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Progressive time delay to remediate letter discrimination difficulty

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ABSTRACT

Reading is hindered when students have difficulty discriminating letters. Given their visual similarity, the letters *b* and *d* can be challenging for some individuals. Progressive time delay (PTD) was used to teach two first-grade students to discriminate between the letters *b* and *d*. During the procedure, a problem was presented and a prompt immediately provided. As students correctly responded to the problem, the delay between the problem and the prompt was gradually increased. Student 1 mastered the discrimination after four sessions and skills were maintained. Student 2 showed gradual improvement but continued to make some errors. Implications for practice are discussed.

KEYWORDS: progressive time delay, letter discrimination

There are approximately 44 phonemes or sounds in the English language. These phonemes are mapped on to letters, letter combinations, and spelling rules to form written words. The letters and letter combinations for each phoneme are called phonograms. The job of the reading teacher is to teach the student to respond differentially to each of the phonograms. Differential reinforcement is commonly used to produce discriminative behavior. Therefore, responding in a certain way in the presence of one stimulus is reinforced, while other responses are not reinforced, and responding in a different way to another stimulus is reinforced, and so on. However, this approach is not always effective in all situations. A particularly difficult discrimination involves letters that are the reverse of each other, such as *b* and *d* and *p* and *q* (Asso & Wyke, 1971). Prior to letters, the name of an object does not change based on its orientation. A chair is still a chair and mommy is still mommy, regardless of their orientation, but, of course, the orientation of letters can change their name. It may be that this previous learning history, in which orientation has not been a feature related to a reinforcement contingency, makes the discrimination of these letters especially demanding (Gibson, Gibson, Pick, & Osser, 1962). The letters *b* and *d* are also problematic because the sounds they represent are similar (Carnine, Kame'Enui, Silbert, & Tarver, 2003). In behavior analysis, specialized teaching procedures, generally called errorless learning, have been developed and used with all types of learners to teach difficult discriminations (e.g., Etzel & LeBlanc, 1979; Sidman, 2010; Terrace, 1963). The procedures may not result in completely errorless performance, but errors are minimized, which is important because of the tendency for errors to produce more errors (Sidman & Stoddard, 1966). Errorless learning procedures include stimulus fading, stimulus shaping, and prompt delay.

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Errorless learning and letter discrimination

Previous researchers have investigated the use of errorless learning procedures on discriminating alphabet letters. Stimulus fading was compared to a trial and error (i.e., differential reinforcement) procedure by Griffiths and Griffiths (1976) to teach *b*–*d* and *p*–*q* letter discriminations to four and five year old preschoolers. Pictorial prompts were paired with the letters and gradually faded. For example, a picture of a baseball bat with a ball lying next to it was on a flashcard next to the letter *b*. The bat and baseball resembled the letter *b*. Fewer trials to criterion were required for the discrimination using stimulus fading than trial and error, and few or no errors were made by each child when stimulus fading was used. All children preferred stimulus fading to trial and error.

A series of experiments evaluated the effects of superimposition with stimulus fading and an intervening response on a *b*–*d* discrimination task with preschoolers and then with older children with mental retardation (Lancioni, Hoogeveen, Smeets, Boelens, & Leonard, 1989). In the first experiment a bunny face was superimposed on the letter *b* and faded over trials. This procedure was not effective. In the next part of the study, an intervening response was taught to the letter *b* by teaching the children to move a wooden carrot to the mouth of the bunny superimposed on the letter *b*. It was hypothesized that this would require the children to focus more on the orientation of the letter as the carrot was moved

