Research Reports

Efficacy of Using Vocabulary Flashcards in Braille

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Despite the fact that academic vocabulary growth is an important area on which to focus for the success of students (Nagy & Townsend, 2012), little research attention has been given to academic vocabulary instruction for students who read braille. The majority of vocabulary research with this population focuses on a functional approach to literacy rather than on academic vocabulary. Of this research, most is from the perspective of practice. D'Aurizio (2011) shared a case study of one student's progress over four years of learning words using a functional approach. Campbell (2011), McMillan (2015), and Schles (2015) all provided progress monitoring data on student word reading over time, and all showed dramatic improvements in the number of mastered words.

Hooper, Ivy, and Hatton (2014) researched functional vocabulary instruction using a multiple probe design. They used constant time delay to teach four students 12 words each, using 5 × 7 index cards. Although they had success with three of the four participants, there was a great deal of variability in the data. Based on the success of constant time delay to teach functional vocabulary words, Ivy and Hooper (2015) conducted another study using constant time delay to teach academic vocabulary. In that study, they used 3 × 5 index cards to teach academic vocabulary words to two students (a third participant learned notation in the Nemeth Braille Code for Mathematics and Science Notation). Results showed that constant time delay was an effective procedure for teaching academic vocabulary. One participant learned 37 out of 40 words, and the second participant learned 30 out of 40 words using the procedure. The remaining words were identified by the participants outside of the instructional condition, meaning they either generalized their learning from other word sets or learned to identify the words through other means.

Savaiano, Compton, Hatton, and Lloyd (2016) used an adapted alternating treatments design to examine whether students would learn vocabulary words faster with auditory-only instruction or when 2 × 3 flashcards were used. They taught three students 18 words each and found that participants learned the words in both conditions, but that all three participants learned faster in the auditory-only condition. Despite learning faster (Savaiano et al. defined "efficiency" as reaching mastery in fewer sessions) in the auditory-only condition, all three participants learned how to spell words learned in the flashcard condition. Participants did not learn to spell words in the auditory-only condition. Neither study of constant time delay measured whether students were able to write the words learned. Though Campbell (2011), D'Aurizio (2011), McMillan (2015), and Schles (2015) mention writing tasks that went along with vocabulary instruction, no data on writing were provided.

There is mounting evidence that using flashcards is an effective method of teaching academic vocabulary words to students who read braille. The present study was conducted in response to the findings of Savaiano et al. (2016), who concluded that, although the auditory-only instruction was experimentally more efficient, the difference in the number of sessions required to achieve mastery was not instructionally relevant, especially when considering the improvement in spelling during the flashcard condition.

In the present study, we examined whether vocabulary flashcards facilitate spelling acquisition. To address this question, we used flashcards to teach the meanings of novel words to a student who reads braille. Instruction

included the following components: the target word was spoken aloud, the target word was used aloud in a sentence, and the target word definition was spoken aloud. The flashcard was presented after all three spoken components, and no instructions were provided related to spelling. This study addressed the following research questions: Are flashcards paired with auditory instruction effective for teaching the meanings of words to students who read braille? Can students who read braille learn to spell words accurately and incidentally when flashcard vocabulary instruction is used?

Methods

Participants

The Institutional Review Board of Vanderbilt University approved this research, and informed consent and assent were obtained. To be included in the study, a student had to be diagnosed with a visual impairment, read braille at a second-grade level, be enrolled in grades three to six, speak English as a primary language, and have hearing within typical limits. The participant in this study, Peter (a pseudonym), was diagnosed with bilateral anophthalmia and used braille as his primary learning medium. When given the EVALS Braille Reading Assessment (Texas School for the Blind and Visually Impaired, 2007), he was able to immediately and independently identify 131 (69%) of the 189 braille contractions tested. He tested at a 2.5 grade equivalency on the Word Identification and Word Attack subtests of the Woodcock-Johnson III Normative Update Braille Adaptation (WJ-III BA; Jaffe & Henderson, 2010).

Word sets

For a detailed description of the procedures used to select words, definitions, and sentences used in the word sets, see Savaiano et al. (2016). During the initial probe, Peter knew the definitions of two words in word set A, one word in word set B, and four words in word set C. These words were replaced, and in the second session Peter knew the definitions of one word in word set A and one word in word set C. These words were replaced, and in the third session Peter was unable to define any words. The words used in the third session became the final word sets for Peter. Table 1 shows the final word sets and definitions.

Table 1
Final word sets and definitions.

