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Brief Experimental Analysis of Reading Deficits for Children With Attention-Deficit/ Hyperactivity Disorder

Daniel M. Fienup[1,2], Kimberly Reyes-Giordano[1,2], Katarzyna Wolosik[1], Anto Aghjayan[1], and Anil Chacko[3]

Abstract

Reading difficulties are especially high among children with attention-deficit/ hyperactivity disorder (ADHD). Although there are a number of empirically supported reading interventions for children with ADHD, there is little data to guide the selection of the most efficacious reading intervention for a specific child. Brief experimental analysis (BEA) is a procedure that directly compares the efficacy of various academic interventions with the goal of guiding the selection of the intervention that results in optimal efficacy. The current proof of concept study examined the efficacy of the BEA methodology for determining the relative effectiveness of seven reading interventions for children with ADHD. The seven interventions included empirically supported ADHD interventions as well as traditional interventions found in the BEA literature. Six children diagnosed with ADHD completed the proof of concept study. Results indicated that the BEA successfully determined an efficacious intervention for each participant.

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The efficacy of the interventions and the optimal intervention based on BEA procedures varied for each child, suggesting the importance of a BEA approach when comparing various interventions for reading in children with ADHD. Implications and future directions for selecting effective reading interventions for children with ADHD are discussed.

Keywords
ADHD, reading deficits, brief experimental analysis, functional analysis

Attention deficit hyperactivity disorder (ADHD) is characterized by developmentally inappropriate levels of inattention, activity, and/or impulsivity, resulting in significant impacts on various areas of daily life functioning (e.g., family interactions, peer relationships, academic achievement; Barkley, 2005). ADHD is considered one of the most prevalent psychiatric disorders of childhood, affecting 5% of school-aged youth worldwide (Faraone, Sergeant, Gillberg, & Biederman, 2003). ADHD has a complex presentation, owing to commonly observed comorbidity with other psychiatric disorders. For instance, 50% to 60% of youth with ADHD meet criteria for oppositional defiant disorder, 30% present with comorbid conduct disorder, and up to 25% present with anxiety and mood disorders (Jensen et al., 2001). Moreover, research has shown that poor outcomes of children diagnosed with ADHD persist well into adulthood (Klein et al., 2012). ADHD and its associated consequences appear to negatively affect the vast majority of youth throughout life.

Reading difficulties are especially prominent among children with ADHD. A meta-analysis revealed that academic achievement discrepancies between children with and without ADHD were highest with reading (Frazier, Youngstrom, Glutting, & Watkins, 2007). Individuals with ADHD displayed significantly lower academic achievement, in general, than non-ADHD children as measured by standardized achievement tests, but these findings are most pronounced with reading. Similarly, Ford, Poe, and Cox (1993) reported that inattentive behavior occurred more often on reading than math tasks. Given the relationship between reading and education and vocational success (Slavin et al., 1994), reading impairment in children with ADHD is a critical area for remediation.

Academic Interventions for Children With ADHD

There are a number of effective interventions for managing ADHD symptoms and co-occurring problems, such as reading difficulties. The most common treatments include stimulant medication and/or behavioral interventions (Daley & Birchwood, 2010; DuPaul, Eckert, & Vilardo, 2012). Although stimulant medications are the most common treatment, stimulants do not necessarily improve reading performance directly (Langberg & Becker, 2012). Stimulants may help individuals with ADHD to attend and stay on task; however, medication does not have direct, long-term positive effects on reading achievement (Raggi & Chronis, 2006).

Alternatively, a recent meta-analysis demonstrated that academic interventions for children with ADHD can have large effects on reading achievement (effect size [ES] = 1.53; DuPaul et al., 2012). One strategy used to improve reading among children with ADHD is computer-assisted instruction (CAI). CAI is a method that allows a student to practice and review academic material independently using computer software. This type of intervention may involve presentation of specific instructional objectives, division of material into smaller chunks, providing immediate performance feedback, and using repeated trials and individualized activities. Previous research suggested that CAI improves the sustained attention and work performance of children with ADHD (Raggi & Chronis, 2006) and has a positive effect on reading (ES = 7.93; Clarfield & Stoner, 2005, as reported in DuPaul et al., 2012).

Another class of interventions involves revising curricula to accommodate the individual needs of a student, to reduce problem behavior, and to increase appropriate behaviors (DuPaul & Eckert, 1998). One example of a curricula-altering intervention is choice-making, in which a student is permitted to choose an activity from two or more concurrently presented options. It has been found that choice-making decreases disruptive behavior and increases on-task engagement in children with ADHD (Dyer, Dunlap, & Winterling, 1990). Manipulating stimulation levels (MSL) is another way to modify curriculum. Zentall (1989) investigated the effects of adding color to relevant cues during spelling tasks to increase attention and performance of children reported to be hyperactive. This study found that the addition of color to emphasize relevant cues increased student's attention to important details and increased academic performance.

Selecting Optimal Academic Interventions

One difficulty many educators encounter is selecting the most efficacious academic intervention to address reading difficulties for a specific child with ADHD. CAI, choice, and MSL have all received empirical support (Daley & Birchwood, 2010; DuPaul & Eckert, 1998; Jitendra, DuPaul, Someki, & Tresco, 2008; Raggi & Chronis, 2006), thus making these interventions suitable for children with ADHD. However, to the best of our knowledge, there have been no studies that evaluate the comparative effectiveness of these interventions or, more importantly, to evaluate a process to select the most efficacious intervention for a given child. As Daly, Martens, Barnett, Witt, and Olson (2007) stated, "Decisions regarding intervention effectiveness are unavoidably individualized" (p. 564). Thus, the current literature provides little guidance for selecting the most efficacious reading interventions—among a set of potential reading interventions for a particular child with ADHD. DuPaul and Eckert (1997) suggest functional assessment as a procedure for gathering data toward making a decision regarding the selection of the most efficacious intervention for a child.

