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ESTABLISHING SELF-INSTRUCTION SKILLS BY TEACHING MANDS FOR INFORMATIONAL INQUIRIES WITH INTELLIGENT VOICE ASSISTANTS USING PROGRESSIVE TIME DELAY

Taylor Rae Kelley
University of Kentucky, taylor.kelley1717@gmail.com
Author ORCID Identifier:
https://orcid.org/0009-0006-4280-1502
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Taylor Rae Kelley, Student

Dr. Sally Shepley, Major Professor

Dr. Melinda Ault, Director of Graduate Studies

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THESIS

A thesis submitted in partial fulfillment of the
requirements for the degree of Master of Science in the
College of Education
at the University of Kentucky

By

Taylor Rae Kelley

Lexington, Kentucky

Director: Dr. Sally Shepley, Professor of Applied Behavior Analysis and Special Education

Lexington, Kentucky

2023

https://orcid.org/0009-0006-4280-1502

ABSTRACT OF THESIS

ESTABLISHING SELF-INSTRUCTION SKILLS BY TEACHING MANDS FOR INFORMATIONAL INQUIRIES WITH INTELLIGENT VOICE ASSISTANTS USING PROGRESSIVE TIME DELAY

In this study, unknown questions were posed to four high school students with intellectual disabilities, and they were directed to use intelligent voice assistants to mand for the answers. This self-instruction skill was taught using progressive time delay within a multiple probe across participants design with embedded generalization probes. Participants were trained to initiate Siri® or Google Assistant™ before baseline sessions were conducted. The effectiveness of progressive time delay to teach this skill was evaluated when questions were presented by research implementers and when presented by untrained communication partners. Implementers exposed participants to additional voice commands at the end of progressive time delay sessions to assess if the participants would learn nontarget commands incidentally after being taught to mand for information with the intelligent voice assistants. The results indicate that progressive time delay is an effective method for teaching adolescents with intellectual disabilities to self-instruct with intelligent voice assistants, however modifications may be needed to ensure that the skill generalizes when presented with an unknown question by an indigenous communication partner. The results suggest that learning to self-instruct and being exposed to other intelligent voice assistant skills may lead to the acquisition of additional untrained voice commands.

KEYWORDS: Intelligent Voice Assistant, mands, self-instruction, Siri®, Google Assistant™, intellectual disability, progressive time delay

Taylor Rae Kelley

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Date

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By
Taylor Rae Kelley

Sally Shepley
Director of Thesis

Melinda Ault
Director of Graduate Studies

04/17/2023
Date

DEDICATION

To my children, Robin, and Benjamin, I am incredibly proud of the unique and amazing people that you are becoming. Pursue your passions, embrace challenges, and never settle for anything less than what brings you true happiness.

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I would like to thank my fiancé, JT Miller, for his unwavering love, support, and patience throughout my graduate training. Without his encouragement, this thesis would not have been possible.

I also want to extend my heartfelt appreciation to my thesis chair, Sally Shepley, for her enthusiastic spirit, valuable guidance, and dedication to my project. Her innovative ideas, passion, and humanity in this field truly inspire me. I feel privileged to have worked alongside all the members of my thesis committee, the educators in the classroom where this study was conducted, and our outstanding research team. Their insights and other assistance were pivotal to the success of the study.

Lastly, to the clients who have had an enormous impact on my personal and professional development, I want to announce my pride and admiration for your accomplishments. They are a constant source of motivation for me. I want to remind you to always believe in yourselves. From the bottom of my heart, I thank you all for allowing me to be a part of your journey.

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INTRODUCTION

People with intellectual disability (ID) and other neurodevelopmental disorders have support needs throughout their lifespan that vary based on the strengths, challenges, and personal characteristics of the individual (AIDD, 2023; Burke et al., 2019). The diagnostic features of ID include impairments in adaptive functioning that are critical for independent daily living activities (APA, 2013). Additionally, individuals must display significant challenges in the domain of intellectual functioning to meet the Diagnostic and Statistics Manual 5 (DSM-5) criteria for ID (APA, 2013). These impairments influence the ability to use critical thinking and logic to solve problems, plan for multi-step processes, conceptualize abstract ideas, modify behavior based on personal experiences, and understand or memorize information that is presented to them as effortlessly and to the same degree that is anticipated in typical development (Saad & ElAdl, 2019).

Although supportive professional and personal relationships are instrumental to the welfare of individuals with ID in meeting a variety of critical needs, social support mechanisms also pose a challenging paradox by jeopardizing the autonomy and self-determination of people with ID. The desire to live and work independently is a common expression made by individuals with ID (Sandjojo et al., 2019). People of all abilities exhibit varying degrees of independence, as every person will sometimes encounter situations in which they need to recruit assistance (Sandjojo et al., 2019). Nonetheless, it is critical to empower people with disabilities to be self-reliant to the extent that they can be since independence is known to relate to levels of happiness and quality of life (Dollar et al., 2012; Haigh et al., 2013). Modern human service standards highlight the pivotal

role that self-direction has in enhancing the overall satisfaction reported by individuals with ID and therefore require that consumer values guide all care decisions (AIDD, 2023).

Abundant assistance also potentially serves as an abolishing operation for effortful actions, reducing self-direction that may eventually lead to significant long-term learning—a situation sometimes observed by direct support professionals in residential and day program settings (Sandjojo et al., 2019). Furthermore, when people with ID are faced with tasks, they are often non-contingently reinforced by others performing the actions for them without requiring any goal-directed behaviors from the individual to work towards the objective or overcome related challenges (Sandjojo et al., 2019). Gacek et al. (2017) posited that repeatedly exposing individuals with ID to tasks that were too difficult to complete resulted in displays of learned helplessness, a psychological phenomenon that occurs when several attempts to access a reinforcing consequence fail, and as a result, a person engages in escape or avoidance behaviors in the future when faced with similar tasks. Infrequently accessing desired outcomes with effortful behavior may be punishing for individuals with ID, therefore warranting a need for facilitating simple low-effort successes within daily endeavors.

Many of the tasks that people with disabilities look to supportive professionals or family to do for them are undertakings that they could navigate independently of another person, given the right tools and guidance on how to self-manage their behavior. Self-management enables people to reach behavioral goals, solve problems, learn skills, and manage time independent of another person (Browder & Shapiro, 1985). Identifying efficient technologies and teaching the necessary skill sets to access them is one way to

encourage people with disabilities to take an active role in managing their behavior and their environments. Mobile devices have proven to be relevant assistants for many individuals with cognitive impairments to meet individualized needs and to self-instruct. Lancioni et al. (2022) used mobile devices to teach adults with intellectual and sensory disabilities to complete multi-step tasks such as doing laundry using auditory prompts that triggered the next step in a series when a step was completed as monitored by movement sensors in the subject's environment. Shepley et al. (2019) used progressive time delay (PTD) to help elementary-aged students with ID establish self-instruction skills that allowed them to access a video activity schedule on mobile devices to guide them through the steps required to complete parts of their daily routines. Nevertheless, some people with physical limitations cannot perform the necessary motor tasks to successfully use mobile technologies for searching functions without adaptations (Baldauf et al., 2018). Others with extensive intellectual delays may not be able to access content due to associated difficulties with reading comprehension and writing (Baldauf et al., 2018).

Intelligent voice assistants (IVAs) are becoming more appealing as they grow in popularity, prices fall, and artificial intelligence developments become more robust (Baldauf et al., 2018). Up to 46% of adults surveyed by the Pew Research Center (2017) report that they use IVA either as standalone devices or built into mobile technologies. Pradhan et al.'s (2018) analysis of Amazon Alexa reviews indicate that IVAs are socially acceptable for users with various disabilities. High levels of satisfaction were reported for using Alexa to assist with the completion of daily tasks and the interface was reported to be simple and effortless enough to be used effectively. Also, some participants used

Alexa for unpredicted purposes such as supplementing speech therapy, for learning support, and to aid with recalling information.

Alexa offers accessibility features designed specifically for meeting the needs of users with disabilities, such as adaptive listening, a feature that directs the smart assistant to wait for longer periods of time to process and respond to user speech which counteracts reduced speech intelligibility or variations in a user's speed of speech production (Amazon, n.d.). Likewise, Siri® has several capabilities to offer users with disabilities; for example, users can activate Assistive Touch interfaces on mobile devices which adapts the input method so that those with limb differences can use their device in alternative ways to access content (Apple, n.d.). IVAs that are built into mobile devices are becoming ubiquitous, accompanying users everywhere, a convenience that cannot be matched with human assistance due to the competing responsibilities and personal needs that other humans have (Lancioni et al., 2022).

Lancioni et al. (2022) assert that individuals with ID commonly spend significant amounts of time unengaged and waiting for others to present them with activities if they are not taught to independently seek stimulation. Consequently, they taught 12 individuals aged 23 to 45 with intellectual plus visual and motor disabilities to squeeze a hand-pressure device to initiate a voice recording of a verbal request for preferred music, voices, noises, or non-auditory sensory stimulation to Google Assistant™ which was built-into a mobile phone. The IVA then delivered the designated response to a connected speaker or smart plugs that were configured for use with air-dryers or devices producing vibrations. All participants independently accessed the available self-regulation stimuli with the support of sensors and IVA technologies.

Generating a request for a specified response, or manding, is a prerequisite skill needed to effectively use IVAs. Once a user can effectively mand for what they are interested in, novel mands may be trained, leading to more complex verbal behavior (Winburn et al., 2002). Manding with an IVA opens limitless opportunities for the user to learn new information about their environment (e.g., weather forecast, facts about a city, operating hours for local businesses, news events; Terzopoulos & Satrazemi, 2020). Users can use IVAs as self-management tools to assist with the completion of functional daily living tasks (e.g., creating a grocery list, ordering supplies, setting a timer, announcing a reminder, sounding an alarm; Terzopoulos & Satrazemi, 2020). IVAs also promote accessibility to engage with preferred leisure stimuli (e.g., streaming songs or videos, playing interactive games, learning facts about favorite celebrities) and allow users to remotely control aspects of the physical environment (e.g., turning on lights, activating a vacuum cleaner, adjusting the thermostat, dialing a phone number, sending a message; Terzopoulos & Satrazemi, 2020).

Calzi (2020) highlighted the importance of instructing high schoolers with ID to self-instruct to learn unknown information. Calzi (2020) proposed that implementing mand training with a PTD teaching method would result in the participants producing vocal mands to Siri® that would result in learning without reliance on others. The study was unable to be completed as planned due to school closures resulting from the Covid-19 pandemic—yet the question still warrants investigation. Despite the social significance of Calzi's (2020) research question, no other studies that assess the use of systematic instruction on the acquisition of mands with IVAs were identified following a review of the special education and applied behavior analysis literature.

This study aims to evaluate if PTD is an effective intervention for teaching individuals with ID to mand for information. A secondary objective is assessing if participants will mand for untrained purposes by inquiring about preferred media or setting reminders when exposed to these skills incidentally and presented with opportunities. Finally, the study will assess if the subjects generalize this skill to self-instruct to retrieve answers when approached by an untrained communicative partner and presented with an unknown question.

The following research questions will be addressed in this study:

1. Is there a functional relation between the implementation of PTD to teach adolescents and young adults with ID to mand for answers to unknown questions using an IVA?
2. When presented with incidental learning opportunities is there an increase in the number of requests produced by the participants using the voice assistant for untrained purposes (i.e., preferred media inquiries and setting reminders)?
3. If the manding skill is acquired, will the participant generalize this behavior to access information in response to presentation of an unknown question by an untrained communicative partner?

METHOD

Participants

Students

Four adolescents were recruited from special education classrooms for high school students with moderate and severe disabilities. A group of seven potential participants were identified by their teacher and then screened by the investigator. Three of these students met the criteria and were included. A single student from another classroom was referred and included after being screened for inclusion criteria. Information about each participant's characteristics was gathered through a teacher interview, direct observation of the student, and a review of their records.

All participants demonstrated the following inclusion criteria: (a) educational eligibility of ID, (b) followed directions to complete simple 5-step chained tasks, (c) maintained attention on tasks for 5 min or longer, (d) initiated communication with others in full sentences using either vocal speech or a speech generating device (SGD), (e) vocalized or generated messages freely and independently (i.e., did not need a model to imitate vocally or a pre-programmed message on a SGD device), (f) articulated or generated speech that was intelligible and functionally understood by others, (g) had reliable access to a mobile device (e.g., cellphone, tablet), (h) demonstrated behaviors that indicate discrimination between responses for known and unknown information (e.g., answering posed known questions, shrugging or staying silent when information isn't known), (i) maintained an 80% or higher rate of school attendance for 9 weeks prior to the start of the study, (j) assented to participate in the study, and (k) were permitted to participate by a legally responsible individual who provided informed consent. Vocal

speakers who displayed significant articulation challenges (e.g., could not be reliably understood by an IVA) were excluded from the study as well as non-vocal speakers who could only output targeted communication options that were pre-programmed into their SGD. These screening criteria were assessed using the screening form in Appendix A.