Word set	Word	Definition
A	Sprint	A fast run
	Immense	Huge
	Scorn	Extreme dislike
	Diversity	Variety
	Dual	Having two parts
	Deface	Ruin the surface
B	Mimic	To imitate or copy
	Conjugation	The way a verb changes
	Wrath	Anger
	Reliable	Dependable
	Frail	Weak
	Rapid	Very fast
C	Graceful	Smooth and elegant
	Ramp	Slope to join two levels
	Indolence	Laziness
	Moss	Green plant with no flowers
	Persuasive	Convincing
	Fraternal	Brotherly

Response definitions and measurement procedures

Data on two dependent variables were collected during each session: definition recall and spelling. Since our research question on efficacy related to word meanings, definition recall was the dependent variable used to guide experimental design decisions.

Definition recall. *Definition recall* refers to the ability to produce the meaning of a target word when prompted with the question, "What does [word] mean?" A score of 0, 1, or 2 was recorded for each target word. A

score of 2 was recorded for correct responses. A score of 1 was recorded for marginal or generalized responses, and a score of 0 was recorded for incorrect responses. A total score for definition recall was calculated for each word set by adding the individual scores for the six words within each set, and this score was graphed.

Spelling. *Spelling* refers to the ability to write a word in braille using the correct letters and contractions. A score of 0, 1, or 2 was recorded for each target word. A score of 2 was recorded for correct spellings using all appropriate letters and contractions. A score of 1 was recorded for spellings that were correct, but did not include appropriate contractions. A score of 0 was recorded for words that were spelled incorrectly or not spelled. A total score for spelling was calculated for each word set by adding the individual scores for the six words within each set, and this score was graphed.

Experimental design

A multiple-probe design across word sets (Gast, Lloyd, & Ledford, 2014) was used to determine the effects of a flashcard vocabulary instruction strategy on correct definitions and correct spellings. Definition recall was the primary dependent measure on which design decisions were based. Multiple-probe designs are appropriate for irreversible behaviors, such as vocabulary learning. Each session took place on separate, consecutive school days during the academic year.

Probe. For the initial probe condition, data were collected on Peter's definition recall and spelling of target words until a stable baseline was established. Because it was critical that he not know the meanings of target words, when a score of 1 or 2 was recorded during an initial probe, the word was replaced. Data were collected using probe procedures until three consecutive data points were collected with scores of 0 recorded for all words.

Each probe session followed the same procedures. The investigator asked Peter, "What does [word] mean?" and waited for a verbal response. Then the investigator asked, "How do you spell [word]?" and waited for the student to braille a response. All word sets were assessed in probe sessions.

Intervention. Each intervention session included a probe of all word sets for definition recall and spelling at the beginning of the session, prior to instruction. During instruction, the first author gained Peter's attention and said, "The first word is [word]. What is the word?" After the student repeated the target word the investigator provided praise and continued, "[Word] means [definition]. [Uses word in a sentence]. What does [word] mean?" After the student repeated the definition, the investigator provided praise and placed the flashcard on a rubber mat in front of Peter saying, "This is the word, [word]." After Peter moved his hands across the word, he returned the flashcard and the first author continued to the next word. This procedure continued until all the words in the set were covered. Intervention sessions continued until Peter reached mastery. Mastery was defined as a total score of 12 for three consecutive sessions.

Interobserver agreement

Independent coders were trained to collect interobserver agreement data for both dependent variables (definition recall and spelling) until coders reached 90% agreement with the first author. A point-by-point method was used to calculate interobserver agreement for definition recall and spelling. Interobserver agreement data were collected on 38% of sessions. Average interobserver agreement was 99.4 (94.4–100) for definition recall and 98.9 (94.4–100) for spelling.

Procedural fidelity

Data on procedural fidelity were collected through event recording (Ayres & Gast,

2010). The independent observer recorded occurrence or nonoccurrence of each step of the procedure. Some steps were meant to occur once per session, and some steps occurred or did not occur multiple times per session. The average percent fidelity for each step was calculated as the number of observed occurrences divided by the number of expected occurrences, multiplied by 100.

Procedural fidelity data were collected for 42% of all sessions. Average procedural fidelity was 100 during probe sessions and 99.6 (66.7–100) during intervention sessions. The procedural step that fell below levels of acceptance, flashcard provided, was during the first intervention session and was due to confusion about the location of the procedural step on the data collection form. The form was revised and used in remaining probes.

Results

Using the vocabulary instruction procedures outlined above, Peter learned the definitions of all 18 target words, and he learned the spellings, including contractions, of 16 out of 18 words. Figure 1 presents Peter's total scores for definition recall. Figure 2 presents Peter's total scores for spelling. The total length of the study was two months (26 days in January and February) from the first session to the final probe.

