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Reading Comprehension Interventions for Students With Autism Spectrum Disorders: An Alternating Treatments Comparison

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Abstract

We conducted two separate but related single-case studies using alternating treatment designs to investigate the effects of two single-component reading interventions: question development and anaphoric cueing. In each study, we compared a typical intervention approach (Study 1, question development; Study 2, anaphoric cueing) with an alternate approach that included the addition of applied behavior analysis (ABA) techniques. The treatments that included ABA techniques were designed to improve the performance of students with autism spectrum disorders (ASD) on curriculum-based measures (CBM) of reading and on-task behavior measures during the reading tasks. The ABA techniques included the use of visual supports, a token economy, and the use of readings based on the perseverative interests of students. Four students in Grades 3 to 5 identified with ASD participated—two students in each study. Study 1 evaluated the relative effects of question development plus ABA compared with question development on CBM reading probes and an on-task behavior measure for two students. Study 2 evaluated the relative effects of anaphoric cueing plus ABA compared with anaphoric cueing on CBM reading probes and an on-task behavior measure for two students. The results indicated that the treatments that included ABA techniques were more effective than treatments that did not include ABA. These data support the use of ABA techniques for the enhancement of question development and anaphoric cueing as a means to improve reading comprehension and on-task behavior for students with ASD.

Keywords

autism, reading comprehension, behavior, intervention

The Center for Disease Control recently recognized ASD as the fastest growing developmental disability with 1 of every 88 children identified with ASD (Centers for Disease Control and Prevention Morbidity and Mortality Weekly Report [MMWR], 2012). Characteristics of individuals with ASD include significant difficulties in socialization and communication and restricted interests and behaviors (American Psychiatric Association [APA], 2000). Previous studies of reading performance for students with ASD suggest that many of these students may have unique profiles of reading with strengths in basic reading skills (i.e., word recognition) coupled with difficulties in reading comprehension (Asberg, Kopp, Berg-Kelly, & Gillberg, 2010; Chiang & Lin, 2007; Nation, Clarke, Wright, & Williams, 2006). Students with ASD performed less well than students without ASD on a test of reading comprehension, despite the fact that the two groups of students were well matched in terms of reading accuracy (Frith & Snowling, 1983). Consistent with this, a study by Minshew, Goldstein, Taylor, and Siegel (1994) indicated that levels of reading comprehension were significantly lower in students with

ASD relative to IQ-matched controls. The unique reading profiles of students with ASD indicate a need to further investigate the use and development of evidence-based reading interventions as a means to improve the reading performance of this population of students. Explanations of the unique challenges faced by students with ASD in developing reading comprehension skills include difficulty in summarizing salient points (i.e., Happe & Frith, 2006) and identifying different perspectives of characters represented in text (e.g., Baron-Cohen, 1989; Frith, 1989; Leslie, 1987). Additional research is needed to determine which aspects of reading interventions facilitate students with ASDs' understanding of text.

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The issue of providing effective reading comprehension instruction is further complicated by the unique and challenging behaviors often present for students with ASD during academic instruction (Goodman & Williams, 2007; Marks et al., 2003). Students with ASD often typically display self-stimulatory behaviors, impaired communication and language skills, and resistance to participation in instructional activities (APA, 2000). In addition, students with ASD often demonstrate difficulty with processing auditory information (Lincoln, Courchesne, Harms, & Allen, 1995) with a tendency to focus only on selective parts of the message (Burke & Cerniglia, 1990). Without the use of behavioral interventions and instructional modifications during academic instruction, these types of issues can often impede levels of on-task behavior and jeopardize student learning (Goodman & Williams, 2007; Marks et al., 2003).

Reading Intervention Research for Students With ASD

To better understand the interventions associated with improved reading comprehension outcomes for students with ASD, we synthesized studies of reading comprehension interventions with this population published between 1980 and 2012 (El Zein, Solis, Vaughn, & McCulley, 2014). Of the 12 identified studies, 3 were treatment and comparison designs and 8 were single-case designs. Treatment conditions included strategy instruction (Asberg & Sandberg, 2010; Wahlberg & Magliano, 2004; Whalon & Hanline, 2008; Van Riper, 2010), explicit instruction (Flores & Ganz, 2007; Ganz & Flores, 2009; Knight, 2010), and anaphoric cueing (Campbell, 2010; O'Connor & Klein, 2004). Examples of strategy instruction interventions in this synthesis included the use of Question–Answer–Relation (QAR; Asberg & Sandberg, 2010) and reciprocal questioning (Whalon & Hanline, 2008), which both require students to follow specific instructional procedures in developing questions about text.

Three studies from this synthesis guided the development of the two interventions we chose to investigate further: question development (Asberg & Sandberg, 2010) and anaphoric cueing (Campbell, 2010; O'Connor & Klein, 2004). We chose these interventions based on the preliminary empirical evidence, and both interventions aligned with descriptions commonly posited as potential causes that impede reading comprehension for students with ASD. Question development potentially remediates difficulties with appropriately identifying and organizing salient points (i.e., Happe & Frith, 2006), and anaphoric cueing potentially remediates difficulties with perspective taking and understanding of story characters (e.g., Baron-Cohen, 1989; Frith, 1989; Leslie, 1987).

Asberg and Sandberg (2010) investigated the use of the QAR strategy (Raphael, 1982) for students with ASD, aged 10 to 15 years. After reading, students used the QAR strategy, which consisted of students developing three different question types: (a) right there (literal questions with answers located in one portion of the text), (b) think and search (questions with answer located in different portions of the text), and (c) author and you (inferential questions with answers not necessarily found in the text). A pre–post study design compared the performance of 12 students with ASD on a standardized measure, the *Discourse Comprehension Test* (DCT; Brookshire & Nicholas, 1993). A within-group comparison indicated improvement for students with ASD after the intervention on the DCT ($p = .02$, $d = 1.35$). There is also empirical evidence supporting the effectiveness of question development interventions for students with learning disabilities (e.g., Graves & Levin, 1989; Mason, 2004; Taylor, Alber, & Walker, 2002; Wong & Jones, 1982).

Anaphoric devices inform readers where to search for a referent, typically a pronoun, and serve as a pragmatic signal identifying the referent that was recently discussed (Ehrlich, Remond, & Tardieu, 1999). Difficulties resolving pronouns in text, which aligns with understanding perspectives of characters in text, may affect the reading comprehension of students with ASD. A study by O'Connor and Klein (2004) sought to determine the effects of three different treatment conditions on the reading comprehension of participants with ASD. A previewing strategy, cloze task, and anaphoric cueing interventions were administered to students ($N = 20$) in a pre–post study design. Results showed more than half of the participants with ASD ($n = 11$) increased performance on the researcher-developed measure under the anaphoric cueing treatment but not the previewing strategy or cloze task treatments. These findings suggested anaphoric cueing as a promising reading comprehension intervention for students with ASD. Campbell (2010) also investigated an anaphoric cueing intervention through a pretest–posttest matched control group design for students with ASD ($N = 21$) as a means to improve their understanding of text. Two weeks following the intervention, the *Woodcock Johnson III* passage comprehension subtest (Woodcock, McGrew, & Mather, 2001) was administered to participants. A between-group comparison of pretest and posttest scores indicated improvement for students with ASD after the intervention ($p < .05$, $d = 1.96$).

