Article

Hammill Institute on Disabilities

Journal of Positive Behavior Interventions
2021, Vol. 23(2) 118–129

DOI: 10.1177/1098300720929680
jpbi.sagepub.com
SAGE

The Effect of Computer-Assisted Instruction on Challenging Behavior and Academic Engagement

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Abstract

Students with intellectual and developmental disabilities (IDD) require intensive supports, including those that target behavior, to make progress on literacy goals. In this study, we investigated whether computer-assisted instruction (CAI) may be one effective method to decrease challenging behavior and increase academic engagement. Participants were three students with IDD (7 to 9 years old) who engaged in challenging behaviors during instruction. We used a single-case alternating treatments design to compare levels of challenging behavior and academic engagement during paper-based and CAI (i.e., tablet computer-based) literacy instruction. Results indicated that CAI was associated with decreased challenging behavior and increased academic engagement for two of three participants. In addition, the CAI condition corresponded with higher scores on academic performance assessments for one participant. Although teacher and student measures of social validity were positive, there was limited evidence that results maintained. These findings are described in relation to their limitations, future directions for research, and impact on practitioners.

Keywords

literacy, computer-assisted instruction, challenging behavior, intellectual disability, developmental disability

Despite increasing evidence that students with intellectual and developmental disabilities (IDD) can acquire reading skills (Allor et al., 2014), their literacy achievement lags behind peers with other disabilities (Wei et al., 2011). One contributing factor is that students with IDD often engage in challenging behavior and display low levels of engagement during instruction (Allor et al., 2018; Geiger et al., 2010). Such behavior patterns may develop because specific instructional features are aversive, and challenging behavior effectively results in avoidance and escape from instruction (i.e., negative reinforcement; Geiger et al., 2010). Students who continually respond to reading instruction with challenging behavior are likely to receive less instruction and demonstrate slower progress than peers (McIntosh et al., 2008). Conversely, students who spend more time academically engaged are more likely to benefit from instruction (Rock, 2005). Thus, reducing challenging behavior and increasing academic engagement during literacy instruction may facilitate greater literacy improvements for students with IDD.

Computer-Assisted Literacy Instruction

Incorporating student preference during academic instruction may reduce aversive qualities, leading to reduced challenging behavior and increased academic engagement. Researchers have reported that students with IDD may prefer using devices such as iPads over more traditional, paper-based instruction (Kagohara et al., 2013). In addition, research indicates that computer-assisted instruction (CAI; that is, using computer programs to teach concepts or skills) can result in improved literacy outcomes for students with IDD (Wehmeyer et al., 2004). This research has included various devices such as laptops, tablets, and audio players (Kagohara et al., 2013; Root et al., 2017; Wehmeyer et al., 2004). However, the link between CAI and student behavior has not yet been thoroughly investigated (Kagohara et al., 2013; Knight et al., 2013).

Despite limited research on the relation between CAI and challenging behavior or engagement, there are several features of CAI that may contribute to its appeal. These features include the following: (a) immediate reinforcement for correct responding; (b) embedded scaffolds for navigating content (e.g., visual prompts); (c) use of interactive,

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Action Editor: Lise Fox

game-like formats; (d) predictable and sequential activities; (e) a multitude of materials/stimuli contained within one device; and (f) ease of use for students with fine motor difficulties (Clinton, 2019; Knight et al., 2013; Wehmeyer et al., 2004). In addition, students who enjoy tech-based leisure activities (e.g., videos, games) may engage with CAI if those preferred leisure tasks are available afterward.

Previous Research on the Effects of CAI

We were able to identify three published studies in which researchers: (a) included students with disabilities; (b) experimentally compared CAI and other instructional modes; and (c) measured challenging behavior or engagement. Kern et al. (2001) conducted a study with two 11-year-old boys with emotional and behavioral disorders (EBD). Pre-intervention assessment results suggested that both students engaged in noncompliance in response to paper-and-pencil writing tasks and both preferred computer-based tasks. Kern et al. then compared traditional medium (i.e., paper-and-pencil writing) and preferred medium (i.e., computer writing) conditions. In both conditions, students received points after completing the assignment which they later exchanged for tangibles. Data from the single-case A-B-A-B designs indicated functional relations between increased engagement and reduced disruptive behavior in the computer-based condition for both participants. These results indicated that a teacher could incorporate CAI with positive effects while continuing typical classroom procedures.

Neely et al. (2013) also conducted a single-case A-B-A-B design study to compare levels of behavior in traditional (i.e., paper and pencil) and iPad-based conditions. Participants were two students with autism (3 and 7 years old) who engaged in challenging behaviors during academic tasks (i.e., subtraction, matching color cards) and preferred technology as reinforcers. Behavioral function questionnaires and single-function functional analyses (FAs) indicated that both students' behaviors were maintained by escape. Next, Neely et al. compared challenging behavior during traditional and iPad conditions; notably, escape for challenging behaviors was available in both conditions. Researchers identified a functional relation—the iPad was associated with reductions in challenging behavior and increases in engagement for both students. These results indicated that CAI may improve escape-maintained behavior, even in the absence of escape extinction.

Most recently, Zein et al. (2016) compared two modes of reading comprehension instruction—teacher-directed instruction and iPad-assisted instruction—with three male students with autism spectrum disorder (ASD; 9 to 10 years old). In teacher-directed instruction, students read a passage and wrote responses on a main idea graphic organizer. In iPad-assisted instruction, students read a passage and used the *Space Voyage* iPad app to select a main idea statement. Teachers used a token economy to reward student behavior with access to tangibles (e.g., games, snacks) in both conditions. Data within the single-case alternating treatments design (ATD) indicated a functional relation between iPad-assisted instruction and fewer task refusals for two of three students. However, it should be noted that differences between iPad-assisted instruction tasks (i.e., selecting a response) and teacher-directed instruction tasks (i.e., generating multiple responses) may partially account for these findings.

