Examining an Effect of Fluency: Application of Letter Sound Writing and Oral Word Segmentation to Spelling Words

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This study examined a critical learning outcome of behavioral fluency, *application.* Application refers to the combination of two or more behaviors that form a composite or compound behavior. Three students with specific learning disabilities in reading learned two behaviors, how to write a set of letter sounds they heard and orally segment words into their constituent letter-sound correspondences. The procedures involved providing instruction and practice to a fluency criterion for both letter sound writing and segmenting words into sounds. Results showed that all three students applied the two element behaviors to a non-instructed compound behavior of spelling real and nonsense words.

Typical elementary spelling instruction frequently consists of a providing a list of words to memorize and a weekly spelling test (Dixon, 1993). By committing spellings words to memory, students may not synthesize or gain a complete understanding of the spelling process. Further, students tend to hold onto the memorized words until the weekly test and then forget the spellings once they have completed the exam (Wright, 2000).

Sight word memorization strategies for spelling do not provide great applicability because they rely on sight memory rather than a generalizable skill (Dixon, 1991). Correctly memorizing 10 words leaves students with the 10 words they can spell. Some students may induce correct spellings for other words based on the patterns they encounter while other students will not. With 500 spellings representing the 44 phonemes of English speech (Tompkins, 1998) and many words with irregular spellings (Simonsen & Gunter, 2001), learning to spell can present many challenges for students. Such factors make it especially difficult for students with learning problems to master even regular spellings (Mercer & Mercer, 2001). Therefore, relying exclusively on strategies that do not promote generalization can waste time and prove counter productive for students with learning disabilities.

Reviews of the spelling literature for students with learning disabilities do establish promising practices for instruction and remediation (e.g., Graham, 1999; McNaughton, Hughes, & Clark, 1994). These reviews also suggest future studies address interventions for different achievement levels (McNaughton, et al, 1994) and strategies that can integrate basic spelling skills with more advanced strategies (Mushinski Fulk, & Stormont-Spurgin, 1995). *Fluency* is a research topic not present in reviews that has the potential to help students at different achievement levels and can promote application of basic skill components to advanced composite spelling skills.

Fluency has received attention in the reading literature and is considered an important part of reading intervention and practice (National Reading Panel, 2000). Fluency aids readers in a number of ways. For example, fluently decoding or recognizing words in prose leaves more attention for comprehension (Kuhn & Stahl, 2003). At units smaller than sentences and paragraphs, fluently identifying letter sounds aids word recognition which also has an effect on oral reading fluency (Mercer, Campbell, Miller, Mercer, & Lane, 2000). Perhaps a similar relationship exists for spelling. Namely, becoming fluent with foundational elements of spelling may impact the larger more complex compound behavior of spelling words. If such a relationship exists it would fall under a critical learning outcome associated with fluency called *application* (Binder, 1996).

Application expresses the relationship of component, or element behaviors that apply to a composite or compound behavior (Barrett, 1979; Binder, 1996; Haughton, 1972, 1980). Students who fluently answer addition facts can show application when they later add decimals. Adding decimals requires a number of component or element skills with basic addition facts anchoring the strategy. Students who can not add facts accurately, rapidly, and automatically will have difficulty adding decimals which requires fluent addition skills.

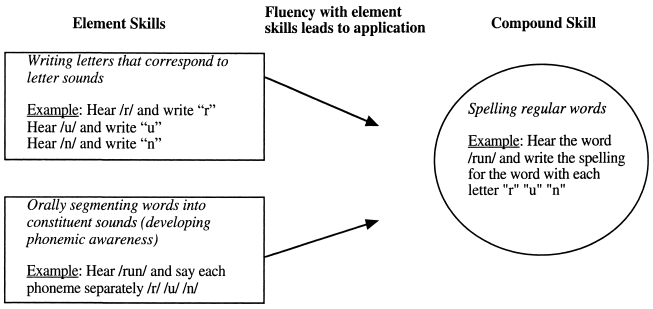
Bucklin, Dickinson, and Brethower (2000) conducted an experimental study showing the effects of application. Thirty college students learned two pairs of associations, Hebrew symbols and nonsense syllables and nonsense syllables and Arabic numbers. The experimenters put the students in two groups. One group practiced the two sets of associations to fluent levels while the other group practiced until they became highly accurate or acquired the set of associations. Results indicated the students in the fluency practice group could apply their element skills to a new, untaught compound skill (i.e., students wrote answers to arithmetic problems written with Hebrew symbols) significantly better than the practice to accuracy group of students. The results from Bucklin et al. (2000) and application data from other investigations in mathematics and reading skills (e. g., Haughton, 1972; Mercer et al., 2000) suggests a novel instructional/remedial approach for spelling. Namely, prac-

ticing element skills of spelling may improve the compound performance of spelling words.