Intervention Enhancements—Applied Behavior Analysis (ABA)–Based Techniques

Although the identified interventions of questions development and anaphoric cueing appeared to align well with the specific difficulties of reading comprehension for students

with ASD, we also wanted to leverage opportunities to proactively address the off-task behaviors that students with ASD often display during academic instruction (Goodman & Williams, 2007; Marks et al., 2003). Furthermore, we wanted to integrate features of instruction that aligned with cognitive strengths of visual processing that are typical of many students with ASD (Freeman, Ritvo, Needleman, & Yokota, 1985; Yirmiya & Sigman, 1991). ABA-based techniques have been utilized with students with ASD during academic instruction to successfully promote learning and behavior change (Heflin & Alberto, 2001). ABA-based techniques that have been used to enhance the effectiveness of academic interventions have included positive reinforcement through token economies (Adcock & Cuvo, 2009), instructional support materials such as visuals and checklists (Heflin & Alberto, 2001), and instruction based on interests identified from preference assessments (Piazza, Fisher, Hagopian, Bowman, & Toole, 1996). Preference assessments administered to students with ASD have been used to identify perseverative interests as reinforcers to decrease disruptive behavior and increase on-task behavior (Koegel, Singh, & Koegel, 2010). Evidence has suggested that using perseverative interests as reinforcers may increase correct responding during academic tasks for students with ASD (Charlop-Christy & Haymes, 1998; Vismara & Lyons, 2007).

There is also evidence supporting the notion that students with ASD often display strengths in visual processing (Allen, Lincoln, & Kaufman, 1991; Rumsey & Hamburger, 1990; Yirmiya & Sigman, 1991). Graphic organizers facilitate learning (e.g., semantic maps, cognitive maps, story maps, Venn diagrams) and understanding of text through visual displays of content that assist readers as an organizational framework for relating prior knowledge to new information (i.e., Simmons, Griffin, & Kame'enui, 1988). Previous reviews of graphic organizer interventions for students with learning disabilities have been associated with improved reading comprehension (Dexter, Park, & Hughes, 2011; Kim, Vaughn, Wanzek, & Wei, 2004). Furthermore, previous studies have also suggested that the use of graphic organizers improved performance of students with ASD on measures of reading comprehension (Mims, Hudson, & Browder, 2012; Van Riper, 2010).

Rationale and Purpose

Although ABA techniques have been demonstrated to be effective in the treatment of challenging behavior and skill acquisition for students with ASD (Horner, Carr, Strain, Todd, & Reed, 2002), less is known about how the use of ABA techniques might improve the efficacy of reading interventions. We conducted two separate studies to evaluate the effects of two treatments with preliminary evidence of effectiveness for students with ASD: question development and anaphoric cueing. The purpose of Study 1 was to

compare question development plus ABA treatment with a question development treatment. The purpose of Study 2 was to compare anaphoric cueing plus ABA treatment with an anaphoric cueing treatment. Our aim for both studies was to determine whether the addition of ABA techniques to these treatments better supported the instructional and behavioral needs of students with ASD when compared with the treatments without ABA techniques. In both studies, we compared the relative effects using alternating treatment experimental designs to determine whether performance on reading outcomes and measures of on-task behavior improved with the addition of ABA techniques. We hypothesized that in both studies, the most effective interventions would be those that included the addition of ABA techniques.

Study 1

Study 1 compared question development plus ABA treatment with question development treatment. The study addressed the following research questions:

Research Question 1: Does a question development plus ABA treatment result in improved performance on curriculum-based measures (CBM) reading probes for students with ASD when compared with a question development only treatment?

Research Question 2: Does a question development plus ABA treatment increase on-task behavior for students with ASD when compared with a question development only treatment?

Method

We used an alternating treatment design to evaluate the relative effects of question development plus ABA treatment and a question development treatment. Alternating treatments were randomly delivered in 30-min sessions, 4 to 5 times per week for 2 weeks.

Participants and setting

Students. Both participants were male native English-speaking students attending public school. The first participant, Kevin (age 13), was previously diagnosed with autism, attention deficit hyperactivity disorder (ADHD), and speech impairment (SI). The other participant, Sean (age 12), was previously diagnosed with autism and SI. Both participants received educational services in special education and general education classes with inclusion and behavior supports. See Table 1 for additional information on participants including diagnosis, age, grade, IQ scores, and reading scores reported as part of eligibility evaluations and Individualized Education Plans (IEPs).

Table 1. Participant Information for Study 1.

Participant	Diagnosis	Age (years)	Grade	IQ information	Reading scores
Kevin	Autism, ADHD, SI	13	5	WISC-IV: FS = 95	WJ-III: Basic reading: SS = 70 Reading comprehension: SS = 75
Sean	Autism, SI	12	5	WISC-IV: FS = 104	DIBELS: ORF = 140 WCPM; RT = 52 WCPM; SRI: 4th grade level

Note. ADHD = attention deficit hyperactivity disorder; SI = speech impairment; WISC-IV = Wechsler intelligence Scales for Children—Fourth Edition; FS = full scale; WJ-III = Woodcock Johnson—Third Edition; SS = standard score; DIBELS = Dynamic Indicators of Basic Early Literacy Skill; ORF = oral reading fluency; WCPM = words correct per minute; RT = retell; SRI = Scholastic Reading Inventory.

Instructor and setting. The instructor was a graduate student with extensive background in techniques of ABA, a master's degree in education, and 3 years of teaching experience focused on providing services to students with ASD. The study took place in a rural school district about 40 miles outside a major metropolitan area in the southwestern part of the United States. The district consisted of three high schools, two middle schools, two intermediate schools, and six elementary schools, which together served about 9,000 students. The district reported a student population consisting of 37% White, 53% Hispanic, 6% African American, 1% Native American, and 3% Other. The study occurred in the special education or literacy classroom located in the participating schools. The intervention was delivered one-on-one in a quiet area away from other students.

Procedures

Participant selection and screening criteria. Based on a description of potential participants provided by researchers, district personnel identified a pool of 15 participants, Grades 3 to 8, who were currently receiving special education services under the eligibility category of autism or Asperger syndrome. Parent consent forms were sent home to parents followed with phone calls made by district personnel to answer questions about the study. Parent and student consents were obtained for nine students who were then screened for participation in the study. Participants were selected based on the following set of criteria: (a) a diagnosis of an ASD (e.g., autism, Asperger syndrome, pervasive developmental disability [PDD], or PDD—not otherwise specified), (b) proficiency on a screening measure to assess the understanding of pronoun meaning and question types (i.e., who, what, when, where, why, and how), (c) evidence of reading comprehension deficits (e.g., scores on standardized reading comprehension assessment, teacher reports, IEP reading goals) according to reports from district personnel, and (d) adequate attentiveness skills during one-on-one reading instruction sessions. For students who met the criteria, a perseverative interest was identified to serve as the basis of reading material for the question development plus ABA treatment.

Professional development and instructor support. The instructor attended a 1-day professional development session provided by an experienced member of the research team with expertise in reading instruction. Topics covered during the professional development included the following: an overview of the study, training on explicit instruction, implementation of anaphoric cueing and question development instructional routines, and integration of ABA techniques including the use of token economies, graphic organizers, and perseverative interest readings. The trainer also provided weekly coaching sessions to support the instructor by observing and providing feedback on instruction.

