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INTERTRIAL INTERVAL DURATION AND LEARNING IN AUTISTIC CHILDREN

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This study investigated the influence of intertrial interval duration on the performance of autistic children during teaching situations. The children were taught under the same conditions existing in their regular programs, except that the length of time between trials was systematically manipulated. With both multiple baseline and repeated reversal designs, two lengths of intertrial interval were employed: *short* intervals with the S^D for any given trial presented approximately one second following the reinforcer for the previous trial versus *long* intervals with the S^D presented four or more seconds following the reinforcer for the previous trial. The results showed that: (1) the short intertrial intervals always produced higher levels of correct responding than the long intervals; and (2) there were improving trends in performance and rapid acquisition with the short intertrial intervals, in contrast to minimal or no change with the long intervals. The results are discussed in terms of utilizing information about child and task characteristics in terms of selecting optimal intervals. The data suggest that manipulations made between trials have a large influence on autistic children's learning.

DESCRIPTORS: intertrial intervals, stimulus control, instructions, discrimination training, autistic children

In recent years, some understanding of autistic children's behaviors has been achieved through both the manipulation of reinforcement contingencies (cf. review articles by Koegel, Egel, & Dunlap, in press; Lovaas & Newsom, 1976; Lovaas, Schreibman, & Koegel, 1974; Rincover & Koegel, 1977) and the manipulation of discriminative and prompt stimuli antecedent to the children's responding (e.g., Koegel & Schreibman, 1974; Lovaas, Schreibman, Koegel, & Rehm, 1971; Rincover & Koegel, 1975; Sailor & Taman, 1972; Schreibman, 1975). The ramifications of these variables for teaching autistic children have been discussed in detail by Schreibman and Koegel (in press).

In addition to examining the influence of stimuli presented during a given trial, several investigators have suggested the importance of manipulations made between trials, or during intertrial intervals (ITI's). Holt and Shafer (1973) state that the length of the ITI is a "temporal variable that may influence number of trials to criterion, final performance reached, and stability of final performance" (page 181). Aspects of this hypothesis have been studied with pigeons (Croll, 1970; Holt, 1973; Holt & Shafer, 1973), infants (Watson, 1967), preschoolers (Bogartz & Pederson, 1966; Croll, 1970), and adults (Bourne & Bunderson, 1963; Bourne, Guy, Dodd, & Justesen, 1965; Grobe, Pettibone, & Martin, 1973). In a similar line of investigation, Carnine (1976) found that increasing the rates of presenting instructions (essentially shortening the ITI's) served to increase

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correct responding and participation and reduce off-task behavior in a study with low achieving first graders.

Although research on ITI manipulations has not been conducted specifically with autistic children, there are some data that suggest that ITI may be an important parameter. For example, Carr, Newsom, and Binkoff (1976) reported that filling the ITI with nontask stimuli improved learning behavior and decreased disruptions.

Overall then, the literature suggests that manipulations of ITI (particularly ITI duration) may provide a meaningful improvement in the efficiency of teaching autistic children. Because of the literature reviewed above, and because of our own clinical experience, we suspected that relatively short ITI's might be particularly effective for the autistic population. This variable (ITI duration) was therefore systematically manipulated in the context of two experimental designs: a multiple baseline and a repeated reversal design.

METHOD

Subjects

Three autistic children participated in this experiment. All were diagnosed autistic by at least two agencies according to the criteria specified by the United States National Society for Autistic Children (cf. Ritvo & Freeman, 1978). All of the children engaged in high levels of self-stimulatory behavior, had frequent tantrums, and tended to avoid social contact. None of the children had any appropriate conversational speech: Child 1, an 8-year-old boy, was primarily echolalic, but was beginning to learn functional speech in his treatment program (cf. Lovaas & Newsom, 1976; Lovaas, Schreibman, & Koegel, 1974; Risley & Wolf, 1967 for examples of this type of program); Child 2, a 7-year-old girl, was completely nonverbal and would only produce sounds in a repetitive self-stimulatory manner; and Child 3 was an 11-year-old boy who was originally nonverbal, but had learned a functional vocabulary of several hundred words in his treatment program (cf. Hewett, 1965; Lovaas, Schreibman, & Koegel, 1974, for examples of this type of treatment program). On standardized tests the children were functioning far below their chronological age levels, although each child engaged in occasional fairly high level splinter skills. All three children were formally untestable with most standardized testing procedures; however, Child 1 received an IQ estimate of 50 and Child 2 an estimate of 27, in both cases with batteries of informal testing procedures based on the Merrill-Palmer Scale, Leiter International Performance Scale, and Cattell Infant Intelligence Scales. On the Vineland Social Maturity Scale, Child 2 was estimated to be functioning below the 2-year-old level, and Children 1 and 3 were estimated to be functioning at about the 3.5-year level. All three children were enrolled in our experimental autism clinic located in the Speech and Hearing Center at the University of California at Santa Barbara. The children were selected from the total clinic population because, at the time of the study, they were consistently available for prolonged observation and because their clinicians reported difficulty in teaching certain target behaviors that were considered to be basic to their planned curricula.

