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A computer-based instructional program to teach braille reading to sighted individuals

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A COMPUTER-BASED INSTRUCTIONAL PROGRAM TO TEACH BRAILLE READING TO SIGHTED INDIVIDUALS

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Abstract

There is a need for efficient braille training methods for instructors of the visually impaired. This study evaluated the use of a computer-based program intended to train the relation of braille characters to English letters using a matching-to-sample procedure with 4 sighted college students. Each participant mastered matching visual depictions of the braille alphabet to their text counterparts. Further, each participant demonstrated the ability to read a braille passage following this exposure. These gains maintained at variable levels at a follow-up probe 2 to 4 weeks following training.

Keywords: Braille, alphabet, matching-to-sample, computer-based learning

Introduction

As of 2002, approximately 1.4 million children under the age of 15 worldwide met the ICD-10 criteria for blindness (Resnikoff et.al. 2004) with vision worse than 20/400 acuity or less than 10 degrees of the visual field in the best eye with the best corrective device possible; even greater numbers met the criteria for legal blindness (visual acuity 20/200 or less with less than 20 degrees of the visual field) or low vision (visual acuity between 20/70 and 20/200). Among the many learning challenges faced by students with visual impairments, the development of literacy is particularly concerning with the literacy rates for visually impaired students having decreased considerably in recent years while the visually impaired population has grown (Braille Institute, 2010). Approximately 89% of blind students demonstrated some means of literacy in 1968, however, this percentage decreased to about 36% by 1993; the visually impaired population has increased by more than 30,000 during this same time period.

One form of literacy for the legally blind is the braille code in which each letter and number of the English alphabet is represented by a unique tactile symbol composed of the presence or absence of a raised dot in up to 6 locations in a cell comprised of 2 columns and 3 rows. Each dot is approximately 1 mm in diameter and there is approximately 1.5 mm between the midpoints of each dot location within a standard cell. Each word of the English language can be transcribed into braille with a point-to-point correspondence between the text letter and the braille symbol[1].

Disturbingly, only 22% of student readers with visual impairments reported braille as their primary form of reading. Classroom-based braille instruction has decreased in recent years. In 1968, 40% of students with visual impairment enrolled in elementary and secondary education were reported to be reading braille, but in more recent years these estimated rates dropped to between 9 and 22% reading braille (Braille Institute, 2010; American Printing House for the Blind, 2009). Some have suggested that individuals with visual impairment may be less reliant on braille with the increase in the availability of large print books and advances in technology that make auditory media more available and accessible (Johnson, 1996). Although technology may replace the need for braille literacy under some circumstances, the complete omission of braille literacy may limit individuals' opportunities for independence throughout life. Ryles (1996) reported that adults who were congenitally-legally blind and were taught braille as their first means of literacy had higher employment rates, higher educational levels, and better financial stability, on average, than adults with similar disabilities but first taught as large print readers.

In addition to technological advances, several sources have suggested that declining braille instruction is attributable, in part, to a deficit in qualified braille instructors (Bell, 2010; Mason, Davidson, & McNerney, 2000; Johnson, 1996; National Federation of the Blind, 2009; Ponchillia & Durant, 1995), a lack of training programs, and nonunified standards in those programs that do exist (Amato, 2009). In addition, general education teachers with no braille training are often responsible for teaching early braille skills (Johnson, 1996). Although there is currently a great deal of disagreement regarding the methods that should be used to train braille instructors and the criteria that should be used to determine a qualification of competency (Bell, 2010; Johnson, 1996; National Blindness Professional Certification Board, 2009; Rosenblum, Lewis & D'Andrea, 2010), there is a general consensus that an instructor would need to be capable of fluent braille reading themselves. There is no current procedure for developing braille reading repertoires among potential braille instructors. Therefore, the goal of our current study was to develop a rapid, computer-based instructional program to teach braille reading to these teachers.

The reading repertoire required of a braille instructor is slightly different from that of a typical braille reader. That is, assuming a sighted instructor, a braille instructor does not necessarily need to read braille tactually, but rather would read a braille passage visually such that they could provide prompting and corrective feedback to a student. Most instructors-in-training will also differ from their students in that they, the instructors, already possess a visual reading repertoire, whereas the majority of students learning braille will have not read visually. Thus, braille instruction with visually intact adults may capitalize on those adults' prior reading repertoires by attempting to establish equivalence relations between printed text and braille symbols.