Gideon was a 20-year-old bi-racial male diagnosed with autism spectrum disorder. The Childhood Autism Rating Scale Second Edition (CARS 2) was administered 9 years earlier, the score is reported in Table 1. Gideon communicated vocally in full sentences with clear and intelligible articulation. Gideon's individualized education plan (IEP) outlined that he received speech and language services as well as consultation from occupational therapy. During Gideon's most recent special education evaluation, 7 years prior to the study, the Kaufman Assessment Battery for Children Second Edition (KABC II) was administered. This score is also reported in Table 1.

The investigator noted that Gideon had challenges with expressive language and at times struggled to form messages with the correct syntax and word order to share his intended message. His teacher shared that he frequently rambled or talked in circles before being able to coherently state his point. Gideon enjoyed being around and joking with others, creating videos on his phone, listening to hip hop music, and working part time at a local hospital. At the start of the study, Gideon consistently carried a mobile phone with an Android™ operating system that had access to Google Assistant™. During screening, Gideon reported to the investigator that he was not familiar with any of the named voice assistants (i.e., Amazon Alexa, Google Assistant™, or Siri®) or any uses for them.

Aaron was a 17-year-old African male served under the eligibility of mild ID. He had not received any formal medical diagnosis. His test scores on the Universal Nonverbal Intelligence Test™ (UNIT™ 2) are reported in Table 1. He spoke in full sentences and was easily understood by others. Aaron received speech therapy as a related service in his IEP. His teacher relayed that Aaron needed additional time to process information and the investigator noted that it was often difficult for him to recall information from memory. Discerning appropriate social behavior was reported to occasionally be challenging for Aaron. He liked to listen to rap music, watch religious inspirational videos, and fist bump teachers and peers. Aaron did not bring a mobile phone to school, but self-reported that he used a Samsung phone at home to browse videos during free time. Aaron stated that he was not familiar with any IVAs or the tasks that they are able to do.

Penelope was a 17-year-old Caucasian female who received a diagnosis of Rubinstein-Taybi Syndrome at birth. Her IEP services included speech and consultation from occupational therapy and physical therapy. Penelope spoke in full sentences and in a clear, intelligible manner. She was evaluated six years prior to participating in the study, the results of the KABC and other assessments is included in Table 1. Penelope enjoyed watching inspirational videos, listening to music, and socializing. She reliably brought her personal Apple iPhone to school. When asked about voice assistants by the investigator, Penelope reported she was somewhat familiar with Siri®. The investigator proceeded to list common functions that Siri® is used for. Penelope relayed that she only initiated Siri to play favorite music, ask to hear a joke, or to ask for a story and told the investigator that she never asked Siri® unknown questions.

Spencer was a 19-year-old Caucasian male with autism spectrum disorder. Spencer was evaluated and diagnosed at age 1. He was assessed with the Gilliam Autism Rating Scale 2 (GARS 2) and CARS 2 however the scores were not reported in his IEP. Spencer received speech, music therapy, and consultation from occupational therapy as related services in his IEP. Outside of school, Spencer was reported to receive applied behavior analysis services. Spencer rarely initiated any conversation with others and his teacher indicated that social interactions were unpreferred. When others engaged with him first, Spencer would respond with a message that was contextually appropriate. His length of utterance varied depending on the prompt given but were complete sentences. Spencer's speech was frequently too loud or too soft and oftentimes he needed a reminder from teachers to adjust his volume. Sometimes Spencer spoke with a rapid pace that required communication partners to listen intently, but overall, he articulated messages clearly enough that others could reliably comprehend what he was saying.

Spencer liked relaxing on a beanbag, taking walks, playing guitar, and interacting with preferred plush items. Spencer had an Apple iPad® that he used at school and was always accessible to him. When asked if he was familiar with voice assistants, Spencer reported that he did not use Siri® or any other IVAs.

Table 1 *Participant Education Evaluation Scores*

Participant	*IQ Score*	*Adaptive Behavior Score*	*Autism Rating*
Gideon	58[a]	72[e]	49[g]
Aaron	68[b]	53[e]	---
Penelope	59[c]	54[f]	---
Spencer	52[d]	60[e]	NR

Key: NR- evaluation indicated, but results not reported

Note. [a]KABC II Crystallized Fluid Intelligence, [b]Unit 2, [c]KABC Nonverbal Index, [d]SB-5 Full Scale, [e]Vineland II, [f]Vineland III, [g]CARS 2

Others

The investigator was a graduate student pursuing a master's degree in applied behavior analysis. She had over 10 years of experience working with individuals with ID in residential placements, day programs, and community settings as a former direct support professional. She held bachelor's degrees in Disability Studies and Psychology. To minimize adaptation threats to the study's internal validity, the investigator was present in the classroom for more than 5 hr prior to beginning the research (Gast & Ledford, 2018). During this time, the investigator provided positive attention to the participants while learning about their interests and conducting preference assessments to determine a hierarchy of the most preferred media for each participant. This also allowed the investigator to pair their presence with the participants' favorite music, games, and trivia. The investigator was responsible for conducting some intervention sessions and collecting procedural fidelity during generalization sessions.

Other graduate students in an Applied Behavior Analysis degree program were trained by the investigator to implement sessions, collect primary data, collect secondary data for interobserver agreement (IOA), and score procedural fidelity. The graduate students were familiar to the participants, having spent several hours in the classroom prior to the start of this study. The investigator taught the other graduate students the study procedures using model-lead-test until each student performed all steps twice with 100% fidelity. Data collection training also was conducted using model-lead-test. Teachers and paraeducators who worked with the participants in the classroom each day

conducted generalization sessions but did not provide any study-related training or intervention sessions. Peer tutors who had interacted with the classroom participants conducted generalization sessions, too. Instructions for generalization sessions were explained by the investigator immediately before they were implemented, and communication partners had the opportunity to ask questions.

Instructional Setting and Arrangement

A high school special education classroom was the setting for all sessions. The ongoing activities happening in the environment at the time of each session varied (e.g., group instruction, transitioning to specials, planned breaks). The investigator conducted technology training with each participant in a 1:1 instructional arrangement. This instruction was provided at a table in an adjoining room that connected to the main classroom. The investigator conducted probe and PTD sessions during naturally occurring opportunities such as transitions to activities in other areas of the school, or during post-instruction breaks. Participants who were not the direct recipient of the session were out of range to hear or see any of the procedures to ensure they did not have any exposure to the target skill outside of their own sessions.

Materials and Equipment

The participants used a mobile device to access one of two IVAs (i.e., Apple Siri® or Google Assistant™). Students were taught to use the IVA on a mobile phone or iPod touch® provided by the researcher that matched with the IVA embedded on their personal devices so that the intervention had greater social significance and validity. Participants are more likely to maintain a skill that they can practically use every day (in comparison with learning to use an IVA they do not own or use outside of the study).

Gideon and Aaron used Google Assistant™ on an LG Stylo™ 2. Penelope and Spencer used Siri® on an Apple iPod touch- 7th Generation.

The investigator confirmed that the designated device was in the participants' possession or view (e.g., in their pocket or on a nearby table surface) before beginning sessions. A list of presumed unknown questions organized by category (i.e., academics, functional life/career skills, popular culture/recreation/leisure) was generated for the study. Additionally, a list of known questions was generated for each participant in the study, containing predetermined questions that they had demonstrated they could answer. Various data sheets were used (i.e., baseline, intervention, generalization, reliability, social validity) as well as a list of the participant's music preferences. The investigator used an iPhone® 11 with the music app, Spotify, to conduct preference assessments with each participant. A stopwatch was used by the implementer to record the student's duration of engagement with each song.

Preference Assessment

The investigator conducted a free operant preference assessment of music with participants to determine genres, artists, and songs that they each preferred. The results of the free operant preference assessment were applied within incidental learning opportunities where the implementer requested music that was preferred by the participant. During the investigator's assessment, the participant was directed to freely select whatever music they wanted to listen to on an iPad using Spotify. The participant was taking a scheduled break during the assessment and was able to engage in other activities while simultaneously listening to music. Other activities on the iPad were limited using the guided access feature to ensure that the participant could not access

other content that would be incompatible with Spotify. The participants could independently make selections with touch or ask for assistance searching for desired content. The investigator helped locate music when it was requested but did not make any suggestions to persuade the participant's choices. The artist and song choices made by the participant were recorded on the free operant preferences data sheet each time that a song was played for 10 s or longer. A stopwatch was used by the investigator to record and report the duration of engagement with the song on the datasheet (see Appendix C). Additional free-operant music choices were recorded by the teacher when she observed any of the participants in the study freely selecting songs to play during the school day.

Known and Unknown Questions

During each session, two known questions and five to seven unknown questions were randomly selected and asked. Known questions were determined prior to beginning the study during one-on-one trivia activities led by the investigator. Due to challenges with the feasibility of formally assessing all unknown questions, the investigator assumed unknown questions were in fact unknown but planned for the possibility that participants may state the answer to the intended unknown question. At least one alternative unknown question was prepared for each session. If the participant stated the answer, and therefore, did not need to use the voice assistant to respond to one of the questions that the investigator had mistakenly anticipated would be unknown then an alternative question was asked. All unknown questions that were selected consisted of no more than nine total words and had factual answers that would not vary based on individual opinions or other subjective analyses (e.g., How many stars are in the constellation Sirius?). The inquiries

were also concisely and coherently stated to ensure the questions could be easily imitated in their existing forms by the participants and would function as mands to the IVA.

The researcher generated questions related to each participant's interests or content they were exposed to in school and posed them to the participant as a trivia game. The questions that participants answered correctly were consolidated into the list of known questions. A teacher interview was conducted to aggregate a list of unknown questions for all participants. Selection of questions was also based on relevant student interests that were either assessed by the investigator within the preference assessments or learned through direct observations of the student prior to beginning the study (e.g., sports teams, hobbies, career goals), searching topics of current news publications, and through examination of grade-level content. Questions the participant was observed answering were the only ones assumed as known questions within the study, see Appendix C for each participant's known questions.

The questions were divided categorically into (a) academic; (b) functional life and career skills; and (c) pop culture, recreation, and leisure. Each category consisted of 10 known questions and 50 unknown questions. Questions in the academic category included math calculations, geometry equations, definitions, synonyms, and other grade-level content. Functional life and career skills consisted of measurement conversions, retail store hours, prices of services or goods, weather forecasts, recipes, directions to community locations, and other practical inquiries to support self-sustainability or job tasks. Within the popular culture, recreation, and leisure category, questions pertained to current events, celebrities, sports teams, or the participants' other hobbies and interests

(e.g., car specs). See Appendix D for a sample of known questions that are organized categorically.

Questions were defined as unknown when the student verbalized anything other than the correct answer or if they did not provide a verbal response to the question within 5 s of being asked. For a detailed description of data collection on unknown questions see the section outlining the primary dependent variable. Known questions are defined as any question that the participant provided a correct verbal response to within 5 s of the question being asked by the communication partner. The participants' responses to known questions were collected and included providing a verbal answer, manding the IVA, not responding, or answering incorrectly. The implementer corrected participant errors anytime that they answered incorrectly or manded the IVA (e.g., "You can tell me this without Alexa, you know the answer!" "You know the answer, it's _____").

Dependent Variables

Primary Dependent Variable

The participants' frequency of independent mands for unknown information using the IVA on their device was the primary dependent variable. The behavior was defined as any instance of the student inquiring using the IVA within 5 s of being asked an unknown question with a message that included the needed semantics to portray the intended message. The word order did not need to be imitated or correspond exactly to how the question was phrased to the participant, but the way it was restated could not change the meaning of the question. For example, if the implementer asked, "What ingredient can be substituted for buttermilk?" the participant could state, "What can you use to cook with if you don't have buttermilk?" but not "What can buttermilk be used for?"

Manding correctly within 5 s of the communication partner asking the question was scored as an unprompted correct response. An unprompted incorrect response consisted of the participant stating anything other than the question or a variation of the question presented by the communication partner before a prompt was delivered. The participant correctly manding within 5 s of the prompt was a prompted correct response, whereas saying anything else after delivery of the prompt was an incorrect prompted response. If the participant did not communicatively respond within 5 s of the prompt being delivered it was scored as a prompted no response. The participant's unprompted and prompted correct mands were the only responses graphed.

The implementer asked five to seven unknown questions to create opportunities for the participant to mand for unknown information during each session. Questions presented by the implementer to the participant were selected based on the ongoing classroom activities (e.g., leisure questions during free time and academics during instruction time). The percentage of correct independent mands produced was calculated by dividing the number of correct mands by the total opportunities presented and then multiplying this quotient by 100.

Secondary Dependent Variables

The response of the IVA and the participant's interaction with the technology were recorded as secondary dependent variables following every instance of target behavior (i.e., manding for unknown information). These variables were measured to determine if IVAs offer a socially significant and valid solution to answering authentic questions that arise within the daily lives of the participants. The implementer reported if the IVA dictated a correct or incorrect answer, generated a link to a correct or incorrect

answer, responded with a statement that the question was not understood, or reported that the answer was unknown. Based on the generated IVA response to the question, the implementer documented the participant's engagement with the IVA's response, such as scanning any provided information (i.e., clicking link, watching video, scrolling responses), restating the answer that was provided, indicating that the IVA provided an incorrect answer, or no engagement. The percentage of correct answers dictated by each IVA was calculated and reported in addition to the percentage of correct answers which each participant engaged with.

