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EFFECTS OF WAIT-TIME AND INTERTRIAL INTERVAL DURATIONS ON LEARNING BY CHILDREN WITH MULTIPLE HANDICAPS

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We investigated the influence of teacher wait-time and intertrial interval durations on the performance of 4 multiply handicapped students during instruction in 10 skills. Four experimental conditions were evaluated: long wait-time and long intertrial interval, long wait-time and short intertrial interval, short wait-time and long intertrial interval, and short wait-time and short intertrial interval. Instructors attempted to keep short intervals as close as possible to 1 s and long intervals as close as possible to 10 s for both variables. Results showed that student performance was superior under the long wait-time conditions irrespective of the length of the intertrial interval.

DESCRIPTORS: intertrial interval, wait-time, children, alternating treatment, instructional pacing

The effects of teacher pacing during instruction have been investigated in both special and regular education settings. The manipulation of variables such as rate of teacher presentation (Carnine, 1976, 1981; Englert, 1983, 1984), time-delayed prompts (Browder, Morris, & Snell, 1981), forced response delay (Dyer, Christian, & Luce, 1982; Lowry & Ross, 1975), teacher wait-time (Lee, O'Shea, & Dykes, 1987; Rowe, 1974), and intertrial interval (Dunlap, Dyer, & Koegel, 1983; Koegel, Dunlap, & Dyer, 1980) has allowed researchers to develop some guidelines for effective instruction. Teacher wait-time (WT) and intertrial interval (ITI) are two temporal variables that have been shown to be functionally related to student learning. Wait-time refers to the time that a teacher allows for a student to respond before recording a trial as correct or incorrect, and ITI refers to the pause between instructional trials or questions.

Carnine (1976) found that fast-paced instruction was accompanied by a higher percentage of correct responses to teacher-presented tasks than was slow-paced instruction with nonhandicapped students. Englert (1983, 1984) divided teacher interns into two effectiveness groups based on their students' achievement and found that the more effective teachers presented a significantly higher number of trials per minute than the less effective teachers did.

Other researchers (e.g., Fagan, Hassler, & Szabo, 1981; Rowe, 1974) have suggested that extending the time a teacher waits for a student response before proceeding with the lesson increases the length and quality of student responses. Lee et al. (1987) found that extending wait-time from 1 to 5 s resulted in enhanced responding from multiply handicapped preschool children. The developmentally delayed children in this study produced more frequent and more accurate responses to teacher requests under the longer WT condition than under the shorter WT condition.

Although there has been little systematic research examining the effects of ITI duration, the findings so far have been impressive. In two separate reports (Dunlap et al., 1983; Koegel et al., 1980), ITI duration has proven to be a potent variable for influencing learning in autistic children. In the first study, the performance of 3 subjects was examined across seven different tasks. This investigation revealed that short ITIs of 1 to 4 s were associated consistently with higher levels of correct responding and with more rapid acquisition than were long

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ITIs of 5 to 26 s. In the follow-up study, the relationships between ITI duration and the correct responding and self-stimulation of 4 autistic children were examined. As anticipated, short ITIs were associated with decreased levels of autistic self-stimulation (e.g., stereotyped repetitive vocalizations, repetitive hand shaking, playing with saliva) and increased levels of correct responding for each subject. Other nonautistic self-stimulatory behaviors such as lightly tapping furniture with the hand or swinging legs were also monitored during this investigation, but were apparently not affected by variations in ITI duration.

The proponents of the direct instruction model and commercial curricula based on it (e.g., Distar Reading; Engleman & Bruner, 1974) advocate a teaching model that includes extended WTs and brief ITIs. They suggest that students be given ample time to respond to a task and that the time between tasks be shortened. Thus far, there have been few, if any, studies conducted to assess systematically the combined effects of manipulating both WT and ITI durations. The purposes of the present investigation were to determine whether student performance is functionally related to WT duration and ITI duration and to determine what combination of WT and ITI durations maximizes the performance of students with multiple handicaps.

METHOD

Subjects

Four multiply handicapped elementary school-age children residing at the Children's Mental Health Unit on the University of Florida campus served as subjects. The subjects were functioning below their chronological age levels on standardized tests and were referred to our program because of behavioral excesses and intellectual deficits. General levels of functioning were estimated using scores from the Stanford Binet, K-ABC, Hiskey-Nebraska Test of Learning Aptitude, PPVT, and the Brigance Inventory of Early Development.

Tim was an 11-year-old male who had been referred for behavior and learning problems including aggression, hyperactivity, property destruction, language disability, and severe attention deficit. Tim had been placed in self-contained classes for mentally retarded and emotionally disturbed children and had most recently been receiving homebound instruction. His DSM III diagnosis was Frontal Lobe Syndrome. Tim was believed to be functioning at the 5-year level, and his IQ was estimated to be 58.

Katy was an 11-year-old female with a DSM III diagnosis of Organic Brain Syndrome. Problem behaviors at the time of admission included aggression (up to 240 occurrences per day), hyperactivity and impulsivity, tactile defensiveness, severe speech and language delay, and short attention span. She had been served previously in classes for preschool handicapped, multihandicapped, and emotionally handicapped, language impaired children. She received an IQ estimate of 56 and was believed to be functioning at the 5-year level.

