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Reading comprehension intervention for students with autism spectrum disorder level 1 using the iPad graphic organizer app

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Abstract

Research has found that students with autism spectrum disorder (ASD) may face difficulties in reading comprehension. This study explored the functional relationship between the use of a graphic organizer (GO) app on the iPad and the number of correct independent responses to reading comprehension questions by one student with ASD Level 1. The study used an applied behavior analysis intervention that used an ABAB design. Aseven-question reading comprehension questionnaire was used to collect data Strong evidence was found of a functional relationship between the use of the graphic organizer (GO) on the iPad and an increase in correct independent responses by the student. Future research can develop to replicate the results and further explore how the use of a GO app on the iPad affects reading comprehension in students with ASD.

Keywords: ASD level 1, Autism spectrum disorder, Booster app for iPad, Reading comprehension.

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Contents

Contribution of this paper to the literature

This study extends the literature on digital graphic organizer (GO) interventions by examining their effect on the reading comprehension of a student with autism spectrum disorder (ASD) Level 1.

1. Introduction

According to the American Psychiatric Association (2013), the defining trait of individuals with autism spectrum disorder (ASD) is a tendency toward social and communication deficits. This includes behaviors such as responding inappropriately in conversation and misreading non-verbal interactions. The *DSM-5* further characterized ASD into three levels of severity: the first level needed the least support, the second required substantial support and the third required the greatest accommodation. Research has also found that due to these factors and other ASD-related cognitive-processing deficits, students may face challenges in reading comprehension (Engel, 2018; O'Connor & Klein, 2004; Randi, Newman, & Grigorenko, 2010). These problems may involve difficulty in understanding the narrative text, story elements (e.g., setting, characters, sequence, plot, etc.) and struggling with decoding words (Gately, 2008; McIntyre et al., 2017; Randi et al., 2010; Stringfield, Luscre, & Gast, 2011; Williamson, 2012). These issues are often attributed to a deficit in Theory of Mind (ToM) which is the ability to understand others' perspectives (Kimhi, 2014). In the context of reading comprehension challenges, the deficit in ToM means that the child with ASD may have difficulty in understanding the feelings of characters in a text and difficulty related to those feelings to their own. Understanding the ToM deficit can aid in developing strategies and interventions to help these students (Gately, 2008).

Applied Behavior Analysis (ABA) has been well-established as useful in the treatment and support of individuals with ASD as it improves a variety of skills (Centers for Disease Control and Prevention, 2022). Pivotal Response Training (PRT) which was developed by Koegel and Koegel (2019) emerged from ABA use specifically with children with autism and subsequently children with ASD to target "behaviors that will have a widespread effect on development" (Koegel, Koegel, Harrower, & Carter, 1999). Moreover, Koegel and Koegel (2019) have described how PRT is particularly useful for children with ASD.

The graphic organizer (GO) app has been identified as an effective tool for supporting students with ASD (Accardo, 2015; Bethune & Wood, 2013; Knight, Spooner, Browder, Smith, & Wood, 2013; O'Connor & Klein, 2004; Stringfield et al., 2011; Zakas, Browder, Ahlgrim-Delzell, & Heafner, 2013). GOs are maps or visual displays that can include pictures, boxes, lines and visual maps that show how information is related to a text (Gately, 2008; Hall, Kent, McCulley, Davis, & Wanzek, 2013). Such tools can help students respond to the reading process including identifying characters and other story elements, determining cause and effect and understanding main ideas (Hall et al., 2013; Stringfield et al., 2011). Similarly, research has identified the use of iPads in the educational setting as being useful to students (Alqahtani, 2020; Browder, Root, Wood, & Allison, 2017; El Zein et al., 2016; O'Malley, Lewis, Donehower, & Stone, 2014). For example, Browder et al. (2017) examined the effect of GO story maps on the iPad in interventions aimed at improving reading comprehension for students with ASD employing a multiple probe design with three students with the condition in grades 3–5. This study measured three dependent variables in each probe: (a) story element words; (b) labeling of the electronic touch-based story map and (c) the number of comprehension questions answered independently and correctly. Participants were first taught to identify story elements after which they listened to age-appropriate text passages. They were asked to complete an online story map and orally answer questions related to the story elements. During the intervention, participants received explicit instruction on how to complete story maps while reading the passage on the iPad. The study found a functional relationship between the labeling of the story elements map on an iPad and comprehension of story element questions. El Zein et al. (2016) examined the use of a GO app on reading comprehension comparing the effectiveness of an iPad-assisted intervention versus a teacher-directed one. In their study, an "alternating treatment research design" was employed with three elementary school students with ASD aged 9–12 years during a 4-week academic summer camp held at an assistive technology lab. Thirty-five sessions were lasting for 20 minutes conducted over 16 days to compare the effectiveness of a reading comprehension intervention whether instruction was teacher-directed or iPad-assisted. During the teacher-directed sessions, the participants used paper GOs to identify the main idea of a fourth- or fifth-grade text passage after reading it. The students were verbally praised by the instructor when they gave a correct answer and were provided with corrective feedback that employed prompting techniques when they gave an incorrect response. In the iPad-assisted sessions, the researchers provided the students with a picture that represented the topic of the passage using the Space Voyage app to allow participants to identify the correct main idea of a passage after reading it. In these sessions, the teachers did not assist students but the app provided them feedback based on whether they selected an incorrect or correct response. Both interventions enhance reading comprehension, the teacher-directed intervention was found to be more effective at promoting target behaviors. In a study that employed a single subject research design with ABC, Suboleski (2014) examined the effect of a GO app for the iPad to improve reading comprehension skills. This study involved five high school students, two students had conditions that now fall under the spectrum (i.e., high-functioning autism and pervasive developmental disorder). The intervention was conducted with visual organization using traditional paper GOs and an app called Reading Comprehension Booster. The study used multiple-choice reading comprehension quizzes to assess the effectiveness of the intervention. During the 2-week baseline, the students read stories and completed multiple-choice reading comprehension questions without the use of any GO app. Next, the first intervention was introduced for 3 weeks during which the students were provided traditional paper GOs. Again, the students read stories and completed multiple-choice questions related to their reading comprehension of texts. During the final 3 weeks, the second intervention was implemented during which the students used the GO app on the iPad, read stories and completed multiple-choice questions. After using the digital GO app, three participants out of the five participants performed the best on the reading comprehension quizzes while the other two students performed best after using the paper GOs.