Nontarget Voice Commands

Data were collected to ascertain if nontarget skills were acquired through incidental learning opportunities embedded at the end of every time delay session. Following the last question in the session, the investigator suggested accessing an environmental change (e.g., "It's been a long day, I would love to hear a joke right now!") that could be produced by a vocal command to the voice assistant to set a reminder, alarm, or access media (e.g., song, joke, story, or other voice assistant skill). Only skills that Penelope reported she had not used with Siri® were suggested to her given that she did have reported experience with some voice commands. No direct training or prompting for any nontarget skill was provided to participants. The total number of independent nontarget inquiries using the voice assistant were measured as either an occurrence on nonoccurence across non-target probe sessions for each participant. The number of sessions before the participant produced an independent inquiry were reported for nontarget commands for each participant as a measure of the efficiency of incidental learning opportunities on the acquisition of novel commands.

Experimental Design

The design of the study was a single case multiple probe across participants design to measure the effectiveness of PTD to teach self-instruction by manding for unknown information using an IVA (Gast et al., 2018). Intermittent generalization probes assessed whether participants would generalize the use of IVA to self-instruct when untrained communication partners asked them unknown questions. In this design, participants with similar characteristics or behaviors were introduced to the intervention sequentially at separate points in time (Gast et al., 2018). Stable data are needed within each tier and the change in target behavior (i.e., manding for unknown information) must change for each participant when the intervention is started with them, and not at any other time, so that the change in target behavior is not likely to be attributed to any other variables in the environment (Gast & Ledford, 2018).

Multiple probe across participants is a suitable design for the research questions in this study because the primary dependent variable is a non-reversible behavior (Ledford et al., 2019). The chosen design is more appropriate than a multiple baseline across participants design because the testing threats are reduced with less pre-intervention exposure to the task being instructed (Gast et al., 2018). Multiple probe across participants designs also do not require consecutive probe sessions which increases the likelihood that implementers performed procedural tasks with high fidelity, limiting the procedural drift and measurement bias throughout the baseline conditions.

An implementer conducted at least three probe sessions before the intervention was introduced to each participant. Each untrained communication partner conducted at least one baseline generalization probe. Gideon was intentionally selected as the first

participant to receive the PTD intervention due to the limited time that he was available to participate in the study because of his upcoming graduation. Spencer was designated by the investigator as the last participant to receive the intervention due to his loud volume to prevent others in the study from hearing him initiate Siri®. The order in which the remaining two participants began the intervention condition was randomized using an online list randomizer (i.e., https://wheelofnames.com/). Intervention sessions were conducted by the investigator and graduate students asking the participants questions to occasion mands to acquire unknown information. The participant reached mastery once they independently manded for 80% or more of trials for three sessions conducted across at least 2 days.

The next participant was introduced to the intervention when the former participant demonstrated one intervention session at 80% or greater unprompted correct responses. Prior to beginning the intervention with the subsequent participant, all remaining participants completed a probe session with the implementer. Participants in previous tiers were evaluated for maintenance of the target skill (e.g., manding for unknown information). While participants were waiting to move into the intervention condition, they received intermittent probes at least once a week to monitor the stability of their data. The procedures were implemented until all participants across all tiers met the mastery criterion.

Technology Screening and Training

The investigator conducted training with each participant to ensure that participants were able to use their device's IVA to produce mands to open the camera, open the calendar, and look at photos. If the participant could not complete the task

independently, models and prompts were delivered by the investigator to teach the skill to completion using the task analyses below (i.e., Table 2 and Table 3). The technology training was mastered when the participant demonstrated all three skills independently during a probe conducted on a separate day (See Appendix E for technology training datasheet).

Table 2 *Accessing Siri® Task Analysis*

Task Analysis for Activating Siri®
1. Pick up device and enter passcode (i.e., 1-2-3-4) to unlock it
2. Press and hold down home button (center) or say "Hey Siri®"
3. Wait for the blue orb at bottom of the screen to appear
4. Ask the question

Table 3 *Accessing Google Assistant™ Task Analysis*

Task Analysis for Activating Google Assistant™
1. Pick up device and enter passcode (i.e., 1-2-3-4) to unlock it
2. Press and hold down the home icon (bottom middle of device touchscreen), tap microphone icon on the search ba**r** widget, or say "Ok Google"
3. Wait for chime to sound and assistant logo to appear
4. Ask the question

General Procedures

Sessions occurred in a one-to-one conversational arrangement across different blocks of time in the classroom during scheduled leisure breaks. Two known questions and five to seven unknown questions were chosen at random. If questions were closely

related, they were asked in a series without any time between. If the questions did not share any similarity, then the implementer paused before posing the unrelated question so that it was more natural. Unknown questions were not used again once they had been asked unless the answer to the question changed daily (e.g., “What is the weather like in Boston today?”). To prevent unintentional observational learning from occurring, all other participants were out of hearing range while sessions were conducted. See Appendix F for a sample script demonstrating the conversational flow during a typical session. After completion of all PTD sessions, the implementer suggested playing preferred media or performing another nontarget skill that the IVA could be used for. The implementer provided a 3 s pause to occasion an opportunity for the participant to initiate a vocal command, before demonstrating the skill if it was not performed by the participant.

Baseline Probes

The implementer prepared for each baseline probe by ensuring that the participants had their IVA device in their immediate proximity (e.g., on a desk, in their pocket, in their hand) during the minute leading up to the session. When an unknown question was presented, the implementer waited 5 s for the student to produce a mand to the IVA inquiring about the unknown information. If the participant manded correctly, the implementer delivered behavior-specific praise (e.g., “Oh, good idea asking Siri®!”), then recorded data on the IVA’s response as well as the participant’s interaction with the answer. When participants stated an incorrect answer, said that they did not know the answer, or vocalized anything other than a correct mand the trial concluded with a neutral response from the implementer (e.g., “Huh, I don’t know the answer to that either”). If

the participant did not respond to the question presented, then the implementer recorded no response and then presented the next question or ended the session if no more questions remained. The planned implementer responses for baseline sessions are depicted in Figure 1. See Appendix F for baseline and maintenance datasheets.

Figure 1 Baseline and Maintenance Session Implementer Responses

Responses to Unknown Questions			
Learner Response	**Unprompted Correct**	**Unprompted Incorrect / States I Don't Know**	**No Response**
Implementer Response	Behavior-specific praise once voice assistant finishes : "Good job asking <voice assistant>"	"Hm, I don't think that's right" Or "I don't know either"	Proceed to next question or end session if it is final question
Responses to Known Questions			
Learner Response	**Vocalizes Answer**	**Initiates Assistant**	**No Response**
Implementer Response	"Thanks for answering my question"	"You don't need <voice assistant>, you know this."	Proceed to next question or end session if it is the final question

Progressive Time Delay

At the beginning of instructional sessions, the implementer ensured that the participant had their IVA device within a 2 ft proximity. For participants with an SGD, the implementer ensured the device was within their immediate reach. The implementer then ensured the participant's attention by saying their name and waiting for eye contact before asking a question. When an unknown question was presented, the implementer started implementing the PTD procedures with a 0 s delay interval between asking the question and delivery of the controlling prompt. For all participants, the controlling prompt was a verbal directive to ask the question using the IVA followed by restating the unknown question immediately (e.g., "Ask Siri®. What time does Kroger open on Sundays?"). This delay interval increased by 1s following any session where the participant responded with 80% or higher correct responses until reaching a terminal 5 s

delay. To promote generalization the prompt varied between six options (i.e., “Ask <IVA name>.,” “I’m not sure. Find out by asking <IVA name>.,” “I don’t know that answer, ask <IVA name>.,” I don’t know, ask <IVA name> for help.,” “Hmm…when I don’t know something I ask <IVA name>,” “Try asking <IVA name>,” and “Hm, let’s ask <IVA name> for the answer”). See Appendix G for the progressive time delay datasheet.

0 s Delay Sessions. The implementer began 0 s delay trials by ensuring the participant’s attention and asking the question. The implementer provided the controlling prompt immediately after asking unknown questions. If the participant produced a mand within 5 s after the controlling prompt was recorded as a prompted correct. Secondary data were collected to note how the IVA responded and if the participant engaged with the answer. The implementer repeated the controlling prompt and recorded a prompted incorrect if the participant began initiating an incorrect response within 5 s of the first controlling prompt being stated. If the student did not initiate a mand, no response was marked, and they proceeded to the next trial. If the participant produced a correct mand within 5 s of the controlling prompt for 80% of trials during a single session, then the delay interval was increased by 1 s in the following session. See Figure 2 for planned implementer responses during PTD sessions.

Figure 2 Progressive Time Delay Session Implementer Responses

Responses to Unknown Questions					
Learner Response	**Unprompted Correct**	**Unprompted Incorrect**	**Prompted Correct**	**Prompted Incorrect**	**No Response**
Implementer Response	Behavior-specific praise once voice assistant finishes “Good job asking <voice assistant>”	Directive “wait if you don’t know” followed by delivery of the controlling prompt	Behavior-specific praise once voice assistant finishes	Mark incorrect and restate controlling prompt	Proceed to next question if applicable
Responses to Known Questions					
Learner Response	**Vocalizes Answer**		**Initiates Assistant**		**No Response**

Implementer Response	"Thanks for answering my question." ---It doesn't matter if uncertain about accuracy of answer----	Correction "you don't need <voice assistant>, you know this."	Proceed to next question or end session if it is the final question

Delay trials. The implementer ensured the student's attention before asking questions during delay trials. When unknown questions were asked the learner was provided with a specified delay time, ranging from 1 to 5 s, to produce a mand before the implementer responded. The delay interval increased by 1 s when 80% of trials within a session resulted in unprompted correct or prompted correct responses. The terminal delay interval used was 5 s. The implementer's consequences for prompted correct, prompted incorrect, and no response were the same as those used for 0 s delay trials. If the participant produced the mand unprompted, the implementer gave the student behavior-specific praise (e.g., "I like how you asked Siri® when you didn't know the answer!") after the IVA and participant both disengaged from the inquiry and response. The mastery criterion for each participant was three sessions with 80% or more unprompted correct manding using the IVA across two or more days.

Maintenance and Generalization

Maintenance probes were conducted with each participant weekly once participants met the mastery criterion across all tiers. Probe sessions paralleled baseline probes, using the same procedures and implementer responses. Generalization probes adhered to these same procedures but were shortened to three to four unknown questions and no known questions so that they required less time from communication partners. Generalization partners were instructed to respond to the students' answers to questions in the way that they normally would. Generalization probes were conducted intermittently throughout baseline and intervention conditions. They occurred every eight

to ten sessions and were conducted by either a teacher or a peer mentor. The implementer reviewed probe procedures with generalization partners directly before they conducted each probe session. The communication partners were invited to ask questions and offered a chance to practice the procedures with the implementer before implementation. See Appendix H for the datasheets used during generalization sessions.

Incidental Learning Opportunities

After each time delay or maintenance session was conducted, participants were exposed to the implementer occasioning other types of inquiries with their IVA to encourage incidental learning. These inquiries began with the investigator cueing opportunities to perform skills or access media on the IVA (e.g., "Since you have some free time we could listen to Taylor Swift!," "It might be helpful to have a reminder that spring break starts this Friday!"). The investigator did not imply or state that there was an expectation for the participant to do anything but paused for a 5 s to occasion an opportunity for the participant to produce a mand. The instructor did not provide any instructions or prompts during the incidental learning portion of the session. If the participant did not spontaneously mand during the delay, the investigator modeled the mand (e.g., "Okay Google, play Anti-Hero by Taylor Swift," "Siri®, remind me that spring break starts on Friday") and the incidental learning opportunity ended. If the participant produced the mand, the investigator commented on the IVA's action (e.g., "Oh, I love that song!" or "It's so helpful to have a reminder!"). If the participant produced the mand but made an error, the instructor waited for the IVA to disengage and then manded for the IVA to perform the desired task without directing the participant to try again or make any corrections.

Social Validity

A brief teacher interview was conducted at the study's end to assess the intervention's social validity. The investigator posed the following questions: (a) Have you observed the participants using the IVA outside of the study sessions? (b) What purposes have you observed these students using the IVA for? (c) Do you perceive the IVAs to be helpful for any of the participants in school? (d) Do you think the IVAs will help your students be successful in any other environments? (e) Do you perceive the IVAs to be disruptive or used excessively by any of the participants? (f) Overall, do you feel that self-instructing with IVAs in the classroom is an acceptable intervention for students? The written survey is included in Appendix I.

Reliability and Fidelity

A primary and secondary data collector gathered data on the target behavior (i.e., manding for information), the IVA's response, and the participants' interactions with the response for 20% of sessions across all participants and conditions. IOA was calculated using the point-by-point agreement (i.e., the number of agreements was divided by the total number of agreements and disagreements and then multiplied by 100; Ledford et al., 2018). See Appendices D, E, and F for the PF steps and IOA responses collected on session data sheets.