These studies provide some evidence that CAI can reduce challenging behavior and increase engagement; nonetheless, there are limitations that warrant further investigation. First, these three studies included only seven students (five with ASD, two with EBD). Extending this research to include students with IDD is a logical next step, considering that CAI is increasingly used with this population (Kagohara et al., 2013) and challenging behavior is often a concern (Allor et al., 2018). Second, there is currently limited guidance on using assessments within this context. Both Kern et al. (2001) and Zein et al. (2016) used caregiver interviews and student assessments; whereas, Neely et al. (2013) conducted an experimental analysis. CAI can be characterized as incorporating student preferences, but none of these authors conducted a direct preference assessment. Third, none of these studies included social validity data, and it is important to determine whether stakeholders consider CAI acceptable and effective. Finally, there is a need to investigate whether CAI can support intensive literacy intervention for students with IDD, who often require extended intervention dosage to make measurable reading progress (Allor et al., 2014). Current CAI research included brief sessions (i.e., 5 to 20 min), focused on isolated tasks (e.g., subtraction), and lacked maintenance data. There is a need for researchers to investigate whether longer sessions focused on multiple literacy subskills (e.g., phonological awareness, phonics) result in similar effects and whether those effects maintain across time.

The Present Study

The purpose of this study was to compare the effect of CAI versus traditional instruction on challenging behavior and academic engagement. We extended previous research by including students with IDD, conducting pre-intervention preference assessments, implementing a comprehensive literacy intervention, and collecting social validity data. We included participants who engaged in challenging behaviors during instruction and who were interested in technology based on teacher report. Teachers implemented paper-based and iPad-based versions of *Friends on the Block* (FOTB)—a comprehensive, text-based literacy intervention with emerging evidence supporting its effectiveness for students with IDD (see Allor et al., 2018; Conner et al., 2020). Our primary research question was "Compared to paper-based literacy instruction, does CAI result in lower levels of challenging behavior and higher levels of engagement for students with IDD?" Our secondary aims were to describe: (a) correspondence between data from preference assessments and response to intervention conditions, (b) maintenance of results during a "superior alone" condition, (c) social validity using information from teacher surveys and a student choice assessment, and (d) academic performance data across conditions.

Method

Participant Recruitment and Screening

This study was approved by a university-based Institutional Review Board and a school district in TN. Eligible students (a) were identified with IDD (e.g., intellectual disability [ID]; ASD) by their school district; (b) were in elementary school; (c) used spoken English as their primary form of communication; (d) could hear and see well enough for typical classroom instruction; (e) were available for up to 5 months with the same educator for four, 30-min sessions per week; (f) engaged in high-frequency, low-intensity challenging behaviors during instruction; and (g) were interested in technology (teacher report). We received teacher and parent consent and student assent prior to interacting with potentially eligible students.

We e-mailed flyers to 14 teachers who were nominated by university research staff and scheduled 15-min phone calls with responders. We screened students with a multiple-gating procedure adapted from the *Systematic Screening for Behavior Disorders* (SSBD; Walker et al., 2014). First, teachers nominated, in rank order, up to three students who met inclusion criteria and identified the behaviors of concern. Second, we observed up to three times (15 to 20 min) during one-on-one reading instruction. If challenging behavior occurred for at least 10% of one or more observations (measured with 10-s partial interval recording), we administered the FOTB performance assessment. Students who scored 10 or fewer correct out of 12 items were included in the study (see the dependent variable section). Five students completed the screening procedure and three met inclusion criteria.

Participants and Settings

Table 1 includes detailed characteristics of our three participants. Participants were male students who were 7 to 9 years old and were identified with ID or ASD. Intelligence quotient (IQ) scores ranged from 40 to 78 on a researcher-administered assessment (*Kaufman Brief Intelligence Test–2nd Edition* [KBIT-2]; Kaufman & Kaufman, 2004). Participants' raw scores on the researcher-administered *Test of Preschool Early Literacy* (TOPEL; Lonigan et al., 2007) subtests ranged from 3 to 24 on Print Knowledge (PK), 1 to 52 on Definitional Vocabulary (DV), and 3 to 13 on Phonological Awareness (PA). These were all lower than the 50th percentile raw scores (PK = 25; DV = 61; PA = 22) of the oldest age included in the TOPEL normative sample (5 years, 11 months old). None of the students had previous experience with the FOTB intervention. During the study, their teachers continued providing concurrent literacy instruction that included packaged curricula and teacher-designed lessons.

All students received FOTB intervention from their special education teachers. All teachers were White, non-Hispanic females between the ages of 30 and 54 years old and had master's degrees in special education. Their special education teaching experience ranged from 1 to 9 years, and each teacher had taught the participating student for 1 to 3 years. After Berto's pre-intervention assessments, school administrators put a former teacher in charge of his literacy instruction due to unrelated staff reductions. This teacher consented to participate in the study and reported that Berto had typically engaged in challenging behaviors during instruction with her (similar to the first teacher). Due to time constraints, we did not conduct a second screening.

Sessions took place in three public schools in TN. Teachers implemented one-on-one FOTB sessions in their special education classrooms. The first author trained teachers and was present during all sessions to video record and provide procedural coaching as needed. She was a doctoral student who had previously worked as a special education teacher and had 3 years of experience training educators to implement literacy and behavioral interventions. One or two other adults and students were often present in the classrooms; however, we requested that they refrain from interacting with participants during sessions.

Preference Assessment Procedures

The first author conducted a multiple stimulus without replacement (MSWO; DeLeon & Iwata, 1996) preference assessment and a concurrent operants analysis (COA; Harding et al., 1999) with each participant in a quiet area of each classroom. Previous research on CAI did not include preference assessments; thus, these assessments were exploratory. We used MSWO data to determine students' preference for leisure items, and we used COA data to determine students' preference for instructional activities. We then compared results from the two assessments and evaluated their correspondence with intervention data.

MSWO. Each student completed three MSWO sessions that followed procedures described by DeLeon and Iwata (1996). Stimuli included an iPad and five to seven other items that teachers reported were typically available during

Table 1. Student Demographics, Assessment Performance, Challenging Behaviors, Technology Access, and IEP Goals.