An equivalence relation, based upon the stimulus equivalence paradigm, is a behavioral pattern in which, following learning of certain relations between at least 3 classes of stimuli, individuals will also demonstrate the untrained emergence of additional relations (Sidman & Tailby, 1982). For instance, given stimuli A, B, and C, when an individual is taught to select stimulus B when presented with stimulus A (AB relation) and to select stimulus C when presented with stimulus B (BC relation), stimulus equivalence would be demonstrated by the emergence of (a) reflexive relations (i.e., the individual would then accurately select each stimulus when provided with itself as a comparison; the AA, BB, and CC relations), (b) the symmetric relations (i.e., the individual would accurately select the reverse of the trained relations; the BA and the CB relations), and (c) transitive relations (i.e., the individual would accurately respond given the stimuli which had never been directly paired during training (i.e., the AC and CA relations; Green & Saunders, 1998). Instruction informed by stimulus equivalence research allows an instructor greater teaching efficiency in that by targeting particular relations, relations between important classes of stimuli can also emerge without direct instruction. These forms of equivalence-based instruction have been successfully implemented, and their emergent relations successfully observed, across a wide variety of populations including individuals with learning deficits, brain damage, cognitive impairments, and developmental disabilities and have targeted such skills as mathematics, geography, and emotional recognition (Guercio, Podolska-Schroeder, & Rehfeldt, 2004; Leblanc, Miguel, Cummings, Goldsmith, & Carr 2003; Hall, DeBernardis, & Reiss, 2006; Lynch & Cuvo, 1995).

Toussaint and Tiger (2010) demonstrated the utility of low-tech equivalence-based instruction to teach relations between printed text letters and their braille counterparts with 4 children with degenerative visual impairments who had already learned to read printed text. The training involved a matching-to-sample procedure in which the experimenters presented a braille letter as a sample stimulus (A) and taught students to select a printed-text letter comparison (B) from an array of letters (i.e., taught the AB relation); these children had the pre-requisite ability to match text letters (B) to their spoken names (C) (BC and CB relations). After mastering the AB relation, the participants were then able to (a) select the braille character when provided with the text (BA relation; i.e. demonstrating symmetry) and (b) were able to select the appropriate braille character when given the spoken name (CA relation) and to speak the correct name when given the braille character (AC relation; i.e. demonstrating transitivity). Although these relations are important prerequisites to reading using the braille code, reading obviously requires more advanced skills than letter naming and matching. Although reading ability was not assessed in this study, it is reasonable to suggest that if individuals possess the pre-requisite ability to read printed text and if they are trained to relate printed-text characters to braille characters, then the corresponding ability to read braille may emerge as an additional transitive relation. That is, it may be the case that establishing equivalencies between braille characters and printed letters would be sufficient to generate rudimentary braille reading repertoires for those with a strong print reading repertoire.

We designed the current study as a preliminary evaluation of a training program targeted towards braille instructors using instructional procedures similar to those of Toussaint and Tiger (2010). We recruited 4 college students to participate and we taught them the relation between braille characters and English letters in a computer-based, matching-to-sample format. We also pre- and post-tested these participants' abilities to read a braille passage to assess the untrained emergence of braille reading following this training program.

Methods

Participants

We recruited 4 undergraduate students enrolled at Louisiana State University as participants. Maureen was an 18-year-old Caucasian female, Rick was a 21-year-old Caucasian male, Sarah was a 21-year-old African American female, and Amy was a 19-year-old African American female. We did not inquire whether the students had any prior experience with the braille code; rather, we directly assessed braille skills during a pretest (described below). We recruited all participants through the psychology department experiment research pool; each participant received research credits as compensation for participation. Professors in courses the students were enrolled gave extra credit in exchange for the research credits. Participants volunteered for the experiment using an on-line scheduling system. We required the students to sign up for two sessions. We used the first session for the formal evaluation of the instructional program. We arranged the second session 7 to 14 days after completion of the initial session to assess the maintenance of braille skills. We later rescheduled some timeslots due to missed appointments.

Procedure Overview

The experiment took place in an office on the Louisiana State University campus. Participants began their first session by reading and signing an informed consent document that explained the procedures and purpose of the study. They also completed a brief demographics form. In order to ensure their reading fluency, we asked participants to read a 6th grade passage from the Oral Reading Fluency (ORF) subtest of the Dynamic Indicators of Basic Early Literacy Skills (DIBELS) (Good, Kaminski & Dill, 2007). We also assessed their braille reading ability by asking them to read a 1st grade passage from the same assessment that we transcribed into braille, translating all text letters into lower case braille characters (Figure 1 & 2). We programmed the instructional program using PracticeMill software (Peladeau, 2000); participants completed the training on an HP mini laptop computer running Microsoft Windows XP.

My Rock Collection

I started a rock collection. It began when I visited the coast. There were so many rocks on the beach. They were wet and shiny from the water. They came in many beautiful colors. They were pink, green, black, and white. Some rocks had been worn by the waves. One even had a hole in it. When the rocks dried they were not so colorful.

Figure 1. Sample of reading material for the pre- and post-instruction reading probes in standard English text.

