Supporting the Implementation of Behavioral Interventions using a Smart Technology Platform

by

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Abstract

A smart technology platform that guides behavior-change agents in the implementation of behavioral interventions may be useful for maintaining high, long-term treatment fidelity. The current study evaluated (a) whether the smart technology platform is effective in increasing and maintaining high levels of treatment fidelity in untrained individuals, and (b) whether behavioral interventions implemented with the support of the smart technology platform promote the acquisition or generalization of skills by children with autism. Two experiments were conducted at a university-based autism clinic. Participants were five untrained staff and three children with autism. The results of Experiment 1 show that participants' treatment integrity increased by 20% on average when it was guided by the smart technology platform. However, there was no increase in the children's correct responding compared to the baseline. The results of Experiment 2 indicated that the participants' treatment integrity increased by 30% and 32% when guided by the smart technology platform, again with no increase in the children's correct responding compared to the baseline. Maintenance probes conducted 6 weeks after the last session in Experiment 2 indicated that the smart technology platform maintained the same level of treatment integrity for both participants. The results of this study suggest the smart technology platform may be a useful tool for increasing and maintaining high levels of treatment fidelity in untrained individuals.

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Chapter 1

Literature Review

Autism spectrum disorder (ASD) is a developmental disability associated with deficits in communication, social interactions, and restrictive, repetitive behaviors (American Psychiatric Association, 2013). In 2018, the overall ASD prevalence in the United States per 1,000 children aged 8 years was 23, which means that one in 44 children is diagnosed with ASD (Maenner et al., 2018). At present, there are no cures available for ASD; however, a timely start of therapy can significantly improve a child's adaptive and communication skills and enhance the quality of life of the child and their family, thereby making the prognosis for their further development and socialization more optimistic (Educating Children with Autism, 2011).

Currently, Applied Behavior Analysis (ABA) is considered the most effective and scientifically validated approach to improving deficits related to ASD (National Autism Center, 2015). ABA uses the principles of behavior to improve the socially significant behavior of individuals (Cooper et al., 2020). It includes several tools that have been well researched and shown to be effective and therefore considered "evidence-based," including discrete trial training, reinforcement, prompting, picture exchange communication system, and others (Wong et al., 2015).

Early Intensive Behavioral Intervention

One of the more established treatments based on the principles of ABA for children with ASD is Early Intensive Behavioral Intervention (EIBI). EIBI involves the delivery of individualized behavioral interventions and promotes learning, skill development, and behavior change and is typically delivered for several years for 20 to 40 hr per week (Reichow et al., 2014). A systematic review by Reichow et al. (2014) showed that EIBI is effective in increasing adaptive behaviors, daily living skills, IQ level, and measures of

communication and language skills in children with ASD. However, to maintain the effectiveness of the intervention, the treatment has to be implemented with high fidelity (Mandell, 2013); requiring services to be delivered by highly trained individuals with expertise in behavioral services.

For EIBI intervention to be the most effective, it is crucial for children to start therapy at a young age and for the intensity of therapy to be based on medical necessity (Georgia Institute of Technology, 2022). Granpeesheh et al. (2009) evaluated treatment progress for 245 children from different age groups receiving ABA therapy and concluded that the younger a child was at the start of services the more effective the intervention would be, even with low intensity. Additionally, for children 2 to 7 years old, an increase in treatment intensity, defined as hours per week of intervention for up to 42 hr per week in total, leads to an increase in the mastery of the new skills. For children ages 7 to 11, however, the increase in intervention intensity does not influence their progress. This means that maximizing the intensity of ABA therapy in younger kids can lead to long-term improvements and more positive treatment outcomes. Perry et al. (2011) conducted an analysis of the predictors of outcomes of the ABA treatment for 332 children ages 2 to 7 and found that younger kids who were in the treatment longer achieved better progress. Moreover, Piccininni et al. (2017) in their study on the economic effect of wait times for ABA treatment for children with ASD concluded that the sooner a child with ASD has access to behavioral treatment, the better the effectiveness of the treatment in relation to the person's independence. Further, Piccininni et al. also found that early intervention is linked to lower projected lifetime costs of behavioral services.

Usually, EIBI intervention is delivered in a tiered service-delivery model by behavioral technicians directly supervised by a board-certified behavior analyst (The Council of Autism Service Providers, 2020). Thus, behavior analysts are responsible for designing

and monitoring treatment programs for clients, whereas behavioral technicians are responsible for directly implementing those programs with clients. Onboarding, training, monitoring, and supervising direct-line staff is very resource intensive and requires the availability of behavior analysts to properly oversee and support staff (Luczynski et al., 2014).

Barriers to Access Behavioral Interventions

In the United States, there are currently not enough trained behavior analysts or specialists to serve the entire population with autism and developmental disabilities. Zhang and Cummings (2019) analyzed data from the Behavior Analyst Certification Board for 2018. They compared the number of certified behavior analysts in each state to the benchmark established by the Board and concluded that the supply of behavior analysts is variable across states and is insufficient in 49 states. That is, the number of ABA professionals is not adequate to meet the needs of the population of children with ASD in most of the states across the country. This disparity is even more evident in rural and remote communities (e.g., Antezana et al., 2017; Sapiets, 2021; Scarpa et al., 2020). Mello et al. (2016) compared the accessibility of services for children with ASD living in rural and non-rural counties and found there was a smaller percentage of behavior specialists present in these communities. Overall, families living in rural areas must travel longer distances to receive behavioral treatment for their children and have a lower perception of the effectiveness of the treatment. Given the increase in the number of children diagnosed with autism annually (Centers for Disease Control and Prevention, 2012) and the continued need for services for adolescents and adults with ASD (Dudley, 2019), the disparity among the number of service providers available and the number of individuals needing services continues to grow.

Another barrier that limits access to ABA services is the high cost for families and the government. Early behavioral intervention for one child with ASD costs $40,000 per year on

average, ranging from $20,000 to $60,000 (Chasson et al., 2007). Buescher et al. (2014) analyzed the economic burden of services for individuals with ASD and concluded that the average lifespan cost for supporting each individual with ASD was $1.4 to $2.5 million. The main part of those expenses was for special education services and parental productivity loss. Considering the growing population with ASD diagnoses in the US, by 2025, the annual costs would be $461 billion and would exceed annual expenses for conditions such as diabetes and Attention-deficit/hyperactivity disorder (Leigh & Du, 2015). However, it is important to note that without behavioral interventions, the costs across the lifespan of each individual with ASD might be much greater. Chasson et al. (2007) compared the costs for 18 years of special education to 3 years of EIBI in the state of Texas. The researchers concluded that the state would save $208,500 per child by implementing the early intervention. An analysis conducted by Cooper (2021) with data from North Carolina obtained similar results, indicating that the average annual saving per child would be $250,000.

In a study by Sallows and Graupner (2005), a caregiver-implemented EIBI alternative decreased the costs of the treatment by almost half from $40,000 to $22,500 per child per year. Sallows and Graupner compared two groups of children with ASD: one group was receiving EIBI in the clinical setting by trained clinicians and the other group was receiving the same intervention from their caregivers, who were receiving supervision from a behavioral specialist once every 2 weeks for 3 hr. Both groups of children demonstrated approximately similar increases in IQ scale, language, adaptive, and communication skills, suggesting trained and supervised caregivers might be an effective and less costly substitute for clinic-based and expert-delivered ABA intervention.

