Procedural Adaptations for Use of Constant Time Delay to Teach Highly Motivating Words to Beginning Braille Readers

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Structured abstract: *Introduction:* Constant time delay is an evidence-based practice to teach sight word recognition to students with a variety of disabilities. To date, two studies have documented its effectiveness for teaching braille. *Methods:* Using a multiple-baseline design, we evaluated the effectiveness of constant time delay to teach highly motivating words to three beginning braille readers with developmental disabilities. Procedural variations included a pre-teaching and assessment tool, a higher criterion for mastery, an increased number of trials per session, and remediated instructional feedback. *Results:* A functional relation was established for all three participants. Students reached mastery in four to 12 sessions in less than one hour of instruction. Although the number of correct responses decreased over time, long-term maintenance was demonstrated. *Discussion:* Results suggest that constant time delay is a promising strategy for teaching highly motivating words to early braille readers. Replication is required to establish constant time delay as an evidence-based practice for braille literacy. *Implications for practitioners:* Practitioners are encouraged to incorporate constant time delay into a comprehensive literacy program with opportunities to generalize word reading to other contexts.

Constant time delay is an effective, easy-to-implement procedure to teach sight words to children with disabilities (Browder, Ahlgrim-Delzell, Spooner, Mims, & Baker, 2009). The use of constant time delay to teach sight words involves two stages: first, in zero-second delay trials, the teacher shows a word and directs a student to read the word immediately after her prompt (for example, that word is "word"); second, the teacher then shows the word and inserts a prespecified time delay (usually five seconds) in which the student can read the word independently before the prompt is given. Students are given several opportunities to read the word correctly in the first stage before the time delay is introduced. Two studies have shown that constant time delay can be effective in teaching automatic recognition of braille words or symbols (Hooper, Ivy, & Hatton, 2014; Ivy & Hooper, 2015). Participants in these studies represented children not previously represented in the constant time delay literature. The present study is a replication of the Hooper et al. study with procedural variations.

Hooper et al. (2014) taught highly motivating words to students, aged 10 to 11 years, whose multiple disabilities included visual impairment. Previously, these students had little to no decoding skills, although some could recognize most or all letters of the braille alphabet and could inconsistently recognize their names. The decision to teach highly motivating words was inspired by Wormsley's (2011) *Individual Meaning-centered Approach to Braille Literacy (I-M-ABLE).* Wormsley suggests that letters alone may be abstract and meaningless to students with multiple disabilities and visual impairments, whereas words have significance and can provide a foundation for early literacy. Using the constant time delay procedure, adapted to include verbal and physical controlling prompts (full manual guidance) to draw attention to salient tactual components of words, students reached mastery in automatic recognition of nine to 12 words within one to two months of daily instruction. However, maintenance of acquisition was poor. Nevertheless, for students with multiple disabilities and visual impairments, who may not respond to traditional literacy programs, using constant time delay to teach highly motivating words appears to be a promising instructional practice.

Replication is essential for identifying evidence-based practices and increasing generalization of findings from studies using single-case design (Cook & Cook, 2013; Horner et al., 2005). Ferrell (2006) explicated the need for replication of research findings in the field of visual impairment. Given the efficacy and efficiency of constant time delay procedures, it would be beneficial to test procedures with younger students. In addition, procedural variations may increase the efficiency of interventions, allowing teachers to make the best use of the time needed to reach mastery and maintain learning in their students. For the current study of younger students, we designed a pre-teaching and assessment tool to increase students' familiarity with the materials and procedures, and to ensure students met inclusion criteria. To improve efficiency, we removed the physical controlling prompts and the pointing out of salient features of words. To improve maintenance, we set a higher mastery criterion than Hooper et al. (2014), doubled the exposure to words, and implemented minimal instructional feedback for words that were not maintained.

This study was designed as a systematic replication of Hooper et al. (2014) to evaluate the efficacy of constant time delay to teach highly motivating braille words to young students with multiple disabilities. The following research questions guided this study: (a) Does the use of constant time delay with only verbal prompts increase recognition of highly motivating words for beginning braille readers with multiple disabilities? (b) How many constant time delay trials and sessions are needed to reach pre-set mastery levels? and (c) Do students maintain knowledge of the words they learned?

Methods

Participants

Participants were three students between the ages of 6 and 10 years with multiple disabilities who were enrolled in a specialized school for students with visual impairments. All were in the same early elementary classroom. To participate, students had to: (a) meet eligibility criteria regarding their multiple disabilities and visual impairment, (b) use braille as their primary literacy medium, (c) wait five seconds and attend to a task, (d) verbally imitate, (e) track braille line and identify a symbol that was different, (f) find braille lead-in and lead-out lines, (g) have typical hearing, and (h) use English as their primary language. Information about students, whose names are indicated here as pseudonyms, was obtained through record review.

