EFFECTS OF INCREMENTAL REHEARSAL ON SIGHT WORD AND LETTER ACQUISITION AMONG STUDENTS WITH DEVELOPMENTAL DISABILITIES

by

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(Under the Direction of Scott Ardoin)

ABSTRACT

Incremental rehearsal (IR) is a flashcard intervention that involves interspersal of previously mastered targets and immediate error correction. Previous research indicates that IR is an effective intervention for teaching discrete skills. Much of existing research, however, was conducted with typically developing students. The current study aimed to extend the literature by implementing IR with students diagnosed with developmental disabilities and receiving instruction with a self-contained special-education setting. A multiple probe design across sets of stimuli was used to evaluate the effectiveness of IR on sight word and letter acquisition among three early elementary students with autism and speech-language impairment. Results indicated that IR was effective for all participants. Future research should compare IR to other flashcard interventions regularly employed with this student population.

INDEX WORDS: Incremental rehearsal, flashcard interventions, sight word interventions, special education

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DEDICATION

This work is dedicated to the Center for Autism and Behavioral Education Research at the University of Georgia. The CABER staff, students, and families have allowed me to take part in work I love and have taught me how to do this work better.

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INTRODUCTION

Reading is a crucial skill for students to develop as it plays an essential role in their continued academic development. In 2000, the National Reading Panel published a comprehensive report identifying key topics related to reading instruction that warranted intensive research; these topics included phonemic awareness, phonics instruction, fluency, vocabulary, and text comprehension (National Reading Panel, 2000). The ultimate goal of reading instruction is for students to comprehend the text, and this ability involves a number of skills and processes (Sideridis, Morgan, & Simos, 2013). Research indicates that early phonetic skills are predictive of later reading comprehension ability (Double, McGrane, Stiff, & Hopfenbeck, 2019) and that reading fluency measures are predictive of comprehension of text (Uysal & Bilge, 2018). Many evidence-based reading interventions focus on improving phonics skills and fluency as a means of improving overall reading ability (Haager, Dimino, & Windmueller, 2014) and interventions targeting sight word acquisition improve students' performance on both fluency and compression measures (Gonzales, 2017). The purpose of the current study was to examine the effects of an intervention, incremental rehearsal (IR), designed to improve the sight word skills of students with autism spectrum disorder (ASD).

Reading Instruction and Intervention for Students with Disabilities

Reading is an essential instructional goal for all students, including those with disabilities (Hua et al., 2012). For students with moderate to severe disabilities, reading goals tend to focus on the acquisition of functional sight words and vocabulary (Browder,

Wakeman, Spooner, Ahlgrim-Delzell, & Algozzine, 2006). Snow, Burns, and Griffin (1998) argued that simply teaching students to memorize individual words leads to students failing to acquire the skill of reading simple connected text. Alberto, Waugh, and Fredrick (2010) addressed this concern by using simultaneous prompting to teach five participants with moderate intellectual disability to read individual sight words and connected text. After being taught individual sight words, the students were taught to read the words in succession. All five participants successfully acquired sight words, connected text, and demonstrated comprehension of the connected text phrases. This study demonstrated that simultaneous prompting is an effective method to teach students with disabilities to read connected text and that teaching sight words in this manner does not necessarily hinder students' abilities to read and comprehend connected text (Alberto et al., 2010).

For students with disabilities, interventions targeting vocabulary and sight word acquisition tend to rely nearly exclusively on prompting procedures such as simultaneous prompting, constant time delay, progressive time delay and system of least prompts; these interventions also typically include scheduled reinforcement and programmed error correction (Browder & Xin, 1998). A substantial amount of the current literature on sight word instruction and intervention for students with disabilities focuses on flashcard instruction coupled with specific prompting procedures. Many of these studies compare prompting procedures used with flashcard instruction and indicate that the procedures are equally effective but report mixed results on efficiency of the interventions (Akcin, 2013; Klaus, Hixson, Drevon, & Nutkins, 2019; Swain, Lane, & Gast, 2015). Specifically, Swain et al. (2014) used an adapted alternating treatments design to compare the use of

constant time delay and simultaneous prompting procedures with flashcard instruction to teach sight words to four students with moderate intellectual disability or a dual diagnosis of ASD and moderate intellectual disability. Results indicated that the procedures were equally effective in teaching sight words to these students. Constant time delay used with flashcard instruction resulted in fewer errors, and simultaneous prompting used with flashcard instruction resulted in less instructional time needed to meet mastery criteria (Swain et al., 2014). Akcin (2013) also examined the effectiveness of prompting procedures used with flashcard instruction to teach sight words to three students with ASD. An adapted alternating treatments design was used to compare constant time delay and stimulus fading procedures. Similar to Swain et al. (2014), Akcin (2013) found that the two instructional procedures were equally effective. Skills acquired using both methods generalized although constant time delay resulted in fewer trials to mastery criteria (Akcin, 2013).

Educators and researchers have attempted to improve upon traditional drill flashcard methods by incorporating other evidence based practices (Albers & Hoffman, 2012; Hayter, Scott, McLaughlin, & Weber, 2007; Kaufman, McLaughlin, Derby, & Waco, 2011; LeBrun, Jones, Neyman, McLaughlin, & Schuler, 2014). IR is one such intervention (Tucker, 1998). IR is a flashcard intervention that incorporates simultaneous prompting and programmed error correction and has shown to be effective in teaching sight words (Burns & Boice, 2009; Burns et al., 2004; Nist & Joseph, 2008). IR may be particularly beneficial for students with disabilities given that it provides a high number of opportunities to respond and promotes high levels of correct responding by incorporating previously mastered targets.