Despite the efforts of these researchers, there is still relatively little work on the use of iPads to support academic skills in those with ASD. (El Zein et al., 2016). Moreover, studies investigating the effectiveness of GO

app for iPad to improve reading comprehension (Browder et al., 2017; Kellems, Gabrielsen, & Williams, 2016; Suboleski, 2014). Therefore, based on the established literature on the effectiveness of ABA interventions and the use of PRT in particular, this research was designed with an ABAB design to evaluate the effectiveness of an IPad with a GO app to determine whether there is a functional relationship between the use of a GO app on iPad and the number of correct independent responses to reading comprehension questions given by a child with ASD Level 1.

2. Method

2.1. Research Design

Gast and Baekey (2014) recommended the use of ABAB as an experimental design to establish a functional relationship between the introduction of an intervention and changes in student performance to determine whether the intervention has been successful. In ABAB design, the researcher focuses on the measurement of the first baseline (A1), the measurement of the first intervention (B1), the measurement of the second baseline (A2) after withdrawal of the first intervention and then the measurement of the second intervention (B2). It is considered one of the simplest designs to use in applied research in educational settings (Gast & Baekey, 2014). Therefore, this single-subject study included four phases: (a) the first baseline, (b) the GO app on the iPad intervention, (c) second baseline, again without the use of GO on the iPad and (d) returning to the intervention using GO on the iPad. Five data points were collected in each of the four phases. To determine the appropriateness of the texts for the student's ability and needs, both the materials and the research procedures of the study were validated by an expert with a master's degree in special education and over 5 years of experience teaching reading to students with ASD in Virginia elementary schools. This study also followed the single-subject design standards described by Kratochwill et al. (2013): (a) the independent variable was introduced through ABAB phases; (b) in each phase, interobserver agreement (IOA; IOA = 98.72%) was measured; (c) four attempts were made to demonstrate an effect of the intervention at five points in time and (d) in the baseline phase and GO on the iPad use phase, five data points were collected from the participant to demonstrate an effect.

2.2. Participants

The George Mason University Institutional Review Board approved the study before it began. In addition, the following inclusion criteria were established for the participants: (a) eligibility for special education services due to an ASD diagnosis, (b) no significant hearing impairment (c) ability to communicate verbally, (d) grade-level appropriate handwriting skills, (e) ability to follow conversation, (g) no challenging behaviors (self-injurious or aggressive behavior), (h) ability to understand grade 2-level texts, (i) ability to independently use an iPad and (j) not familiar with any GO app. Although the participant was chosen due to the researcher's familiarity with his family and situation (convenience sampling), elements of purposive sampling were also employed to identify an appropriate individual for the case study. According to Reybold, Lammert, and Stribling (2013), purposive sampling "is the best strategy to obtain 'information-rich' cases that can give in-depth insight into the subject of study" (p. 702). The child's mother was a classmate of the researcher and in that setting, they had discussed the fact that she had a child with high-functioning autism. Based on this, she was approached and asked if she and her husband would be willing to have their son participate. Once both parents had agreed, they were sent a consent form through email in which it was stated that participation was voluntary. All data about the child would be kept confidential and that a pseudonym ("Tony") would be used to further protect the child's identity in all written reports. After the parents' consent had been obtained, the student was also asked for his consent. The consent form for the child was written in a language appropriate to the student's reading comprehension level to promote his understanding of its content; the form was read aloud to the student.

Certain characteristics of the child made him an appropriate choice for the study. Tony was a 10-year-old American male in grade 4 receiving special education services for ASD Level 1 (referred to in this case as "high-functioning autism" by the parents) who was performing below fourth-grade equivalency levels in reading comprehension and who exhibited problems with decoding. According to his mother, Tony's Individualized Education Program (IEP) stated certain literacy goals which included learning to answer questions about a text, understand the sequence of events described in a text and make predictions about the main idea of a text. Tony often had difficulties with these different aspects of reading comprehension. In addition, he was scoring lower than his grade level and lower than his peers on standardized testing on reading comprehension. Despite Tony's willingness to spend a lot of time on his reading schoolwork, he was not showing improvement in reading comprehension. Therefore, appropriate supports that would be useful to him were being sought.