A functional analysis of reading deficits (Daly, Witt, Martens, & Dool, 1997) provides a solution for deciding which reading intervention to implement for a specific child with ADHD. A functional analysis of reading deficits seeks to identify instructional components that positively affect academic performance. Daly et al. suggest five hypotheses for academic skill deficits: (1) insufficient motivation, (2) insufficient practice, (3) insufficient instruction, (4) insufficient generalization, and (5) instructional materials are too difficult. These hypotheses can be examined within a Brief Experimental Analysis (BEA). A BEA utilizes single-subject research designs to compare multiple treatments. Interventions that align with different hypotheses for academic skill deficits are selected. Experimental control is demonstrated when an intervention produces a higher level of academic performance than other interventions. This approach also provides evidence of intervention efficacy before implementing an intervention; thus, the intervention selection process is driven by a learner's academic performance data. With a BEA of reading deficits, an instructor implements interventions and evaluates academic performance (Burns & Wagner, 2008). The goal is to identify interventions that produce the highest level of reading performance. Words read correctly per minute (WRCM), or reading fluency, is typically used to evaluate reading interventions (Burns & Wagner, 2008).

The following are examples of general interventions applied to evaluate each of the five academic skill deficit hypotheses. To evaluate the effect of motivation (Hypothesis 1), the instructor provides rewards contingent on increases in reading fluency (called Incentive). To evaluate the effect of practice (Hypothesis 2), a child reads a passage multiple times (called Repeated Readings, RR). Various instructional interventions (Hypothesis 3), such as phrase drill (PD) and listening passage preview (LPP), can be used to evaluate the insufficient instruction hypothesis. PD involves repeated practice and feedback on words read incorrectly. For LPP, the instructor models correct reading of a passage for the child. Generalization issues (Hypothesis 4) can be addressed by targeting skills in isolation and then teaching how to engage in this skill with new instructional materials. If academic materials are too difficult (Hypothesis 5), prerequisite skills should be targeted first. A common intervention is to use easier reading materials, or materials from a prior grade level. By directly comparing intervention components, BEA methods gather data on the function of academic deficits toward selecting interventions that will maximize reading performance.

Reading interventions that have empirical support for children with ADHD can be re-conceptualized according to Daly et al.'s (1997) hypotheses. For instance, choice can be conceptualized as addressing a motivational deficit (Hypothesis 1). Choice may be effective because following the students lead in selecting instructional materials may lead to materials that are more reinforcing for the student. CAI appears to be in line with improving instruction (Hypothesis 3) because this intervention often includes practice and response-specific feedback. MSL is more difficult to map onto Daly's hypotheses. On the one hand, this intervention may be designed to make relevant features of a task more salient and hence be instructional (Hypothesis 3). On the other hand, this intervention is designed to increase attention to task by making academic material more stimulating, which may be good fit with motivational interventions (Hypothesis 1). CAI, choice, and MSL are all designed to improve performance during instruction for children with ADHD.

BEA has been successfully applied to reading fluency issues. Burns and Wagner (2008) conducted a meta-analysis of 13 BEA of reading deficits studies. The authors found that studies tended to identify a "most effective" intervention that produced reading fluency that was 73% higher (about 30 WRCM) than baseline reading fluency. This is a clinically significant finding. According to published reading fluency norms (e.g., Center on Teaching and Learning, 2012; Good, Kaminski, & Dill, 2007), this difference equals about a half year of expected reading gains.

Despite the abundance of ADHD reading studies and BEAs of reading, to date, only one study has evaluated a functional analysis of reading deficits with children with ADHD. Noell and colleagues (1998) examined the efficacy of three different reading strategies on oral reading fluency. A baseline reading fluency was established with each participant. Next, a contingent reward was applied. If a student did not improve on measures of reading fluency, then modeling and practice were added to contingent rewards. If the combined treatment was effective, then only modeling and practice were applied to test the possibility that modeling and practice were sufficient to increase oral reading fluency. The results identified individual treatment packages that benefited each participant; two participants responded best when reward, practice, and modeling were combined, whereas one participant demonstrated the greatest increase in reading fluency when only modeling and practice were applied. The ESs of these interventions were reported as 1.20 and 3.38 in a recent meta-analysis (DuPaul et al., 2012).

The current proof-of-concept study sought to examine the utility and appropriateness of using a BEA for children with ADHD. The extent to which methods traditionally used in BEA (incentive, RR, LPP, PD) are effective for children with ADHD is unknown given that the attention, activity, and impulsivity characteristics of this population may prove implementation of BEA procedures difficult. Similarly, difficulties with attention, activity, and impulsivity may create variability in outcomes that make detecting differential effects of intervention difficult. As such, traditional BEA procedures may have to be modified for children with ADHD.