Natalie

Natalie, a Hispanic, female, day student, was 6 years, 2 months old. According to medical records, she was diagnosed with optic nerve hypoplasia with no light perception. Braille was her primary literacy medium and, as of January 14, 2014, she was showing progress with writing single braille letters on a Perkins braillewriter. She had documented developmental delays.

Tyler

Tyler, an African American, male, day student, was 6 years, 8 months old. Records indicated that he had bilateral anophthalmia with no light perception. According to his academic records, as of January 14, 2014, Tyler was beginning to understand the concept of reading simple sentences in braille and was doing well with whole-word alphabetic contractions. He had documented developmental delays.

Christopher

Christopher, a Caucasian, male, residential student, was 10 years, 2 months old. His primary visual condition was retinopathy of prematurity, with light perception in his right eye and no light perception in his left eye. As of January 15, 2014, Christopher could identify 10 letters of the braille alphabet. In addition to his visual impairment, Christopher was diagnosed with an intellectual disability.

Setting

Experimental procedures occurred in an unused classroom in the participants' specialized school. Sessions were conducted one on one, and other research personnel were present during most sessions. Participants used appropriately sized tables and chairs and were seated across from the interventionist, who was a master's-level graduate student in a pre-service teacher preparation program in visual impairment.

Word selection and materials

Twelve words were chosen for each participant, following procedures described in Hooper et al. (2014). They were based on results of inventories given to the participants, their parents, and their teachers. For each participant, the selected words were placed into four word sets of three words each. Words in each set were tactually distinct (that is, no words began with the same letter). For Natalie, the words were (a) Miss Fran, kitchen, braille; (b) mom, glitter, lunch; (c) dad, princess, Niala; and (d) Christian, nail polish, brother. For Tyler, the words were (a) mom, story, braille; (b) Miss Fran, God, science; (c) Jesus, lunch, piano; and (d) dad, sister, music. For Christopher, the words were (a) mom, laundry, cars;

(b) NLS player, lunch, stories; (c) Diego, pool, braille; and (d) Miss Fran, ducks, vacuum.

Word cards were created on 3-by-5–inch note cards using a Perkins braillewriter in contracted braille. The top right corner of each card was cut off to facilitate orientation of the cards. Each word was centered on an individual card with a space before and after. A lead-in line (a series of dots 2–5) preceded the word, and an equal length lead-out line followed the word. Word cards were presented in their correct orientation on a 27-by-27–centimeter (roughly 10.5-by-10.5–inch) nonslip mat in front of participants to provide stability.

Experimental design

A multiple-probe design across behaviors (word sets) was selected to test the efficacy of constant time delay. The time-lagged introduction of constant time delay across word sets minimized threats to internal validity such as maturation, history, and testing. A functional relation between constant time delay and word recognition would be demonstrated by three within-subject replications of effect, with increases in level and trend occurring only when constant time delay is implemented.

Response definitions and measurement system

Data were collected using event recording on a trial-by-trial basis. Five possible responses were mutually exclusive and exhaustive, and identical to those previously used for braille literacy (Hooper et al., 2014; Ivy & Hooper, 2015). These responses were "correct anticipation" (an independent, correct response); "correct wait" (a prompted, correct response); "nonwait error" (an error prior to prompt); "wait error" (an error after prompt); and "no response." Each response definition included a dimension of verbal accuracy and tracking accuracy. The metric used to determine a functional relation was the percentage of correct anticipations out of the total number of trials per session.

Conditions and procedures

Pre-experimental procedures were developed to ensure participants met inclusion criteria. Experimental conditions included probe and intervention. Probes conducted prior to intervention with all word sets established a baseline. Probes conducted after intervention demonstrated maintenance of learning.

Pre-experimental procedures

A preteaching and assessment activity, designed for this study, was conducted to ensure participants could wait and attend to a task for five seconds, verbally imitate, track a line of braille, identify a symbol that was different, and find braille lead-in and lead-out lines. Materials required for the activity included a word card with the student's name and two word cards with novel words that were not targeted for intervention. Word cards were constructed and the setting was arranged as they were for experimental sessions. At the beginning of the session, the following directions were given: "Today I am going to work with you to see what you know about braille. I have some things I want to show you. This will not take a lot of time. It's important, though, that you try your best. Will you try your best for me

Table 1
Pre-experimental procedures.