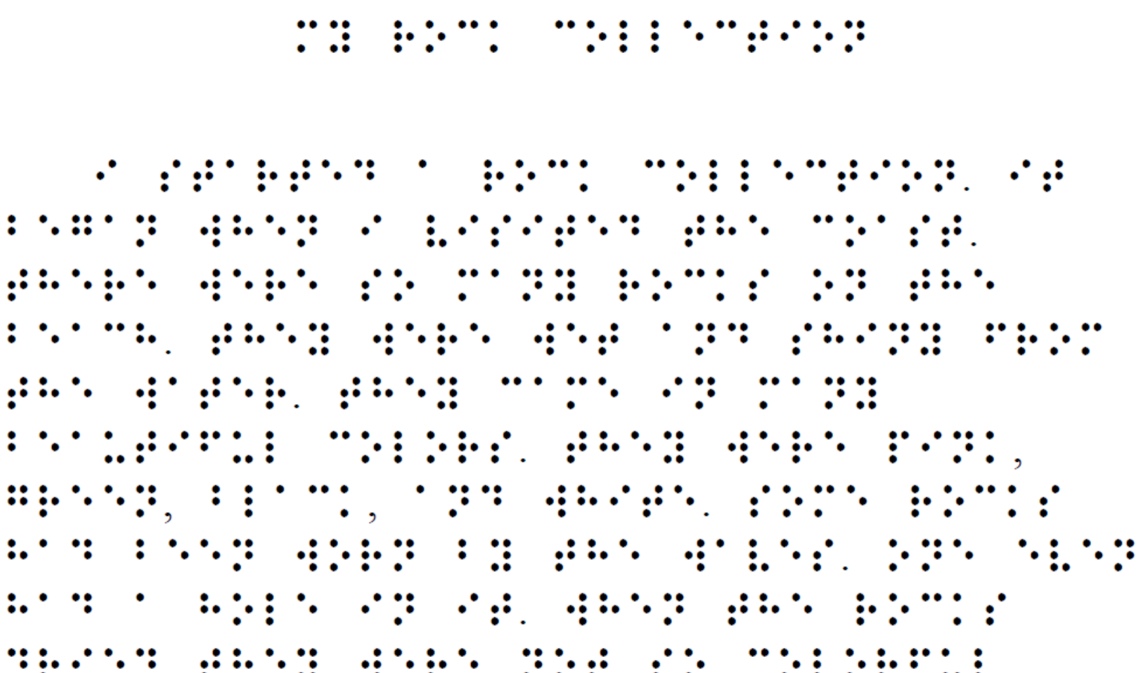

Figure 2. Sample of reading material for the pre- and post-instruction reading probes translated into the braille code.

Pre-Instruction Probes

Printed Text Reading Probe. Before beginning the braille assessment, participants completed the pre-requisite reading assessment, with the experimenter scoring the passage using the criteria described in the DIBELS manual (Good et al., 2007). The experimenter instructed the participant to read passage as quickly and accurately as possible in one minute. We set the prerequisite requirement at reading the passage at least at the 6^{th} grade level, determined by at least 125 words read correctly in the 1 min time limit. This criterion is the benchmark for not at risk in the progress monitoring scoring protocol included in the DIBELS assessment.

Braille Reading Probe. For the pre-instruction braille reading probe, the experimenter provided the participant with the braille passage and asked him or her to read every word of the passage aloud, to skip any unknown words, or to state that they could not read the passage. The experimenter scored these probes by reading along on a second, printed text version of the passage. The experimenter stopped the session when (a) the participant stated they could not read any of the passage, (b) if they attempted to read but did not read any word correctly after the first line, or (c) after 5 minutes of reading, whichever occurred first. If any participant had a correct response during this phase we would have excluded that participant from further participation in this study.

Instruction Program

Prior to initiating instruction, we conducted a baseline assessment of matching the 26 letters of the English alphabet to their braille counterparts using the computer-based format. The layout of the screen included a braille character as a sample stimulus and 5 or 6 English-letter multiple-choice options as the comparison array (see top portion of Figure 3 for an example). During this baseline, participants had only one opportunity per session to identify the correct letter; the program did not provide any feedback for correct or incorrect responses. Participants responded by clicking the radio button adjacent to the comparison stimulus (text letter); after selecting a response the next question automatically appeared. The program presented each letter once during each baseline session; resulting in 26 trials per session. We staggered the initiation of instructional sessions in a non-concurrent, multiple baseline across participants design.

Following baseline, we randomly divided the alphabet into 5 letter sets with 5 or 6 letters in each set. We arranged each leach letter set into one of five training units. Each session of a training unit included 3 presentations of each target letter as a sample stimulus plus a single presentation of all previously mastered letters as sample stimuli to ensure continued practice with mastered letters. For example, Unit 1 consisted of the letter set (O, G, K, A and Y) with each letter being presented 3 times. After meeting mastery criterion (two consecutive sessions with accurate responding of 95% of higher), participants began Unit 2. Sessions in Unit 2 included 1-trial presentations of each of the letters from Unit 1 (O, G, K, A and Y) and 3-trial presentations of each letter in the new set (D, V, S, H and T); members of each training set were randomly interspersed. The participant did not have access to later units until completing the earlier units at mastery levels.