The current study extends the literature in a number of ways. First, empirically supported academic interventions for children with ADHD (e.g., CAI, choice, MSL) were added to the standard battery of BEA reading interventions to compare the relative effects of both traditional ADHD interventions and interventions traditionally implemented in a BEA with non-ADHD participants. We chose these interventions because they are commonly cited in reviews of ADHD academic interventions, but there are no studies that compare the effects of these interventions with other interventions. Second, this study extends the ADHD literature by directly comparing multiple academic interventions and working toward a method of selecting an optimal reading intervention at an individual level. Third, this study extends the work of Noell et al. (1998), the only functional analysis of reading deficits study conducted with children with ADHD, by examining a more comprehensive range of function hypotheses and intervention strategies for children with ADHD.

Method

Participants

Six children diagnosed with ADHD participated in the study. Participants were recruited through flyers posted on a college campus. Participants' parents contacted the first author and child participants were invited for an initial evaluation if she or he met the following criteria: (a) native English speaker, (b) previous diagnosis of ADHD by a health care provider, and (c) parent report of reading difficulties.

During the intake session, researchers administered a number of standardized assessments. Researchers administered the Kiddie–Sads–Present and Lifetime Version (K-SADS-PL; Kaufman, Birmaher, Brent, Rao, & Ryan, 1996) to each child's parents to gather information about *Diagnostic and*

Statistical Manual of Mental Health Disorders (4th ed., *DSM-IV*; American Psychiatric Association, 1994) ADHD symptoms and associated impairment. In addition, each participant's parent and teacher completed the Disruptive Behavior Disorders (DBD) rating scale (Pelham, Gnagy, Greenslade, & Milich, 2002). These assessments were used to confirm the previous diagnosis of ADHD. During the initial session, researchers administered the *Woodcock Reading Mastery Test–Revised* (*2nd edition*; WRMT-R; Woodcock, 1998) to the child participants to gauge reading level. During the intake, researchers also inquired about medication use for ADHD and all parents reported that child participants had taken medications in the past, but no child was currently prescribed medication for the treatment of ADHD.

For each participant, we report general information, parent reported reading concerns, school placement, ADHD diagnostic information, and standardized reading performance. The WRMT-R provides standard scores and percentile rankings for overall reading as well as three clusters (readiness, basic skills, reading comprehension). We only report cluster scores that fell in the below average range. All other cluster scores were in the average range.

Michael was an 8-year-old Asian male who was in Grade 3.2. His mother reported that inattention negatively affected his reading rate and that Michael avoided tasks that required sustained attention such as reading and writing. He was in a general education classroom and was provided special education support services for an Emotional Disorder. Based on the intake evaluation, Michael met diagnostic criteria for ADHD, Combined type. On the WRMT-R, Michael's total standard score was 95 (37th percentile) and he scored in the below average range for both readiness (86 standard score) and reading comprehension (88 standard score) clusters. Michael's reading level was assessed at 2.6 grade level, which was below his current placement in school. During the study, Michael read third-grade reading passages.

Gretchen was a 9.9-year-old Hispanic female who was in Grade 4.6. Her mother reported that Gretchen was behind her peers in reading and that Gretchen struggled to attend to reading tasks. Gretchen was in a general education classroom and received additional reading help from a reading specialist; however, there was no individualized education plan (IEP). Based on the intake evaluation, Gretchen met the diagnostic criteria for ADHD, Inattentive type. On the WRMT-R, Gretchen's total standard score was 90 (25th percentile) and she scored in the lower part of the average range for both basic skills (90 standard score) and reading comprehension (92 standard score) clusters. Gretchen's reading level was assessed at 3.1 grade level, which was below her current placement in school. During the study, Gretchen read third-grade reading passages.

Evan was a 9.8-year-old Asian male who had just completed fourth grade. His mother reported that Evan had speech difficulties, a narrow range of reading interests, and had difficulty focusing during reading tasks. Evan was in a general education classroom and did not qualify for special education services. Based on the intake evaluation, Evan met the diagnostic criteria for ADHD, Combined type. On the WRMT-R, Evan's total standard score was 101 (53rd percentile) and he scored in the average range for all clusters except the readiness cluster where Evan's performance was below average (standard score of 86). Evan's reading level was assessed at 5.0 grade level, which was on par with his educational progression. During the study, Evan read fifth-grade reading passages.

Karen was a 12.5-year-old Caucasian female who was in Grade 7.2. Her mother reported that Karen was several reading levels behind in school and that her reading deficits negatively affected all of her academic subjects as reading was heavily emphasized in all classes. Karen was in a co-taught general education classroom and received special education services for reading, which included additional instruction for reading and tests in other subjects were read to her. Based on intake evaluation, Karen met the diagnostic criteria for ADHD, Inattentive type. On the WRMT-R, Karen's total standard score was 91 (28th percentile) and she scored in the below average range for both readiness (89 standard score) and basic skills (88 standard score) clusters. Karen's reading level was assessed at 5.0 grade level, which was substantially below her current placement in school. During the study, Karen read fifth-grade reading passages.

Jeremy was a 9.9-year-old Asian male who was in Grade 4.7. His mother reported that he struggled with reading more than listening comprehension and that he struggled with motivation to read. He was in a general education classroom, received extra help with reading from his teacher, but no individualized services were provided. Based on the intake evaluation, Jeremy met the diagnostic criteria for ADHD, Inattentive type. On the WRMT-R, Jeremy's total standard score was 100 (50th percentile) and he scored in the below average range for the readiness cluster (89 standard score). Jeremy's reading level was assessed at 4.7 grade level, which matched his current placement in school. During the study, Jeremy read fifth-grade reading passages.