Definition recall

Data for the initial probe (P1) show that Peter did not know the definitions of the 18 target words. Peter reached mastery in session 11 for word set A, in session 17 for word set B, and in session 24 for word set C. Following implementation of the flashcard instruction (see I1 in Figure 1), there was an immediate increase in level and trend. Using the visual analysis steps defined by Gast and Spriggs (2014), the changes in relative and absolute level as well as in trend were increasing and improving. The increase in level was maintained through subsequent probes (see P2, P3, and P4 in Figure 1), showing a sustained improvement in definition recall. This basic effect was replicated across all word sets, showing a functional relation between the flashcard instruction and increased definition recall.

Spelling

Data for the initial probe (P1) show that Peter was able to correctly spell at least one word in each word set. Following implementation of the flashcard instruction (see I1 in Figure 2), there was an immediate increase in level and trend. In the second probe condition (see P2 in Figure 2), correct spelling in word set A was variable but maintained an elevated level, and correct spelling in word sets B and C decreased. The increases in level of correct spelling were maintained through subsequent probes (see P2, P3, and P4 in Figure 2), showing a sustained improvement in correct spelling. This effect was replicated across all word sets.

Discussion

This study was designed to evaluate whether students who are blind can learn to spell words accurately and incidentally when academic vocabulary instruction is used. Our study was based on previous research by Savaiano et al. (2016) showing that an auditory-only condition was more efficient than a flashcard condition, but that students learned how to spell vocabulary words when the flashcard was present. Through a modification of the Savaiano et al. procedure, we found that flashcard instruction was effective in teaching Peter the meanings of all 18 words, and that Peter was able to learn the correct spelling for 16 out of 18 words without any instruction related to spelling.

Limitations

Although the main effect of flashcard instruction was replicated across all word sets, there are limitations to the generalizability of