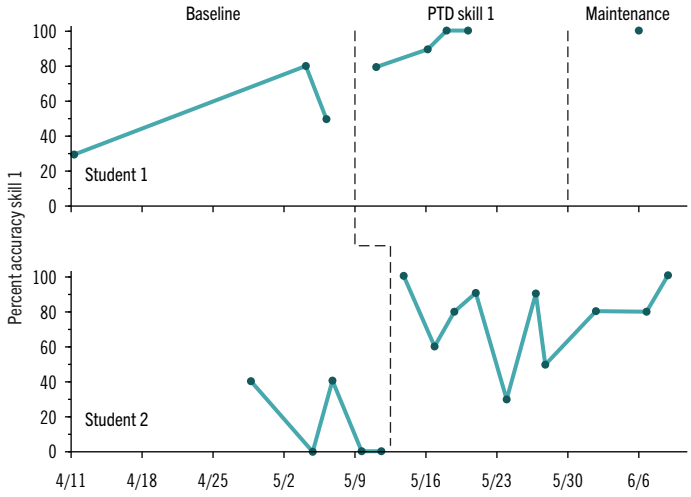

Figure 1. Pointing to letter after hearing letter name (Skill 1)

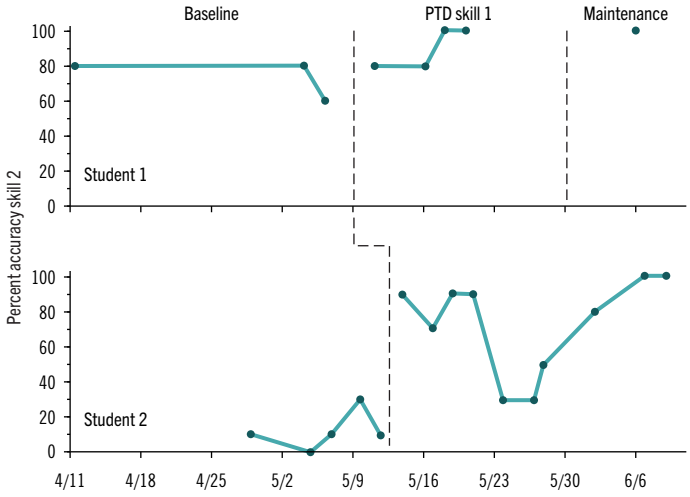

Figure 2. Pointing to letter after hearing letter sound (Skill 2)

from the left to the bunny's mouth. This procedure was also not effective. Next, bunny faces were placed on both letters (*b* and *d*). The experimenter demonstrated moving the carrot to both letters using the left to right motion and indicated that it was wrong with the *d* rabbit (i.e., the carrot went towards the back of the head of the *d* rabbit). The children were taught to move the carrot to the correct rabbit. This training required the children to focus on the orientation of the letter. As in the previous conditions, the bunny faces were faded. The children were successful on the *b*–*d* discrimination test after this training. Similar results were found for the preschoolers and for the older children with mental retardation.

Another study compared stimulus fading and constant time delay for teaching preschoolers to point to easily confused letters and numbers (Bradley-Johnson, Sunderman, & Johnson, 1983). The stimulus fading procedure involved adding color prompts that highlighted distinctive features of the stimuli. Correct responses were reinforced with a penny and praise. In the time delay condition, the experimenter waited four seconds before pointing to the correct letter or number. Correct responses that occurred before the prompt were reinforced with a penny and praise. The children in the time delay condition made significantly fewer errors on a posttest than those in the stimulus fading group or the control condition.

Comparison of procedures

When typical instructional procedures are ineffective for learners, errorless learning procedures should be pursued. Stimulus shaping, in which the physical features (topography) of the stimulus are progressively altered from a beginning stimulus to the final discriminative stimulus (Etzel & LeBlanc, 1979), has demonstrated efficacy (Schilmoeller, Schilmoeller, Etzel, & LeBlanc, 1979; Sidman & Stoddard, 1966) especially if the features of the stimulus being shaped are related to the final criterion to be discriminated (Etzel, 1997; Schilmoeller, Schilmoeller, Etzel, & LeBlanc, 1979). Stimulus fading has also shown to be effective in teaching discriminations, especially when the fading is criterion-related (Gold & Barclay, 1973), but creating the materials for stimulus fading and stimulus shaping can be time intensive. Constant time delay has also been shown to be a valuable method and it is easy to implement, but it may be less efficient than progressive time delay, which, generally requires less trials to reach criterion and produces less errors (Walker, 2008). In constant time delay the delay is constant, but in progressive time delay the interval between the prompt and the question vary. Initially, the prompt follows the question immediately, and then the interval between the prompt and the question is lengthened based on correct responding by the learner.