Fidelity of implementation. To ensure that intervention treatments were implemented as intended, we developed an implementation validity checklist (IVC). We evaluated fidelity by coding the instructional sequences and documenting the presence or absence of each critical component on a 4-point Likert-type scale. The components of instruction included the following: (a) instructional procedures, (b) use of visual supports, (c) checklists, and (d) token economy. We assessed each component on a 4-point Likert-type scale of 1 (*low adherence*), 2 (*mid-low adherence*), 3 (*mid-high adherence*), and 4 (*very high adherence*), or not observed (N/O). The instructional procedures component outlined the expected instruction of the question development only treatment. The other three components outlined the expected instruction of the ABA techniques in the question development plus ABA treatment. All four components were coded for both treatments. In addition, global indicators of instruction quality and implementation quality were assessed on a scale of 1 (*lowest quality*) to 7 (*highest quality*). A senior researcher established as the gold standard trained a second researcher by viewing a videotaped session of the question plus ABA treatment. The two researchers then coded a second videotaped session independently. Interrater reliability of 100% was reached between the two researchers, which was in adherence to the gold standard method (Gwet, 2001).

We coded in-person observations and sessions from videotaped copies, for a total of six sessions (35.2% of sessions). Four sessions (23.5% of sessions) were randomly

selected and coded through in-person observations during the question development plus ABA treatment and the question development treatment. The remaining two sessions (11.6%) were randomly selected between the two treatments and coded from videotapes of sessions. For the question development plus ABA treatment, very high adherence (score of 4 on Likert-type scale) was observed for all coded sessions indicating that all required elements and procedures were present across all four components—instructional procedures, visual supports, checklists, and token economy. For the question development only treatment, very high adherence (score of 4 on Likert-type scale) was observed indicating all of the required elements and procedures were present for the instructional procedures component. However, for the remaining three components (visual supports, checklists, and token economy), scores of N/O were observed for all coded sessions indicating that these three components were not present for the coded sessions. Researchers also rated the instructor on a two global items scored on a scale of 1 (*low*) to 7 (*high*) related to (a) quality of teacher instruction and (b) quality of teacher's behavior management. Across both treatments, the global indicators of quality indicated high levels of implementation (all scores of 7 on Likert-type scales) occurred. Findings from the fidelity data indicated that the instructor adhered to the intended instructional components for 100% of the coded sessions in both treatment conditions.

Description of intervention

Question development. The question development treatment was a modified version of the QAR strategy (Raphael, 1982), with a focus on facilitating students' ability to develop questions based on text content. After reading a paragraph of text, students were asked to develop literal or "right there" questions after being provided question stems (e.g., who, what, where, when). These are literal questions that are explicitly stated in the text. A detailed instructional procedure was outlined in a lesson plan format, which described an explicit instructional routine of modeling, guided practice, and independent practice. The instructor asked the student to read the section of text aloud. Next, the instructor would ask the student to identify a question about the text that starts with one of the question stems included on the graphic organizer. If the student did not develop a question, the instructor would model development of a question, point out key information, and re-ask the student to develop a different question from the text.

Question development plus ABA. The question development plus ABA treatment followed similar instructional procedures as the question development treatment with the addition of procedures that included the use of a graphic organizer (see Figure 1), a token economy, and readings based on perseverative interests. We conceptualized the

WHO?	
WHAT?	
WHEN?	
WHERE?	

Figure 1. Question development graphic organizer.

ABA treatment as utilizing the graphic organizer as an antecedent and organizer prior to reading and the perseverative interest reading as a reinforcer to assist in improving reading performance. The perseverative interests of both participants focused on characters from popular media. A second set of lesson plans and additional materials were developed to support the use of the additional features for the question development plus ABA treatment.

Prior to reading, visual supports (i.e., graphic organizer) were used to preview text. The ABA component emphasized during instruction was positive reinforcement, which consisted of earning *tokens* on a fixed interval schedule of every 5 min. A continuous positive reinforcement schedule was implemented that included the use of tangible and/or social reinforcers selected based on the results of an individualized preference assessment conducted prior to intervention (Piazza et al., 1996). As a self-monitoring procedure, a checklist with the tasks to be completed per session was also used to allow the student to monitor his own progress toward completing assignments. Tasks on the checklist included the following: (a) I read the text, (b) I used the graphic organizer, (c) I answered the practice questions, and (d) I completed the quiz.

Text selection. For both treatment conditions, a systematic process was followed in selecting and adapting text. First, a general bank of passages was identified representing a variety of text length and difficulty, as well as a balance of expository and narrative texts. Next, all passages were analyzed to assess their Lexile® level ("Get a Lexile Text Measure," 2013). Text levels ranged from L515-L1100 (third–sixth grade equivalency), and length of passages ranged from 60-word, single paragraphs to multiple paragraphs of more than 150 words in length. Finally, passages were placed in general categories (i.e., "single paragraph/easy," "multi-paragraph/medium," "single paragraph/hard"). For each participant, text levels were chosen that most appropriately matched their reading level-based recommendations from school personnel, observation of reading by researchers, and identification of text levels participants could read orally with accuracy at or above

90%. The content of texts used for the question development treatment was representative of topics typically read about in language arts and reading classes for the grades of the participants. The content of texts used for the question development plus ABA treatment was about topics associated with each student's perseverative interest. The CBM probes were closely aligned with reading level during the instruction. We identified and adapted text from a variety of sources including passages used for fluency practice, basal programs, and text designed to improve reading comprehension.

Dependent variables

CBMs. Reading performance was assessed with CBM reading probes. Use of researcher-developed CBM reading probes as a means of assessing reading comprehension has occurred previously as dependent measures of reading comprehension in studies of students with ASD (Carnahan & Williamson, 2013). Participants were administered CBM reading probes immediately following each intervention session. The text selected for the CBM reading probes aligned with the text in each treatment condition. Visual supports were not provided as part of the CBM reading probes. Students read a passage aloud, and at predetermined stopping points were asked to complete a reading task similar to the reading tasks required of them in the lessons. For the question development intervention, participants were asked to develop a question that starts with who, what, when, or where. Participants were provided five opportunities to respond per CBM reading probe.

On-task behavior. Student on-task behavior was measured through review of videos of the instructional sessions with student behaviors coded *on-task* or *off-task behavior*. Based on the nature of the reading assignments during both treatments (e.g., reading tasks, setting, materials) and the findings from close observations of participant behaviors, on-task behavior was defined as the participant (a) sitting in seat, (b) looking at the assignment or the instructor, (c) using instructional materials in the intended manner (e.g., pencil for writing), and (d) engaging appropriately in the task (e.g., comments and questions relevant to task). Off-task behavior was defined as a vocal or a motor behavior that was inconsistent with the learning task. Examples of off-task behaviors included not participating in the task, leaving seat without the instructor's instruction, turning away from materials or instructor, putting head down on table, making comments or asking questions that were irrelevant to the topic of reading, inappropriate use of materials, and looking away from materials or instructor for longer than 2 s.

Scoring and data collection. To assure reliability and validity of scoring, all CBM reading probes were administered by

the same instructor and were videotaped for later scoring. An independent researcher who was unaware of students' assignment to treatment conditions conducted the scoring of the CBM reading probes. The researcher who conducted the scoring was provided 3 hr of training, and interrater reliability between the scorer and the gold standard researcher was obtained at above 90%. Each answer was rated on a scale of 2 to 0 where 2 = *student produced a high-quality correct response with no prompting*, 1 = *student produced a partially correct response or prompting occurred*, 0 = *student produced no response or an incorrect response after being prompted*. The maximum score for each CBM reading probe was 10 points. The number of points scored for each CBM reading probe was multiplied by 10 to obtain the percent score.