Student	Demographics	IQ[a] (90% CI)	TOPEL[b] scores	Challenging behaviors	Access to technology Type	Use	Min/day	Reading IEP goals
Jalen	Disability: ID Age: 7:4 Race: B Ethnicity: N-H	78 (73–84)	PK: 24 DV: 17 PA: 3	Aggression Verbal protests Shouting/crying/noises Head down Non-compliance Out of seat Property damage	Smart board Computer/ laptop Tablet	A; L A; L A; L	60 30 30	Identify upper- and lowercase letters
Koby	Disability: ASD Age: 7:4 Race: B Ethnicity: N-H	54 (50–60)	PK: 52 DV: 1 PA: 6	Aggression Verbal protests Shouting/crying/noises Non-compliance Out of seat Property damage	Computer/ laptop Audio player Projector	A; L L A; L	60 15 5	Identify letter sounds; Identify sight words; Read phrases with sight words & pictures
Berto	Disability: ID; DS Age: 9:2 Race: W Ethnicity: H	40 (36–49)	PK: 13 DV: 4 PA: 3	Verbal protests Shouting/crying/noises Non-compliance Out of seat Property damage Removing clothing	Tablet Projector Computer/ laptop	L A; L A	20 15 5	Identify sight words; Identify functional/ safety words

Note. A = academic; ASD = autism spectrum disorder; B = Black; CI = confidence interval; DS = Down syndrome; DV = Definitional Vocabulary; H = Hispanic; ID = intellectual disability; IEP = individualized education program; IQ = intelligence quotient; L = leisure; N-H = non-Hispanic; PA = Phonological Awareness; PK = Print Knowledge; W = White.
[a]*Kaufman Brief Intelligence Test–2nd Edition* (Kaufman & Kaufman, 2004); composite standard scores reported.
[b]*Test of Preschool Early Literacy* (Lonigan et al., 2007); raw scores reported.

leisure times (e.g., a book, drawing materials). We combined data from the three sessions and calculated the percentage of trials in which each item was selected by dividing the total number of trials in which the item was chosen by the total number of trials in which it was presented. We concluded that students "highly preferred" the two items with the highest percentages.

Research assistants (RAs) collected interobserver agreement (IOA) and procedural fidelity (PF) data for one session per student (33.33%). We calculated IOA by scoring agreement on each item's ranking, dividing the number of agreements by the sum of agreements plus disagreements, and multiplying by 100. We used a direct observation method for PF; data collectors tallied whether each required behavior (e.g., rotating materials, giving the student access for at least 15 s) was correct or incorrect. We then calculated PF percentage by dividing the number correct by the total numbers of procedures and multiplying by 100. IOA and PF were 100% for Jalen and Berto's sessions. For Koby's sessions, IOA was 100% and PF was 90%.

COA. The COA included three conditions adapted from Harding et al. (1999). Data from Condition 1 confirmed that students would interact with the iPad and researcher during a noninstructional activity. Choices were (a) working on writing sheet independently or (b) playing on an iPad with attention. Data from Condition 2 indicated students' preferred mode for an instructional activity without demands. Choices were (c) listening to an iPad story or (d) listening to a paper story (both read by the researcher). Data from Condition 3 indicated students' preferred mode for an instructional activity with demands. Choices (e and f) were identical to Condition 2 except that the researcher gave demands to touch pictures on each page (with verbal-model prompt sequence). We selected books with high-interest topics (e.g., bugs) from Reading A-Z Level G (readinga-z.com). Within a trial, each choice contained two identical books; however, we changed the books in between trials to avoid satiation.

During each 3-min session, colored tape designated the two available choices (i.e., sides of a table). An RA described each choice and allowed the student to interact with materials. Then the RA directed the student to stand away from the table and "make a choice." During sessions, students could freely move between choices. When a student entered a choice area, the first author immediately implemented the condition and continued until he moved to a different area. After each session, we re-presented the same choices on opposite sides to detect preference stability and rule out side-bias. We concluded that a student preferred a choice if he spent at least 2 of 3 min (66.6% of session) in that choice for two consecutive sessions.

During all sessions, an RA used a smart phone app (counteeapp.com) to record decision-making data; final data were collected from videos. We collected IOA and PF from randomly selected video recordings of 33.33% to 37.50% of sessions. We used the calculator on counteeapp.com set to 10-s intervals to obtain the percentage of proportional agreement between data collectors. We directly observed PF for both set-up (e.g., explaining rules; checklist) and condition procedures (e.g., placing demands, rule reminders). We calculated PF percentage with the same method as we used for the MSWO. Mean IOA was 99.38% for Jalen, 99.03% for Koby, and 93.98% for Berto (IOA per session ranged from 83.33% to 100%). Mean PF was 93.63% for Jalen (range = 90%–100%) and 100% for Koby and Berto.

Intervention Overview

Intervention sessions included a subset of FOTB activities (Allor et al., 2018) which we adapted to decrease the potential confound of session-based variation. Sessions were 25 min, four to five times per week. Teachers read one story per week, the order of which was randomly selected for each participant (a specific sequence is not required for students to access the texts within a level). All students began in Level 1 and could begin Level 2 in the "superior alone" phase after correctly responding to 10 or more items (83.33%) on two consecutive performance assessments. If data were below this criterion after 4 weeks, teachers re-presented the stories in the same sequence. Level 1 includes four stories, six letter sounds (/c/, /f/, /p/, /m/, /s/, /t/), and six sight words (I, a, like, not, want, do). Level 2 introduces four new stories, three new letter sounds (/d/, /j/, /n/), and eight sight words (dad, is, Mom, the, here, look, see, where). We did not adapt these targets; they were identical to those in the FOTB teacher guide. Each intervention session included four steps.

Step 1: Performance assessment (5 min). Teachers read the lesson rules (*Have a safe body, Stay in our area, Be kind to others*), stated whether the session was paper-based or CAI, and referenced a visual schedule while naming each lesson step. Teachers then administered the daily performance assessment. The rules and visual schedule were paper-based for all sessions so they could remain visible during instruction. Assessment items were printed on cardstock for paper sessions and presented via a flashcard app for CAI sessions.