During at least 20% of sessions across all participants and conditions PF data on planned implementer behaviors were recorded by a primary and secondary data collector. This was calculated by dividing the number of correctly implemented steps by the total number of planned steps (Ledford et al., 2018). All PF sessions were assessed for the following steps: (a) IVA device and SGD if applicable are in 1 m proximity of student

before session is started, (b) the volume is at an audible level, (c) no other participants are within hearing range (d) the environment is free of excessive background noises (e) the attention of the student is on the implementer before the session begins (f) an unknown/known question is asked, (g) the specified time delay is provided and prompt is delivered if needed, and (h) the appropriate response is provided by the implementer. The final four steps were assessed for completion during each trial within the session (i.e., at least seven times based on the number of questions asked).

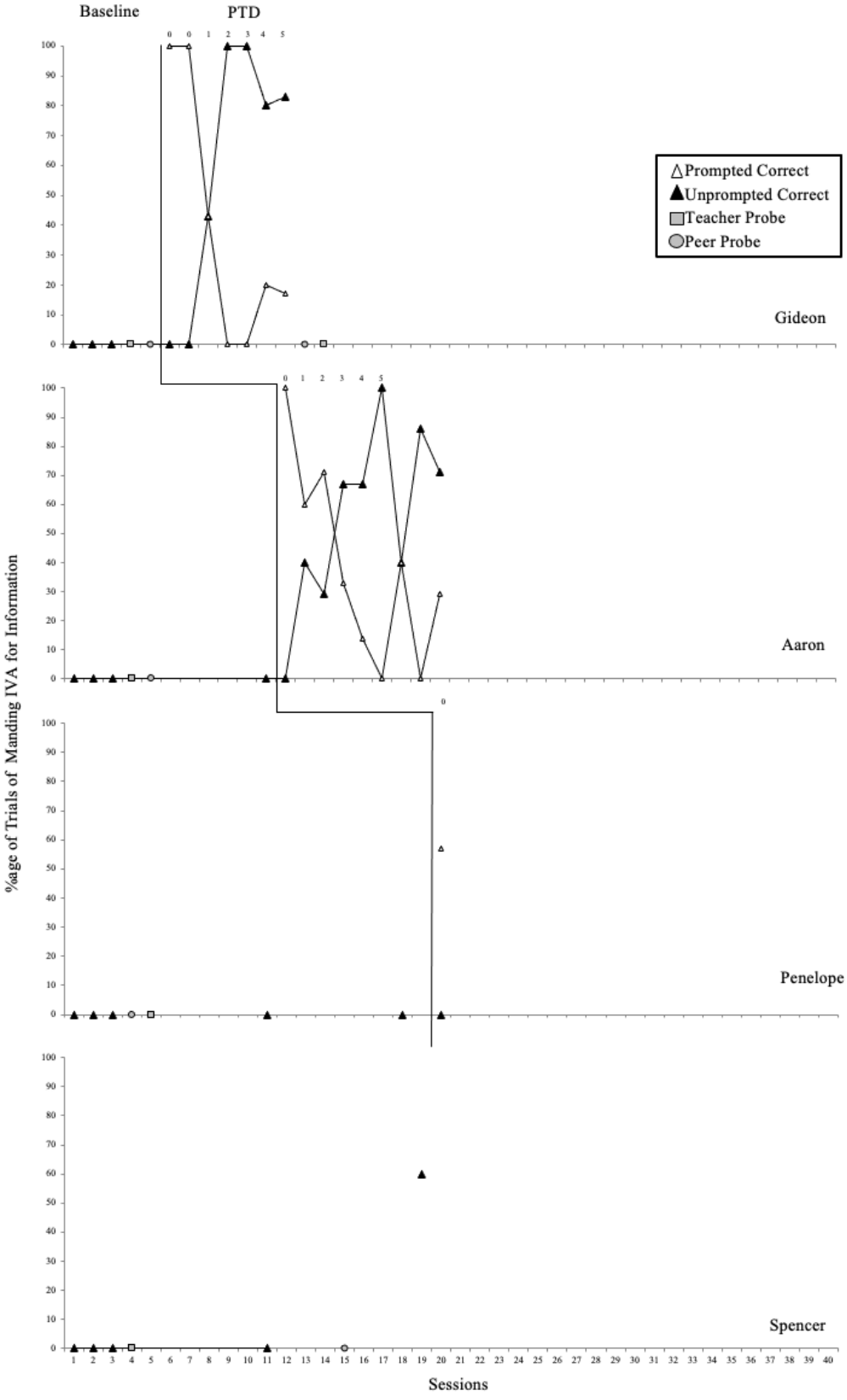
RESULTS

Acquisition of Manding

Figure 3 shows the student response data, and the results discussed in this section portray the data collected through March 31, 2023. This study is still in-progress with an anticipated completion date by May 2023. Only two participants were exposed to the PTD intervention within the data included for analysis. During the study, data were inspected using visual analysis to interpret significant changes in level, trend, or overlap within and between conditions. The consistency and immediacy of effects were also visually analyzed. A decision was made regarding the presence or absence of a demonstration of effect within each individual participant tier. Confirmation of a functional relation requires a demonstration of three effects, and therefore could not be obtained by analyzing only two tiers and only two possible demonstrations of effect.

The percentage of trials where participants initiated an IVA to mand for unknown information across communication partners is depicted in Figure 3. Sessions with the investigator or other members of the research team are represented by triangles. Open triangles indicate that the response was prompted while closed triangles correspond with unprompted responses. Generalization probe sessions conducted by a teacher or paraeducator in the classroom are represented by open squares, while generalization probes conducted by a peer mentor in the class are displayed as open circles.

Figure 3 *Graph of Results*



Gideon scored 0% unprompted correct during all three baseline sessions and two generalization probes. Baseline probes were conducted with all other participants and baseline data were stable when the intervention was introduced to Gideon. The responses made by Gideon during the PTD sessions are displayed in Table 3. The controlling prompt was emitted during the first two sessions with a 0 s delay. The first session resulted in 0% unprompted correct responses and 100% prompted correct. One additional 0 s delay trial, a methodological error due to miscommunication amongst the research team, was conducted with the same results. During the next session, the controlling prompt was delivered after a 1 s delay. During this session 43% of trials resulted in unprompted correct responses. Each of the subsequent sessions met the criteria for increasing the time delay by 1 s (i.e., 80% or more correct either prompted or unprompted).

During Gideon's ninth session, he opted to stop using the phone with Google Assistant™ that was provided by the researcher and instead used his new iPhone with Siri® to mand for information. During the 2 s and 3 s session, Gideon responded with 100% unprompted correct responses. In the 4 s session, 80% of trials resulted in unprompted correct responses. At the 5s session, Gideon vocalized unprompted correct responses 83% of the time and therefore met mastery criteria for the intervention (i.e., 80% or greater unprompted correct across at least two days). Overall, Gideon's unprompted mands for unknown information demonstrated an accelerating trend in a therapeutic direction, reaching mastery criterion in 6 sessions. Gideon graduated high school the day after finishing the intervention condition and therefore no maintenance data were able to be collected.

Table 4 *Intervention Session Data for Gideon*

Delay	0 s	0 s	1 s	2 s	3 s	4 s	5 s
Session	6	7	8	9	10	11	12
PC	100%	100%	43%	0%	0%	20%	17%
PI	0%	0%	14%	0%	0%	0%	0%
UC	0%	0%	43%	100%	100%	80%	83%
UI	0%	0%	0%	0%	0%	0%	0%
NR	0%	0%	0%	0%	0%	0%	0%

Note. UC=unprompted correct, UI=unprompted incorrect, PC=prompted correct, PI=prompted incorrect, NR=no response

After Gideon had an intervention session with 80% unprompted correct responses, the researcher conducted a probe with each participant. The data for all participants were stable. During all baseline and generalization probes Aaron responded to unknown questions with 0% unprompted correct responses. For the first intervention session a 0 s delay was implemented, resulting in 0% unprompted correct and 100% prompted correct responses. See Table 5 for the data for all of Aaron's responses during intervention sessions. Aaron's performance had an immediate therapeutic acceleration when the 1 s time delay was introduced, improving from 0% to 40% unprompted correct responses. For the next session, he had slightly fewer unprompted correct responses (i.e., 29%) but then advanced for the following three sessions (i.e., 67%, 67%, 100%). At session 13, Aaron regressed to 40% unprompted correct, but quickly recovered during session 14 (i.e., 86%). In session 15, Aaron scored slightly lower with 71% unprompted correct responses. Overall, there is clear differentiation in Aaron's performance at baseline and intervention levels with improvement from 0% unprompted correct to 86%

during his best performance across nine sessions. Although the direction of the data is therapeutic when analyzing across conditions, the data within the intervention condition are unstable. Aaron has not met mastery criteria and more intervention sessions are planned until he reliably demonstrates 80% or higher unprompted correct responses across at least two days.

Table 5 *Intervention Session Data for Aaron*

Delay	0 s	1 s	2 s	3 s	4 s	5 s			
Session	7	8	9	10	11	12	13	14	15
PC	100%	60%	71%	33%	17%	0%	40%	0%	29%
PI	0%	0%	0%	0%	0%	0%	20%	0%	0%
UC	0%	40%	29%	67%	67%	100%	40%	86%	71%
UI	0%	0%	0%	0%	17%	0%	0%	14%	0%
NR	0%	0%	0%	0%	0%	0%	0%	0%	0%

Note. UC=unprompted correct, UI=unprompted incorrect, PC=prompted correct, PI=prompted incorrect, NR=no response

Once Aaron had a session with 80% unprompted correct responses, a baseline probe was conducted with Penelope and Spencer in preparation for introducing the intervention condition with Penelope. Spencer unexpectedly emitted 60% unprompted correct responses. The study is currently in progress and more baseline probes are planned to assess for further covariation and ensure stable responding before introducing him to PTD. A single 0 s intervention session has been conducted with Penelope, resulting in 0% unprompted correct and 57% prompted correct responses. See Table 6 for a breakdown of all reported responses made by Penelope. Another 0 s delay session will

be repeated with Penelope as the delay will not be increased until she responds correctly to unknown questions 80% or more of the time.

Table 6 *Intervention Session Data for Penelope*

Delay	0 s
Session	7
PC	57%
PI	14%
UC	0%
UI	0%
NR	29%

Note. UC=unprompted correct, UI=unprompted incorrect, PC=prompted correct, PI=prompted incorrect, NR=no response

Secondary Dependent Variables

IVA Response

The secondary data collected when the participants initiated a mand to their IVA are summarized for each participant in Tables 7 (Gideon), 8 (Aaron), and 9 (Penelope). Across the recorded responses for all participants, most of the time the IVA linked to information (range 50-76%). Between 45% to 53% of the time, a direct answer was given by the IVA. It should be noted that most of the direct answers included an audible response, but on a few occasions, the answer appeared as text but was not vocalized by the IVA. Occasionally the IVA did not understand the participant's question (range 25-37%). Rarely, the IVA provided information that was incorrect or did not answer the target question (0-21%). Oftentimes this occurred in response to a question that was misunderstood by the IVA.

Table 7 *Secondary Dependent Variables of Gideon*

IVA Responses		Student Engagement	
Linked to information	68%	Scanned information	58%
Answered directly	45%	Vocalized answer	13%
Did not understand	37%	Indicated wrong answer	0%
Provided wrong answer	21%	No engagement	39%
		Restated the mand	2%

Table 8 *Secondary Dependent Variables of Aaron*

IVA Responses		Student Engagement	
Linked to information	76%	Scanned information	42%
Answered directly	53%	Vocalized answer	16%
Did not understand	27%	Indicated wrong answer	3%
Provided wrong answer	7%	No engagement	49%
		Restated the mand	4%

Table 9 *Secondary Dependent Variables of Penelope*

IVA Responses		Student Engagement	
Linked to information	50%	Scanned information	0%
Answered directly	50%	Vocalized answer	0%
Did not understand	25%	Indicated wrong answer	0%
Provided wrong answer	0%	No engagement	100%
		Restated the mand	0%

Participant Engagement

Most of the time, Gideon responded to the IVA by visually interacting with the results (e.g., scrolling, scanning; 58% of trials). Gideon never indicated that the IVA responded with incorrect information. Gideon vocalized the correct answer indicated by the IVA 13% of the time. According to the data collection protocol, a restated mand was only recorded if the IVA answered a misunderstood question and the participant then re-presented the question. This only occurred for 2% of sessions, however implementers noted that Gideon self-corrected before the IVA emitted a response. For 39% of trials where the IVA was initiated, Gideon did not respond to the information it provided. The engagement data for Gideon are reported in Table 7.

Slightly less than half of the time, Aaron did not engage with the voice assistant (i.e., 49%). When Aaron did engage, he was most likely to interact with the information by visually scanning or scrolling through the search results generated by the IVA (i.e., 42% of trials). Less frequently, Aaron vocalized the answer (i.e., 16%), indicated the IVA's response was wrong (i.e., 3%), or restated the mand to the IVA (i.e., 4%). The results for Aaron's engagement are depicted in Table 8.