2.3. Setting

The study was conducted in the apartment where the student resided with his parents in private rooms on the second floor where Wi-Fi and other facilities are available. This natural setting was chosen because it was familiar, convenient and comfortable for the student because it was possible to conduct the research in private. I met the student in his rooms that contained a table (70 x 30 in), floor light and electrical outlets. During the sessions, the student and I sat in adjacent chairs that were placed close together so that it could be confirmed that the child was following the topic of the discussion. The observer (the mother or father) sat apart from the researcher and the child so that the progress of the intervention could be easily tracked. Sometimes noise from elsewhere in the building could be audible, the doors to the private room where the research was conducted were kept closed during each session.

2.4. Materials

The materials of the study included the texts used for the intervention and the seven-question assessment. Based on the recommendations of the expert consulted, grade 2 level books from the *Tommy Tales* series were used (Learning, 2022). These texts were considered appropriate as they are related to one another are the same length (nine pages each), contain the same characters and include a variety of engaging topics. To further ensure that the materials were suitable, six stories from the series were randomly selected and reviewed by an expert who

confirmed that they were appropriate for students with ASD Level 1. The books were downloaded, converted into PDFs and printed out prior to each session.

Then, seven questions were developed to assess reading comprehension for each story throughout the study (see Table 1). I developed these questions after which they were reviewed for appropriateness by an expert. The questions were designed to elicit answers from the participant regarding: (a) characters, (b) location, (c) time, (d) the first event, (e) the second event, (f) the third event and (g) the main idea. These questions were also printed out and kept available during each session for reference. The delivery of the assessment took 21 minutes.

Table 1. Reading comprehension questions used for assessment.

Story-grammar	Concept comprehension questions
Characters	Who are the characters?
Location	Where the story happens?
Time	When did it happen?
First event	Tell me what happened in the story first?
Second event	Tell me what happened next in the story?
Third event	Tell me what happened in the story at the end?
Main idea	What is the main idea of the story?

Additionally, answer key scripts were created for each reading comprehension question which were also validated by the expert and were available for use during each phase of each session. The answer key was constructed so that the researcher and the observer could independently rate the answers of the participant. It established how to rate answers (correct, partially correct or incorrect). As before, the expert reviewed all the answer keys created for each of the 20 books and confirmed they were appropriate and accurate. The following describes the specific materials used for each phase:

1. Baseline Materials: (a) 10 printed stories from the Tommy Tales Grade 2 stories; (b) seven comprehension questions that were printed out and placed in front of the student on the table; (c) a digital timer to ensure the student completed the tasks in the allotted time; (d) a laptop that allowed each session to be audio-recorded for reference later and (e) some blank sheets of paper and colored pencils for the use of the student.
2. Treatment Materials: (a) 10 different printed stories from the Tommy Tales Grade 2 book series; (b) a digital timer; (c) the Reading Comprehension Booster app on an iPad which includes a GO; (d) blank sheets of paper and colored pencils for the use of the student.

3. Research Procedure

3.1. Dependent and Independent Variables

For this study, the dependent variable was the student's verbal responses to reading comprehension questions related to the story elements of each book. Event recording as described by Ayres and Ledford (2014) was used to assess the responses where "1" was assigned for a correct answer, ".5" was assigned for a partially correct answer and "0" was assigned for an incorrect answer. The researcher then counted all the correct responses and all the partially correct responses during each session and summed them to determine a final score for the given session. For example, for "wh" questions, the student needed to name all the characters described in the story to obtain a correct score (1). If the student mentioned one character instead of naming all characters, this was scored as partially correct (0.5). If the student mentioned something else that was not related to the story, this was scored as 0. The same basic format was used to score answers to "where " and "when" questions as well as questions regarding the sequence of events of the story (i.e., "first," "next " and "end" questions) and questions about the story's main idea. This *method*ology was also used for the intervention phases except that the student was using the GO app on the iPad to record his answers. The student scored partially correct (0.5) if he only mentioned one thing or one word related to the story on the app. The student scored "0" if he mentioned something else that was not in the book or if he left the GO blank.

The independent variable in the study was the use of the Reading Comprehension Booster app. The purpose of the study was to determine if there was a functional relationship between GO use and the number of correct responses to reading comprehension questions. The Reading Comprehension Booster app on the iPad was used to examine how the iPad could help a fourth-grade student with level 1 ASD improve reading comprehension. This is an interactive app designed by an expert in the field of differentiated instruction and is based on the idea of paper bookmarks and a specific reading focus. Each booster in the app encourages the student to record responses while listening to a story. Opening the app, the student sees eight bookmark windows (see Figure 1).