Step 2: Warm-up (5 min). Students practiced blending the onset-time and identifying the first sound of four words from the story with an "I do-We do-You do" procedure. For example, the teacher modeled blending with, "I will say the sounds in a word, then I will say the word. I'll do the first one. Listen /nnn/ /ot/. That word is *not.* Say *not.*" The student blended the second word with the teacher, and then independently blended a word. Finally, the teacher guided the student through identifying five letter sounds and five sight words (displayed on paper or iPad). These procedures were identical to those described in the FOTB teacher guide.

Step 3: Story reading (10 min). Each story included six pages. Teachers read complex "helper" text, and then students read instructional-level text with picture support (e.g., *I like pizza* with pizza depicted underneath). Teachers then used a script to ask one simple recall question per page (FOTB typically includes higher order questions). For example, questions for *A Healthy Breakfast* included "What is this?" while pointing to pictures (e.g., oatmeal, milk). Teachers corrected errors with an "I do-We do-You do" procedure (e.g., "Eggs are white. Say white with me. Good. You try again. What color are the eggs?") These procedures were the same during each session for a given story (FOTB typically includes prediction questions on Day 1 and review questions on Day 4). Materials for paper sessions resembled trade books; teachers used the Books app during CAI sessions.

Step 4: Text building (5 min). Last, teachers led two text-building games. In Build-A-Word, students arranged individual letters to build each of the six target sight words with a model of the word present. In Build-A-Sentence, students arranged individual words to build five to seven total sentences. Students played paper games on laminated cardstock with hook-and-loop fastener and CAI games through an app. The app included one model of each task, animations with sounds effects, and praise statements (e.g., "Great job! Let's build another one!"). During paper games, teachers provided one model and praised after each opportunity. Allor et al. (2018) developed these games and shared them with our research team; however, FOTB typically includes multiple, paper-based learning games (e.g., sorting, reading fluency).

Data Collection and Dependent Variables

The percentage of intervals with challenging behavior and academic engagement were the primary and secondary dependent variables, respectively. We collected these data from video recordings with ProCoderDV software (Tapp, 2003). RAs divided the video recording of each session into 10-s intervals, coded all intervals, and estimated duration by calculating the percentage of intervals with each behavior (i.e., occurrences divided by the total number of intervals and multiplied by 100). All RAs were graduate students who were trained to 90% reliability with the first author's "gold standard" prior to beginning data collection.

Behavior definitions. We defined challenging behavior as "behavior that interfered with or interrupted a teacher's presentation of a lesson." Examples included shouting or making noises above conversational levels, verbal protests (e.g., "No, I won't do that."), crying, damaging materials (e.g., pushing, throwing, crumpling), stepping or running away from the area, and aggression (e.g., hitting). Non-examples included talking or making noises at a conversational level, touching materials, or standing up during the lesson. We defined academic engagement as interacting with the teacher and/or materials as directed (adapted from Bruhn et al., 2017). Examples included looking at the teacher while she was speaking (eye contact not required), using materials in a contextually appropriate way, and talking to the teacher about lesson content. Non-examples included looking away from the teacher or materials during instruction and behaviors that were not challenging behavior but were unrelated to instruction (e.g., talking about an off-topic subject).

We estimated the duration of challenging behavior by coding if it occurred for any portion of each 10-s interval (i.e., partial interval recording). If challenging behavior occurred across multiple consecutive intervals, we coded it as occurring in each one. We estimated the duration of academic engagement by coding if a student was engaged at the exact moment each 10-s interval ended (i.e., momentary time sampling). We chose these two measurement systems so that data collectors could give their full attention to each behavior separately.

Academic performance assessments. We collected data on students' academic performance by recording the number of correct items on a daily assessment. Level 1 items included the six letter sounds taught during FOTB Step 2 and the six sight words taught during Steps 2 through 4 (Allor et al., 2018 measured only sight word progress). During Level 2 sessions, teachers shuffled the full decks of letters/words and assessed the first six items from each deck. This content was identical in both conditions (i.e., CAI and paper); however, we hypothesized that challenging behavior could influence academic performance (e.g., some behaviors were incompatible with correct responding). We also used performance data to determine progression from Level 1 to Level 2. Teachers administered assessments by shuffling the deck (cardstock during paper sessions and digital during CAI) and then presenting each card while asking, "What sound?" or "What word?" They scored "1" if the student responded correctly within 5 s and "0" if the student responded incorrectly or did not respond within 5 s. Scores could range from 0 to 12.

IOA and PF

We collected IOA and PF data on 30% of each participant's sessions, distributed across conditions and phases. We calculated IOA and PF percentages with the same method described in the MSWO section. Across participants, mean challenging behavior IOA was 95.30% or greater (range = 90.60%–100%), mean academic engagement IOA was 87.80% or greater (range = 77.17%–98.25%), and mean performance assessment IOA (point-by-point) was 96.67% or greater (range = 83.33%–100%). IOA results for paper and CAI sessions were comparable. When IOA was below 90%, the first author viewed video segments with RAs and discussed the correct codes.

The first author used a direct observation method to collect in vivo PF data. The fidelity form listed necessary procedures for each intervention step (e.g., reviewing rules, reading text in story). A procedure was "correct" each time a teacher completed it as trained and "incorrect" each time a teacher engaged in a required procedure incorrectly or skipped the procedure. We also used a rating scale to compare teachers' tone and interactions during sessions; these procedures and results are available as a supplemental file. Mean PF for all teachers was 89.86% or greater (range = 77.85%–98.59%). Results for paper and CAI sessions were comparable for Jalen and Koby. Berto's teacher demonstrated higher PF in CAI sessions (Paper M = 89.86%; CAI M = 96.03%).

