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Effects of an iPad-Based Augmentative and Alternative Communication Intervention on Wh-Question Answering Skills of an Adolescent with Autism Spectrum Disorders

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SUMMARY

This study examined an intervention package incorporating an iPad-based augmentative and alternative communication (AAC) application, Proloquo2Go, to improve wh-question-answering skills in a 15-year-old adolescent with autism. A single-case, multiple baseline design across three types of wh-questions ("what," "where," and "who") was employed. The intervention included a least-to-most prompting hierarchy, interval reinforcement, cue cards, and question-related visuals. Results indicated a functional relationship between the intervention package and increased unprompted correct responses for each wh-question type. Additionally, the participant maintained these gains following a two-week break, and generalization probes revealed consistent performance across novel settings, different individuals, and varied question formats. These findings suggest that iPad-based AAC interventions, particularly those that combine structured prompting and reinforcement strategies, may effectively enhance and sustain communication skills in adolescents with autism.

Keywords: Autism spectrum disorder, augmentative and alternative communication, wh-questions

INTRODUCTION

Autism Spectrum Disorder (ASD) is a complex neurodevelopmental condition characterized by persistent challenges in social communication and interaction alongside restricted, repetitive patterns of behavior, interests, or activities (American Psychiatric Association, 2013). A significant proportion of individuals with ASD experience difficulties with both receptive and expressive language, including understanding and responding to wh- questions (Tager-Flusberg, 1994). Some individuals with ASD may not develop spoken language, while others may develop extensive vocabulary (Tager-Flusberg & Kasari, 2013). However, regardless of spoken language ability, many individuals with ASD face challenges in social communication, finding it difficult to understand nuanced language, maintain back-and-forth conversations, or read subtle social signals (Volkmar et al., 2014). These difficulties can extend to nonverbal communication, such as using and interpreting body language, making eye contact, and understanding facial expressions (Lord et al., 2020). Difficulties with answering wh- questions (who, what, where, when, why) are particularly common and can create significant barriers to social participation and learning. This may be related to challenges in processing language, grasping the meaning of different question types, and/or producing a relevant response. Earlier research suggests that children with ASD frequently experience delays in both producing and understanding wh-questions (Tager-Flusberg, 1994; Goodwin, Fein, & Naigles, 2012). Some researchers claim that these difficulties arise from the intricate grammatical structures in wh-questions (Eigsti, Bennetto & Dadlani, 2007), whereas others assert that the observed challenges in wh-question production among children with ASD are more closely linked to pragmatic factors than to grammar ones (Shilpashri & Shyamala, 2020; Tager-Flusberg, 1994). Communication challenges of individuals with ASD have long gained the attention of researchers. While some researchers conducted intervention studies to improve the basic communication skills of individuals with ASD to help them meet their daily needs, such as requesting a desired item (Alzrayer et al., 2019; Genc-Tosun & Kurt, 2017), others focused on improving more advanced communication skills of verbal individuals with ASD, such as answering wh- questions (e.g., Jahr, 2001; Krantz et al., 1981; Secan et al.,1989). The majority of research on the comprehension of wh–question–answering examined exclusively individuals with ASD who were verbal. Comprehension of wh- questions should also be a priority for training non-verbal and minimally verbal children with ASD, as these skills are crucial (Shilpashri & Shyamalaand, 2020) for establishing and maintaining healthy social ties with others in their environment.

Given these varied communication challenges, Augmentative and Alternative Communication (AAC) systems can be a key resource for individuals with ASD who are nonverbal or minimally verbal. AAC includes methods and tools designed to support or replace spoken language (Beukelman & Light, 2020). AAC is typically divided into unaided and aided forms. Unaided AAC involves approaches that do not rely on external equipment, such as gestures or sign language. In contrast, aided AAC requires some kind of device and can be further categorized into low-tech options (e.g., picture exchange systems) and high-tech solutions (e.g., speech-generating devices [SGDs]). SGDs are electronic tools that provide synthesized or digitized speech output devices or communication-focused mobile apps (Beukelman & Light, 2020). SGDs can support various communication goals, including making requests, identifying items, sharing opinions, or responding to questions (Schlosser, 2003). For individuals with ASD, AAC can provide a way to convey needs and preferences, engage more fully in social interactions, and bolster language development (Ganz et al., 2014). By offering alternative communication pathways, AAC can significantly improve the quality of life for people with ASD and their families (Beukelman & Light, 2020; Ganz et al., 2014; Schlosser & Wendt, 2008).