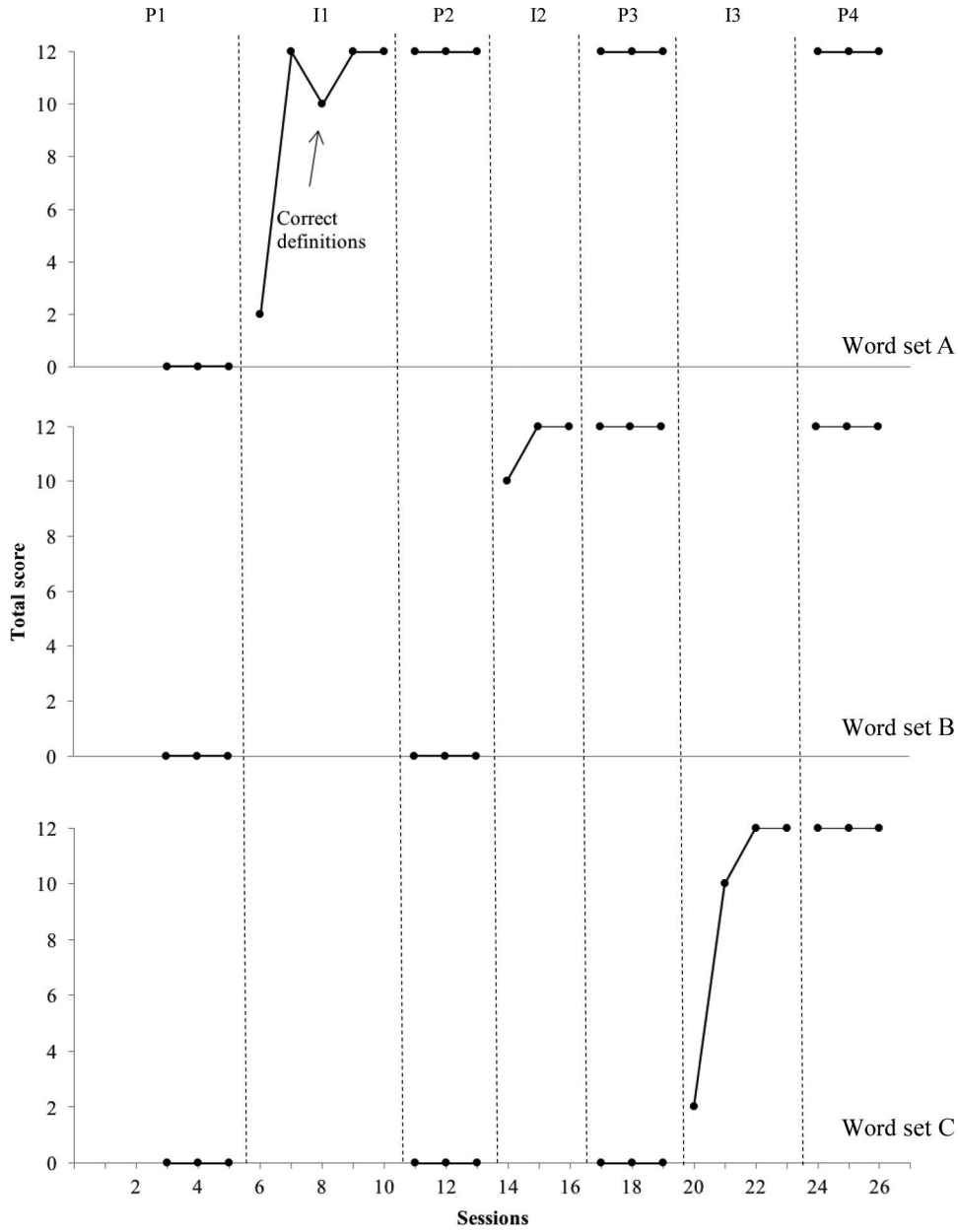

Figure 1. Total score for all target word definitions recalled.

findings from single-subject experimental designs. Peter attended a specialized school for visually impaired students, in modified academic programs, and had no light perception. His results may not reflect the performance of students in different settings or with different characteristics. In addition, only one participant was included in the present study. Although a multiple-probe design across behaviors (word sets) does not require multiple participants, the findings would be stronger if replicated across multiple participants. Even with one participant, however, this study extends the field's knowledge of the efficacy of

