Journal of Behavioral Education
https://doi.org/10.1007/s10864-023-09533-5

ORIGINAL PAPER

# The Effects of a Computer-Based Phrase Reading Intervention on Isolated Word Reading in Post-secondary Students with Disabilities

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Accepted: 20 October 2023


## Abstract

The effects of a computer-based reading intervention on whole word reading in three post-secondary students with intellectual and/or developmental disability were evaluated using a multiple baseline across tasks (i.e., word sets) design. Words were selected from each student's elective undergraduate social science course materials. During this stimulus–response–stimulus–response intervention, the computer presented target words embedded within short phrases and the student had 3 s to read the phrase before a recording of the phrase was played. The student then repeated the phrase, and the computer screen provided a new word phrase and the next trial began. During assessment, students read target words in isolation. These words had to be read correctly within 3 s across two consecutive assessments to be considered acquired. Visual analysis of the repeated measures graphs suggests nine demonstrations of a treatment effect and provides evidence of experimental control across all three students. The current results showed that learning to read content-specific words when they were embedded in phrases resulted in generalization (i.e., allowed students to read the words in isolation). Discussion focuses on implications, limitations, and future research.

**Keywords** Computer phrase reading intervention · Post-secondary student with disability · Content-specific words · Learning trials

## Introduction

While phonemic approaches to teaching reading are supported by extensive research, there are instances when teaching students to read whole words may be beneficial (Browder & Spooner, 2011; Ehri, 2005). For example, students with reading deficits who have failed to develop phonemic skills despite receiving years of general, remedial, and special education services may benefit from whole word instruction

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Published online: 18 November 2023

targeting high-frequency words (Browder et al., 2006; Cazzell et al., 2017, 2020; Yaw et al., 2014). Also, students with reading deficits may benefit from learning content-specific words found in secondary and college classes (Cazzell et al., 2016).

Students with a disability enrolled in post-secondary education programs often take elective courses with all other college students (Grigal et al., 2019). When these students have reading skill deficits, they may struggle with content-specific words (e.g., amygdala) that are found in text and instructional materials, such as PowerPoint® presentations (Wright et al., 2021). Being able to read these content-specific words may enhance their learning, engagement, and confidence as they participate in these courses.

Computer-based reading interventions have been used to enhance reading performance (Aspiranti & Hilton-Prillhart, 2021; Cazzell et al., 2016, 2017, 2020; Hilton-Prillhart et al., 2011; Yaw et al., 2011, 2012, 2014). Many computer-based reading researchers have applied stimulus–response–stimulus–response (S–R–S–R) learning trials to enhance word or phrase reading. These interventions were designed to model traditional flashcard instruction. A stimulus (in this case a word/phrase on the screen) is followed by an interval in which the student responds by reading the word/phrase (i.e., response interval). After that interval, a second stimulus is delivered which is an audio recording of the word/phrase. This second stimulus is followed by another response interval in which the student repeats the word or phrase before another word is presented on the screen, initiating the next S–R–S–R trial.

These computer-based interventions have many advantages over traditional flashcard instruction (Cazzell et al., 2016, 2017, 2020; Yaw et al., 2011, 2014). The interventions allow idiosyncratic words or phrases to be targeted. Also, the interventions are generally brief, requiring only 2 to 4 min of student time (Yaw et al., 2011). Finally, because they are computer-based, teachers are not required to deliver interventions to students individually.

Researchers have demonstrated the efficacy of traditional and computer-based flashcard interventions on sight-word acquisition. These interventions have been used to increase word reading automaticity (e.g., accurate reading within 3 s) in students who are receiving tiered reading intervention services (Hilton-Prillhart et al., 2011), students with learning disabilities (Kim et al., 2017), as well as individuals with intellectual and/or developmental disability (Cazzell et al., 2016, 2017, 2020; Yaw et al., 2011, 2012). Cazzell et al., (2016) examined the effects of a computer-based flashcard reading intervention on the acquisition of health-related words in three students enrolled in a post-secondary education program for students with intellectual disability. Each of these students was taking an elective in the College of Nursing, and words were selected from course textbooks. Cazzell et al. found that the intervention increased word reading across all participants.

While Cazzell and colleagues' (2016) results supported the use of the computer-based intervention, maintenance data produced inconsistent results. This limitation of whole word reading interventions has been noted by other researchers (Alberto et al., 2010; Begeny et al., 2006). Another concern with teaching words in isolation is generalization. After reviewing the research on students with intellectual disability, Browder et al., (2006) concluded that there is evidence supporting the teaching of whole words; however, whole word instruction has not been demonstrated to foster strong

generalization in students with intellectual disability. Results from a Martin-Chang et al. (2007) study supported this conclusion as they found that words taught in isolation were often not read accurately when embedded in text.

To address maintenance and generalization concerns, researchers have focused on teaching words embedded in phrases (Alberto et al., 2010; Begeny et al., 2006; Cates & Rhymer, 2006). Archer and Bryant (2001) taught students to read unknown words embedded in sentences or in isolation using S–R–S flashcard trials. Dahl (1974) taught students words in context and words in isolation. Students who learned words in context demonstrated greater accuracy and comprehension when reading text than those who learned words in isolation. Alberto et al. (2013) showed that teaching meaningful phrases increased generalized reading to real world text and elected reading materials. After reviewing the literature, Alberto et al. (2010) concluded that repeated and targeted phrase practice may enhance students' ability to read words in context, reading fluency, and reading comprehension.

Researchers have begun to investigate tablet-based interventions to enhance phrase reading in elementary students with and without intellectual disability (Aspiranti & Hilton-Prillhart, 2021; Aspiranti et al., 2022). These interventions are similar to the S–R–S–R whole word interventions provided via computers (e.g., Cazzell et al., 2016; Hilton-Prillhart et al., 2011). Results indicated that phrases were quickly acquired and that students were able to maintain previously acquired phrases. Although phrases were rapidly acquired in both studies, researchers were unable to determine whether students were correctly identifying individual targeted words included in each phrase, or if students used already known words embedded in phrases and phrase memorization to read targeted words. Thus, students may be learning to read words embedded in specific phrases but struggle to read those words when they are presented in a different context (e.g., in isolation or when embedded in other phrases or text).

## Purpose of the Present Study

It is possible that learning to read words in phrases may not teach students to read words in isolation without any context cues (Aspiranti et al., 2022). In the present study, we evaluated the efficacy of a computer-based phrase-reading intervention (CBPRI) in post-secondary students with intellectual and/or developmental disability. Our primary goal was to examine whether S–R–S–R phrase-reading learning trials would increase students' word reading in isolation without the aid of the surrounding stimuli (i.e., other words in phrase), which would constitute a form of generalized responding.

