

*USING A MODIFIED CONSTANT PROMPT-DELAY PROCEDURE TO TEACH
SPELLING TO STUDENTS WITH PHYSICAL DISABILITIES*

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Current research suggests that constant delay is an effective means of teaching students through near-errorless learning. The current study examined how procedures used in previous research may be modified so that constant delay can be implemented with students who have physical disabilities that prevent them from engaging in fluent academic responding. A multiple baseline design with probes was used to assess the effectiveness of a modified constant-delay procedure in teaching spelling to students with physical disabilities. This procedure was found to be effective for all 3 students.

DESCRIPTORS: constant time delay, delayed prompts, physical disabilities, spelling instruction

Students with physical disabilities often fall under the category of orthopedic impairment. Under this category, there are students with neuromotor impairments (e.g., cerebral palsy, spina bifida), degenerative diseases (e.g., muscular dystrophy, spinal muscular atrophy), and orthopedic and musculoskeletal disorders (e.g., limb deficiencies, juvenile arthritis; Bigge, Best, & Heller, 2001). These students may vary widely in intellectual ability and may have additional impairments (e.g., visual impairments, seizure disorders).

Despite the wide array of differences among students with physical disabilities, there are several common factors that these students often share that could negatively affect their educational performance. These factors include motor limitations, restricted means of communication, fatigue and endurance limitations, health factors, experiential deficits, and interactional effects of ad-

ditional disabilities (Heller & Swinehart-Jones, 2003). To address these issues, instructional strategies often need to be modified and used in conjunction with assistive technology.

Constant delay (also called constant time delay; CTD) is an instructional strategy that has been effectively used in teaching spelling skills to students with learning disabilities (Stevens & Schuster, 1987) and in combination with computer-assisted instruction for students with mild intellectual disabilities (Stevens, Blackhurst, & Slaton, 1991). CTD has also been used to instruct nonacademic tasks such as appropriate toy play and requesting skills to individuals with physical disabilities and severe or profound intellectual disabilities (Crawford & Schuster, 1993; Kratzer, Spooner, Test, & Koorland, 1993).

Procedurally, CTD involves the delivery of an instructional cue that is followed by the presentation of a controlling prompt (e.g., providing an example of a correct answer). During the initial stages of CTD, the controlling prompt is presented simultaneously with the instructional cue to teach the student the correct response. In subsequent sessions, the instructor gives the instructional cue and then delays the presen-

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tation of the controlling prompt for a brief period so the student may respond independent of the prompt (Wolery, Ault, & Doyle, 1992).

The delay interval used in CTD procedures typically ranges from 2 s to 5 s (Zhang, Horvat, & Gast, 1994). However, relatively short delays may preclude responding in the absence of the controlling prompt for students with physical disabilities. That is, the delay may need to be longer when a student has a physical disability that interferes with his or her ability to respond quickly (Wolery et al., 1992). For example, the initial delay interval may be determined by examining the time it takes for a student with a physical disability who is fluent in the skill to initiate the response and then adding 2 s (Crawford & Schuster, 1993).

Due to the diversity of skills across individuals with physical disabilities, the fluency of responding may vary widely. Thus, additional time intervals may be needed to promote initiation and fluent task completion. A duration interval may be set for the amount of time that the individual is provided to complete the target response (Wolery et al., 1992), with a failure to complete the task within the prespecified interval being a duration error (Zhang et al., 1994). Finally, an interresponse interval may be considered in which a response is recorded as incorrect if the student does not respond for a predetermined length of time.

In summary, there have been relatively few demonstrations of CTD procedures that have been modified to meet the needs of students with physical disabilities (e.g., Crawford & Schuster, 1993; Kratzer et al., 1993), and the previous investigations have evaluated CTD for students with significant cognitive impairments. Thus, in the current study we evaluated the utility of a modified CTD procedure to teach spelling to students with physical disabilities who had mild to typical levels of intellectual functioning. We

modified the CTD procedure by using several different intervals to accommodate the individual differences associated with the participants' physical disabilities. Spelling was chosen as the target task because of its importance in writing and in allowing students to create novel messages on augmentative communication devices that can be understood by others (Van Daal & Van der Leij, 1992). In addition, the current study measured whether observational learning of nontargeted spelling words occurred during small-group instruction.