Teacher behavior	Student response		
Place the card with student's name on the rubber mat in front of student. Tell the student to look at the word card and ask, "What's on the card?"	Identified braille on the card	Yes	No
	Recognized name	Yes	No
	Tracked from left to right	Yes	No
	Used lead-in and lead-out lines	Yes	No
Tell the student, "Now I will show you some parts of the braille." Use hand-under-hand to show components (first in order, then out of order). Then ask the student to put his or her fingers on the components as you name them. Explain that all the word cards will have the same components: lead-in, word, lead-out.	Identified lead-in line (out of order)	Yes	No
	Identified word (out of order)	Yes	No
	Identified lead-out line (out of order)	Yes	No
	Recognized name without prompting	Yes	No
Tell the student, "Now let's see how well you follow directions." Lead the student through general procedures for a trial: 1. Find the beginning of the lead-in line. 2. Find the end of the lead-in line. 3. Now read your name out loud.	Found the end of the lead-in line	Yes	No
	Waited for instructional cue	Yes	No
	Read name aloud	Yes	No
	Tracked name beginning to end	Yes	No
Tell the student, "Now let's look at another word card. You probably don't know this word and that's okay. If you don't know the word, just say I don't know, but follow my directions. Okay?" Lead the student through a probe trial.	Found the end of the lead-in line	Yes	No
	Read the word or said "I don't know"	Yes	No
	Tracked the word beginning to end	Yes	No
Tell the student, "Now I'm going to teach you this word! First, I will read a word and then you can read it after me. Just follow my directions." Lead the student through a zero-second delay trial.	Found the end of the lead-in line	Yes	No
	Repeated the word after the prompt	Yes	No
	Tracked the word beginning to end	Yes	No
Tell the student, "All right, let's try something new. I want to see if you can read this word all by yourself. If you don't know the word, just wait, and I'll read it to you, then you can read it after me." Lead the student through a five-second delay trial.	Found the end of the lead-in line	Yes	No
	Read the word, or waited five-second delay	Yes	No
	Tracked the word beginning to end	Yes	No
Repeat the five-second delay trial procedure with a novel word.	Found the end of the lead-in line	Yes	No
	Read the word	Yes	No
	Waited five-second delay	Yes	No
	Tracked the word beginning to end	Yes	No
Repeat the five-second delay trial procedure with the student's name.	Found the end of the lead-in line	Yes	No
	Read the word	Yes	No
	Waited five-second delay	Yes	No
	Tracked the word beginning to end	Yes	No

today? Great!" The interventionist then followed the procedures outlined in Table 1. The interventionist and a second observer independently assessed students' ability to follow directions and demonstrate understanding of braille concepts identified as prerequisite skills and inclusion criteria, using the checklist provided in Table 1. Students were required to independently locate the word, lead-in line, and lead-out line on three word cards with 100% mastery to participate in the study.

General experimental procedures

In all conditions, one or two sessions of 36 trials occurred, with at least an hour between sessions. Sessions lasted seven to 15 minutes. A different word card was presented for each trial. Positive reinforcement for attending behavior (for example, "Thank you for working with me today") was given on every third trial in all conditions. For all correct responses (correct anticipation and correct waits) contingent praise was given (such as "That's right! Great reading!"). Errors (nonwait errors or wait errors) were followed with reminders (for instance, "Remember to wait if you don't know the word" or "Remember to read the word after me"). If students did not track a word from beginning to end, they were told to "remember to look at the whole word." At the start of each session, the interventionist read the appropriate scripted direction for that condition. Then the interventionist placed a word card in the center of the braille mat in front of the student with her hand covering the entire word but not the lead-in line. The interventionist told the participant to find the end of the lead-in line, gave the instructional cue ("Read the word") and then removed her hand, revealing the word.

Probe procedures

Four or five probe conditions occurred for each participant. Probe conditions occurred at the beginning of the study, at the end of the study, and between intervention phases. Three sessions occurred in each probe condition. During probe sessions, participants were exposed to all words in each word set, including those not yet taught. To keep the number of trials per session constant across conditions, during probe sessions participants received multiple exposures only to the words taught in previous and subsequent intervention conditions, and single exposures to words in other word sets. In the first probe condition, three exposures were given to each of the words in word set A. In the second, third, and fourth probe conditions, two exposures were given to words in previous and subsequent word sets. In the fifth probe condition, three exposures were given to words in word set D.

At the start of each probe session, the interventionist read the following scripted directions: "Today I will show you some words. If you know the word, read it. If you do not know the word, wait, and I will show you a new word. Do you understand?" During probe sessions, the interventionist started a five-second mental count after revealing the word on the card and giving the instructional cue. No controlling prompt was given during probe conditions. After the count, participants' responses were recorded as correct anticipation, nonwait error, or no response.

Constant time delay procedures

The only difference between probe and intervention conditions was the implementation of a systematic prompting procedure. The first session of each intervention condition consisted of zero-second delay trials. At the beginning of the zero-second delay sessions, the interventionist said: "Today I am going to show you some words. First, I will read the word. Then you can read it after me. Do you understand?" After revealing the word and providing the instructional cue, the interventionist immediately gave the controlling prompt ("That word is ___") and then began a five-second mental count. At the end of the count, the interventionist recorded the participants' response as correct wait, wait error, or no response. We predetermined that each participant must respond with 100% correct waits for one session before moving to the five-second delay; however, in two cases we made exceptions, which are discussed in Results.