On-task behavior was measured using a 30-s whole interval recording system. The observer recorded whether the participant was on-task during the entire 30-s interval (i.e., engaging in on-task behavior with zero occurrences of off-task behaviors). The number of intervals during which the participant was on-task for the whole period is divided by the total number of session intervals and then multiplied by 100 to obtain percent of on-task intervals. To assure reliability of on-task behavior recording, the same gold standard procedure described above was followed (i.e., training the second observer and reaching reliability of scoring greater than 90% agreement).

Interobserver agreement (IOA). A second independent observer collected data on CBM reading probes for 100% of all sessions for both participants. Agreement data were calculated on an item-by-item basis. An agreement was defined as both observers rendering an identical score for a CBM probe item (e.g., a score of 0, 1, or 2). Percentage agreement for each probe was calculated by dividing the number of agreements across probe items by the number of agreements plus disagreements; and we multiplied the resulting number by 100 to convert the result to a percentage. Mean agreement was 100% for Kevin and 94% for Sean.

For on-task behavior, a second independent observer collected data during 38% of sessions for Kevin and 33% of sessions for Sean via video recordings. IOA was calculated using interval-by-interval comparisons. We summed the number of intervals in agreement, divided the resulting number by the total number of intervals for the session, and multiplied the resulting number by 100 to convert the result to a percentage. Mean agreement was 92% for Kevin and 92% for Sean.

Data analysis. In single-subject research designs, a non-regression approach may be paired with a visual analysis of the data to ensure a more comprehensive understanding of the treatment(s) effects (Olive & Franco, 2007). The visual

Table 2. Mean Scores for Accuracy of Responding to CBM Reading Probes for Study 1.

Participant	QD (% correct)	QD + ABA (% correct)	PND (%)
Kevin	48	73	0
Sean	47	74	100

Note. CBM = curriculum-based measures; QD = question development; QD + ABA = question development plus applied behavior analysis; PND = percentage of non-overlapping data.

Table 3. Mean Scores for On-Task Intervals for Study 1.

Participant	QD (% correct)	QD + ABA (% correct)	PND (%)
Kevin	78	95	100
Sean	85	98	100

Note. QD = question development; QD + ABA = question development plus applied behavior analysis; PND = percentage of non-overlapping data.

analysis we conducted involved interpretation of the level, trend, immediacy, and magnitude of performance change observed in both alternating treatments (Horner, Carr, Halle, McGee, & Odom, 2005). In addition to visual analysis, we used percentage of non-overlapping data (PND), a procedure that requires identifying the points of performance that are above the highest data point existing in baseline (for multiple-baseline designs) or Treatment 1 (for alternating treatments designs). Scruggs and Mastropieri (1998) provided the following criteria for PND interpretation: (a) more than 90% of PND = very effective treatment, (b) 70% to 90% of PND = effective treatment, (c) 50% to 70% of PND = questionable treatment, (d) less than 50% of PND = ineffective treatment.

Results

Table 2 reports percent mean scores for CBM reading probes and PND scores, and Table 3 reports percent mean scores for the on-task behavior measure. The top panel of Figure 2 shows the percentage of correct responses on CBM reading probes for Kevin. Overall, Kevin's scores on CBM reading probes were higher during the question development plus ABA treatment ($M = 73\%$) relative to his scores during the question development treatment ($M = 48\%$). Although clear differentiation was observed initially between the scores during the two treatments and the difference in overall means suggested that question development plus ABA was more effective, it should be noted that Kevin's scores during the question development treatment increased during the course of the evaluation with equal scores observed during the final session of each treatment. The PND score for Kevin on CBM reading probes was 0%. The same scores on the CBM reading probes occurred between conditions during the final two

sessions, which caused the low PND score for Kevin. The bottom panel of Figure 2 shows percentage of on-task behavior for Kevin. Kevin exhibited high levels of on-task behavior during the question development plus ABA treatment ($M = 95\%$) relative to those observed during the question development treatment ($M = 78\%$). Although clear differentiation was demonstrated regarding on-task behavior across the two treatments, increasing percentages were observed during the question development treatment such that similar percentages were observed during the final session of each treatment. It should also be noted, however, that percentages during the question development plus ABA treatment were considerably more stable across the evaluation (range = 89% to 98%) relative to the question development treatment (range = 58% to 90%). The PND for on-task behavior for Kevin was 75% in favor of question development plus ABA.

The top panel of Figure 3 shows the percentage of correct responses on CBM reading probes for Sean. Sean scores on CBM reading probes were consistently higher during the question development plus ABA treatment ($M = 74\%$) relative to his scores during the question development treatment ($M = 47\%$). The PND score for Sean on CBM reading probes was 100% in favor of question development plus ABA. The bottom panel of Figure 3 shows the percentage of on-task behavior for Sean. Sean exhibited consistently higher levels of on-task behavior during the question development plus ABA treatment ($M = 98\%$) relative to those observed during the question development treatment ($M = 85\%$). The PND for on-task behavior for Sean was 100% in favor of question development plus ABA.

Study 2

Study 2 compared an anaphoric cueing plus ABA treatment with an anaphoric cueing only treatment. The study addressed the following research questions:

Research Question 1: Does an anaphoric cueing plus ABA treatment result in improved performance on CBM reading probes for students with ASD when compared with an anaphoric cueing only treatment?

Research Question 2: Does an anaphoric cueing plus ABA treatment result in increased levels of on-task behavior for students with ASD when compared with an anaphoric cueing only treatment?

Method

Design. We used an alternating treatment design to evaluate the relative effects of anaphoric cueing plus ABA treatment and an anaphoric cueing only treatment. Alternating treatments were randomly delivered in 30-min sessions, 4 to 5 times per week for 2 weeks. The instructor, setting, participant selection criteria, professional development, text selection,