Incremental Rehearsal (IR)

IR is a systematic flashcard intervention that involves interspersing known stimuli when teaching unknown stimuli in order to facilitate high levels of correct responding and increase opportunities to respond (Tucker, 1998). Increasing opportunities to respond is considered an evidence-based teacher practice that is recommend for students who struggle behaviorally and academically (Martin et al., 2018). Increasing opportunities to respond improves academic performance (Martin et al., 2018; Skinner, Belfiore, Mace, Williams-Wilson, & Johns, 1997; Skinner, 1994), increases on-task behavior, and decreases disruptive behavior (Martin et al., 2018; Sutherland & Wehby, 2001). Additionally, IR involves immediate error correction, which is also an evidence based and effective instructional strategy (Marchand-Martella, Slocum, & Martella, 2004; Silbert, Carnine, & Stein, 1981). Ultimately, this increased number of opportunities to respond coupled with immediate error correction and interspersal of known stimuli serve as the foundation of IR as an evidence based academic intervention.

The general procedure used when implementing IR involves presentation of an unknown stimulus with an immediate model of the correct response followed by presentation of a known stimulus and subsequent re-presentation of the unknown without a model. Immediate error correction is provided if an incorrect response is given and the pattern is repeated such that the student is exposed two known stimuli, the unknown, three known stimuli, the unknown, etc. This continues until nine known stimuli have been interspersed and the unknown stimulus has been presented ten times. The previously unknown stimulus is then considered a known stimulus and the procedure is repeated to

teach a new unknown stimulus, incorporating the newly acquired stimulus as a known (Tucker, 1988).

Research indicates that IR is an effective intervention for teaching both mathematics (Burns, 2005; Burns et al., 2019; Codding, Archer, & Connell, 2010) and reading skills (Burns & Boice, 2009; Burns, Dean, & Foley, 2004; MacQuarrie, Tucker, Burns, & Hartman, 2002; Nist & Joseph, 2008; Peterson et al., 2014; Rahn et al., 2015) to typically developing students and students with learning disabilities. Burns et al. (2019), compared IR to the traditional dill flashcard method and found that, although the two methods were equally efficient in teaching multiplication facts, IR resulted in better performance in maintenance sessions. Codding et al. (2010) used IR to teach single digit multiplication facts and found that the skills maintained over time and generalized to fraction problems and word problems. Additionally, researchers have successfully taught phonics skills to younger students through implementation of IR. Two recent studies evaluated the effects of IR on letter-sound correspondence in Kindergarten and first-grade English language learners using a multiple baseline design across sets of stimuli (Peterson et al., 2014; Rahn et al., 2015). Result from both studies suggested IR to be an effective intervention with percentage of all non-overlapping data ranging from 94% to 100%.

There is also substantial research examining the effectiveness of IR as a sight word intervention. Several groups of researchers have documented success in teaching word recognition to students with mild intellectual disabilities, learning disabilities, and students without disabilities (Burns & Boice, 2009; Burns et al., 2004; Nist & Joseph, 2008). Specifically, Burns and Boice (2009) compared traditional drill practice to IR and

another commonly used intervention to teach sight words to students with disabilities. They found that IR led to two to three times more words retained than the other methods and suggested that "high opportunities to respond presented within a high ratio of known to unknown words [leads] to the best retention" (Burns & Boice, 2009, p. 289). Importantly, teaching word recognition through IR appears to lead to improvements on other reading measures. Burns et al. (2004) found that teaching key sight words with IR to students identified as having a reading disability led to statistically significant improvements on reading fluency and comprehension measures.

In addition to the body of literature demonstrating that IR leads to improvements in acquisition of sight words, math facts, and similar discrete skills (Burns & Boice, 2009; Nist & Joseph, 2008; Peterson et al., 2014) there is also evidence that skills taught using IR maintain better over time than skills taught using traditional drill practice. MacQuarrie et al. (2002) evaluated the effects of IR on sight word and vocabulary acquisition in 51 third and seventh grade students. Results were consistent with those of Burns et al. (2019) and showed that the intervention was effective and resulted in better maintenance than traditional drill practice.

There is a substantial body of research suggesting that IR is an effective intervention practice for promoting sight word acquisition (Burns & Boice, 2009; Burns et al., 2004; MacQuarrie et al., 2002; Nist & Joseph, 2008). Much of this research, however, has focused on typically developing students and students with learning disabilities. Burns and Boice (2009) examined the effectiveness of IR in a population of students with mild intellectual disability and found that IR was more effective than

traditional drill practice in teaching sight words, but there is a notable lack of research on use of IR with students with moderate to severe disabilities.

Purpose

The purpose of this study was to evaluate the effects of IR on sight word and letter name acquisition among students with developmental disabilities. Given the lack of current research investigating the use of IR in populations of students with moderate to severe disabilities, this study attempts to extend the current literature by implementing the intervention with three students with developmental disabilities.

METHODS

Participants

Participants were three students in a public Kindergarten through second grade special education classroom for students with low incidence disabilities and significant behavioral needs. Alex was a 5-year 4-month-old male Kindergarten student diagnosed with ASD and speech-language impairment. David was a 6-year 11-month-old male first grade student diagnosed with ASD and speech-language impairment. Julie was a 6-year 2-month-old female Kindergarten student diagnosed with ASD and speech-language impairment. Alex and David both had previous experience with discrete trial training and flashcard instruction in the classroom. All three participants received academic and behavioral supports including programmed reinforcement, token boards, and visual schedules. Expressively identifying letters or sight words was consistent with goals in each participant's Individualized Education Program (IEP).