Experimental Design and Data Analysis

We used an alternating treatments single-case research design (ATD; Barlow & Hayes, 1979) to evaluate the effects of paper-based instruction versus CAI on challenging behavior and academic engagement. During the intervention comparison phase, teachers conducted each pair of sessions in a block-randomized order. We used visual analysis of graphed data to determine whether there was differentiation (i.e., vertical separation) between data paths. Teachers continued until three consecutive series of challenging behavior data demonstrated differentiation or after 10 series (i.e., 20 sessions). We then conducted a "superior alone" phase (Barlow & Hayes, 1979) for 10 sessions to describe whether results maintained over time. We omitted this phase if neither condition was superior.

We evaluated assessment correspondence (a secondary aim) by comparing data from each student's preference assessments with intervention comparison data. If CAI resulted in reduced challenging behaviors, we concluded there was (a) high correspondence if all preference assessment data indicated technology was preferred, (b) moderate correspondence if a portion of preference assessment data indicated technology was preferred (e.g., MSWO but not COA; a portion of COA), and (c) low correspondence if preference assessments indicated technology was *not* preferred.

Social Validity

We collected social validity data from both students and teachers. After the intervention comparison phase, we collected data on students' condition preference with a concurrent chains procedure (Hanley, 2010). Teachers displayed the visual schedule symbols for both conditions, stated "choose one," and then implemented a brief session of the chosen condition with the performance assessment omitted. They repeated this once or twice each day until the student chose the same condition on three consecutive occasions. We planned to discontinue if they completed 10 sessions without a clear preference. At the conclusion of the study, teachers completed a 12-item survey that included statements pertaining to the goals, procedures, and results of both conditions. Teachers rated each statement on a Likert-type scale (1 = *strongly disagree*; 5 = *strongly agree*) to provide indirect data on their experience.

Results

Jalen

MSWO data (see Figure 1) indicated that Jalen highly preferred tangibles that were not technology-based—magnetic tiles (60%) and drawing materials (37.50%). COA data did not clearly indicate whether Jalen preferred iPad-based activities. During Condition 1, he consistently chose iPad with attention (85% and 88.89% of time). Across Condition 2, data indicate that Jalen preferred listening to a story on iPad (range = 33.88%–96.11%). In Condition 3, data from three of four sessions indicate that Jalen allocated more time to listening to a story on iPad (range = 0%–91.11%) than paper (range = 0%–83.33%). Jalen began engaging in challenging behaviors during Condition 3; therefore, we discontinued the COA after the fourth session.

Jalen completed 10 intervention comparison sessions (see Figure 2). Challenging behavior was variable in the paper condition (*M* = 16.17%, range = 4%–32.04%) and was relatively low and stable in CAI (*M* = 7.11%, range = 4.9%–11.41%). Although data from initial sessions were similar in level and overlapped, the vertical separation across the phase suggests a functional relation in which challenging behavior was lower in CAI. Academic engagement in the paper condition was variable (*M* = 68.85%, range = 47.57%–85%) and increased across the final three sessions. In CAI, academic engagement was relatively stable and high (*M* = 84.46%, range = 83.22%–90.85%). Thus, a functional relation was evident in which academic engagement was consistently higher in CAI. Performance data in CAI were low and stable (range = three to four correct items), whereas data in the paper condition were low and more variable (range = one to four correct items). There was not a consistent pattern of differentiation across the phase.

Jalen completed 10 CAI superior alone sessions. During the first six sessions, challenging behavior increased (range = 3.88%–32.09%) and engagement decreased (range = 58.1%–83.74%). We hypothesized that these patterns were related to reduced novelty because he began repeating the FOTB Level 1 sequence due to low performance assessment data. Therefore, starting with Session 7, his teacher gave Jalen a choice of which Level 1 story to complete. Data across the final three sessions display a decreasing trend for challenging behavior (45.75%–0%) and an increasing trend for academic engagement (44.96%–94.29%). Academic performance data were stable and remained at a level similar to CAI data in the comparison phase (range = three to five items correct).

Koby

MSWO data indicated that Koby's highly preferred items were videos on a computer (75% of trials) and a stuffed animal toy (50% of trials). Koby's COA data indicate that he consistently preferred iPad conditions. In Condition 1, his time allocated to playing on the iPad with attention ranged from 90% to 95%. In Condition 2, Koby allocated 96.67% of both sessions to listening to a story on the iPad. In Condition 3, Koby allocated 96.11% of the first session and 94.44% of the second session to completing demands while listening to a story on the iPad. Koby did not allocate any time to other choices.

Koby completed 20 sessions of the intervention comparison. Challenging behavior in CAI decreased through Session 11 and then remained low and stable through Session 20 (*M* = 5.68%, range = 0.72%–16.25%). Paper-based data were variable throughout the phase (M = 11.59%, range = 0.76%–23.13%). Nonetheless, vertical separation between data paths suggests a functional relation between CAI and reduced challenging behavior. Academic engagement data overlapped in Sessions 1 through 8. In Sessions 9 to 20, CAI data remained high and stable and paper-based data decreased. Across the phase, mean academic engagement was 86.03% in CAI (range = 74.85%–95.75%) and 75.25% in paper (range = 60.45%–91.37%). These data indicate a functional relation between CAI sessions and higher levels of academic engagement. Academic performance data in both conditions displayed an increasing trend in Sessions 1 to 10 (range = eight to 11 correct items). From Sessions 10 to 12, Koby scored 12 on all assessments. Thus, both conditions supported high academic performance.

Koby completed 10 sessions in the superior alone (CAI) condition and began Level 2 at the beginning of the phase. Both behavior data paths were variable across this phase—challenging behavior ranged from 3.77% to 23.39% and academic engagement ranged from 66.48% to 89.72%. Performance assessment data initially decreased to lower than the comparison phase, which we expected due to the change in content from Level 1 to Level 2. Subsequently, an increasing trend from 6 to 11 items correct was evident across the phase.