We programmed presentation of instruction sessions similar to baseline probes, except that in addition to presenting the letters in sets, the program provided immediate feedback following each response. If the participant selected the correct comparison, the feedback ‘Great!’ appeared on the screen along with a prompt for the participant to press the space bar to continue to the next item. If the participant selected the incorrect comparison, an immediate auditory beep sounded and a message appeared on-screen with corrective feedback (e.g. ‘No. The correct answer is ‘Y’’). Following this immediate corrective feedback (see bottom portion of Figure 3

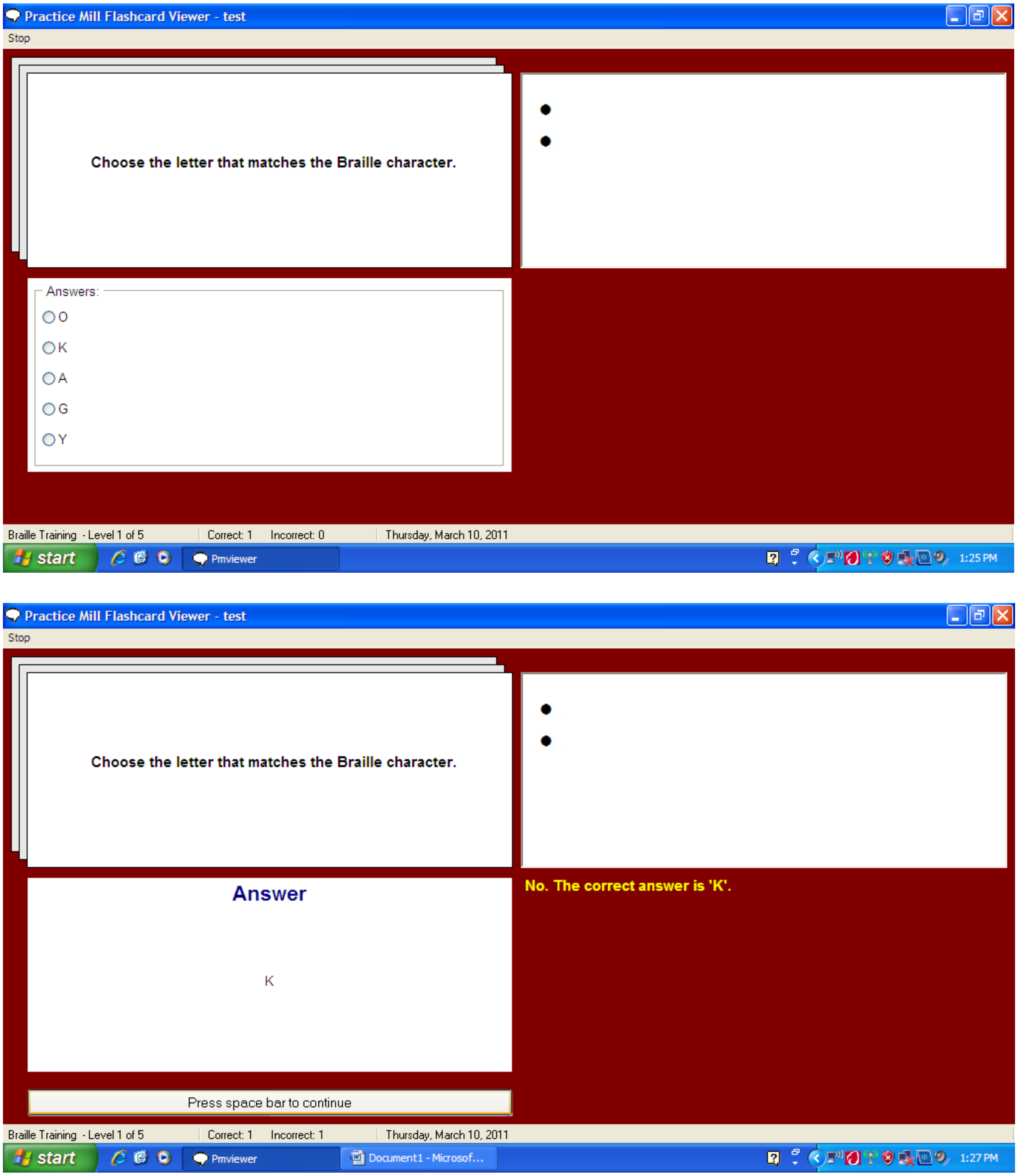

Figure 3. Print screen of the PracticeMill computer program. The top image is the display of a training session, identical to the pre- and post- instruction letter-acquisition assessments with the exception of the bottom bar listing the correct/incorrect responses removed. The bottom image is an example of corrective feedback provided if the incorrect response was chose during training.

for an example), presentation of the same stimulus occurred requiring the participant to select the correct comparison before advancing to a new trial. We did not include responding during these error correction trials in the subsequent data analysis.

After mastery of the last unit, the participants completed a post-instruction letter-identification assessment which was identical to the pre-training baseline (i.e., all 26 letters provided presented 1 trial each without response feedback). We then also conducted a post-training assessment of braille reading by asking the participants to read the same transcribed DIBELS passage we presented prior to training.