METHOD

Participants and Settings

Three students participated in this study. All students attended a self-contained program for students with orthopedic impairments in a suburban elementary school and were included in general education classrooms for parts of the school day. All students functioned below grade level in spelling performance and had additional disabilities (e.g., visual impairments). Two of the students (Lexie and Autumn) had prior experience with CTD for some areas of instruction (e.g., sight-word recognition), but not for spelling.

Lexie was a 10-year-old fourth-grade student who had spastic quadriplegic cerebral palsy. Her speech was clear with no articulation errors, and she had nystagmus and a visual acuity of 20/40 for both eyes. Lexie could read Size 14 font but typically used Size 28 font because of visual tracking problems. Although she was able to write most single letters and numbers with a pencil adapted with a pencil grip, she required a laptop computer with word processing software due to fatigue and illegibility of many of her written letters. Lexie typed with her left index finger and thumb only, and her fluency was affected by limited finger use and poor trunk stability while typing. She

displayed a grade equivalence of 2:5 (second grade, 5th month) for spelling on the Wechsler Individual Achievement Test (WIAT), and her Stanford-Binet IQ indicated that she was functioning in a normal range of intelligence.

Juana was a 10-year-old fourth-grade student who had myelomeningocele spina bifida and clear speech articulation. Juana had good motor control of her right hand; however, her left hand was contracted and was used primarily to stabilize materials. For handwriting, Juana used a pencil grip on her pencil and dark-line paper to help with maintaining appropriate size and spacing of written text. Her papers were secured on a clipboard on top of a slantboard with a 45° angle. She had a spelling grade equivalent of 2:3 on the WIAT; her IQ scores were unavailable.

Autumn was a 12-year-old fifth-grade student who had spastic quadriplegic cerebral palsy with mildly dysarthric speech. She also had a visual impairment that resulted in a visual acuity of 20/200. She could accurately identify letters and numbers on her computer when the font size was 24 or higher, and she used an onscreen keyboard on a laptop computer via a trackball for written output. Her fluency was relatively slow because she required numerous small movements on the trackball to move to each letter. Her spelling ability was a 1:1 grade equivalent on the WIAT, and she was functioning in the mild range of mental retardation.

Small-group instructional sessions took place in a classroom within the school. Sessions occurred with the students' wheelchairs positioned in a semicircle, with a classroom paraprofessional standing facing the students. The teacher moved next to each student to provide individual instruction when it was the student's turn to spell one of her targeted words. From this position, the teacher could see the onscreen displays of the student's laptop computer or paper on the

slantboard. This seating arrangement also allowed the students to see large cards held up by the paraprofessional for the purpose of observational instruction (described below). All sessions occurred during the students' language arts time, and the target words were not taught at any other time during the school day.

Preexperimental Observations

Word selection. Prior to the onset of the study, the students were tested on a subset of the county's high-frequency word list to determine which words they were unable to spell. Testing began at the start of the list and continued until the student misspelled a total of 27 words. Students were not given any instruction during the pretest, nor were they told if their answers were correct. Incorrect words for all students were compared across students, and target words for the investigation were selected based on all students having spelled them incorrectly. From the list of target words, each student was assigned nine different spelling words, so that the target words varied across students. Autumn was assigned words at a lower grade level because her spelling ability was lower than the other 2 students, and the rest of the words were randomly assigned between Lexie and Juana. Each student's nine words were divided into three subsets of three words (see Table 1).

Development of delay intervals. Three interval lengths were developed to promote fluent responding during the intervention. The initial delay interval (i.e., the initiation interval) was determined by recording the latency to initiation over multiple trials. Initiation was defined as the student moving her hand onto the input device (e.g., keyboard) or picking up the pencil. A 5-s delay interval was determined as an easily obtainable time frame for all 3 students to initiate the response. Duration intervals were determined based on the amount of time that it

took for the student to complete spelling the word from initiation (moving onto the input device or pencil) to cessation (defined as pressing the space key after the word was spelled or by putting the pencil down). The average completion times for Lexie and Juana were 28 s and 24 s, respectively, which resulted in a 35-s interval for both participants. Autumn's average time was 53 s, which resulted in a 60-s interval. The inter-response interval was set at 10 s between the initiation of each letter, based on Autumn's interresponse time for known words (i.e., 10 s), which was the longest of all students.

Individual Instruction

CTD procedure. Individual instruction for the separate word sets began with the following directions delivered to the 3 students by the teacher:

I want you to spell some words. If you are sure you know the answer, type or write it. If you do not know, do not guess. Wait, and I will help you so that you can get all of the answers right. If you get 90% of the answers right, either with my help or without my help, you will get to earn a coupon which is good for some free choice activities.