Reviews of the spelling literature and other research indicate that two behaviors most likely function as foundational or element skills for spelling: letter sound correspondences, and phonemic awareness (Ball & Blachman, 1991; Ehri, 1989; Graham, 1999; Simonsen & Gunter, 2001: Tangel & Blachman, 1992; Treiman & Baron, 1983). Although spelling can become more complex when word length increases and letters and syllables have irregular sounds, students can spell simple words when they have some knowledge of spelling and segmentation skills (Castiglioni-Spalten & Ehri, 2003). As Graham (1999) suggests, if unable to spell a word students may use a basic spelling strategy that includes *segmenting the word's pronunciation into phonemes and accessing corresponding graphemes* (p. 87). Figure 1 shows a model of practicing to fluency the two element behaviors of (1) writing letters corresponding to letter sounds and (2) orally segmenting words into their constituent sounds. This applied experiment investigated the combinatory effect of application to help three students with learning disabilities spell words better by developing a basic spelling strategy.

Figure 1

A model of two elements behaviors combining when fluent to produce a compound behavior.



Method

Participants and Setting

Three second grade students with learning disabilities who received language arts instruction in a learning support classroom served as the participants for this study. The students attended school in a small rural town in Northwest Pennsylvania and had similar middle class socioeconomic and ethnic backgrounds. The three students, Jack, 7 years old, Amy and Tye, both 8 years old, all had specific learning disabilities in reading and displayed generally poor phonics skills in both reading and spelling according to their teacher. A segmentation pretest that called for the students to orally segment five consonant-vowel-consonant words revealed deficits with phonemic awareness among all three students. Because the students demonstrated a lack of progress learning to spell words and exhibited difficulties with phonemic awareness, namely segmenting words into sounds, the experimenter selected the students for the intervention.

Response Measurement and Reliability

The dependent measure consisted of students' spelling words. The students heard a word dictated by the experimenter and then wrote letters for each word on standard lined notebook paper. The spelling list included regular words. Regular words have letters which represent their most common sound (Carnine, Silbert, Kameenui, & Tarver, 2004). Table 1 shows a sample of some of the regular words, both real and nonsense, used in the experiment. The experimenter created a stock of words from the following letters /h/, /s/, /d/, /m/, /f/, /t/, /a/, /e/, and /i/. Table 1 also displays the word types (Carnine, et al., 2004) which consisted of vowel-consonant (VC), consonant-vowel (CV) and consonant-vowel-consonant (CVC) words.

Each of the three word lists contained an equal number of real and nonsense words. The experimenter individually presented a different list to a student each day on a rotating basis (e.g., Monday, list 1; Tuesday, list 2; Wednesday, list 3). After giving the spelling list, the experimenter collected the student's paper. Students did not receive corrective feedback for their responses. Two observers received training for scoring the dependent measure. Both observers scored 33% of the dependent measure taken, spelling words, for each student. To calculate reliability, each observer's score was compared with the other's for agreement or nonagreement. The reliability score came from the number of disagreements for correctly spelled words divided by the total number of agreements and disagreements and then multiplied by 100.

Table 1

Representative samples of real and nonsense words used as the dependent measure.

Vowel-consonant	Consonant-vowel	Consonant-vowel-consonant
it	he	mad
at	me	sit
id	sa	faf
af	fi	tid

Experimental Design

The experimenters used a multiple probe design (Horner & Baer, 1978). The multiple probe, like the multi-

ple baseline, has the advantage of examining *irreversible* behaviors. In this experiment, irreversible behaviors included learning to spell words, writing letter names, and segmenting words into their constituent sounds. Further, the multiple probe serves as the design of choice when repeatedly measuring a behavior that has the potential to cause discomfort or unpleasantness (Cooper, Heron, & Heward. 1987). All three students previously experienced a significant amount of failure learning to spell words. The experimenters determined consistent misspellings of words without corrective feedback would have led to student discomfort.