Betty was an 8-year-old female who had been referred for learning and behavior problems including multiple developmental delays (especially speech and language), attention deficits, hypotonicity, hyperactivity, and aggression. She had been served in a class for children with multiple handicaps prior to admission to our program. Betty received an IQ estimate of 52 and was believed to be functioning at the 3.5-year level. She also suffered from a sensorineural hearing loss and petit mal epilepsy.

Larry was a 5-year-old male with DSM III diagnoses of developmental delay, developmental language disorder, conduct disorder, and developmental articulation disorder. Referral problems included fire setting, self-injurious behavior, tantrums, noncompliance, aggression, and nocturnal enuresis. His speech was often completely unintelligible. He had been previously enrolled in early intervention programs. Although a formal IQ estimate was not available, developmental measures revealed that Larry's speech and language skills were at the 3-year level and overall functioning was at the 4-year level.

Setting

All instructional sessions were conducted in a small, quiet classroom at about the same time each day with only the instructor and student present. Subjects were familiar with the classroom setting because they received daily instruction in the same room as part of their ongoing treatment program. One-way observation windows permitted direct observation and videotaping.

Independent Variables

Teacher WT and ITI durations were the two independent variables. Wait-time is the time that an instructor allows for a student to respond before recording a trial as correct or incorrect. There were two levels of this variable; short WT (1 s), and long WT (10 s). Intertrial interval is the time that an instructor pauses between the completion of one learning trial and the beginning of the subsequent learning trial. There were two levels of this variable; short ITI (1 s), and long ITI (10 s). The following combinations of variables and levels constituted the experimental conditions of this study: long WT and long ITI, long WT and short ITI, short WT and long ITI, and short WT and short ITI. Each subject received instruction under each condition. WT was defined as beginning when the discriminative stimulus was presented to the student and ending when the student initiated a response or when the time limit criterion was met, whichever occurred first. Intertrial interval was defined as beginning when one trial ended (signaled by delivery of a positive reinforcer or the end of the WT interval, whichever came first) and ending with the presentation of the discriminative stimulus for the subsequent trial.

Dependent Variables

The dependent variables in this investigation were the students' number and percentage of correct and incorrect responses during individual learning trials. Correct and incorrect responses were defined topographically for each learning task. Student performance data (correct vs. incorrect) were collected by the teachers during instructional sessions. Definitions of the scoring criteria are available from the authors upon request.

Experimental Tasks

The tasks chosen for investigation were ones that allowed the experimenters to collect accurate trial-by-trial data and to manipulate the temporal variables under investigation while providing ongoing instruction to the children. Each child was taught at least two separate tasks. For all tasks in this study, mastery was defined as 100% correct responding under more than one condition for at least 2 consecutive days. The following child/task combinations were included:

Tim/Task 1. Tim was taught to read the number words from "one" to "twenty" in increments of five words (i.e., one to five, then one to 10, etc.). The words were printed on flash cards, and Tim was shown a card and asked "What is this word?" He responded by reading the word aloud to the instructor.

Tim/Task 2. Tim learned to identify the number words from "one" to "twenty" by pointing. The instructor presented Tim with the printed words "one" to "five" and asked him to point to a designated number (e.g., "Point to four."). The number of words was increased by five when the student demonstrated mastery.

Tim/Task 3. Tim was taught to count pennies up to five. Five pennies were placed on the table and Tim was asked to give some to the instructor (e.g., "Give me two pennies."). The number of pennies requested was sequenced randomly; Tim responded by placing the coins in the instructor's hand.

Tim/Task 4. Tim learned to read 20 three-letter, consonant-vowel-consonant words (e.g., "men") presented in random sequence. The words were printed on flash cards, and Tim was shown a card and asked "What's this word?" He responded by reading the word aloud. Instruction began with five words, and five additional words were added to the task each time mastery was demonstrated. Each set of five words contained each of the five vowels.

Katy/Task 1. Katy was taught to identify letter sounds from the Distar Reading curriculum (Engleman & Bruner, 1974). She was shown a printed letter or letters and responded by verbally producing the sound that the letters represented. Five sounds were chosen from her instructional program and were presented in random sequence. New sounds replaced old ones when mastery was demonstrated.

Katy/Task 2. Katy performed the same letter sounds task with the response changed from a verbal identification of the sounds to a nonverbal pointing response. She was presented with a printed list of the letters in the curriculum and asked to point to the letter representing the sound verbalized by the instructor.

Betty/Task 1. Betty was taught to discriminate between coins (penny and quarter, dime and quarter). Two coins were presented, and Betty was instructed to "Touch the penny (or quarter)." She responded by touching one of the coins with her index finger.

Betty/Task 2. Betty also learned to discriminate between numerals using a nonverbal response. Two wooden blocks with numerals painted on them were placed in front of her, and she was instructed to give one to the instructor (e.g., "Give me number eight."). Betty responded by placing a block in the instructor's hand.

Larry/Task 1. Larry was taught the same numeric discrimination task described above (Betty/Task 2) using the same methods.

Larry/Task 2. Larry also learned to count objects up to seven using counting rods. Initially, five rods were placed in front of him, and Larry was asked to give some to the instructor (e.g., "Give me four."). He responded by placing the rods in the instructor's hand.

Experimental Design

An alternating treatments design (Tawney & Gast, 1984) in which the four treatment conditions were counterbalanced randomly within sessions was used. Each subject received each treatment each day. In this manner, systematic replications of experimental effects within and across subjects, as well as across experimental tasks, could be accomplished.

