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Auditory sequencing problems were seen as contributing heavily to neurologically involved children's language impairment, and several procedures for training auditory sequencing were explored. Five of the procedures were found to contribute considerably to an efficient and effective training program. These procedures included (1) the immediate initiation of two-choice discrimination training, (2) differential reinforcement, (3) a gradual approach to the final discrimination, (4) the use of prompts, and (5) explicit delineation of the contingencies between the stimulus and the behavior. The paper describes the five procedures and discusses the efficacy of using them in training three neurologically impaired children to respond appropriately to sequences of verbal stimuli. References and tables are included. (Author/RT)

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ABSTRACT

Auditory sequencing problems are thought to contribute heavily to neurologically involved children's language impairment. The present research explored several procedures for training auditory sequencing. Five of the procedures were found to contribute considerably to an efficient and effective training program. The procedures included: (1) the immediate initiation of two-choice discrimination training, (2) differential reinforcement, (3) a gradual approach to the final discrimination, (4) the use of prompts, and (5) making explicit the contingencies between the stimulus and behavior.

This paper describes the five procedures and discusses the efficacy of using them in training three neurologically impaired children to respond appropriately to sequences of verbal stimuli.

Procedures for Training Neurologically Involved Children to Respond to Sequentially Presented Verbal Stimuli

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A commonly reported deficit of neurologically handicapped children is their inability to respond appropriately to sequentially presented items (Eisenson, 1968; de Hirsch, 1967). An auditory sequencing deficit is thought to contribute heavily to the children's language impairment because language, of course, consists of temporally presented stimuli. Since the children have problems in verbal sequencing, they have primary problems in learning to talk and learning to respond appropriately when others talk to them.

The research I will discuss recognized that all language impaired children do not learn sequencing by the usualy methods, and attempted to develop procedures which could be used to train the children in the required behavior. Procedures for the training program were developed on the principles derived from experimental studies in functional analysis. The study tried to evaluate the effectiveness of some of these procedures when they were applied to training neurologically involved children to sequence.

Subjects

Our population consisted of three children referred to our laboratory because they had problems in learning to respond to auditorally presented material. Background information on the children revealed that all of them displayed some evidence of possible neurological involvement. On standard instruments their verbal scores were well below age level. All were described as language impaired with auditory perceptual problems, and as evidencing poor auditory memory. The subjects ranged in age from 6 to 11 years. According to audiometric evaluations the children had normal hearing.

Apparatus

The training apparatus included a desk panel containing three buttons about two inches apart and placed in a horizontal row. Projectors with different colored lights were situated behind the buttons. The center button could be illuminated by a

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white light. Initially the left button was illuminated by a green light and the right side button by a red light. The positions of the red and green lights were shifted from session to session. A reinforcement tray was placed in the center of the panel slightly below the row of buttons. When a child made a correct response, a yellow light in the reinforcement tray flashed and a reinforcer dropped into the tray. Verbal stimuli for each task in the program were recorded on tape loops, played on a tape recorder in the control room, and presented to the children over a loudspeaker situated in the subject room. Automatic programming and recording instrumentation was used to present the stimuli and record the responses.

Tasks

The program was designed to train the children to respond to longer verbal sequences by gradually increasing the number of items in a sequence. Three tasks were included in the program: (1) Task 1 was a discrimination between "red" and "green." The child heard either the word "red" or the word "green" over the speaker and if he responded on the appropriately colored button, he received an M & M. (2) Task 2 was a discrimination between two different sequences of two color names, "red" and "green", e.g., "red-green" versus "red-red." If the child made two responses to the buttons and they were in the correct sequence he received a reinforcer. Any other response was not reinforced. (3) Task 3 was a discrimination between two different combinations of "red" and "green" presented in a sequence of three, e.g., "red-green-red" and "green-red-red."

The children were presented with each task until they made 80% or more correct responses within one session of 20 or more trials. No child progressed to the next task in the program until he had reached criterion on the previous task.

Because of the children's extremely limited language no verbal directions were used during the entire training program. A baseline of inappropriate responding to a three-item verbal sequence was obtained for the subjects, although it was difficult, since some of the children stopped responding before the end of the session.