Setting

All sessions were conducted with one-to-one teacher-child ratios in small clinic rooms on the university campus. Each room contained a small table, two small chairs, and a large wall clock with a clearly visible second hand (in order to help in easily determining ITI duration). Sessions ranged in length from 5 to 15 min, with no more than three sessions per day and no more than three days between sessions. There were no systematic differences in the number of trials per session or condition.

Teachers

Each child worked with a specific teacher assigned to conduct all programs in the child's

clinic curriculum. All teachers were advanced undergraduate university students who had completed at least two courses in operant conditioning, at least one lecture course in the behavior modification treatment of autism, and at least two practicum courses involving direct behavioral treatment of autistic children. In 11 of the 21 conditions in this investigation, the teachers were naive with respect to the anticipated relative success of the long vs. short ITI conditions.

Selection of Target Behaviors

The tasks selected for each child were scheduled to be taught at that point in their regular clinic treatment programs (see Table 1). No changes were made for the purpose of this study, other than to control the length of the ITI's for specific numbers of trials (see below).

Length of Intertrial Interval

For the purpose of this investigation ITI was defined as the period of time between the termination of the verbal consequence (e.g., "good") for one trial, and the onset of an instruction (e.g., "Say 'ah' ") for the following trial.

In certain instances with Child 2 (who received primary reinforcers in addition to verbal consequences), the child continued to consume the reinforcer (swallow the juice) during the ITI. Consumption was always completed before introduction of the following S^D. When a child engaged in off-task behavior during the ITI, the scheduled S^D was nevertheless presented at the scheduled time. This procedure was adopted in order to adhere to the prescribed ITI duration and because "paced" instructions have been demonstrated to be an effective alternative to punishment procedures in some cases (Plummer, Baer, & LeBlanc, 1977). During the particularly long ITI's, the teachers typically recorded data or sat quietly observing the clock while waiting to present the next S^D.

In the short ITI condition, the instruction was presented approximately 1 sec following the verbal consequence for the preceding trial, with a maximum range of 1 to 4 sec for the entire ITI. In the long ITI condition, the instruction was presented at least 4 sec following the verbal consequence for the preceding trial, with a maximum range of 4 to 26 sec for the entire ITI. That is, for any given child/task, the long ITI's averaged approximately 4 to 5 times longer than the short ITI's. In order to maintain ease and naturalness of instruction, the exact length of each ITI was allowed to vary slightly from trial to trial (depending on exactly how long it took the child to consume the reinforcer, the therapist to arrange the stimuli, etc.). The procedure for determining the exact length of an ITI on any given trial was designed to obtain maximum precision while permitting the teachers to work in as natural a manner as possible. The exact instructions given to a teacher, therefore, varied from asking the teachers to present ITI's of a natural length (given that the length coincided with the average length ITI scheduled in that condition), to instructing the teacher to attempt to average "n" seconds per ITI throughout the condition. For one child/task combination (Child 2/Task 2), in order to maximize precision, an outside experimenter cued the teacher at the exact time each S^D was scheduled. In all cases, the teachers were requested to attempt to keep all behaviors (other than ITI duration) constant across conditions.

Design

In one analysis in this investigation a multiple-baseline design was employed. During the baseline conditions, two children received treatment (on a total of three target behaviors) with the therapists using long ITI's. After a different, randomly assigned number of baseline trials for each child/task (100, 240, and 1,020 trials, respectively), the short ITI condition was introduced for the same number of trials, or until the children acquired the behavior (14 correct out of 15 unprompted trials) whichever occurred first.

In the other analysis, a reversal design was employed. The three children were taught a total

Table 1

Tasks (S^Ds, Responses, and Reinforcers), number of trials per condition, and typical length of ITI per condition for each child/task combination.