Spelling was taught using a CTD procedure (based on Wolery et al., 1992). During CTD, the controlling prompt was a combination of a visual prompt (an index card containing the correctly spelled word typed in Size 48 font) and the teacher spelling the word aloud while pointing letter by letter. In the first session for each word set, instruction began at a 0-s delay in which the instructional cue (i.e., "spell [word]") and the controlling prompt were presented simultaneously. Thereafter, delivery of the controlling prompt was delayed until the 5-s initiation interval elapsed without the student attempting the response.

In addition to delivering the controlling

Table 1
Target Words

Student	Target words	Trials to mastery
Lexie	since	10
	again	7
	through	15
	story	10
	always	22
	might	10
	those	15
	around	19
	thought	12
	Juana	number
where		7
together		20
almost		22
while		24
sentence		27
animal		25
whole		9
Autumn	children	18
	new	41
	very	40
	made	31
	any	23
	work	28
	line	26
	use	18
	down	18
	were	21

Note. Trials to mastery refers to 100% independent responses for three consecutive trials, maintained throughout the phase.

prompt after the initiation interval, the controlling prompt was also introduced if either of two other intervals elapsed without the response being completed. The controlling prompt was delivered if 35 s elapsed without the response being completed by Lexie and Juana or if 60 s elapsed without the response being completed by Autumn. Finally, the controlling prompt was delivered if more than 10 s elapsed between the typing of individual letters (i.e., the intertrial interval).

Individual trials were conducted in random order by placing all students' words on index cards in a bag; the teacher drew out a card to begin the trial. For each trial, the teacher called the student's name, asked the

student if she was ready, and then delivered the instructional cue (i.e., "Spell [word]"). Each student responded when it was her turn by handwriting the answer (for Juana) or by typing on the laptop. Each session consisted of three trials for each word in the student's word set, for a total of nine trials for each student in a session.

As in other investigations (e.g., Crawford & Schuster, 1993), descriptive praise or error statements were provided throughout the CTD procedure. If the student spelled a word without the controlling prompt, the teacher gave verbal praise such as "Wow, that is correct." When the student waited for the controlling prompt and then had a correct response, the teacher said, "Good, you waited correctly and got the right answer." If the student spelled a word incorrectly, error statements were provided followed by teacher delivery of the controlling prompt for correct spelling. If an error occurred before the controlling prompt was delivered, the teacher said, "No, that is not correct. Remember, if you don't know, wait and I will help you." If an error occurred after the controlling prompt, the teacher said, "No, that is not correct. You must look carefully at the word so that you spell it correctly." If the student did not respond after given the controlling prompt, the teacher said, "You need to pay attention to the word and type it on your keyboard (or write it on your paper)."

In addition to descriptive praise and error statements, each student earned a coupon if she spelled 90% or more of the words correctly. Three coupons could be exchanged for an activity reinforcer (e.g., computer time, free time, trip to the library, run an errand) of the student's choice.

Observational Instruction

During all sessions, a classroom paraprofessional was present in the middle of the group of students. While 1 student received individual instruction from the teacher, the

paraprofessional presented a card containing that student's words in 150-point font to the other (nontargeted) students. The card was not presented until the target student's trial for a given word was completed. The nontargeted students were not required to respond to the larger card when it was presented, and there were no consequences if they did respond. At the end of the investigation, each student was tested on the other students' targeted words in a manner similar to the pretesting described above. Observational learning was evaluated by comparing each student's performance on the other students' words based on the pre- and posttest data.

Response Measurement and Reliability

The teacher served as the primary data collector and conducted all sessions. Data were collected on two types of correct responses: independent responses and prompted responses. *Independent responses* were defined as a student's initiation of a response within 5 s of the teacher's initial request and completion of the spelling word within the predetermined duration or interresponse intervals (i.e., correctly spelling the word before the controlling prompt was delivered). *Prompted responses* were defined as the student correctly spelling the word after the controlling prompt was delivered (based on the passage of one of the three intervals described above).

Data were also collected on incorrect responses, which consisted of multiple types of errors. Nonwaiting errors were those in which the student initiated the response within 5 s but spelled the word incorrectly. Waiting errors were those in which the student spelled the word incorrectly following the delivery of the controlling prompt. Incomplete-response errors occurred when the 10-s initiation interval elapsed. Duration-interval errors occurred when the student initiated the response but failed to complete

the word within the given time interval. Across each session, the number of errors was combined to yield a measure of incorrect responses.