Nathan was a 9.8-year-old Caucasian male who was in Grade 4.7. His mother reported that the participant was nearly held back a year in school due to his reading difficulties and had scored poorly on the state exam. He was in a general education classroom and had an IEP that allowed him additional time for taking tests. Based on intake evaluation, Nathan met the diagnostic criteria for ADHD, Combined type. On the WRMT-R, Nathan's total standard score was 99 (46th percentile) and he scored in the below average range for the readiness cluster (81 standard score). Nathan's reading level was assessed at 4.5 grade level, which approximated his current placement in school. During the study, Nathan read fifth-grade reading passages. He completed the BEA during the summer between fourth and fifth grades.

Setting and Materials

Sessions were conducted in a small room that was part of a university clinic. All sessions were videotaped. Two interventionists and a participant were present in the room during each reading intervention session. The room consisted of two desks with chairs, a large bookshelf filled with toys and books, and a computer desk. The participant was seated at a desk next to or across from the first interventionist and the second interventionist was seated in the back of the room. The first interventionist implemented the interventions and the second interventionist was responsible for operating the video camera, timing the passages, evaluating treatment integrity, and managing paperwork and forms used during sessions.

Participants read oral reading fluency passages from the Dynamic Indicators of Basic Early Literacy Skills (DIBELS; Good et al., 2007) and experimenters scored readings using scoring sheets provided by the same source. In one condition, called MSL, the readings were displayed on an iPad 2 device. The stories were made into pdf files and displayed on the iPad using a pdf reader application. Otherwise, the readings were printed on standard size paper. Participants were assigned to a particular grade level of passages based on the overall grade level indicated by the WRMT-R.

All reading and data collection materials were organized in binders. Each binder contained 27 reading probes divided into three sections for administration across three sessions. Within a session, a participant was exposed to seven different interventions. All interventions were assigned one reading probe with the exception of the incentive and choice interventions, which were assigned two reading probes. The order of interventions within a session and the assignment of specific reading probes to interventions were randomized using random numbers generated in Microsoft Excel. Randomization occurred prior to the start of the first reading intervention session and the binders with all reading materials were created in accordance with the randomized order and assignment.

Some interventions required additional materials. During the CAI intervention, researchers provided participants with a Dell laptop computer. During the incentive intervention, researchers presented tangible objects, which consisted of inexpensive ($1-2) tangible objects (e.g., colorful erasers, crayons, toy cars, key chains, fun facts book), in a medium sized box.

Dependent Variable

Reading fluency, defined as the number of WRCM, served as the dependent variable for this study. A correctly read word was defined as a word pronounced accurately within 3 s. An error was defined as a word pronounced incorrectly (e.g., incorrect tense, singular vs. plural forms, omitting or adding "s" endings), an omitted word, or hesitation for more than 3 s. The total WRCM was calculated by subtracting errors from the total number of words read during the first min of reading.

Procedure

All sessions and conditions followed a general procedure. Sessions were conducted once a week for three consecutive weeks and each lasted approximately 60 to 90 min. During a session, a participant completed all seven intervention conditions. Each intervention was followed by a reading probe. For a reading probe, the student sat next to the interventionist and the interventionist provided the child with a reading. The interventionist instructed the participant to read the passage. While the participant read, the interventionist remained silent; however, if the student read a word incorrectly or paused for 3 s, the interventionist provided the correct word. When the participant finished the reading probe, the interventionist verbally praised the participant for completing the story and a 5-min break commenced. Each intervention differed in terms of what came before or after the reading probe. Below are descriptions of the unique procedural differences among interventions.

Seven interventions were included in this study: Incentive, Choice, RR, LPP, PD, CAI, and MSL. Interventions were selected (a) to sample various hypotheses for academic deficits proposed by Daly et al.'s (1997) and (b) to include both empirically supported academic interventions for children with ADHD and traditional interventions found in the BEA literature. Specifically, Incentive and Choice conditions addressed the hypothesis that the participant lacked motivation. The incentive condition was adapted from BEA literature (e.g., Daly, Martens, Hamler, Dool, & Eckert, 1999; Daly, Murdoch, Lillenstein, Webber, & Lentz, 2002), whereas Choice procedure was adapted from ADHD research (e.g., Dyer et al., 1990). The RR condition, which was adapted from BEA literature (e.g., Daly et al., 1999; Daly et al., 2002), addresses the hypothesis that the participant did not have enough opportunities to practice the skill. LPP, PD, and CAI interventions examined the insufficient instruction hypothesis. LPP and PD conditions were adapted from BEA literature (e.g., Daly et al., 1999; Daly et al., 2002) whereas CAI was adapted from ADHD research (e.g., Raggi & Chronis, 2006). MSL was adapted from the ADHD literature (Zentall, 1989).

Each condition varied in length based on the procedures, but all conditions lasted approximately 6 min or less. The choice and MSL conditions involved reading one passage and took the length of a reading probe. The incentive, RR, and LPP conditions took approximately twice as long as two stories were read. The CAI condition involved using a computer program for 3 min followed by a reading probe. The PD intervention took the longest time because of the intensity of prompting and feedback that occurred during the first of two readings.