Maintenance Probes

Each participant returned for a follow-up maintenance session, three participants returned in the planned 7-14 days following the initial training session. One participant encountered scheduling difficulties and completed the maintenance 24 days following initial training. Participants again completed the letter identification and braille reading probe at this time in an identical fashion to the pre- and post-instruction probes, but with a new ORF passage to prevent practice effects. These passages are designed to be of equivalent difficulties with an alternate-form reliability ranging from .89-.94 (Good, Kaminski & Dill, 2007). Therefore this difference should not inhibit comparison between the post-instruction and maintenance probes.

Measurement and Inter-Observer Agreement

In scoring of the text and braille reading probes, the experimenter left words read correctly blank and placed a slash through any word that was read incorrectly or not read. If a student misread a word and self-corrected the word before moving on, the experimenter marked it with a ‘sc’ and counted it as a correct word. At the end of the assessment the experimenter placed a bracket around the last word read correctly to denote the total words read. The experimenter scored the passages by counting the total number of words read correctly.

A second observer independently scored, either simultaneously or from an audio-recorded version of the session, 31% of the ORF assessments. We calculated interobserver agreement (IOA) by comparing the two observers' recordings on a word-by-word basis. We scored each word in agreement if both observers scored a word identically or in disagreement if the observers did not mark the same response for a word. We then summed the number of words in agreement, divided this sum by the total number of words read (if the total number of words read in the time limit differed between the two observers, then we used the larger number of words recorded for this calculation), and converted this quotient into the percentage of words agreed upon. The mean inter-observer agreement was 96.3% (range, 82 to 100%). The PracticeMill software automatically scores and reports participants' responding during the baseline and instructional procedures and records the time spent in training; no IOA assessments were necessary.

Results

Training Sessions

Maureen (top panel in Figure 4) accurately selected text letters given a braille sample during 20% of trials in her single baseline session (chance levels given 5 comparison stimuli). She then began the training program and mastered each of the 5 instructional units in 15 total sessions. The total instructional time from the point she started the instructional program (not including the baseline probes) to the point she completed her final session of Unit 5 was 18 min and 50 s. After completing this training, her letter accuracy increased to 100%.

Rick (second panel in Figure 4) accurately selected text letters given a braille sample during a mean of 26.9% of trials in his 3-session baseline. He then began the training program and mastered each of the 5 instructional units in 20 total sessions. The total instructional time from the point he started the instructional program (not including the baseline probes) to the point he completed his final session of Unit 5 was 18 min and 30 s. After completing this training, his letter accuracy increased to 100%.

Sarah (third panel in Figure 4) accurately selected text letters given a braille sample during a mean of 16.2% of trials in her 5-session baseline. She then began the training program and mastered each of the 5 instructional units in 23 total sessions. The total instructional time from the point she started the instructional program (not including the baseline probes) to the point she completed her final session of Unit 5 was 22 min and 37 s. After completing this training, letter accuracy increased to 100%.

Amy (bottom panel in Figure 4) accurately selected text letters given a braille sample during a mean of 30.2% of trials in her 7-session baseline. She then began the training program and mastered each of the 5 instructional units in 23 total sessions. The total instructional time from the point she started the instructional program (not including the baseline probes) to the point she completed her final session of Unit 5 was 37 min and 46 s. After completing this training, letter accuracy increased to 88.5%.