The engagement data reported for Penelope in Table 9 only reflect the answers for four instances where she manded the IVA within one session. During this session, she never engaged with the search results or the responses provided by the IVA.

Incidental Learning Opportunities

The implementer suggested activities that could be inquired for using the IVA including performing routine tasks (e.g., set timer or alarm) or accessing media for leisure

throughout the study. The types of skills presented to each participant with corresponding session numbers and responses are listed for each participant in Tables 9 (Gideon), 10 (Aaron), and 11 (Penelope). The implementer suggested listening to hip hop music twice and listening to an inspiring quote four times to Gideon throughout the study following the completion of intervention sessions. Gideon did not perform any of the tasks suggested using any IVA, but on two occasions after the activity was suggested Gideon responded by stating that he would rather watch videos on an app. Gideon proceeded to make a voice command to open the application on his phone (i.e., "Siri®, open YouTube). After PTD Sessions, Aaron was presented with opportunities to set reminders for events, listen to his favorite rapper, open a video application, set alarms, and set a timer were suggested to Aaron after PTD sessions. Aaron independently initiated Google to set reminders for important events (i.e., start of school break and planned community excursion) on two occasions. This occurred after the ninth and eleventh sessions. Aaron never initiated any of the other nontarget IVA skills. Penelope was presented with an opportunity to create a reminder. She did not use Siri® to do this. Spencer has not been exposed to incidental learning opportunities to use voice commands as he is still waiting to be introduced to the PTD intervention.

Table 10 *Nontarget Voice Commands for Gideon*

Session	Skill	Independent Performance
6	Quote	No
7	Quote	No
8	Music	No
9	Quote	No
10	Music	No
11	Quote	No
12	Quote	No

Table 11 *Nontarget Voice Commands for Aaron*

Session	Skill	Independent Performance
8	Video	No
9	Reminder	Yes
11	Reminder	Yes
12	Alarm	No
13	Reminder	No
14	Reminder	No
15	Timer	No

Table 12 *Nontarget Voice Commands for Penelope*

Session	Skill	Independent Performance
7	Reminder	No

Reliability and Fidelity

Interobserver Agreement

Interobserver agreement was collected for 33% of Gideon's baseline sessions, 29% of intervention sessions, and 25% of generalization probes. Baseline session and generalization probe IOA was 100%. The average IOA for interventions session was 93% (range 86-100%). IOA was collected for 25% of Aaron's baseline sessions, and 38% of intervention sessions, and 50% of generalization probes. Baseline session IOA was 86%, average intervention IOA was 96% (range 89-100), and IOA for generalization probes was 100%. For Penelope's sessions, IOA was collected in 60% of baseline condition sessions, 50% of generalization probes, and 0% of interventions sessions. All baseline and generalization sessions have 100% IOA. Only one intervention session has been held with Penelope and more intervention sessions are planned with IOA data collection. Spencer's baseline sessions had IOA collected 40% of baseline sessions and it was collected for 50% of generalization probes. For all sessions in all conditions with Spencer, IOA was 100%.

Procedural Fidelity

PF was collected for 33% of Gideon's baseline sessions. 29% of intervention sessions, and 25% of generalization probes. Generalization probes and baseline sessions with Gideon had 100% PF. Average PF for Gideon's intervention sessions was 91% (range 85-97%). PF was collected for 25% of Aaron's baseline sessions, 38% of intervention sessions, and 50% of generalization probes. PF for Aaron was 100% in baseline and generalization probe conditions and averaged to 95% in the intervention condition (range 86-100%). During Penelope's baseline condition had PF for 60% of

baseline sessions and 50% of generalization probes. IOA was 100% for both conditions. No PF was collected for Penelope's intervention session due to only completing one and because there are plans for future sessions where PF will be collected. For Spencer's sessions, PF was collected for 40% of baseline sessions and 50% of generalization probes. All of Spencer's sessions had PF scores of 100%. Infrequent procedural errors captured in the data above included failing to present a nontarget skill and perform the associated steps and failing to praise to the participant for initiating the IVA.

DISCUSSION

The goals of this study were (a) to evaluate if PTD is an effective teaching method to teach adolescents and adults with ID to mand for unknown information using an IVA, (b) to assess if the manding skill would generalize and be performed when unknown questions were posed by an untrained communication partner, and (c) to evaluate if using IVAs to mand for unknown information and being exposed to additional voice commands would incidentally lead to the acquisition of nontarget voice commands.

Accessing Unknown Information

Demonstrations of effect that PTD is effective for teaching informational mands were observed for Gideon and Aaron. Demonstrations of effect have not yet been observed for other participants, however, the study is incomplete at this time. A functional relation requires a minimum of three demonstrations of effect; therefore, the presence or absence of a functional relation cannot be determined without evaluating the effects of the intervention for one or more participants in the study (Barton et al., 2018). Gideon acquired the manding skill and reached the mastery criterion. The PTD intervention resulted in some therapeutic acceleration for Aaron, although the degree of improvement was variable. Several variables may have contributed to Aaron's inconsistent performance. The classroom had varying levels of distraction dependent on the ongoing activities at the time of the session. At times, Aaron's attention fluctuated or he experienced difficulties recalling the question that was asked even after the implementer repeated it following the controlling prompt. Notably, during sessions 9-15 Aaron was fasting in observance of a religious holiday. On several occasions, Aaron stated that he was tired, and the implementer noted observable signs of fatigue. Thus, it is

likely that Aaron's performance for these sessions may not have been representative of his abilities.

Another possible confounding variable was the level of interest that Aaron had in the content of the unknown questions. When questions surrounded his interests, Aaron was more likely to initiate the voice assistant unprompted. Similarly, Penelope responded to unknown questions with prompted correct responses slightly more than half of the time (i.e., 57%) during her first and only intervention session. Penelope appeared to ignore the controlling prompt provided by the implementer for some trials when the question did not interest her. In one trial, Penelope vocalized "nah" to indicate her disinterest after the controlling prompt directive to ask Siri® had been delivered. Penelope started asking other questions that interested her instead (i.e., "What does the fox say?", "What is the weather for today?", "What is ten plus ten?", "What time is it?"). Therefore, it is concluded that Penelope's performance reflects a performance deficit rather than the absence of the manding skill. It is expected that Penelope's performance would improve drastically if the questions were all more relevant to her and to the environment or activities that she is in.

Future research could formulate questions that were more natural and contextually appropriate based on the ongoing activities. Another suggestion is to comparatively analyze manding behavior and participant engagement when the target information to inquire the IVA about is preferred compared with when the question they are asked includes neutral content. Alternatively, studies could assign tasks to participants that require them to use the information they manded for. Future research should parse out the variables surrounding motivation for manding and engagement with the answer provided

by the IVA. Furthermore, separate assessment is necessary to determine if once a manding skill is acquired that participants are able to practically apply it to authentic daily tasks.

Although the researcher screened participants to evaluate if they had any previous experience manding IVAs for unknown information, either directly or indirectly through observations of family members or others, it is a limitation that the self-reports provided by participants could not be verified by the researcher. Common problems that correspond with inaccuracy of self-report measures for people with ID include errors resulting from recency bias (i.e., choosing the last option that was presented), dysfunction in information processing and recall due to intellectual impairment, or because a response is posed in a suggestive matter (e.g., the question was leading either intentionally or unintentionally; Emerson et al., 2013).

Spencer had not participated in any intervention sessions, however during baseline at session 8 he went from 0% unprompted correct responses to 60%. Although the researcher ensured that sessions were always conducted at least 1 meter away from others who were in the study to safeguard against unintended observational learning, all sessions occurred in Spencer's classroom and participant volume could not be controlled for. Therefore, it is plausible that Spencer may have overheard another participant mand for information. Additionally, during the preceding generalization session, the peer implementer stated a directive to Spencer instructing him to use the iPod touch to answer the questions that he asked before the implementer was able to interrupt. Spencer did not initiate Siri® during this generalization probe but did so during the next baseline probe.

Generalization to Routine Communication Partners

Generalization to untrained communication partners was not observed for Gideon and remains to be evaluated for the other participants upon completion of the study. Although Gideon did not respond by asking the IVA unknown questions that were posed to him by his teachers or peers, he did ask an unprompted follow-up question during session 10. The implementer had previously asked him "How much torque does a 2020 Rav4 have?". After obtaining the answer using Siri®, Gideon inquired about the torque for a car that he was interested in, a 2013 Volkswagen Passat, using the IVA. This suggests that some generalization occurred in response to questions that Gideon develops autonomously. Still, it is unknown if the manding skill was maintained and repeated for any other self-generated questions. For Aaron and Penelope, performance of the manding skill when presented with unknown questions by untrained communication partners has not yet been assessed since implementation of intervention sessions. Therefore, it is unclear if they will generalize the manding skill. This remains to be assessed for Spencer as well after he is exposed to the intervention. Further research is needed to analyze procedural steps, dosages, or other modifications that would promote generalization of the manding skill.

Performance of Nontarget Skills

The intended nontarget voice commands were never performed by Gideon or Savannah but were sometimes performed by Aaron. Aaron performed one of the four nontarget skills presented to him. He performed the skill (i.e., setting a reminder) the first two times that it was presented to him but not on the third and fourth presentations. During some sessions, Aaron indicated that he was observing a religious holiday that prohibited him from consuming music. Consequently, Aaron nor the implementer

manded for the intended nontarget skill to play music that had been planned for the session and the skill was modified for future sessions. Despite not performing the planned nontarget skills presented during intervention sessions, Gideon generated unintended and untrained mands to open preferred applications on his phone. Gideon may have generalized this use of his IVA from the technology training given that the investigator taught participants to open other apps (i.e., the camera and calendar).

IVA and Participant Characteristics

For Gideon, questions that contained more syllables were sometimes articulated with errors. Additionally, sometimes the IVA misunderstood what participants were asking. Gideon was noted to edit the dictation text that was generated to transcribe what he asked, modifying it to say what he had authentically asked. Gideon and Aaron were both observed restating their questions as well to ensure that the voice assistant provided a response to their intended questions. Despite the success of their adaptations, this study excluded participants with speech that was not well understood by others. Future studies could assess the efficacy of IVAs for individuals with non-standard speech by incorporating developing technologies, such as Voiceitt, a mobile application that uses artificial intelligence to decipher the speech of people with various communication disorders (Fuld, 2019). Machine learning allows the application to collect, analyze, and interpret an individual's vocalizations to transform their communicative utterances into speech output that is comprehensible by others. Future studies should include individuals who communicate using speech-generating devices to assess the utility of IVA for people with ID who rely on these devices for communication.

For some questions, Gideon initiated the voice assistant, but the sentence structure that he generated did not always have accurate syntax to match the question that was presented. When this occurred, Gideon still obtained related information since the question still pertained to the topic that he was presented with. Practically, the IVA still offered some assistance that may or may not have been valuable depending on the information that might be needed for the situation. At times, in response to very targeted questions, the IVAs provided considerably long answers, contributing additional details. To identify the answer to functionally respond to a partner's question or to apply it to a need, these scenarios would require the user to discriminate the target information from the distracting supportive details that were offered. Presumably, this may explain why both Gideon and Aaron frequently did not engage with the response, sometimes turning the screen of their device to the implementer to show them the links and answers provided by their IVAs but did not reliably vocalize the answer. Nonetheless, background information may help the user obtain a greater depth of understanding in some circumstances.

The broad spectrum of challenges associated with ID is very individualized and therefore it is reasonable to suspect that differences in literacy or other measures of adaptive functioning may be indicative of how effective of a tool IVA will be for an individual. Gideon was able to edit dictated text that appeared after he vocalized a mand to the IVA to correct any errors and Aaron was able to engage with the search results by reading them. Nonetheless, it is worthwhile to assess the utility of IVA for users who cannot read or write, given that many individuals with ID cannot. Further study is needed to compare the utility of IVA as a manding tool for learners with diverse characteristics.

Social Validity

At the conclusion of the study, the participants' teachers will be given a survey of her reflections and input regarding the utility of the intervention. During the study, one teacher has made multiple statements indicating that she is learning new information about her students and their interests as she watches how they engage with the questions asked and with the IVA. During the sessions, Aaron unexpectedly began responding to the implementers by elaborating on the topics presented to him with further questions and comments. The information provided by Google Assistant™ search results served as a catalyst for social skills development as he engaged in back-and-forth conversation with implementers. Aaron has inquired to implementers about their music and food interests following questions pertaining to those topics. Additionally, Aaron has scrolled through the search results that were provided and commented on images and other content.

Penelope did not perform the intended nontarget skill to set a reminder for an upcoming school break, but she did perform several other skills that she shared she knew during screening (i.e., requesting stories and knock-knock jokes). Although these additional nontarget skills were not learned within the context of the study, Penelope's unprompted performance of them surrounding use of the IVA demonstrates the social acceptability of the tool. Penelope also initiated non-informational conversations with Siri® by commenting "Siri®, I'm tired" and similar statements. Frequently, when members of the research team were present in her school, Penelope inquired about the principal investigator of this study and excitedly asked when she could use the iPod touch again. Aaron asked implementers to use the cellphone to listen to music on Spotify, when he was not prohibited from it during the religious holiday, and he also used the phone to

play games or watch videos outside of the study sessions. The nature of mobile technologies allows access to information, applications, and preferred media that is valued by the user. Therefore, mobile devices and by extension embedded IVAs can easily be paired with preferred stimuli which may make IVAs highly motivating for individuals with ID to engage with.