Setting and Materials

Sessions were conducted at a table in the corner of the participants' classroom. Sessions occurred during class-wide regularly scheduled 1:1 worktime. The researcher was seated at the table next to the student. For each participant, six known stimuli and 15 unknown stimuli were identified. Researchers elected to use six known stimuli, as opposed to the standard nine, in order to ensure that sessions required no more than 15 minutes as this was the amount of time that participants were accustomed to working. For Alex, known and unknown stimuli were sight words consistent with IEP goals. For

David, known stimuli were capital letters that he could successfully expressively identify, and unknown stimuli were sight words consistent with IEP goals. For Julie, known stimuli were illustrated pictures of animals that she could successfully expressively identify, and unknown stimuli were capital letters that she was asked to expressively identify. Illustrated images of common animals were found online, printed in colored ink, and glued onto the index cards. Sight words and capital letters were hand written in black ink onto white index cards (3 in. by 5 in.); a small number was printed on the back of the card for the researcher to reference. The number indicated what number stimuli the item was and whether it was a known or unknown. David and Julie both used token board systems in the classroom during work sessions, and these same token boards and schedules of reinforcement were used during this study.

Dependent Variable

The dependent variable was the number of targets correctly identified during a probe prior to each teaching session. Before teaching sessions began, the researcher presented each unknown stimulus to the student for 8 s. If the student responded correctly within 8 s, the word was marked correct. If the student corrected an initial incorrect response within 8 s of presentation, the word was scored correct. If the student made no response within 8 s or responded incorrectly, the word was scored incorrect. Researchers allowed 8 s to respond as opposed to the standard 5 s based on pilot work (Swilley & Ardoin, 2019) and prior classroom experience with the participants. Mastery criteria was defined as 100 % accuracy across three consecutive data collection days.

Design

A multiple probe design across sets of stimuli was used to evaluate the effects of IR on letter identification and sight word acquisition with the three participants. For each participant, unknown stimuli were randomly assigned to one of three sets. Known stimuli used for each participant remained constant across all sets. Sessions were conducted three to four times per week.

Interobserver Agreement and Procedural Fidelity

Sessions were recorded on a laptop with the screen covered. The laptop camera was oriented in a way that allowed full view of the student, researcher, and flashcard being shown. A second observer watched the recordings and scored words as correct or incorrect according to the definition previously presented. Interobserver agreement (IOA) was obtained for approximately 40% (range, 33% – 50 %) of sessions across each set for each participant. The sessions that were scored for IOA and procedural fidelity were randomly selected. IOA was calculated for each session by dividing the number of agreements by the sum of the number of agreements and disagreements and multiplying by 100. An agreement was defined as the researcher and the second observer both scoring a response as correct or incorrect. A disagreement was defined as the researcher and the second observer scoring a response differently from one another. The mean IOA across participants was 97.6% (range, 80% - 100%). The majority of disagreements occurred due to difficulty understanding participants' speech.

Procedural fidelity data was collected in the same manner as IOA. The second observer was trained on the procedures used to implement IR in this study and given a checklist that explicitly denoted the steps to be followed. The second observer used this checklist to score procedural fidelity of the same randomly selected recorded sessions.

Each step was scored as complete or incomplete. In order to be scored complete, a specific step had to be implemented successfully every time the step was carried out. Mean procedural fidelity was calculated for each session by dividing the number of complete steps by the sum of the complete and incomplete steps and multiplying by 100. The mean procedural fidelity across participants was 99.8% (range, 91% - 100%).

Procedures

Reinforcement Procedures. Classroom staff implemented specific reinforcement procedures in the school setting with each participant. Reinforcement procedures used in this study were consistent with those implemented by classroom staff. Reinforcers were identified as highly preferred tangibles through a multiple stimulus without replacement preference assessment implemented by special education classroom staff prior the commencement of this study. Reinforcement procedures were identical across all phases of this study (screening, baseline, intervention, and maintenance).

Alex. Immediately prior to the beginning of a session, Alex was presented with the option to work for a highly preferred edible or one of two highly preferred tangibles. If he selected the edible, he was given one edible on a fixed ratio (FR) 5 schedule. If he selected one of the tangibles, Alex was given 2 min access to the item at the end of the session. The researcher provided vocal reminders that Alex was working for the item approximately every 2 min. The researcher also provided vocal praise after each response. During screening, baseline, and maintenance sessions, all responses were reinforced regardless of whether a response was correct. During IR sessions, only correct responses were reinforced, and Alex received reinforcement regardless of whether the response was independent or prompted.

David. David used a token board and received tokens on a FR 1 schedule; he exchanged tokens for a tangible on a FR 3 schedule. After earning three tokens, David was presented with three highly preferred edibles and one highly preferred tangible and allowed to select one. He received one edible or 30 s access to the tangible. The researcher also provided vocal praise after each response. During screening, baseline, and maintenance sessions, all responses were reinforced regardless of whether a response was correct. During IR sessions, only correct responses were reinforced, and David received reinforcement regardless of whether the response was independent or prompted.