## Method

### Participants and Setting

Participants included three students who were enrolled in a post-secondary education program for students with intellectual and/or developmental disability at a university in the southeastern USA. Two of the participants self-identified as female,

and one participant self-identified as male. All participants were between 20 and 22 years old and identified as Caucasian. All three participants received special education services in high school. Student reading levels ranged from third through ninth grade. Participant data were de-identified, and pseudonyms are used in the reporting of this study. Research procedures were conducted in a small section of a room that was designated for study space during a brief segment of each student's daily study session period or break period.

## Materials

Target words were gathered from the glossary section of each student's respective social science course textbook (see Appendix A). The researcher created the stimuli used during assessments by printing each word in black Times New Roman 20-point font on a 3 × 5, unlined index card. Words were present with all lowercase letters.

Step-by-step instructions from Hopkins et al. (2011) were used to design the CBPRI using laptop computers and Microsoft® PowerPoint®. Researchers developed intervention materials by preparing a separate S–R–S–R learning trial clip for each two- or three-word phrase containing an unknown word. The first stimulus was the phrase appearing on the computer screen centered on the PowerPoint® slide in lowercase, black, 48 point, Times New Roman font. After 3 s, a recording of an experimenter reading the phrase being read was played, which required approximately 2 s. After the recording was played and while the phrase was still presented on the screen, the student had another 3 s response interval to read or repeat the phrase. Thus, each learning trial required about 8 s, two 3 s response intervals and 2 s for the recording of the phrase being played. After the second 3 s response interval ended, another clip containing the next S–R–S–R trial began as the next phrase appeared on the computer screen. As 21 trials were conducted per session, each session required 168 s.

The CBPRI did not include any evaluation of student reading (e.g., no speech recognition or evaluation software). The intervention was designed so that students could use the recording of the word being played to evaluate their response during the first interval and/or prompt accurate reading during the second response interval. Thus, after the student pressed the space bar to start the CBPRI, it proceeded sequentially through all 21 trials, regardless of student responses.

## Measures

Unknown word acquisition was the dependent variable. Unknown words were those that were never read correctly within 3 s over five pretesting assessments. For a word to be considered acquired, students were required to correctly read the word within 3 s across two consecutive assessments. Words were only scored as correct when the entire word was read correctly within 3 s. Words were not considered correct when part of the

word was mispronounced (e.g., pronounced silent letters), sounds, pre-fixes, or suffixes were added or omitted (e.g., did not pronounce the s at the end of the word), or students dropped the volume of their reading to a level which prevent researchers from determining if the entire words were read correctly (e.g., student stated the first two syllables clearly and then dropped their voice and muddled something incoherent on the third syllable). An experimenter-constructed social validity form was completed by each participant after the study was completed (see Table 2).

## Experimental Design and Analysis

For each student, a multiple baseline across tasks (i.e., three mutually exclusive sets of seven unknown words) design was used to evaluate the efficacy of the CBPRI on word acquisition (Kazdin, 2020). This design was appropriate because maintenance of acquired words was anticipated as these words were included in the materials (e.g., text, PowerPoint® slides) that students used for their elective classes. Phase changes were applied (i.e., the intervention was applied to the next set of word) after participants acquired five or more of the seven words from a set. There was one exception. If a student read five or more words correctly on a Thursday or one day before a holiday, we continued with the intervention with that set for one more day. This was done to avoid introducing a new word set when the next application of that word set could not occur until after the weekend or holiday, which would result in at least a 70-h delay before students were exposed to that new word set a second time.

The criterion for altering word sets at five, rather than all seven words acquired from a word set, was established for applied reasons. We were concerned that some students may struggle to read some words, especially difficult to pronounce words. As students were being exposed to these words in their college classes, we wanted to teach as many words as possible within the time allotted for the study. Thus, a criterion of five words was established to avoid spending multiple sessions (e.g., five or more sessions) where a student could only acquire one or two additional words. By moving to another set of words after five words were acquired, we hope to allow them to acquire many more words in the same number of sessions. Because assessments always included all 21 words, seven from each set, maintenance data for Sets A and B words were collected after the intervention was moved to the next set of words. No maintenance data were collected for Set C words.

Each students' data were analyzed for each set of words. Visual analysis of within and across phase data (level, trends, variability, and immediacy of changes) displayed on time-series graphs was used to interpret results (Kazdin, 2020). This visual analysis was supplemented with *Tau* effects size calculations (Parker et al., 2011).

## Procedures

After university approval was provided, informed consents and assents were obtained for each participant. All procedures were conducted by the primary experimenter working individually with each student at a table. Pretesting assessments

were used to identify an individualized pool of 21 unknown words for each participant. Next the primary experimenter constructed CBPRI materials, students were trained, and the intervention was applied to three sets of words (i.e., Sets A, B, and C words) sequentially.

### Pretest Assessments and Baseline Phase

During each pretest session, the primary experimenter assessed each participant on 100 words that the primary experimenter obtained from the glossary section of each of student's social science course textbooks. All words were printed on unlined $3 \times 5$ index cards. Before each of the pretesting sessions, students were instructed to try to read each word presented on an index cards to the best of their ability. They were informed that after 3 s they would be presented with the next word. Finally, they were asked if they had any questions before beginning. Participants were pretested across five consecutive school days. Each day, the 100 words were presented in random order and no feedback was given to participants. Any words read correctly on any session were excluded from the intervention. From the remaining unknown words, 21 words were randomly selected for each student and randomly assigned to three sets (i.e., Sets A, B, and C) each containing 7 unknown words.

Pretest session data were also used for baseline data for two reasons. Repeatedly asking students to read unknown words without any instruction could cause negative side effects and hinder learning (Cuvo, 1979; Horner & Baer, 1978). Also, students were enrolled in their elective courses and using pretesting data for baseline allowed us to advance students to the intervention sooner.

### Computer-Based Phrase Reading Intervention

After pretesting, researchers developed the CBPRI and training materials for each student. Next, they trained each student how to respond during the CBPRI and then began the intervention immediately after training. After this first intervention session, each session began with each student being assessed across all 21 words. Immediately following the assessment, participants completed a CBPRI targeting one of the three sets of words. Thus, assessment occurred at least 21 h after their last intervention session.