Future studies should capitalize on the interests of participants to ensure that performing tasks with IVA are motivating so that their responses are more likely to match with their capabilities.

Conclusion

IVAs have been used for a variety of purposes in traditional home settings, educational institutions, and within skilled care environments. IVAs can perform routine tasks, communicate with other smart technology to alter the environment, provide an engaging modality for students in classroom activities, initiate prompts in memory care for individuals with dementia or related impairments, and can even implement cognitive behavior therapy techniques (Baldauf, 2018; Terzopoulos & Satratzemi, 2020). Despite the numerous promising features of IVAs that could potentially serve compensatory functions for individuals with cognitive limitations, few studies have investigated the utility of IVA as assistive technologies for people with ID. The findings of this study provide limited support that people with ID can be taught to self-instruct using IVAs.

APPENDICES

Appendix A. Screening Form

Name: Initial Screening Date:

Personal Device Type(s)	Personal phone Personal tablet Device must be provided
Voice Assistant(s) on personal device(s)	Siri® Google Alexa
Do they reliably have access to a personal device?	Probe 1(date:) Yes No Probe 2(date:) Yes No Probe 3(date:) Yes No
Does participant report the use of any voice assistants?	Siri® Google Alexa How or for what?
Verbal imitation (full sentences- may prompt them to ask a person a question)	1- “ Yes No 2- “ Yes No 3- “ Yes No
Follow 3-5 steps for a chained task	1- Yes No 2- Yes No 3- Yes No
Is speech intelligible without any accessibility modifications?	Yes No Comments:
Are modifications needed?	Yes No Instructor prompts to talk slowly and clearly Delayed IVA response time Repeat attempts occasionally but not always Other:
If needed, were voice commands successful with the modifications? Attempted on:	N/A Probe 1: Open <app> Yes No Trials Needed: Probe 2: Give me directions to <location> Yes No Trials Needed: Probe 3: Create a note that says <message> Yes No Trials Needed:

AAC User	Yes No Can freely synthesize new messages? Y N How long does this take? Device Model & Communication App:
Attendance 80% or better for past 9 weeks	Yes No
IEP Eligibility Category	
Age	
Race	
Gender	
Known Interests	
Known Scheduling Needs	
Other information	

Appendix B. Free Operant Preference Assessment Datasheet

Participant Initials: Start Time:
Date: End Time:

Song	Artist	Duration of Engagement (seconds)

Appendix C. List of Known Questions

Gideon

1. What channel plays the Fairly Oddparents?
2. What shows are on Nickelodeon?
3. What channel does Spongebob play on?
4. Who is Spongebob's best friend?
5. What kind of fish is Patrick on Spongebob Squarepants?
6. What animal is Sandy from Spongebob Squarepants?
7. What color was Wanda's hair on the Fairly Odd Parents?
8. What kind of sport can you do on ice?
9. Who was the main character on the Fairly Odd Parents?
10. Who was Timmy's crush on Fairly Oddparents?
11. What channel plays the news?
12. What channel can you watch sports on?
13. What kind of shows can you watch on ESPN?
14. Who is your favorite singer?
15. What year did Hotel Transylvania 1 come out?
16. What year was Hotel Transylvania 2 released?
17. What year was The Friday after Next Released?
18. When was Turbo released?
19. When did Ted 1 come out?
20. What year did Ted 2 come out?
21. When did the Adam Sandler movie, Pop Star, come out?
22. When was Mr. Deeds released?
23. What year did Madagascar 1 come out?
24. When did Madagascar 2 come out?
25. What year was Madagascar 3 released?
26. When did the Big Lebowski come out?
27. What year was Mo' Money released?
28. What is the name of an Adam Sandler movie?
29. What year did The Longest Yard come out?
30. What year did Grown Ups 1 come out?
31. When did Grown Ups 2 come out?
32. What year was Bedtime Stories starring Adam Sandler released?
33. When was the movie Click released?
34. Who is on the Frosted Flakes box?

Aaron

1. What genre does Lil' Durk sing?
2. Who has Lil' Durk made music with?
3. What is the fastest cat? Cheetah
4. What does McDonald's sell?
5. Where can you buy a burger meal?
6. What grocery stores are nearby?
7. What sport does the team, The Grizzlies, play?
8. What is the mascot for The Grizzlies?
9. What color is spiderman?
10. What heroes are in avengers?
11. Who is spiderman's enemy?
12. What hero is Bruce Wayne?
13. What hero is Peter Parker?
14. What is Tony Stark's hero identity?

Penelope

1. On Good Luck Charlie, who are Charlie's parents?
2. Who are Charlie's sisters on Good Luck Charlie?
3. Who are Charlie's Brothers on Good Luck Charlie?
4. What streaming service does Good Luck Charlie play on?
5. What does Bob do for a living on Good Luck Charlie?
6. Who's Teddy's boyfriend on Good Luck Charlie?
7. What is an exterminator?
8. What kind of food does Fazoli's serve?
9. Who makes Rav4 cars?
10. Where do you live?
11. What state is Lexington in?
12. What shoe brand uses a checkmark logo?
13. How do you spell cat?
14. How do you spell dog?
15. Who is the main character in Frozen?
16. Who is the snowman in the movie, Frozen?
17. Who is Elsa's sister in the movie, Frozen?
18. What is the weather like where Anna and Elsa live?
19. What is the name of a Disney princess?
20. Where does the Disney princess, Ariel, live?
21. What sound does a cow make?
22. Who is mickey mouse's girlfriend?
23. Who is Donald Duck's girlfriend?

24. What's the name of Mickey Mouse's dog?
25. What color are avatars on the planet Pandora?
26. Who is the main character in the movie Avatar?

Spencer

1. What color does the man in the hat wear in Curious George?
2. What kind of animal is Curious George?
3. What kind of can does Oscar the Grouch live in?
4. What color is this [point to an item]?
5. What tool can you use to solve a math problem?
6. What does a watch do?
7. What is the name of Elmo's fish?
8. What kind of fish is Dorothy?
9. What is the name of the bird on Sesame Street?
10. What color is Big Bird from Sesame Street?
11. Who does the letter of the day on Sesame Street
12. What is the weather like when it's summer?
13. What is the weather like when it's winter?
14. Who is Bert's best friend?
15. Who is Ernie's best friend?
16. Who has a rubber ducky on Sesame Street?
17. Who is Grover's superhero identity?
18. Who is the elephant in Sesame Street
19. Who takes care of Curious George?
20. What channel plays sesame street?
21. Where do you go to work out?
22. What holiday do you hide eggs for?
23. What is the first day of the weekend?
24. Where do you go to get care if you are sick?
25. What do monkeys eat?
26. What show is Batley from?
27. Who is Blue's owner?
28. What makes blue wag his tail on Blue's Clues?
29. Where does Blue get his mail from on Blue's clues?

Appendix D. Sample of Presumed Unknown Questions

	Academics	Functional Life & Career Skills	Pop Culture, Recreation, & Leisure
1	What is the formula for <calculation>?	What are the hours at <retail store>?	When is <special event>?
2	What is < 3 digit #> divided by < 3 digit #>?	What is the weather today in <city>?	Who sings <song>?
3	What is <3 digit # > times <3 digit #>?	Who can I call nearby to repair <item>?	What is <musician's> latest album?
4	What is the national anthem in <country>?	How many miles away am I from <location>?	Who are the members of <band>?
5	What is the state bird of <state>?	What is the average price of <item or service>?	What genre of music is <artist>?
6	Who is the governor of <state>?	How many <measurement unit> are in <other unit>?	What is <singer> popular song?
7	What does <abbreviation> stand for?	Where can I find <item> nearby?	Who performed at <special event>?
8	What is another word for <word>?	What is <_20%> of <number>?	Who is the actor in <new movie>?
9	What is an antonym for <word>?	Which <product> brand has the best ratings?	What movie won <award show>?
10	What is the definition of <word>?	Where can I get <service> nearby?	What actor plays <character in movie>?
11	How many moons does <planet> have?	Where can I get <service> nearby?	Who is the host of <tv show>?
12	How many stars are in <constellation>?	How long are <animal> pregnant?	When does <tv show> start?
13	Who was the <number> president of the US?	How long does <animal> egg take to hatch?	Who won <show> this year?
14	What kind of government does <country> have?	What are baby <animal> called?	How old is <famous actor>?
15	What is the largest bone in <animal> body?	What is the slogan for <business>?	Who is <actor> married to?
16	What year was <historic event>?	What year was <business> established?	Who are the judges on <show>?
17	When was the first <item> made?	What is <business> logo?	What sport does <athlete> play?
18	What money do they use in <country>?	How much is sales tax in <state>?	Who plays for <sports team>?
19	What is the national anthem in <country>?	What language is spoken in <country>?	What is the mascot for <sports team>?
20	Is <animal> and endangered species?	What tool do you use to <task>?	What team does <athlete> play for?

21	What year was <historic building> constructed?	How many babies do <animal> have at once?	Who coaches <sports team>?
22	When was <historic figure> born?	How much <OTC med> do adults take?	Where does <sports team> play?
23	When did historic figure> die?	Is <food> safe for <pet>?	Who won <sports game> last night?
24	How did <historic figure> die?	How long is a term for <political office>?	What was the score of <sports game> last night?
25	How do you say <word> in <language>?	When will the next election for <office> be?	Who did <sports team> last play?
26	What's the abbreviation for <chemistry element>?	What color is complementary to <color>?	What sports are in the summer Olympics?
27	Who wrote <literary work>?	What food group is <food> in?	When is <sports event> this year?
28	What countries fought in <war>?	Is <flower> edible?	How many songs are in <musical/play>?
29	Where was <historic figure> born?	What are the symptoms of <illness>?	How many movies has <actor> been in?
30	What computer program can I use to <task>?	What are signs of <food> spoiling?	Who is <political office> of <area>?
31	How do I cite a <source> in APA?	What can be substituted for <ingredient> in recipes?	Who holds the world record for <skill>?
32	What is an <alliteration/allegory/ metaphor/analogy/etc.>?	What season do you plant <fruit/vegetable>?	How fast can a <car model and year> go?
33	What is <physics law>?	What is the recommended daily intake for <nutrient>?	How many books has <author> written?
34	What is the density of <element>?	How often should <plant> be watered?	What is <author's> best-selling book?
35	What is the atomic number of <element>?	How much sunlight does a <plant> need?	Who is the director of <movie>?
36	What is the Earth's <outer core/inner core/ mantle/crust> made of?	What temperature is <meat> when cooked?	Who is the author of <book>?
37	How thick is the Earth's <layer>?	What is the recommended tire pressure for <car model>?	Who is the main character in <show/book/movie>?
38	How are <igneous/metamorphic/ Sedimentary> rocks formed?	How often should you get <car service>?	Who won the last season of <gameshow>?
39	What is does <cell structure-nucleus/ Mitochondria/Ribosomes> do?	What is the shelf life of <food>?	What is the birthstone for <month>?

40	How long is a <century/millenia/eon>?	What is a <household tool> used for?	When are <astrology sign> born?
41	What is <oligarchy/ matriarchy/ Patriarchy/ Communism/ socialism/ autocracy>?	What do <animal> eat ?	What years were <zodiac sign> born in Chinese astrology?
42	What is the biggest export in <region>?	What is <medical supply/medication> used for?	What is the prize for winners of <gameshow>?
43	How many rivers are in <state>?	What is a safe <oxygen or blood sugar> range?	Where was the <year and season> Olympics held?
44	How do you calculate <resting/active> heart rate?	What is a safe blood pressure range?	What is the goal of <game>?
45	What symphonies did <classic musician> compose?	What is the phone number for <local business>?	How many players are in <game>?
46	Who painted <famous painting>?	Who is the <political office>?	How many <artist> songs are there?
47	Where are the <mountain range>?	Who is running for <office> in the next election?	How many plays did <writer> write?
48	How deep is <body of water>?	How often should you replace <car fluid>?	Where was the setting of <movie/book/play>?
49	How many species of <animal> are there?	What is the zip code for <city>?	How many pages is <book>?
50	Where do <animal> live?	What does a <medical specialist> do?	When is the next <eclipse or astronomy event>?

Appendix E. Technology Training Data Sheet

Participant:		Probes- set alarm, look at photos, open camera								
Training Session Date(s):		Session 1 Date:			Session 2 Date:			Session 3 Date:		
Siri® Task Analysis		Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 7	Trial 8	Trial 9
1	Pick up device									
2	Press and hold down lock button (right side of device) or say "Hey Siri®"									
3	Wait for the blue orb at bottom of screen to appear									
4	Initiate vocal command									
% Correct										

Key: correct (+), incorrect (-), no response (0).