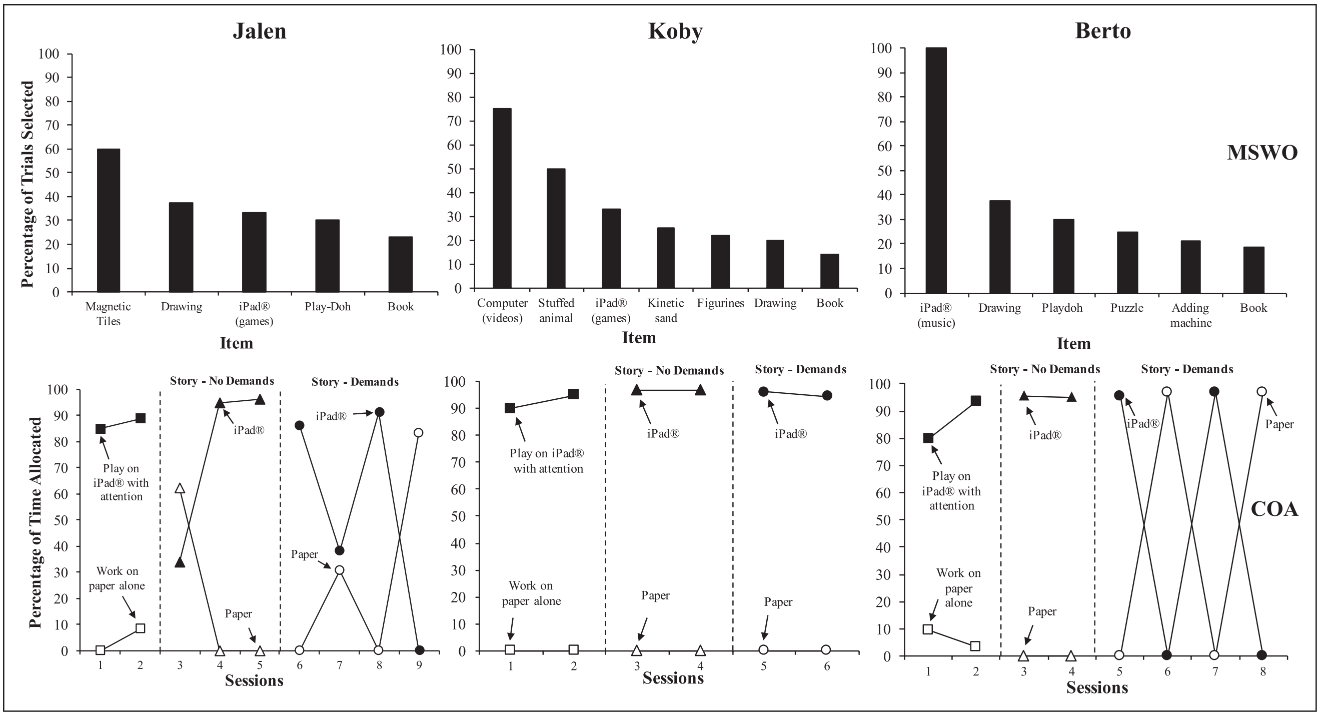

Figure 1. Multiple stimulus without replacement (MSWO) preference assessment and concurrent operants analysis (COA) results by participant.

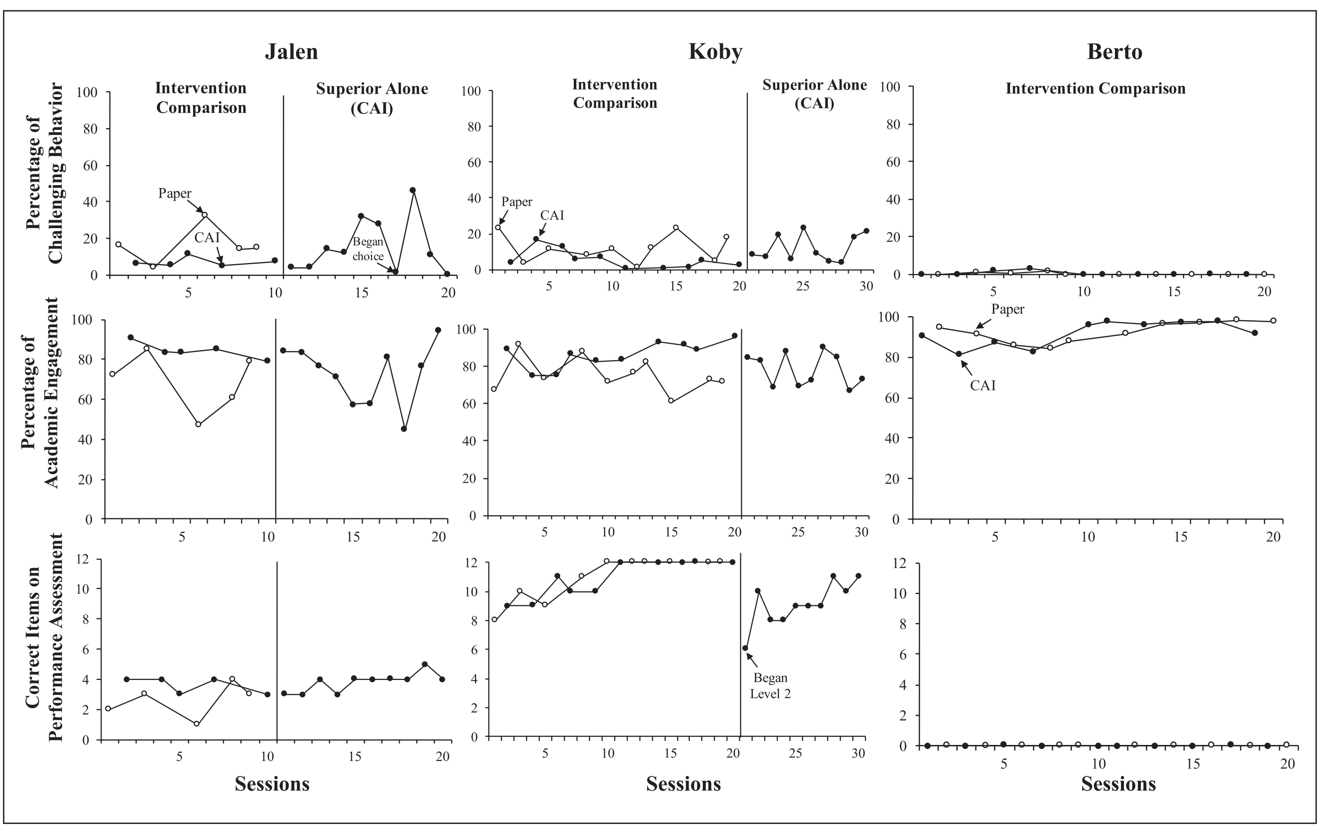

Figure 2. Intervention results by student.
Note. CAI = computer-assisted instruction.

