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TEACHING BRAILLE LINE TRACKING USING STIMULUS FADING

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Line tracking is a prerequisite skill for braille literacy that involves moving one's finger horizontally across a line of braille text and identifying when a line ends so the reader may reset his or her finger on the subsequent line. Current procedures for teaching line tracking are incomplete, because they focus on tracking lines with only small gaps between characters. The current study extended previous line-tracking instruction using stimulus fading to teach tracking across larger gaps. After instruction, all participants showed improvement in line tracking, and 2 of 3 participants met mastery criteria for tracking across extended spaces.

Key words: braille, errorless learning, line tracking, literacy, stimulus fading, visual impairment

Braille is a common form of literacy among individuals with visual impairments. Despite the increasing availability of alternative technologies, braille literacy remains an important educational goal for children with visual impairments. A recent survey of adults with visual impairments indicated that respondents preferred braille reading to alternative technologies, found braille reading to be crucial for certain subject areas, and believed that early braille instruction was important for later literacy (D'Andrea, 2012).

Before reading braille, learners must develop prerequisite skills such as tactile discriminations and appropriate hand mechanics. Line tracking is one of these appropriate hand mechanics. It involves using the index finger of the left hand (a) to mark the onset of a line and (b) to move vertically between lines. The right hand must move horizontally in a continuous motion to avoid repeatedly feeling one letter (i.e., scrubbing), which is detrimental to braille fluency (Davidson, Wiles-Kettenmann, Haber, & Appelle, 1980).

Mangold (1978) evaluated a program to teach line tracking to legally blind braille learners. Thirty student participants were divided into 15 matched pairs; one participant received the experimental program and one received braille education as usual. Initially, Mangold presented lines of varying lengths that were composed of identical braille characters without spaces (6.2 mm between characters) and then increased the difficulty by including tracking across (a) dissimilar characters without spaces, (b) like characters with two spaces, and (c) dissimilar characters with two spaces. The protocol followed a precision teaching model with criterion tests, predetermined goals for mastery, and rewards for progressing between worksheets. Participants in the experimental group scored higher on a posttest line-tracking assessment than the control participants. This program has since served as the standard for teaching line tracking.

Although the program is effective, the terminal goal of Mangold's (1978) training program did not encompass all of the line-tracking skills required of braille readers. In particular, the program assessed tracking with at most a two-space gap between

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characters; this is similar to the spacing observed in most text. However, tracking across larger gaps is necessary in certain situations (e.g., reading diagrams or figures; Braille Authority of North America, 2012). It also allows easier translation of educational print material that is commonly used in discrete-trial training into braille material. The current study evaluated procedures similar to the initial steps of the Mangold (1978) program, but with the goal of incorporating greater space between characters. To that end we used stimulus fading, an approach shown to be effective at teaching a variety of skills (e.g., de Graaff, Verhoeven, Bosman, & Hasselman, 2007; Schiff, Tarbox, Lanagan, & Farag, 2011).

METHOD

Participants, Setting, and Materials

Lisa was a 4-year-old girl who had been diagnosed as blind, but was otherwise typically developing. Matt was a 6-year-old boy who had been diagnosed as legally blind and had an educational classification of other health impairment. Katie was a 5-year-old girl who had been diagnosed as legally blind and developmentally delayed. All participants were nominated by a teacher and administrator as students who were ready to begin braille instruction. We conducted sessions in the students' classrooms and prepared stimuli using a Perkins Braillewriter on standard braille paper.

Measurement and Interobserver Agreement

Each session consisted of 10 trials. Data collectors scored trials as correct if the participant (a) held the left index finger at the start of the line, (b) moved the right index finger continuously over the line from left to right, and (c) said "stop" within 5 s of the right finger making contact with the final character of the line. Participants could move their finger past the last dot to identify the end of the line, as long as they remained in the correct vertical location. Otherwise, trials were scored as incorrect (data on error types are available from the first author). A second observer collected data independently during a minimum of 25% of sessions for each participant. We compared records on a trial-by-trial basis; records were identical (either both marked correct or with the same error) on 99% (range, 90% to 100%), 95% (range, 70% to 100%), and 97% (range, 80% to 100%) of trials for Lisa, Matt, and Katie, respectively.