Data on independent responses, prompted responses, and incorrect responses were analyzed by dividing the number of trials in which each response occurred (the responses were exclusionary) by the number of trials in a session (i.e., nine). These data were then multiplied by 100% to yield the percentage of occurrence for each response.

Throughout 50% of all sessions, a second classroom paraprofessional collected data on treatment integrity and on student responses. Treatment integrity was measured by the observer circling a plus sign (when the teacher followed all components of the procedure correctly) or a minus sign (when the teacher did not follow at least one component of the procedure correctly) for each trial during the entire session. For each session, the number of pluses were divided by the sum of the number of pluses and minuses and multiplied by 100% to yield an index of treatment integrity. Across all sessions, treatment integrity ranged from 98.2% to 100%, with a mean of 99.7%.

Interobserver agreement was calculated for each session by comparing the number of correct and incorrect student responses that were recorded separately by the teacher and the paraprofessional on a trial-by-trial basis. An agreement was defined as the two observers recording the same number of independent, prompted, and incorrect responses in a given trial. A disagreement occurred if the number of independent, prompted, and incorrect responses differed (for any type of response) in a trial. The number of agreements for independent, prompted, and incorrect responses in a trial was divided by the number of agreements plus disagreements in that trial and was summed across all trials for each session. The resulting quotient was multiplied by

100%. During all sessions, agreement was 100% for independent, prompted, and incorrect responses.

Experimental Conditions

Baseline probes. The purpose of the baseline probes was to evaluate spelling before and after individual instruction with the CTD procedure. Probes were important to demonstrate the functional relation between spelling and the CTD procedure in that the students should correctly spell only those words on which they had received prior instruction. Other than the instructional cue (i.e., "Spell [word]"), no prompts, differential feedback, or programmed reinforcers were provided during the baseline probes.

At the beginning of the study, three probe sessions were conducted for each word set to establish baseline levels of independent responding (data for the first probe session were taken from the pretest word assessment). Once mastery criterion was reached with the first word set during instruction with the CTD procedure, probe sessions were conducted again to assess response maintenance in the absence of any programmed instruction for the word set. Throughout the analysis, probe data were collected on all word sets to assess acquisition of untaught words prior to and after instruction and to assess maintenance of responding for previously taught word sets. In total, the probe condition was conducted four times with each word set.

Once the CTD procedure and subsequent baseline probes had been conducted across all word sets, a final probe session was conducted for all participants after the investigation was completed. The follow-up probe was conducted 23 days after the study for Lexie, 11 days for Juana, and 10 days for Autumn.

Instruction with CTD. The CTD procedure was sequentially introduced across the three word sets using a multiple baseline de-