Procedure

Independent variable. The experimenter used two independent variables, writing letter sounds and segmenting words into sounds. Each independent variable required students to first acquire the target behavior and then practice to a fluency criterion.

Letter Sound Writing. The experimenter selected /h/, /s/, /d/, /m/, /f/, /t/, /a/, /e/, and /i/ for letter sound writing. The selected letter sounds, except for /e/, used their *most common sounds* (Carnine et al.. 1997), which meant the vowels /a/ and /i/ produced the short sound. The experimenter taught the long sound for /e/ because it made more words than the short sound when combined with the other letters. Students first acquired the letter sounds and then practiced to a fluency criterion. During both acquisition and the practice to fluency sessions the experimenter worked with students on an individual basis. The multiple probe design specified that students would enter the letter sound writing phase at staggered times. When one student reached the predetermined criteria for the independent variable, the next student began learning how to write letter sounds.

For the acquisition condition of the letter sound writing phase, the teacher provided instruction by saying a sound, writing the corresponding letter on a chalkboard, and then saying the letter sound again. The experimenter gave instruction for all of the targeted letter sounds. Next, a student heard a sound said by the experimenter and would write the appropriate letter correspondence on standard lined notebook paper. The teacher would provide immediate corrective feedback for the student. Students remained in the acquisition criterion until they achieved 90% accuracy or nine sounds out of ten on a written letter sound test.

After each student achieved the accuracy goal of 90% correct, practicing to the fluency criterion began. Students listened to a 60-second audio tape of letter sounds given in random order at a rate of one letter sound per second. As the students heard the sounds, they wrote down the corresponding letters to the sounds they heard. All sounds written by the students received an incorrect or correct score when matched against a master list of nine possible letter sounds. After observing students' frequency of writing letters, the experimenter set the criterion at 30 letters per minute for the fluency criterion.

Oral Ward Segmentation. After students reached criterion for letter sound writing they received the second independent variable oral word segmentation. The student heard a word, said a letter sound, and simultaneously moved a colored piece of felt (c.f., Ball & Blachman, 1991). As in the letter sound writing phase, the children first acquired oral word segmentation and then practiced to fluency. In the acquisition and practice to a fluency criterion the experimenter worked with students individually. The experimenter selected target words from a master list of VC, CV, and CVC regular real words. The words consisted of the letter sounds used during letter sound writing but never appeared in the dependent measure spelling words. The experimenter provided instructions, modeled segmenting, and guided the students responses when segmenting words into sounds.

The experimenter would direct the student to *show* and *tell* the sounds in the words. For instance, the experimenter said the word *sit*. If the student responded correctly the experimenter would say /s/, and simultaneously move one colored piece of felt forward, then say /i/ and move another felt piece and finally say /t/ while moving a third felt piece. The experimenter then asked the student a series of questions related to the pieces of felt like: *What sound comes before the /t/? What sound comes after the /i/?* If the student responded correctly the experimenter provided affirmation and praise. If the student answered incorrectly the experimenter provided immediate corrective feedback by telling and modeling the correct answer by saying the sounds and moving the felt pieces and leading the student to perform the correct response. Once a student could correctly move the felt pieces forward with the corresponding sounds at 90% accuracy, or nine correct answers out of ten, the student began practicing to a fluency criterion.

During practice students worked toward developing proficiency with oral segmentation of words into sounds. The experimenter implemented the same procedures as in acquisition with the addition of telling the student to *go fast.* All students had their fluency goal derived from Haughton (1996) who proposed the goal of twenty correct responses in one minute. The experimenter counted a movement of a felt piece and the proper identification of the sound as one correct response. If a word had three sounds and the student correctly moved three felt pieces for each sound and said each sound correctly, then the experimenter scored the performance as three correct responses. The experimenter also counted each answer the student made after moving the felt pieces as correct or incorrect. Students did not receive immediate corrective feedback for errors but did so after the one minute ended. After two days of making twenty or more

correct responses in one minute the student met the fluency criterion.