Procedure

Each stimulus sheet contained five horizontal lines with 27 adjacent locations for braille characters (total line length was 16.7 cm); each line was separated vertically by 3 cm. The first author initiated each trial by presenting the stimulus sheet in front of the participant, placing the participant's left index finger at the left portion of the top line on the sheet, and saying, "track the line and say 'stop' when you reach the end." Each of the five lines of braille served as the target stimulus during two trials in each session. For Matt and Katie, the experimenter presented stimuli under a small tray (0.3 m tall and 0.6 m wide) placed on the table and covered on three sides by fabric (open towards the experimenter). The participants placed their hands under the tray to ensure tactile exposure only. We conducted two to six sessions per day, depending on the students' availability.

During baseline, the lines consisted of four instances of the braille letter A. The first A was in the left position; the remaining three instances were randomly placed in each location (distance ranged from approximately 3 cm to 6 cm). A trial ended after 5 s or when the participant said "stop"; the experimenter did not provide feedback. During instruction, lines initially consisted of 27 instances of the braille letter A (Training Step 1). The experimenter provided praise and a token following each correct trial; participants later exchanged tokens for free time. After an incorrect response, the experimenter physically guided the participant to make the correct motor response, modeled the vocal response ("stop") at the end of the line, and initiated the next trial.

After meeting mastery criterion (90% of trials correct for two consecutive sessions) at the current training step, the experimenter presented stimuli from the next training step, in which one additional character was omitted from each line. A random number generator selected numbers between 2 and 27 without replacement to determine the characters omitted, but the first character remained constant. The characters that corresponded with these positions were then removed, creating a variety of possible gap sizes at each step. This process was completed five times, forming five unique lines on each stimulus sheet, which were used for all participants. There were up to 24 training steps. After every three mastered training steps, we conducted probe sessions (identical to baseline) to determine if additional training steps were necessary. If responding during a probe was at mastery level, we repeated the probe; otherwise we initiated the next training step. The instruction phase was implemented in a multiple baseline across participants; Matt's and Katie's evaluations were completed concurrently after the completion of Lisa's evaluation.

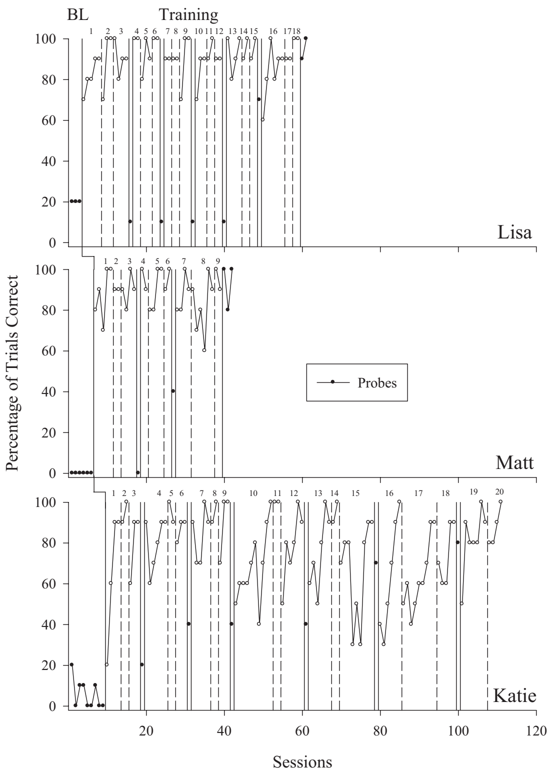

Figure 1. Percentage of trials correct during baseline, instructional, and probe sessions. Each instructional step removed one character from the 27-character line used in Step 1. BL = baseline.

RESULTS AND DISCUSSION

Lisa (Figure 1, top) tracked correctly during 20% of trials during baseline. She progressed rapidly through the programmed fading steps. She required no more than six sessions of exposure to any condition to meet mastery criterion at that level, and she met mastery criterion in two sessions (fewest possible) during 10 training steps. She demonstrated mastery of the terminal line (containing four dots) under probe conditions after mastery of the training step with 10 characters per line (18 training steps completed in 51 total training sessions). Matt (Figure 1, middle) demonstrated no correct responses during baseline. He required no more than six sessions at any training level and met the terminal mastery criterion following the training step with 19 characters per line (nine training steps completed in 31 total training sessions). Katie (Figure 1, bottom) tracked correctly during 5.6% of trials in baseline. She required the greatest number of both training steps and sessions per step. She completed 20 training steps in 96 sessions. However, she left school unexpectedly and could not complete the program. She responded correctly on 80% of trials during her final probe following Training Step 18.