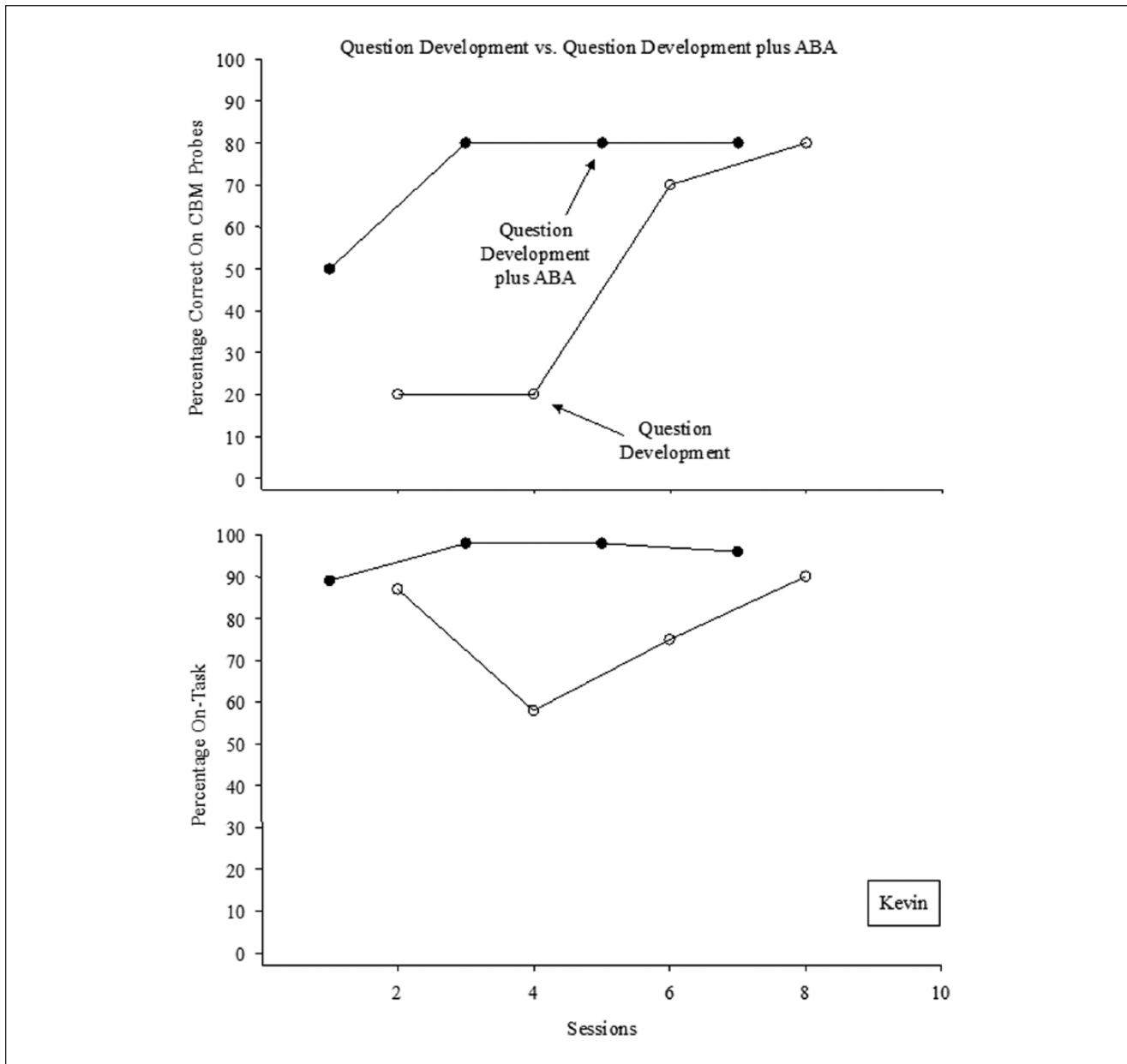


Figure 2. Percentage correct on CBM reading probes (top) and percentage on-task (bottom) during question development and question development plus ABA for Kevin.

Note. CBM = curriculum-based measures; ABA = applied behavior analysis.

scoring and data collection, IOA, and data analysis were the same as Study 1. The operational definition for on-task behavior and procedures for scoring and data collection and text selection were identical to those used during Study 1.

Participants. Both participants were male native English-speaking students attending public school. The first participant, Tom (age 10), was previously diagnosed with autism and SI. The other participant, Gary (age 10), was previously diagnosed with Asperger Syndrome and SI. Both

participants received educational services in special education and general education classes with inclusion and behavior supports. Table 4 includes additional information on participants in Study 2 including diagnosis, age, grade, IQ scores, and reading scores reported as part of eligibility evaluations and IEPs.

Procedures

Fidelity of implementation. The same process for establishing interrater reliability was used as described in Study

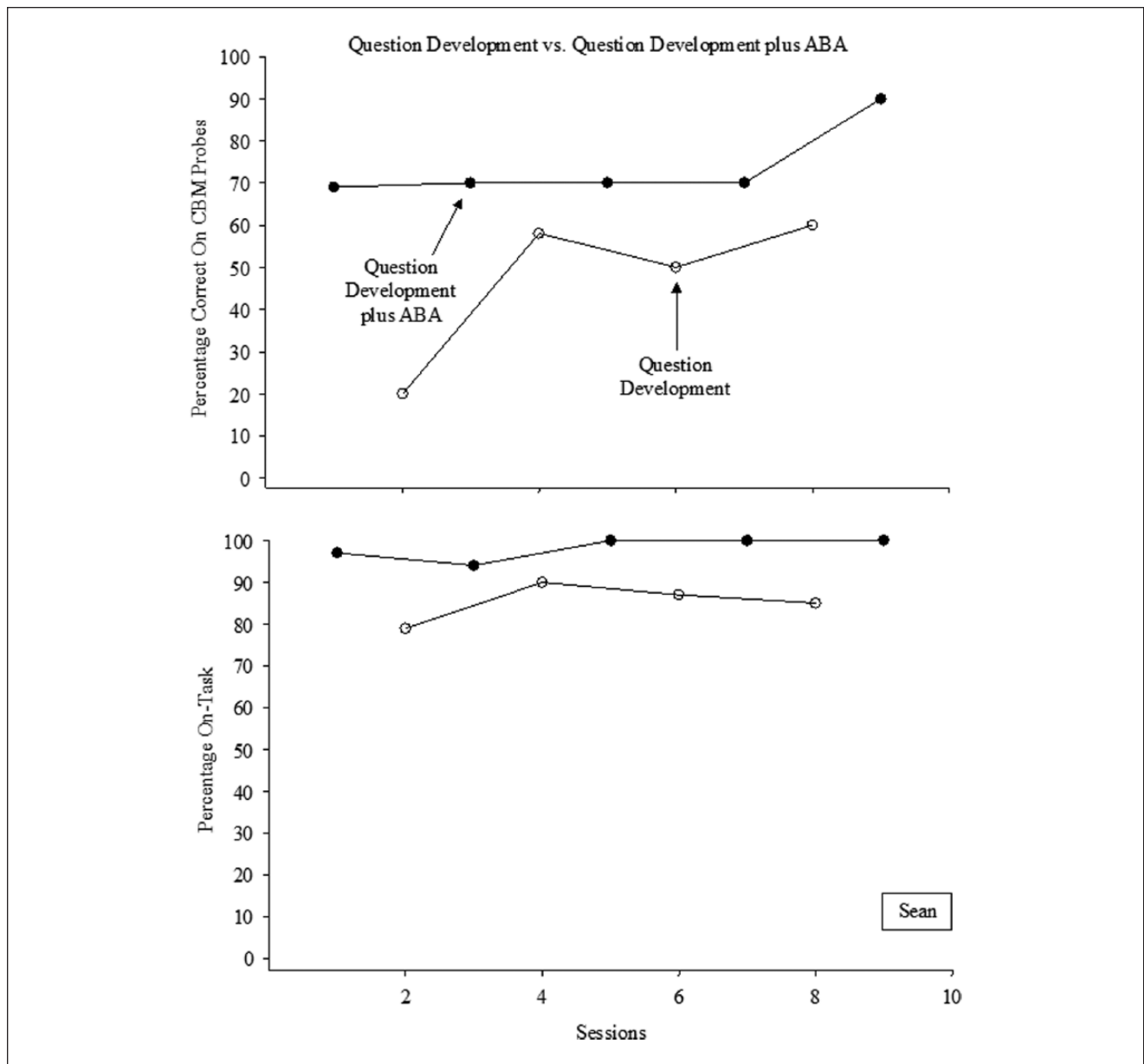


Figure 3. Percentage correct on CBM reading probes (top) and percentage on-task (bottom) during question development and question development plus ABA for Sean.

Note. CBM = curriculum-based measures; ABA = applied behavior analysis.