There may be occasions when stimulus control does not transfer with time delay procedures because the participant always waits for the prompt, even when the delay is large (Glat, Gould, & Stoddard, 1994; Oppenheimer, Saunders, & Spradlin, 1993). One study required participants to emit an overt differential response after the problem was presented, which facilitated correct performance under the progressive time delay procedure (Glat, Gould, & Stoddard, 1994). This may have been helpful because it forced the participants to attend to the problem. Progressive time delay may not be effective with all students; therefore, practitioners should be prepared to implement more intensive instructional procedures, such as stimulus fading and stimulus shaping when necessary (Etzel & LeBlanc, 1979).

This study investigated whether progressive time delay is an effective procedure for remediating student difficulties in discriminating between the letters *b* and *d*. Another question of interest was whether there would be generalization or transfer across different discriminative behaviors. In the following procedures, successful discrimination between the letters *b* and *d* involved a hierarchy of four skills related to *b* and *d* letter discrimination. Would teaching the first skill result in the acquisition of the other skills and would the skills be maintained over time?

» METHOD

Participants and setting

Participants were two first-grade-students at an elementary school located in an affluent town in Michigan. The study took place during the spring, past the period when most first grade students

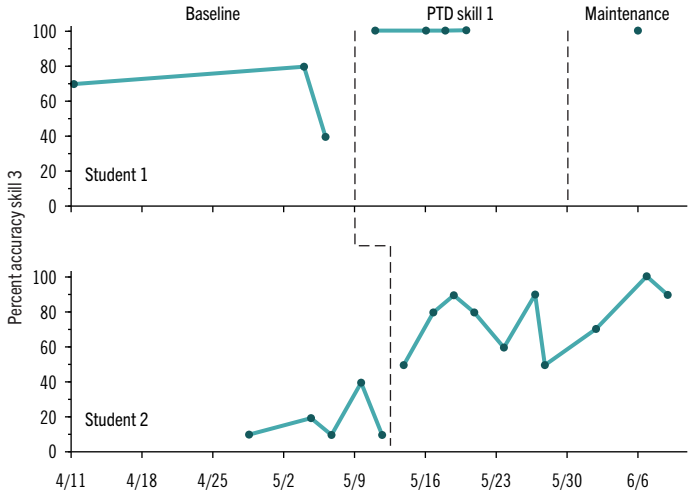

Figure 3. Saying letter name after researcher points to letter (Skill 3)

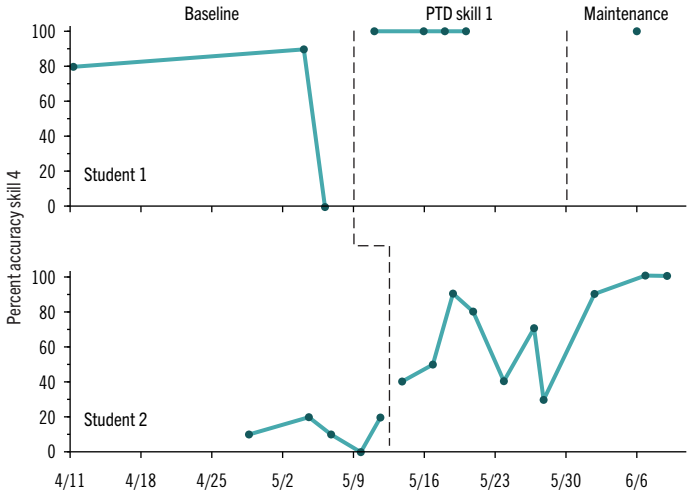

Figure 4. Saying letter sound after examiner points to letter (Skill 4)