Procedures

Five of the principles or procedures which were used will be discussed because they contributed most to the efficiency of the program. The first question asked if a child would learn to discriminate faster if we first established an on-off discrimination in which only one stimulus was presented and he learned to respond when the verbal stimulus was present and not to respond when the verbal stimulus was absent, or would he learn faster if we started discrimination training between two verbal stimuli immediately without first establishing responses to one of the two discriminative stimuli. In this question we were concerned primarily with the presentation of the antecedent event, the discriminative stimulus, but it cannot be considered independently from a question concerning a subsequent event, the usefulness of differential reinforcement.

According to the results from other experimental studies, teaching an organism to respond appropriately in the presence of one item before training discrimination between two items is less effective than presenting a discrimination from the beginning of training (Terrace, 1966; Blough, 1966). Results from our study were in agreement with the results of other discrimination studies.

Let's briefly discuss some of the reasons for the results. If a child is trained to respond to a red button in the presence of the verbal stimulus, "red", and is not presented with any other color or color name, he will probably respond correctly 100% of the time. This training, however, teaches the child to respond to sound. It does not teach him to respond to the color red, or the color name "red", even though he

has been in the presence of only that stimulus. If another color name is substituted for "red" while the red light remains on, the child will continue to respond as he did when the color was red. In other words, his response has not come under the control of the particular dimensions of the red light or the verbal "red", as differentiated from the dimensions of any other color.

Our single stimulus procedure may have been less effective for another reason. In an on-off procedure the stimulus is presented for a specified interval of time and the child is reinforced for responding. When the stimulus is off, however, responses are not reinforced. Unfortunately, no behavior is reinforced during the stimulus off period. The child is not reinforced for sitting quietly, for responding, or for any other behavior. Therefore, he is likely to start emitting many other behaviors, such as leaving his chair, playing with shoes, and so forth. When the stimulus is presented again, these behaviors may be completely incompatible with the emission of appropriate behavior, in which case they will interfere with the child's responding to the discriminative stimulus. The result is that training with the on-off procedure will require more time than a two-stimulus procedure.

The importance of reinforcement cannot be overemphasized. Just how important was demonstrated in the baseline procedures in which no consequences were provided for responses; the children stopped responding. Once training was initiated, however, and correct responses were reinforced, the children continued to respond.

As I mentioned earlier, one cannot really separate the effectiveness of the antecedent from the subsequent events in the study, but reinforcement was more frequent in the two-item procedure. The child, of course, was never required to sit without responding for any great length of time. Instead he was provided with more opportunities to make responses which would be reinforced if they were correct. The more frequent the correct responses, the more reinforcers the child acquired. Clinicians sometimes encounter difficulties in getting children to continue to respond if

consequences are not carefully programmed into their training. If no consequences, or irrelevant consequences occur in the environment, the result may be a cessation of all behavior. Sometimes clinicians conclude that a child stops responding because he is incapable of learning the task, but this may not be true. What may actually be happening is that the child's behavior is under extinction. It has been established that if a response occurs and no consequences occur, then the behavior in all probability will decrease and finally may be extinguished entirely.

Another question asked if acquisition of the final behavior, a three sequence response to a three item verbal stimulus, would be accomplished more efficiently if we trained that response from the beginning, or if it would be more efficient to start with a simple response which could be gradually developed into a three sequence response. We found very early that the children did not learn the three sequence response if that were the only one we tried to train. Frequently, if a child fails to learn a discrimination we would do well to look carefully at the procedures for presenting the stimuli.

A procedure which has been used successfully to train difficult discriminations is a gradual progression (Terrace, 1966; Sidman, 1967; Hively, 1962), and this was the approach we found to be most efficient. Experimental evidence suggests that whenever a difficult discrimination is to be learned, it is better to start training with an easy, but related discrimination, rather than the difficult discrimination.