Incentive. During the incentive condition, the participant read two unique passages, both of which were administered as reading probes. After the first reading probe, the second interventionist presented a box of rewards to the participant and asked the participant to choose a reward to access following task completion. While this occurred, the first interventionist calculated the WRCM for the initial reading passage and multiplied that number by 1.05. The new number, which was 5% higher than the first reading's WRCM, became the target WRCM for the second reading. A reading probe was conducted on a new reading passage and the interventionist told the participant that if she or he was able to read faster and with fewer errors on the new reading, she or he could keep the reward she or he chose. After the second reading probe was administered, the interventionist calculated the WRCM and contingently provided the reward to the child based on meeting the second reading criterion (105% WRCM of first reading).

Choice. In the choice condition, the student was presented with two reading passages. The participant chose one reading passage to read, which was administered and scored as a reading probe.

RR. In the RR condition, experimenters conducted two consecutive reading probes on the same reading passage and the second reading was scored.

LPP. In the LPP condition, the interventionist read the story out loud while the student followed along with his or her finger. Then, a reading probe was conducted while the participant read the same story.

PD. In the PD condition, the same reading was presented twice, like with RR. During the first reading, when a participant committed a reading error (i.e., paused for more than 3 s, omitted a word, read a word incorrectly), the interventionist said the word, instructed the participant to read the erred word 3 times aloud, then instructed the student to begin reading from the start of the sentence to give the participant the opportunity to read the word in context. After conducting the PD procedure during one reading of the passage, the interventionist re-presented the same story and conducted and scored a reading probe, as described above.

CAI. During the CAI condition, participants completed a computer program designed by the first author. The program required the student to listen to a word (through headphones) and then click on the correct spelling of the word (three variations were presented). The participant earned a point for each correct selection and the interventionist instructed the participant to earn as many points as she or he could obtain. The words that were practiced were chosen by the interventions a priori and were determined to be the 10 most difficult words in the passage. The computer program automatically terminated after 3 min and the interventionist conducted a reading probe on a story containing the words that had been practiced.

MSL. During the MSL condition, the interventionist presented the reading on an iPad 2 and conducted a reading probe.

Experimental Design

An alternating treatments design was used to evaluate the effects of the reading interventions on reading fluency. The order of the presenting seven interventions within a session and the assignment of reading passages to specific interventions were randomized for each participant. A 5-min break occurred between each intervention to decrease the likelihood of fatigue or carryover effects.

Interobserver Agreement and Treatment Integrity

Two to three independent observers scored 100% of the reading probes. All reading probes were scored by watching video recordings of sessions on a computer. The first two observers recorded whether each word in a reading passage was read correctly or incorrectly. Then, using an item-by-item interobserver agreement procedure, each word was scored as either an agreement (both observers had the same correct or incorrect recording) or a disagreement. Interobserver agreement was calculated by dividing the number of agreements by the total number of words and multiplying by 100. Interobserver agreement was 98.6% (91.1% to 100.0%). To ensure accurate reporting of data, a third observer recoded all disagreements. The third

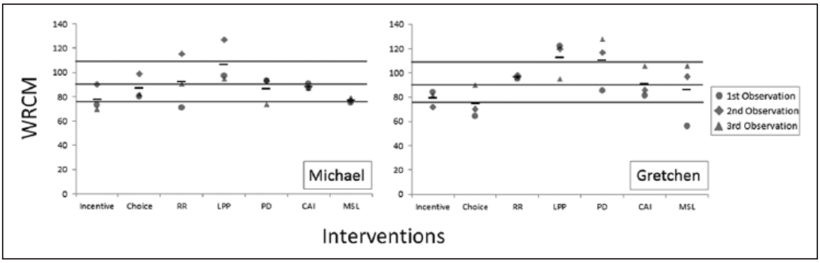

Figure 1. The graphs display individual performances (circles, diamonds, and triangles) and average performance (bar) per intervention for Michael and Gretchen, who read third-grade reading passages. The three horizontal lines represent reading fluency expected at the beginning, middle, and end of third grade.
Note. RR = repeated readings; LPP = listening passage preview; PD = phrase drill; CAI = computer-assisted instruction; MSL = manipulating stimulation levels.

independent observer watched videotapes of reading probes and made a final judgment of whether the word was read correctly or incorrectly by the participant.

Treatment integrity data were collected during a minimum of 33% of each participant's sessions and for 77% of all sessions (range = 33.3% to 100.0% of each participant's interventions). An observer, who had not conducted the intervention, recorded whether the interventionist was seated next to the participant, read scripted instructions, implemented intervention strategies (e.g., correction procedure during PD), praised the child for effort, and conducted a reading probe accurately. Each intervention had between six and nine steps. Overall integrity was 99.1%. There were seven observations during which the interventionist did not praise the child's effort for reading, which tended to occur because the child immediately initiated a conversation about the content of the reading passage or the activity to be used during the 5-min break. All instructions, interventions, and reading probe procedures were conducted with 100% integrity for all conditions and participants.