have mastered *b* and *d* letter discrimination. Thus, deficits in this area were viewed as significant and requiring remediation to effectively progress with reading development. Student 1 was in general education and Student 2 had an Individualized Education Plan (IEP). Student 2 was eligible in the state of Michigan as a student with a Speech and Language Impairment. The participants were recruited with assistance from all first-grade teachers at the participants' school. Teachers were provided a description of an informal assessment to identify students demonstrating difficulty discriminating between letters *b* and *d*. The description asked teachers if students reversed the two letters in their writing or reversed the sounds in reading. It also asked teachers to have students read a sequence of letters, which included the letters *b* and *d*, and it asked them to have the students read words containing these letters. Following parent consent and child assent, each student's *b* and *d* discrimination skills were assessed by the first author. Student performance on the first of four skills on this assessment determined inclusion in the study. The inclusion criterion was less than or equal to 7 out of 10 correct answers on this task. The data from the inclusion assessment was used as the first data point in the baseline condition.

All sessions took place in the students' school building in a private room with minimal distractions. Intervention sessions were held approximately three times per week, lasted about 15 minutes, and took place over approximately four weeks.

The materials used for the progressive time delay procedure were a timer and two 3"×5" index cards. One card had the letter *b* printed on it, and the other with the letter *d*. Using size 48 Arial font, the letters were printed onto printing labels and were attached to the center of the cards.

Design

The study employed a multiple baseline across two participants. Following the third baseline assessment, the first participant entered the intervention phase. The remaining participant continued in the baseline phase for two additional assessments before beginning the intervention.

Treatment integrity

A treatment integrity checklist was completed by a school psychology graduate student trained in administering the intervention. Responses to the questions on the checklist were answered as either "yes" or "no" and reflected the instructor's adherence to seven components of the intervention. Observations of the sessions were made possible by using audio-visual recordings of the sessions. A minimum of 20 percent of the total intervention sessions were evaluated for treatment integrity. The results indicated 93% of questions on the checklists were answered in favor of maintaining strict adherence to the intervention's components.

Dependent variable

The dependent variable was the percent correct for each of the following four skills:

Skill 1 – Hear letter name → point to letter

Skill 2 – Hear letter sound → point to letter

Skill 3 – See letter → say name

Skill 4 – See letter → say letter sound

The first skill (Skill 1) measured was the ability of the student to point to the correct letter, either *b* or *d*, in response to the instructor's verbal request. It was also of interest to observe whether teaching Skill 1 generalized to the remaining skills (Skills 2, 3, and 4). A data recording sheet was used to track dependent variable measurement.

Interobserver agreement

Video recordings of the sessions permitted a graduate student trained in behavioral observations to record student responses on at least 20 percent of sessions. Using trial-by-trial agreement, interobserver agreement was calculated by dividing the number of agreements multiplied by 100, by agreements plus disagreements. When averaged across the three participants, interobserver agreement calculations yielded an average of 99.17% agreement between raters. Individual interobserver agreement results for Student 1 and Student 2 were 99.17%, and 98.75%, respectively.

Procedure

Measurement of the dependent variable. Ten test trials were conducted to measure the accuracy of each of the four skills (i.e., forty total trials). During the intervention phase, the test trials occurred immediately following the progressive time delay instruction. Correct and incorrect responses were recorded and percent accuracy was calculated for each of the four skills based on the 10 trials. For each skill there were five trials for each letter. The left-right position of the letters was pseudo-randomly determined, such that over the ten trials each letter was on the right and left sides an equal amount.

The following was the method of assessment:

Skill 1. The examiner presented both cards to the participant at once, and asked the student to point to the letter *b* (or *d*, depending on pseudo-randomization).