For the purposes of the study, the student was directed to use only four of the bookmark windows: characters, setting, story sequence and "make your own idea." During the intervention phase, when the student clicked on the character bookmarks, he saw a picture of a person or an animal. Thus, during intervention, he either chose people or animals when they appeared in the story. He also had the option to record his answer in the same application. Then, the student had to go back to setting bookmarks to answer the "when and where questions." In this feature, the student saw three features where he could locate the setting: "where," "when," and "weather." The student was directed to use only the "when" and "where" features and did not use "whether" because he only needed to answer "who," "where " and "when" questions. In the "when" feature, the student saw a green plus sign beside the clock which indicated that he could see multiple options such as the time of the day, season and century. Thus, if he chose, for example, "season," then he would see spring, summer, fall or winter. If he chose "time of the day," he would see morning, afternoon, etc. The student used these options to essentially indicate when the story took place these options were used to indicate setting. The student had to click on the "where" feature to indicate where the story happened. In this feature, he saw the options "map," "nature," "urban," and "picture of places " as well as "enter your own text." Therefore, if the student was asked, "Where did the story happen?" he needed to click on the green plus sign to indicate where the story took place in detail. He also had the option to record his answer, draw or use the "make your own" feature to add text. This allowed the student to answer questions about setting in any manner that he was comfortable using.

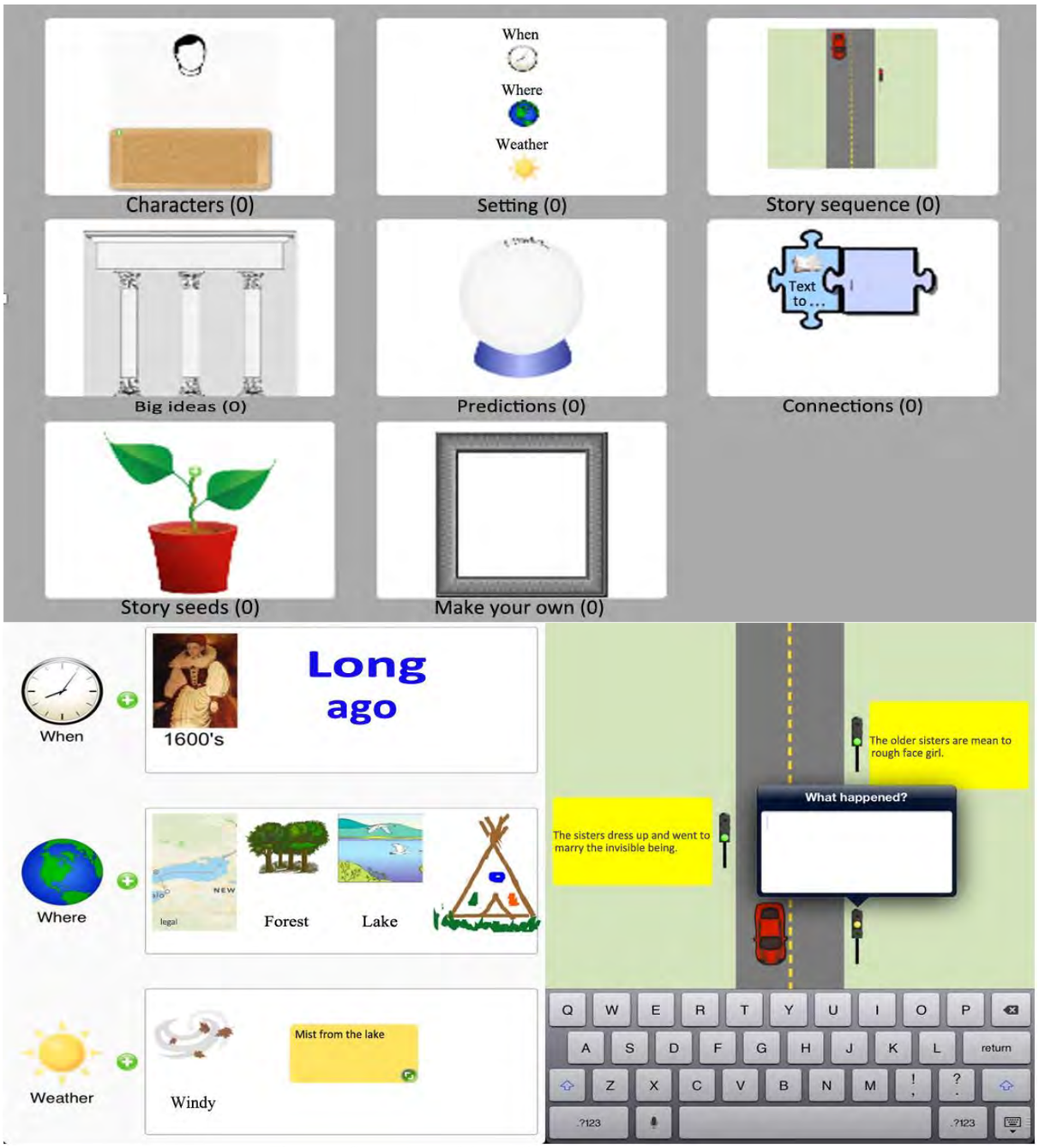

Figure 1. Screenshots of the reading comprehension booster app.