Traditional AAC systems often involve picture symbols, communication boards, or dedicated speech-generating devices (SGDs). However, these systems can be expensive, cumbersome, and may carry social stigma (Mirenda, 2009). The advent of mobile technologies, particularly touchscreen devices like the iPad has revolutionized the field of AAC. iPad offers several advantages over traditional AAC systems, including affordability, portability, ease of use, and social acceptability (Kagohara et al., 2013; King, 2011). The availability of specialized AAC applications, such as Proloquo2Go, has further enhanced the appeal of touchscreen mobile devices as powerful communication tools for individuals with ASD. Much of the research on tablet-based AAC focused on teaching basic requesting skills to individuals with ASD. Studies have shown that individuals with ASD can successfully learn to use tablet-based AAC to request preferred items and activities (Alzrayer et al., 2017; Gevarter et al., 2014, Gevarter et al., 2021; Flores et al., 2012; Lorah et al., 2014; van der Meer et al., 2013; Sawchak et al., 2023; Waddington et al. 2014; Waddington et al., 2023). While teaching requesting is a crucial first step, researchers have begun to explore the use of mobile touch-screen device-based AAC for developing more complex communication skills, such as commenting, answering questions, and engaging in social interactions. Recent studies have specifically investigated the efficacy of iPad-based AAC interventions for improving wh-question-answering skills in individuals with ASD, e.g., Lorah et al., 2015; Strasberger & Ferreri, 2014). Building on the foundational work, recent research has continued to explore the effectiveness of iPad-based AAC interventions for teaching wh-question answering. Systematic instruction is typically part of a behavioral intervention framework, which often includes elements such as prompting, reinforcement, discrete trials, time delay, and least-to-most prompting strategies (Genç-Tosun et al., 2023; Lorah, 2022).

Strasberger & Ferreri (2014) used a multiple baseline design to examine how four children with ASD (aged 5–12) learned to respond to the questions “What do you want?” and “What is your name?” using an iPod Touch® with Proloquo2Go™ as a speech-generating device (SGD). The intervention incorporated peer-assisted training, where a trained peer and researcher guided each child through a two-step response sequence. Results showed that three of the four children successfully acquired, maintained, and generalized responses to “What do you want?”, while only two reached mastery for “What is your name?”. This shows the potential of SGDs to facilitate social question-answer exchanges for individuals with ASD.

Lorah et al. (2015) investigated the impact of iPad® and the application Proloqu2Go™, time delay, and physical prompting on teaching individuals with ASD to answer simple questions such as “How old are you,” “What is your favorite toy/food,” and “What is your name.” Participants responded by selecting the correct picture from a set of five options Their findings indicated that two out of three participants successfully acquired and retained the skill.

Genç-Tosun et al. (2023) examined the effectiveness of an iPad-based speech-generating app, “Dokun Konuş,” combined with systematic instruction in teaching complex communication skills to two 5-year-old boys with ASD. Conducted in home and classroom settings, the intervention targeted multi-step communication tasks, such as answering "What do you want?" "What is this? /What does it do?" type of questions. The intervention involved systematic instruction, including graduated guidance, discrete trial teaching, time delay, and reinforcement. Both participants achieved mastery, defined as 90% accuracy over three sessions, and demonstrated stable skill maintenance up to five weeks post-intervention. Generalization to new settings and implementers was also observed. Social validity ratings highlighted the intervention's practicality and effectiveness, with interobserver reliability at 100% and treatment fidelity averaging 99%. The study underscores the potential of iPad-based SGDs for enhancing advanced communication skills in children with ASD.

Zibin et al. (2023) examined the impact of a supportive application on understanding and responding to Arabic content questions among 25 children (20 verbal and five nonverbal) aged 6-16 from three autism centers in Amman, Jordan. The research utilized a pre-test and post-test design, providing individualized, daily one-hour training sessions in a quiet environment supported by the application over three weeks. The application was designed as a prototype incorporating visual and auditory stimuli, and the results showed statistically significant improvements. Verbal children performed better compared to nonverbal children, while questions requiring cause-and-effect reasoning were identified as the most challenging area for all participants. Feedback from teachers confirmed that the application enhanced the children's interactions with teachers and caregivers, expanded their vocabulary, and positively influenced their communication skills.

The literature on iPad-based AAC interventions for individuals with ASD is rapidly expanding. Recent research provides strong evidence that these interventions can be effective in teaching a range of communication skills. The use of evidence-based teaching strategies, such as prompting, reinforcement, and visual supports, appears to enhance the effectiveness of these interventions (Lorah et al., 2022). As technology continues to evolve, it is likely that iPad-based AAC will play an increasingly important role in supporting the communication needs of individuals with ASD, enabling them to participate more fully in social, academic, and community life. However, published research on using iPad-based AAC for teaching wh-question-answering skills, particularly in adolescents, is still limited. This study aimed to address this gap by investigating the effects of an iPad-based AAC intervention on the wh-question-answering skills of an adolescent with ASD. Specifically, the research questions were:

1. Is there a functional relationship between the ability of an adolescent with ASD to answer wh- questions and the implementation of an intervention package that includes an iPad-based Proloquo2Go application, a least-to-most prompting hierarchy, interval reinforcement, cue cards, and question-related visuals?

2. Can an adolescent with ASD maintain the learned wh-question-answering skills two weeks after the intervention is completed?