Results

Figure 2 shows the results of the dependent measure spelling words while Figure 3 displays the independent variable writing letter sounds and orally segmenting words into sounds. The three Standard Celeration Charts in Figure 3 have proportional, multiply-divide horizontal axes (Graf & Lindsley, 2002; Pennypacker, Gutierrez, & Lindsley, 2003). The vertical axis has proportional increments that proceed by multiplying or dividing. Moving from 1 to 2 shows the same proportion as moving from 100 to 200 (logarithmic scale). The three conventions [dots (•), X's, and pluses (+)], mean the following: dots represent correct performances, X's signify incorrect performances, and the pluses express the one minute counting time or observational period when the experimenter counted the corrects and incorrects. The multiply-divide axis of the Standard Celeration Chart allows celeration measurements or the weekly *acceleration* or deceleration of a behavior. A times 2 celeration means a behavior has doubled or multiplied by a factor of 2 in one week. The experimenters used Standard Celeration Charts in Figure 3 to observe celeration measures.

Jack. In the baseline phase, Jack (Figure 2) consistently wrote between 60 and 70% correct words from the spelling list. Jack's stable performance indicated that he could spell some of the words but not with high degrees of accuracy. Following the introduction of the independent variable letter sounds writing, Jack's spelling performance dips well below the previus level. The remaining data in the letter sound writing phase show a level similar to baseline. Following the introduction of the independent variable letter sounds writing, the first spelling data point dips well below the previous level. The remaining data in the letter sound writing phase show a level similar to baseline. The remaining data in the set resume a similar trend to his baseline spelling performance. After introducing oral word segmentation, Jack's performance increased until he met the criterion of two days at 100% correct.

Figure 3 displays Jack's written letter sound frequencies. In 3 days, practiced over 2 weeks, Jack met the fluency criterion. Celeration lines indicate Jack's correct learning responses accelerated by 1.7 while his incorrects decelerated by 1.7. Figure 3 also depicts Jack's oral word segmentation frequencies. Jack learned to segment words quickly as indicated by his acceleration by 2.3. Incorrect responses reduced by a factor of 3.0. Meeting the criteria for both independent variables occurred in a time span of 5 weeks.

Amy. Amy's spelling performance in baseline. Figure 2, has two data points with similar accuracy 60 and 64%. The last two data points also have comparable accuracy, 40 and 34%, but occur at a lower level. Amy begins to spell more words correctly during the introduction of letter sound writing. As Amy moves from letter sound writing to oral segmentation her trend continues to increase until she spells words at the criterion of 100% for two days. Figure 3 shows Amy's correct letter sound writing accelerated rapidly by 3.5 and her incorrects decelerated by 4.5. Amy reached criterion for letter sound writing in less than one week. Her correct responses for oral segmentation accelerated by 1.45

Figure 2

The percentage of correctly spelled real and nonsense words.