Participant:		Probes- set alarm, look at photos, open camera								
Training Session Date(s):		Session 1 Date:			Session 2 Date:			Session 3 Date:		
Siri® Task Analysis		Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 7	Trial 8	Trial 9
1	Pick up device									
2	Press and hold down home button (bottom middle of device) or say "Ok Google"									
3	Wait for sound to chime and assistant logo to appear									
4	Initiate vocal command									
% Correct										

Key: correct (+), incorrect (-), no response (0).

Appendix F. Baseline and Maintenance Session Datasheet

Condition:	Baseline	Maintenance	Fidelity:
Date:	Participant:	Session:	Implementer:

Device is in 1m proximity of student before session is started	+ -
Device volume is at an audible level	+ -
The attention of the student is on the implementer before the session begins	+ -
The environment is free of excessive background noises	+ -
No other participants are within hearing range	+ -

Key: occurrence unprompted correct (UC), unprompted incorrect (UI), prompted correct (PC), prompted incorrect (PI), no response (NR), occurrence (+), nonoccurrence (-)

1	Question asked Known Unknown	" ?"			+ -
Student response		**Unknown-** Unprompted Correct **Known-** Vocalizes an Answer	Unprompted Incorrect Initiates Assistant	No Response No Response	
Correct response by implementer					+ -
Assistant responds to question	+ -	Link to information	Answers directly	Does not understand	Provides wrong answer
Student engages with answer	+ -	Scans/Interacts	Vocalizes answer	Indicates answer was wrong	Restates mand NR
2	Question asked Known Unknown	" ?"			+ -
Student response		**Unknown-** Unprompted Correct **Known-** Vocalizes an Answer	Unprompted Incorrect Initiates Assistant	No Response No Response	
Correct response by implementer					+ -
Assistant responds to question	+ -	Link to information	Answers directly	Does not understand	Provides wrong answer
Student engages with answer	+ -	Scans/Interacts	Vocalizes answer	Indicates answer was wrong	Restates mand NR
3	Question asked Known Unknown	" ?"			+ -
Student response		**Unknown-** Unprompted Correct **Known-** Vocalizes an Answer	Unprompted Incorrect Initiates Assistant	No Response No Response	
Correct response by implementer					+ -
Assistant responds to question	+ -	Link to information	Answers directly	Does not understand	Provides wrong answer
Student engages with answer	+ -	Scans/Interacts	Vocalizes answer	Indicates answer was wrong	Restates mand NR
4	Question asked Known Unknown	" ?"			+ -
Student response		**Unknown-** Unprompted Correct **Known-** Vocalizes an Answer	Unprompted Incorrect Initiates Assistant	No Response No Response	
Correct response by implementer					+ -
Assistant responds to question	+ -	Link to information	Answers directly	Does not understand	Provides wrong answer

Student engages with answer	+ -	Scans/Interacts Vocalizes answer Indicates answer was wrong Restates mand NR	
5 Question asked Known Unknown	“ ?”		+ -
Student response	**Unknown-** Unprompted Correct Unprompted Incorrect No Response **Known-** Vocalizes an Answer Initiates Assistant No Response		
Correct response by implementer			+ -
Assistant responds to question	+ -	Link to information Answers directly Does not understand Provides wrong answer	
Student engages with answer	+ -	Scans/Interacts Vocalizes answer Indicates answer was wrong Restates mand NR	
6 Question asked Known Unknown	“ ?”		+ -
Student response	**Unknown-** Unprompted Correct Unprompted Incorrect No Response **Known-** Vocalizes an Answer Initiates Assistant No Response		
Correct response by implementer			+ -
Assistant responds to question	+ -	Link to information Answers directly Does not understand Provides wrong answer	
Student engages with answer	+ -	Scans/Interacts Vocalizes answer Indicates answer was wrong Restates mand NR	
7 Question asked Known Unknown	“ ?”		+ -
Student response	**Unknown-** Unprompted Correct Unprompted Incorrect No Response **Known-** Vocalizes an Answer Initiates Assistant No Response		
Correct response by implementer			+ -
Assistant responds to question	+ -	Link to information Answers directly Does not understand Provides wrong answer	
Student engages with answer	+ -	Scans/Interacts Vocalizes answer Indicates answer was wrong Restates mand NR	
8 Question asked Known Unknown	“ ?”		+ -
Student response	**Unknown-** Unprompted Correct Unprompted Incorrect No Response **Known-** Vocalizes an Answer Initiates Assistant No Response		
Correct response by implementer			+ -
Assistant responds to question	+ -	Link to information Answers directly Does not understand Provides wrong answer	
Student engages with answer	+ -	Scans/Interacts Vocalizes answer Indicates answer was wrong Restates mand NR	
9 Question asked Known Unknown	“ ?”		+ -
Student response	**Unknown-** Unprompted Correct Unprompted Incorrect No Response **Known-** Vocalizes an Answer Initiates Assistant No Response		
Correct response by implementer			+ -
Assistant responds to question	+ -	Link to information Answers directly Does not understand Provides wrong answer	
Student engages with answer	+ -	Scans/Interacts Vocalizes answer Indicates answer was wrong Restates mand NR	
10 Question asked Known Unknown	“ ?”		+ -
Student response	**Unknown-** Unprompted Correct Unprompted Incorrect No Response **Known-** Vocalizes an Answer Initiates Assistant No Response		

Correct response by implementer		+ -
Assistant responds to question	+ -	Link to information Answers directly Does not understand Provides wrong answer
Student engages with answer	+ -	Scans/Interacts Vocalizes answer Indicates answer was wrong Restates mand NR
Student engages with answer	+ -	Scans/Interacts Vocalizes answer Indicates answer was wrong Restates mand NR

Session Notes:

Mands for Unknown Questions (Total=_____questions)					
Total % Mands for Unknown Info	**Unprompted Correct** ___/___(# unknown) _____%	**Unprompted Incorrect** ___/___(# unknown) _____%	**Prompted Correct** ___/___(# unknown) _____%	**Prompted Incorrect** ___/___(# unknown) _____%	**No Response** ___/___(# unknown) _____%
Secondary Dependent Variables (Total=_____questions)					
Assistant Response __/____(# unknown) _____%	**Link to information** __/____(# unknown) _____%	**Answers directly** ___/___(# unknown) _____%	**Does not understand** ___/___(# unknown) _____%		**Provides wrong answer** ___/___(# unknown) _____%
Student Engagement __/____(# unknown) _____%	**Scans/Interacts** ___/___(# unknown) _____%	**Vocalizes answer** ___/___(# unknown) _____%	**Indicates that the answer was wrong** ___/___(# unknown) _____%	**Restates mand** ___/___(# unknown) _____%	**No Response** ___/___(# unknown) _____%
Responses to Known Questions (Total=_____questions)					
Student Responses	**Vocalizes Answer** ____/____(known) _____%		**Initiates Assistant** ____/____(known) _____%		**No Response** ____/____(known) _____%
Non-Target Voice Command: _____ Initiated by Participant: Yes No					

Procedural Fidelity	_____/_____ (steps for # total questions asked) _____% (7Q = 19 steps; 8Q = 21 steps; 9Q = 23 steps; 10Q = 25 steps)

Appendix G. Progressive Time Delay Session Datasheet

Delay Interval: 0-s 1-s 2-s 3-s 4-s 5-s			Fidelity:
Date:	Participant:	Session:	Implementer:

Device is in 1m proximity of student before session is started	+ -
Device volume is at an audible level	+ -
The attention of the student is on the implementer before the session begins	+ -
The environment is free of excessive background noises	+ -
No other participants are within 1m	+ -

Key: occurrence unprompted correct (UC), unprompted incorrect (UI), prompted correct (PC), prompted incorrect (PI), no response (NR), occurrence (+), nonoccurrence (-)

1	Question asked Known Unknown	“ ?”	+ -
Implementer provided specified time delay			+ -
Correct controlling prompt provided if needed		“Ask <voice assistant>”	+ -
Question was repeated after the controlling prompt if provided			+ -
Student response		**Unknown-** UC UI PC PI NR **Known-** Vocalizes Answer Initiates Assistant No Response	
Correct response by implementer			+ -
Assistant responds to question	+ -	Link to information Answers directly Does not understand Provides wrong answer	
Student engages with answer	+ -	Scans/Interacts Vocalizes answer Indicates answer was wrong Restates mand NR	
2	Question asked Known Unknown	“ ?”	+ -
Implementer provided specified time delay			+ -
Correct controlling prompt provided if needed		“I’m not sure. Find out by asking <voice assistant>”	+ -
Question was repeated after controlling prompt if provided			+ -
Student response		**Unknown-** UC UI PC PI NR **Known-** Vocalizes Answer Initiates Assistant No Response	
Correct response by implementer			+ -
Assistant responds to question	+ -	Link to information Answers directly Does not understand Provides wrong answer	
Student engages with answer	+ -	Scans/Interacts Vocalizes answer Indicates answer was wrong Restates mand NR	
3	Question asked Known Unknown	“ ?”	+ -
Implementer provided specified time delay			+ -
Correct controlling prompt provided if needed		“I don't know, ask <voice assistant> for help”	+ -
Question was repeated after the controlling prompt if provided			+ -
Student response		**Unknown-** UC UI PC PI NR **Known-** Vocalizes Answer Initiates Assistant No Response	
Correct response by implementer			+ -

Assistant responds to question		+ -	Link to information Answers directly Does not understand Provides wrong answer
Student engages with answer		+ -	Scans/Interacts Vocalizes answer Indicates answer was wrong Restates mand NR
4	Question asked Known Unknown	“ ?”	+ -
Implementer provided specified time delay			+ -
Correct controlling prompt provided if needed		“Hmm…when I don’t know something I ask <voice assistant>. Try asking.”	+ -
Question was repeated after controlling prompt if provided			+ -
Student response		**Unknown-** UC UI PC PI NR **Known-** Vocalizes Answer Initiates Assistant No Response	
Correct response by implementer			+ -
Assistant responds to question		+ -	Link to information Answers directly Does not understand Provides wrong answer
Student engages with answer		+ -	Scans/Interacts Vocalizes answer Indicates answer was wrong Restates mand NR
5	Question asked Known Unknown	“ ?”	+ -
Implementer provided specified time delay			+ -
Correct controlling prompt provided if needed		“Hm, let’s ask <voice assistant> for the answer.”	+ -
Question was repeated after controlling prompt if provided			+ -
Student response		**Unknown-** UC UI PC PI NR **Known-** Vocalizes Answer Initiates Assistant No Response	
Correct response by implementer			+ -
Assistant responds to question		+ -	Link to information Answers directly Does not understand Provides wrong answer
Student engages with answer		+ -	Scans/Interacts Vocalizes answer Indicates answer was wrong Restates mand NR
6	Question asked Known Unknown	“ ?”	+ -
Implementer provided specified time delay			+ -
Correct controlling prompt provided if needed		“I don’t know that answer, ask <voice assistant>.”	+ -
Question was repeated after controlling prompt if provided			+ -
Student response		**Unknown-** UC UI PC PI NR **Known-** Vocalizes Answer Initiates Assistant No Response	
Correct response by implementer			+ -
Assistant responds to question		+ -	Link to information Answers directly Does not understand Provides wrong answer
Student engages with answer		+ -	Scans/Interacts Vocalizes answer Indicates answer was wrong Restates mand NR
7	Question asked Known Unknown	“ ?”	+ -
Implementer provided specified time delay			+ -
Correct controlling prompt provided if needed		“Ask <voice assistant>”	+ -
Question was repeated after controlling prompt if provided			+ -
Student response		**Unknown-** UC UI PC PI NR	

	Known-	Vocalizes Answer Initiates Assistant No Response	
Correct response by implementer			+ -
Assistant responds to question	+ -	Link to information Answers directly Does not understand Provides wrong answer	
Student engages with answer	+ -	Scans/Interacts Vocalizes answer Indicates answer was wrong Restates mand NR	
8 Question asked	“		+ -
Known Unknown	?”		
Implementer provided specified time delay			+ -
Correct controlling prompt provided if needed	“I’m not sure. Find out by asking <voice assistant>”		+ -
Question was repeated after controlling prompt if provided			+ -
Student response	**Unknown-**	UC UI PC PI NR	
	Known-	Vocalizes Answer Initiates Assistant No Response	
Correct response by implementer			+ -
Assistant responds to question	+ -	Link to information Answers directly Does not understand Provides wrong answer	
Student engages with answer	+ -	Scans/Interacts Vocalizes answer Indicates answer was wrong Restates mand NR	
9 Question asked	“		+ -
Known Unknown	?”		
Implementer provided specified time delay			+ -
Correct controlling prompt provided if needed	“I don't know, ask <voice assistant> for help”		+ -
Question was repeated after controlling prompt if provided			+ -
Student response	**Unknown-**	UC UI PC PI NR	
	Known-	Vocalizes Answer Initiates Assistant No Response	
Correct response by implementer			+ -
Assistant responds to question	+ -	Link to information Answers directly Does not understand Provides wrong answer	
Student engages with answer	+ -	Scans/Interacts Vocalizes answer Indicates answer was wrong Restates mand NR	
10 Question asked	“		+ -
Known Unknown	?”		
Implementer provided specified time delay			+ -
Correct controlling prompt provided if needed	“Hmm…when I don’t know something I ask <voice assistant>. Try asking.”		+ -
Question was repeated after controlling prompt if provided			+ -
Student response	**Unknown-**	UC UI PC PI NR	
	Known-	Vocalizes Answer Initiates Assistant No Response	
Correct response by implementer			+ -
Assistant responds to question	+ -	Link to information Answers directly Does not understand Provides wrong answer	
Student engages with answer	+ -	Scans/Interacts Vocalizes answer Indicates answer was wrong Restates mand NR	
Student engages with answer	+ -	Scans/Interacts Vocalizes answer Indicates answer was wrong Restates mand NR	