Moreover, a study by Leonardo et al. (2011) indicated that children whose caregivers were involved in the treatment process and implemented behavioral programs additionally at home outperformed children who were only receiving behavior treatment in a clinic with a

therapist, as demonstrated by progress on a variety of skills and challenging behaviors. Relatedly, Strauss et al. (2012) concluded that caregiver inclusion in child intervention significantly affected the intervention outcomes leading to improvement in measures of autism severity, and developmental and language skills. It is worth noting, however, that high treatment integrity was promoted by caregiver training and constant supervision of program implementation, leading to a decrease in challenging behavior and an increase in correct responding in their children with ASD. Overall, caregiver involvement in the implementation of a behavioral intervention to a child with ASD offers a viable alternative to mitigate barriers such as lack of ABA clinicians or resources, high therapy costs, and interruption of therapy due to external circumstances.

Behavior Change Agents

In many cases, the only direct-line behavior change agents available for some children, particularly in remote and underserved communities, are caregivers, teachers, and other paraprofessionals working with the child in school and home settings. One way to alleviate the difficulty accessing services is to harness the existing resources of the behavior change agents already in the child's environment. One limiting factor, however, is these individuals typically have little to no training in behavior analysis. There are many demonstrations in the literature of caregivers and other non-ABA paraprofessionals successfully being trained to implement behavioral interventions with children (e.g., Bessette & Wills, 2007; Gillett & LeBlanc, 2007; Lafasakis & Sturmey, 2007; Lindgren & Wacker, 2016; McCammon et al., 2021; Reagon & Higbee, 2009; Ruppel et al., 2021; Walker et al., 2021). Even with some training, for the implementation of behavioral programs to be delivered with high fidelity resulting in positive clinical outcomes, these individuals would require support from behavior analysts.

One option for this oversight is to provide supervision and support via telehealth (Bloomfield et al.,2021). Even though telehealth consultations with behavior analysts are less costly and provide a way to coach and support behavior-change agents implementing behavioral interventions, there are several obstacles to telehealth treatment (Rios et al., 2018). One of the main obstacles to providing telehealth consultations is that it still requires a behavior analyst to be available synchronously during the call. In an attempt to mitigate this barrier, researchers have evaluated providing support to caregivers and implementers via asynchronous remote means. Gerencser et al. (2020) highlighted several asynchronous training methods: providing self-studied written instructions with role-playing and content assessment parts, video modeling with demonstrated target behavior, and interactive computer-based training provided through the Internet that includes all previous training methods. For instance, Wainer and Ingersoll (2013) analyzed the effectiveness of a self-directed, internet-based, distance-learning program for caregivers aiming to teach imitation skills to their kids with ASD. The average amount of time that took participants to complete the program was two weeks. Results indicated that self-directed distance-learning programs might be an effective substitute for in-person caregiver training.

Online manualized training is another approach for coaching caregivers and staff remotely. Novotny et al. (2020) provided caregivers with children with ASD access to website-based training on how to teach their children safety skills. Most of the caregivers implemented the intervention with high fidelity after the web-based training and all children showed improvement in safety skills. Relatedly, Blackman et al. (2020) compared the effectiveness of web-based self-paced training modules to in-vivo caregiver training implemented for six weeks each and found that both delivery methods were equally effective in improving caregiver interactions with their child and increasing caregiver knowledge of ABA strategies. Higbee et al. (2016) also demonstrated that interactive computer training was

effective in training students and professionals to implement behavioral teaching procedures. For most of the participants, however, additional feedback was necessary to master the procedures.

Supporting Behavior Change Agents

Although caregivers and other implementers of behavioral programs can achieve high levels of treatment fidelity from remote, asynchronous coaching, the training takes time which can delay the beginning of the intervention for a child or become another obstacle to the treatment. Moreover, even when training is completed, there is often no other source of support from experts (Cook et al., 2022). This might create an obstacle to the long-term maintenance of high treatment fidelity of interventions implemented by non-experts. Technological tools can help support the implementation of ABA services by caregivers and other behavior-change agents (e.g., behavior technicians, paraprofessionals) without the need for preceding extensive training and direct support and guidance from a trained professional during every interaction with the child. Although a technological tool cannot fully substitute a trained professional, it can help alleviate barriers to services in some communities.

Implementation of Behavioral Interventions Using Smart Technology Platform

Unfortunately, to date, no research has evaluated technologies that can assist untrained caregivers and other behavior-change agents to implement ABA interventions providing them with real-time guidance. A recently developed smart technology known as GAINS (Guidance, Assessment, and Information System) could help facilitate the accurate implementation of behavioral interventions by non-experts. The system consists of a website that can be accessed from an Internet browser and an app that can be installed on any portable device such as an Android® or Apple® based smartphone or tablet. Via the website, behavior analysts choose and customize behavior programs based on a client's individual needs and assign those programs to implementers (e.g., caregivers, behavior technicians).

Customization of skill acquisition programs is possible by modifying targeted skills, instructions, and a number of trials, prompts fading, and skill mastery criteria for two classes of ABA procedures: discrete trial teaching (DTT) and task analysis (TA). An example of program customization is illustrated in Figure 1.

The primary purpose of this technology is to help facilitate access to behavioral services for children with ASD without sacrificing the integrity of the intervention. With the technology guiding implementers to accurately deliver the ABA intervention, behavioral services could be started earlier because families would not have to wait for the availability of a trained implementer. The same is true for families who live in areas without local trained providers. The high cost of the ABA intervention could also be significantly reduced, as behavior analysts would not need to monitor every session synchronously but instead would review data and provide consultation as needed. In addition, it is possible that the generalization of skills to the natural environment would be facilitated as skills would be taught by people who spend the most time with the child in natural settings (e.g., home, school).

Despite all the potential benefits of such a technological tool, there is still no empirical support for its utility. Thus, the purpose of the current project was two-fold:

1. Evaluate the effectiveness of the smart technology platform GAINS in guiding and supporting implementers (i.e., caregiver or untrained clinician) in the delivery of ABA programs with high fidelity.

2. Evaluate whether behavioral interventions implemented with the support of GAINS promote the acquisition or generalization of skills by children with ASD.

Chapter 2

Experiment 1

The purpose of this study was to evaluate whether the treatment integrity demonstrated by participants when their performance was guided by the smart technology platform GAINS would improve relative to when their performance was guided by a paper protocol. A non-concurrent multiple baseline across participants research design was used in this experiment.

Method

Participants. The participants were three student clinicians who volunteered at a university-based EIBI clinic to learn how to work directly with a child in a clinical setting. All had little to no previous experience implementing behavioral interventions, were able to follow written and vocal multistep instructions, and were fluent in English (the language used for instructions). Children involved in the study were two boys with ASD between the age of 3 to 4 years who at the moment of the study received an ABA intervention for 9 to 11 hr per week at the university-based EIBI clinic. Before the start of the study, all participants gave their consent to participate and for video recordings to be used by researchers for data coding. For the children participants, their caregivers gave their written consent for their child to participate in the research activities conducted at the clinic. Participants were informed they could withdraw from the study at any time and that this would not affect their educational opportunities. The demographic information of the participants is in Tables 1 and 2.