### Developing the CBPRI

Before training students, the experimenter identified all words that were never read correctly during pretesting and randomly selected 21 words per student to be included in the intervention. These 21 words were then randomly assigned to one of three sets. For each of the unknown words, researchers developed a brief two- or three-word phrase to be presented during the intervention (see Appendix A) and

then used Microsoft® PowerPoint® to develop a S–R–S–R clip for each phrase. Interventions were constructed for each set of seven phrases by sequencing the seven clips in random order and combining three of these seven-clip sequences so that each intervention contained 21 clips (i.e., 21 S–R–S–R learning trials) with each phrase being presented three time. As each learning trial (i.e., clip) required about 8 s (i.e., 3 s to read the phrase that appeared on the screen, 2 s for audio recording of the phrase to be played, and another 3 s to read the phrase before the next clip was played), the CBPRI required 168 s.

### Intervention Training

After researchers developed the interventions, they trained students how to respond during the CBPRI. Using each student's pretesting data, the experimenter selected two words read correctly over the last three pretesting assessments and two unknown words (i.e., never read correctly during pretesting) that were not included in the 21 phrases used during the intervention. Brief phrases and S–R–S–R clips were developed along with a CBPRI which only contained phrases for these four words. Instructions, adapted from a previous study (Cazzell et al., 2020), were read aloud to the students. The instructions were:

> *When you are ready, press the spacebar to see your first phrase. When the phrase appears, attempt to read the phrase to the best of your ability within 3s. Then, wait to hear the phrase being read aloud to you. Once you hear the phrase, repeat the phrase aloud. The program will transition to the next phrase automatically. You will repeat this procedure for every phrase. Do you have any questions?*

On the first training session, experimenters provided verbal prompts to students as they progressed through the four-clip sequence. Then, each student was asked to practice using the four-clip training three more times. Over the three practice sessions, all participants demonstrated the ability to use the intervention with no prompting beyond being told to press the space bar to begin.

### Intervention Implementation

For each student, immediately after their CBPRI training, implementation of the intervention began, starting with the seven Set A words and phrases. Instructions similar to training instructions were read aloud, but the experimenter informed the student that they would work on the intervention for about 3 min. The intervention began when the experimenter instructed the students to press the space bar. The CBPRI then provided the 21 S–R–S–R trials (21 clips). During the first and all subsequent interventions, the experimenter always read instructions allowed and never paused the intervention or provided additional instructional prompts. After each 168 s CBPRI, the experimenter praised students for working hard to learn the

phrases. Sessions were conducted during consecutive school days and only skipped when a participant was absent.

After this first training and intervention session, each subsequent session began with an assessment of all 21 words (7 words from three sets) presented on index cards in random order. Thus, there was a delay of at least 21.5 h between each intervention and assessment. With one exception, assessment instructions and procedures were identical to pretesting (e.g., primary experimenter presented words on index cards every 3 s, and words read correctly within 3 s were scored as correct). The one difference between pretesting assessments and intervention phase assessments is that only the 21 selected unknown words were assessed during the intervention phase. A word was considered acquired after it was read correctly within 3 s across two consecutive assessments.

### Acceptability

After experimental procedures were completed, each participant completed an acceptability questionnaire (see Supplemental Materials) that contained five Likert scale items (strongly disagree = 1, strongly agree = 5). Another researcher administered the questionnaire individually by reading each item aloud as the student followed along. The researchers responded to any questions and provided clarification when needed.

### Procedural Integrity and Interobserver Agreement

A second researcher independently observed and recorded procedural integrity data and words read correctly within 3 s during assessments. These data were collected for each student across 20% of pretest/baseline assessments and 22% of treatment phase assessments. An adapted version of the procedural integrity checklist developed by Cazzell et al. (2020) served as a protocol for the lead researcher and was used by a second researcher to record procedural integrity data (see Appendix B). Procedural integrity was 100% for all sessions. Interobserver agreement was calculated by dividing the number of agreements on words read correctly within 3 s by the number of agreements plus the number of disagreements, then multiplying by 100. Average interobserver agreement across sessions was 98%. During baseline assessments, average interobserver agreement was 99% with a range of 98–100%. During intervention assessments, average interobserver agreement was 97% with a range of 86–100%.

## Results

Figures 1, 2 and 3 present the number of words acquired for Maggie, Megan, and Caleb across baseline, intervention, and maintenance phases for all three sets of words. As pretesting data were used for baseline, baseline data were zero across the

first five baseline sessions for all students and word sets. Because a word was not considered acquired until it was read correctly across two consecutive assessment sessions, it was rare to see any increases in words acquired following the first intervention session.

## Maggie

Figure 1 shows that Maggie began to acquire Set A words following the second intervention session and then showed a rapid increase in words acquired following