When a child begins to respond correctly to the first discriminative stimulus in the program,he is acquiring the requisite behaviors for the difficult discrimination. When the appropriate responding has stabilized, the complexity of the stimulus may be gradually and progressively increased as training progresses to the final and most difficult discrimination. For example, if one were to train a child to discriminate between the phonemes /v/ and /z/, a difficult discrimination, it might be accomplished more efficiently if one would start with an easier phoneme discrimination, /t/ and

/v/, for example, and gradually work to the final, more difficult one (McReynolds, 1966).

There are several reasons why a gradual approach is more effective when a difficult discrimination is to be acquired. The terminal behavior, the terminal discrimination, may consist of such a complex stimulus that it will have several dimensions, any one of which may be controlling the child's responses. If the controlling dimension is an irrelevant one, any changes in that dimension may result in the disintegration of the discrimination.

In a step by step approach the relevant stimulus dimensions are enhanced. The experimenter, starting with a simple stimulus in which the important dimension is the prevalent one, is increasing the probability that the child will begin to respond to the appropriate aspect of the stimulus. Later when the stimulus becomes more complex and other dimensions are added, the behavior will remain under the control of the appropriate dimension because the control has been established in earlier training.

Another reason for using a gradual approach is the decrease in errors. Frequently, if a child is started on a task in which he makes a great many errors, so that his responses are not reinforced, he is likely to stop responding altogether. The clinician may again interpret this as evidence that the child is unable to learn the task. If an easy discrimination task is used correct responses increase, the number of reinforcers increase, and the child's behavior is maintained. The clinician is increasing the likelihood that the child will acquire the discrimination.

I can't emphasize enough the importance of a step by step approach. Not only is it valuable for training children to emit some very complex behaviors, but it is most valuable to clinicians for evaluating their training procedures. We frequently operate on assumptions which have not been explored to determine whether they are, in fact, important for good training. Because of this we may design programs and use them over and over again without ever attempting to determine

whether some other approach would be more efficient. The goal of good clinical practice is not only to design training programs which result in the acquisition of the requisite behaviors, but to find the most effective and efficient way to accomplish this, that is, training programs which require the least amount of time and effort by both the child and the clinician. A carefully constructed step by step program allows the clinician to evaluate the contribution of each step to the total program.

The gradual approach was used to train the children in our program to respond appropriately to a three item verbal sequence such as, "red-green-red" versus "green-green-red." Training was started with the most simple discrimination, red versus green, and the difficulty of the task was gradually increased by increasing the number of red and green items in a sequence.

Prompts can be used to increase the efficiency of discrimination training (Terrace, 1966; Bloudh, 1966; Spradlin and Girardeau, 1966). In this procedure the clinician initially utilizes additional stimuli to maximize the likelihood that a response will occur in the presence of the stimulus in which he is most interested. For example, an individual might want to teach a child to discriminate between two forms. If he knew that the child had difficulty in learning a form discrimination, but was able to quickly acquire a color discrimination, the clinician might want to use color as prompts for teaching form discrimination. He could program the training stimuli so that the forms would be superimposed upon two differently colored backgrounds. After correct responding to the forms with the colored backgrounds had been acquired, the colors could gradually be withdrawn, or faded, until only the forms remained. The responses would then be maintained only on the basis of form. A child might acquire a form discrimination much less painfully with color prompts than if he had been started directly with the form discrimination.

In training children to respond appropriately to acoustically presented stimuli,

visual fading procedures may be effective. In our research lights were used in conjunction with the auditory signals whenever necessary.

First the correct button, either the red or green one, was illuminated by the appropriately colored light. The button to be illuminated depended upon whether the verbal stimulus was "red" or "green". The button inappropriate for responding was not illuminated. As the child began to respond appropriately, the intensity of the light behind the incorrect button was gradually increased by small increments until each button was illuminated at full intensity. At this stage, the child was making the discrimination on the basis of the verbal stimulus alone with no prompts from the brightness of the lights. This procedure is a useful one for teaching two different responses in the presence of two different stimuli. It is a very effective way to teach the child to switch from one response to another in the appropriate stimulus situation, and to eliminate or prevent position responding.