Experimental Design and Dependent Variables. A single case, two-tier nonconcurrent multiple baseline across participants research design was used for Experiment 1 (Barlow & Hersen, 1984). The multiple baseline design was chosen as the skills that were taught during the training could not be readily withdrawn or reversed (Baer et al., 1968). A nonconcurrent multiple baseline design was used as the data for every participant was not

collected simultaneously to account for variables beyond the researcher's control (e.g., client's attendance, and implementers' availability; Harvey et al., 2004). To control for the threat of maturation, phase change from the baseline to treatment condition took place at significantly varied intervals across all three participants, thus each participant experienced a different period of maturation before the phase change occurred: the same day between baseline and treatment conditions and 3 weeks between the initial and updated treatment conditions for Maggie, one month for Zyon, and 5 days for Jane (Slocum et al., 2022).

First, each participant experienced the baseline condition. For the first participant, 3 baseline data points were collected, and as soon as the data path did not show any increasing trend, the GAINS treatment condition for this participant was introduced, and the same pattern was applied to the other two participants. However, due to the lower level of treatment integrity, one of the participants did not terminate the session after the child's attempt to leave the instructional area during the Manding program, resulting in a higher number of baseline sessions. Thus, for two participants the length of the baseline condition consisted of 5 sessions. Each session consisted of 5 trials.

The independent variable was the method of the delivery of the instructions to the participant – printed paper protocol (baseline) or GAINS app (intervention). The main dependent variables were the participants' correct implementation of the behavioral intervention (i.e., treatment integrity) and the child's correct responses. The child's engagement in challenging behavior was also scored using the momentary time sampling data recording method with 10 s intervals to calculate a percentage of the session a child engaged in challenging behavior.

Procedure

Baseline. Prior to the start of the baseline phase, all participants received brief 5 to 10 min verbal instructions on how to implement behavioral interventions. Instructions consisted

of explanations of how many trials should be conducted for each program, what items to use as potential reinforcers, and a brief description of the contents of the protocol (e.g., presentation of a discriminative stimulus, target response, prompting, and consequences). The tangibles that were used as potential reinforcers for children's correct responses were identified using preference assessment procedures conducted by each child's primary clinician prior to the beginning of the study. Next, participants were given an opportunity to clarify and ask questions but no further instructions on how to implement the protocols were provided. Each participant was given a printed copy of the protocol, instructions for recording and scoring sessions, and data sheets. During the baseline phase, participants implemented a specific skill acquisition program that clinicians working with the child identified as an area in need of further instruction (e.g., manding or listener responding, see Appendices A and B for sample written programs used during baseline). Before introducing the treatment condition for the first tier, the baseline phase was implemented for at least three sessions until there were no increasing trends in the responding.

Treatment. Figures 2 and 3 illustrate the visual guidance provided by the app for the treatment condition for a task analysis program to teach manding and listener response. The same protocol as the one used during baseline was used during this condition.

The GAINS app can be programmed to provide several options for scoring trials. In Figs. 2 and 3, if a participant responds correctly, the user taps the green '+' and the app moves to the next step (bottom left). If the participant responds incorrectly or does not respond, the user taps the red '-' and the app provides additional guidance by instructing the user to provide a prompt (bottom right). To promote treatment fidelity, the program updates automatically based on the pre-determined and programmed prompts, mastery criteria, and recorded participant responses.

As in baseline, sessions were video recorded and uploaded to Box for scoring of treatment integrity, child's correct responding and challenging behavior, and to calculate interobserver agreement.

Treatment Integrity

Treatment integrity was scored for each baseline and treatment session by one of the researchers using a treatment integrity checklist while watching video recordings of the sessions. The treatment integrity checklist consists of six to nine statements following the program procedure (e.g., The instructional area is clear of distractors; get child's attention; wait for 5 sec for the child's independent response, etc.). Each trial conducted by participants was scored as "yes" or "no" for each of the statements (see Appendix C for the sample treatment integrity checklist used for the imitation program in Experiments 1 and 2). The number of positive responses was then calculated and converted to percent correct.

Interobserver Agreement

Interobserver agreement (IOA) was calculated for the treatment integrity data and was scored by a trained independent, secondary observer who reviewed video recordings of at least 40% of the sessions conducted during the baseline and treatment phases for each participant across both experiments. IOA was calculated to evaluate the reliability of collected data and to prevent biases while comparing the participant's responses during baseline and treatment phases (Cooper et al., 2020).

The IOA data for Maggie and Jane were obtained by event recording. The total count was expressed as a percentage of agreement between the total number of responses recorded by two observers. Thus, to calculate IOA, the data sheets filled out by the first observer and the second independent observer were analyzed by counting all the correct independent responses and then the smaller of the count was divided by the larger count and multiplied by 100. The mean IOA for Maggie and Jane was 93% (range, 86% to 97%). For Zyon's

treatment integrity, the agreement was obtained by total count IOA and calculated by dividing the smaller percent of Zyon's correct responding by the larger percent scored by the primary and the secondary observers and then multiplied by 100. The mean IOA for Zyon was 97% (range, 95% to 99%).

Results

The results of Experiment 1 for all three participants (Maggie, Zyon, and Jane) are shown in Figure 4 in the non-concurrent two-tier multiple baseline design graph. For Maggie who was conducting the listener response program with Jared, the initial level of treatment integrity was relatively high (M=71%), and the introduction of the GAINS condition did not improve the treatment integrity significantly (M=73%). Anecdotally, researchers observed that Maggie's errors were stemming mainly from inaccurate operational definitions of the target behaviors. The instructions in the GAINS app were modified and more detailed operational definitions and the procedure were added. This modification resulted in an increase in Maggie's treatment integrity to 85% correct responding on average. The child's correct responding was gradually increasing across the whole period of the program implementation provided by Maggie and did not increase after the researchers modified the instructions which resulted in an increase in the clinician's treatment integrity. This continuation of a baseline pattern of responding that persisted during the treatment phase could be explained by the "transition state" phenomenon. According to Brogan et al. (2019), the transition state can last for 4.9 sessions on average prior to eliciting any behavior change. Additionally, in the study by Brand et al. (2019), the initial exposure to treatment integrity errors produced distinctive and enduring effects on the clients' performance and sometimes resulted in delays in skill acquisition even after the intervention was delivered with a high level of integrity.

For Zyon who was conducting the listener response program with Gary, the level of correct implementation increased from the initial 54% with the printed program to 70% of correct responding with the GAINS app and was stable during each condition. The child's level of correct responding decreased rapidly after the first session of the paper program condition was implemented and then stayed at the approximately same level throughout the entire period of program implementation (10% and 15% of correct responding during the paper program and GAINS conditions respectively).

Jane's performance implementing the manding program with Gary with the printed instructions showed a decreasing trend and was 56% on average (from the initial 75% down to 35% of correct responding). After the introduction of the GAINS condition, the clinician's performance increased to the mean of 85% correct responding (range, 79% to 91%). The child's independent correct responding showed a high degree of variability across both conditions, but the average level of correct responding increased from 30% during the paper program condition to 68% correct responding during the GAINS condition.