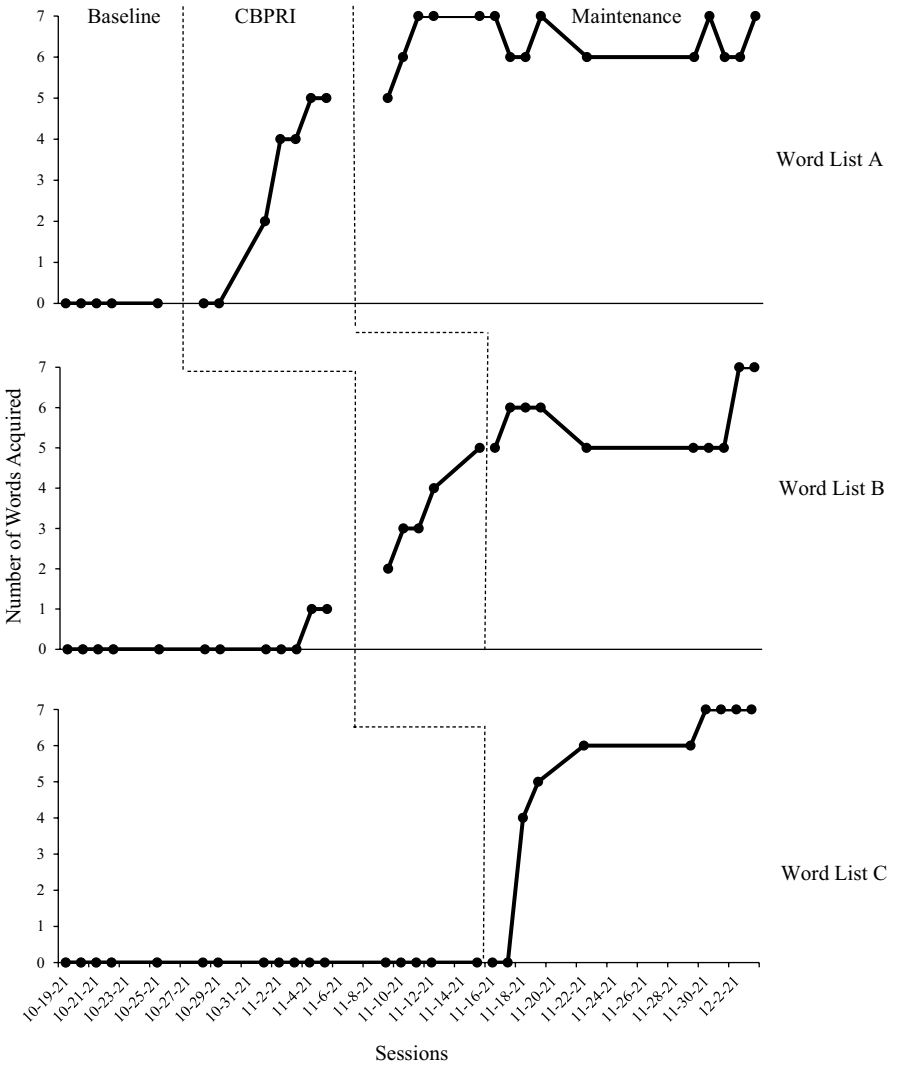


**Fig. 1** Words acquired by Maggie across phases

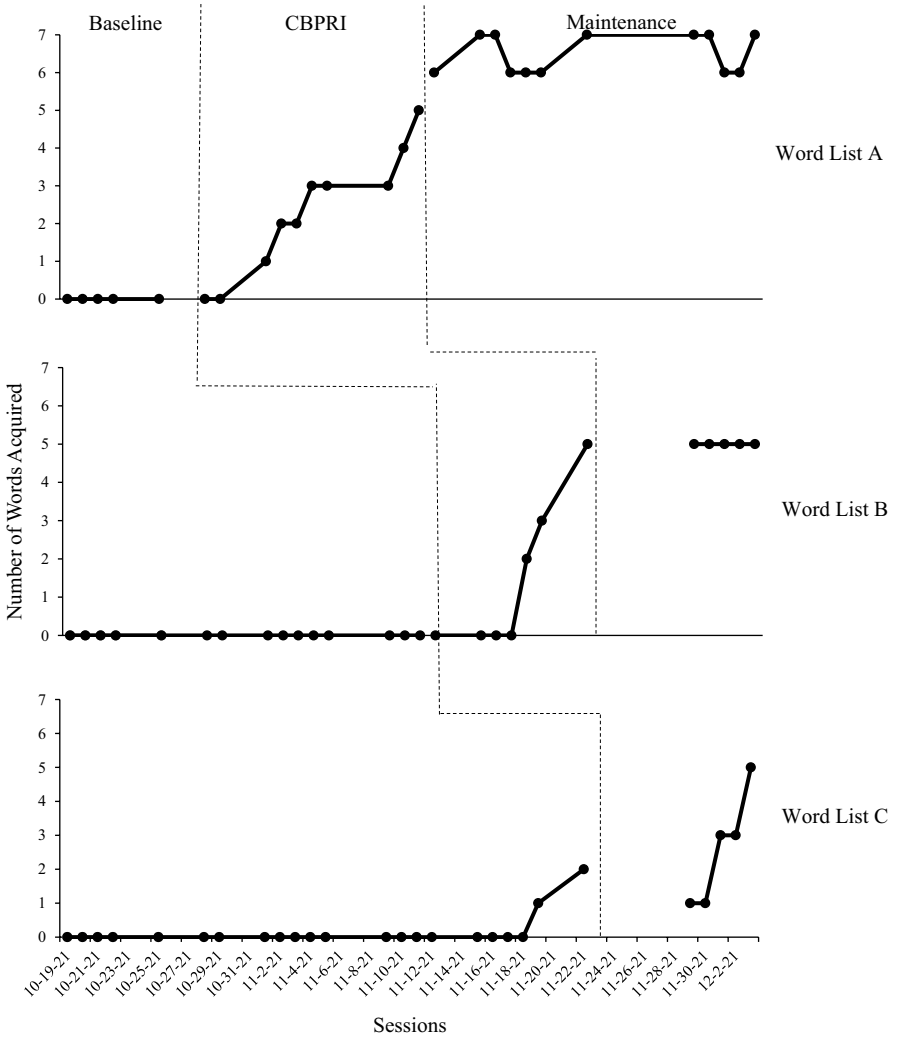


**Fig. 2** Words acquired by Megan across phases

intervention sessions three and four. Then, word acquisition during the intervention phase slowed. During the maintenance phase, Maggie continued to acquire unknown Set A words when the intervention was no longer applied to Set A. After the first maintenance phase, Maggie fluctuated between six and seven Set A words acquired for the remainder of the maintenance phase.

Baseline data for Set B words were stable at zero until just before the implementation of the intervention, when Maggie acquired one word. Upon implementation of

