of agreements plus disagreements (when the behavior was categorized differently by each observer). Here it was possible to make comparisons between the recordings of the three recorders, i.e. A vs. B; A vs. C; and B vs. C.

The subjects were exposed individually to the program five days a week, with each session lasting approximately thirty minutes. Every morning at the beginning of the session, the subjects were tested by presenting ten number-symbols and then number-words in order to evaluate their daily performance along the different experimental conditions.

The experimental conditions for the subjects, A (Evelyne), and B (Mariane), were the following: machine training, baseline, experimental phase, post test, and generalization test.

MACHINE TRAINING:

In the machine training conditions, the subjects were trained to operate the machine so they could match the presented stimuli in the form described previously. The verbal and motor prompts of the experimenter were gradually
faded out until the subjects reached the criterion of performance on the matching-to-sample responses. A color discrimination program was used for such training. During this phase, information that could affect the development of the program was obtained (reinforcers preferred, other skills, disruptive behaviors, etc.).

BASELINE:

During the six sessions of baseline, the ten number-words and the ten number-symbols were presented to the subjects and they were asked to read the number. Their responses were recorded as correct or incorrect and no consequences followed their responses.

EXPERIMENTAL PHASE:

During the experimental phase, the subjects were asked to work on the programmed teaching machine with the two series of printed materials: number-symbols and number-words. For the purpose of the experiments (to evaluate and measure differences in the reading learning as a function of the different features of the printed stimuli), one number-stimulus of each of the three categories, a) "fading and generalization"; b) "fading without generalization"; and c) "no fading", was taught daily. The numbers 2, 5, and 9 were selected to be taught using "fading and generalization". In the "no fading" category, the numbers 1, 4, and 7 were included. The numbers that were taught with "fading without
The subjects were exposed to the three different conditions, (a), (b), and (c), for five consecutive days. After the first three numbers of the three categories were taught, the second three numbers of the three categories were utilized for five days, and then the last three numbers of each category were presented.

The same procedure used with the number-symbol was followed for teaching the number-words. Here the number-words ONE, THREE, and FOUR were taught with condition (a), TWO, FIVE, and EIGHT with condition (b), and SIX, SEVEN, and NINE with condition (c). One number of each condition was selected and exposed daily to the subjects for five days; the same operation was repeated until all nine number-words were taught. For each of the two series of stimuli, the consequences for responding were the same. The correct matching responses to the sample stimulus were followed by the delivery of one token, the bulb lighting up, the chime sounding, and simultaneously the experimenter verbally reinforcing the subject saying "Good response!", or "Very good!". However, if the subjects failed to match the sample stimulus, a ten-second time out was applied, withdrawing any visual and physical contact and, immediately afterward, a loud verbal disapproval, "No! You are not right!" was presented contingent on the incorrect response. Simultaneously, the bulb, the buzzer, and the machine were not activated, and
the subjects were required to repeat the same trial.

POST TEST:

After teaching three numbers (one from each category), a post test was presented with the list of the ten number-symbols and the ten number-words learned being evaluated without any consequences for the response.

GENERALIZATION TEST:

Following the post test, a generalization test was administered, where the subjects discriminated between numbers or words of different colors, sizes, and styles, than the numbers learned during the training procedures.

As was previously indicated, both subject A and subject B were exposed to the same experimental conditions. The only difference was that each subject started to participate in the experiment at a different time. Subject A was exposed to the machine training and baseline first; by the time she completed the experimental phase for the first three numbers (2, 1, and 3), subject B was incorporated into the baseline phase of the experiment.
RESULTS

RELIABILITY:

For the twelve reliability checks made during the experiment (three consecutive days during both the word-symbols and word-numbers training for each subject), the inter-observer agreement ranged from 85% to 100% with a mean of 90%.

Figure 1 shows the percent of correct responses of each number-symbol for each session during baseline phase, the experimental phase, and the post test conditions.

This figure shows the percentage of word-symbols that were presented to subject 1 (Evelyne). Every number was arbitrarily assigned a percentage with two values: 0% indicating that the number had not been acquired and 100% indicating that the number was established for the child. The numbers that were presented during baseline and the experimental phase are represented by black circles; those numbers presented during the post test are represented by black triangles.

The zero percentage level of performance indicated in Figure 1 shows that subject 1 could not discriminate any of the nine number-symbols that were presented during the baseline of each condition. The numbers 2, 5, and 9 were taught under the "fading and generalization" condition were acquired
**FIGURE 1** Percentage of number-symbols identified by subject 1, during baseline, experimental phase and post test.
by the subject and were also correctly discriminated during the post test. Of the numbers presented under the condition “no fading” (1, 4, 7) only the number-symbol 1 was discriminated during the training and post test.