Given that a client's challenging behavior can interfere with an instructor's ability to implement behavioral programming effectively (Berdeaux et al., 2022), researchers collected data on clients' challenging behavior as defined in their individual behavior intervention plans throughout the study. The level of challenging behavior displayed by each child was variable across all three participants, programs, and conditions. There was no systematic relation between participants' treatment integrity and clients' challenging behavior (see Figure 5).

The general results of Experiment 1 indicated some level of effectiveness of the GAINS app in increasing participants' treatment integrity. However, two of the implementers who participated in the study were enrolled in the graduate ABA course and had some training in behavior analysis but little experience implementing behavioral interventions

before their participation in the study, which could still affect their performance and the results obtained. Additionally, a two-tier nonconcurrent multiple baseline across participants research design used in Experiment 1, did not demonstrate the strongest experimental control as it did not provide sufficient consistent and replicated changes of the main dependent variable (Kazdin, 2020). To increase the level of experimental control and account for variables such as the threat of coincidental events, as well as to add across-tier comparisons (Slocum et al., 2022), another experiment using a different research design was run with novel participants who had no previous experience or training in behavior analysis.

Experiment 2

In Experiment 1, participants' treatment integrity had modest increases when the smart technology platform was implemented. Because there were no within-participant comparisons, there are limitations regarding the conclusions one can draw regarding whether these increases were a result of the intervention. The purpose of this study was to further evaluate the smart technology platform GAINS using a multiple baseline across skills research design, which allowed for within-participant comparison of treatment integrity.

Method

Participants. The participants were 2 student clinicians recruited from a university-based EIBI clinic to work directly with a child in a clinical setting. Neither participant had previous experience implementing behavioral interventions, were able to follow written and vocal multistep instructions, and were fluent in English (the language used for instructions). Children involved in the study were two boys with ASD 2 and 4 years old who at the moment of the study received an ABA intervention at the university-based EIBI clinic. Before the start of the study, all participants gave their consent to participate and for video recordings to be used by researchers for data coding. For the children participants, their caregivers gave their written consent for their child to participate in the research activities conducted at the

clinic. Participants were informed they could withdraw from the study at any time and that this would not affect their educational opportunities. The demographic information of the participants is in Tables 1 and 2.

Experimental Design and Dependent Variables. A single case, three-tiered concurrent multiple baseline across programs research design was used for 2 participants to determine the effects of independent variables across three skill-acquisition programs (Byiers et al., 2012; Rapp et al., 2011). The multiple baseline design was chosen as the skills that were taught during the training could not be readily withdrawn or reversed (Baer et al., 1968). Concurrent multiple baseline across programs design was used to ensure that the change in implementers' performance was not simply a practice effect due to longer exposure to the intervention (Coon & Rapp, 2018). For participant Anna, the reversal phase was introduced for the first program (Listener Response) to evaluate whether the introduction of the app condition would affect the clinician's performance with the paper program and whether the conditions have an effect on the child's performance and engagement in challenging behavior.

First, for each participant, two sessions aiming to establish rapport with the assigned child were conducted for two days lasting 60 to 90 minutes each. During those sessions, each participant was instructed to "observe the clinician's work with the child and join them for the play activities during the client's free time". Each participant and clinic staff member were instructed that the main goals during those first two appointments were for the participant to: build a rapport with a child (pairing); identify their potential reinforcers; observe and learn how to handle noncompliance, elopement, and other minor challenging behaviors to minimize these behavior interfering while implementing the programs with the child independently. Clinic staff were also instructed not to provide any teaching or explanation of any teaching programs to the participants. The instruction document that was

used to familiarize participants and the staff members with the goals and procedures of this study is included as Appendix D. This document was emailed to the clinic's staff members and participants one week prior to the start of the data collection and was discussed in person with each participant the same day before the first observation session.

The clinic's staff member was present during each participant-child interaction, and one of the researchers was present during each teaching session and video recorded the sessions. A personal phone or a tablet was used to record videos of each session to determine how accurately participants implement the intervention and calculate treatment integrity. These recordings were used to score the child's independent, correct responses and challenging behavior across sessions.

The same dependent variables as in Experiment 1 were used for this study.

Procedure

Baseline. This condition was conducted in the same manner as described in Experiment 1. After participants observed their assigned child's sessions across two days, each participant experienced the baseline condition with the printed program for all three skill-acquisition programs. Three programs were identified and prepared for each child by their primary clinicians based on the child's deficits and were modified by the author to match the programming in the app. Anna implemented Listener Response, Intraverbal, and Imitation programs with Gary, and Helen implemented Listener Response, Imitation, and Visual Matching programs with Milo (see Appendices E and F for examples of the programs used during baseline in Experiment 2). The tangibles used as reinforcers for children's correct responses were identified using preference assessment procedures conducted by each child's primary clinician prior to the beginning of the study. At least three baseline sessions were conducted for each participant, each data point representing one session consisting of five trials. As soon as the performance of one of the programs reached a steady state condition

(showed no increasing trend), the researcher introduced the GAINS condition for this program, while continuing to collect baseline data for the two remaining programs.

Treatment. Participants began the intervention phase in a stepwise manner, as per the concurrent multiple baseline experimental design. During this phase, participants continued to implement two of three skill acquisition programs in the baseline condition, while starting to implement the third program in the treatment condition. This third program was the same skill acquisition program as in baseline with the exception that instead of using a paper version of the protocol and data sheet, participants used the GAINS app for guidance and data collection. Researchers set up the GAINS app on a tablet with the skill acquisition programs for each child. The GAINS app provided step-by-step instructions to the participant regarding what to do and/or say at each step of the trial (e.g., setting up, delivering instruction, prompting, reinforcing). The information presented via the app matched the information presented to participants on the paper protocol. The GAINS app also allowed the implementer to collect data on the child's performance. Researchers offered participants visual and/or auditory via headphones options for receiving instructions from the GAINS app during the treatment condition. Anna used visual instructions for the Listener response and Intraverbal programs, and visual and auditory instructions with the Imitation program. Helen used visual and auditory instructions for all three programs.

The criteria for the treatment integrity to move to the maintenance probes was 80% correct across two consecutive sessions for both participants. Most of the studies that evaluated the effects of the implementers' level of treatment integrity on clients' skill acquisition, primarily assessed the impact of the error type or 0%, 50%, or 100% of treatment integrity on the skill acquisition or behavior reduction in clients, and generally concluded that the higher level of treatment integrity resulted in faster and successful skill acquisition in clients (Brand et al., 2019; DiGennaro Reed et al., 2011; Fryling et al., 2013; Groskreutz et

al., 2011). The results of the study by Falakfarsa et al. (2023) showed that 80% treatment integrity produced corresponding effects on the participants' correct responding as 100% treatment integrity.

Interobserver agreement

The same procedure to obtain interobserver agreement (IOA) for the main dependent variable as in Experiment 1 was used in this experiment. At least 40% of the sessions were scored by the secondary observer to obtain IOA.

For Experiment 2, the mean IOA for Anna for the Listener response program was 96% (range, 89% to 100%), and for the Intraverbal and Imitation programs 98% (range, 96% to 100%). The mean IOA for Helen was 98% (range, 95% to 100%) for the Listener response program, 99% (range, 97% to 100%) for the Imitation program, and 97% (range, 89% to 100%) for the Visual matching program.