3. Can an adolescent with ASD generalize the learned wh-question-answering skills to novel conditions across different people, different settings, and different questions?

METHOD

This study examined the potential effectiveness of an intervention package incorporating an iPad-based AAC application, Proloquo2Go, in enhancing the ability of an adolescent with ASD spectrum disorder (ASD) to answer "what," "where," and "who" questions. A multiple baseline design across three types of "wh-" questions (what, where, who) was implemented to evaluate the intervention effect.

Participant

The participant, referred to as Adam (pseudonym), was a 15-year-old homeschooled adolescent diagnosed with ASD. Adam met the selection criteria for this study, which included: (1) a valid diagnosis of ASD, (2) demonstrated difficulties in answering "what," "where," and "who" questions, (3) communication challenges, (4) prior use of an iPad for entertainment but no prior experience with the Proloquo2Go application, (5) no sensory or physical impairments that could interfere with iPad use, and (6) consent from his family to participate in the study and allow data collection at home.

Before the study began, Adam was assessed using the Gilliam Autism Rating Scale-Second Edition (GARS-2), a standardized tool designed to evaluate communication and behavioral characteristics in individuals with ASD. Adam scored 85 on the communication subscale. According to his family, Adam had been assessed at 18 months due to delays in speech and play skills and was diagnosed with ASD at the age of two. Following his diagnosis, Adam began receiving occupational therapy, speech therapy, and Applied Behavior Analysis (ABA) therapy.

Regarding communication, Adam’s family reported that he primarily expressed his needs and requests using single-word or two-word phrases but had difficulty initiating or sustaining conversations. They noted that Adam frequently exhibited immediate and delayed echolalia, often repeating lines from movies or song lyrics. Additionally, Adam had difficulty understanding and responding to "what," "where," and "who" questions, frequently providing irrelevant answers such as "yes" or "no" or not responding at all.

Adam's strengths included his proficiency with technological devices, such as iPads and computers. His family mentioned that Adam enjoyed playing games and watching videos on the iPad. Furthermore, Adam demonstrated hyperlexia, a skill that allowed him to read fluently regardless of the size of his vocabulary.

Interventionist

The interventionist was a master’s student enrolled in a special education program. Serving as a teaching assistant in an AAC laboratory, the interventionist had hands-on experience supporting children with ASD in school settings.

Setting and materials

The baseline, intervention, and follow-up sessions of the study were conducted at Adam’s home, specifically at the kitchen table. During these sessions, Adam and the researcher sat across from each other, with the iPad placed on the table to allow Adam easy access. A second iPad, used to present visuals, was held by the researcher. The generalization sessions took place in three different community settings that Adam frequently visited in his daily life: a bookstore, the food court of a shopping mall, and a restaurant. These locations were selected in collaboration with Adam’s family to ensure relevance and familiarity.

The primary material used in the study was an iPad with 16 GB of memory and the Proloquo2Go (version 1.7) application, a dynamic-screen, voice-output AAC tool. This application enables users to communicate by selecting pre-recorded words and phrases, organizing symbols into categories, or constructing sentences using the virtual keyboard. For this study, the voice output was set to a female voice named "Heather." Separate folders were created in the application for each question type (“What,” “Where,” “Who”), and these folders contained buttons with possible answers. When pressed, the application read the phrase written on the button aloud.

To enhance engagement and make the questions more concrete, question-related visuals were incorporated into the intervention. These visuals were selected based on Adam’s interests, such as his favorite cartoon characters and activities, and were displayed on the second iPad. Additionally, cue cards with the words “What,” “Where,” and “Who” were used in one phase of the intervention to indicate the type of question being asked. These cards featured black text on a white background and did not include any images.

Data collection involved the use of a video camera and tripod to record the sessions. Data collection forms and procedure checklists were utilized to ensure consistency and accuracy throughout the process.

Response definition and measurement

The primary dependent measure in this study was the number of independently performed responses recorded during each session. During baseline assessment, intervention, follow-up, and generalization probes, Adam was expected to answer questions presented by the researcher using the iPad.

For the baseline probe, a data sheet was used to document Adam’s responses to each question during the session. Independently performed answers were recorded as correct and symbolized with the letter “I.” An incorrect response during the baseline probe was defined as steps that Adam did not complete independently and was symbolized with the letter “P.”

During the intervention phase, a correct answer was defined as independently performing all steps in the task analysis without assistance. Incorrect responses in the intervention phase were defined as any step that required prompting to complete, also symbolized with the letter “P.” In this study, mastery was defined as achieving a minimum of 3 independent (correct answers) out of 5 questions across three consecutive sessions.

At the end of data collection for both the baseline and intervention phases, only the independently performed steps were counted to calculate the total score for each session.

Inter-observer agreement

Reliability was assessed for the presence and absence of appropriate responses during intervention sessions. To ensure accuracy, all intervention and baseline sessions were videotaped, allowing for the reliability measurement of the recorded data. Data were initially recorded by the researcher during the baseline and intervention phases. A randomly selected 15% of baseline sessions and 15% of intervention sessions were independently coded for reliability by a trained doctoral student.