In subsequent sessions, a five-second delay occurred after the instructional cue, allowing participants to respond independently or to wait to receive a prompt if they did not know the word. Correct answers given before or after prompting resulted in the same reinforcement. Participants were given the following instructions at the beginning of each five-second-delay session: "Today I will show you some words. If you know the word, read it. If you do not know the word, wait, and I will read the word to you. Then you can read the word. Do you understand?" After revealing the word and providing the instructional cue, the interventionist began a five-second mental count. If the participant did not respond within five seconds, the interventionist gave the controlling prompt, and began another five-second mental count. After the student provided a response or the time lapsed, the participant's response was recorded as a correct anticipation, correct wait, nonwait error, wait error, or no response. Participants were required to have three consecutive sessions with at least 94.4% correct anticipations (34 out of 36 trials) before proceeding to the subsequent probe condition.

Retraining procedures

Retraining for tracking occurred for one participant, Christopher. During the first probe and the first session of the first intervention, Christopher appeared to only attend to the first character of each word, resulting in many errors. To reduce errors and increase correct responses, a retraining session occurred. Using a novel word card, Christopher was asked to find the end of the lead-in line, and to then read the word or say "I don't know" if he did not know it. Then he was asked to go back to the end of the lead-in line and read each letter of the word, to encourage him to look at the whole word. Help to read letters was provided as needed. The interventionist then read the word and instructed him to read the word after her. Using this same procedure, Christopher was shown another novel word card and then his name until he was able to correctly identify each letter and the entire word. Finally, the words were presented randomly. The interventionist practiced this procedure with Christopher until the interventionist and second observer agreed that Christopher was tracking and attending to the whole word rather than just the initial letter.

Remediated instructional feedback

Christopher and Natalie were unable to recognize multiple words from previously instructed word sets. Research personnel decided to implement instructional feedback during the final probe condition for these two participants. Minimal instructional feedback was provided only for words that participants did not correctly identify in all three sessions of the previous probe condition. If a student responded with a no response or nonwait error, the interventionist corrected the student by saying, "This word is ___."

Reliability

An expert implementer trained the interventionist and a second observer to carry out procedures and accurately collect data. The following steps were considered essential for procedural fidelity:

1. participants' feet were flat on the floor,
2. the desk height was near the waist,
3. the rubber braille mat was placed properly,
4. the student was greeted,
5. word card order was randomized,
6. directions were appropriately scripted,
7. the word set was correct and complete,
8. the student was dismissed,
9. the braille was intact,
10. the word card was centered on the mat for each trial,
11. an attending cue was given,
12. an instructional cue was given,
13. the time delay and mental count were appropriate,
14. a verbal controlling prompt was given,
15. a physical controlling prompt was not provided,
16. correct instructional feedback was provided,
17. verbal praise for attending was provided,
18. no additional assistance was provided, and
19. no exposures to the word were given before the attending cue.

Data on variables one through eight were collected once per session. Data on the remaining variables were collected on a trial-by-trial basis. Several practice sessions were then video recorded. The interventionist and second observer later independently observed practice sessions and collected data on the dependent variable and accuracy of procedural steps. They compared scores and discussed errors to address discrepancies. Training continued until 95% or higher interobserver agreement and procedural fidelity were achieved for probe, zero-second delay, and five-second delay sessions.

The second observer independently collected data for interobserver agreement and procedural fidelity for 33% or more experimental sessions during each probe and intervention condition for each participant. This observer's dependent variable data were also indicated on the same graph as the primary investigator's data. Interobserver agreement was calculated using the point-by-point method and formula: number of agreements divided by the number of agreements and disagreements multiplied by 100 (Ayres & Gast, 2010). During intervention, mean interobserver agreement was 100% for Natalie and Tyler, and 99.3% (97 to 100%) for Christopher. During probe, mean interobserver agreement was 100% for Natalie and Tyler, and 99.8% (97 to 100%) for Christopher.