Results

Figure 6 displays Anna's percentage of procedural steps completed accurately as well as the percentage of the child's correct responding and engagement in challenging behavior across all three programs. The gap after session 29 in the Listener Response program and before session 30 in the Intraverbal program on the graph (Fig. 6) occurred due to technological difficulties preventing researchers from scoring the permanent product of sessions 32 (Listener Response), 5, 24, 27 (Intraverbal), and 17 (Imitation).

Anna's performance during the baseline condition implementing the listener response program was 45% on average and showed a decreasing trend, and after the GAINS condition was introduced, there was a rapid increase in the performance accuracy to an average of 82% correct (ranging from 76% to 95% correct responding), indicating a 37% increase in the treatment integrity. When the paper program condition was reintroduced after exposure to the app condition, the participant's treatment integrity increased to 85% correct responding per

session on average. The mean percentage of performance accuracy with the printed program for the second program (Intraverbal) was 64% and after the GAINS condition was introduced, the performance accuracy increased to 85% on average, indicating a 20% increase in the treatment integrity compared to the baseline. The treatment integrity during the baseline condition for the last Imitation program was 62% and after the introduction of the GAINS condition, the participant's performance increased to 95% on average, indicating a 30% increase in the performance accuracy compared to the paper baseline condition. Generally, the GAINS condition improved the Anna's performance across all three programs by 20 to 37%.

The child's performance for the listener response program worsened after the GAINS condition was introduced (from the mean 61% to the mean 34% of correct responding) and improved again after the paper condition was introduced the second time (from the mean 34% to the mean 53% of correct responding). It is important to note that the percentage of child's engaging in challenging behavior increased with the worsening of the child's performance and decreased with the improvement of the child's performance (from a mean of 26% during the baseline to 53% during the first time the GAINS condition was introduced, back to 23% when the baseline condition was reintroduced, and to 47% with the reintroduced GAINS condition). However, the integrity of the program implementation increased even though the child's performance was worsening and the engagement in challenging behavior was increasing, indicating a high level of control of the GAINS condition over the clinician's behavior. For the intraverbal program, the child's correct responding was at 0% across all conditions. For the imitation program, the child's performance slightly improved (from the mean 16% of correct responding to the 33%) after the introduction of the app condition and with the increase of the clinician's treatment integrity. Anna maintained the same level of

treatment integrity across all three programs when the maintenance probes were conducted 6 weeks after the last session of the GAINS app condition.

Anecdotal observations suggested the child's challenging behavior during sessions (e.g., attempts to grab materials or elope) could have interfered with the participant's ability to implement the protocol. To evaluate whether this was the case, the participants' percentage of correct treatment integrity was plotted as a function of the percentage of the session the child was engaging in challenging behavior (Figures 7 and 8). There was a systematic relation between the participant's treatment integrity and the child's challenging behavior for the Imitation program, and no systematic relation for the two other programs (Listener response and Intraverbal). It is possible that this relation during the Imitation program occurred as it was the only program that was run with the audio instructions provided through the headphones to guide Anna during the GAINS app condition instead of the visual written instructions that she was reading from the screen for the other two programs. This resulted in a lower level of the child's challenging behavior as the child did not attempt to grab the tablet while the participant was using the GAINS app as it happened with the other two programs where Anna was holding a tablet in her hands or within her reach to read the instructions from the screen.

The results for Anna indicate an overall effectiveness of the GAINS app in improving the participant's performance for all three programs (from 60% correct on average during the paper program condition to 85% correct on average during the GAINS app condition), and a small effect in the increase of the child's independent correct responding for the Imitation program (from 16% correct on average during the paper program condition to 40% correct on average during the GAINS app condition). The across-tier analysis indicates that the higher level of treatment integrity promoted by the GAINS app during the implementation of one program did not generalize to the other programs.

Treatment integrity error analysis was only run for Experiment 2 as the treatment effect of the GAINS condition was evaluated across different programs for each participant. The analysis indicated that during the paper program condition, Anna's lowest performance was scored for providing timely and correct prompting and implementing error correction (Figure 9) and after the introduction of the GAINS app condition, providing timely and correct prompting score increased for all three programs by 50% to 70%, and for implementing the error correction increased for the listener response and intraverbal programs on 80% on average. For the listener response and imitation programs, the GAINS condition also resulted in an improvement in Anna's performance in getting the child's attention before providing the instruction, providing the child time to respond independently before providing prompting and providing a reinforcer and behavior-specific praise contingent on the child's correct responding.

The reversal phase in the Listener response program indicated that after exposure to the GAINS condition, Anna's performance with the paper program improved compared to both the baseline paper and the treatment GAINS conditions for getting the child's attention before providing the instruction, delivering the correct instruction, implementing error correction, and providing a reinforcer contingent on child's correct responding evaluation points, and decreased only for providing timely and correct prompting and providing the child time to respond independently before providing prompting.

The error analysis also indicated that for the Intraverbal and Imitation programs, Anna was consistent with providing reinforcement contingent on the child's correct responding and moving to the next trial or ending the session if 5 trials were completed across both conditions: paper program and GAINS. For the Intraverbal program only, Anna was also consistent with getting the child's attention before providing the instruction and providing

behavior-specific praise contingent on the child's correct responding across the paper program and GAINS conditions.

Figure 10 represents Helen's performance as well as the percentage of the child's correct responding and engagement in challenging behavior across all three programs. Helen's performance during the baseline condition implementing the Listener Response program was 43% on average and showed a decreasing trend, and after the GAINS condition was introduced, there was an increase in the performance accuracy of 77% and higher, indicating a 35% increase in the treatment integrity compared to the paper program. The mean percentage of performance accuracy for the second program (Imitation) was 49% and after the app condition was introduced, the performance accuracy increased to 82% on average, indicating a 33% increase in the treatment integrity compared to the baseline. The treatment integrity during the baseline condition for the last Visual Matching program was 52% on average and after the introduction of the GAINS condition, the participant's performance increased to 81% on average, indicating a 29% increase in the performance accuracy compared to the paper baseline condition. Generally, the GAINS app condition resulted in the improvement of the participant's performance by 29 to 35% across all three programs.

For the Imitation program, the child's correct responding was at 0% across both conditions. And for the two remaining programs (Listener Response and Visual Matching) the data on the child's independent correct responding was not collected or scored as the teaching procedure implied immediate prompting from Helen and did not imply the possibility for the independent responding by the child. The maintenance probes conducted 6 weeks after the last session and the last participant-child contact demonstrated the corresponding level of Helen's performance compared to the treatment condition across all three programs.

Overall, the results for Helen indicated the effectiveness of the GAINS app in improving the participant's performance for all three programs, with an increase from an average of 49% correct during the paper program condition to an average of 80% correct during the GAINS app condition across all three skill-acquisition programs. The across-tier analysis indicates that the higher level of treatment integrity promoted by the GAINS app condition during the implementation of the Listener Response program did not generalize to the Imitation program. However, there was an increase in the performance accuracy for two sessions of the baseline condition for the Visual Matching program after the GAINS condition was introduced for the Imitation program (from an average of 49% to 61% of correct responding).