Julie. Julie used a token board and received tokens on a FR 1 schedule; she exchanged tokens for a tangible on a FR 5 schedule. After earning five tokens, Julie was presented with three edibles and allowed to select one. She received one edible of her choice. The researcher also provided vocal praise after each response. During screening, baseline, and maintenance sessions, all responses were reinforced regardless of response accuracy. During IR sessions, only correct responses were reinforced, and Julie received reinforcement regardless of whether the response was independent or prompted.

Screening. Prior to beginning baseline, the researcher conducted probes of stimuli with each participant in order to determine known stimuli and unknown stimuli to be used during the study. Stimuli for each participant were selected based on current IEP goals and teacher interview. During screening sessions, the researcher presented each stimuli student with the prompt “what is it?” or “what word?” The student had 8 s to respond and received reinforcement regardless of response accuracy. The researcher provided no corrective feedback and recorded response accuracy. In order to be considered a known stimuli, the participant had to correctly identify the stimuli across

three consecutive screening sessions. In order to be considered an unknown stimuli, the participant had to fail to correctly identify the stimuli across three consecutive screening sessions.

After stimuli were identified, 15 unknown stimuli were randomly assigned to one of three sets for each participant (five per set), and six known stimuli were randomly selected for each participant. The same known stimuli were used across all sets.

Baseline. During baseline sessions, the researcher presented each unknown stimuli in the set sequentially to the student with the prompt "what is it?" or "what word?" The student had 8 s to respond and received reinforcement regardless of whether a response was correct. The researcher provided no corrective feedback and recorded if responses were correct or incorrect.

Incremental Rehearsal (IR). In intervention conditions, the researcher began each session by probing the unknown stimuli, using procedures identical to those employed during baseline sessions. The researcher provided no corrective feedback and provided vocal praise and reinforcement for each response during the probe. Any stimuli that the student correctly identified during the probe were considered knowns for the current IR session, and any stimuli the student failed to correctly identify during the probe were considered unknowns for the current IR session.

Upon completion of the probe, the researcher immediately began the IR session. The IR session ended after 10 min or after all unknowns were taught. The researcher began the teaching session by presenting the first unknown (U1) with the prompt "what is it?" or "what word?" and immediately providing a vocal model of the correct response. The student had 8 s to respond. If the student responded incorrectly, the researcher

repeated the vocal model. Immediately upon the correct response, the researcher provided reinforcement. The researcher then presented the first known stimuli (K1) followed by U1. Next, the researcher presented K1, K2, then U1. This pattern continued until six knowns were presented such that the final trial included K1, K2, K3, K4, K5, K6, U1. Upon any incorrect response, the researcher provided an immediate vocal model of the correct response. Reinforcement was provided immediately upon a correct response. If the student correctly identified U1 across the last three consecutive presentations, U1 became K1, and the researcher taught U2 using procedures identical to those described above. If the student failed to correctly identify U1 across the last three consecutive presentations, the researcher taught U1 again, implementing the procedure from the beginning. Only six known stimuli were used at any given time, and previously unknown stimuli always became the first knowns presented because this provides increased opportunities to respond to most recently acquired targets.

Maintenance. In order to assess retention of acquired targets, maintenance sessions were conducted at day 3, day 7, and day 14 following mastery of each set when possible. During maintenance sessions, the researcher presented each unknown stimuli in the set sequentially to the student with the prompt “what is it?” or “what word?” The student had 8 s to respond and received reinforcement regardless of whether a response was correct. The researcher provided no corrective feedback and recorded if responses were correct or incorrect.

RESULTS

Results for the three participants are presented in Figures 1, 2 and 3. The figures provide multiple probe data for Alex, David, and Julie respectively. Each data point represents the number of targets correctly identified. Because the study took place in a school setting, sessions could not be conducted during school breaks; a one month intermission in sessions due to a school break is indicated by dashed lines on the graph.

Overall, IR intervention was effective for all three participants across all sets of stimuli. Baseline data across all sets remained stable until intervention. When intervention began in a set, correct responding in that set accelerated while baseline data for other the set(s) remained stable until intervention. This trend was seen across all participants. In general, upon beginning intervention, there was a quick increase in correct responding, and maintenance data suggest that the acquired targets were retained even after cessation of IR sessions.

Alex. Across all three sets of stimuli, Alex's correct responding immediately increased upon implementation of intervention, and he met mastery criteria for each set within five to seven sessions (M = 5.7) (Figure 1). For stimuli Set 1, Alex's baseline data remained stable at zero words correctly identified for six consecutive sessions; upon beginning IR intervention, Alex's correct responding immediately increased to two words correctly identified. While correct responding for set 1 was accelerating, baseline data for Sets 2 and 3 remained stable. Alex correctly identified all five stimuli in Set 1 after three IR sessions, and met mastery criteria after five sessions. Alex's correct responding

maintained across all five stimuli in maintenance sessions conducted at 3 days and 7 days following the date that he met mastery criteria for Set 1. Further maintenance sessions could not be conducted due to a school break. For stimuli Set 2, Alex's baseline data increased from zero words correctly identified to one word correctly identified in session 11. IR intervention was mistakenly implemented despite the increasing trend in baseline data. After one IR session, Alex's responding immediately increased to two words correctly identified. In order to obtain stable baseline data, researchers returned to baseline conditions for Set 2 with Alex after only one IR session. After again obtaining stable baseline data, researchers returned to IR intervention conditions. Alex's correct responding immediately increased to four words correctly identified while baseline data for Set 3 remained stable. Alex met mastery criteria after seven sessions, and his correct responding maintained across all five stimuli in maintenance sessions conducted at 4 days, 7 days, and 14 days following the date that he met mastery criteria for Set 2. For stimuli Set 3, the trend in Alex's data matched that of Set 1. Alex's baseline data remained stable until implementation of IR. Upon beginning IR, Alex's correct responding immediately increased to two words correctly identified, and he met mastery criteria after five sessions. Alex's correct responding maintained across all five stimuli in maintenance sessions conducted at 4 days, 10 days, and 14 days following the date that he met mastery criteria for set 3.