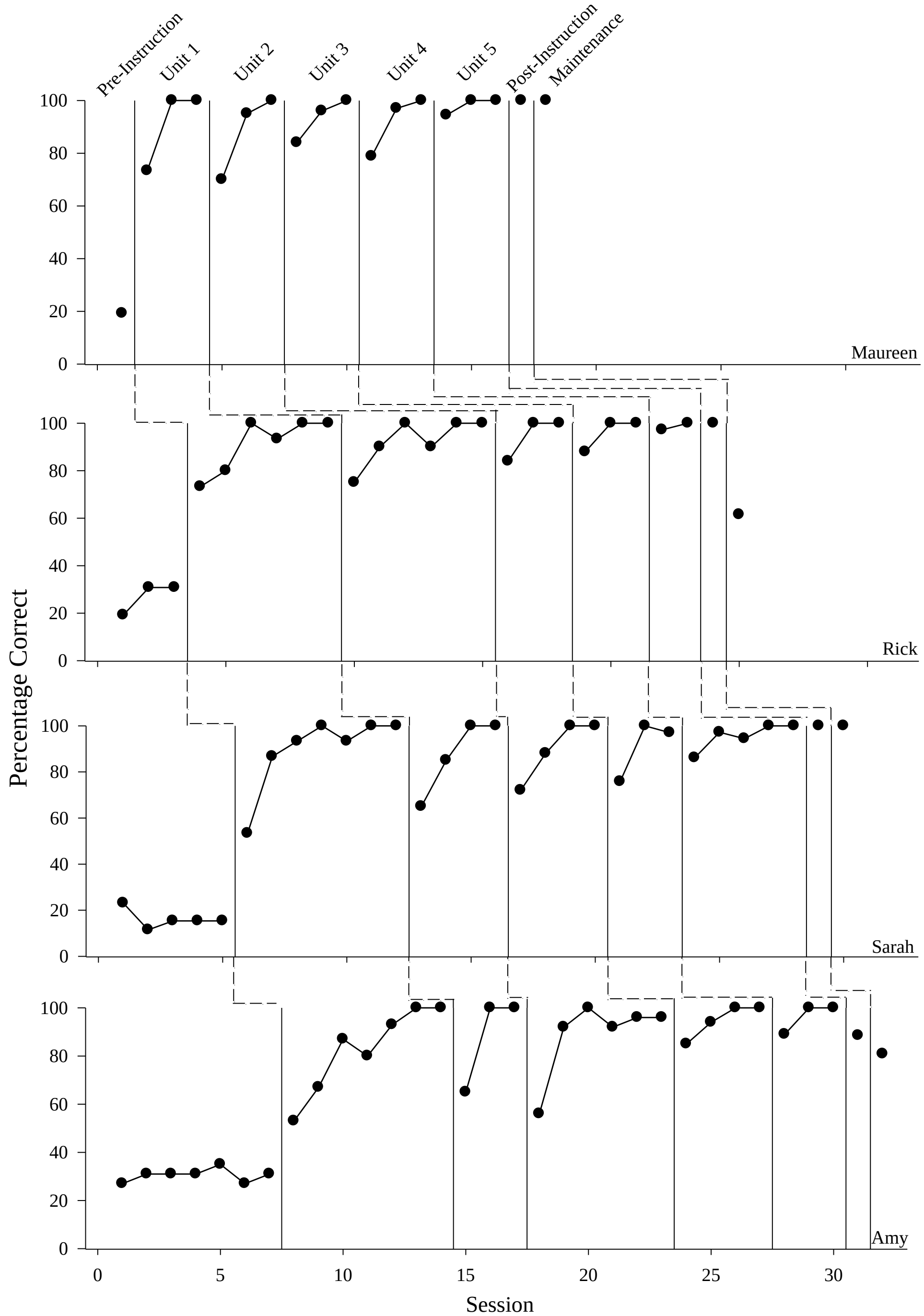

Figure 4. Results from the training sessions displayed across all four participants in a multiple-baseline design.

All participants successfully acquired mastery of all 5 units. Participants completed the training sequence in a mean of 20.25 sessions and a range of 15 to 23, which required a mean of 24.4 min (range, 18.5 min to 37.78 min) to complete the entire training.

We provide a summary of the difference between each participant's braille-to-text letter matching in a bar chart format in Figure 5. Participants pre-instruction scores are the composite mean of their baseline levels of accuracy. Each of the participants responded at near chance levels during baseline (exact percentages described above). Maureen, Rick, and Sarah each responded at 100% accuracy in the post-instruction probe conducted immediately following completion of the training program; Amy responded at 88.5% accuracy (it is worth noting that Amy experienced the longest baseline periods; anecdotally she appeared fatigued by the end of her session). Maureen and Sarah continued to respond with 100% accuracy; Rick and Amy's accuracy decreased to 61.5% and 80.8%, respectively.

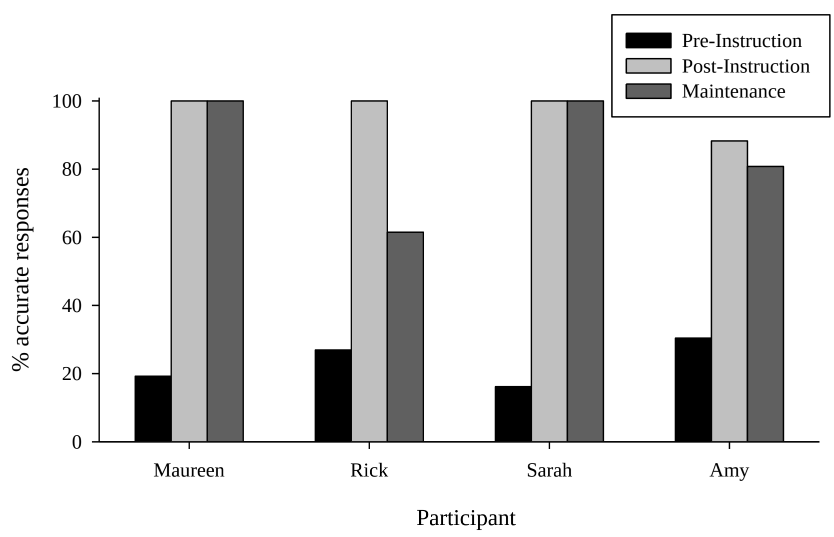

Figure 5. Accuracy for all four participants for the letter-acquisition probes, including pre-instruction, post-instruction, and maintenance probes

Braille Reading Probes

The results from the three braille reading probes for each participant are depicted in Figure 6. None of the participants read a braille word correctly during the initial pre-training probe. After training, Maureen, Rick, Sarah, and Amy read 21, 38, 19, and 2 words correctly, respectively, immediately following the computer-based instruction and 23, 10, 7, and 0 words correctly, respectively, at their maintenance probe.