Skill 2. The examiner presented both cards to the participant at once, and asked the student to point to the letter that made the /*b*/ sound (or /*d*/).

Skill 3. The examiner presented one letter at a time to the participant and asked, "What letter?"

Skill 4. The examiner presented one letter at a time to the participant and asked, "What sound?"

Intervention: progressive time delay (PTD). The PTD procedure targeted the less accurate letter, as identified on the most recent assessment of the dependent variable. To describe the procedure for Skill 1, *b* will be assumed to be the less accurate letter. To begin, one *b* and one *d* flashcard were laid flat on the desk in front of the participant. The student was instructed to point to the letter *b*, and then the instructor immediately pointed to the letter *b*, thereby prompting the correct response. If the student did not then point to the letter *b*, the instructor told the student to point to it. Student responses were considered correct if the correct response occurred before or after the prompt. In other words, the response was correct whether it was prompted or unprompted.

Following five consecutive correct responses, the delay between the presentation of the problem and the prompt increased by 1 second. The delay between the problem and the prompt continued to increase by 1 second after every five consecutive correct responses up to a 5 second delay. However, when an incorrect response occurred, with or without a prompt, the instructor reversed the procedure back to the previous delay interval. For example, if the delay between the problem and the prompt was at 2 seconds, and the student emitted an incorrect answer during the third trial, the instructor immediately shortened the delay to 1 second. Five consecutive correct responses would then be required before advancing to the 2-second delay interval again.

Skill progression. Progression to the subsequent skill was based on achieving 100% accuracy, for both letters, on two consecutive dependent variable assessments. It was anticipated that mastery of an earlier skill might result in transfer or generalization across skills. Therefore, if mastery of a skill resulted in subsequent skill mastery, the PTD procedure was not necessary for those skills which already met the mastery criterion. Once mastery was established for all four skills, the participant met the exit criterion for the study.

Maintenance. The intervention ended when the participant learned the skills. Two to four weeks after the intervention phase, ten test trials were again administered to assess each of the four skills for Student 1.

» RESULTS

Figures 1 through 4 display the percentage of correct responses for each of the four skills. Percent accuracy for Skill 1 during baseline yielded means of 53.3%, and 16% for Students 1 and 2 respectively. Student 1's performance increased to 100% correct by the third session of the intervention. Student 2's performance was below chance level during baseline and improved during the intervention, but Student 2 still made errors during most of the intervention sessions. The percentage of non-overlapping data points (NPD) between baseline and intervention phases for Skill 1 yielded percentages of 75%, and 90% for students 1 and 2, respectively.

With instruction only in Skill 1, Student 1 met the exit criterion for all four skills. For Student 2, the school year expired before meeting the exit criterion on Skill 1. Thus, only Skill 1 was taught in this study. The instruction on Skill 1 appears to have improved performance on Skills 2, 3, and 4 for both students.

Differences between baseline and intervention means for Skill 2 yielded positive mean increases 16.7% (Student 1) and 61% (Student 2), while NPD for Students 1 and 2 were 50%, and 80%, respectively. For Skill 3, positive increases in means were observed for Student 1 (36.7%) and Student 2 (58%), with 100% NPD for both students. Similar results were observed on Skill 4, with Student 1 and Student 2 achieving 100% non-overlapping data and mean increases of 43.3% (Student 1) and 57% (Student 2). An immediate change in skill was observed upon change from baseline to intervention condition for all skills except for Student 2 Skill 2.

The maintenance assessment yielded scores of 100% accuracy on all four skills for Student 1. Student 2 did not receive the maintenance assessment because the school year ended prior to meeting the mastery criteria.

» DISCUSSION

Students 1 and 2 showed improvement during the intervention, but Student 2 continued to make some errors. There was evidence of generalization or transfer across skills as instruction on Skill 1 was associated with improvements in the other skills.