Experimental Procedures

An instructor presented each student with 20 learning trials (five trials in four conditions) for each task. Each student received a total of from 20 (one task) to 60 (three tasks) learning trials per session. Sessions were conducted 4 days per week at about the same time each day. The number of days during which performance was assessed for each child was determined on the basis of progress made toward the mastery criteria described above. A verbal cue ("Are you ready?") served as a discriminative stimulus to signal the onset of each set of five trials. There was no correction procedure for errors, and verbal feedback was the only positive reinforcer used during experimental learning trials.

When two-choice discrimination tasks were presented, the location of the positive or correct stimulus and the designation of which choice was correct were counterbalanced randomly to ensure that no position hypothesis would produce other than chance performance and that no position hypothesis would be reinforced differentially. Balanced sequences were developed for both one binary variable (e.g., left or right location) and for two binary variables (e.g., left or right location and designation of which stimulus was correct) (Fellows, 1967).

The experimenters and two special education students served as the instructors, observers, and recorders and implemented all of the procedures for this study. The teachers and observers were advanced undergraduate and graduate students in special education with extensive training and experience in recording behavior of children with disabilities. All participated in training sessions prior to recording the current data to ensure that the independent variable was implemented accurately and that the dependent variable was recorded reliably.

Reliability of the Independent Variables

The accurate implementation of the independent variables in this investigation across instructors was

Table 1
Mean (and Median) Values for Student Task Performance

Child/Task	Conditions (wait-time/intertrial interval)			
	Short/Short	Short/Long	Long/Short	Long/Long
Tim/Task 1	3.2 (3)	3.1 (3)	4.6 (5)	4.6 (5)
Tim/Task 2	3.3 (3.5)	2.4 (2)	4.8 (5)	4.7 (5)
Tim/Task 3	4.5 (5)	3.8 (4)	4.3 (4.5)	4.5 (5)
Tim/Task 4	3.8 (4)	3.7 (4)	4.6 (5)	4.6 (5)
Katy/Task 1	4.0 (4)	4.3 (4)	4.5 (5)	4.5 (4.5)
Katy/Task 2	3.8 (4)	4.0 (4)	4.9 (5)	4.9 (5)
Betty/Task 1	3.8 (3)	3.0 (3)	4.1 (5)	4.1 (5)
Betty/Task 2	3.1 (3)	3.9 (4)	4.4 (5)	4.4 (5)
Larry/Task 1	3.6 (3.5)	2.7 (3)	4.6 (5)	3.8 (4)
Larry/Task 2	3.8 (4)	3.0 (2.5)	4.4 (5)	4.5 (5)

furthered by providing training sessions for the instructors and by monitoring the durations during instructional sessions. Although both instructors demonstrated proficiency at pacing task trials according to prearranged temporal guidelines prior to the initiation of the study, monitoring the actual WT and ITI durations was performed to ensure that instructors did not drift from the target durations during the course of the study. Instructors attempted to keep short intervals as close as possible to 1 s and to keep long intervals as close as possible to 10 s for both variables. Measurements of WT and ITI durations were taken during 18 sessions using a digital display stopwatch. Altogether, 320 ITI and 42 WT durations were assessed. All measured intervals approximated the desired durations. Short WTs averaged 2.2 s (range, 0.7 to 5.6), long WTs averaged 8.5 s (range, 5.4 to 13.0), short ITIs averaged 2.5 s (range, 0.5 to 6.0), and long ITIs averaged 10.8 s (range, 6.5 to 19.3).

Reliability of the Dependent Variables

Reliability of the dependent variables was assessed using videotapes taken of 3 of the 4 children across six of the 10 child/task combinations presented across 102 trials. Two observers (one of whom was naive with respect to the purposes of the study) independently recorded whether the child responded correctly or incorrectly, on a trial-by-trial basis. Percentage agreement was calculated by dividing the total number of agreements by the total number of agreements plus disagreements and multiplying by 100. Percentage agreement averaged 99%, with a range of 95% to 100% across tasks and children.

RESULTS

Data regarding the effects of WT and ITI on student performance are presented in Table 1. Because trials were presented in sets of five, student performance for each condition on each day is tabulated as the number of correct responses per set. Mean and median values indicate that student performance was superior during the long WT conditions. The long WT/short ITI condition resulted in median values of five for all but one child/task combination. Similarly, the long WT/long ITI condition resulted in median performance levels of five for all but two child/task combinations. The short WT/long ITI condition, however, never resulted in median performance levels of five, and the short WT/short ITI condition did so only once.

Data on student responding were analyzed further by calculating the percentage of correct responding across days for each child/task combination under each of the four experimental conditions. In Figure 1, these data are displayed for comparison of experimental effects. Student performance measures are grouped by subject/task