The observer was trained to differentiate between independent and prompted responses. Inter-observer agreement was calculated using the formula: the number of agreements divided by the sum of agreements and disagreements multiplied by 100. The inter-observer reliability scores were 97% for "what" questions, 90% for "where" questions, and 96% for "who" questions, indicating a high level of agreement across the measured categories.

Procedural reliability

In order to assess procedural reliability, two trained graduate students blind to the study completed the fidelity checklists after watching a total of 25% of the baseline, intervention, and follow-up sessions’ videos for each question type. For the treatment of fidelity, a checklist that included the steps that are critical to the appropriate implementation of the study phases was created by the researcher and provided to procedural-reliability raters. The results of this assessment showed that the researcher implemented the study with 97% accuracy.

Data analysis

In each session, Adam's correct and incorrect responses to the questions, the responses that occurred within the 15-second time delay, and the types of prompts used were recorded on the data collection form. Data gathered in this study were transferred to a graph. Graphed data were analyzed by using visual analysis with respect to trend, slope, level, variability, and statistical analysis techniques. Tau-U online calculator tool was used to calculate effect sizes Tarlow (2016). Tau-U is a method for computing effect sizes in single-case experimental research designs and is also described as the analysis of non-overlapping data between baseline and intervention phases (Lee & Cherney, 2018). According to Parker et al. (2011), Tau-U values below 0.5 indicate minimal or no effect, values from 0.5 to 0.69 indicate a moderate effect, and values from 0.7 to 1.0 represent a high level of effect.

Data collection and reliability

Inter-observer agreement was calculated by having an independent observer code Adam’s response by watching the video recordings and comparing these codes with the researcher's codes. Procedural fidelity was determined by having an independent observer watch the video recordings of the intervention sessions and evaluate whether the researcher correctly applied the intervention steps using a checklist.

Experimental design

In the study, a multiple baseline across behaviors design was used across three different types of "wh-" questions ("what," "where," "who"). This design allows the effect of the intervention to be demonstrated by the intervention initiated at different times for each behavior (question type). In this way, stronger evidence is obtained that the observed behavior change is due to the applied intervention rather than coincidental events. The study consists of four phases following the pre-baseline assessment: baseline, intervention, follow-up, and generalization. Each phase is explained in detail below.

Pre-Baseline

The pre-baseline assessment took a total of six sessions and was conducted in the same setting as the baseline and intervention sessions. Video recording was employed to increase the participant's familiarity with the baseline and intervention procedures. During the pre-baseline assessment, the researcher administered the Gilliam Autism Rating Scale (GARS-2nd Ed.) and shared the participant's score with his parents. Since the intervention comprised visual materials to produce the wh- questions, the researcher observed the participant's interest in age-appropriate magazines, pictures, and videos. Based on the observation and scores derived from the pre-baseline assessment, the researcher prepared the questions and accompanying visuals for each question.

Baseline

Baseline data for the three types of questions were collected during the initial wave of data collection. In this phase, Adam's ability to independently and accurately answer "wh-" questions without prompts or assistance was assessed. During each session, Adam was presented with a total of 15 questions, comprising five questions from each question type ("what," "where," and "who"). The researcher asked each question verbally, accompanied by a related visual shown to Adam prior to the question. Adam was given up to 15 seconds to respond. If no correct response was provided within the time limit, the researcher moved on to the next question. Correct answers using Proloquo2Go were marked with a "+" sign, while incorrect answers or no response were marked with a "-" sign on the data form. The intervention phase began after stable baseline data were collected for at least three consecutive sessions for "what" questions. This ensured that a clear baseline trend was established before implementing the intervention.

Intervention

The intervention phase was divided into three sub-phases: (1) Initial Intervention, (2) Intervention with Cue Cards, and (3) Intervention without Cue Cards. The intervention was implemented sequentially for each question type. Specifically, the intervention for "what" questions was completed first, followed by the intervention for "where" questions, and finally, the intervention for "who" questions.

Initial Intervention

During this phase, Adam received instructions on how to answer each type of question using the Proloquo2Go application correctly. He was required to complete each step outlined in the task analysis for responding to "what," "where," and "who" questions. Table 1 provides a detailed breakdown of the task analysis for these question types.

Table 1 Task analysis for answering to "what, where, who" questions.