All the number-symbols, 3, 6, and 8, which were presented under the “fading without generalization” condition were established and later correctly identified during the post test.

Figure 2 shows the percentage on number-symbols presented to subject 1. As in Figure 1, a percentage with two values (0% and 100%); black circles for numbers presented during baseline and experimental phase and black triangles for the numbers presented in the post test were used. This figure shows that during the baseline stage no correct discriminations for the nine number-words were made.

The following result was found during the experimental phase and post test: the number-words: one, three, and four, which were taught using the “fading and generalization” procedure, were acquired by the subject.

Opposite results were found for the number-words two, five, and eight for which fading was not used. None of them were established nor were they discriminated during the post test.

The number-words six, seven, and nine presented under the condition “fading without generalization” were all established; during the post test each was discriminated.
FIGURE 2 Percentage of number-words identified by subject 1, during baseline, experimental phase and post test.
The nine number-symbols that were presented for subject 2 (Mariane) are illustrated in Figure 3; like graphs 1 and 2 a percentage with two values for each number, black circles for the numbers presented during baseline and experimental phase; and black triangles for the numbers of the post test were used.

Figure 3 shows that the numbers taught using "fading and generalization" were learned (2, 5, and 9). While the number 1 was acquired during the experimental phase and recognized during the post test; the other two numbers under the "fading" condition were not.

The subject learned to discriminate those numbers taught under the condition "fading without generalization" (3, 6, and 8); each was correctly identified during the post test.

Figure 4 presents the nine number-words presented to subject 2. Six number-words (one, three, four, six, seven, and nine) were learned during the training and discrimination; during the post test when the first and third conditions were applied. None of the three number-words taught with "no fading" were learned.

The baseline for each word in the three conditions shows no learning prior to the experimental session.

Tables 1 and 2 indicate the percentage of number-stimuli that were correctly discriminated during the baseline, experimental phase, post test, and generalization for both subjects. The percentage of the numbers in each condition was obtained by
SUBJECT M.

Percentage of numbers - symbols identified during baseline, experimental, and generalization phases.

Discriminations during baseline and experimental phase.

△ Discriminations during post-test phase.

FIGURE 3: Percentage of number-symbols identified by subject 2, during baseline experimental phase and post test.

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SUBJECT M.

Discriminations during baseline and experimental phase.

Discriminations during post-test.

FIGURE 4 Percentage of number-words identified by subject 2, during baseline, experimental phase and post test.

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multiplying the total number of stimuli present by 100%; this result was divided by the number of stimuli correctly discriminated.

Subject 1, during the baseline, did not discriminate any of the symbols presented. For the numbers which were taught with the "fading and generalization", and "fading without generalization" conditions a percentage of 100% was reached during the experimental phase and post test. A percentage of 33.3% was reached for the numbers under the condition "no fading".

During the generalization, the following results were obtained: "fading and generalization": 86%; "no fading": 33.3%; "fading without generalization": 46.6%.

For the number-words the following percentages are indicated: baseline: 0.0% for the number-words under each condition; experimental phase: 100% for condition (a) "fading and generalization"; 0.0% for condition (b) "no fading"; 100% for condition (c) "fading without generalization". The post test produced the same results as the experimental phase. Generalization: condition (a) 66%; condition (b) 6.6% and condition (c) 46.6%.

Table 2 shows the data for subject 2. A 0.0% of number-symbols read was found during the baseline; during the experimental phase and the post test a percentage of 100 was reached for the numbers taught with the third condition. However, the numbers taught with the third condition remained
TABLE 1
Percentage of number-stimuli correctly discriminated.

SUBJECT 1

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at the level of the baseline. For the generalization the following results were obtained: numbers under condition (a) 80%; numbers under condition (b) 33.3%; and numbers under condition (c) 40%.

When the number-words were presented to subject 2, percentages of 100 for the numbers taught with the second and third conditions during the experimental phase and the post test were reached. Those numbers presented under the third condition yielded percentages of 0.0, during the four phases of the experiment. During the generalization phase, a percentage of 66 was found for the numbers under the first condition and a percentage of 40 for the numbers under the third condition.

Figure 5 shows the percentage of numbers correctly discriminated by subject 1 during the baseline, experimental phase, post test, and generalization phase for each of the conditions.

The percentage of numbers that were correctly identified by subject 2, during the baseline, experimental phase, post test, and generalization where the stimuli under conditions (a), (b), and (c) are presented in Figure 6.