David. Across all sets of stimuli, David's correct responding increased following implementation of IR intervention, and he met mastery criteria for each set within 9 to 21 sessions (M = 15) (Figure 2). For stimuli Set 1, David's baseline data remained stable at zero words correctly identified for six consecutive sessions; upon beginning IR

intervention, David's correct responding immediately increased to two words correctly identified. While correct responding for Set 1 was accelerating, baseline data for Sets 2 and 3 remained stable at zero. David correctly identified all five stimuli in Set 1 after seven IR sessions and met mastery criteria after nine sessions. David correctly identified all five stimuli on maintenance Day 3 for Set 1; he correctly identified 4 of 5 stimuli on maintenance Day 8. Further maintenance sessions were not conducted due to a school break. For stimuli Set 2, the trend in David's data followed that of Set 1. David's baseline data remained stable until implementation of IR, and he met mastery criteria after 21 sessions. Baseline data for Set 3 remained stable during this time. He correctly identified 4 of 5 stimuli during maintenance session Day 3 and all five stimuli on maintenance session Day 7. Further maintenance sessions were not conducted due to a school break.

Julie. Across all sets of stimuli, Julie's correct responding increased within the first two session of IR intervention, and she met mastery criteria for each set within 11 to 18 sessions (M = 14.5) (Figure 3). For stimuli Set 1, Julie's baseline data remained stable at zero letters correctly identified for six consecutive sessions; upon beginning IR intervention, Julie's correct responding increased to one letter correctly identified after two sessions. While correct responding for Set 1 was accelerating, baseline data for Sets 2 and 3 remained stable at 0. Julie correctly identified all five stimuli in Set 1 after 18 IR sessions, and met mastery criteria after 20 sessions. She correctly identified all five stimuli on maintenance Day 3, Day 7, and Day 14 for Set 1. For stimuli Set 2, the trend in Julie's data followed that of Set 1. Julie's baseline data remained stable until implementation of IR, and she met mastery criteria after 11 sessions. Baseline data for Set 3 remained stable during this time. Julie correctly identified all five stimuli on

maintenance Day 4 for Set 2. Further maintenance sessions were not conducted due to a school break.

DISCUSSION

Reading is a foundational skill that is important for all students, including those with disabilities (Hua et al., 2012). Given that reading goals for students with moderate to severe disabilities tend to focus on acquisition of sight words and vocabulary (Browder et al., 2006), it is essential that educators have access to appropriate and effective methods of teaching these skills to this population of students. Past studies indicate that IR improves acquisition of sight words, math facts, and other discrete skills among students with and without disabilities (Burns & Boice, 2009; MacQuarrie at al., 2002; Nist & Joseph, 2008; Peterson et al., 2014) and that IR is a more effective intervention than traditional drill and practice flashcard methods (Burns et al., 2019; Burns & Boice, 2009; MacQuarrie et al., 2002). Much of this research, however, was conducted with typically developing students and students with mild disabilities. Given that IR provides increased opportunities to respond and facilitates high levels of correct responding (Tucker, 1998) IR may be particularly beneficial for students with moderate to severe disabilities. This study aimed to address the lack of literature focused on IR intervention within this student population by examining the effects of IR on sight word and letter name acquisition in three students with developmental disabilities.

Modifications to Incremental Rehearsal Procedures

This study differed from past studies using IR in several notable ways. First, this study used only six known stimuli rather than the standard nine. Based upon past work with the three participants, researchers suspected that using nine known stimuli would

result in sessions requiring significantly more time than the participants were accustomed to working in the classroom. Although the use of only six known stimuli meant that unknown stimuli were rehearsed fewer times per cycle than in the standard IR procedure, researchers addressed this by requiring that the participant correctly identify the unknown stimulus on the final three consecutive presentations before moving on to teach the next unknown. In other words, if a participant failed to correctly identify the unknown stimulus in the final three consecutive presentations, the cycle was repeated and that unknown stimulus was retaught and rehearsed seven more times. The standard IR procedure does not require that a student correctly identify the first unknown stimulus in the final presentations before introducing a new unknown.

A second way in which this study deviated from standard IR procedures was in allowing 8 s for participants to respond as opposed the standard 5 s. As mentioned previously, this decision was based upon past pilot work (Swilley & Ardoin, 2019) and previous experience in the classroom with the participants. Finally, this study differed from past studies using IR in that Julie's known stimuli and unknown stimuli were not in the same class. Julie's sets of unknown stimuli were comprised of capital letters, and her set of known stimuli was made up of illustrations of common animals. This was due to the fact that, before beginning IR intervention, Julie could not expressively identify any letters, shapes, numbers, or colors.