To calculate procedural fidelity, a positive score (plus sign) was given if steps were implemented correctly, and a negative score (minus sign) was given if steps were implemented incorrectly. Procedural fidelity was calculated for each behavior using the following formula: number of positive scores divided by the

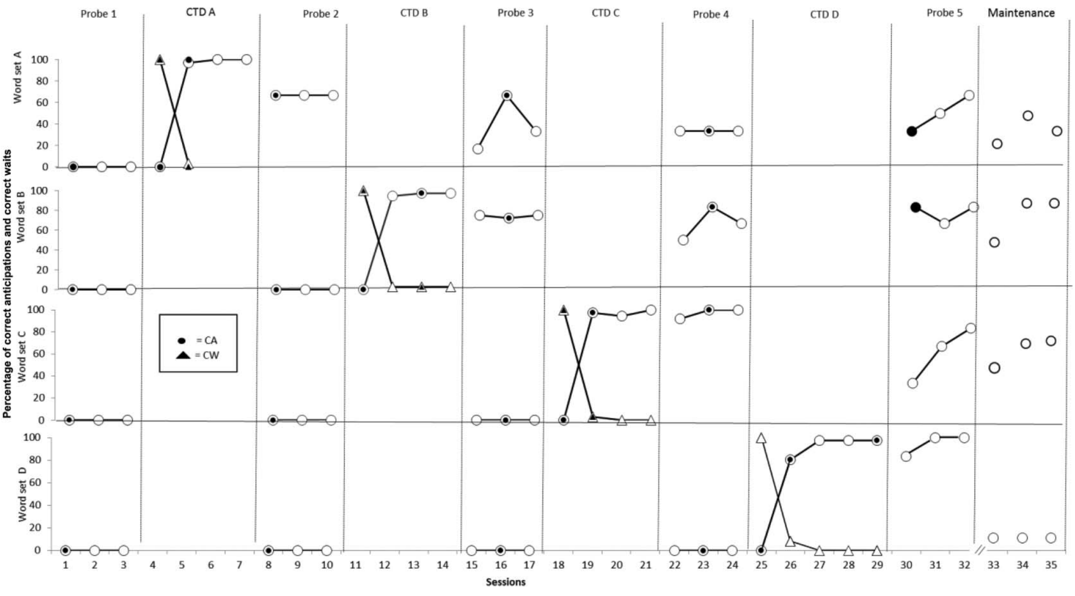

Figure 1. Percentage of correct anticipations (CA) and correct waits (CW) for Natalie. Data from an independent observer are indicated with solid shapes. (CTD = constant time delay.)

number of positive and negative scores multiplied by 100 (Ayres & Gast, 2010). For Natalie, procedural fidelity was 100% in all sessions with the exception of two different intervention sessions in which verbal praise for attending behaviors was implemented with 97.2% accuracy. For Tyler, procedural fidelity was 100% in all sessions except a single intervention session in which the interventionist was not observed to shuffle the word card order prior to beginning the session. For Christopher, procedural fidelity was 100% except for one session in which correct instructional feedback was provided 91.7% of the time, and during intervention conditions praise for attending behaviors was implemented on average with 99% (94 to 100%) accuracy.

Maintenance and social validity

Social validity was assessed subjectively and objectively. Following the experiment, the participants' teacher rated her level of agreement with five statements using a 4-point Likert scale (1 = strongly disagree, 4 = strongly agree). Statements were related to the perceived importance of the study goals for the respondent and student, and how likely he or she would be to implement constant time delay independently. In addition, long-term maintenance data were collected during the following school year, approximately four months after the last probe session. Those data were collected once a week for three consecutive weeks. During each session, participants were presented three opportunities to read each word they had learned. Materials were the same as those used in experimental sessions, and word presentation order was randomized.

Results

Using the constant time delay procedure, one participant learned 12 highly motivating words, and two participants learned nine words each, as demonstrated in