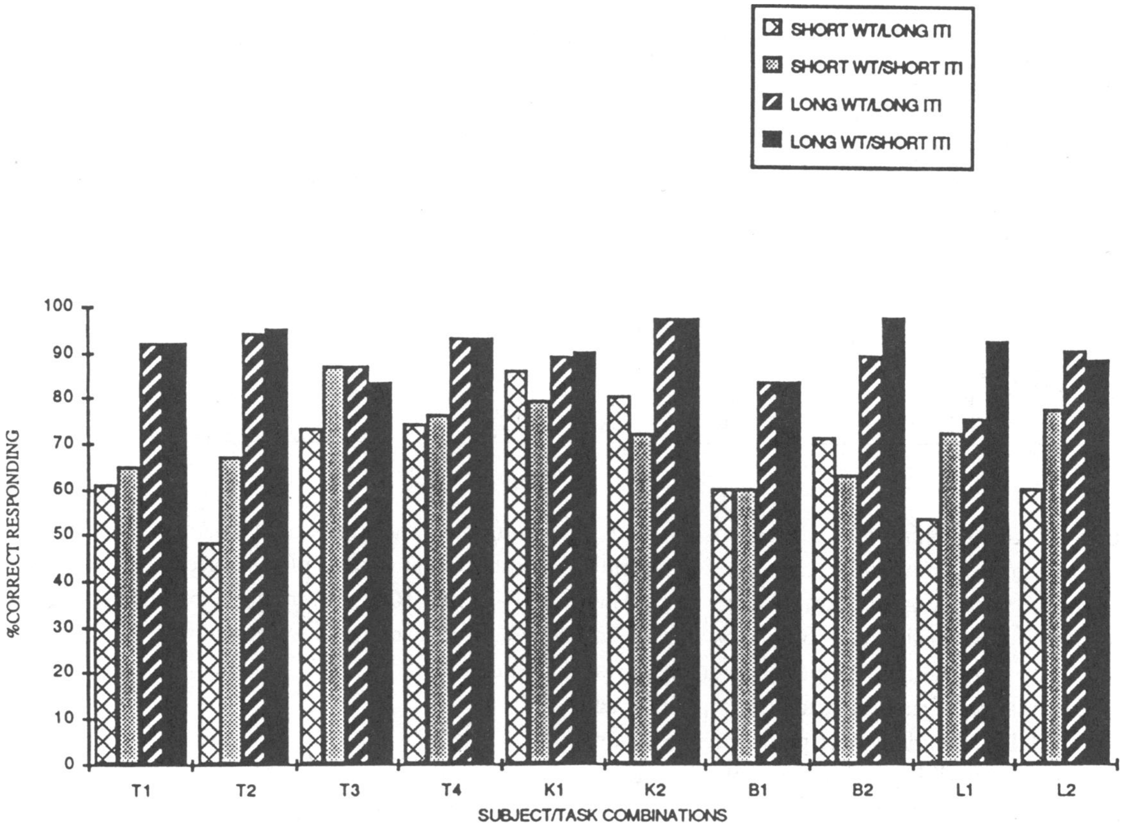


Figure 1. Performance by subject and task.

combinations. When viewed from this perspective, performance under the long WT conditions was superior to performance under the short WT conditions for nine of the 10 child/task combinations. The long WT/short ITI condition resulted in the greatest percentage of correct responses for four of the 10 child/task combinations (Tim/Task 2, Katy/Task 1, Betty/Task 2, Larry/Task 1). The long WT/long ITI condition resulted in superior performance for one child/task combination (Larry/Task 2). In four of the five remaining child/task combinations, correct responding was equally high under the long WT/short ITI and long WT/long ITI conditions. Tim's performance on Task 3 was best during the short WT/short ITI and the long WT/long ITI conditions. It should be noted, however, that data were collected across the fewest number of days for this child/task combination. Across students and tasks, the mean and median levels of correct responding for the long WT/short ITI condition were 91% and 92%, respectively. The level of correct responding for the long WT/long ITI condition was nearly as high (M = 88.8%, median = 90%). Performance levels for the short WT/short ITI condition (M = 71.8%, median = 72%) and the short WT/long ITI condition (M = 66.6%, median = 71%) were noticeably lower.

To evaluate the effects of the WT variable alone, student performance data for short and long WTs were compared without regard to ITI duration. In Figures 2 through 5, performance data for the 10 child/task combinations are presented. For three of the child/task combinations (Tim/Task 1, Tim/Task 2, Betty/Task 2), performance was superior under the long WT condition on every day of the study. For two additional child/task combinations (Tim/Task 3, Tim/Task 4) performance under the long WT condition was superior or equal to performance under the short WT condition on every day of the study. Overall, performance was superior