Numbers	Tasks
1	Take your iPad
2	Slide arrow to unlock the iPad
3	Tap on the owl symbol to open the Proloquo2Go
4	Tap on "What /Where/Who" to see the answer options
5	Read the options and choose the answer to the question
6	Tap on the message window to speak your answer
7	Tap on the "X" to clear the message window
8	Tap on "Back" to go back to your folders

The teaching sessions were conducted using least-to-most prompting and a 15-second constant time delay. Before each question, the researcher showed Adam the question-related visual and then asked the question verbally. Adam was given 15 seconds to answer the question. If Adam responded correctly within 15 seconds (i.e., pressed the correct button on Proloquo2Go), he was verbally praised by the researcher ("Well done, you answered correctly!") and provided access to a favorite food or activity. If Adam did not respond correctly or responded incorrectly within 15 seconds, the researcher provided prompts in the order of gesture prompt, verbal prompt, modeling, and physical prompt. In the gesture prompt phase, the researcher pointed to the correct button on Proloquo2Go. In the verbal prompt phase, the researcher said what the correct answer was (e.g., "You need to say apple."). In the modeling phase, the researcher modeled for Adam by pressing the correct button on Proloquo2Go himself. In the physical prompt phase, the researcher helped Adam press the correct button by holding his hand. If Adam still did not respond correctly despite all the prompts, the next question was asked. In each session, five questions were asked for each question type.

Intervention with Cue Cards

During this phase, Adam was presented with a mix of three question types ("what," "where," and "who") with the use of cue cards to indicate the question type being asked. The cue cards, labeled with "What," "Where," or "Who," were shown to Adam before each question. The researcher randomly selected a cue card, displayed it to Adam, and then asked the corresponding question. Adam was required to identify the question type by referring to the cue card and locate the correct answer in the relevant folder on the Proloquo2Go application. The least-to-most prompting strategy and the 15-second constant time delay method from the initial intervention phase were also applied in this phase to support Adam's responses.

Intervention without Cue Cards

During this phase, Adam was presented with a mix of all three question types without the use of cue cards. He was required to identify the question type by listening carefully and navigating to the appropriate folder on the Proloquo2Go application to select the correct answer. The least-to-most prompting strategy and the 15-second constant time delay method, previously used in the initial intervention phase, were also implemented in this phase to support Adam's responses.

Follow-up

Follow-up sessions were conducted two weeks after the completion of the intervention to assess the maintenance of Adam's ability to answer "what," "where," and "who" questions. During these sessions, the same procedures used in the intervention phase were implemented, but no prompts or reinforcement were provided. In each session, a total of 15 questions were asked, consisting of five questions for each question type.

Generalization

Generalization sessions were conducted to assess whether Adam could apply the skills he had learned to different settings, people, and questions. These sessions took place after the intervention phase in three community settings that Adam frequently visited: a bookstore, the food court of a shopping mall, and a restaurant. Additionally, the sessions were facilitated by individuals Adam had not met before (the research assistants) to evaluate generalization across people.

In each setting, Adam was asked "what," "where," and "who" questions specific to the environment. For instance, in the bookstore, questions included "What is sold here?" "Where are the books?" and "Who is at the checkout?" During these sessions, no question-related visuals were provided, and Adam did not receive any prompts or reinforcement to ensure an authentic assessment of his generalized skills.

FINDINGS

The purpose of this study was to examine the effects of an iPad-based AAC intervention on the wh–question–answering skill of an adolescent with ASD. Visual analysis of graphical data used to evaluate changes in Adam's performance in answering wh- questions. Figure 1 shows the graphed data. Visual analysis of the multiple baseline data across the three types of wh-questions (“What,” “Where,” and “Who”) indicates that unprompted correct responses were low or near zero during baseline for all question types. Once the intervention was introduced, there was a marked increase in unprompted correct responses to each question type, with scores generally stabilizing between three and five correct responses per session. Performance remained at these higher levels through subsequent phases—whether cue cards were present or removed—and was sustained across breaks indicated by the dotted and dashed lines. Additionally, based on Figure 1, the participant’s unprompted correct responses remained high for all three wh-question types (“What,” “Where,” and “Who”) during the follow-up and generalization phases. In each case, the data points indicate four or five correct responses per session, with no observed declines from the levels reached during the prior intervention phases. This pattern suggests that the gains in wh-question-answering skills were maintained following the scheduled break. Also, generalization data show that elevated response levels (mostly four or five correct responses) persisted, suggesting that improvements were maintained over time and transferred to contexts beyond the primary intervention setting.

Findings related to what questions

Table 2 shows that during baseline (N = 3), the participant’s mean number of unprompted correct responses remained at 0.00 (range = 0–0). Once the initial intervention began (N = 12), performance improved notably, with a mean of 3.58 (range = 1–5). During the intervention with cue cards (N = 3), Adam achieved the highest possible mean of 5.00 (range = 5–5), and although a minor decrease was observed when cue cards were removed (N = 7, mean = 4.71, range = 4–5), performance remained high. At follow-up (N = 5, mean = 5.00) and in generalization sessions (N = 3, mean = 5.00), Adam consistently responded with full accuracy.