Results

The individual reading fluency performances of the six participants are displayed in Figures 1 and 2. The figures plot individual observations of intervention effects as well as the average WRCM across three observations for all seven different interventions. The participants are grouped according to reading passage grade level. The horizontal lines on the graph represent grade specific DIBELS norms, which indicate reading goals for students at the

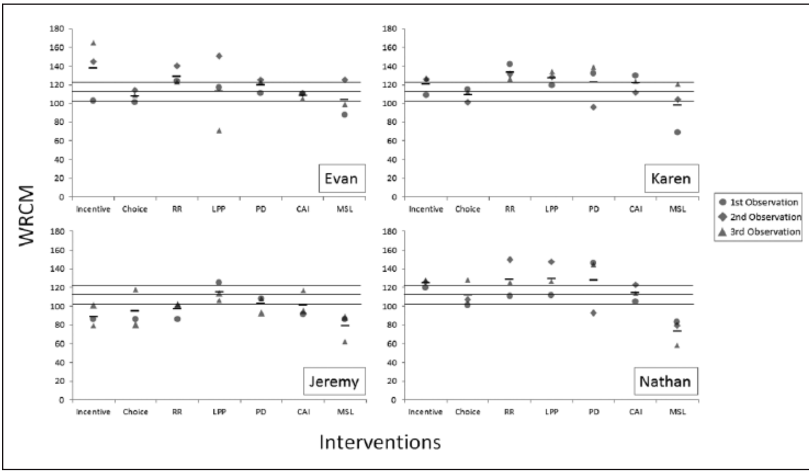

Figure 2. The graphs display individual performances (circles, diamonds, and triangles) and average performance (bar) per intervention for Evan, Karen, Jeremy, and Nathan, who read fifth-grade reading passages. The three horizontal lines represent reading fluency expected at the beginning, middle, and end of fifth grade.
Note. WRCM = words read correctly per minute; RR = repeated readings; LPP = listening passage preview; PD = phrase drill; CAI = computer-assisted instruction; MSL = manipulating stimulation levels.

beginning, middle, and end of a school year (from bottom to top). Table 1 displays percentage of errors per intervention observation. Burns and Wagner (2008) argued that to produce significant results, the interventions should result in a difference of 30 WRCM between the best and worst performing interventions in a BEA; thus, this information is reported below.

Figure 1 displays the reading fluency results for Michael and Gretchen, who read third-grade reading passages. The horizontal lines display third-grade DIBELS norms for the beginning, middle, and end of the school year, which were 77, 92, and 110 WRCM, respectively. For Michael (left panel of Figure 1), all interventions produced an average WRCM expected of third graders. Both RR ($M = 92.3$) and LPP ($M = 106.6$) produced average WRCM that were expected between the middle and end of third grade. The LPP intervention, which addresses instructional deficits, produced the highest average WRCM and all three observations were at a level expected at the middle or end of third grade. LPP also produced the lowest average percentage of errors (see Table 1). The lowest reading fluency was observed with the MSL intervention (M = 77.0), which also produced one of the highest percentages of errors (9.0). The

Table 1. Percentage of Errors per Reading.

Participant	Session	Interventions						
		Incentive	Choice	RR	LPP	PD	CAI	MSL
Michael	1	8.8	7.0	7.8	3.0	5.1	6.2	7.4
	2	7.2	8.3	1.7	8.0	7.0	3.3	9.4
	3	12.5	3.5	7.1	4.0	17.8	6.5	10.2
	M	9.5	6.3	5.5	5.0	10.0	5.3	9.0
Gretchen	1	6.7	11.1	5.0	3.9	2.3	8.0	12.5
	2	7.7	10.3	5.8	4.8	2.5	10.4	5.8
	3	5.8	5.3	6.7	6.9	10.5	1.9	2.8
	M	6.7	8.9	5.8	5.2	5.1	6.7	7.0
Evan	1	2.8	3.8	3.1	1.7	0.9	4.3	3.3
	2	1.4	2.6	3.4	1.9	4.6	5.9	10.1
	3	0.6	2.7	2.4	11.3	2.4	4.5	2.0
	M	1.6	3.0	3.0	5.0	2.6	4.9	5.1
Karen	1	5.2	6.5	3.4	6.3	2.9	1.5	13.8
	2	5.3	5.6	3.7	4.5	5.9	4.3	8.0
	3	4.5	5.1	6.0	2.9	5.4	7.5	6.9
	M	5.0	5.7	4.3	4.6	4.8	4.4	9.5
Jeremy	1	6.5	4.4	4.4	1.6	1.8	2.2	2.3
	2	1.0	5.9	1.9	0.0	2.1	2.1	2.2
	3	1.3	0.0	1.0	0.9	1.8	0.0	4.6
	M	2.9	3.4	2.4	0.8	1.9	1.4	3.0
Nathan	1	2.4	3.8	0.9	0.9	0.0	2.8	6.7
	2	1.6	2.7	1.3	0.7	4.1	1.6	4.8
	3	3.0	0.0	0.8	0.8	0.0	3.4	6.5
	M	2.3	2.2	1.0	0.8	1.4	2.6	6.0

Note. RR = repeated readings; LPP = listening passage preview; PD = phrase drill; CAI = computer-assisted instruction; MSL = manipulating stimulation levels.

difference between the best and worst performing interventions was 29.3 WRCM, which is within 1 WRCM of the Burns and Wagner (2008) standard.

For Gretchen (right panel of Figure 1), all interventions produced an average WRCM expected of third graders, with the exception of the choice intervention. For two of the three sessions, choice produced WRCM below the norm expected at the beginning of third grade. Both incentive and MSL produced average WRCM that were expected between the beginning and middle of third grade; RR and CAI produced reading fluency that was expected between the middle and end of third grade; and LPP (M = 112.3) and PD

(M = 110.0) produced reading fluency expected at the end of the third grade. The LPP and PD interventions, which address instructional deficits, produced the highest average WRCM and the lowest average percentage of errors (see Table 1). The lowest reading fluency was observed with the choice intervention (M = 74.7), which also had the highest average percentage of errors (8.9). The difference between the best and worst performing interventions was 37.7 WRCM, which suggests this BEA produced significant differentiation.