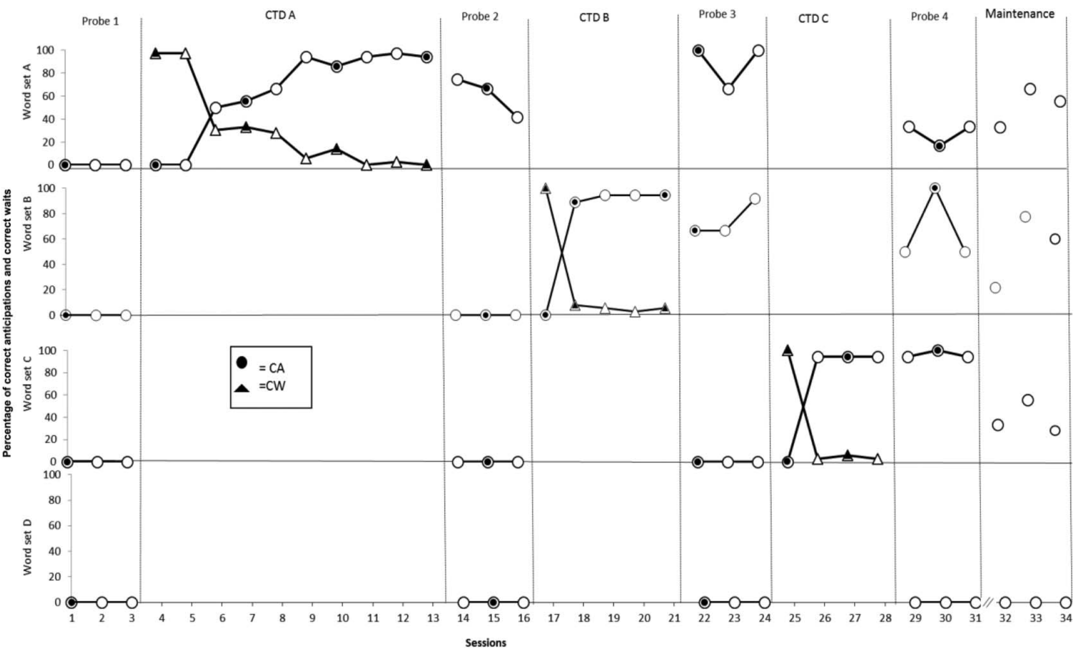

Figure 2. Percentage of correct anticipations (CA) and correct waits (CW) for Tyler. Data from an independent observer are indicated with solid shapes. (CTD = constant time delay.)

Figures 1, 2, and 3. Visual analysis shows an immediate increase in the level of correct anticipations when constant time delay was introduced, and this effect was replicated across at least three word sets for all three participants. Therefore, a functional relation was documented between constant time delay and braille word recognition. Table 2 shows the total duration of instruction, sessions to mastery, and percentage of errors for each participant for each word set.

Natalie

Natalie learned 12 new, highly motivating words over the course of 17 instructional sessions. She did not identify any words prior to instruction. Natalie required only one zero-second delay session for each word set, and was able to reach mastery in five or fewer sessions for each word set. Mean percentage of correct anticipations during five-second delay sessions was 99.1%, 96.3%, 97.2%, and 93% for word sets A, B, C, and D, respectively. With each introduction of a new word set, maintenance of the previous word set declined. During the final probe condition, remediated instructional feedback was provided for two words, *Miss Fran* and *kitchen*. Following instructional feedback, Natalie was able to identify each word in 50% of trials in the final probe session. Mean percentage of correct anticipations during probes 2, 3, 4, and 5 for word set A was 66.7%, 38.9%, 33.3%, and 50%, respectively. Mean percentage of correct anticipations during probes 3, 4, and 5 for word set B was 74.1%, 66.7%, and 77.7%, respectively. Mean percentage of correct anticipations during probes 4 and 5 for word set C was 97.2% and 61.1%, respectively. Mean percentage of correct anticipations during probe

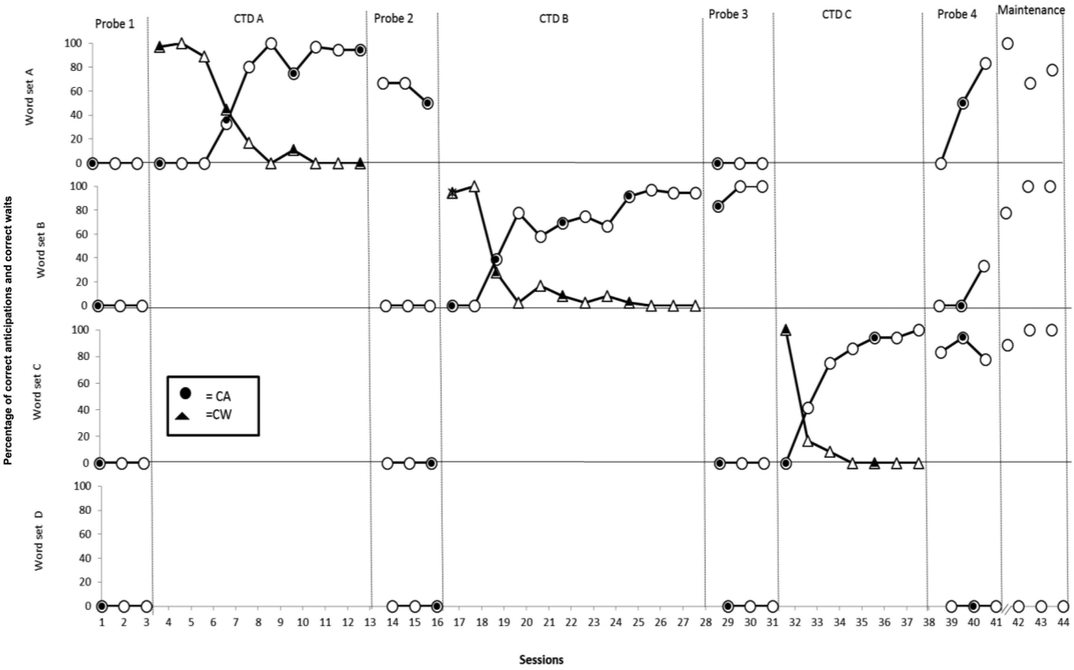

Figure 3. Percentage of correct anticipations (CA) and correct waits (CW) for Christopher. Data from an independent observer are indicated with solid shapes. (CTD = constant time delay.)