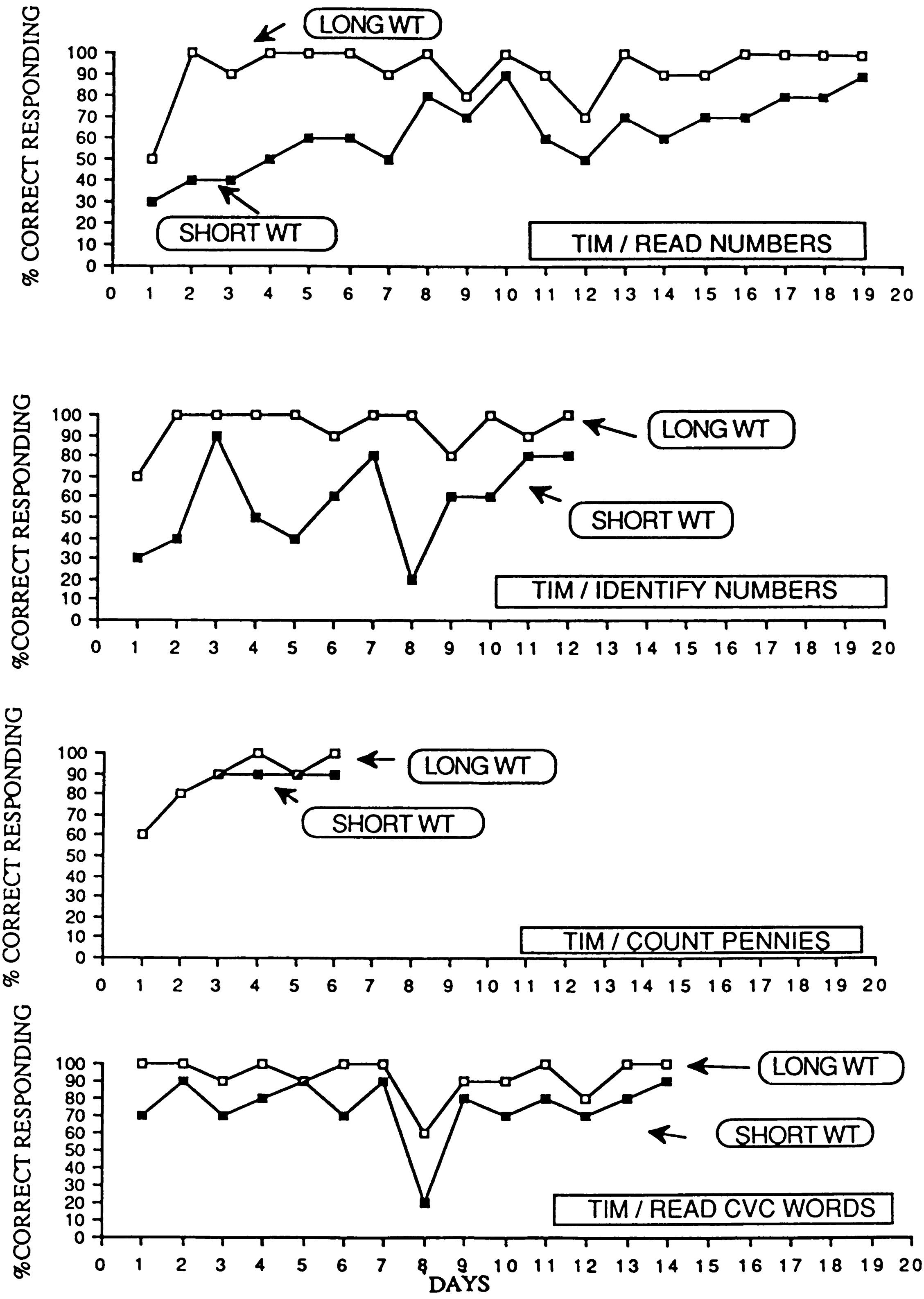
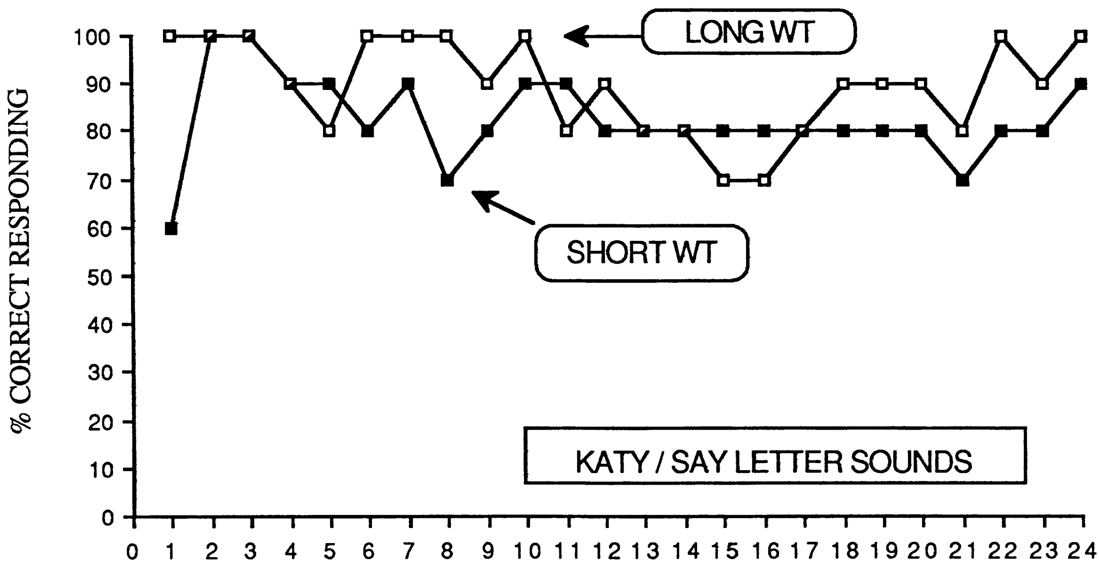


Figure 2. Tim's long and short wait-time (WT) performance.