Effectiveness and Efficiency of Incremental Rehearsal Intervention

Despite these differences, IR was an effective intervention for all three participants, and findings replicated those of previous studies with typically developing populations. Correct responding increased upon beginning IR intervention, and baseline

data for Sets 2 and 3 remained stable while correct responding accelerated for Set 1 across all participants. Correct responding appeared to maintain across all maintenance sessions. The intervention was notably more efficient for Alex than for the other two participants; this may be explained by the fact that he was more academically advanced than the other two participants and attended to stimuli with less prompting. For David, more sessions to meet mastery criteria were likely necessary because of problem behavior that occurred at school. In particular, after a school break, classroom staff noted an increase in non-compliance and other problem behavior; these behaviors impacted the number of targets that could be taught per session which slowed David's progress. For Julie, more sessions to meet mastery criteria were likely necessary because of her difficulty attending to stimuli for long periods of time; Julie required frequent prompting to attend to the stimuli and stopped responding for long periods of time during sessions, limiting the number of targets that could be taught per session.

Additional factors that may have affected participants' progress throughout the course of the study include the school schedule, reinforcement procedures, and inherent differences in each set of stimuli. Because this study took place in a classroom setting, sessions could not be run on days of scheduled field trips or during school breaks. Field trips occurred twice every month, and three school breaks occurred during the course of the study in addition to interruptions caused by participant illness. These interruptions may have slowed the participants' progress but are consistent with what is likely to occur in self-contained classroom settings thus increasing the external validity of these findings. Providing reinforcement on such dense schedules decreased the amount of targets that could be taught in each session but likewise increases external validity as such

procedures frequently must be implemented when working with students with moderate and severe disabilities. Finally, although the stimuli were randomly assigned to sets, there is an inherent chance that one set may have contained more difficult stimuli, which may have resulted in some sets requiring a greater number of sessions to meet mastery criteria (e.g., David's Set 2, see Figure 2).

When interpreting maintenance data, it is important to note that not all unknown stimuli were rehearsed the same number of times. Because the unknown targets were taught in a set sequence, those targets earlier in the sequence were rehearsed more than those targets later in the sequence. Maintenance data did not show a difference in retention of stimuli based upon the sequence in which they were taught, indicating that the unknown stimuli that were rehearsed fewer times were retained equally as well as those stimuli rehearsed a greater number of times.

Limitations and Future Directions

There were several limitations of this study. First, the schedule of reinforcement changed from baseline to intervention conditions. During baseline, all responses were reinforced; during intervention, only correct responses were reinforced. This change in the schedule of reinforcement could be interpreted as manipulation of a second independent variable between baseline and intervention conditions. Second, in multiple baseline and multiple probe designs, the participants are often quite similar and interventions tend to target the same skills across participants. In this study, each participant's sets of knowns and unknowns were comprised of different types of stimuli compared to the other participants. Although this may limit the strength of evidence, it may also make the results more generalizable across skills and academic levels. Finally,

researchers began IR intervention for Set 2 with Alex despite an increasing trend in baseline data (Figure 1). Researchers attempted to correct this by returning to baseline conditions and obtaining stable baseline data before returning to IR sessions with Set 2. This potentially reduces the strength of evidence provided by Alex's data. However, the increase in correct responding immediately following re-implementation of IR for Alex's Set 2 stimuli, coupled with the trends across Alex's other sets of stimuli and among the other two participants, is strong evidence in support of the effectiveness of IR and indicates that the trend would likely have been similar for Alex's Set 2 data.

This study provides strong evidence that IR is an effective intervention for improving sight word and letter acquisition among students with dual diagnoses of ASD and speech-language impairment. Likely, IR is effective for this population of students because it provides increased opportunities to respond and facilitates high levels of correct responding, allowing for more frequent reinforcement with less response effort. Future research should investigate the use of IR for teaching other discrete skills to students with developmental disabilities. Additionally, future research should compare IR to traditional drill and practice and to other flashcard methods in order to examine the efficiency of IR compared to these other interventions. Past research shows that constant time delay (Akcin, 2013; Swain et al., 2014), simultaneous prompting (Klaus et al., 2019; Swain et al., 2014), and other flashcard methods (Browder & Xin, 1998) are effective for teaching sight words to students with disabilities. When comparing traditional drill practice flashcard methods to IR, studies show that IR leads to improved maintenance of sight words among typically developing students (MacQuarrie et al., 2002). Additionally, Burns and Boice (2009) found that IR was the most effective sight word intervention for

students with mild intellectual disabilities when compared to two other commonly used interventions. Future studies should examine whether these trends are also seen among students with moderate to severe developmental disabilities.