Berto

Berto's MSWO data indicated that his highest preferred choices were music on an iPad (100% of trials) and drawing materials (37.5% of trials). During COA Condition 1, data indicate that Berto preferred playing on the iPad with attention (range of time allocated = 80%–93.33%), and data from Condition 2 indicate that Berto preferred listening to a story on the iPad (range of time allocated = 95%–95.56%). Data from Condition 3 are highly variable and indicate that Berto did not prefer either completing demands while listening to a story on the iPad (range of time allocated = 0%–96.67%) or paper (range of time allocated = 0%–96.67%). Berto began engaging in challenging behaviors during Condition 3 (e.g., low-intensity aggression); therefore, we discontinued the COA after four sessions.

Berto completed 20 sessions of the intervention comparison. Across the phase, challenging behavior in both conditions was low (paper M = 0.37%, range = 0%–1.65%; CAI M = 0.49%, range = 0%–3.31%). Academic engagement was high across both conditions and data paths frequently overlapped (paper M = 92.37%, range = 84.30%–97.96%; CAI M = 91.74%, range = 81.06%–97.71%). Academic performance data was 0 during all sessions. Thus, there was not a functional relation between either condition and any of the dependent variables. Berto did not complete a superior alone condition.

Correspondence of Assessment Data and Intervention Condition Data

Correspondence between assessment and intervention data ranged from moderate (Jalen and Berto) to high (Koby). Koby's MSWO and COA data both indicated he highly preferred technology; subsequently, his challenging behavior was lowest in CAI sessions. Jalen's MSWO data did not indicate the iPad was preferred and only a portion of the COA indicated the iPad was preferred. However, his challenging behavior reduced in the CAI condition. Berto's MSWO data indicated listening to music on an iPad was his highest preferred activity and a portion of COA results indicated Berto preferred iPad-based activities. However, Berto's data in COA Condition 3 were variable and did not indicate a clear preference, which aligns with the lack of differentiation in the intervention comparison.

Social Validity

We collected direct social validity data from students with a concurrent chains procedure. All three students completed three consecutive sessions in which they chose CAI over paper-based instruction. This indicates that students preferred CAI sessions and suggests that CAI was a socially valid method of instruction from their perspectives. Teachers then responded to a social validity survey. All teachers *strongly agreed* (rating = 5) or *agreed* (rating = 4) with most statements related to intervention goals and procedures (e.g., the importance of reducing challenging behavior during instruction, feasibility of implementing FOTB in either format, willingness to continue). As an exception, Jalen's teacher was not willing and able to continue using paper-based FOTB (rating = 3). Teacher ratings of challenging behavior and academic engagement results were the most variable (range = 2–5). However, responses generally aligned with student data (i.e., two teachers perceived condition-based differences; one did not).

Discussion

We conducted this study to extend previous research on implementing CAI to decrease challenging behavior and increase engagement for students with IDD. We asked the question, "Compared to paper-based literacy instruction, does CAI result in lower levels of challenging behavior and higher levels of academic engagement?" Three elementary students with IDD participated. Researchers conducted preference assessments to determine whether students chose to interact with iPad-based leisure and academic activities, and then special education teachers implemented two versions of FOTB within an alternating treatments single-case design.

Effect of CAI on Challenging Behavior and Academic Engagement

Two of the three students' data indicated a functional relation—CAI consistently resulted in lower levels of challenging behavior and higher levels of engagement than paper-based instruction. For the third participant (Berto), both conditions were associated with zero or near-zero levels of challenging behavior and consistently high levels of engagement. Jalen and Koby's results align with previous research indicating that CAI can reduce challenging behavior and increase engagement during academic instruction (Kern et al., 2001; Neely et al., 2013; Zein et al., 2016) and provide the third example of using tablet computers (i.e., iPads) for this purpose. Jalen's results are the first example of CAI improving behavior for a student with ID (previous research included students with EBD or ASD). Compared with previous studies, we implemented a multicomponent intervention with relatively long sessions (25 min; previous research used single-component instruction and 5–20 min sessions). Based on our findings, it seems that CAI may improve some students' behavior for extended sessions and across varied demands. For other students, both conditions may lead to similarly positive outcomes.

Multiple CAI components may have reduced aversive features of instruction and influenced two of the three students' behavior. First, iPad stimuli were more interactive than paper stimuli (i.e., reinforcement was immediate; Wehmeyer et al., 2004). The iPad-based text building games included sound effects and immediate, enthusiastic praise. In contrast, teacher praise during paper-based games frequently varied in immediacy and tone. Second, these participants had histories of positive associations with technology. Notably, Jalen and Koby had more frequent academic and leisure access to technology than Berto (up to 120 and 80 min/day compared with 35 min/day [see Table 1]). Third, instructional features of FOTB that were present in both conditions (e.g., repetition, structure, scaffolding) could have positively impacted behavior. This may explain two data patterns that (a) challenging behavior was relatively low across both conditions for all students and undifferentiated for Berto, and (b) challenging behavior data paths for both Jalen and Koby overlapped during initial sessions.

Secondary Study Aims

There were four secondary aims in this study. The first was to investigate whether pre-intervention assessment data aligned with challenging behavior data from the two treatment conditions. Previously published studies did not use direct preference assessments within this context. One student's data demonstrated high correspondence and two students' data demonstrated moderate correspondence. The variation within these results indicates that future research is needed to determine whether preference assessments such as MSWOs and COAs can help practitioners determine whether to use CAI.