1. We used an adapted version of the IVC checklist from Study 1 that included changes to the instructional procedures component, which outlined the expected instruction during the anaphoric cueing treatment. The visual supports, checklists, and token economy components were the same as the IVC used in Study 1. We coded three sessions from in-person observations and 4 sessions from videotaped copies for a total of seven coded sessions. Three in-person sessions (20.0%) were randomly selected and coded for fidelity for the anaphoric cueing plus ABA treatment and anaphoric

cueing treatment. The remaining 4 sessions (26.7%) were randomly selected videotaped copies of sessions of both the anaphoric cueing plus ABA treatment and the anaphoric cueing treatment. A total of 7 of the 15 sessions (46.7%) were coded for fidelity.

For the anaphoric cueing plus ABA treatment, very high adherence (score of 4 on Likert-type scale) was observed for all coded sessions indicating that all required elements and procedures were present across all four components—instructional procedures, visual supports, checklists, and

Table 4. Participant Information for Study 2.

Participant	Diagnosis	Age (years)	Grade	IQ score	Reading scores
Tom	Autism, SI	10	3	WNV FS = 95	DRA = 28
Gary	AS, SI	10	3	WJ-III-TCA: SS = 104	NR

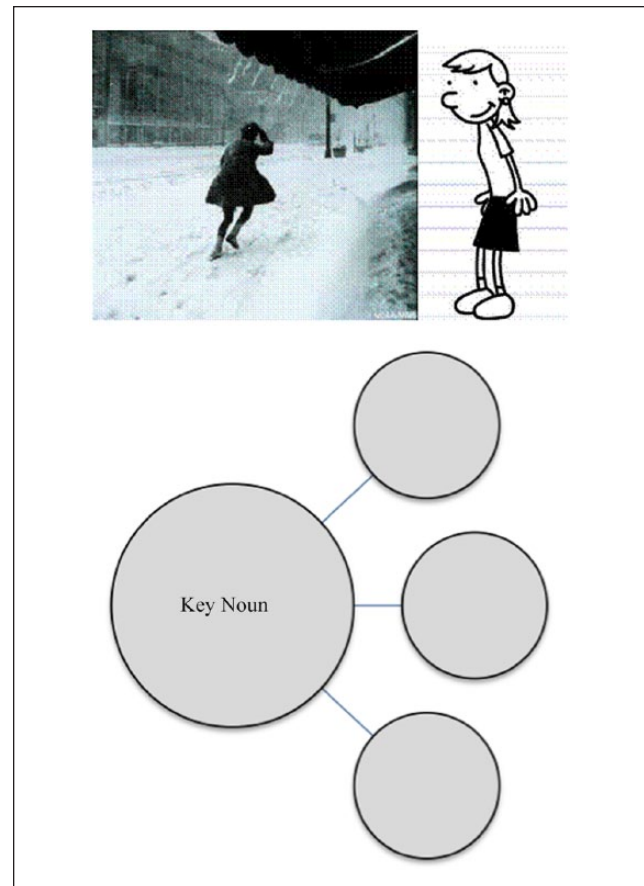
Note. SI = speech impairment; WNV = Nonverbal Wechsler Scales of Ability; FS = full scale; DRA = Developmental Reading Assessment; AS = Asperger Syndrome; WJ-III-TCA = Woodcock Johnson–Third Edition, Test of Cognitive Abilities; SS = standard score; IEP = Individualized Education Plan; NR = not reported.

token economy. For the anaphoric cueing only treatment, very high adherence (scores of 4 on Likert-type scale) was present for the instructional procedures component. However, for the remaining three components (visual supports, checklists, and token economy), scores of N/O were observed for all coded sessions indicating that these components were not present for the anaphoric cueing only treatment. The scores for the global indicators of quality across both treatments indicated high levels of implementation (scores of 7 on Likert-type scales). Findings from the fidelity data indicated that the instructor adhered to the intended instructional components for 100% of the coded sessions in both treatment conditions.

Description of intervention

Anaphoric cueing. The primary focus of the anaphoric cueing intervention was on pronouns, the most common form of anaphora (Ehrlich et al., 1999). A detailed instructional procedure was outlined in lesson plan format, which described an explicit instructional routine of modeling, guided practice, and independent practice. The instructor explained to students that sometimes in stories, there are short ways of saying things. These shortcuts point back to something else in the story that has been said before. The referents were underlined and in boldfaced type. Students were asked to name a word that could be used instead of the shortcut word. For example, in the sentence, “Gregory bundled up in his warmest clothes before he went outside to play,” the pronouns *his* and *he* would be in boldface type and underlined. The student would be asked to identify that both pronouns represent the character (Gregory) in the story.

Anaphoric cueing plus ABA. The anaphoric cueing plus ABA treatment followed similar instructional procedures as the anaphoric cueing only treatment with the addition of the ABA techniques of visual supports, token economy, and readings based on perseverative interests (see Figure 4 for an example of the visual and graphic organizer). The use of the ABA techniques was identical to Study 1. A second set of lesson plans and additional materials were developed to support the use of the additional features for the anaphoric cueing plus ABA treatment.

**Figure 4.** Anaphoric Cueing visual and graphic organizer.

Dependent variables

CBM. For the anaphoric cueing treatments, participants were asked to identify the referent of a boldfaced, underlined word in a sentence. The text selected for these CBM reading probes aligned with the text in each treatment condition. Visual supports were not provided as part of the CBM reading probes. Students read a passage aloud, and when they encountered a boldfaced, underlined word, they were asked to identify the word's referent. Participants were provided five opportunities to respond per CBM reading probe.

Table 5. Mean Scores for Accuracy of Responding to CBM Reading Probes for Study 2.

Participant	AC (% correct)	AC + ABA (% correct)	PND (%)
Tom	48	76	75
Gary	65	83	75

Note. CBM = curriculum-based measures; AC = anaphoric cueing; AC + ABA = anaphoric cueing plus applied behavior analysis; PND = percentage of non-overlapping data.

Table 6. Mean Scores for On-Task Intervals for Study 2.

Participant	AC (% correct)	AC + ABA (% correct)	PND (%)
Tom	72	97	100
Gary	74	94	100

Note. CBM = curriculum-based measures; AC = anaphoric cueing; AC + ABA = anaphoric cueing plus applied behavior analysis; PND = percentage of non-overlapping data.

IOA. IOA procedures were identical to those used during Study 1. A second independent observer collected data on CBM reading probes for 100% of all sessions for both participants. For CBM probes, mean agreement was 98% for Tom and 94% for Gary. For the on-task behavior, a second independent observer collected data during 38% of sessions for both participants via video recordings. For on-task behavior, mean agreement was 96% for Tom and 96% for Gary.

Results

Table 5 reports percent mean scores for CBM reading probes and PND scores, and Table 6 reports percent mean scores for the on-task behavior measure. The top panel of Figure 5 shows the percentage of correct responding on CBM reading probes for Tom. Tom's scores on CBM reading probes were considerably higher during the anaphoric cueing plus ABA treatment ($M = 76\%$) relative to his scores during the anaphoric cueing treatment ($M = 48\%$). The PND score for Tom on CBM reading probes was 75% in favor of anaphoric cueing plus ABA. The bottom panel of Figure 5 shows percentage of on-task behavior for Tom. Tom exhibited considerably higher levels of on-task behavior during the anaphoric cueing plus ABA treatment ($M = 97\%$) relative to those observed during the anaphoric cueing treatment ($M = 72\%$). The PND for on-task behavior for Tom was 100% in favor of anaphoric cueing plus ABA treatment.