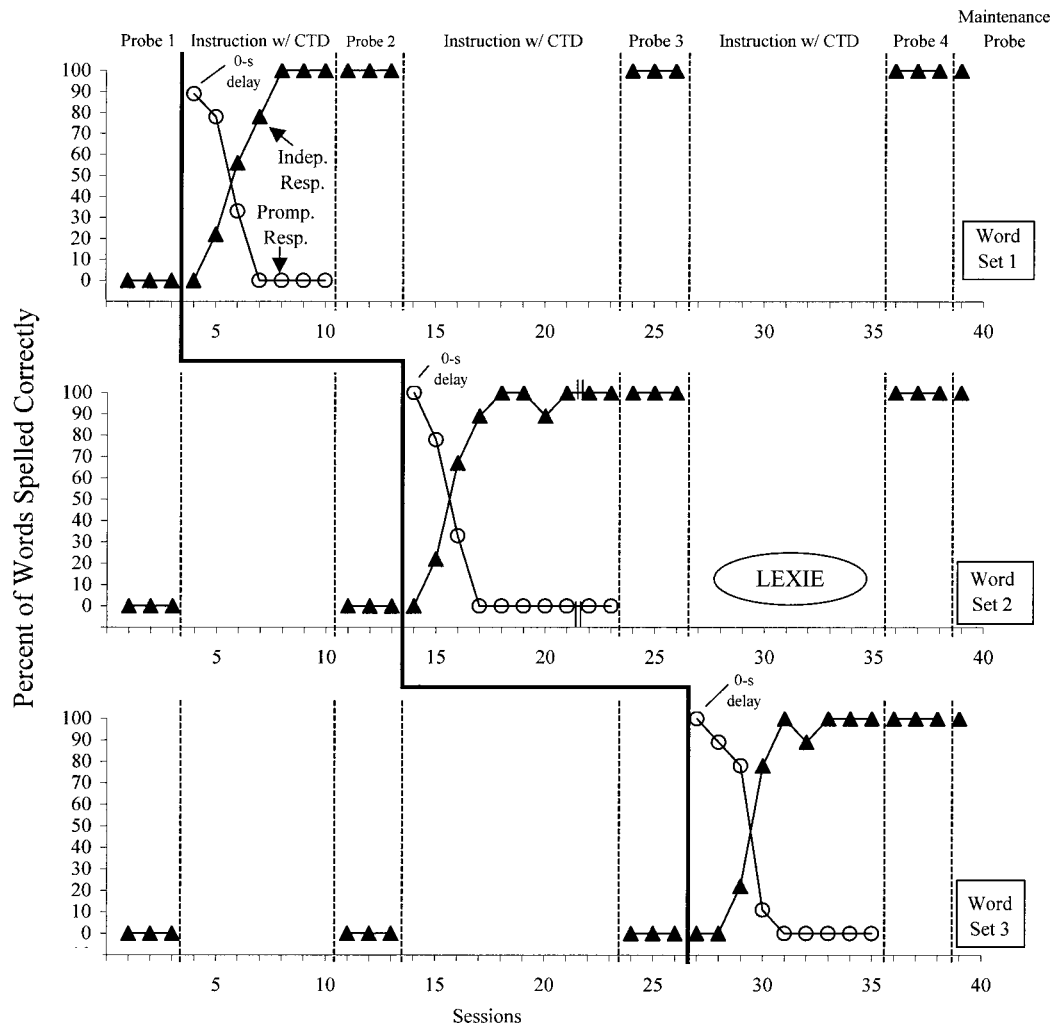


Figure 1. Percentage of words spelled correctly by Lexie during probe and instruction with CTD phases. The line break between Sessions 21 and 22 represents the week of spring break.

sign. After the conclusion of the first probe phase, the intervention was randomly implemented with one word set and the students' did not receive intervention for the other two word sets. Criterion for mastery was met when the student had 100% independent responses for the targeted word set on three consecutive sessions. Thereafter, probe data were collected on all word sets, and the CTD procedure was subsequently introduced across the second word set. After the subsequent probe sessions, the CTD procedure was introduced for the final word set.

RESULTS

Lexie

The data on independent and prompted responses for Lexie are shown in Figure 1. For Word Set 1, introduction of the CTD procedure resulted in a gradual increase in independent responses that was associated with a decrease in prompted responses. Lexie reached mastery criterion on the first word set after seven sessions with the CTD procedure in effect. Independent responding for Word Set 1 was maintained during the sub-