The current study extended previous research on teaching line tracking to early braille learners; the current procedures ensured that readers could track lines of braille with spaces as long as 6 cm for the two participants who completed training. The ability to track over long distances is important for reading irregular text (e.g., symbols or graphs) and is also useful when learning character discrimination. After completion of this study, Lisa and Matt participated in a study designed to teach braille character discrimination in a match-to-sample arrangement; tracking from sample across comparisons necessitated longer line tracking.

The current procedures were similar to those described by Mangold (1978) in that we progressed systematically from relatively easy to more difficult skills and provided intermittent probes to determine mastery. However, there are some notable differences. In particular, Mangold taught tracking across diverse characters, whereas we taught and assessed tracking using a single character. We selected the braille A to minimize spacing variability and to provide a robust tracking challenge. The letter A contains a single dot in the top left column and thus permitted the least amount of vertical deflection while tracking (compared to the letter L with three vertically aligned dots in the left column; one could track from the top of one letter to the bottom of the next while technically remaining in contact). However, future research should evaluate if introducing varied characters during line-tracking training assists in generalization of line tracking across characters or promotes subsequent character discrimination.

The current study also extends stimulus-fading procedures to a novel dependent variable. Stimulus fading is designed to promote transfer of stimulus control while the chance of error is reduced. In the current example, a continuous line of dots exerted stimulus control over learners' tracking across a horizontal line. Through the gradual reduction of raised dots, we were able to transfer stimulus control to an array of dots with larger gaps (baseline conditions), and we did so with learners who made relatively few errors along the way.

It is interesting to note that the point of stimulus control transfer was different for each participant. That is, Lisa and Matt required 18 and 9 training steps, respectively, before responding at mastery levels in baseline. By contrast, Katie completed 20 training steps and did not meet mastery levels. These outcomes (a) call for a larger scale evaluation to determine heuristics regarding training time and (b) highlight the importance of conducting periodic probes of terminal discriminations. That is, without conducting probes, we would likely have continued to train all 27 training steps unnecessarily. However, there is an efficiency trade-off between the time required to conduct terminal probes and the amount of time saved in unnecessary training. We conducted probes after mastery of every three training steps, but we selected this frequency purely for convenience. Given the brevity of the probe sessions and the training steps saved, the conduct of probes yielded a net time savings. However, it may be possible to engineer a greater time economy by minimizing the frequency of probes. For instance, if the earliest transfer of stimulus control occurred after nine training steps, we could omit probes until after Training Step 9. Future replications would be necessary to identify such patterns. In addition, more efficient instruction might have resulted from a more stringent mastery criterion.

Line tracking is a small piece of the behavioral repertoire necessary for braille reading. Larger and more comprehensive programs (e.g., Mangold, 1978) have included line-tracking procedures that are similar to the one described in this study as well as more advanced programs (e.g., character discrimination, phonetic relations). However, like most manualized treatments, the efficacy of individual components of the program has not been evaluated. Thus, the current study both supports and extends the approach to teaching line tracking promoted by Mangold (1978).

Although line tracking is widely considered to be a prerequisite skill for fluent braille reading (and our experience supports this notion), it would be valuable for researchers to demonstrate the necessity of line tracking in more advanced braille reading. After the development of line tracking, learners proceed to learn character discrimination by either identifying two characters as the same or different or by selecting characters in a match-to-sample arrangement. Future studies could evaluate whether acquisition of line tracking facilitates acquisition of these discriminations, or conversely, whether line tracking could be acquired concomitantly and without being specifically targeted.

Future research should also evaluate acquisition and generalization of line-tracking skills given different between-step mastery criteria. In the current study, we required two consecutive sessions with 90% responding. Given the importance of line tracking, it may be preferable to set a more stringent criterion, because line-tracking errors are likely to be highly detrimental to later reading fluency. A more stringent criterion might also minimize the persistence of errors, as was observed in Katie's data. Finally, future research should evaluate the acceptability and feasibility of implementation by classroom teachers.

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