To evaluate whether the child's challenging behaviors during sessions interfered with the participant's ability to implement the protocol in Helen's and Milo's case, the participant's percentage correct treatment integrity was plotted as a function of the percentage of the session the child was engaging in challenging behavior (see the combined graph as Figure 11). There was a systematic relation between participants' treatment integrity and clients' challenging behavior for all three programs (Listener response, Imitation, and Visual matching).

Treatment integrity error analysis for Helen indicated that during the paper program condition, Helen's lowest performance for all three programs was scored for providing the correct instruction and providing timely and correct prompting, and after the introduction of the GAINS app condition, both points' scores increased significantly for all three programs (on 50% and on 80% on average for both points respectively; Figure 12). However, for the Imitation program, the GAINS condition did not improve the accuracy of providing the instruction only once. The introduction of the GAINS condition also resulted in some level of improvement in Helen's performance for providing a reinforcer contingent on the child's

correct responding for all three programs (improved by M=24%). For the Visual Matching program, with the introduction of the GAINS condition, Helen's performance improved in getting the child's attention before providing the instruction and presenting the instructional material in the correct order (improved by M=20%).

The error analysis also demonstrated that Helen was consistent with providing behavior-specific praise contingent on the child's correct responding across both conditions: paper program and GAINS, and across all three programs: Listener Response, Imitation, and Visual Matching (from 91 to 100% of correct responding across all three programs and both conditions).

Social Validity

At the conclusion of the study, participants completed a social validity and usability questionnaire regarding ease of use, quality of the assistance provided, the convenience of the data collection, and how likely they are to use the app in the future. The questionnaire used a 5-point scale to rate each statement from "strongly disagree" to "strongly agree" and was sent out to the participants via email as a link to the Qualtrics survey. The questionnaire is included in Appendix G.

Both participants agreed or strongly agreed on statements related to the GAINS app's ease of use, the ease and effectiveness of following instructions provided by the app, and their willingness to use the app in the future. Both participants also agreed that the audio assistance was very helpful, and that audio alone was enough to implement the programs. One of the participants disagreed with the statement that the display is easy to read and that it does not interfere with staying engaged with the learner. The learner this participant was working with was frequently attempting to grab the tablet or touch the screen when the participant was implementing the programs using the GAINS app which was scored as the child's challenging behavior.

General Discussion

One of the primary research objectives of this study was to evaluate the effectiveness of the GAINS technology in guiding the user in the process of implementing ABA programs. The hypothesis was that there will be lower levels of treatment integrity during the baseline phase, during which participants did not receive support while implementing the behavioral intervention, and the treatment integrity of the implementation will increase once the GAINS app is introduced. Similarly, the child's correct responding will increase when the GAINS app is introduced, as the intervention is implemented more accurately.

The results of Experiment 1 indicated some level of effectiveness of the GAINS app as evidenced by a small increase in the participants' treatment integrity (from 59% correct responses with the paper program to 77% correct responses with the GAINS app condition on average), and no significant increase in the clients' correct responding compared to the baseline (from 22% correct responses with the paper program to 33% correct responses with the GAINS app condition on average; see the treatment integrity and clients' independent performance data graphed in Fig. 4). The results of Experiment 2 indicated a greater effect of the GAINS app in improving the participant's performance for all three programs for both participants, and both participants reached the criteria of 80% and higher correct responding across at least 3 sessions (from 60% and 49% correct with the paper program to 85% and 80% correct with the GAINS app condition on average for Anna and Helen respectively), and a small effect in the increase of the child's independent correct responding for one of the programs (from 16% correct with the paper program to 40% correct with the GAINS app condition on average for the Imitation program implemented by Anna; see the treatment integrity and clients' independent performance data graphed in Figs. 6 and 10). The across-tier analysis indicates that the higher level of treatment integrity promoted by the GAINS app

during the implementation of one program did not generalize to the other programs for Anna and generalized to the last program (Visual Matching) for Helen.

While the current study demonstrated the effectiveness of the GAINS app in increasing and maintaining higher levels of treatment integrity in untrained clinicians, the expected relationship between the treatment implementation fidelity and the child's correct responding was not found (Brand et. Al., 2019; Carroll et al., 2013). This finding could be linked to the relatively short period of data collection. For Experiment 1 the data collection was run for one to three days only and for Experiment 2 was run for several sessions over around one month and then one more maintenance session was run 6 weeks later, which was enough to reach the mastery criteria for treatment integrity across at least 2 sessions by some of the participants but wasn't enough to master any of the programs taught to children. As was mentioned earlier, this trend in children's responding could also be explained by the "transition state" phenomenon, which, according to Brogan et al. (2019), can last for 4.9 sessions on average prior to the treatment producing any behavior change. Additionally, in the study by Brand et al. (2019), the initial exposure to treatment integrity errors produces distinctive and enduring effects on the clients' performance and sometimes resulted in delays in skill acquisition even after the intervention was delivered with a high level of integrity.

The decrease in the child's correct responding and increase in the level of challenging behavior after the increase in the treatment integrity due to the introduction of the GAINS condition during the implementation of the Listener Response program by Anna could be explained by the implementation of the extinction procedure. When due to the change in the reinforcement schedule the child was attempting to leave the instructional area after the delivery of a tangible that was previously signaling the availability of a break, the participant had to block each instance of the elopement attempt resulting in the child's extinction burst and resistance to extinction during five more sessions. Thus, the results of the study also

indicate that the GAINS app has a high level of control over the participants' behavior, as even though while the child was going through an extinction-induced increase of challenging behavior and decreased level of correct responding following the correct implementation of the procedure with the GAINS app, the participant kept following the instructions provided by the GAINS app, and the integrity of the program implementation stayed high.

The reversal phase added for Anna implementing the Listener response program showed that the high level of treatment integrity implementing the program with the GAINS app generalized to implementing the program with the paper protocol, even though the initial level of treatment integrity implementing this program with the paper program was low (M=45% correct responding by implementer during the initial paper program condition, M=83% during the GAINS app condition, and M=86% during the reversal paper program condition). Considering that one of the participants reported that it was inconvenient for them to use the GAINS app and stay engaged with the client, future studies could focus on evaluating the effectiveness of the GAINS app when training clinicians to implement novel programs. The GAINS app in this situation could potentially be used as a temporary option during the training period only to support the implementation of novel programs and increase the treatment integrity of the implementers.

Another potential for future research of the smart technology platform is to incorporate other features of the platform for skills, environments, and learners that require the implementer to have more freehand. E.g., the audio instructions and a Bluetooth-operated remote should be used for guidance and data collection with clients who attempt to grab the tablet while the implementer is running programs or while teaching students skills in environments that are incompatible with holding and operating an electronic device such as phone or tablet (e.g., swimming).

The fact that there was some relation between the participants' performance and children's challenging behavior for some of the participants and implemented programs indicates the usefulness of integrating additional features to the GAINS app to guide implementers on managing children's challenging behavior: antecedent as well as consequence strategies on how to minimize or manage the occurrence of challenging behavior such as elopement, grabbing, etc. to ensure the high levels of treatment integrity (Berdeaux et al., 2022).