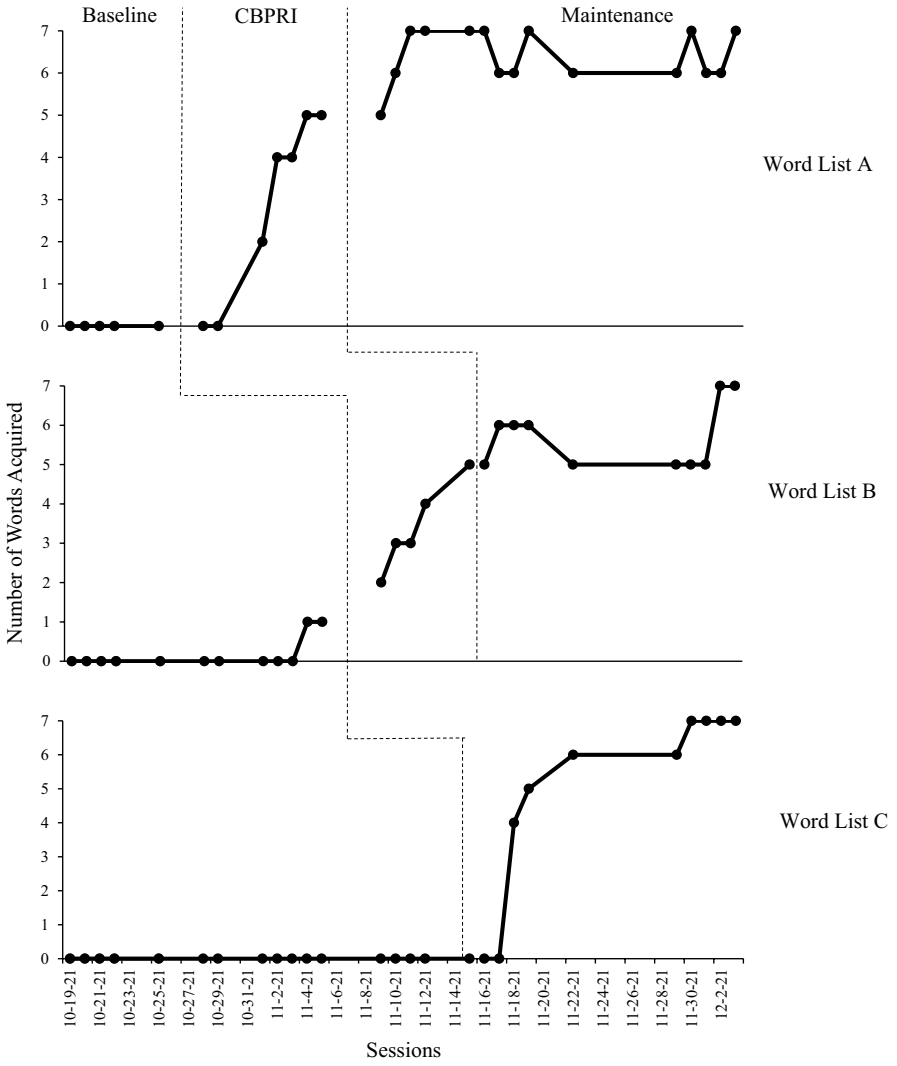


**Fig. 3** Words acquired by Caleb across phases

the intervention, there was an immediate increase in the number of words acquired. The acquired Set B word on the first day following the first intervention phase session indicates Maggie read the word correctly on the final baseline session. There is an increasing trend in Set B words acquired during the intervention phase. Upon initiation of the maintenance phase, Maggie acquired one more Set B word, which remained stable for three sessions. Over the next three maintenance sessions, Maggie reverted to reading five Set B words correctly within 3 s. Data collected over

the final two maintenance sessions indicated that Maggie acquired all seven Set B words.

No Set C words were acquired during baseline. After the intervention was implemented, there was an increasing trend in words acquired which decelerated as Maggie acquired more words. As this was the last word set, intervention continued after Maggie met criteria. Data show that Maggie acquired all seven Set C words in eight sessions.

The final data collection points indicated Maggie acquired all 21 words. For each word set, Maggie showed increases in words acquired shortly after the intervention was applied, providing three demonstrations of a treatment effect. Although Maggie acquired one Set B word over 12 baseline sessions, her rates of Set B word acquisition increased after the intervention was applied. The increase in words acquired after the intervention was applied and the small increase in only Set B words during baseline established experimental control by providing repeated evidence that the CBPRI, as opposed to threats to internal validity, caused most of the increases in Maggie's acquisition (Kazdin, 2020).

### Megan

Figure 2 displays the number of words acquired by Megan across phases. Upon implementation of the intervention, Megan began to acquire Set A words following three intervention sessions, followed by an increasing trend, which started gradually and accelerated before transitioning to the maintenance phase. During the first maintenance phase, there was an immediate increase in Set A word acquisition. For the remainder of the Set A maintenance phase, Megan fluctuated between six and seven words acquired.

Baseline data for Set B words remained at zero. No immediate growth in Set B word acquisition was seen after the intervention was applied. Following three intervention sessions, an increasing trend was observed as Megan acquired five Set B words across the next three sessions. No additional Set B words were acquired during the maintenance phase.

Baseline data for Word Set C were stable at zero until just before the implementation of the intervention when Megan acquired two words. One of the acquired Set C words was lost immediately after the intervention was applied to this word set. After two intervention sessions, Megan began to acquire words, reaching the five-word criterion after five intervention sessions.

The final data collection points indicated that Megan acquired 17 of the 21 words. For each word set, Megan showed increases in words acquired shortly after the intervention was applied. Although Megan acquired two Set C words over 22 baseline sessions, her rate of Set C word acquisition increased after the intervention was applied. The increase in words acquired after the intervention was applied established experimental control by providing repeated evidence that the CBPRI caused most of the increases in Megan's word acquisition.

### Caleb

Figure 3 shows the number of words acquired by Caleb. Caleb began acquiring Set A words after three intervention sessions and then his learning increased rapidly as he acquired five words following the final five intervention session. All acquired Set A words were maintained after the intervention was applied to subsequent word sets. During maintenance, Caleb increased his Set A words acquired and his performance fluctuated between six and seven words acquired over the final 15 maintenance assessments.

Baseline data for Set B words were stable at zero until the final two baseline phases when Caleb acquired one word. After the intervention was applied, Caleb immediately began acquiring Set B words and showed a fairly steady increase, reaching the criteria of five words acquired in five sessions. During the maintenance phase, Caleb continued to acquire Set B words but the trend was not stable. He reached the maximum of seven words on the final two maintenance assessments.

During the baseline phase for Set C words, Caleb acquired no words. When the intervention was implemented, there was not an immediate increase in Set C words acquired. However, following the fourth CBPRI session there was a rapid increase in words acquired and Caleb acquired five Set C words following five CBPRI sessions. During five more session, he acquired all seven Set C words.

The final data collection point indicated that Caleb acquired all 21 words. Caleb acquired one Set B word over 12 baseline phase assessments; however, across all word sets his rate of word acquisition was much more rapid after the intervention was applied. Thus, experimental control was established for Caleb.

## Effect Size

A web-based calculator (Vannest et al, 2016) was used to calculate Tau scores which provide a calculation of effect size through the percentage of non-overlapping data (Parker et al., 2011). To identify trends in baseline phases, each baseline phase was contrasted with itself. Across all nine baseline phases, no baseline trends were significant; thus, we calculated *Tau* statistics, as opposed to *Tau-U*. *Tau* and *p* values for each baseline to intervention phase comparison are displayed in Table 1. These data show that for Set B words the effect size for Megan was 0.50 and the $p = 0.077$.

**Table 1** Effect sizes (Tau) and P values for each student

| | Set A | | Set B | | Set C | | Omnibus | |
|---|---|---|---|---|---|---|---|---|
| | Tau | P value | Tau | P value | Tau | P value | Tau | P value |
| Maggie | 0.714 | 0.042 | 1.000 | 0.002 | 0.800 | 0.001 | 0.838 | 0.001 |
| Megan | 0.800 | 0.014 | 0.500 | 0.077 | 0.945 | 0.001 | 0.739 | 0.001 |
| Caleb | 0.714 | 0.042 | 1.000 | 0.002 | 0.727 | 0.002 | 0.798 | 0.001 |

With this one exception, all other *Tau* scores exceed 0.714 and all *p* values were less than 0.05. For each student, Omnibus *p* values were all less than 0.001 and omnibus *Tau* scores ranged from 0.739 to 0.838. These data support our visual analyses and suggest that the CBPRI enhanced word acquisition.