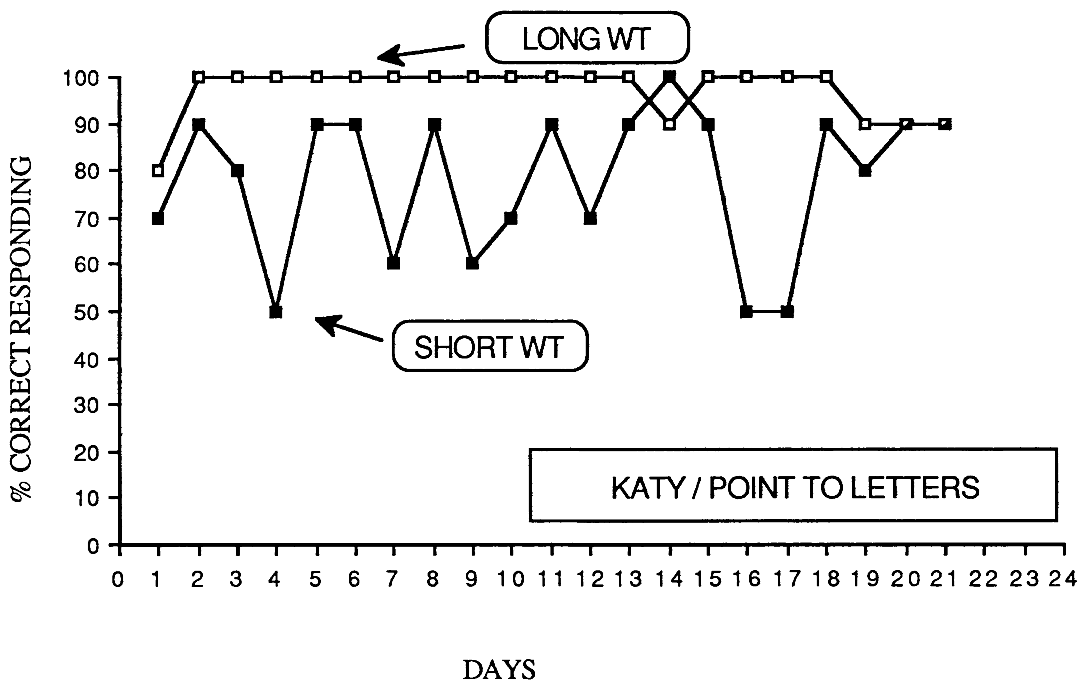


Figure 3. Katy's long and short wait-time (WT) performance.

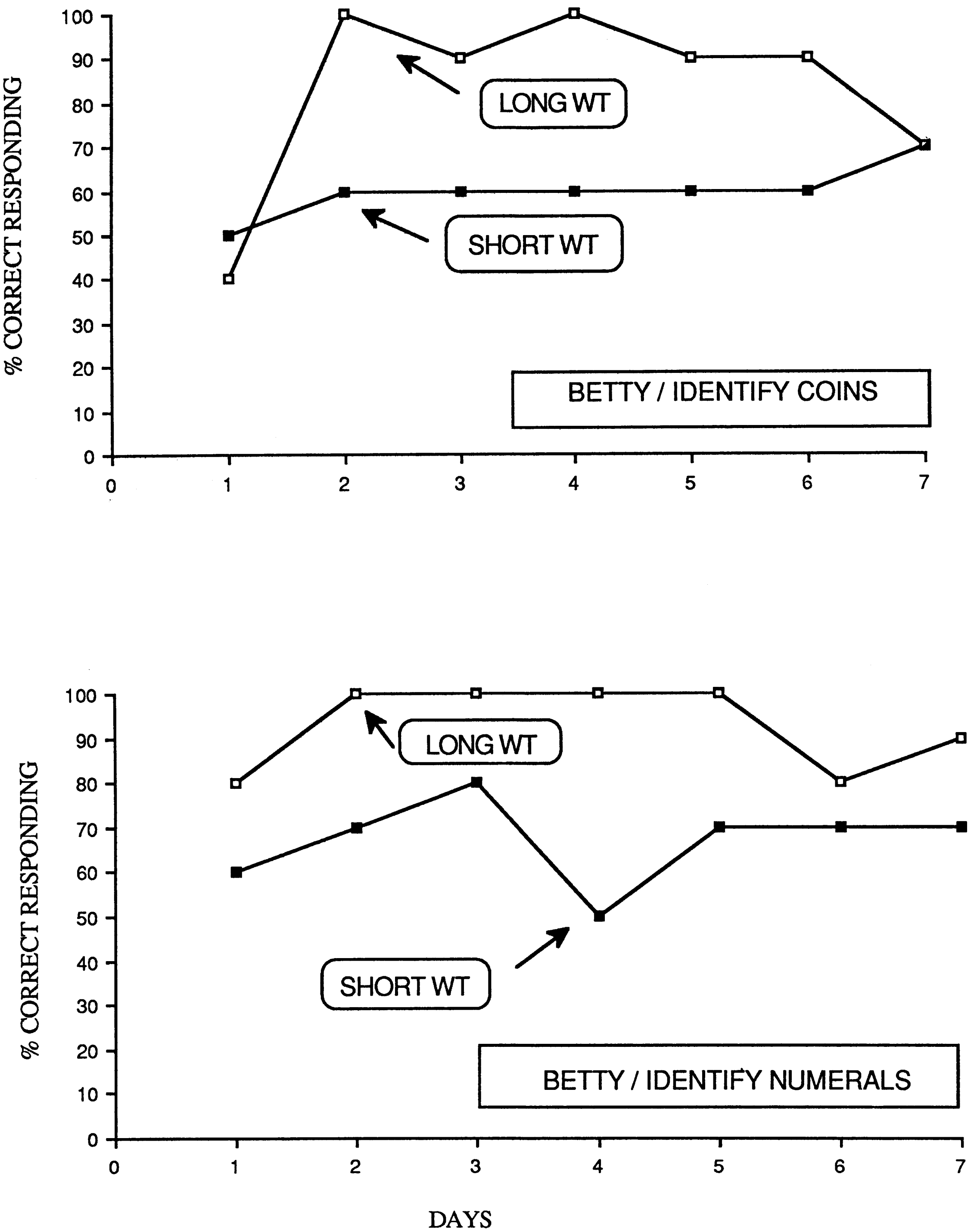
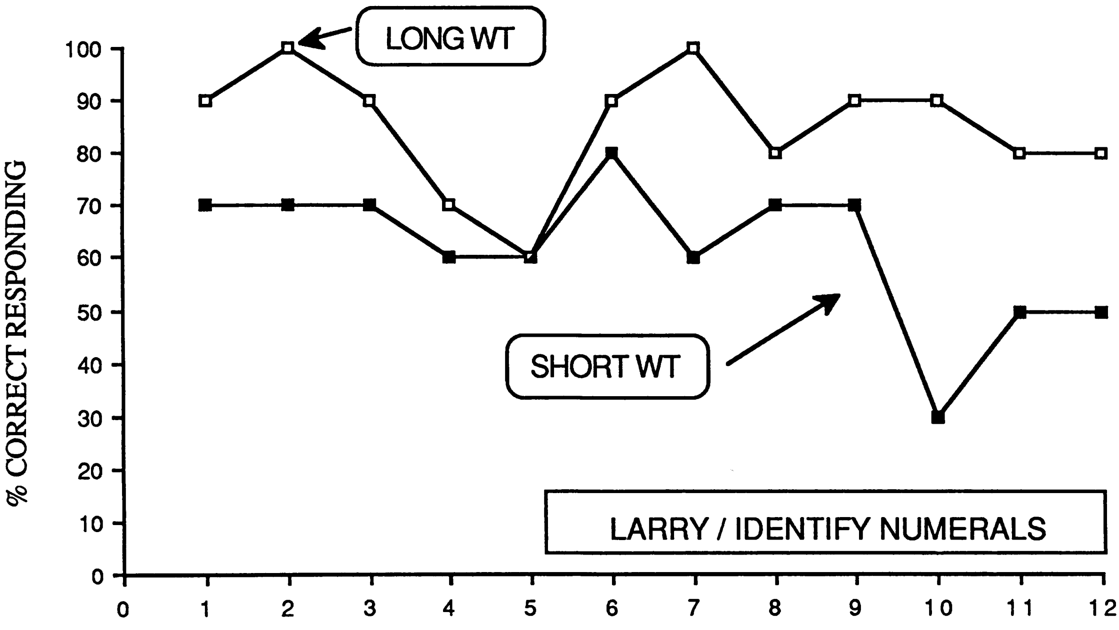