Finally, all the participants involved in the study were under 23 years old and were undergraduate or graduate-level students who did not have a prior history of interacting with the children participants. Involving caregivers of children with autism in future studies would provide information on the effectiveness of the GAINS in guiding the behavior of individuals who had a long prior history of interacting with a child in different environments (e.g., caregivers, teachers).

There are a few limitations in the present studies worth noting. As was mentioned prior, both experiments were conducted during relatively short time periods. Even though 9 to 15 conducted sessions were enough to determine that the GAINS app is effective in promoting and maintaining a high level of implementers' treatment integrity, this number of sessions was not enough for any child to master targets taught to determine if the use of the app resulting in an increased level of treatment integrity would result in an eventual increase in the children's performance as indicated by multiple studies (Bergmann et al., 2021; Bottini et al., 2020; DeGennaro Reed et al., 2011). Additionally, fewer sessions resulted in an inability to advance through the prompting levels. As a result, the child's correct responding was not scored for two programs for Helen, as required immediate prompting provided by the implementer.

The second limitation of the current study was that in this study we did not target the acquisition of behavioral programs by children. From the clinical standpoint, the level of treatment integrity is a valid concern to address as there is a notable number of studies reporting the relation between the level of treatment integrity of an implementer and clients' performance (Bergman et al., 2021; Bottini et al., 2020; Carroll et al., 2013; Groskreutz et al., 2011). But it is important to evaluate whether the increase in treatment integrity promoted by the GAINS app would actually result in skill acquisition in children with autism.

A third limitation is the technological difficulties that occurred in Experiment 2 for Anna. Those errors in video recording prevented the researchers from reviewing and scoring five sessions (sessions 5, 17, 24, 27, and 32), resulting in potential inconsistencies and leading to breaks in the data paths and impeding visual analysis of the graph.

Another limitation of this study is the level of experimental control derived from the experimental designs that were used. For Experiment 1, where we used a two-tier nonconcurrent multiple baseline across participants research design, a strong experimental control was not demonstrated as it did not provide sufficient consistent and replicated changes of the main dependent variable (Kazdin, 2020). For Experiment 2 we used a three-tier concurrent multiple baseline across behaviors research design which is generally associated with a much stronger experimental control than the one used in Experiment 1 (Cooper et al., 2020; Kazdin, 2021). However, for one of the participants (Helen), the experimental control was compromised due to the slight increase in the treatment integrity for the Visual Matching program potentially due to the longer exposure to the programs' implementation, or due to the exposure to the GAINS condition for other programs, which posed a threat to internal validity (Slocum et al., 2022).

And lastly, no operational definitions were provided for targets taught to children in Experiment 1, resulting in treatment integrity errors and inconsistency (e.g., different

topographies of the instruction “Touch your feet” were reinforced by participants). Future research should provide detailed operational definitions for each target taught to the student.

Conclusions

Currently, there are very few options available that help to mitigate the barriers that limit access to ABA services for the population of children with autism. The barriers such as the disparity among the number of service providers available and the rising number of individuals diagnosed with autism (Centers for Disease Control and Prevention, 2012; Dudley, 2019), and the high cost of ABA therapy for families and the government (Chasson et al., 2007; Buescher et al., 2014), can be mitigated by harnessing the existing resources of the behavior change agents already available in the children’s environment to implement the behavior intervention (Sallows & Graupner, 2005; Walker et al., 2021). This became possible with the support of technology providing training to caregivers and implementers via various asynchronous teaching methods (Gerencser et al., 2020). The main disadvantage of the training option is that teaching untrained individuals to implement behavioral interventions with high fidelity can take up to several weeks (Blackman et al., 2020), and often require the preceding training and direct support and guidance from a trained professional for the implementation of behavioral programs to be delivered with high fidelity in a long run (Higbee et al., 2016). To facilitate the above-listed obstacles, we evaluated the smart technology platform GAINS to determine if it can successfully assist untrained caregivers and other behavior-change agents to implement ABA interventions with a high level of integrity and result in positive clinical outcomes. Overall, we found increases in treatment integrity of participants’ implementation of the behavioral protocols across two experiments, but the clients’ behavior did not improve.

The results of this study have clinical implications for behavior analysts working with underserved populations of families with children with autism. We found that the smart

technology platform can help facilitate access to behavioral services for children with ASD without sacrificing the integrity of the intervention. Additionally, with the technology guiding implementers to accurately deliver the ABA intervention, behavioral services could be started earlier because families would not have to wait for the availability of a trained implementer. The same is true for families who live in areas without local trained providers. The high cost of the ABA intervention could also be significantly reduced, as behavior analysts would not need to monitor every session synchronously but instead would review data and provide consultation as needed. Although the GAINS app as well as any other technological tool cannot fully substitute a trained professional, it can help alleviate some barriers to behavioral treatment.

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Table 1

Demographic information of the participants in Experiment 1 and 2

Participant	Experiment	Age (years)	Gender identity	Race	Education	Primary Language
Maggie	1	23	Female	White	Bachelor's degree	English
Zyon	1	21	Male	White	Some college credit	English
Jane	1	22	Female	White	Bachelor's degree	English
Anna	2	20	Female	Black	Some college credit	English
Helen	2	18	Female	White	Some college credit	English

Table 2

Demographic information of the children participants in Experiment 1 and 2

Participant	Experiment	Age (years)	Sex	Race	Diagnosis	Communication	Primary Language
Jared	1	4	Male	White	ASD	Spoken phrases	English
Gary	1, 2	4	Male	White	ASD	Spoken phrases	English
Milo	2	3	Male	White	ASD	Emerging sounds	English