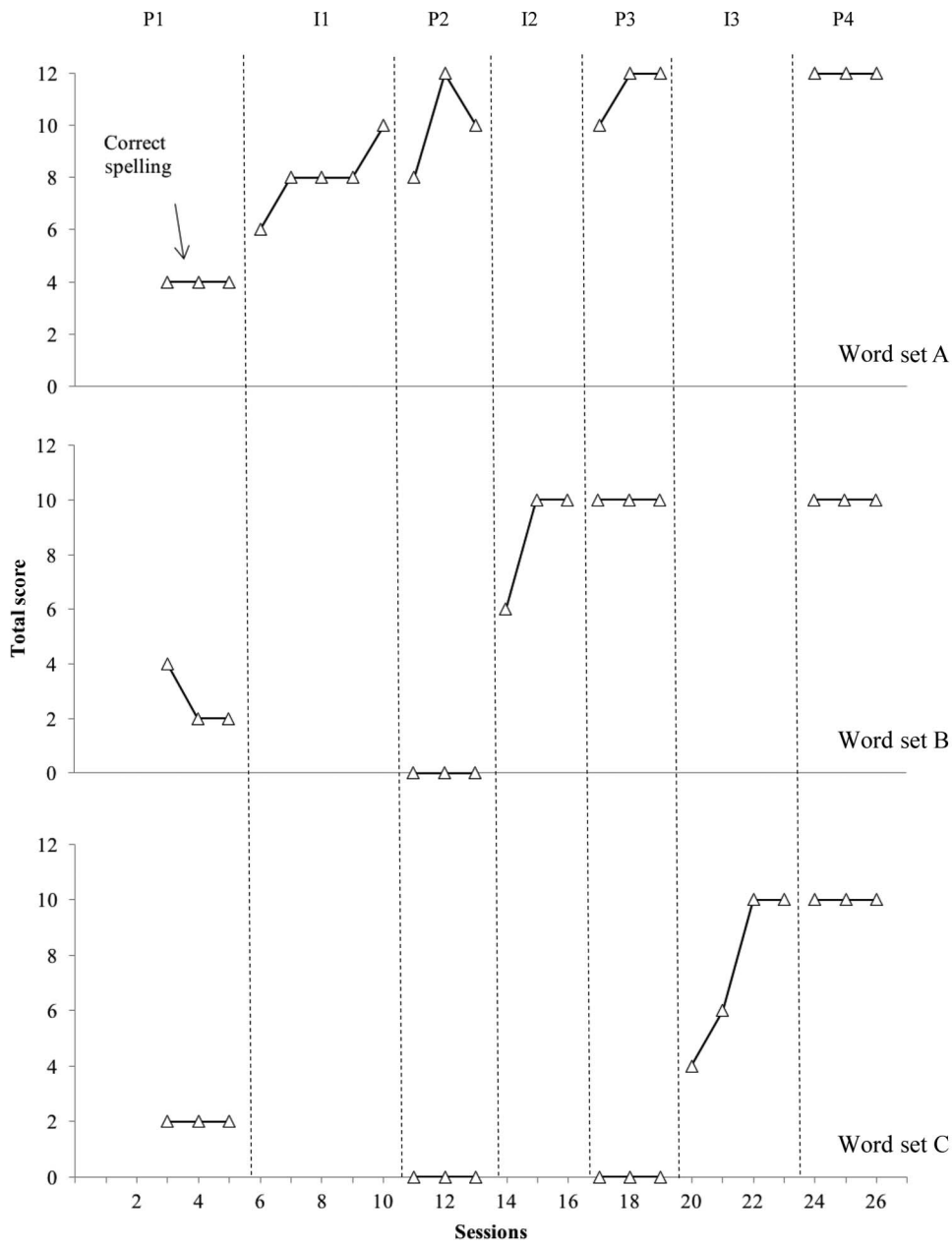

Figure 2. Total score for all target word spellings.

using flashcards with braille readers to teach vocabulary directly while also incidentally teaching spelling.

Implications for research and practice

At the beginning of the study, Peter was able to correctly spell at least one word in each word set. During the second probe session (see P2 in Figure 2), however, Peter did not spell any words correctly in word set B or word set C. In fact, Peter responded, "I don't know" for all the words in those sets when asked, "How do you spell [word]?" For example, even though Peter spelled "ramp"

correctly in sessions 3, 4, and 5, he did not attempt to spell the word "ramp" in sessions 11, 12, or 13. Our hypothesis for this is that prior to session 6 (the first instructional session) Peter was guessing the spelling for all 18 words. After the first instructional session, the presence of flashcards for word set A pointed out that there was a correct way to spell the words and he self-corrected his spelling of those words. Then, when asked to spell words for which he had not seen a flashcard, Peter did not guess. Instead, he said, "I don't know," and waited until flashcards were provided for that set of words before attempting to spell them again. This result for spelling was unexpected. In the Savaiano et al. (2016) study, participants continued to guess the spelling of words in the auditory-only condition even after flashcards had been introduced in another condition.

The present study showed that using flashcards to teach new word meanings can be effective, with Peter reaching mastery in four to six sessions. In the Savaiano et al. (2016) study, participants reached mastery in the flashcard condition between 6 and 23 instructional sessions. This finding suggests that it was not the flashcard itself, but rather the procedures used that caused the flashcard instruction to be less efficient.

In the previous study, flashcards were presented at the same time as auditory information. It is possible that the simultaneous introduction of competing sensory stimuli affected students' working memory and led to more sessions being needed to reach mastery. In the present study, auditory information was provided prior to the introduction of a flashcard, possibly simplifying the working memory load for Peter and making the adapted procedure more efficient. Teachers who use flashcards during instruction might pay attention to how often they are asking students to read and listen to competing stimuli (meaning that the student is asked to read one thing and listen to a different thing at the same time).

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Oral Braille Reading Decoding Strategies of Middle School Students Who Are Blind or Have Low Vision

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The value of literacy is widely recognized. Libraries host story time for young children to encourage interest in reading. Preschools begin literacy instruction with identification and writing of letters. Groups of friends meet for monthly book clubs. Information is more often shared in text messages, e-mail messages, Facebook posts, and Twitter posts called tweets than by telephone calls or face-to-face conversations.

However, students who are visually impaired (that is, those who are blind or have low vision) may face unique literacy challenges as they learn to read and write braille. One such challenge relates to slower reading speeds for students who read braille as compared to those who read print. Wall Emerson, Holbrook, and D'Andrea (2009) found that for students in grades one through four, on average, the reading rates for print readers were approximately 1.5 to 2 times faster than the rates for braille readers, with the differences increasing as the grades advanced. One reason that braille often results in slower reading rates than print is related to perceptual span (Savaiano, Compton, & Hatton, 2014), the number of symbols that can be perceived at one time that provide useful information while reading (Raynor, 1986). For skilled print readers, the width of perceptual span is 14 to 16 characters (Raynor, 1986); however, braille readers perceive significantly fewer cells at a time (Savaiano et al., 2014). One solution to the smaller perceptual span encountered by braille readers is the use of contractions, which allows for combinations of letters to be presented in fewer cells, but this arrangement brings its own challenges. In addition to learning letters, sounds, grammar, and spelling, braille readers must learn almost 200 contractions and composition signs and the rules for using such symbols (Wall Emerson et al., 2009). This extra hurdle influences the decoding skills of braille students. For example, when the contraction for *one* is used in the word *money*, decoding can be challenging because of the syllable break in the middle of the *one* unit and because the letters *o, n,* and *e* sound differently in the word *money* than they do in the word *one*, which is most commonly associated with the contraction.