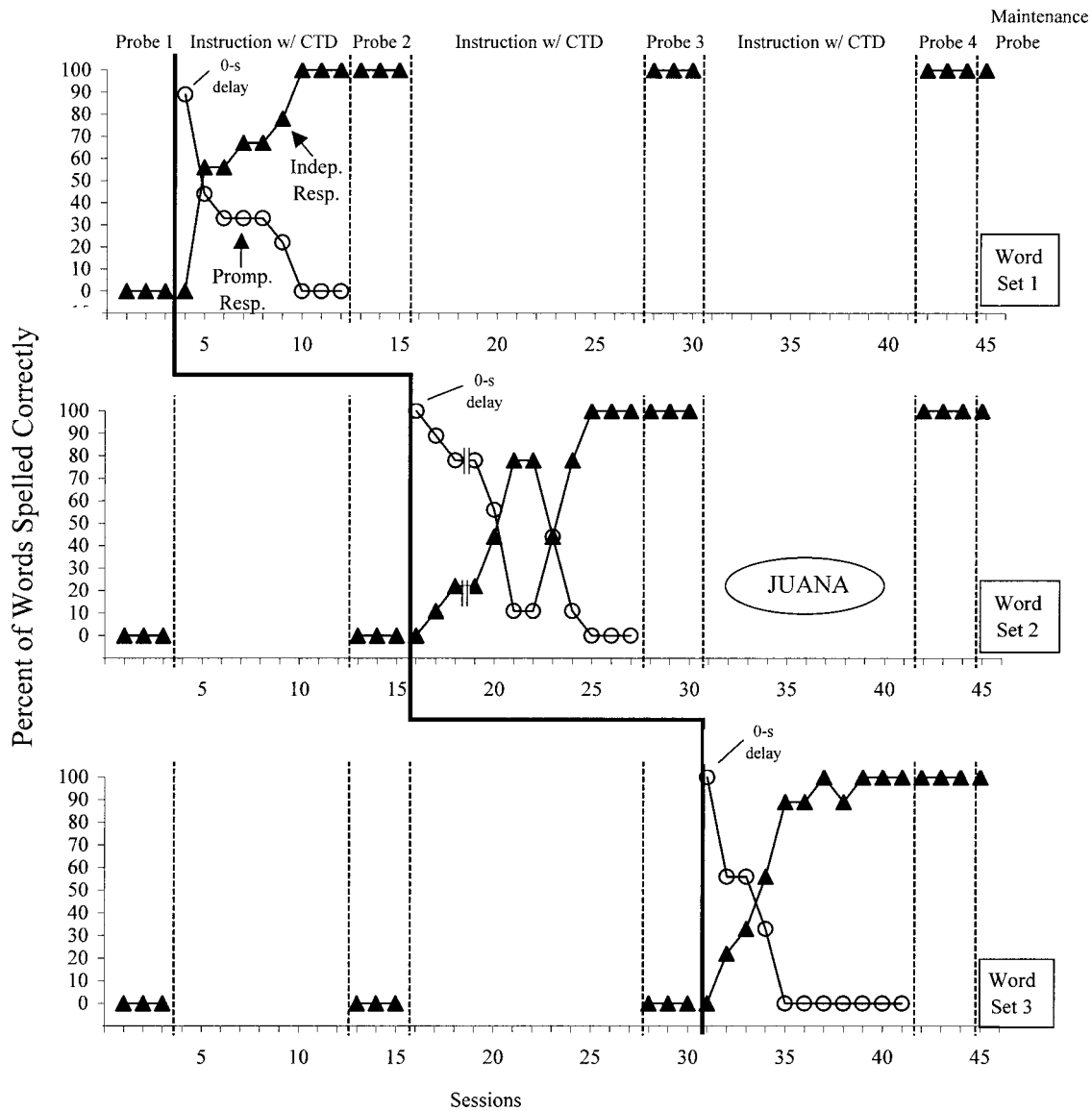


Figure 2. Percentage of words spelled correctly by Juana during probe and instruction with CTD phases. The line break between Sessions 18 and 19 represents the week of spring break.

sequent probe trials. A similar effect following introduction of the CTD procedure was observed for Word Set 2 and Word Set 3. Lexie reached mastery criterion after 10 and 9 sessions for Word Sets 2 and 3, respectively. Independent responding was maintained in the probe that was conducted 23 days later. Across all word sets, incorrect responses covaried with the occurrence of independent and prompted responses. Incor-

rect responses averaged 2.4%, 1.1%, and 3.7% across Word Sets 1, 2, and 3, respectively (data not shown).

Juana

Juana's data are shown in Figure 2. No independent responses were observed during the initial baseline probes. When the CTD procedure was introduced for the first set of words, we observed an increase in indepen-