Session Notes:

Delay: 0-s 1-s 2-s 3-s 4-s 5-s			Fidelity:
Date:	Participant:	Session:	Implementer:

Mands for Unknown Questions (Total=_____questions)					
Total % Mands for Unknown Info	**Unprompted Correct** ___/___(# unknown) _____%	**Unprompted Incorrect** ___/___(# unknown) _____%	**Prompted Correct** ___/___(# unknown) _____%	**Prompted Incorrect** ___/___(# unknown) _____%	**No Response** ___/___(# unknown) _____%
Secondary Dependent Variables (Total=_____questions)					
Assistant Response __/____(# unknown) _____%	**Link to information** __/____(# unknown) _____%	**Answers directly** ___/___(# unknown) _____%	**Does not understand** ___/___(# unknown) _____%		**Provides wrong answer** ___/___(# unknown) _____%
Student Engagement __/____(# unknown) _____%	**Scans/Interacts** ___/___(# unknown) _____%	**Vocalizes answer** ___/___(# unknown) _____%	**Indicates that the answer was wrong** ___/___(# unknown) _____%	**Restates mand** ___/___(# unknown) _____%	**No Response** ___/___(# unknown) _____%
Responses to Known Questions (Total=_____questions)					
Student Responses	**Vocalizes Answer** ____/____(known) _____%		**Initiates Assistant** ____/____(known) _____%		**No Response** ____/____(known) _____%

Procedural Fidelity	_____/_____ (steps for # total questions asked) _____% (7Q = 44 steps; 8Q = 49 steps; 9Q = 54 steps; 10Q = 59 steps)

Appendix H. Generalization Session Datasheet

Condition: Generalization			Fidelity:
Date:	Participant:	Session:	Implementer:

Device is in 1m proximity of student before session is started	+ -
Device volume is at an audible level	+ -
The attention of the student is on the implementer before the session begins	+ -
The environment is free of excessive background noises	+ -
No other participants are within hearing range	+ -

Key: occurrence unprompted correct (UC), unprompted incorrect (UI), prompted correct (PC), prompted incorrect (PI), no response (NR), occurrence (+), nonoccurrence (-)

1	Question asked Known Unknown	" ?"			+ -
Student response		**Unknown-** Unprompted Correct **Known-** Vocalizes an Answer	Unprompted Incorrect Initiates Assistant	No Response No Response	
Assistant responds to question	+ -	Link to information	Answers directly	Does not understand	Provides wrong answer
Student engages with answer	+ -	Scans/Interacts	Vocalizes answer	Indicates answer was wrong	Restates mand NR
2	Question asked Known Unknown	" ?"			+ -
Student response		**Unknown-** Unprompted Correct **Known-** Vocalizes an Answer	Unprompted Incorrect Initiates Assistant	No Response No Response	
Assistant responds to question	+ -	Link to information	Answers directly	Does not understand	Provides wrong answer
Student engages with answer	+ -	Scans/Interacts	Vocalizes answer	Indicates answer was wrong	Restates mand NR
3	Question asked Known Unknown	" ?"			+ -
Student response		**Unknown-** Unprompted Correct **Known-** Vocalizes an Answer	Unprompted Incorrect Initiates Assistant	No Response No Response	
Assistant responds to question	+ -	Link to information	Answers directly	Does not understand	Provides wrong answer
Student engages with answer	+ -	Scans/Interacts	Vocalizes answer	Indicates answer was wrong	Restates mand NR
4	Question asked Known Unknown	" ?"			+ -
Student response		**Unknown-** Unprompted Correct **Known-** Vocalizes an Answer	Unprompted Incorrect Initiates Assistant	No Response No Response	
Assistant responds to question	+ -	Link to information	Answers directly	Does not understand	Provides wrong answer
Student engages with answer	+ -	Scans/Interacts	Vocalizes answer	Indicates answer was wrong	Restates mand NR

Session Notes:

Mands for Unknown Questions (Total=_____questions)			
Total % Mands for Unknown Info	**Unprompted Correct** ___/___(# unknown) _____%	**Unprompted Incorrect** ___/___(# unknown) _____%	**No Response** ___/___(# unknown) _____%
Responses to Known Questions (Total=_____questions)			
Student Responses	**Vocalizes Answer** ____/____(known) _____%	**Initiates Assistant** ____/____(known) _____%	**No Response** ____/____(known) _____%

Procedural Fidelity	_____/_____ (steps for # total questions asked) _____% (7Q = 19 steps; 8Q = 21 steps; 9Q = 23 steps; 10Q = 25 steps)

Appendix I. Social Validity Survey

1. Have you observed the participants using the IVA outside of the study sessions?

2. What purposes have you observed these students using the IVA for?

3. Do you perceive the IVAs to be helpful for any of the participants in school?

4. Do you think the IVAs will help your students be successful in any other environments?

5. Do you perceive the IVAs to be disruptive or used excessively by any of the participants?

6. Overall, do you feel that self-instructing with IVAs in the classroom is an acceptable intervention for students?

REFERENCES

Amazon. (n.d.) *Alexa Accessibility.* https://www.amazon.com/b/?node=21101808011&ref=pe_alxhub_aucc_en_us_NV_L4_0_HUB_ACC

American Association for Intellectual and Developmental Disabilities (AAIDD). (2023). *FAQs on Intellectual Disability.* https://www.aaidd.org/intellectual-disability/faqs-on-intellectual-disability

Apple. (n.d.). *Accessibility*. https://www.apple.com/accessibility/mobility/

American Psychiatric Association (APA). (2013). *Diagnostic and Statistical Manual of Mental Disorders (DSM-5®)*. American Psychiatric Publishing.

Baldauf, M., Bosch, R., Frei, C., Hautle, F., Jenny, M. (2018). Exploring requirements and opportunities of conversational user interfaces for the cognitively impaired. In *Proceedings of the 20th International Conference on human-computer interaction with mobile devices and services adjunct* (pp. 119–126). ACM. https://doi.org/10.1145/3236112.3236128

Barton, E. E., Lloyd, B. P., Spriggs, A. D., & Gast, D. L. (2018). Visual analysis of graphic data. In D. L. Gast & J. R. Ledford (Eds.), *Single case research methodology: Applications in special education and behavioral sciences* (3rd ed., pp. 179-214). Routledge.

Burke, S. L., Wagner, E., Marolda, H., Quintana, J. E., & Maddux, M. (2019). Gap analysis of service needs for adults with neurodevelopmental disorders. *Journal of Intellectual Disabilities, 23*(1), 97–116. https://doi.org/10.1177/1744629517726209

Browder, D. M., & Shapiro, E. S. (1985). Applications of self-management to individuals with severe handicaps: A review. *Journal of the Association for Persons with Severe Handicaps*, *10*(4), 200– 208. https://doi.org/10.1177/154079698501000

Calzi, M. N. (2020) Progressive time delay to teach high school students with intellectual disability to initiate manding Siri® for unknown information. *Theses and Dissertations—Early Childhood, Special Education, and Rehabilitation Counseling*, *82*. https://uknowledge.uky.edu/edsrc_etds/82

Dollar, C. A., Fredrick, L. D., Alberto, P. A., & Luke, J. K. (2012). Using simultaneous prompting to teach independent living and leisure skills to adults with severe intellectual disabilities. *Research in Developmental Disabilities*, *33*(1), 189– 195. https://doi.org/10.1016/j.ridd.2011.09.001

Emerson, E., Felce, D., & Stancliffe, R., J. (2013). Issues concerning self-report data and population-based data sets involving people with intellectual disabilities. *Intellectual and Developmental Disabilities*, *51*(5), 333–348. https://doi.org/10.1352/1934-9556-51.5.333

Fuld, H. (2019, October 31). Voiceitt: Using AI to give a voice to those who need it most. *The Jerusalem Post*, 16. https://www.jpost.com/opinion/voiceitt-using-ai-to-give-a-voice-to-those-who-need-it-most-606499

Gacek, M., Smoleń, T., & Pilecka, W. (2017). Consequences of learned helplessness and recognition of the state of cognitive exhaustion in persons with mild intellectual disability. *Advances in Cognitive Psychology*, *13*(1), 42–51. https://doi.org/10.5709/acp-0205-6

Gast, D. L., Lloyd, B. P., & Ledford, J. R. (2018). Multiple baseline and multiple probe

designs. In J. R. Ledford & D. L. Gast (Eds.), *Single case research methodology: Applications in special education and behavioral sciences* (3rd ed., pp. 239-281). Routledge.

Gast, D. L., & Ledford, J. R. (2018). Research approaches in applied settings. In J.R. Ledford & D. L. Gast (Eds.), *Single case research methodology: Applications in special education and behavioral sciences* (3rd ed., pp. 1-26). Routledge.

Haigh, A., Lee, D., Shaw, C., Hawthorne, M., Chamberlain, S., Newman, D. W., & Beail, N. (2013). What things make people with a learning disability happy and satisfied with their lives: An inclusive research project. *Journal of Applied Research in Intellectual Disabilities*, *26*(1), 26– 33. https://doi.org/10.1111/jar.12012

Lancioni, Singh, N. N., O'Reilly, M. F., Sigafoos, J., Alberti, G., Del Gaudio, V., Abbatantuono, C., Taurisano, P., & Desideri, L. (2022). People with intellectual and sensory disabilities can independently start and perform functional daily activities with the support of simple technology. *PloS One*, *17*(6), e0269793–e0269793. https://doi.org/10.1371/journal.pone.0269793

Lancioni, G. E., Singh, N. N., O'Reilly, M. F., Sigafoos, G. A., Campodonico, F., Acquaviva, G., Chiariello, V., & Desideri, L. (2022). Persons with intellectual and multiple disabilities activate via non-verbal responses a smartphone's Google Assistant to access preferred stimulation. *International Journal of Developmental Disabilities*, *68*(4), 518-527. https://doi.org/10.1080/20473869.2020.1827213

Ledford, J. R., Barton, E. E., Severini, K. E., & Zimmerman, K. N. (2019). A primer on

single-case research designs. *American Journal on Intellectual and Developmental Disabilities, 124*(1), 35-56. https://doi.org/10.1352/1944-7558-124.1.35

Ledford, J. R., Lane, J. D., & Gast, D. L. (2018). Dependent variables, measurement, and reliability. In J. R. Ledford & D. L. Gast (Eds.), *Single case research methodology: Applications in special education and behavioral sciences* (3rd ed., pp. 97-131). Routledge.

Pew Research Center (2017). Nearly half of Americans use digital voice assistants, mostly on their smartphones. Retrieved from https://www.pewresearch.org/fact-tank/2017/12/12/nearly-half-of-americans-use-digital-voice-assistants-mostly-on-their-smartphones/

Pradhan, A., Mehta, K., & Findlater, L. (2018). "Accessibility came by accident": Use of voice intelligent personal assistants by people with disabilities. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems.* (p. 459). ACM. https://doi.org/10.1145/3173574.3174033

Saad, M. A. E., & ElAdl, A. M. (2019) Defining intellectual disability (intellectual developmental disability): Insights from DSM-5. *International Journal of Psycho-Education Sciences, 8*(1), 51-54. https://files.eric.ed.gov/fulltext/ED594326.pdf

Sandjojo, J., Gebhardt, W.A., Zedlitz, A.M., Hoekman, J., den Haan, J.A. & Evers, A.W. (2019). Promoting independence of people with intellectual disabilities: A focus group study perspectives from people with intellectual disabilities, legal representatives, and support staff. *Journal of Policy and Practice in Intellectual Disabilities, 16*(1), 37-52. https://doi.org/10.1111/jppi.12265

Shepley, S. B., Spriggs, A. D., Samudre, M. D., & Sartini, E. C. (2019). Initiation and generalization of self-instructed video activity schedules for elementary students with intellectual disability. *The Journal of Special Education, 53*(1), 51-62. https://doi.org/10.1177/0022466918800797

Terzopoulos, G., & Satrazemi, M. (2020). Voice assistants and smart speakers in everyday life and in education. *Informatics in Education, 19*(3), 473-490. https://doi.org/10.15388/infedu.2020.21

Winborn, L., Wacker, D. P., Richman, D. M., Asmus, J., & Geier, D. (2002). Assessment of mand selection for functional communication training packages. *Journal of Applied Behavior Analysis, 35*(3), 295–298. https://doi.org/10.1901/jaba.2002.35-295

VITA

Taylor Rae Kelley

Direct Support Professional 2012-2021

Berea College 2016-2020

Bachelor of Arts in Psychology and Disability Studies