Child	*Task*	*Number of trials per condition*	*Typical length of ITI per condition*
Child 1/ Task 1	Sequencing S^D: "Give me (*colored block*), then (*another colored block*), and then (*another colored block*)" Child's correct response: hand the therapist the three blocks in the correct order Reinforcer: social ("Good work," plus smiles)	10 trials per short ITI condition 10 trials per long ITI condition	short ITI's = 1 sec long ITI's = 5 sec
Child 2/ Task 1	Verbal imitation: S^D: "Say 'ah' " Child's correct response: "Ah" Reinforcer: social ("Good working") and primary (a small portion of fruit juice).	60 trials for the short ITI condition 100 trials for the long ITI condition	short ITI's = 3 sec long ITI's = 12 sec
Child 2/ Task 2	Object discrimination: S^D: "Touch boot" Child's correct response: Touches a boot vs. a cup Reinforcer: social ("Good") and primary (a small portion of fruit juice).	22 & 25 trials for the short ITI conditions 17 trials for the long ITI condition	short ITI's = 3 sec long ITI's = 26 sec
Child 3/ Task 1	Verbal discrimination: S^D: "What is this?" vs. "Color?" (holding up a yellow block) Child's correct response: label the object as a "block" vs. label the color as "yellow." Reinforcer: social ("good," plus smile)	43 trials for the short ITI condition 1020 trials for the long ITI condition	short ITI's = 2 sec long ITI's = 5 sec
Child 3/ Task 2	Prepositions: S^D: Pencil lying *on* vs. partially *under* a piece of paper Correct child's response: "on" vs. "under" Reinforcer: social ("good," plus smile)	114, 34, & 63 trials for the short ITI conditions 116 & 30 trials for long ITI conditions	short ITI's = 1 sec long ITI's = 5 sec
Child 3/ Task 3	Number Discrimination: S^D: "Give me (1, 2, 3, 4, 5, 6, or 7) spoons." Child's correct response: hands therapist the correct number of spoons, from a pile of 7 spoons. Reinforcer: social ("good," plus smile)	20 trials for the short ITI condition 240 trials for the long ITI condition	short ITI's = 2 sec long ITI's = 15 sec
Child 3/ Task 4	Color labeling: S^D: "Color?" (holding up a yellow block) Child's correct response: "Yellow" Reinforcer: social ("good," plus smile)	20 trials per short ITI condition 20 trials per long ITI condition	short ITI's = 1 sec long ITI's = 5 sec

of four target behaviors. Each task was presented for a given number of trials under one of the ITI conditions (e.g., short ITI); then conditions were reversed for a specific number of trials so that the task was presented with the other ITI condition (e.g., long ITI); conditions were then reversed again.

Table 1 shows the specific tasks for each child, including the therapists's instruction, the child's response, the reinforcer(s), the number of trials presented in each condition, and the typical (average, rounded to the nearest second) duration of the ITI for each condition.

Reliability of the Independent Variable (ITI Duration)

In order to ensure reliable measurement of the independent variable (ITI duration), two observers independently recorded ITI durations for 464 trials (representing nine of the 21 ex-

perimental conditions) from video cassettes. Each observer separately reviewed each videotaped trial two times and, during the second viewing with a stopwatch, measured the duration of each ITI to a tenth of a second. The observer used the pause button of the Sony VO 2600 video cassette recorder/player following each ITI in order to allow sufficient time to record the measures on data sheets. The data from the two observers were then compared for reliability on a trial-by-trial basis. Interobserver agreements were defined as measures of ITI duration which were within .5 sec of each other. The point-by-point percent agreement for individual ITI's (total agreements divided by total agreements plus disagreements), averaged 90.1%, with a range of 81.2% to 98.4% for individual sessions.

Reliability of the Dependent Variable (Percent Correct Unprompted Child Responses)

In order to estimate the reliability of recording the percent correct response data, reliability measures were recorded in vivo and from video tape randomly throughout the investigation for 517 trials. During these trials, two observers (one of whom was naive with respect to the hypothesis being studied) independently recorded whether the child responded correctly or incorrectly on all unprompted trials, on a trial-by-trial basis. All reliability calculations were above 97% agreement. There were a total of 505 agreements out of the 517 trials, resulting in an average percent agreement of 97.6% (range: 97.2% to 100% across tasks and children).

RESULTS

Influence of Long vs. Short Intertrial Interval

Figure 1 presents the results of the multiple-baseline analysis. Blocks of 20 trials are plotted along the abscissa with the percent correct of unprompted trials on the ordinate. For example, if in a block of 20 trials, a child had 18 unprompted trials with nine of these being correct, the percent correct for that block was 50%. In this graph, the baselines (with long ITI's) show highly erratic child performance with no indication of improvement. This was true for 100 trials for Child 2/Task 1, for 240 trials for Child 3/Task 3, and for 1,020 trials for Child 3/Task 1. In contrast, when the short ITI condition was introduced, all three children showed immediate increases in correct responding and rapid achievement of the acquisition criterion (14 correct out of 15 unprompted trials). This was true within 60 trials for Child 2/Task 1, within 20 trials for Child 3/Task 1, and within 43 trials for Child 3/Task 3.