Next, the student had to use the story sequence bookmark to tell what happened in the story using a "first, then, end" format. In that bookmark, the student needed to drag a car to the first spotlight and then stop to write, draw or record the first event of the story before the light turned green to let the car move forward. Again, the student had the option to write, record or draw with his finger to answer what happened in the story and then move the car to the next stop where the process repeated until each step of the "first, then, end" format was addressed. The last bookmark that the student used was "make your own idea," so he could tell me the main idea of the story. Similarly, in this window, the student had the option to write, record or draw with his finger to answer the question "I asked about the main idea of the story. If a user needs direction at any time, there is an audio direction format in the app that allows them to press the question mark and listen to or read the directions regarding what to do next. This feature was not used until the end of the stable baseline.

4. Data Collection

All sessions were conducted in a private room in the student's apartment. The entire span of the study was 4 weeks and each session lasted approximately 30 minutes which comprised: (a) the researcher reading aloud one of the 20 texts, (b) the student answering seven questions on reading comprehension during 21-minutes. For each phase of the intervention (1 week), there were 2 days in the week when two sessions were conducted in succession. On these 2 days, the first session would occur (~30 min), then the student would be given a 7-minutes break after which the second session (~30 min) would occur and then the day's meeting would end. In this way, it was possible to conduct five sessions per week while accommodating the schedules of the researcher, the participant and their parents. No text was used more than once over the course of the study. Data were collected for each of the 21-minutes of the session during which the student answered the seven questions.

4.1. Baseline

The first baseline phase (A1) comprised five sessions that ended in one week and lasted approximately 30 minutes each. During each session, the student was provided with a new book for the study; the printed stories

were related to each other. In each session, I read the story loudly and then asked the same seven questions regarding the story elements of the text (see Table 1). The student was then given 3 minutes to respond to each question and the time was tracked using a clock timer for a total of 21 minutes. The author and the observer each independently rated the student's responses as they occurred. If the participant did not provide independent responses within this time frame or initiate an attempt to do so the independent comprehension probe was ended. All seven questions were asked one by one; the student was given the chance to answer all seven questions by recording, drawing or writing an answer to each question. The student was not prompted, meaning the student's answers were not responded to with comments regarding whether they were correct or not. Only no contingent reinforcement phrases were used such as " great job answering questions" or " almost done, keep going." If the student provided an answer (correct or incorrect) or the student did not provide an answer during the allotted time (3 minutes), I moved on to the next question. Feedback specific to participant responses (e.g., "That's correct" or "Try again") was not given. Whenever the student provided correct or incorrect answer, I went on to the next question. Once all seven questions had been answered, the session was considered complete. When two sessions were conducted on the same day, I would tell Tony that he would have a 7-minutes break and that after the break, I would read a different story and ask the same seven reading questions related to the story. Once a stable baseline was achieved, I met with Tony to explain how the GO app on the Reading Comprehension Booster app on the iPad worked. To introduce the digital GO app, one of the texts identified for the study was introduced and the elements of the app were explained in relation to this text. I instructed Tony how to use each feature and how to use each of the four bookmarks; this process included explaining that the student could draw, type or use the Dictaphone function to answer questions. The student was also shown how to access the app's help function by pressing the question mark button. For the story sequence section, I explained how Tony should drag the car on the app to a stoplight where he would be prompted to answer a question about the sequential order of the events in the story until all three stages of the story had been addressed. Finally, I explained the "make your own idea" bookmark where the student could again draw, type or record his voice to articulate the main idea of the story.

4.2. Treatment

The procedures of the treatment were similar to those of the baseline except that at the start of the B1, the student was introduced to the use of the GO app on the iPad. As with A1, five intervention sessions were conducted with Tony in the private room for one week, with two days having two sessions each. Each session again lasted approximately for 30 minutes. The observer and I followed the answer keys to review the participant's responses. After reading a story, I asked Tony seven specific questions that required him to recall facts (story elements) related to the book. The student was then given 3 minutes to respond to each question. If he did not provide independent responses within this time frame or did not initiate an attempt to do so, the independent comprehension probe was ended. All seven questions were asked one by one and Tony was given the chance to answer all seven questions. During the two intervention phases (B1 and B2), Tony was given the choice of recording, drawing or writing the answer to each reading comprehension question using the GO app on the iPad. Although I did not provide feedback on whether his answers were right or wrong, I did prompt him regarding how to use each feature on the iPad including how to access the "help" function. The sessions continued until Tony was able to respond independently to all seven questions. During this time, the observer and I independently observed and scored his responses to the seven questions. Once at least five data points had been administered in the first intervention phase, the intervention was removed from the student and the student went back to the second baseline in order to measure the effectiveness without the iPad using five data points.