The top panel of Figure 6 shows the percentage of correct responding on CBM reading probes for Gary. Gary's scores on CBM reading probes were consistently higher during the anaphoric cueing plus ABA treatment ($M = 83\%$) relative to his scores during the anaphoric cueing treatment

($M = 65\%$). Although clear differentiation was demonstrated regarding scores on CBM reading probes across the two treatments, it should be noted that an increase occurred during the final session of the anaphoric cueing treatment such that overlap was observed with that session and the range of scores during the anaphoric cueing plus ABA treatment. It should also be noted, however, that percentages during the anaphoric cueing plus ABA treatment were considerably more stable across the evaluation (range = 70%–90%) relative to the anaphoric cueing treatment (range = 60%–80%). The PND for scores on CBM reading probes for Gary was 50%. The bottom panel of Figure 6 shows the percentage of on-task behavior for Gary. Gary exhibited considerably higher levels of on-task behavior during the anaphoric cueing plus ABA treatment ($M = 94\%$) relative to those observed during the anaphoric cueing treatment ($M = 74\%$). The PND for on-task behavior for Gary was 100% in favor of anaphoric cueing plus ABA treatment.

Discussion

We conducted two studies comparing treatments that included the addition of ABA techniques to previously developed and tested treatments. In Study 1, we compared a question development plus ABA treatment with a question development treatment. In Study 2, we compared an anaphoric cueing plus ABA treatment with an anaphoric cueing treatment. Our findings indicated that the addition of ABA techniques to question development and anaphoric cueing improved the performance of students with ASD on CBM reading probes and increased the percentage of intervals of on-task behavior. Specifically, on CBM reading probes, the average mean score across both studies during the treatments that included ABA techniques was 77% compared with 52% during treatments without ABA. On the measure of on-task behavior, the average percent mean score across both studies was 96% during the treatments that included ABA compared with 77% during treatments without ABA. The use of the addition of ABA techniques for both question development and anaphoric cueing resulted in higher rates of percent correct responses for all four participants.

Also noteworthy is that in both studies with three of the four participants, there was an upward trend in performance on CBM reading probes across both alternating treatments. Thus, it is possible that the effects of the ABA component(s) may have generalized to the treatment conditions in which those components were not in place. Furthermore, these results suggest that it may be possible to thin and/or fade the use of the ABA-based techniques and enhance maintenance of positive treatment effects during longer durations of instruction.

Perhaps just as important were the high levels of on-task behavior (average mean scores of 96%) during the treatments with ABA techniques. Students with ASD often display

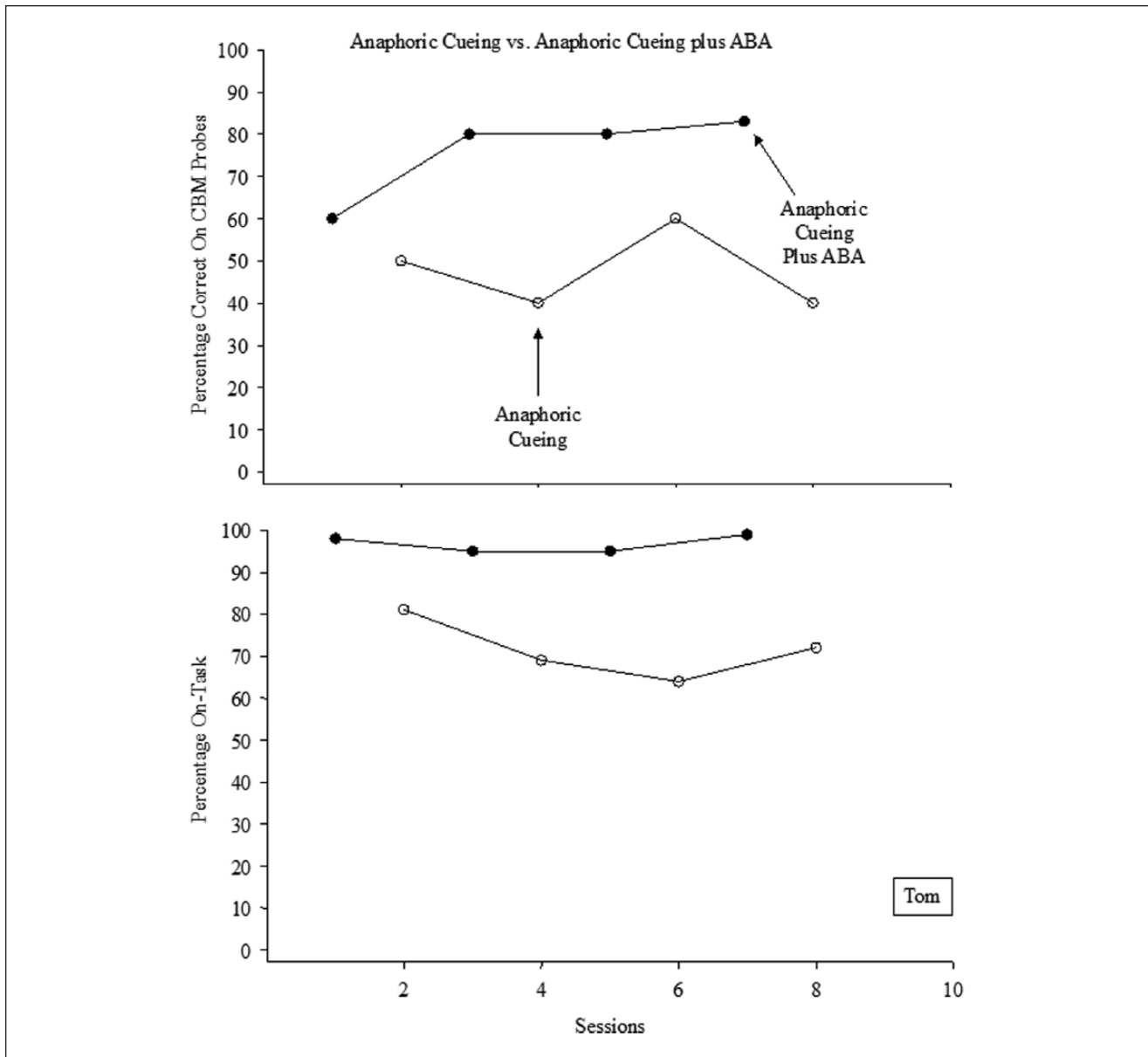


Figure 5. Percentage correct on CBM reading probes (top) and percentage on-task (bottom) during anaphoric cueing and anaphoric cueing plus ABA for Tom.

Note. CBM = curriculum-based measures. ABA = applied behavior analysis.

challenging behaviors during academic instruction (Goodman & Williams, 2007; Marks et al., 2003), particularly instruction addressing an academic area that is challenging (i.e., reading comprehension). Across both studies, students with ASD consistently displayed increased on-task behavior, which in turn reduced the potential for problem behavior to occur.