5 for word set D was 94.4%. These data show the decline in maintenance for previously learned words as new words were learned, and improvement after minimal remediated instructional feedback was given.

Tyler

Tyler learned nine new, highly motivating words over the course of 19 instructional sessions. Although 12 words were selected for Tyler, due to his high number of absences and late starts during the time period in which the study was conducted, only nine words were taught to him. He did not identify any words prior to instruction. For word set A, the interventionist transitioned from delay sessions of zero seconds to five seconds after Tyler achieved 97.2% correct waits for two consecutive sessions. For other word sets, Tyler required only one zero-second delay session to reach 100% correct waits. Tyler required 10 sessions to reach mastery for word set A, but only five sessions for word set B, and 4 sessions for word set C. The mean percentage of correct anticipations during five-second delay sessions was 79.8%, 93.3%, and 94.4% for word sets A, B, and C, respectively. Mean percentage of correct anticipations during probes 2, 3, and 4 for word set A was 61.1%, 88.9%, and 27.7%, respectively. Despite 100% correct responses in the previous probe session, in the final probe condition Tyler was unable to recognize two words from word set A, *mom* and *story*. Mean percentage of correct anticipations during probes 3 and 4 for word set B was 75% and 66.7%, respectively. Mean percentage of correct anticipations during probe 4 for word set C was 96.2%. Time constraints did not allow us to teach word set D to Tyler.

Table 2
Efficiency data by word set for all participants.

	Word set	Duration of instruction in minutes	Sessions to mastery	Errors (%)
Natalie	A	43	4	0
	B	39	4	1.4
	C	38	4	1.4
	D	38	5	4.9
	Mean	39.5	4.3	1.9
Tyler	A	100	10	4.5
	B	42	5	1.1
	C	37	4	1.4
	D	NA	NA	NA
	Mean	59.7	6.3	2.3
Christopher	A	94	10	6.8
	B	103	12	16
	C	49	7	12
	D	NA	NA	NA
	Mean	82	9.7	11.6

NA = Not applicable.

Christopher

Christopher learned nine highly motivating words over the course of 29 sessions of instruction. For word sets A and B, two zero-second delay sessions were needed. Although only two sessions were needed, the interventionist conducted a third zero-second delay session for word set A. Only one zero-second delay session was needed for word set C. Christopher participated in seven, 10, and six sessions for word sets A, B, and C, respectively, to reach mastery. In his first session of five-second delay with word set A, Christopher's error rate was 22.3%, mostly due to failure to track the entire word. Research personnel decided to implement retraining procedures in tracking before continuing intervention. Mean percentage of correct anticipations during five-second delay sessions was 82.1%, 76.4%, and 81.9% for word sets A, B, and C, respectively. Similar to Natalie, probe data show that with each introduction of a new word set, maintenance of the previous word set declined. Mean percentage of correct anticipations during probes 2, 3, and 4 for word set A was 61.1%, 0%, and 44.4%, respectively. During the final probe condition, remediated instructional feedback was provided for word set A (*mom, cars, laundry*). In the final probe session, Christopher received 83.3% correct anticipations for word set A. Mean percentage of correct anticipations during probes 3 and 4 for word set B was 94.4% and 11.1%, respectively. Mean percentage of correct anticipations during probe 4 for word set C was 85.2%. Time constraints did not allow us to teach word set D to Christopher.

Long-term maintenance and social validity

Long-term maintenance data are displayed in Figures 1 through 3. In each session, participants were given three opportunities to read each word they had learned. Natalie learned 12 words, and Christopher and Tyler learned nine words each. Averaged across all three long-term maintenance sessions, Natalie correctly read 29.6%, 77.8%, 59.3%, and 11.1% for word sets A, B, C, and D, respectively. Tyler correctly read 51.9%, 55.6%, and 44.4% for word sets A, B, and C, respectively. He did not correctly read any of word set D, which was not taught during the study. Christopher correctly read 81.5%, 92.6%, and 96.3% for word sets A, B, and C, respectively. He also did not correctly read any of word set D, which was not taught during the study.

All three participants were receiving visual impairment services in the same classroom; thus, one teacher completed the social validity questionnaire. The teacher indicated she "strongly agreed" with all statements indicating that the goals of the study were important to her and the students, that the quantity and quality of words chosen were important and appropriate for the students to learn, and that she planned to use constant time delay to teach highly motivating words in her existing literacy program.

Discussion

In this study, three young braille readers with multiple disabilities learned between nine and 12 words using constant time delay procedures. This study was an extension of Hooper et al. (2014), and it sought to expand the use of constant time delay to younger braille readers. A functional relation was replicated with all three participants. The results of this study corroborate findings of previous research (Hooper et al., 2014; Ivy & Hooper, 2015), suggesting that constant time delay is a promising practice to teach braille word recognition. In addition, the results suggest that verbal controlling prompts are sufficient and effective to teach highly motivating words to young, beginning braille readers with multiple disabilities.