4.3. Interobserver Agreement

The student's mother was recruited to act as the interobserver with the father acting in the role when the mother was unavailable as it was felt that having another stranger present in the room during the sessions would be distracting and possibly upsetting for Tony which would be disruptive to the goals of the study. During the 21-minutes testing of each session, the researcher and the observer each independently scored Tony's answers to each of the seven questions (0, .5, 1). At the end of the day's session, the researcher and the observer would independently sum up Tony's scores for each text that had been presented during the meeting. At the end of the study, all the scoring sheets were collected and tallied at which point the IOA was completed to review the accuracy with which the participant data had been scored. This reliability analysis was done on all the data collected during each session in both the baseline and intervention phases. As noted, an answer key script for each story book had been created that provided multiple examples of what was to be considered correct, partially correct and not correct. For the study, the observer for the majority of the sessions was the mother of the student who was a doctoral student. When the mother was unavailable, the student's father acted as the observer. Prior to the start of the study, both parents were trained in the process and the established scoring conventions. They were shown the data sheets and answer keys and trained on how these should be used during the sessions. I also modeled how to use the answer keys and data sheets and provided examples of what was to be considered correct, partially correct and incorrect. After the training was provided, both observers independently reviewed all the audio materials that were completed by the participant and reviewed the answer keys in order to ensure that all the data scores were done correctly in each session. All probes were scored for responses as compared to the answer keys. At the end of each session, the observer for the session and the researcher reviewed the probes and scored them together. Once the data were reviewed and returned, the total agreement formula $S \div L \times 100$ was applied which involved dividing the smaller number of correct responses by the larger number of correct responses and then multiplying by 100. Interobserver agreement of 98.72% was achieved for all phases.

4.4. Procedural Reliability

Procedural reliability involves the extent to which the established procedures of the study were implemented as planned (Ledford & Gast, 2014). Therefore, procedural reliability analysis was done on all the data collected during sessions in the baseline and intervention phases. To analyze this factor, the two observers were trained prior to the

study in how to assess and rate the researcher's fidelity to the procedures that had been previously established for the study using a researcher-devised procedural reliability (i.e., fidelity) form that provided a description of different components of the procedures (e.g., "researcher uses easy language according to the student's age and ability," "student has 3 minutes to answer each question during all phases"). For each component, there were two response options, "yes" or "no," to indicate the fidelity or lack of fidelity of the implementation. At the end of each session, the observer (the mother or the father) provided the completed procedural reliability data sheet to the researcher. Fidelity was calculated by dividing the number of steps correctly implemented by the total number of procedural steps. The procedural fidelity was 100% in both the baseline and intervention phases and did not vary.

4.5. Social Validity

To collect feedback from the participant on the social significance of the study goals, procedures and outcomes, a questionnaire was developed using language appropriate to the student's age and reading ability (see Table 2). This survey comprised six items, each of which had two response options: "yes" or "no." The participant completed the questionnaire with his parents present after the last day's session. I read each question and waited for the student's responses. This survey took 5 minutes to complete. Additionally, 5 minutes interview was conducted with the student's mother to collect feedback on the social significance of the study goals, procedures and outcomes. This comprised a single, multi-part question: "Do you see an improvement in your son? What do you think was the reason for his improvement? Was it because of the GO on the iPad?"

Table 2. Participant questionnaire.

Introduction: Please help me by answering some questions.		
Questions	**Response options**	
1. Did you like the stories?	Yes	No
2. Did you like answering the questions about the story?	Yes	No
3. Did you enjoy learning how to use GO on the iPad?	Yes	No
4. Did you learn how to find information?	Yes	No
5. Could you now understand the story better?	Yes	No
6. Are you going to be a super reader?	Yes	No

5. Data Analysis

Participant performance on the dependent variable was scored by reviewing the answer key sheets and by listening to the audio recordings again. In addition, participant performance on the independent dependent variable using the GO app on the iPad was reviewed and scored by re-listening to the audio recordings and reviewing the answer key sheets as well. Next, all the data were entered into an Excel spreadsheet and an ABAB visual graphic was created to review the data. Performance data were then reported as the number of responses on the ABAB visual graphic. Descriptive analysis was conducted using the Excel file to calculate the number of responses to reading comprehension questions answered by the participant during the baseline and intervention phases.

5.1. Visual Analysis

Gast and Spriggs (2014) stated several advantages to conduct a visual analysis of graphic data. First, it can be used to evaluate data related to the individual. Additionally, visual analysis forces the researcher to confront the data at multiple intervals which helps in the process of evaluating the results of the work as it is conducted. It also encourages a focus on the analysis of the individual data patterns while helping to make judgments about the effectiveness of the intervention (Gast and Spriggs (2014). For these reasons, visual analysis was used to evaluate the level, variability, trend, overlap, consistency and immediacy of effect in participant data within and between phases (Kratochwill et al., 2013). These findings are presented in Figure 2.