## Student Acceptability

Each participant completed a five-item acceptability questionnaire. All items were rated on a scale from 1 (strongly disagree) to 5 (strongly agree). The items and student responses are displayed in Table 2. All responses were positive, with small variability in responses across participants. The average response was 4.33 for the item "The computer-based reading intervention was easy to use." The average rating was 4.00 for the items "I would like to continue using a computer-based reading intervention" and "Others in my class would like the computer-based reading intervention." For the items "I like using the computer-based reading intervention," and "The computer-based reading intervention helped me learn new words," the average response was a 3.67.

## Discussion

The purpose of the present study was to evaluate the efficacy of a CBPRI in post-secondary students with intellectual and/or developmental disability. Specifically, we evaluated whether words taught in phrases would increase students' ability to read unknown course-specific words in isolation. Visual analysis showed that across each word set, after the intervention was applied, all three students showed an increase in word acquisition learning rates. Additionally, students showed no or small increases in words acquired during baseline phases. Thus, our multiple baseline data provided nine demonstrations of a treatment effect and repeated demonstration of experimental control across all three students (Kazdin, 2020). These visual analyses were supported by our effect size analyses. After the intervention ceased for both Sets A and B, data indicated that students maintained their ability to read the words in isolation.

**Table 2** Student responses to acceptability items with 1 = strongly disagree and 5 = strongly agree

| Acceptability responses | |
|---|---|
| Item | Responses |
| The computer-based reading intervention was easy to use | 5, 4, 4 |
| I would like to continue using a computer-based reading intervention | 5, 4, 3 |
| Others in my class would like the computer-based reading intervention | 4, 4, 4 |
| I like using the computer-based reading intervention | 4, 4, 3 |
| The computer-based reading intervention helped me learn new words | 4, 4, 3 |

The current results are consistent with previous findings of researchers who have evaluated computer-based interventions to teach words or phrases (Aspiranti & Hilton-Prillhart, 2021; Aspiranti et al., 2022; Cazzell et al., 2016, 2017, 2020). Our findings extend this research by demonstrating that teaching words in phrases may enhance students' ability to read words in isolation, without the surrounding text or context cues. These results suggest that students were not learning to read or memorize phrases (Aspiranti et al., 2022); rather, they were learning to read the words within the phrases.

## Limitations and Future Research

While the current data provide strong evidence supporting the intervention's possible efficacy, there were instances of students acquiring words during baseline. Before the intervention was applied, Maggie and Caleb each acquired one Set B word, and Megan acquired two Set C words. Also, maintenance data showed that students continued to acquire words after the intervention was applied to another word set. However, performance on words acquired during maintenance was less stable as students both increased and decreased their word reading accuracy. These small and sometimes inconsistent increases in words acquired during baseline and maintenance phases suggest that some increases in words acquired were not caused solely by the CBPRI. Future researchers may want to determine if the repeated assessments and/or exposure to words during their college class may have caused students to acquire words during baseline and acquire additional words during the maintenance phases (Cazzell et al., 2016; Skinner & Shapiro, 1989; Yaw et al., 2012).

Teaching words in isolation may not allow students to read the words when they are embedded in text, a generalization problem (Alberto et al., 2010; Begeny et al., 2006; Browder et al., 2006; Martin-Chang et al., 2007). Thus, researchers began teaching words in phrases (Alberto et al., 2013; Aspiranti & Hilton-Prillhart, 2021; Aspiranti et al., 2022). We found evidence for generalization in the other direction as teaching words in phrases allowed our participants to read words in isolation. These results suggest that the phrase training procedure did not result in students memorizing phrases or using first letter of first words or phrase length to read phrases correctly. Instead, results suggest that phrase training may be effective because students learned to read the words embedded in the phrases. While these results suggest that teaching words in phrases did result in generalization, researchers should determine if using computer-based and other phrase reading interventions allows students to read words when they are embedded in other phrases or longer text (Alberto et al., 2013).

In the current study, we ceased applying the intervention to one word set and applied it to another after a student acquired five of the seven words, as opposed to all seven words. We did this to maximize the amount of words acquired in the time allotted for the study. Our data from Set C words for Caleb and Maggie suggest that this strategy was successful as learning rates decelerated as more interventions were

applied after students acquire five words. Regardless, these data cannot be generalized to interventions designed to teach all words in a set. Future researchers may want to determine why some words took more sessions to learn and perhaps develop alternative or supplemental procedures for teaching those words.

For students with disabilities, the typical problem is not failure to learn, but not learning fast enough (Skinner et al., 2023). Thus, researchers should conduct studies designed to compare the current CBPRI with other interventions (e.g., computer-based word learning interventions) or adapted CBPRI interventions to determine which procedures result in more rapid learning (e.g., Kupzyk et al., 2011; Skinner et al., 1995; Solomon et al., 2017; Yaw et al., 2014). In the current study, phrases targeted just one unknown word. Future researchers interested in enhancing prevention and remediation efforts should determine if students can learn more words in a similar amount of time when phrases contain multiple unknown words (Skinner, 2008). In the current study, if phrases contained two or more unknown words, researchers may have found that the CBPRI increased the number of words learned during the same amount of instructional time (Poncy et al., 2015; Skinner, 2010).

By teaching words specific to each students' elective college courses, we hoped to enhance students' success and confidence while engaging in course activities (Wright et al., 2021). However, we did not measure these outcomes. Researchers should investigate the efficacy of CBPRIs and similar interventions on these and other outcomes including participation and engagement in courses, acceptability of the courses, interest in course content, and learning outcomes. Also, researchers should evaluate the effects of this intervention on other reading outcomes including reading fluency, comprehension, and vocabulary development (Alberto et al., 2010; Browder et al., 2006).

Researchers should conduct similar studies with larger numbers of students, across settings (e.g., middle and high school students), words (e.g., high-frequency irregular words), and phrases (Alberto et al., 2010). The students in this study read at the third-, sixth-, and ninth-grade levels. Future studies should include students with weaker reading skills. Furthermore, researchers could conduct similar studies with elementary students receiving remedial reading services (e.g., MTSS service) and students with learning disabilities.