Effectiveness of interventions

Question development. Results indicated that students with ASD performed better with the question development plus ABA treatment than with the question development

treatment. When interpreting findings from the CBM reading probes for both participants, one student demonstrated a mean difference of 25% and the other student a mean difference of 27% in favor of the question development plus ABA treatment. Although performance on CBM reading probes for the question development plus ABA treatment was better in the present study, there was little indication for either participant of growth of performance on the CBM reading probes. Both participants initially performed better with the question development plus ABA treatment with a continued trend of higher performance when compared with the

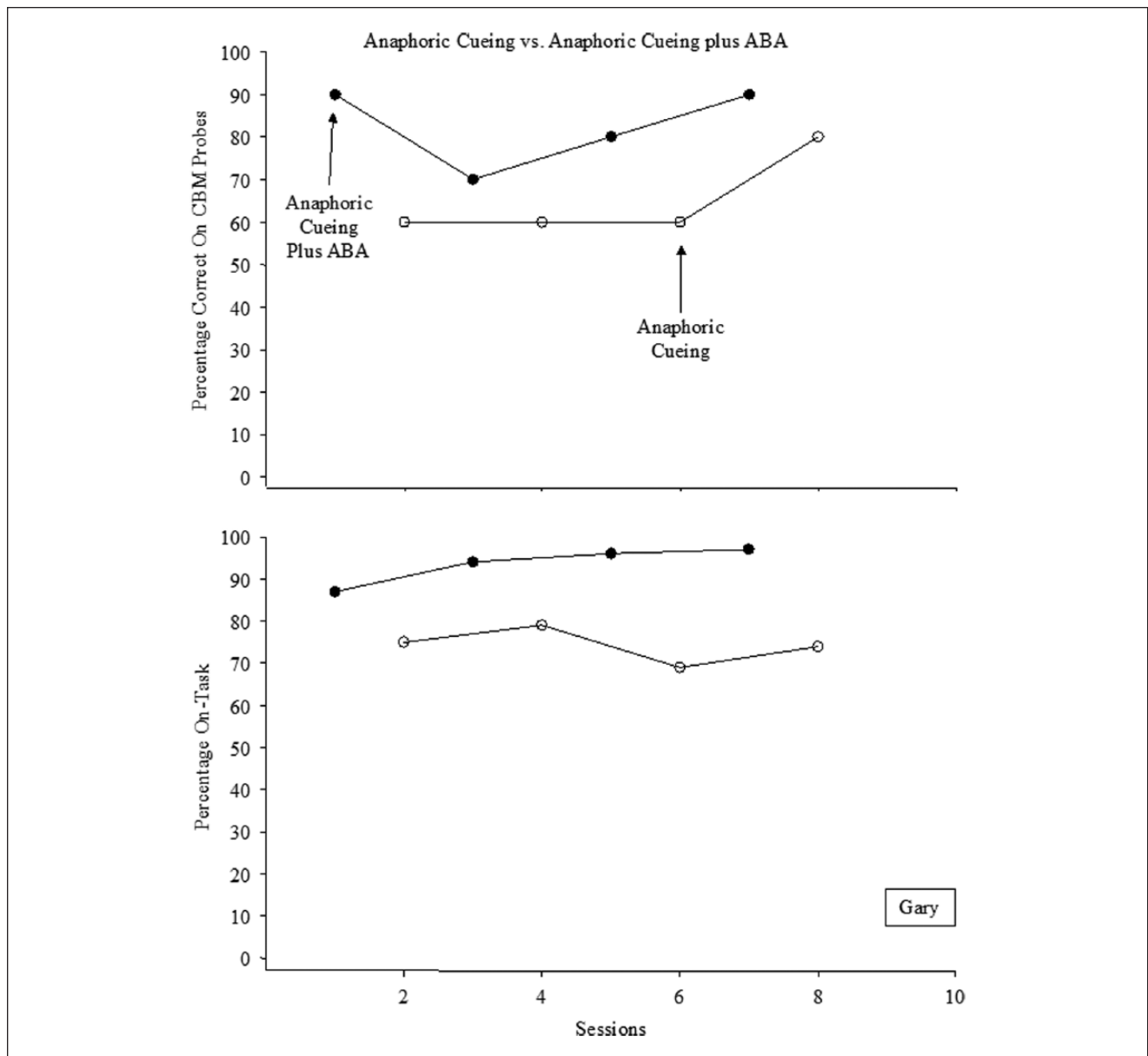


Figure 6. Percentage correct on CBM reading probes (top) and percentage on-task (bottom) during anaphoric cueing and anaphoric cueing plus ABA for Gary.

Note. CBM = curriculum-based measures; ABA = applied behavior analysis.

question development treatment throughout the intervention duration. We interpret this finding as indicative of a positive initial impact from ABA and maintenance of those effects over time.

Anaphoric cueing. Results indicated that students with ASD performed better with the anaphoric cueing plus ABA treatment than with the anaphoric cueing treatment. Interpreting findings from the CBM reading probes for both participants, one student demonstrated a mean difference of 28% and the other student a mean difference

of 18% in favor of the anaphoric cueing plus ABA treatment. Similar to the findings of the question development intervention, with the anaphoric cueing treatments, performance on CBM reading probes for the anaphoric cueing plus ABA treatment was better than the anaphoric cueing treatment; however, there was no indication for either participant of consistent growth on the CBM reading probes. We interpret these findings as indicative of a positive effect of the addition of ABA techniques to instructional practices to improve reading performance for students with ASD.

Limitations

There are several limitations to be considered when interpreting the results of these studies. First, the CBM reading probes, as in most studies using proximal CBM, were not previously validated; thus, the psychometric properties are unknown. As with other intervention research on the topic of reading comprehension, measurement of the dependent variable over short durations is problematic (Snow, 2003). Second, the length of the intervention was too brief to rule out a potential novelty effect of the treatments with the addition of ABA techniques. Third, the alternating treatments within participant design exposed students to two separate but similar treatments, causing a threat to internal validity. In both studies the only difference between the two treatments was the addition of the techniques of ABA: visual supports, token economy, readings based on perseverative interests of students. The instructor provided anecdotal feedback that students began to complain during the treatment sessions without ABA that they did not have the opportunity to read about their perseverative interest on that instructional day. In other words, by providing the treatments in an alternating format, we may have inadvertently reduced on-task behavior and motivation to learn during the treatments without ABA, rather than simply improving performance with the treatments that included ABA. Nonetheless, the alternating treatments design allowed us to compare the different treatments as a means to explore the potential of the addition of ABA techniques as an initial step in determining the feasibility and justification of investing in the enhancements to the instructional materials.

Implications for Practice

These two studies provide additional support for the enhanced value of including ABA-based practices with effective instruction to improve reading comprehension for students with ASD. Teachers of students with ASD should consider incorporating ABA-based instructional and curricular enhancements such as visual supports, token economies, and readings based on perseverative interests. However, practitioners should note the limitations of this study and the sparse evidence in support of these strategies when considering use. Recently, other studies of reading comprehension interventions for students with ASD and low-incidence disabilities have been conducted, which show promise of effective practices including the use of read-alouds (Mims et al., 2012) and the use of modified systems of least intrusive prompting (Browder, Hudson, & Wood, 2013). Practitioners should also consider the instructional practices described in these studies.

Implications for Future Research

The results of the present studies show that the addition of ABA techniques to previously validated reading interventions have initial promise as a means to developing evidence-based reading interventions specifically designed for students with ASD. Additional research is needed with the use of standardized measures and more rigorous researcher-developed measures. Researcher-developed measures that have been previously field-tested and norms developed for typical readers, readers with learning disabilities, and readers with ASD should be considered. Both near transfer and far transfer measures should be considered for use. Measures of social validity as it relates to both students and instructors should also be considered for future studies.

Research designs that include experimental controls with interventions of longer durations should be considered (i.e., multiple-baseline across participants experimental design). Future research studies should consider multicomponent interventions that combine question development and anaphoric cueing with schedules of reinforcers (e.g., tokens, perseverative readings) gradually thinned throughout the duration of the intervention. This approach may promote on-task behavior and accurate responding to CBM reading probes independent of the delivery of reinforcers provided through the addition of ABA as part of the interventions.

Declaration of Conflicting Interests

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