Tables 1 and 2 provide a precise numerical presentation of the data plotted on histograms in Figures 5 and 6. In these figures on the ordinate the subject's performance in terms of percentage of numbers identified is indicated and on the abcissa the different experimental conditions manipu-
SUBJECT E

FADING AND GENERALIZATION
NO FADING
FADING WITHOUT GENERALIZATION

PERCENT OF NUMBER-SYMBOLS READ

0 10 20 30 40 50 60 70 80 90 100

BASELINE EXPERIMENTAL PHASE POST-TEST GENERALIZATION

PERCENT OF NUMBER-WORDS READ

0 10 20 30 40 50 60 70 80 90 100

BASELINE EXPERIMENTAL PHASE POST-TEST GENERALIZATION

FIGURE 5 Percentage of number-symbols and number-words identified by subject 1, during all the experimental phases.

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SUBJECT M.

FIGURE 6 Percentage of number-symbols and number-words identified by subject 2, during all the experimental phases.

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lated for each number under each of the experimental phases is shown.

Here the white bars indicate the percentage of numbers established with "fading and generalization", the bars with the diagonal lines are indicating percentages for numbers taught with "no fading" and the black bars show the percentage of numbers established under the "fading without generalization" condition.
DISCUSSION

The findings of this study indicate that using fading procedure with textual stimuli improves the discrimination task, making the establishment of the reading repertoire easier and more certain. Also, training the subject to respond to stimuli the dimensions of which have been varied, permits the extension of subsequent discrimination to a greater variety of stimuli. The data of subject 1 (Figures 1 and 2) show that those conditions in which fading was presented ("Fading and Generalization" and "Fading without Generalization") were more effective for teaching both the number-symbols and the number-words than the one in which fading was absent ("No Fading").

Similar results were obtained for subject 2 (Figures 3 and 4); the numbers taught under the fading procedures (conditions (a) and (b)) were learned by the subject. Opposite results were found with those numbers in which fading was not used; the one exception being that the number one (1) was easily acquired by both subjects. A possible explanation could be that the easy discrimination of this number was because of the simplicity of its feature.

A comparison of the two kinds of stimuli presented, symbols and words, leads us to the conclusion that the learning of symbols is easier and faster than the learning
of words. As indicated in the graphs, a greater number of sessions were required by both subjects for the acquisition of the words than for the learning of the symbols.

The performance of subjects 1 and 2 were similar, with the difference being that the learning of the words for subject 2 was more delayed (in terms of the number of sessions required) and she also made more errors in the discriminations. The results of the effect of the generalization procedure on the performance of both subjects, suggest that previous training in the discrimination of stimuli whose dimensions are changed, improve the discrimination of the same stimuli even when they are presented with different color, size, or form. A comparison of the performance of both subjects showed the following: a) no significant difference in discrimination response; b) the numbers learned involving the use of "generalization training" generated a greater percentage of numbers discriminated when the generalization test was taken.

The results of this study are consistent with other studies in which the utility of fading in the learning of discrimination tasks was demonstrated with retarded (Sidman, et al, 1967) and normal subjects (Storm and Robinson, 1973).

Bijou (1966) and Moore and Goldiamond (1964) have emphasized the use of fading because it minimizes errors in the responding and facilitates the transference of stimulus control from one dimension to another.
The practical significance of this study can be summarized as follows: a) this program provides a technique which permits the establishment of a reading repertoire for subjects with severe behavioral deficits; b) this program can be utilized with normal young children who are beginning to learn to read; c) due to the nature of the program used, it is possible to measure and analyze experimentally the different components that constitute the subject's learning, permitting the adaptation of the program to the individual subject's needs.

In general the data found in this study indicate that in addition to the motivation variables used, the effectiveness of reading training depends on the manipulations of the textual stimuli to be learned. Since these results were obtained under specific conditions in which the subjects were exposed to three different numbers simultaneously in a limited period of time, subsequent researchers concerned with the teaching of reading repertoire should consider the following: the presentation of the stimuli one at the time; emphasizing the importance of the pre-training phase, since it is during this phase that the researcher may obtain information about the behavioral problems (deficit or excessive behaviors of the experimental subjects; and the kinds of variables with which the behavior can be changed). We can also test the program in order to determine the number of items necessary, the method of stimulus presentation, the
size of the steps, and all the defects yielded at the time of applying the program.

It is possible that by considering both the pre-training stage and the role that fading and generalization play, the researcher will be better able to develop a program which will assure and make effective the subject's acquisition of reading skills.
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