The selection of and the gradual withdrawal of prompts needs careful consideration, however, before they are programmed into the training. All too often when the prompts are removed, the discrimination falls apart because the behavior has not been successfully shifted from the prompts to the new stimuli. Fading can be accomplished only with prompts which can function to shift control, and only if they are gradually withdrawn. In our research we have found that fading is less useful than some other procedures, except for teaching shifting in a two response discrimination.

Among the more common complaints of teachers and clinicians is the problem of a child's attention. Not only may it be difficult to get a child's attention when the stimulus is first introduced, but once training has started, it may be difficult to maintain attention long enough to complete the task. This is sometimes referred to as a "short attention span."

There are a few procedures a clinician can use which might help to alleviate that problem. It has been found that discrimination training is facilitated when one

makes very clear and explicit the contingency between the stimulus and the individual's behavior (Blough, 1966). Several ways are offered for accomplishing this clarity. I will describe one of the procedures we used to clearly define the contingencies for the children.

The procedure was designed to facilitate "attending" to the stimulus each time it was presented. The program was arranged so that the verbal stimulus "red" or "green", and the visual stimulus, the lights, were presented only when the child made a response which would produce them. This was accomplished by the addition of the center button. Before each presentation only the center button was illuminated by a white light. The side buttons remained dark. The child had to push the center button in order to initiate the stimulus. Pushing the center button resulted in the initiation of the verbal stimulus and the center button light was extinguished. Five seconds later the two side buttons were illuminated with their red and green lights. By making the children responsible for the initiation of the stimulus we were increasing the probability that the child was "attending" to the stimulus when it was presented.

Let's look at the results for the three children.

Insert Slide 2 about here

It took subject 1 five sessions to complete the three tasks. This child, by the way, was presented with a fourth task in which he had to make a discrimination between two sequences of four color names (red-red-green-red vs. red-green-green-red) and he reached a criterion of 84% correct in the first session. The second task appeared to be the most difficult one for him.

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The second subject took a little longer to reach criterion on task 2 and 3. But on each

of his tasks, he reached criterion within three sessions. You will note that the child sat through something like 140 presentations or trials in a session.

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Subject three took the most time to complete the three tasks, and as you see, he had much difficulty in task 2 before he reached criterion in that one. Task three took only three sessions to complete, whereas task 2 took 6 sessions.

All of the children learned to make a three-sequence response to a three-item verbal sequence. Stimulus control in the two-item task was acquired more slowly than with the other tasks in the programs for two of the children. This task, of course, presented the children with initial training in sequential responding. Once the children acquired sequential responding the addition of a third item did not make the task a more difficult one. The total time of training in each task usually took less than 1 hour with the exception of Subject 3 who completed the second task in 2 1/2 hours.

Summary

In summary, I have presented and discussed five procedures which were effective in teaching three neurologically involved children to respond appropriately to sequences of verbal stimuli. The procedures included (1) the immediate initiation of discrimination training between two stimuli, (2) differential reinforcement, (3) a gradual approach to the final discrimination, (4) the use of prompts, and (5) making explicit the contingencies between the stimulus and behavior.

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Table 1. Results of training procedures for Subject 1 on three sequencing tasks.

Task	Session	Number of Presentations	Number Correct	Percent Correct
red vs. green	1	24	24	100
red-green vs. red-red	1	90	52	57
	2	106	104	97
green-red-green vs. red-green-red	1	98	86	87

Table 2. Results of training procedures for Subject 2 on three sequencing tasks.

Task	Session	Number of Presentations	Number Correct	Percent Correct
green vs. red	1	20	19	95
red-green	1	142	69	49
vs.	2	140	98	70
red-red	3	106	93	87
green-red-green	1	51	20	39
vs.	2	78	45	57
green-green-red	3	95	78	82

Table 3. Results of training procedures for Subject 3 on three sequencing tasks.

Task	Session	Number of Presentations	Number Correct	Percent Correct
green vs. red	1	28	28	100
red-green vs. red-red	1	82	60	67
	2	72	34	47
	3	78	47	62
	4	83	51	61
	5	84	57	67
	6	89	75	84
green-red-green vs. green-green-red	1	74	51	68
	2	60	39	65
	3	78	67	87