Table 2 Descriptive statistics for "What" questions

	N	Range	Minimum	Maximum	Sum	Mean
Baseline	3	0,00	0,00	0,00	0,00	0,00
Initial Intervention	12	4,00	1,00	5,00	43,00	3,58
Intervention W/ Cue Cards	3	0,00	5,00	5,00	15,00	5,00
Intervention W/O Cue Cards	7	1,00	4,00	5,00	33,00	4,71
Follow-Up	5	0,00	5,00	5,00	25,00	5,00
Generalization	3	0,00	5,00	5,00	15,00	5,00

Findings related to where questions

Table 3 shows that during the baseline phase (N = 9), the mean number of unprompted correct responses to "Where" questions was 1.33 (range = 0–5). Following the onset of the initial intervention (N = 6), performance improved to a mean of 3.50 (range = 3–5). With cue cards in place (N = 3), the mean further increased to 4.66 (range = 4–5), and once cue cards were removed (N = 7), performance reached the maximum mean of 5.00 (range = 5–5). During both the follow-up (N = 5) and generalization sessions (N = 3), Adam continued to respond correctly at the highest level (mean = 5.00).

Table 3 Descriptive Statistics for "Where"

	N	Range	Minimum	Maximum	Sum	Mean
Baseline	9	5,00	0,00	5,00	12,00	1,33
Initial Intervention	6	2,00	3,00	5,00	21,00	3,50
Intervention W/ Cue Cards	3	1,00	4,00	5,00	14,00	4,66
Intervention W/O Cue Cards	7	0,00	5,00	5,00	35,00	5,00
Follow-Up	5	0,00	5,00	5,00	25,00	5,00
Generalization	3	0,00	5,00	5,00	15,00	5,00

Findings related to who questions

Table 4 shows that during baseline (N = 14), the range of unprompted correct responses was 0–4, with a mean of 1.92. In the initial intervention phase (N = 1), the range was 4–4, resulting in a mean of 4.00. During the intervention with cue cards (N = 3), the range was 4–5, and the mean was 4.66. When cue cards were removed (N = 7), the range was 4–5, with a mean of 4.57. In the follow-up phase (N = 5), the range was 5–5, and the mean was 5.00. The same range (5–5) and mean (5.00) were observed during the generalization phase (N =3).

Table 4 Descriptive statistics for "Who"

	N	Range	Minimum	Maximum	Sum	Mean
Baseline	14	4,00	0,00	4,00	27,00	1,92
Initial Intervention	1	0,00	4,00	4,00	4,00	4,00
Intervention W/ Cue Cards	3	1,00	4,00	5,00	14,00	4,66
Intervention W/O Cue Cards	7	1,00	4,00	5,00	32,00	4,57
Follow-Up	5	0,00	5,00	5,00	25,00	5,00
Generalization	3	0,00	5,00	5,00	15,00	5,00