In terms of efficiency, young braille learners in this study mastered sets of three words each in as few as four and no more than 12 sessions ($M = 6.5$) for an average of 58.3 minutes of instruction (range: 37 to 103 minutes) per word set using constant time delay. Therefore, we can infer individual sessions took approximately 8.97 minutes each. Students were required (with few exceptions) to achieve 100% accuracy in zero-second delay sessions before transitioning to five-second delay sessions, and *mastery* was defined as three consecutive sessions at or above 94.4%. Both of these criteria were higher than required by Hooper et al. (2014), predicting that students in the current study would participate in a greater number of instructional sessions. However, in the current study we doubled the number of trials per session, which would offset the number of instructional sessions required while making individual sessions longer. By removing the physical component of the controlling prompt, we decreased session length, permitting more exposure to words. The number of sessions needed to reach mastery was comparable to Hooper et al. (2014), in which students required on average six sessions (range: 4 to 13) to reach mastery. Mean instructional time in Hooper et al. was 42 minutes (range: 17 to 121 minutes) per word set. We infer that individual sessions took approximately seven minutes each, which suggests that the time gained by removing the physical prompt may offset the time needed to double the number of trials per session. Direct experimental comparison of procedural variations is needed to confirm relative efficiency of procedures.

Maintenance of learning is an important factor when evaluating the social validity of an instructional practice. In this study, three patterns in the data were consistent across participants: (a) percentage of correct responses decreased over time; (b) in the final probe condition, percentage of correct responses was greatest for the last word set taught; and (c) in the long-term maintenance condition (collected four months post-study), correct responses were greater for words taught during experimental sessions. The measurement of long-term maintenance was a unique contribution to the literature regarding constant time delay for students with visual impairments, including those with multiple disabilities. Long-term maintenance of words taught supports the social validity of the intervention. Because information was not gathered about the extent to which learning was reinforced following the study, it is impossible to draw conclusions about factors that supported this effect. Nevertheless, it is a promising finding, since either the constant time delay instruction was sufficient to maintain learning over several months, or the goal of the study, highly motivating word recognition, was considered important enough by the student, teacher, or parents to motivate continued practice after the study ended.

Limitations and directions for future research

The results of any one single case study have limited generalizability. The results of this study suggest that the literacy of young elementary students who meet inclusion criteria may benefit from constant time delay. Further replications are needed by additional research groups to comprehensively define for whom and under what conditions constant time delay is effective for promoting braille literacy. A unique contribution of this study is the preteaching and assessment procedures, which can be used to ensure that learners meet inclusion criteria to benefit from instruction, as well as maintenance data collected four months after the study ended. Replication is needed to strengthen external validity, to establish constant time delay as an evidence-based practice for braille literacy, and to experimentally compare procedural variations to improve efficiency and maintenance. Maintenance may be addressed in future studies by incorporating daily exposure to all words learned. The direction to "find the end of the lead-in line" may have inadvertently promoted students to track braille with their index fingers only, and should be reconsidered in future research and practice.

Implications for practitioners

Special educators are required to implement educational strategies supported by evidence and high-quality research (No Child Left Behind Act, 2002; Individuals with Disabilities Education Improvement Act, 2004). Constant time delay is an evidence-based practice to teach literacy skills to special education students with sight, and the research supporting its use with braille readers is growing. The results of this study suggest that constant time delay is an effective strategy to use with early braille readers. Teachers of students with visual impairments can use this research to support their decision to implement constant time delay with beginning braille readers.

The simplicity and efficiency of constant time delay make it a realistic and valuable strategy for teachers implementing a braille literacy program. Its scripted nature makes it relatively easy to implement with fidelity by teachers or paraeducators (Brock & Carter, 2015). Data collection is vital in tracking the progress of students, and educators can use data gained to document learning.

To isolate the effects of constant time delay and demonstrate experimental control, we implemented constant time delay in a highly controlled context. However, in practice we do not recommend that it be implemented in isolation. It should be incorporated into a comprehensive literacy program, with frequent opportunities to read words in a variety of contexts to reinforce the skills gained during constant time delay sessions. By integrating highly motivating words into a literacy program, students are more engaged and encouraged to learn (Wormsley, 2011). Practitioners can use the list of steps described in the Reliability section to implement constant time delay sessions in the classroom. In practice, it is not necessary to hold probe sessions or organize words into sets. Words can be added to an instructional set one or more at a time. However, if mastered words were to be rotated out of the set, periodic review of those words would be an appropriate practice. We did not incorporate this strategy in the present study, so that we could estimate the maintenance effects of constant time delay.

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