Figure 2 displays the results for Evan, Karen, Jeremy, and Nathan, who all read fifth-grade reading passages. The horizontal lines display fifth-grade DIBELS norms for the beginning, middle, and end of the school year, which were 104, 115, and 124 WRCM, respectively. For Evan (top left panel of Figure 2), all interventions produced an average WRCM expected of fifth graders. LPP, CAI, choice, and MSL produced average WRCM that were expected between the beginning and middle of fifth grade; PD produced reading fluency that was expected between the middle and end of fifth grade; and RR (M = 129.0) and incentive (M = 137.7) produced reading fluency expected at the end of the fifth grade. The incentive intervention, which addresses motivational deficits, produced the highest average WRCM and the lowest percentage of errors (see Table 1). The lowest reading fluency was observed with the MSL intervention (M = 104.0), which also produced the highest percentage of errors (5.1). The difference between the best and worst performing interventions was 33.7 WRCM, which suggests this BEA produced significant differentiation.

For Karen (top right panel of Figure 2), all interventions produced an average WRCM expected of fifth graders, with the exception of MSL. For one of the three sessions, MSL produced WRCM below the norm expected at the beginning of fifth grade. Choice produced average WRCM that was expected between the beginning and middle of fifth grade; PD, CAI, and incentive produced reading fluency that was expected between the middle and end of fifth grade; and RR (M = 133.0) and LPP (M = 127) produced reading fluency expected at the end of the fifth grade. RRs, which address practice deficits, produced the highest average WRCM and the lowest percentage of errors (see Table 1). The lowest reading fluency was observed with the MSL intervention (M = 98.0), which also produced the highest percentage of errors (9.5). The difference between the best and worst performing interventions was 35.0 WRCM, which suggests this BEA produced significant differentiation.

For Jeremy (bottom left panel of Figure 2), LPP and PD produced an average WRCM expected of fifth graders. RR, CAI, Incentive, Choice, and MSL produced average WRCM below fifth-grade expectations at the beginning of the year; PD produced reading fluency that was expected between the beginning and middle of fifth grade; and LPP (*M* = 115.0) produced reading fluency expected between the middle and end of the fifth grade. LPP, which address instructional deficits, produced the highest average WRCM and the lowest percentage of errors (see Table 1). The lowest performance was observed with the MSL intervention (*M* = 78.7), which also produced one of the highest percentages of errors (3.0). The difference between the best and worst performing interventions was 36.3 WRCM, which suggests this BEA produced significant differentiation.

For Nathan (bottom right panel of Figure 2), all interventions produced an average WRCM expected of fifth graders, with the exception of MSL. The MSL condition produced WRCM below the norm expected at the beginning of fifth grade. Choice produced reading fluency that was expected between the beginning and middle of fifth grade; CAI produced reading fluency that was expected between the middle and end of fifth grade; and RR (*M* = 128.7), LPP (*M* = 129.0), PD (*M* = 128.0), and Incentive (*M* = 124.7) produced reading fluency expected at the end of the fifth grade. The lowest performance was observed with the MSL intervention (*M* = 73.3), which also produced the highest percentage of errors (6.0, see Table 1). The difference between the best and worst performing interventions was 55.7 WRCM, which suggests this BEA produced significant differentiation. Overall, interventions from multiple hypothesis categories produced high levels of reading fluency. The high levels of reading fluency observed during the RR condition suggest that high levels of reading fluency during instructional interventions (e.g., LPP, PD) was due to the repeated exposure to a reading passage, not the active intervention components (modeling, prompting, and feedback). The consistently high level of reading fluency produced during the incentive condition suggests that motivational factors play a role in Nathan's reading fluency. RR (*M* = 1.0) and incentive (*M* = 2.3) conditions both produced relatively low percentages of errors, with the RR producing consistently lower percentages of errors.

Discussion

The current proof-of-concept study used a BEA to examine the efficacy of reading interventions with children diagnosed with ADHD. The current study evaluated seven interventions consisting of empirically supported interventions for individuals with ADHD as well as interventions described in reading fluency literature. Overall, five of six experimental analyses produced significant results according to the standard articulated by Burns and Wagner (2008) and Michael's BEA was on the cusp of meeting the 30 WRCM differentiation standard. These outcomes allow us to infer that a traditional BEA can be effectively used with children with ADHD, as was first suggested by Noell et al. (1998). The BEA methodology is effective because discriminable intervention outcomes were found for almost all children within the study. Below, we discuss the results of the BEA for study participants, implications for the assessment of reading difficulties in children with ADHD, and future directions in this important, but understudied, area of research.

The effectiveness of specific interventions varied across all six participants, which is to be expected when determining the individualized function of reading deficits. Karen and Nathan performed best when simply allowed to practice reading, suggesting the function of the reading deficit was a lack of sufficient learning trials. Michael, Gretchen, and Jeremy had the highest reading fluency when the interventionist provided active help (modeling reading or corrective feedback), suggesting skill deficits were due to a lack of sufficient instruction. Evan performed the best when he earned a reward contingent on improved reading fluency, suggesting his reading deficit is due to a lack of motivation—his performance may likely further improve if self-identified rewards are used as contingent reinforcers. For all six participants, the top performing intervention was an intervention selected from the BEA literature (e.g., RR, LPP, incentive). For all six participants, the worst performing intervention was an intervention selected from the ADHD literature (e.g., MSL, choice). Most importantly, for each child, the BEA identified interventions that produced reading fluency expected at different points in a school year, thus demonstrating educationally relevant differentiation.