The relatively greater success of the short ITI condition is further illustrated by the reversal analysis shown in Figure 2. (Percentages on the ordinate were calculated in the same way as in Figure 1). In each of the four sets of coordinates shown in Figure 2, percent correct responding for a child/task combination is presented on the ordinate, and the blocks of trials in the reversals of the conditions (short vs. long ITI) are presented on the abscissa. The data show that the short ITI's produced higher percentages of correct responding for all child/task combinations studied. The effect of this independent variable was consistent regardless of the child, task, reinforcer, instructions to the teachers (natural vs. controlled), or number of trials per experimental condition (cf. Table 1). In the first graph presented in Figure 2, (Child 1/Task 1), the therapist began with relatively long ITI's (5 sec). The average percent correct responding across the trials in this condition was 40%. The condition was then reversed to the same task with relatively short ITI's (1 sec). This resulted in an increase in correct responding to 60%. A reversal to the long ITI condition produced a subsequent decrease to only 20% correct responses. This was followed by a final reversal to the short ITI condition, with another replication of the increase to 60% correct responding.

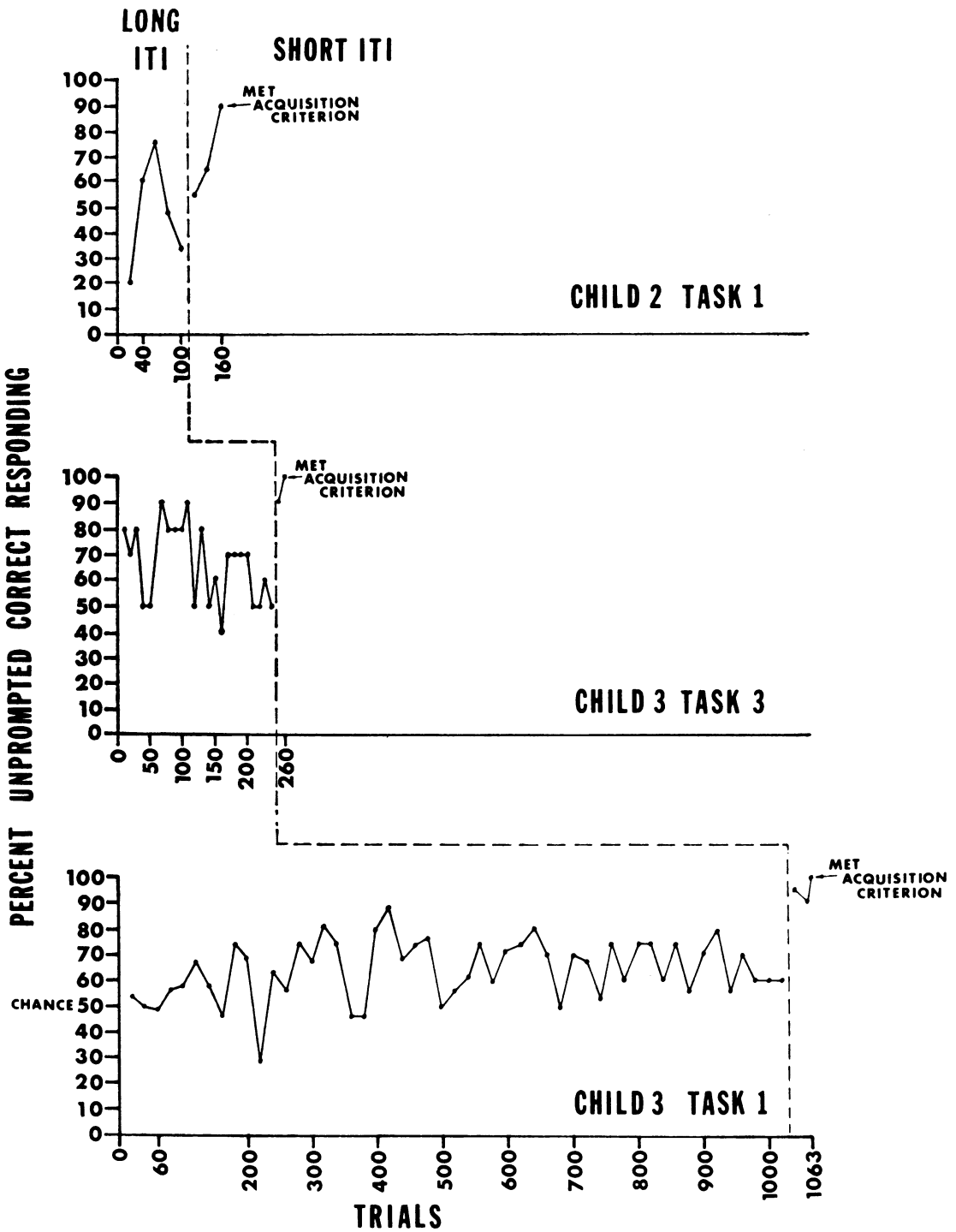

Fig. 1. Results of the multiple-baseline analysis of the influence of long vs. short intertrial intervals on the acquisition of three tasks by autistic children.

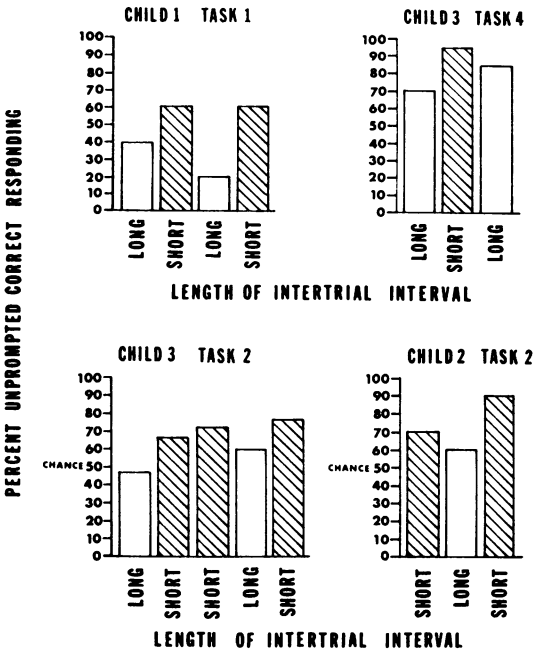

Fig. 2. Results of the repeated reversal analysis of the influence of long vs. short intertrial intervals on correct performance on four additional learning tasks.

Examination of the remaining graphs in Figure 2 reveals essentially the same effect for all child/tasks. That is, the short ITI's always produced higher levels of correct responding than did the long ITI's.

In summary, the overall results from this investigation show that: (1) the short ITI condition always produced higher levels of correct responding than did the long ITI condition for that same task; and (2) there were improving trends and rapid acquisition with the short ITI conditions in contrast to essentially no progress when long ITIs were employed for the same task.

DISCUSSION