## Conclusion

We found evidence of generalization as the computer-delivered phrase learning trials enhanced the students' ability to read course-specific unknown words, when those words were presented in isolation. Also, students maintained their ability to read these words. Researchers should continue to investigate the effects of phrase training interventions on number of words learned, word learning rates, and generalization, including students' ability to read words when embedded in other phrases, other passages, and other formats (e.g., ability to read words embedded on instructors' PowerPoint® slide presentations).

**Supplementary Information** The online version contains supplementary material available at https://doi.org/10.1007/s10864-023-09533-5.

## Declarations

**Conflict of Interest** The authors have no conflicts of interest to report.

**Ethical Approval** The research was approved by the University of Tennessee Human Subjects Research Internal Review Board.

**Informed Consent** Informed consent was obtained from all students or their legal guardians.

## Appendix A

Note: Target words are underlined.

### Maggie

*Word Set A:* overactive amygdala, compliance training, delayed echolalia, coerced labor, placebo drug use, alcohol abstinence, cognitive dissonance.

*Word Set B:* convergent evolution, acculturation process, standpoint epistemology, drug habituation, inferiority complex, kinesthetic learning style, mnemonic device.

*Word Set C:* authoritarian parenting, social cryptomnesia, visual agnosia, diathesis stress model, autogenic training, desensitization therapy, competitive inhibition.

### Megan

*Word Set A:* agoraphobia treatment, cultural assimilation, sleep insomnia, unwanted obsessions, positive reinforcement, emotional trauma, randomizing participants.

*Word Set B:* effective altruism, conformity bias, depth perception, specific phobia, prejudice checking, comparison level, mnemonic device.

*Word Set C:* conscious awareness, overactive amygdala, acute mania, placebo effect, unconscious bias, sensory deprivation, child psychology.

### Caleb

*Word Set A:* acculturation process, large congregation, epidemiology jobs, nonconsumptive water use, tertiary structure, photovoltaic solar panel, hierarchical organization.

*Word Set B:* apartheid state, desertification solutions, interregional migration, participatory democracy, transnational corporations, micropolitan cities, irrational ethnophobia.

*Word Set C:* autocracy government, dispersed settlement, ethical monotheism, remittance transfers, subsistence agriculture, northeast megalopolis, ethnoburb community.

## Appendix B

Treatment Integrity Checklist[1]

Date: _____ Observer: _____

| | | Yes | No |
|---|---|---|---|
| 1 | Set up a workstation containing a desktop and two chairs. | | |
| 2 | Instruct student to sit in the chair of his/her choice. | | |
| 3 | Assess all words via flashcards | | |
| 4 | Instruct student to read the words on the flashcards to the best of his/her ability. | | |
| 5 | Place responses that are correctly identified within 3 seconds in one pile and those that are incorrectly identified or identified after 3 seconds in another. | | |
| 6 | Record student's correct and incorrect responses on datasheets | | |
| 7 | Instruct student that upon pressing the computer space bar, words/phrases will be displayed, and they are to try to "beat the recording" by saying the word/phrase before they hear the recording. | | |
| 8 | Instruct student to repeat the word/phrase after they hear the recording. | | |
| 9 | After the first completion of the intervention, repeat steps 7-8. | | |
| 10 | After the second completion of the intervention, repeat steps 7-8. | | |
| 11 | Thank the student for participating in the intervention and escort out of the room. | | |
| 12 | Steps 2-11 are completed for each student | | |

Number of steps completed: _____

Percentage of steps completed: _____

Comments:

## References

Alberto, P. A., Waugh, R. E., & Fredrick, L. D. (2010). Teaching the reading of connected text through sight-word instruction to students with moderate intellectual disabilities. *Research in Developmental Disabilities, 31*(6), 1467–1474. https://doi.org/10.1016/j.ridd.2010.06.011

Alberto, P. A., Waugh, R. E., Fredrick, L. D., & Davis, D. H. (2013). Sight word literacy: A functional-based approach for identification and comprehension of individual words and connected text. *Education and Training in Autism and Developmental Disabilities*, *48*(3), 332–350. https://www.jstor.org/stable/23879886

Archer, N., & Bryant, P. (2001). Investigating the role of context in learning to read: A direct test of Goodman's model. *British Journal of Psychology, 92*(4), 579–591. https://doi.org/10.1348/000712601162356

Aspiranti, K. B., Dula, M. E., Ebner, S., & Hilton-Prillhart, A. (2022). Increasing sight-phrase reading with an iPad intervention for two students with intellectual disability. *Journal of Intellectual Disabilities*. https://doi.org/10.1177/17446295221083148

Aspiranti, K. B., & Hilton-Prillhart, A. (2021). The effect of a tablet-mediated flashcard intervention on the acquisition and maintenance of sight-word phrases. *School Psychology Review, 52*(1), 1–8. https://doi.org/10.1080/2372966X.2020.1865777

Begeny, J. C., Daly, E. J., & Valleley, R. J. (2006). Improving oral reading fluency through response opportunities: A comparison of phrase drill error correction with repeated readings. *Journal of Behavioral Education, 15*(4), 229–235. https://doi.org/10.1007/s10864-006-9028-4

Browder, D. M., & Spooner, F. H. (2011). *Teaching students with moderate and severe disabilities*. Guilford Press.

Browder, D. M., Wakeman, S. Y., Spooner, F., Ahlgrim-Delzell, L., & Algozzinexya, B. (2006). Research on reading instruction for individuals with significant cognitive disabilities. *Exceptional Children, 72*(4), 392–408. https://doi.org/10.1177/001440290607200401

Cates, G. L., & Rhymer, K. N. (2006). Effects of explicit timing on elementary students' oral reading rates of word phrases. *Reading Improvement, 43*(3), 148–156.

Cazzell, S., Browarnik, B., Skinner, A., Skinner, C., Cihak, D., Ciancio, D., McCurdy, M., & Forbes, B. (2016). Extending research on a computer-based flashcard reading intervention to post-secondary students with intellectual disabilities. *School Psychology Forum, 10*(2), 191–206.

Cazzell, S., Skinner, C. H., Ciancio, D., Aspiranti, K., Watson, T., Taylor, K., McCurdy, M., & Skinner, A. (2017). Evaluating a computer flash-card sight-word recognition intervention with self-determined response intervals in elementary students with intellectual disability. *School Psychology Quarterly, 32*(3), 367–378. https://doi.org/10.1037/spq0000172

Cazzell, S., Skinner, C. H., Taylor, K., McCurdy, M., Ciancio, D., Cihak, D., Skinner, A., & Moore, T. (2020). Comparing computer-based sight-word interventions in students with intellectual disability: Self-determined versus fixed response intervals. *Journal of Behavioral Education, 29*(3), 469–489. https://doi.org/10.1007/s10864-019-09335-8

Cuvo, A. J. (1979). Multiple-baseline design in instructional research: Pitfalls of measurement and procedural advantages. *American Journal of Mental Deficiency, 84*(3), 219–228.