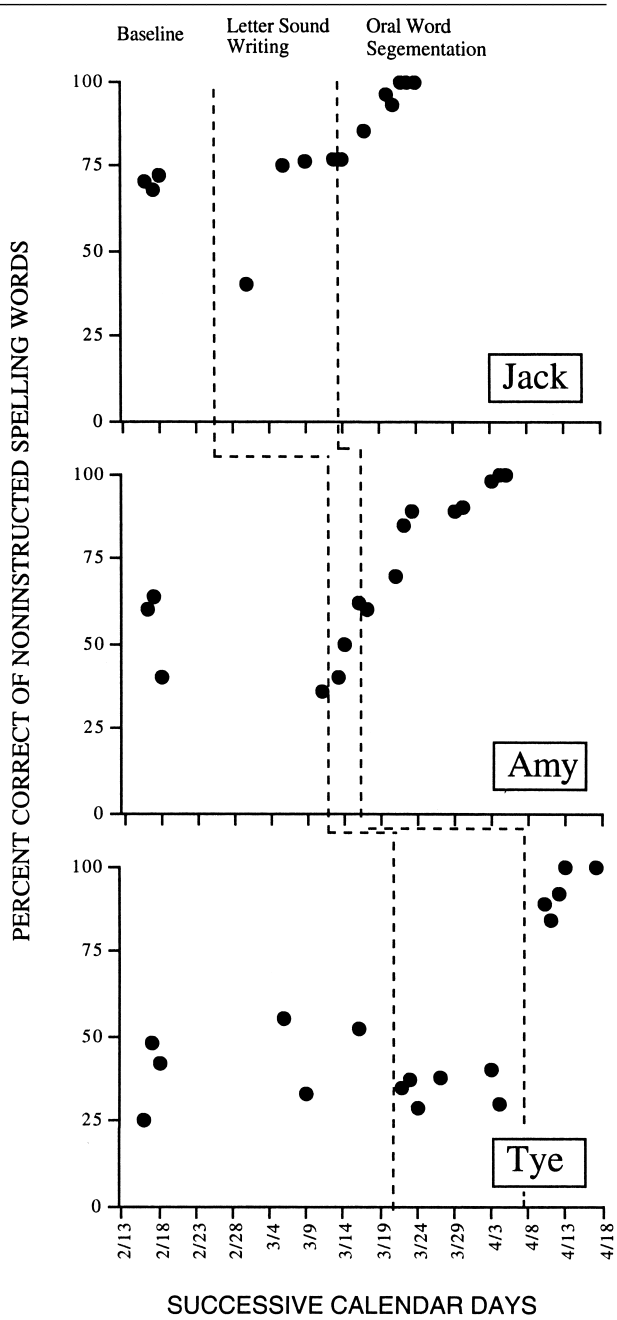
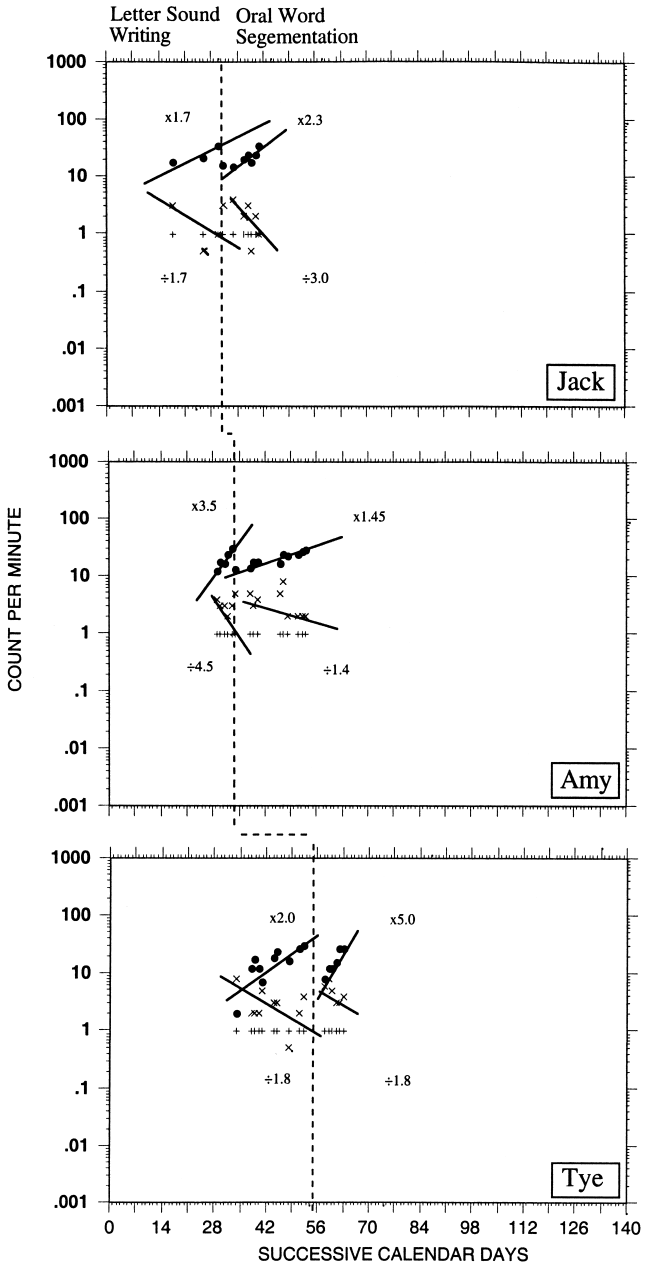


Figure 3

The percentage of correctly spelled real and nonsense words.



and her incorrect responses decelerated by 1.4. Amy met the criteria for both independent variables in 4 weeks.

Tye. Figure 2 shows Tye's baseline performances of correct spelling words ranging from 25 to 55%. He had the lowest spelling accuracy level of the three students. After introducing the letter writing independent variable, Tye spelled fewer words correctly than he did during baseline. When Tye received the oral segmentation independent variable, he began spelling more words correctly and surpassing his baseline level accuracy scores. The bottom panel of Figure 3 depicts the two independent variables letter sound writing and oral segmentation. Tye learned to write the letter sounds quickly, his correct responses accelerated by a factor of 2.0 and incorrect responses decelerated by a factor of 1.8. Tye learned to segment words into sounds in a week, corrects accelerated by a steep factor of 5.0 and incorrects decelerated by 1.8.