The results of this study showed that systematic manipulations of the ITI durations produced differential results in the percentage of correct responding of autistic children. In this study, the superior intervals were those that were relatively short. This may not imply, however, that short intervals will always be superior. Rather, we suspect that the major implications of these data are: (1) that length of ITI is a functional variable, and (2) for these particular child/task combinations, the relatively short ITI's were superior.

The variables that may contribute to a more precise determination of optimal ITI durations are potentially numerous (ranging from possible analogies in the literature on massed vs. distributed practice, to research on ITI directly). Among the most directly relevant variables that have been suggested in the literature are task characteristics such as task complexity and acquisition vs. maintenance; and child characteristics such as age, memory span, attention, and level of off-task behavior (e.g., Bourne & Bunderson, 1963; Croll, 1970; Holt & Shafer, 1973; and Watson, 1967). For example, Watson (1967) has suggested that the memory span of very young children for discriminated operants may be very brief, indicating a brief ITI may be helpful for learning to occur.

The above statements regarding child variables seem particularly applicable to autistic children. For example, autistic children often display MA's in the lower ranges, and are very distractable. In addition, many authors (e.g., Hingtgen & Bryson, 1972) have suggested that short-term memory impairments may contribute to the poor performance of autistic children. Similarly, optimal ITI duration may be related to the extent of off-task (e.g., self-stimulatory) behavior produced by particular children. With children known to display high rates of off-task behavior (e.g., the children in this experiment, and most autistic children), it is possible that short ITI's may reduce the opportunity for such behaviors to occur and, therefore, might facilitate learning (cf. Koegel & Covert, 1972; Risley, 1968). Indeed, our incidental observations over the course of this study suggested that, at least for some child/task combinations, the shorter ITI's seemed to produce a much lower level of self-stimulatory behavior.

In summary, it seems interesting to note that

almost every variable discussed in the ITI duration literature is particularly applicable to the autistic population. As such, this seems like a very promising avenue for future research. Whatever the exact reason for the present results, it seems increasingly important to examine characteristics of the learning situation which occur between trials. The present results show that such variables can have a relatively large influence on teaching these children.

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