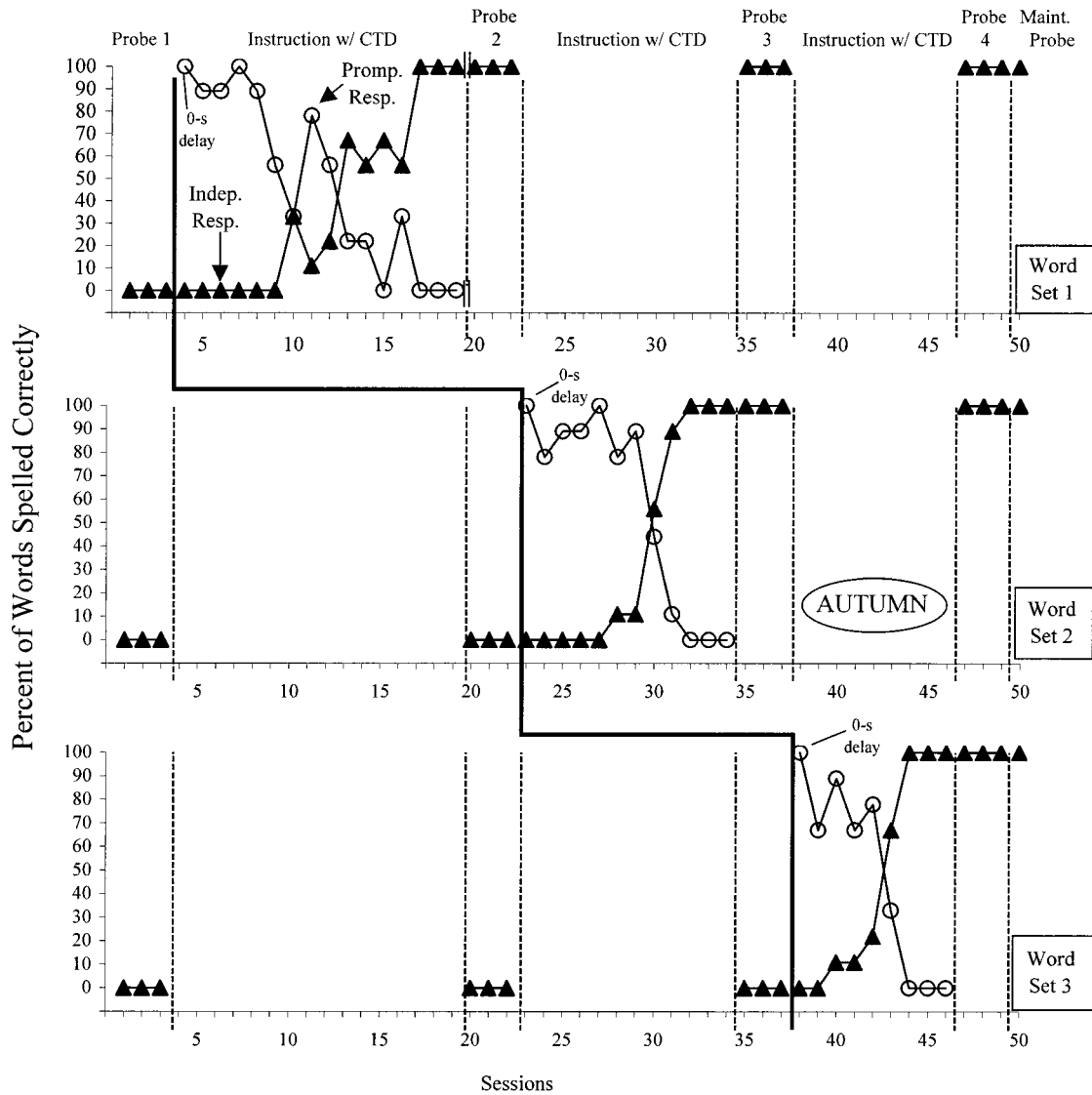


Figure 3. Percentage of words spelled correctly by Autumn during probe and instruction with CTD phases. The line break between Sessions 19 and 20 represents the week of spring break.

dent responses and a decrease in prompted responses. Similar patterns of responding were observed for the remaining two sets of words, with greater variability observed in Word Set 2. Juana reached mastery criterion for the word sets as follows: Word Set 1, 9 sessions; Word Set 2, 12 sessions; Word Set 3, 11 sessions. In the probe conducted 11 days after the completion of the study, Juana's independent responding was maintained at 100% across all three word sets.

Across Word Sets 1, 2, and 3, incorrect responses averaged 2.4%, 3.8%, and 7.0%, respectively (data not shown).

Autumn

Figure 3 depicts the outcome of the CTD intervention for Autumn. After no correct responding occurred in baseline, implementation of CTD produced an increase in correct responding for both prompted and independent responses. After some variability,

Autumn ultimately began to respond without the help of the controlling prompt across all three word sets. Autumn reached mastery criterion for the word sets as follows: Word Set 1, 16 sessions; Word Set 2, 12 sessions; Word Set 3, 9 sessions. Independent responding was maintained during the probe conducted 10 days after the completion of the study. Incorrect responses averaged 13.8%, 4.6%, and 6.1% across Word Sets 1, 2, and 3, respectively (data not shown).

Observational Instruction

Results of the observational learning probes were mixed across participants. As mentioned before, all target words were those that all 3 students did not spell during the pretest. Posttest data showed that Lexie and Juana learned to spell the words of the other students (data not shown). Lexie learned 83% of Autumn's words and 56% of Juana's words. Juana learned 100% of Autumn's words and 33% of Lexie's words. By contrast, Autumn did not accurately spell any of the other students' words, but she made closer approximations (e.g., Autumn spelled the word *around* as "xc" during the pretesting and "orad" during posttesting; data not shown).