Discussion

The present study asked whether practicing elements of spelling to fluency would lead to application of the integrated compound behavior of a basic spelling strategy for three second grade students with learning disabilities. The results show that all three students could spell non-instructed words after becoming fluent with letter sound writing and oral segmentation of words. The multiple probe design shows a consistent relationship among the variables. As each student reached the criterion fluency levels for the two experimental variables, students spelled non-instructed words with high degrees of accuracy specifically, 100%.

The basic spelling strategy appeared to fully emerge after each student attained fluency with a phonemic awareness skill, oral segmentation of words into sounds. Becoming fluent with writing letters, the first phase, did not improve any of the students spelling performances compared to their baseline performance. The three students could fully apply their letter sound knowledge once they reached the fluency criterion for oral segmentation of words. Other studies (Ball & Blachman, 1991; Ehri & Wilce, 1987; Tangel & Blachman, 1992) also show that students who have acquired only the relationship between letter sounds and letter names, do not necessarily learn to spell significantly better. Knowing letter names and their sounds form an essential, but not sufficient behavioral element for spelling words.

To spell non-instructed words each student had to use a basic spelling strategy or the compound behavior. The basic spelling strategy employed two elements as described by Graham (1999), segmenting words into sounds and matching the sounds with letters. As shown in Figure 1, by practicing the skills to fluency both could combine into a new behavior. Baseline spelling performances also support including nonsense words in the daily list. The students demonstrated they used a basic spelling strategy because they spelled words they would likely have never seen or heard.

For reading, Bowers, Golden, Kennedy, and Young (1994) described the function of nonsense words: *Almost by definition, decoding nonwords requires good knowledge and use of phonological codes and sound-symbol correspondences, and a willingness to use an analytic strategy to*

decode rather than rely on a global (typically guessing) strategy (p. 175). The data from the present study suggest that spelling, or encoding, nonsense words also demands the speller to use an analytic strategy. For regular words such as *scat, rat, cap,* or nonsense words like *jat, saf, ak* students could spell the words by analyzing the constituent sounds heard and matching those sounds to the letter which they expressed in written format. Teachers who use the methods in this applied study, however, may wish to limit the use of nonsense words. Nonsense words provide support for the presence of spelling strategy, but teachers should place more emphasis on words students will use and benefit from during expressive writing activities.

The students had five months of previous instruction where they received instruction by memorizing whole words in word lists. Baseline levels reflect the lack of improvement or growth in each student. The Standard Celeration Charts provide information that speaks to the efficacy the procedures had for the three students. The celeration gives a numeric magnitude of the speed at which a student learns a particular task (Lindsley, 1997). In Figure 3, all students exhibit positive accelerations of correct responding and corresponding rapid decelerations of incorrect responding. Celeration measures show behaviors doubling and in some cases almost accelerating by x 6. Such high celerations, or weekly measures of learning, suggest that the procedures created an instructional environment conducive to rapid learning. Overall, it took Jack, Amy, and Tye five weeks or less to each individually meet criterion aims for both independent variable phases.

Limitations

Jack, Amy, and Tye all received 5 months of previous spelling instruction with very little improvement. Therefore the results support the procedures used in the study. The five months of previous instruction, however, did play a role in the emergence of the basic spelling strategy. Because of the prior instruction, definitive conclusions regarding the element skills should not be made. Perhaps another essential element previously taught combined with the two element skills to facilitate highly accurate spelling. Future studies may examine what effects the experimental procedures would have on students who have had no exposure to spelling instruction.

Another limitation of this study comes in Amy's performance during the letter sound writing phase. Amy's data showed an increasing trend in her spelling performance during the letter sound writing phase. Even though Amy's data did not surpass her initial baseline level, the upward trend suggests Amy may have spelled more words correct if the phase continued.

Conclusion

Jack, Amy, and Tye all demonstrated the successful application of a basic spelling strategy as a result of practicing two behavioral elements to predetermined fluency criteria. The procedures produced a robust effect for the three students allowing them to master the spellings of non-instructed real and nonsense words. Future studies can integrate the current findings to investigate methods that produce even more substantial effects helping students with learning disabilities become better spellers.

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