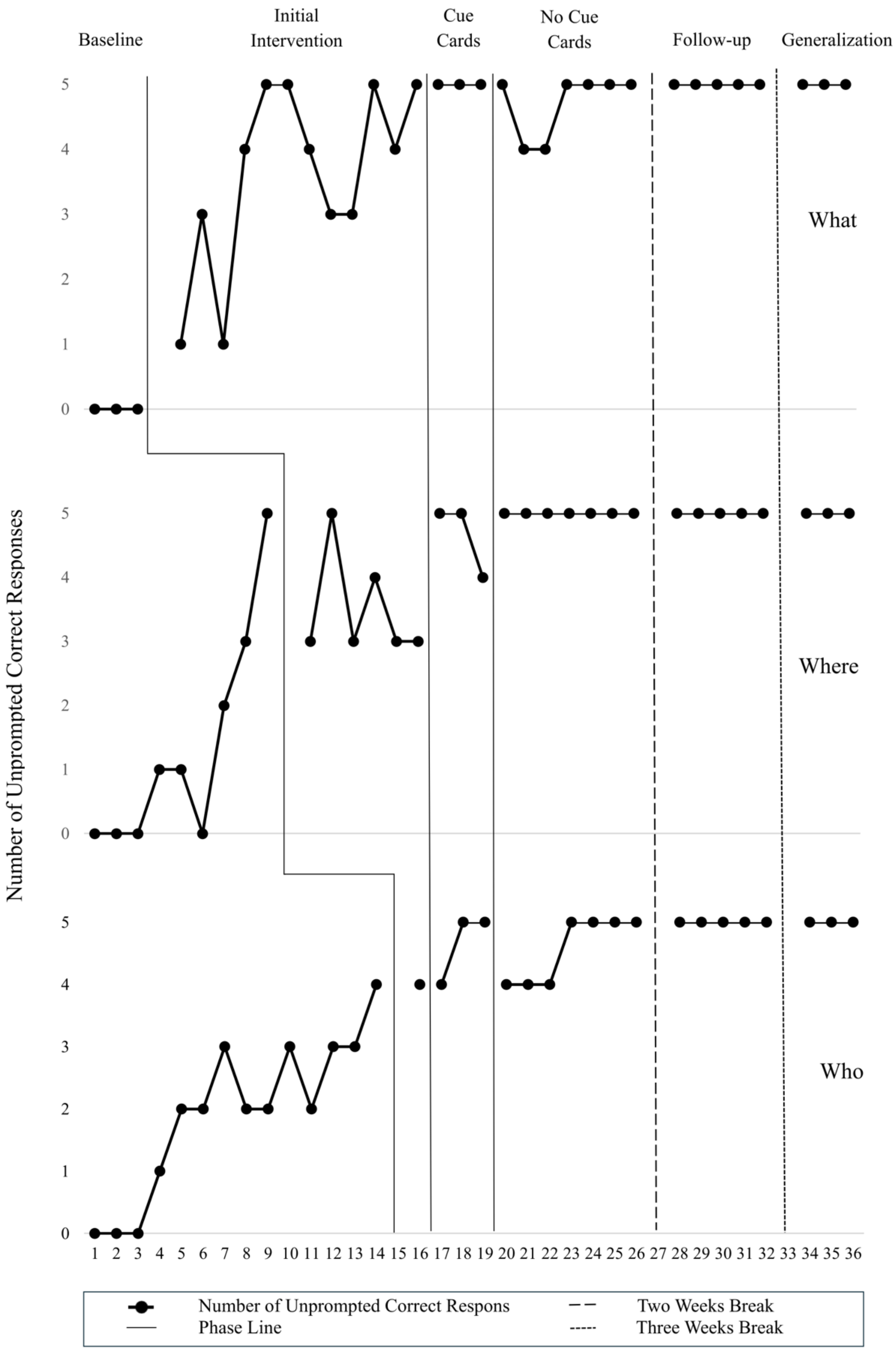

Figure 1. Number of Unprompted Responses to "What," "Where," and "Who" Questions Across the Sessions.

Adam maintained high levels of performance during follow-up (mean of 5.00 for all question types), and he generalized his skills to novel settings, people, and questions during generalization probes (mean of 5.00 for all question types).

A Tau-U analysis was conducted to assess changes in unprompted correct responses across the three wh-question types. The results indicated Tau-U values of 0.51 for “what” questions, 0.65 for “where” questions, and 0.75 for “who” questions. According to guidelines by Parker et al. (2011), values from approximately 0.20 to 0.59 are considered “moderate,” 0.60 to 0.79 are “large,” and 0.80 or higher are “very large.” Thus, the value for “what” questions (0.51) suggests a moderate effect, whereas the values for “where” (0.65) and “who” (0.75) questions indicate large effects.

CONCLUSION AND DISCUSSION

The present study investigated the effects of a multicomponent intervention package on the acquisition, maintenance, and generalization of wh-question-answering skills in an adolescent with ASD. The intervention package comprised an iPad-based Proloquo2Go application, a least-to-most prompting hierarchy, interval reinforcement, cue cards, and question-related visuals. Results indicated a functional relationship between the intervention package and Adam's ability to correctly answer "what," "where," and "who" questions. Adam demonstrated significant improvement from baseline to intervention phases, maintained the acquired skills during a two-week follow-up period, and generalized the skills to novel conditions.

Visual analysis of the slopes of the graph (Figure 1) and statistical analysis revealed that during the first three sessions of the baseline phase, Adam failed to use the iPad to answer wh- questions asked even though he had been using an iPad for a year for entertainment purposes when this study was conducted. In the first session of the baseline phase, Adam exhibited a lot of stereotypical behavior and refused to use the iPad. When the researcher showed the question-related visuals and asked the questions, Adam blurted out one- or two-word utterances related to what he saw in the pictures, used a lot of echolalia, and sang a song repeatedly. Although the baseline phase was intended to capture steady performance before the intervention, Figure 1 shows that Adam’s unprompted correct responses for “where” and “who” questions increased slightly during this period. One possible explanation is that Adam may have begun to transfer or generalize newly emerging skills from “what” questions to these other wh-question types, even before receiving direct instruction for “where” and “who.” This early gain might suggest that he can apply a similar question-response pattern across multiple contexts. However, after the formal intervention started for “where” and “who” questions, there were larger improvements beyond these initial increases, indicating that systematic instruction, prompting, and reinforcement strategies provided additional benefits beyond any unplanned skill transfer.

Even though the intervention phase with cue cards was relatively short, it is possible that this phase supported Adam’s ability to discriminate between the three types of wh-questions and to use the Proloquo2Go application on the iPad to respond to randomly ordered questions. In the first session of this phase, Adam appeared to transfer his newly acquired skill of using Proloquo2Go to answer “what” questions. For “where” and “who” questions, his performance showed slight fluctuations. By the third session of the intervention without cue cards, Adam’s performance had stabilized at 100%. This suggests that with additional practice, Adam may have refined his ability to transfer learned skills to new conditions.