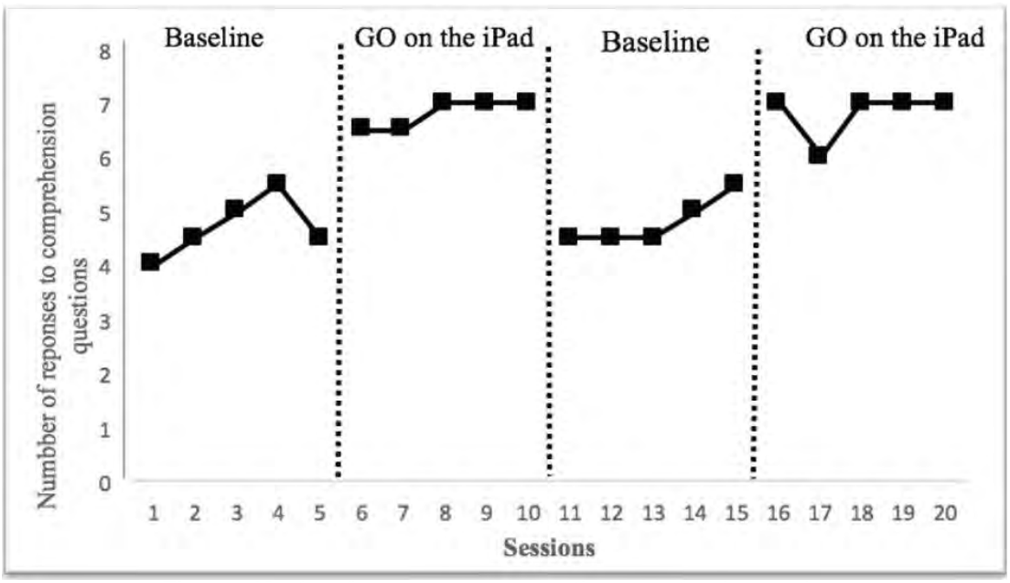

Figure 2. Number of correct responses to reading comprehension questions.

5.2. Social Validity Analyses

To review participant social validity, descriptive analyses were conducted. I calculated the frequency of statements made by the participant on each item on the participant social validity questionnaire to analyze his

responses. To prepare qualitative data for analysis, I reread the notebook that I used during the sessions. After transcribing the interview I conducted with the mother, I used her actual words.

6. Results

This research explored the functional relationship between the use of an iPad-based GO and the number of reading comprehension questions independently answered correctly by the participant. I found a mean increase in the number of correct responses between baseline and treatment phases (see Table 3 and Figure 2). In the baseline phases, the participant demonstrated a mean of 4.75 (SD = 0.49) for reading comprehension questions without the use of the GO app on the iPad. When using the GO app on the iPad during the treatment, the participant demonstrated a mean of 6.80 (SD = 0.35) and thus a mean increase of 2.0 (SD = 0.14). The overall trend was positive and demonstrated upward trends in both the baseline and treatment phases. Both treatment phases were consistently and significantly higher than the two baseline phases. In assessing consistency, the participant demonstrated an increase in the number of correct responses to reading comprehension questions in the intervention phase when using GO on the iPad. In addition, little variability and no outlier data were found to affect the functional relation between use of the GO app and correct responses to the reading comprehension questions. Therefore, based on a visual inspection of the data presented in Figure 2, there is evidence of a high level of effectiveness demonstrating a functional relationship between GO app use and the increase in the number of independent responses to reading comprehension questions.

Table 3. Baseline and treatment statistical analytics.

Phase	*M*	*SD*	*MDN*
A1: Sessions 1–5	4.7	0.57	4.5
B1: Sessions 6–10	6.8	0.27	7.0
A2: Sessions 11–15	4.8	0.45	4.5
B2: Sessions 16–20	6.9	0.22	7.0

Note: SD = Standard deviation; M = Mean; MDN = Median.

In addition, there was relatively higher variability within A1 and B1 when compared with A2 and B2 (see Figure 2). In each treatment phase, the participant demonstrated an immediacy of change upon the introduction of the intervention. This was shown by the lack of overlap between phases. In this study, the percentage of non-overlapping data (PND) was calculated at 100%. All data points in both treatment phases did not overlap with both baseline data point phases indicating that the treatment was highly effective (Ma, 2006).

Regarding the research question, in the A1 sessions the participant demonstrated a lower mean score on the reading comprehension questions (M = 4.7; SD = 0.57). Scores were consistent and trended upward with less variability (see Figure 2). Upon introduction of the first intervention, the participant demonstrated a slight immediacy of effect and the mean score was higher for the intervention phase (M = 6.8, SD = 0.27). During the B1 phase, the trend line also followed an upward pattern with a decrease in variability from the baseline; all data points fell within the 25% stability envelope. The absolute level change between A1 and B1 was +1. Data from the A1 and B1 phases did not overlap resulting in a 100% PND. In Session 6, the participant achieved mastery of responses to reading comprehension questions and he maintained that level across the remaining B1 sessions.

The participant demonstrated low scores in the A2 or second baseline phase (M = 4.8, SD =0.45) regarding independent response to the reading comprehension questions without the use of the GO app on the iPad. The data were consistent and presented an upward trend line with less variability. Using the 80%–20% criteria the data points fall on or within 25% of the median, variability was low in the second baseline phase as all data points fell within 20% of the median line and thus was stable. PND was calculated at 100% indicating no overlap in data between this condition and the intervention phases.

After returning to the intervention for B2, the participant again demonstrated an immediate increase in score and a higher mean score in the intervention phase (M = 6.9, SD = 0.22). The data trended steadily upward during the second intervention phase with a decrease in variability from A2; data points fell within the 20% stability envelope. Again, there was a +1 positive level change between A2 and B2 with 100% PND. The participant achieved mastery of the response to reading comprehension questions in session 16 and maintained it throughout the B2 phase. Participant performance was higher in the intervention phases than in the baseline phases.