The most effective interventions identified by the BEA have implications for participants functioning in school. Two participants were reading below grade level: Gretchen was in Grade 4.6, but had a reading level of 3.1, and completed third-grade reading passages; Karen was in Grade 7.2, had a reading level of 5.0, and completed fifth-grade reading passages. For both of these participants, the BEA identified interventions that produced reading fluency expected at the beginning of the school year and the end of the school year. This is important because the effective interventions can be implemented immediately and the effect is that the participant is immediately reading closer to grade level. The remaining four participants also demonstrated significant differentiation between best and worst performing interventions. However, for Michael, Evan, Jeremy, and Nathan, their reading levels as tested on the WRMT-R were similar to their actual grade level. For these participants, the BEA was able to detect interventions that increased their reading fluency to levels beyond what was expected in their current grade level. This is socially significant for a different reason. Children with ADHD have attentional issues that pervade their academic functioning (Raggi & Chronis, 2006). Identifying and implementing effective interventions that can optimize reading may support long-term academic competencies in this high risk group of children. Reading is a critical academic skill that grows in importance as children transition from being taught how to read to using reading skills to learn new academic content (e.g., social studies, science, etc.) around third or fourth grade (Spor, 2005).

The results of the study support previous literature on the utility of using BEA as a decision tool to choose the most efficacious intervention to improve reading fluency. Specifically, Martens and Gertz (2009) suggested that BEA can be effectively used to compare the effects of two or more competing treatment options. Also, Daly et al. (1999) demonstrated the usefulness and efficiency of BEA in identifying instructional components to improve oral reading fluency. Specifically, they investigated the effectiveness of treatment packages to develop individualized treatment recommendations to four students who had been previously identified as having reading problems. The current study adds to this literature by demonstrating that a BEA can be used to identify differentially effective reading interventions for students diagnosed with ADHD.

The current study did not confirm previous findings that Choice, MSL, and CAI were effective academic interventions (e.g., DuPaul & Eckert, 1998; Raggi & Chronis, 2006). There was no baseline reading fluency measure, so it is unknown whether these interventions produced higher levels of reading fluency than no intervention. The failure to replicate previous findings may stem from the fact that these interventions were compared with other interventions, which is a more rigorous standard than simply demonstrating an intervention is better than no intervention or typical classroom instruction (e.g., Clarfield & Stoner, 2005). Under the conditions of the current study, Choice, MSL, and CAI were less effective than other interventions. In fact, MSL produced the lowest reading fluency for five of six participants and tended to produce relatively higher percentages of errors. The discrepancy between the current study and previous ADHD research may be the result of the specific manner in which these interventions were implemented. MSL and CAI interventions were adapted from previous literature and many procedural variations of these interventions can be found in the literature. It may be the case that other variations of MSL and CAI would have produced better reading fluency. For example, in the MSL condition, participants were required to read the passage on the iPad 2. After completing the intervention, most of the participants made comments that the MSL intervention was their least favorite intervention. A different modality might result in different effects. Future research should continue to investigate the effectiveness of ADHD reading interventions as compared with each other as well as more traditional reading interventions. This research should entail the development of robust versions of MSL and CAI interventions to ensure that the best possible variation of these interventions is then compared with other reading interventions.

Each participant displayed variability in responding to the particular interventions. Variability in responding is a hallmark of ADHD (Barkley, 2005) and, as such, future work on BEA with children with ADHD should take this into account when determining the optimal number of observations of each intervention's effects. Although we found in this investigation that three observations were adequate to obtain discriminable effects, it may be the case that more than three observations would yield more accurate discrimination of effects. Determining the optimal number of observations needed to produce predictive outcomes could be answered by conducting extended analyses, whereby observations of intervention effectiveness are conducted over an extended period. Unfortunately, there are only a few published studies that have examined intervention effectiveness over a long period of time (e.g., VanAuken, Chafouleas, Bradley, & Martens, 2002; Welsch, 2007). Future researchers should examine both the long-term effects of interventions selected from a BEA and the extent to which recommendation based on an acute BEA extend to actual intervention effects in the classroom setting over time.

The current study has some limitations, which need to be addressed in future research. The relatively small sample size limits the external validity of these findings. Similarly, participants were included if his or her parent reported reading difficulties and the current findings may not be representative of children diagnosed with ADHD who have reading difficulties that would require individualized services in a school setting. This study suggests that BEA has utility with children with ADHD; however, it is unclear whether these procedures can be utilized under more routine settings (e.g., schools) with children with ADHD who have significant reading delays. Thus, future research should be conducted in routine settings by routine providers to test the utility of BEA in determining effective reading interventions for children diagnosed with ADHD.

Future research may provide further clarification about the specific interventions that should be included in a BEA of reading deficits for children with ADHD. This model could also be applied to other populations who may have a particular set of reading interventions that have garnered empirical support, but have not been evaluated against other effective reading interventions. Overall, our findings support previous research demonstrating that BEA is a feasible tool in gathering data regarding comparative efficacy of various interventions for reading and extend this literature to children diagnosed with ADHD. To maximize the potential of evidence-based interventions, efficient and effective methods, such as BEA, must be further developed and evaluated. As these preliminary data suggest, individuals will respond differently to different interventions. Systematic methods, such as BEA, should be used to reliably evaluate the array of available evidence-based intervention to identify the intervention that will result in optimal efficacy for a child.

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