Dahl, P. J. R. (1974). *An experimental program for teaching high speed word recognition and comprehension skills. Final Report.* (Report No. 3–1154). National Institute of Education, Washington, D.C. Office of Research. https://files.eric.ed.gov/fulltext/ED099812.pdf

Ehri, L. C. (2005). Learning to read words: Theory, findings, and issues. *Scientific Studies of Reading, 9*(2), 167–188. https://doi.org/10.1207/s1532799xssr0902_4

Grigal, M., Papay, C., Smith, F., Hart, D., & Verbeck, R. (2019). Experiences that predict employment for students with intellectual and developmental disabilities in federally funded higher education programs. *Career Development and Transition for Exceptional Individuals, 42*(1), 17–28. https://doi.org/10.1177/2165143418813358

Hilton-Prillhart, A. N., Hopkins, M. B., Skinner, C. H., & McCane-Bowling, S. (2011). Enhancing sight word reading in second-grade students using a computer-based sight word reading system. *Journal of Evidence-Based Practices for Schools, 12*(2), 205–218.

Hopkins, M. B., Hilton, A. N., & Skinner, C. H. (2011). Implementation guidelines: How to design a computer-based sight-word reading system using Microsoft PowerPoint. *Journal of Evidence-Based Practices in the Schools, 12*, 219–222.

Horner, R. D., & Baer, D. M. (1978). Multiple-probe technique: A variation of the multiple baseline. *Journal of Applied Behavior Analysis, 11*(1), 189–196. https://doi.org/10.1901/jaba.1978.11-189

Kazdin, A. E. (2020). *Single-case research designs: Methods for clinical and applied settings* (3rd ed.). Oxford University Press.

Kim, M. K., Bryant, D. P., Bryant, B. R., & Park, Y. (2017). A synthesis of interventions for improving oral reading fluency of elementary students with learning disabilities. *Preventing School Failure: Alternative Education for Children and Youth, 61*(2), 116–125. https://doi.org/10.1080/1045988X.2016.1212321

Kupzyk, S., Daly, E. J., III., & Andersen, M. N. (2011). A comparison of two flash-card methods for improving sight-word reading. *Journal of Applied Behavior Analysis, 44*, 781–792. https://doi.org/10.1901/jaba.2011.44-781

Martin-Chang, S. L., Levy, B. A., & O'Neil, S. (2007). Word acquisition, retention, and transfer: Findings from contextual and isolated word training. *Journal of Experimental Child Psychology, 96*(1), 37–56. https://doi.org/10.1016/j.jecp.2006.08.004

Parker, R. I., Vannest, K. J., & Davis, J. L. (2011). Effect size in single-case research: A review of nine nonoverlap techniques. *Behavior Modification, 35*(4), 303–322. https://doi.org/10.1177/0145445511399147

Poncy, B. C., Solomon, G. E., Duhon G. J., Skinner, C. H., Moore, K., & Simons, S. (2015). An analysis of learning rate and curricular scope: Caution when choosing academic interventions based on aggregated outcomes. *School Psychology Review*, *44*, 289–305. https://doi.org/10.17105/spr-14-0044.1

Skinner, C. H. (2008). Theoretical and applied implications of precisely measuring learning rates. *School Psychology Review, 37*, 309–315. https://doi.org/10.1080/02796015.2008.12087878

Skinner, C. H. (2010). Applied comparative effectiveness researchers must measure learning rates: A commentary on efficiency articles. *Psychology in the Schools, 47*(166), 172. https://doi.org/10.1002/pits.20461

Skinner, C. H., Belfiore, P. B., & Watson, T. S. (1995). Assessing the relative effects of interventions in students with mild disabilities: Assessing instructional time. *Assessment in Rehabilitation and Exceptionality, 2*, 207–220. https://doi.org/10.1177/073428290202000403. Reprinted in Journal of Psychoeducational Assessment, 20, 345-356, 2002.

Skinner, C. H., Fowler, K., Cates, G. L., Poncy, B., Duhon, G. J., Solomon, B. G., & Belfiore, P. J. (2023). Improving learning science: Evaluating and comparing academic interventions using measures of learning speed. *Psychology in the Schools*. https://doi.org/10.1002/pits.22931

Skinner, C. H., & Shapiro, E. S. (1989). A comparison of taped-words and drill interventions on reading fluency in adolescents with behavior disorders. *Education and Treatment of Children, 12*(2), 123–133.

Solomon, B. G., Poncy, B. C., Caravello, D. J., & Schweiger, E. M. (2017). Examining learning rates in the evaluation of academic interventions that target reading fluency. *Psychology in the Schools, 55*, 1–14. https://doi.org/10.1002/pits.22100

Vannest, K. J., Parker, R. I., Gonen, O., & Adiguzel, T. (2016). *Single case research web based calculators for SCR analysis (version 2.0) [Web-based application]*. Texas A&M University.

Wright, S., Ryan, K., Taylor, K., Turnbull, S., Skinner, C., Beeson, T., Ciancio, D., & Billington, E. (2021). Computer-based reading interventions with a post-secondary student with intellectual disability: Self-determined and fixed response intervals. *International Journal on Social and Education Sciences (IJonSES), 3*(3), 394–409. https://doi.org/10.46328/ijonses.193

Yaw, J., Skinner, C. H., Delisle, J., Skinner, A. L., Maurer, K., Cihak, D., Wilhoit, B., & Booher, J. (2014). Measurement scale influences in the evaluation of sight-word reading interventions. *Journal of Applied Behavior Analysis, 47*(2), 360–379. https://doi.org/10.1002/jaba.126

Yaw, J., Skinner, C. H., Orsega, M. C., Parkhurst, J., Booher, J., & Chambers, K. (2012). Evaluating a computer-based sight-word reading intervention in a student with intellectual disabilities. *Journal of Applied School Psychology, 28*(4), 354–366. https://doi.org/10.1080/15377903.2012.722181

Yaw, J. S., Skinner, C. H., Parkhurst, J., Taylor, C. M., Booher, J., & Chambers, K. (2011). Extending research on a computer-based sight-word reading intervention to a student with autism. *Journal of Behavioral Education, 20*(1), 44–54. https://doi.org/10.1007/s10864-010-9118-1

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