Second, we described maintenance data, which were not reported in previous studies. Two students completed 10 maintenance sessions, and both students' data demonstrated counter-therapeutic changes within that brief time period. This suggests that CAI alone is not a long-term solution for reducing challenging behavior or increasing engagement. One explanation may be that CAI's novelty decreased during the superior alone condition because it was no longer in direct comparison with paper instruction or because of higher dosage (4 days/week instead of 2 days/week). Koby's challenging behavior may have also been affected by increased difficulty of instruction (i.e., he began FOTB Level 2 and correct responding decreased).

Third, we collected social validity data from teachers and students because previous studies did not include such data. Survey data indicated that all teachers thought the goals were important, the procedures were feasible and acceptable, and that students' levels of challenging behavior and academic engagement improved. Furthermore, direct student choice data indicated that students consistently chose to complete iPad-based instead of paper-based sessions. Note that researchers provided iPads with all materials downloaded and organized and were always present to assist with implementation issues (e.g., Wi-Fi connection, locating materials). Teachers' perceptions of the social validity of CAI may differ based on the support available.

Finally, we described academic performance across the two conditions. Although ATD designs are ill-suited for nonreversible behaviors, we hypothesized that student behavior might correlate with correct responding. These data also informed instructional decisions (i.e., progression from FOTB Level 1 to Level 2). There was clear separation between Jalen's CAI and paper data paths, suggesting that he was more likely to respond correctly during CAI. Lower performance in the paper condition may have been related to lower levels of engagement or to incompatible challenging behaviors (e.g., elopement). No patterns emerged for the other two students' performance data. Jalen and Berto's data demonstrated an overall lack of progress. Readers should note that our investigation was primarily focused on challenging behavior and engagement, and we adapted FOTB (Allor et al., 2018) to fit our design. The abbreviated dosage or adaptations may account for the lack of student progress.

Limitations

This study has three primary limitations. First, Berto's zero levels of challenging behavior indicate that he no longer met inclusion criteria when he changed teachers. We continued based on teacher reports of challenging behavior and time constraints (i.e., end of school year). Nonetheless, our conclusions may have been different for a participant who better met inclusion criteria. Second, we discontinued Jalen and Berto's COAs prior to completion because they began to demonstrate challenging behaviors. We hypothesize they experienced satiation due to the repetition of materials and fatigue (appointments lasted 45 min to 1 hr). Clear preferences may have emerged with a larger selection of materials (i.e., stories), additional sessions, or across multiple appointments. Third, any conclusions may be limited to the literacy intervention we used. The adapted version of FOTB was highly structured and repetitive; thus, results may not replicate with less-structured interventions. These features may have contributed to improved behavior in both conditions; however, we did not include a baseline of typical instruction. Also, the commercially available version of FOTB includes more variation with fewer tech-based activities. FOTB implemented as designed by Allor et al. (2018; that is, not with the modifications made for this study) may not produce similar results.

Directions for Future Research

We suggest that future investigators include multiple types of materials within reading interventions for students with IDD to facilitate flexibility, choice, and ongoing novelty.

FOTB provides one example of this in that some materials are available in both paper-based and technology-based formats. There also remains a need to investigate parameters of CAI that lead to reduced challenging behavior. Effects may differ for fully versus partially technology-based sessions. Using CAI for only a portion of sessions may maintain novelty, especially if teachers alternate the tech-based activities. Although, if only a portion of intervention is CAI, dosage may not be high enough to change behavior. Relatedly, current research is limited to one-on-one instructional groups and should be extended to other grouping arrangements. Researchers who investigate small- or large-group CAI may utilize different technology (e.g., interactive white boards) that allows multiple students to interact with materials. Another area of future research pertains to using preference assessments to inform academic instruction. Appointment length and materials may impact student choice, and consequently, a practitioner's ability to use results for decision-making. Researchers should investigate the effects of altering these variables.

Implications for Practitioners

We encourage special educators to incorporate technology into instruction. FOTB may be an excellent choice because materials are commercially available and span 11 levels. However, teachers could also adapt their current materials. The iPad can be a useful tool because an abundance of fully developed and customizable apps are available, and the iPad can display web pages and documents (e.g., PDFs). Teachers could also use other technology with similar functions (e.g., laptops, interactive white boards). Barriers to using technology may include discomfort related to unfamiliarity or lack of time and resources for learning new technology. One way to address these barriers is through Professional Learning Communities (PLCs; Vescio et al., 2008). For example, during 30-min meetings, a peer trainer could (a) briefly describe how to implement the new skill (i.e., a tech-based intervention), (b) model implementation live or use a prerecorded video, (c) allow learners to rehearse and receive feedback until demonstrating competence, and (d) schedule brief (e.g., 5 min) post-training observations to provide feedback on implementation with students. If using videos, the first two steps could be completed during individual planning times. Finally, educators may wonder how to use assessments and whether effects of CAI will maintain. Educators may find that both MSWOs and COAs are acceptable direct measures of student preference because they are relatively brief and include typical classroom materials. Educators may be most confident that CAI will reduce challenging behavior if both assessments clearly indicate the student prefers technology. Results from Neely et al. (2013) suggest that CAI may decrease challenging behavior of students with escape-maintained behavior; thus, teachers who have functional behavior assessment (FBA) data may use behavior function in conjunction with preference data to inform the use of CAI.

Conclusion

This study extended research on using CAI to reduce challenging behavior and increase academic engagement through the inclusion of students with IDD, implementation of a comprehensive literacy intervention, analysis of pre-intervention preference assessments, and collection of social validity data. The results suggest that CAI is socially valid and can improve the behavior of some students with IDD. Despite these promising results, there remains the need for continued research focused on the use of assessment for this purpose and the identification of variables that contribute to both initial results and maintenance of effects.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This research was supported in part by Grant H325D140073 from the Office of Special Education Programs within the U.S. Department of Education, a Vanderbilt University Discovery Grant, and a Peabody College Professional Development Grant. Nothing in the article necessarily reflects the positions or policies of the funding agencies and no official endorsement by them should be inferred.

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Supplemental Material

Supplemental material for this article is available online at https://journals.sagepub.com/doi/suppl/10.1177/1098300720929680

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