DISCUSSION

The purpose of this investigation was to evaluate the utility of a modified CTD procedure for teaching spelling words to students with physical disabilities. For all 3 students, correct responding on the target word sets did not increase until the CTD procedure was introduced. Furthermore, all 3 students were able to maintain accuracy across probe conditions in which the intervention was no longer in place.

To accommodate the students' physical needs in this study, a 5-s delay was used for initial motor movement to the writing device, a duration time limit for completion of

each word was set, and an intertrial interval was used to facilitate paced responding. These intervals were individually determined based on observations of the students' performance during pretesting. Setting multiple delays based on individual criteria is a relatively novel procedure for CTD, and the results of the current investigation suggest that future researchers and practitioners should consider using naturalistic observations to set delay intervals for students with physical disabilities (Crawford & Schuster, 1993). It should be noted, however, that only one of the three intervals (i.e., the duration interval) was individualized for the participants. All other intervals were identical across participants.

Although all students acquired the target words using the modified CTD procedure, it is unclear whether the procedures used in the current investigation are more effective than more commonly used CTD procedures (e.g., Wolery et al., 1992). Thus, the relative contributions of the individual components of the modified CTD procedure remain unknown. Nevertheless, these preliminary data suggest that a modified CTD procedure is effective for teaching academic skills to children with physical disabilities. Future research could conduct within-subject evaluations of CTD procedures that are and are not modified to meet the idiosyncratic needs of each student.

In addition to the evaluation of CTD, we also conducted a pretest–posttest analysis of whether observing the words being taught to another student was sufficient to produce acquisition. Although the pretest–posttest design used for observational learning data was not adequate to demonstrate a functional relation, the data indicated that all 3 students were able to benefit by being exposed to the other students' words. These data suggest that simply repeating the presentation of nontargeted words may be sufficient for some acquisition. Further research is needed

to more closely examine observational learning effects. In addition, performance during observational instruction may have been influenced by the students' history of direct reinforcement for spelling (Bandura, 1975). Finally, Lexie and Juana were able to learn high percentages of Autumn's words (83% and 100%, respectively), possibly because her words were at a lower grade level. By contrast, Lexie and Juana had more difficulty learning each other's words (56% and 33%, respectively), and Autumn demonstrated increased approximations only, further suggesting that acquisition of novel responses may be influenced by response difficulty.

Although all students showed an increase in independent responding following the intervention, it is unclear what operative mechanism accounted for response acquisition. That is, the intervention used in the current investigation consisted of multiple components. In addition to the basic procedures of CTD (i.e., instructional cuing, controlling prompt), the students also received differential feedback for correct and incorrect responses and coupons as a token economy system. It is possible that these components, individually or in combination, may have contributed to the results. Future investigations should examine the individual contribution of each component of such programs to determine which components are related to an increase in correct responding.

Despite the results obtained, the outcome of this investigation is limited by the manner in which the intervention was introduced within the multiple baseline. That is, when the intervention was introduced with one word set, data collection did not occur with the other two data sets until the subsequent probe sessions. Thus, we did not directly test the prediction that behavior change would occur only in the baseline that received intervention because we could not compare responding at the same points in time (Kaz-

din, 1982). However, probe sessions were conducted at the same point in time for all word sets, and these data indicate that acquisition occurred for a given word set only after the intervention had been implemented.

In conclusion, this study supports the use of a CTD procedure as an effective instructional strategy for teaching spelling words to students with physical disabilities. These results also extend the current literature on the application and modification of CTD procedures for instructing students with physical disabilities. When using CTD with students who have physical disabilities, consideration should be given to setting delays that accommodate slower motor movements and to the use of assistive technology devices (e.g., an onscreen keyboard) that might assist with performance.

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STUDY QUESTIONS

1. Briefly describe the general characteristics of the constant prompt-delay procedure.
2. What were the three types of delay intervals used to promote fluent responding, and how was each interval selected?
3. What controlling prompt was used during the constant prompt-delay procedure, and under what conditions was it implemented?
4. What was the difference between an independent and a prompted response?
5. What types of errors were scored as incorrect responses?
6. Summarize the results of this study.
7. What feature of Autumn's data suggested that exposure to words per se may have influenced spelling performance?
8. Why might it be useful to evaluate the separate components of the constant prompt-delay procedure used in the current study, and how would such an evaluation be conducted?

Questions prepared by Jennifer Hammond and David Wilson, University of Florida