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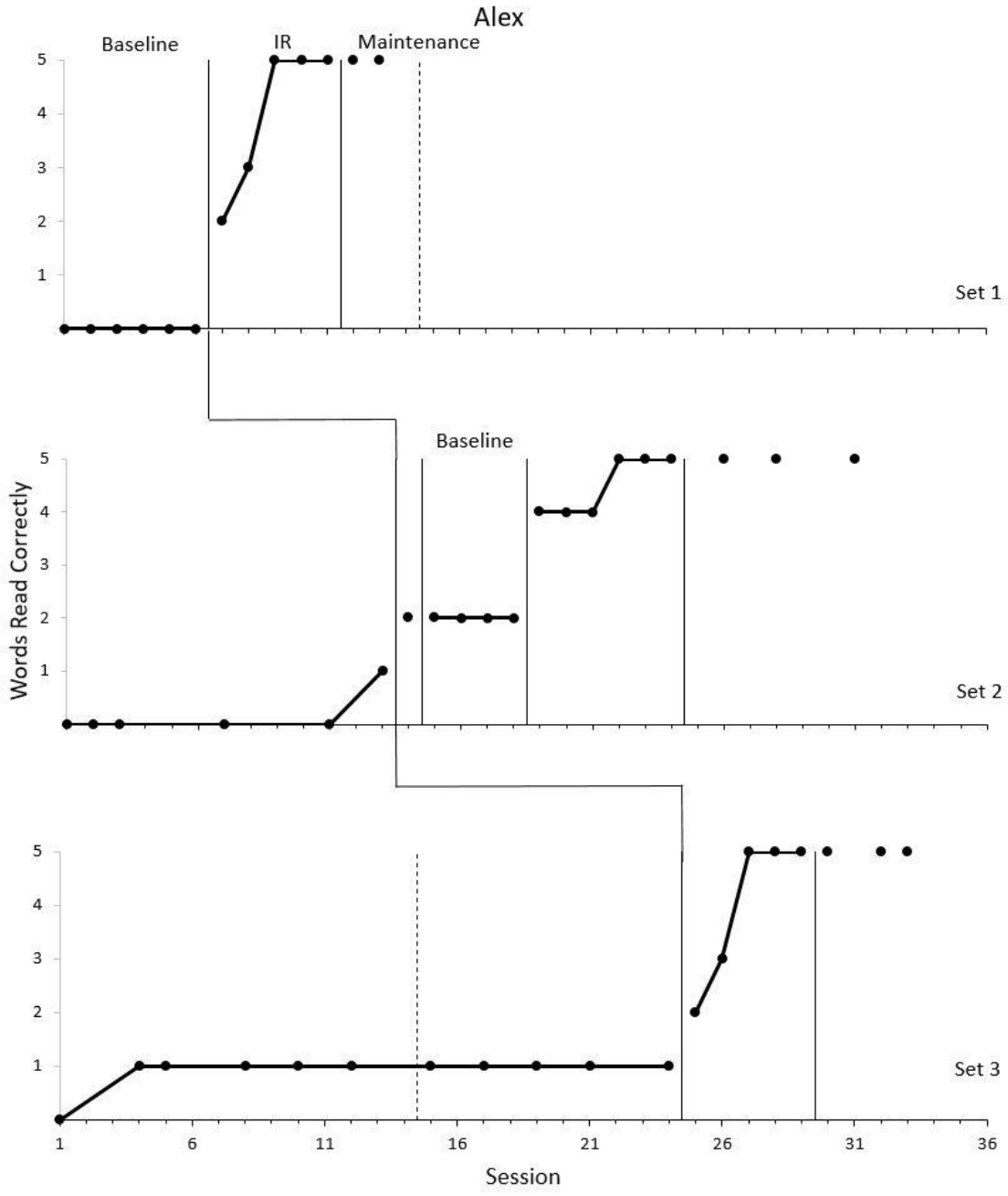

Figure 1. Multiple probe graph for Alex showing the number of correctly idenfied targets during probes. Dashed line indicates a one month break in sessions.