Figure 4. Betty's long and short wait-time (WT) performance.



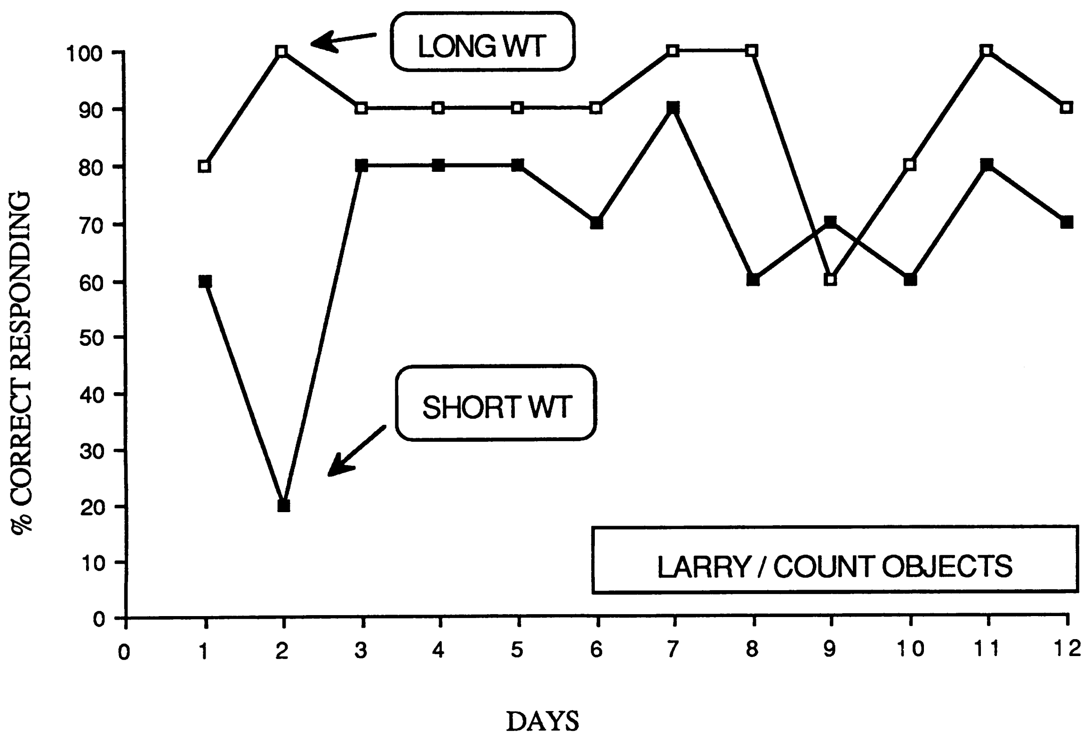


Figure 5. Larry's long and short wait-time (WT) performance.

under the long WT condition for 111 of the 134 (82.8%) days studied. Across all 10 subject/task combinations, the mean and median levels of correct responding for the short WT condition were 69.3% and 71.5%, respectively. For the long WT condition, however, the mean and median levels of correct responding were 89.9% and 91.0%, respectively.