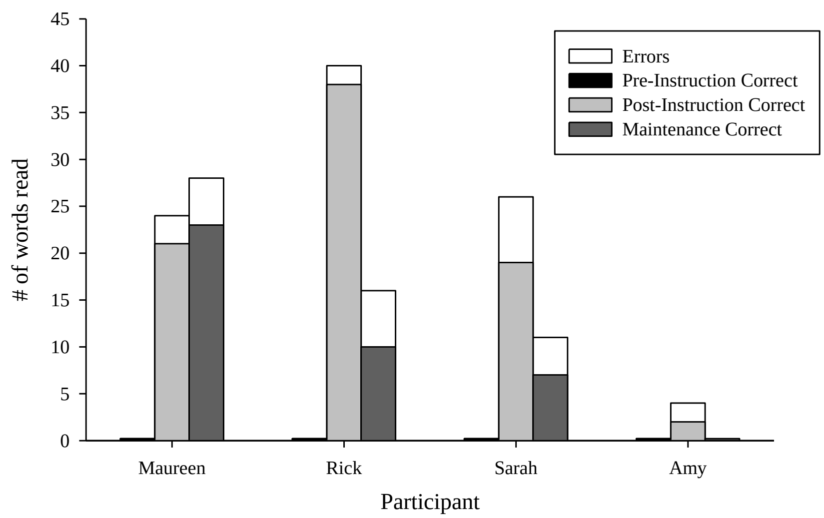

Figure 6. Scores, including words read correctly and incorrectly, for all four participants for the reading probes, including pre-instruction, post-instruction, and maintenance probes and the number of reading errors made at each assessment.

Discussion

We successfully taught 4 college students to match braille characters to their corresponding text letters via a computerized instructional program. Participants required a mean of 24.4 min to complete this instructional program and at the conclusion of their participation, participants not only accurately identified each braille character, but each also demonstrated the emergent skill of reading a passage in braille. Both of these skills maintained at 7 to 24 days follow up (with the exception of reading for Amy). These results demonstrate a novel, efficient, computer based, means of teaching the relation of braille characters to text letters.

These results were similar to those reported by Touissaint and Tiger (2010) in that teaching the braille-to-printed text relation to sighted readers resulted in the emergence of additional relations important to the development of braille literacy, but extend the results of Toussaint and Tiger in several important ways. First, our current study included an adult population (relative to children with degenerative visual impairments in Toussaint and Tiger). We selected college students for this study based upon their demographic similarities to the teachers that would ultimately be targeted by this instructional program (i.e., practicing teachers or college students in special education preparatory programs). It is notable that none of our participants reported prior exposure to the braille code, yet these students completed the full training program in a mean of about 25 minutes. It is not clear at this point, given our small sample size, if this level of efficiency is representative of all learners; we are currently replicating these procedures with larger numbers of undergraduates to answer this question.

Second, our current procedures differed in that our participants responded to visual presentations of braille stimuli, whereas the participants in Toussaint and Tiger learned to respond to tactual braille. As noted previously, the required repertoires of braille instructors differ in this regard relative to their visually impaired students; it is more important for teachers to read braille visually than tactually. However, it would be interesting from a conceptual perspective to assess the emergence of tactual braille reading given this training. It is possible, though not assessed, that relations would have emerged between visual and tactual braille following this instruction (see Bush, 1993 for an example).

Third, we demonstrated that braille reading emerged following instruction in letter matching. This can be considered a transitive relationship between not only the printed letters, the braille characters, and the letter names, but also their individual phonemic sounds, and the manner in which they are blended when combined with other characters. This is important not only from a conceptual level (i.e., the demonstration of a transitive relation), but provides perhaps the most important applied contribution of this study. That is, this brief computer-based instruction was sufficient to generate a braille reading repertoire. It is important to note that our participants were not fluent braille readers; our peak performance of 38 words in 5 min was well below fluency. Additional instruction, practice, and feedback would be needed to achieve fluency, but the current program appears to be both an efficient and effective first step towards this goal.

Fourth, our current instructional program was developed using a computer-based model, relative to the presentation of printed cards from Toussaint and Tiger, which allowed for greater consistency in stimulus presentation, automated scoring and record keeping, minimized concerns regarding procedural integrity, and eliminated the need to train instructors to implement this program. Further, a computer-based model allows for administration via the internet. As pointed out by Johnson (1996), there is a deficit in well-trained instructors for the visually impaired, as well as a deficit in the number of programs to prepare instructors; this limited number of programs makes qualified instructor access a challenge. We are hopeful that a web-based version of this instructional procedure will address some issues of access. We are currently developing a web-based version of this program for evaluation.