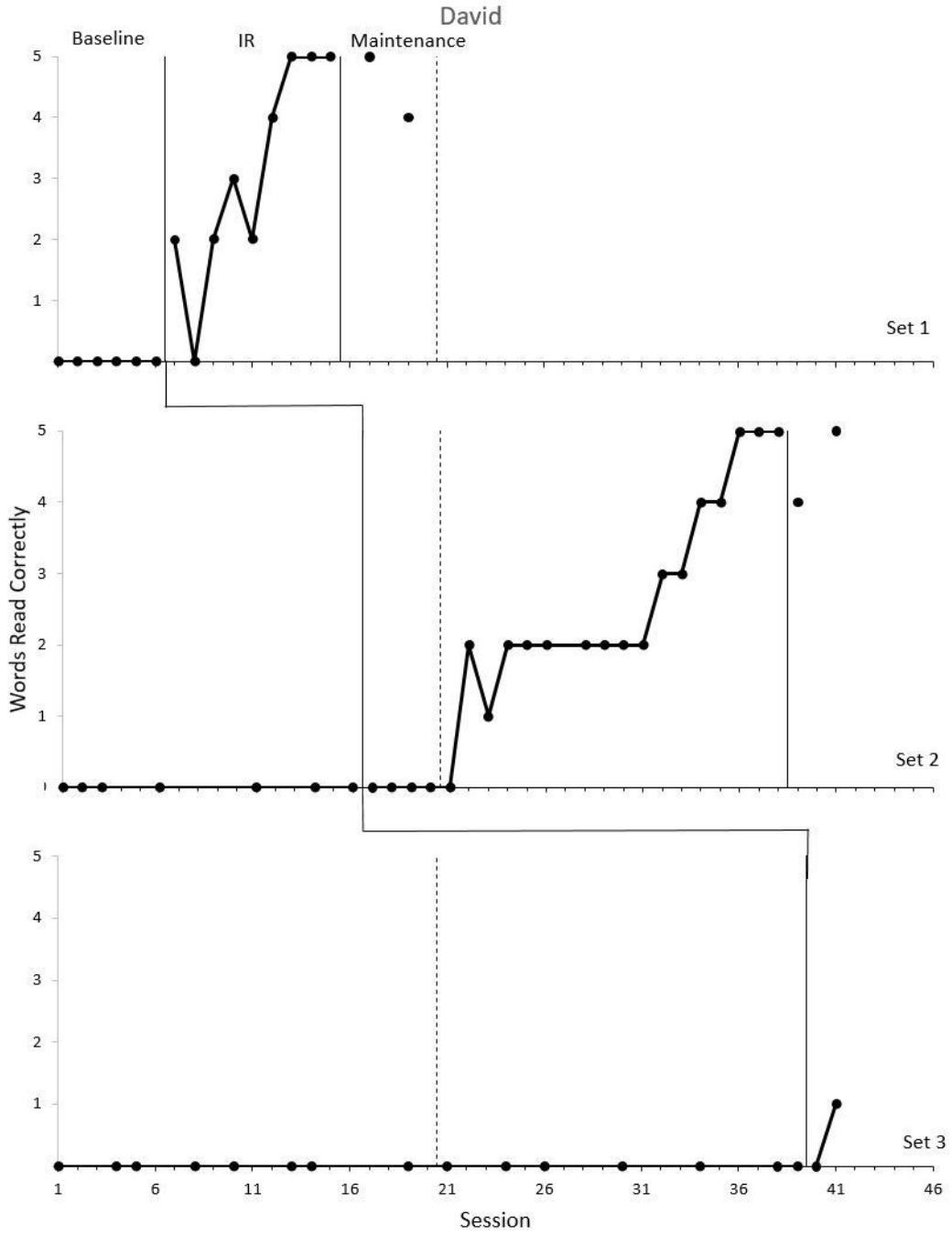

Figure 2. Multiple probe graph for David showing the number of correctly idenfied targets during probes. Dashed line indicates a one month break in sessions.

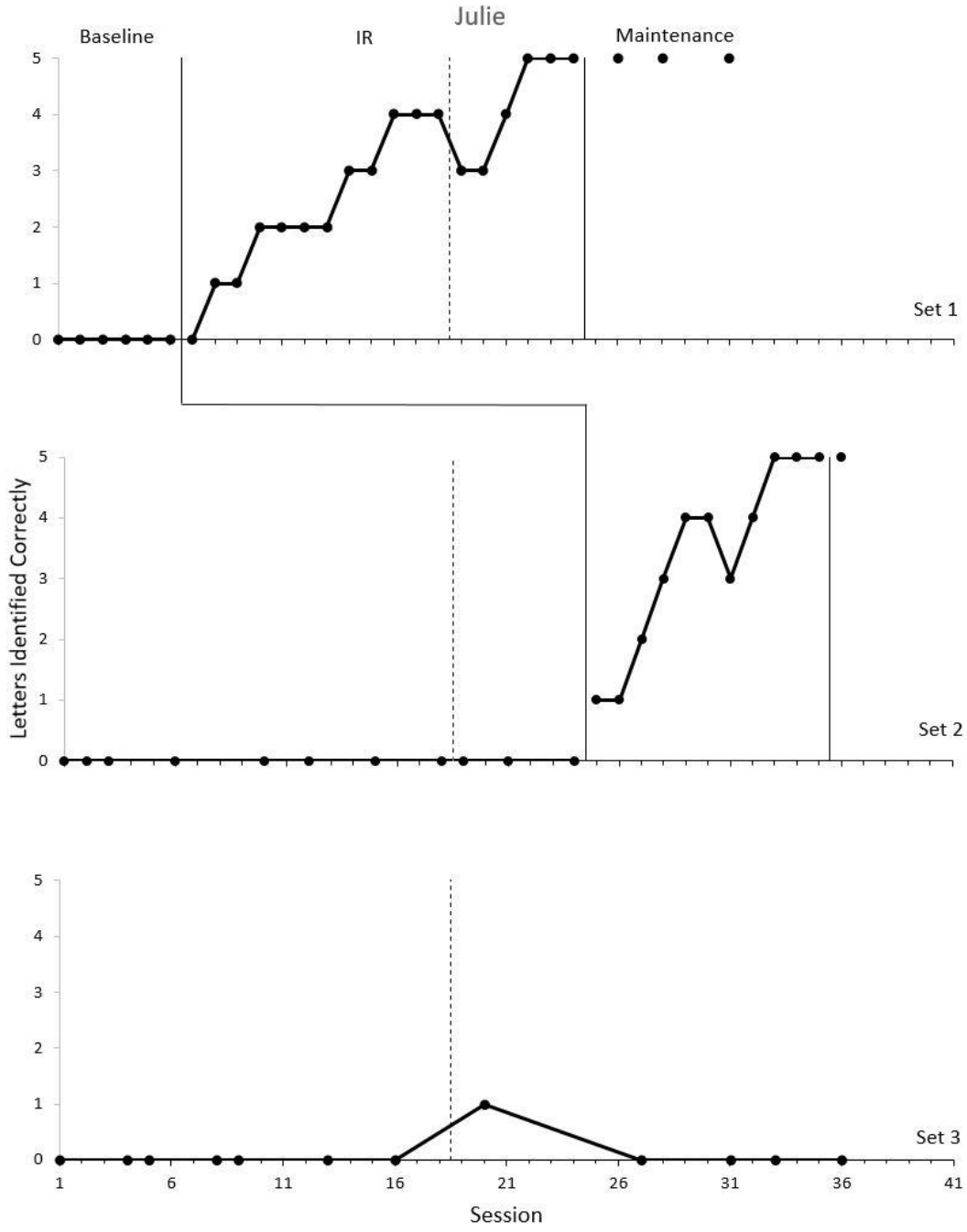

Figure 3. Multiple probe graph for Julie showing the number of correctly idenfied targets during probes. Dashed line indicates a one month break in sessions.