To evaluate the effects of ITI duration alone, student performance data for short and long ITIs were compared without regard to WT duration. Neither the short nor the long ITI condition was consistently associated with superior student performance. Across all 10 subject/task combinations, the mean and median levels of correct responding for the short ITI condition were 81.4% and 83.0%, respectively. For the long ITI condition, the mean and median levels of correct responding were 77.7% and 81.5%, respectively.

DISCUSSION

The results of this study support the findings of previous research on teacher wait-time (Lee et al., 1987; Rowe, 1974; Tobin, 1980) and perhaps extend the generality of previous findings to children with multiple handicaps. In the present investigation, the manipulation of WT duration resulted in changes in levels of correct responding. Typically, longer WTs were found to be superior to those that were shorter. The difference between median performance levels found in this study was nearly 20 percentage points in favor of long WT (71.5% vs. 91.0%). The consistency with which the long WT condition was associated with higher levels of correct responding across days, across students, across tasks, and across instructors suggests that wait-time is a potent variable.

The results of this investigation relative to intertrial interval duration did not support those of previous researchers (Dunlap et al., 1983; Koegel et al., 1980). Although slight differences in favor of the short ITI were observed, student performance was not found to be superior under either of the ITI conditions. These results suggest that ITI duration was not a functional variable for the children and tasks studied here. However, a more plausible explanation is that the effects of the WT variable were more potent than those of the ITI variable for these participants.

However, teachers and researchers should note the possible effects of ITI duration on student learning. Previous researchers have documented the importance of this variable. Koegel et al. (1980) suggested that short intervals may not always be superior. A major implication of their findings is that intertrial interval is a functional variable. The children participating in these studies exhibited autistic self-stimulatory behavior, whereas the children who participated in the present investigation did not engage in self-stimulation during instructional sessions. It may be that this difference in subjects translates into differences in ability to remain on-task between trials and may partially account for the discrepant results.

When median percentages of correct responding were compared across subjects and tasks, the long WT/short ITI condition was slightly superior to the long WT/long ITI condition and greatly superior to the other two experimental conditions. Although the differences between the long WT/short ITI and long WT/long ITI are slight, they may, in fact, be meaningful. When the effects of ITI duration are compared within the two levels of WTs, minor but consistent differences appear. The median level of correct responding for the short ITI was higher than that of the long ITI condition when WTs were long. Similarly, the short ITI condition was associated with higher levels of correct responding than the long ITI conditions when WTs were short. Furthermore, the long WT/short ITI condition was much more time efficient than the long WT/long ITI condition. The average duration of five trials under the short ITI condition was 25 s, whereas the average duration of five trials under the long ITI condition was 60 s. This difference means that students whose teachers use short ITIs may receive more than twice the amount of instructional trials as students whose teachers use long ITIs in addition to maintaining maximum performance levels.

Although the degree to which instructors maintained paced lessons in accordance with predetermined guidelines was not one of the experimental questions addressed in this study, the findings in this area merit discussion given that there may be questions about the practicality of classroom teachers implementing similar strategies. In this study, short WTs, which were intended to last for only 1 s, averaged 2.2 s (median = 2.0). These figures contrast somewhat with those of Rowe (1974) and Tobin (1980), who measured WTs in general education science classrooms and found averages of 1 and 0.5 s, respectively. Instructors in the present investigation were unable to maintain WTs as short as 1 s even though they attempted to do so. Further studies of typical WT durations in special education settings may be worthwhile.

An alternative explanation of the longer durations of the short WT intervals in this experiment involves the measurement system used. In the present investigation, measurements were made using direct and videotape observation and a stopwatch. These measurements were then subject to discrepancy resulting from observer reaction times. This type of imprecision tends to lengthen the measured intervals.

Several limitations of the present investigation may serve to clarify subsequent research directions. First, some of the tasks used in this study were not functional. Further research on these temporal variables across tasks that are functional and age-appropriate (Brown et al., 1979) is warranted. Second, the setting was not typical of public school instruction (i.e., only 1 student and 1 instructor were present in the room). Third, community-based nonschool instruction was not investigated. A clearer understanding of the applicability of these findings to community-based instruction (Falvey, 1985) is needed. Fourth, the use of distributed instead of massed trials may be worthy of investigation. Finally, methodological alterations such as conducting entire sessions with the experimental conditions held constant may yield different results.

In spite of these limitations, the study has several practical implications for classroom teachers. Teachers who extend their WTs are likely to find that students respond with more accurate responses. The assessment of student performance and decisions regarding changes in instructional phases or resetting goals may be influenced by teacher WT. Students with disabilities are often characterized by slow progress towards instructional goals and acquisition of fewer skills during the course of their education. It is crucial, therefore, that they be given ample opportunities to demonstrate their abilities so that instruction may proceed as rapidly as possible. The results of the present investigation suggest that a few extra seconds of teacher WT may, in the long run, hasten progress towards performance criteria set in individualized education plans.

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