The four skills were conceptualized as moving from easy to more difficult. The first two skills involved selecting the correct stimulus and the last two required producing the stimulus. Selection is generally considered easier than production (Vargas, 2009, Chapter 8). Also, it was presumed, based on typical instructional sequences, that students would probably be more familiar with the letter names than the letter sounds. The baseline data, however, do not support this. All of the skills appeared to be of approximate equal difficulty. It was hypothesized that teaching an early skill would result in later skills becoming learned, thus, demonstrating a generalization or transfer effect.

This generalization was most salient for Student 1. For Student 2, the last two sessions (sessions 9 and 10) averaged between 90% and 100% accuracy for the four skills, which suggested that with more time the PTD procedure for Skill 1 may have generalized to mastery of all four skills.

We think it would be unwise for a teacher to assume that teaching one of these skills will lead to the acquisition of the others. Studies have shown that teaching a selection response does not necessarily result in being able to produce the response (e.g., Guess & Baer, 1973; Wynn & Smith, 2003), but it sometimes does, even in people with an intellectual disability (Ribeiro, Elias, Goyos, & Miguel, 2010) or very young children (Horne & Lowe, 1996). Procedures have been developed to teach such transfer (Gilic & Greer, 2011; Horne, Hughes, & Lowe, 2006).

Discrimination skills were assessed 2–4 weeks following the intervention condition to assess whether the skills remained in the student's repertoire. Consistent with results from Walker (2008), the skills were maintained for the student who reached criterion.

One hallmark of PTD is its potential to reduce or eliminate errors while learning. Student 1, who demonstrated the best response to the intervention had low errors. In contrast, Student 2 made incorrect responses about 15–20% of the time during the intervention. The performance of Student 2 was highly variable. In fact, for Skill 1 and Skill 2, the performance was below the 50% chance level in the baseline condition. In Etzel and LeBlanc's (1979) analysis of effective instruction, universally applying instructional procedures will not likely produce universal success. This analysis is congruent with the results of this study, which demonstrated different levels of instructional need between the participants. Student 1 represented a type of student who was not responding to typical instructional methods, yet responded well to the simplified instruction of PTD. Student 2 did not respond well to typical instructional methods and continued to have some difficulty even with PTD. In light of the poor baseline performance, Student 2 may have benefited from more intensive instructional procedures that draw more attention to the differences in spatial orientation between the two letters, such as stimulus fading or stimulus shaping.

Limitations and future research

This study used only a two participant multiple baseline design, therefore, the results should be interpreted cautiously. Student 2 did not reach mastery and, therefore, maintenance data was not collected. Future research should be conducted over a longer time period to evaluate whether skills are maintained. The PTD procedure is quite simple to implement in terms of programming and material development. In contrast, materials and programming for other errorless learning procedures such as stimulus fading can be costly and time intensive (Bradley-Johnson, Sunderman, & Johnson, 1983). However, this effort may be necessary for some learners. Future research that compares stimulus fading or stimulus shaping with PTD for students with the most significant letter discrimination difficulties may clarify the appropriate procedure to use.

Given that the intervention took 15 minutes per session, three times per week, it could be viewed as too time intensive because it is one-on-one. However, when considering the performance of Student 1, the investment of four sessions appears well worth it. Additionally, the potential development of a computer program to carry out the PTD procedure for letter discrimination would eliminate the need for one-on-one instruction. Future studies may also wish to investigate this procedure with four or more participants to better understand participant response to the intervention.

It is likely that some individuals will not respond well to typical methods of instruction for learning difficult discriminations (Etzel & LeBlanc, 1979). This study used a simple errorless teaching procedure, PTD, to reduce the difficulty of the *b* and *d* letter discrimination task and to reduce errors when learning. The results of this study provide some support for the use of PTD as a technique to remediate letter discrimination difficulty and add to the body of literature on errorless learning. ■

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