This study creates a number of important avenues of future research. First, our program targeted only letters within the braille code; additional programming will be necessary to teach braille punctuation, grammar, proof-reading, and rules concerning contractions (frequently referred to as Level-2 or contracted braille) to target skills addressed by the NCLB test for instructors of the visually impaired (National Blindness Professional Certification Board, 2009). Second, we randomly assigned letters to training units in our current study, but it is possible that a more thoughtful arrangement of letters could facilitate the formation of discriminations. In particular, certain braille characters appear very similar (e.g., “I” and “E”; see Figure 7 for the corresponding braille characters). Systematically pairing the most similar stimuli may promote more fine discriminations. Future evaluations will be necessary to determine if this is the case.

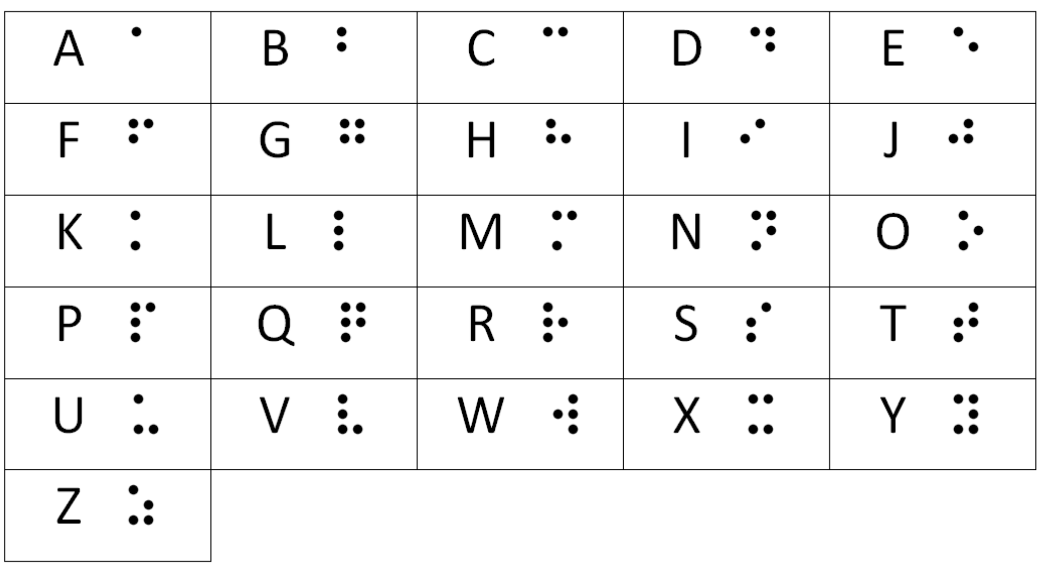

Figure 7. Each English letter corresponding to its braille character.

It would also be interesting to determine if requiring a constructed response in lieu of a selected response (i.e., type the letter in lieu of a multiple choice format) facilitates generalization and maintenance of learning. For example, Tudor (1995) found constructed responding improved the effectiveness of a computer-based program relative to a multiple-choice format. Several studies have suggested that having participants generate a response from all items in a stimulus class (e.g. the entire alphabet), as opposed to choosing a response from a limited subset of the stimulus class (e.g. 5 multiple choice options from the alphabet), can improve performance on a post-test covering the material in training. This is often termed the generation effect and has especially been seen when including stimuli that frequently occur in the individual's environment (Hirshman & Bjork, 1988). We are currently analyzing this by manipulating the response method (i.e. multiple choice or constructed response) and comparing the time in training and reading performance at post-test and maintenance assessment.

This study displayed the effectiveness of a computer-based program for instruction of the relationship between text letters and braille characters. In our population, sighted adults, this trained relation also led to the transitive relation of an improvement in braille reading. This is a valuable extension of past research in that it allows for a training program that can be easily accessible to a large number of people from any location.

End Note

1. This statement is true of alphabetic, or Level-1, braille. Contracted, or Level-2, braille includes a number of contractions of commonly occurring words which are not part of typical English writing. With some debate among the braille community, those contractions are typically introduced following mastery of alphabetic braille.

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Vita

Mindy Scheithauer was born in 1987, in Lorain, Ohio. Mindy graduated from Clearview High School in 2005 with several college credits obtained at Lorain County Community College. After graduation, Mindy attended Ohio University and graduated with a Bachelor of Science degree in psychology in 2007. Following this, Mindy enrolled in a clinical psychology program at Ball State University where she obtained her Master of Science in psychology. In 2009 Mindy was accepted into Louisiana State University's doctoral program in psychology under the supervision of Dr. Jeffrey Tiger where her research interests have focused on behavioral concepts and treatments. She is currently completing her second year of graduate school and intends on pursuing her doctoral degree in psychology with emphasis in biological and clinical psychology.