During the follow-up phase, which occurred after a two-week break, Adam’s performance remained consistent, with a perfect score of 100% for each type of wh-question. It is notable that Adam did not have access to an iPad—either his own or the one used in the study—during the break. Despite this, he sustained his performance, indicating the possibility that his skills were retained. Similarly, the three-week break between the follow-up and generalization phases did not appear to impact his performance negatively. During the generalization phase, Adam achieved 100% accuracy in answering novel questions presented by three different individuals in three new public settings and at different times. Additionally, the related visuals from earlier phases were not used, and the questions were entirely different from those encountered in baseline or intervention. This outcome suggests that Adam may have generalized his skills to new contexts, enabling him to respond accurately under novel conditions.

In a post-research meeting, Adam’s mother shared a notable experience that occurred during a family gathering. While she and Adam’s aunt were discussing a restaurant they had visited, the aunt posed a question to Adam’s sister: “What was the name of the restaurant where we had a family dinner?” Adam unexpectedly answered the question by singing the restaurant’s name multiple times in a playful, rhythmic manner. His mother believed that this response was a result of the AAC intervention and the training he received during this study. She also noted improvements in Adam’s comprehension of questions and his ability to provide appropriate responses. However, further research is needed to validate similar anecdotal observations from parents of children with ASD and to establish a stronger link between AAC interventions and improvements in communication skills. Thus, these findings provide initial support that an iPad-based speech-generating app (SGD) can facilitate the acquisition of communication skills beyond basic requests, an area where the existing literature remains relatively sparse.

There are notable aspects that potentially differentiate the current study from previous research using the same AAC application, Proloquo2Go, on iPod and iPad. First, while prior studies have focused on teaching less complex skills such as basic one-step requesting (van der Meer et al., 2011), multi-step requesting (Achmadi et al., 2012), or picture-naming skills (Kagohara et al., 2012), this study appears to be one of the few research address the improvement of wh-question answering skills in an individual with ASD. Also, the findings are consistent with previous research demonstrating the effectiveness of touch screen device (e.g., iPod, iPad, tablet computers) based AAC interventions (Genç-Tosun et al., 2023; Lorah et al., 2015; Strasberger & Ferreri, 2014; Zibin et al., 2023) incorporating prompting, reinforcement, and visual supports for improving communication skills in individuals with ASD. The current study shares similarities with the work conducted by Genç-Tosun et al. (2023), particularly in that the participant had no prior experience with any AAC system. The present study builds upon Genc-Tosun et al.'s (2023) work by providing evidence of maintenance and generalization of the learned skills, suggesting that the positive effects of such interventions can be durable and extend beyond the specific training context. Additionally, this study incorporates visuals taken from the participant’s favorite cartoons as a context for asking wh-questions, which may add a unique element to its design.

In summary, the present study's results contribute to the growing body of evidence supporting the use of technology-aided, multicomponent interventions to improve the communication skills of individuals with ASD. The findings align with previous research highlighting the effectiveness of AAC devices, prompting hierarchies, reinforcement, and visual supports in promoting skill acquisition, maintenance, and generalization. These results point to the potential of iPad-based AAC applications as valuable tools for improving communication skills in individuals with ASD. However, further research is needed to validate these findings. Future studies focusing on larger and more diverse samples, varied settings, and more complex communication skills will contribute to a deeper understanding of the effectiveness of iPad-based AAC interventions.

Limitations and future research directions

This study has several limitations that should be considered. First, only one participant was included, which limits the generalizability of the findings. Future studies could benefit from including a larger number of participants with diverse characteristics, such as varying age groups and levels of communication skills, to provide a more comprehensive understanding of the intervention’s effectiveness.

Second, the iPad used in this study was restricted to the Proloquo2Go application. This limitation may have caused Adam to perceive the iPad solely as a communication tool. Future research could explore the use of iPads with access to other applications, enabling participants to utilize the device not only for communication but also for entertainment and learning. Additionally, future studies could compare the effectiveness of other AAC applications, such as TD Snap, GoTalk Now Plus, TouchChat, or LAMP Words for Life, to determine the relative benefits of different tools.

Third, the intervention was conducted in a home setting. While this environment offers the advantage of observing individuals with ASD in a natural context, conducting studies in schools or other community settings could provide valuable insights into the intervention’s effectiveness in different environments. Furthermore, involving teachers and other educational professionals in the intervention process could help support the communication development of individuals with ASD. Future research should examine the potential impact of teacher participation on intervention outcomes.

Finally, this study focused exclusively on teaching “what,” “where,” and “who” questions. Expanding the intervention to include more complex question types, such as “why,” “how,” and “when,” could offer additional benefits. Moreover, incorporating question-asking skills into the intervention framework may further support the development of reciprocal communication abilities in individuals with ASD.

Notes

The research presented in this article is based on the first author's master's thesis, titled "Effects of an iPad-Based Augmentative and Alternative Communication Intervention on Wh-Question Answering Skills of an Adolescent with Autism Spectrum Disorders," completed in the School of Teacher Education at Florida State University. This study was also presented at the American Educational Research Association's (AERA) 2016 Annual Conference.

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