6.1. Findings of the Student Survey

The participant stated that he liked reading the books and also agreed with the statement that he liked answering questions about the stories. Moreover, he agreed that he enjoyed learning how to use the GO app on the iPad that he now understood the story better and that he was now a "super reader." His comments were:

> We had an epic day and you are the best reader in the world. First, we read some Tommy books. Second, we take a break. Third, we read another Tommy book. Fourth, we talk about what happened in the story. Fifth, we're done. It made me feel happy.

6.2. Findings from the Interview

The participant's mother believed that her son could not improve in reading without the use of technology. She stated, "My son is a visual learner; I can see that. Therefore, he cannot do very well in other classes without the technology; therefore, using the embedded GO app on the iPad was a very excellent idea." She stated that her son's responses to reading comprehension questions improved after he used the Reading Comprehension Booster app and that the instructions that I had provided on how to use the GO app were appropriate and easy to follow. Moreover, in terms of future use outside of the current study, the mother stated she wanted to talk to her son's teachers about how to incorporate GOs into their instruction by using the Reading Comprehension Booster app.

7. Discussion

The current study expands the previous research by using GOs to support the comprehension of students with ASD through the use of iPads (Browder et al., 2017; El Zein et al., 2016; Suboleski, 2014). The findings of the current study are consistent with those of Suboleski (2014), although his study examined the effects of using GOs on the iPad with students of different ages and more varied disabilities (although two of the five had disabilities now termed ASD). Data from Suboleski (2014) indicated that the Reading Comprehension Booster app correlated with three out of the five students performing better on the reading comprehension quizzes while the other two students performed better after using a paper GO. The current study used the same GO on the iPad and increased the ability to respond to reading comprehension questions.

As shown by a visual inspection of the data presented in Figure 2, there was some drop in the data points during the baseline sessions. This is due to the type of story book that was read to the student. The student performed very well and was able to respond to reading comprehension questions without the use of the GO on the iPad when he liked the story topic or felt he could relate to the information described in the story. In addition, as Gast and Baekey (2014) stated that the absence of the intervention changed the condition. As shown in Figure 2, there was a consistent decreasing trend during A2 which was reversed in the intervention phase. Three data points in the second baseline were stable at 4.5 points; suddenly, the student's performance increased for the last two sessions (sessions 14 and 15). This is because the student knew that the GO on the iPad was going to be reintroduced. Thus, the student was generally enthusiastic about using the iPad and he knew that it would be returned the following day (starting with session 16), his performance increased unexpectedly.

The results of the current study suggest that ASD Level 1 students can benefit from using the GO app on the iPad to support their reading comprehension. Based on Kratochwill et al. (2013) recommendations on how to evaluate single-subject research study evidence standards, the current study found that the participant improved his ability to correctly respond to reading comprehension questions when he used the GO on the iPad from the baseline to the intervention phases. Still, these results should be interpreted with care because of the nature of the ABAB design and the withdrawal of the intervention (Gast & Baekey, 2014). However, the PND was calculated at 100% indicating there was no overlap in data between the baseline and the intervention phases. Using the evaluation criteria for interpreting PND presented in Ma (2006), the findings of this study indicated the GO on the iPad was effective with an ASD level 1 student aged 10 years. The social validity of the effects, goals and procedures was examined through the student questionnaire which found that the student enjoyed using the GO app on the iPad and showed a lot of improvement. The reading comprehension app was found to be helpful for improving comprehension for the student. The student's mother echoed her child's responses stated:

> I could really see why my son was struggling with the reading comprehension questions. I think his school has never used things such as this app even though I have told them many times that my son really does very well with technology. I will make a school visit and observe the literacy teacher. If his teacher does not use the GO app or other technology with my son during the reading lesson, I will definitely recommend that they use this app that you used with him. I am really happy with my son's improvement. I really appreciate you.

8. Recommendations and Implications for Practice

First, future research should replicate this study regarding the use of the Reading Comprehension Booster app with larger sample sizes and different ages to generalize these findings. Second, future researchers could conduct different single subject research designs such as multiple research designs across participants to establish stronger functional relationships between GO on the iPad and an increase in the number of correct responses to reading comprehension questions. Finally, it would be useful for future studies to examine the effectiveness of using the GO app on the iPad in natural school settings.

9. Limitations

There are several limitations in the current study that should be mentioned. The first is that the study only included one participant which limits the applicability of the findings to other children with ASD Level 1 even those who are also 10 years old or in grade 4 (National Research Council, 2001). In addition, all sessions were conducted in a private room rather than in a classroom setting. Moreover, the current study measured the student's responses to reading comprehension questions for story books and was designed to train the student to use the GO app on the iPad to become better organized and to be able to retell the story elements. The study did not assess to what extent the student knew the definitions of the story elements in question. Furthermore, due to the short amount of time available to conduct the study, a maintenance phase was not conducted which is key in single-subject methodology to determine whether the subject is able to maintain the behaviors acquired during the intervention after the intervention has ended. Finally, there are limitations related to the specific participant. Tony's mother provided a lot of information on Tony's achievements and challenges but I was not able to directly access his IEP to determine if any other special needs had been identified. In our sessions, Tony demonstrated a resistance to reading the texts himself which I addressed by reading each story loudly to him. Therefore, while the app is designed to boost reading comprehension, what was examined through the questions, what was measured might be better characterized as listening comprehension.

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