Figure 1

GAINS Manager Customization

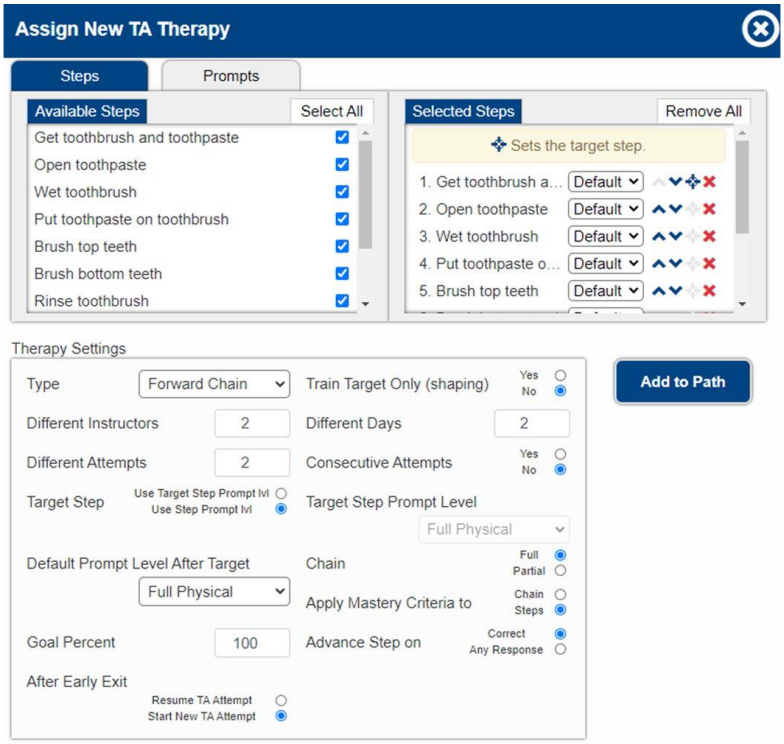


Figure 2

GAINS App Guidance: Manding program

Figure 3

GAINS App Guidance: Listener response program

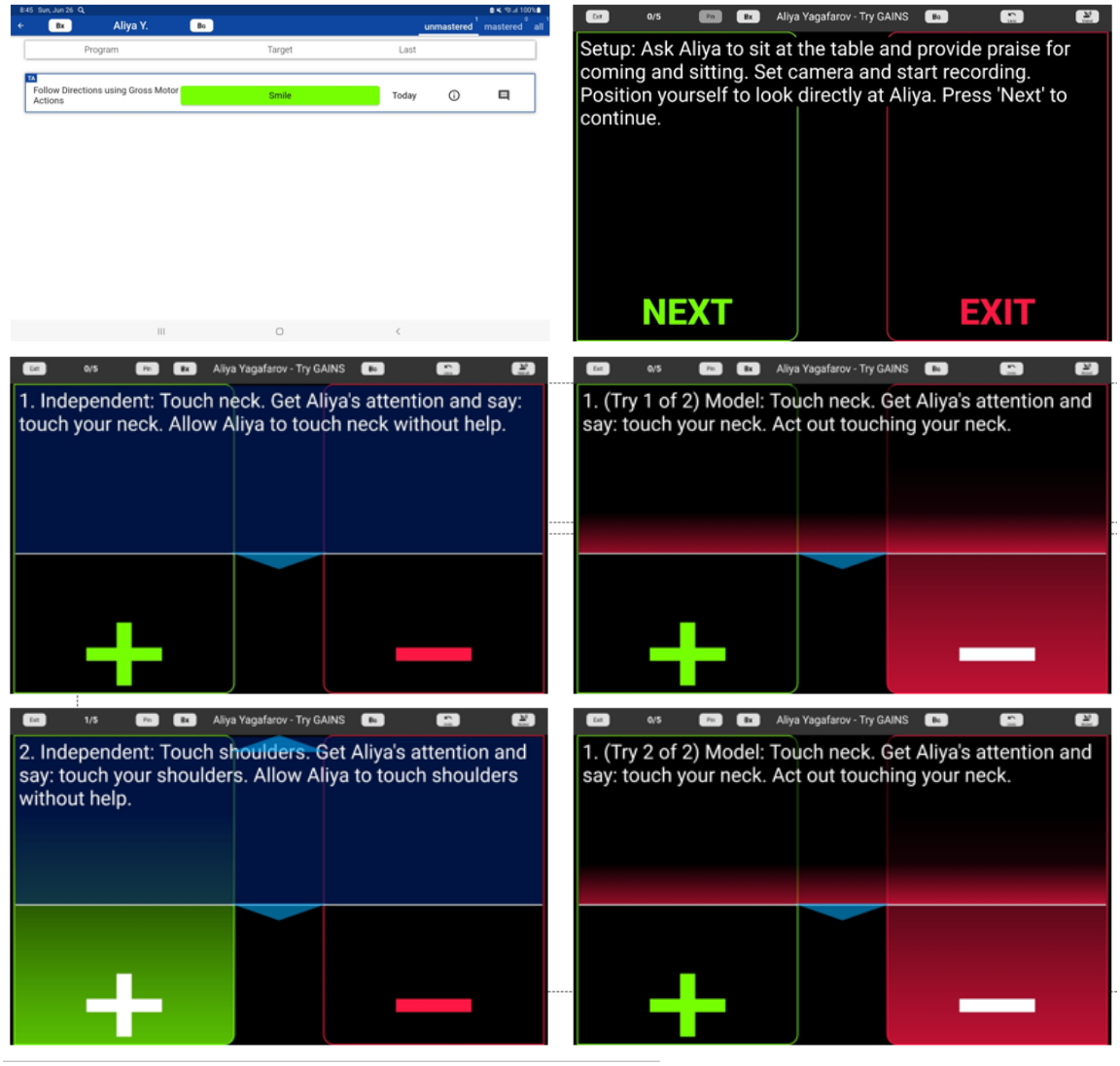
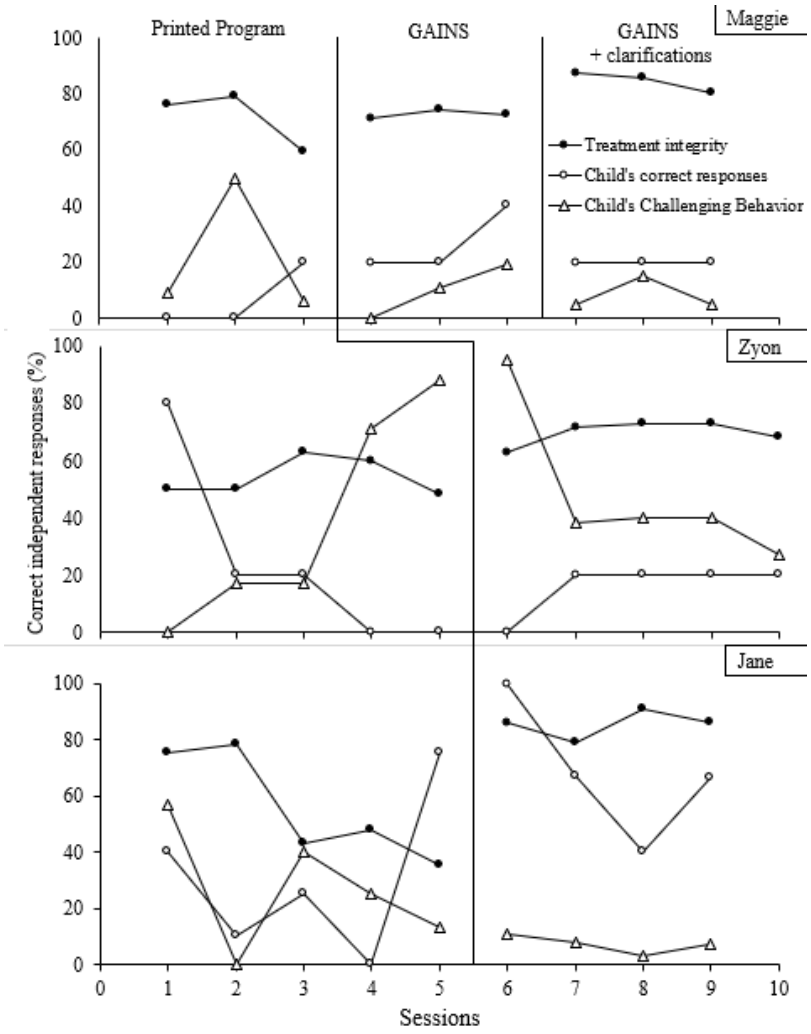


Figure 4

Treatment integrity and children's independent performance in Experiment 1



Note. Closed data points represent the percentage of correct implementation of the behavioral protocol by participants. Open data points represent the correct independent responding by clients during experimental sessions. Solid and dashed lines represent the average for correct implementation and client responding, respectively.

Figure 5

Simple linear regression for the Clinicians' Correct Responding and the Children's Challenging Behavior for all three participants in Experiment 1

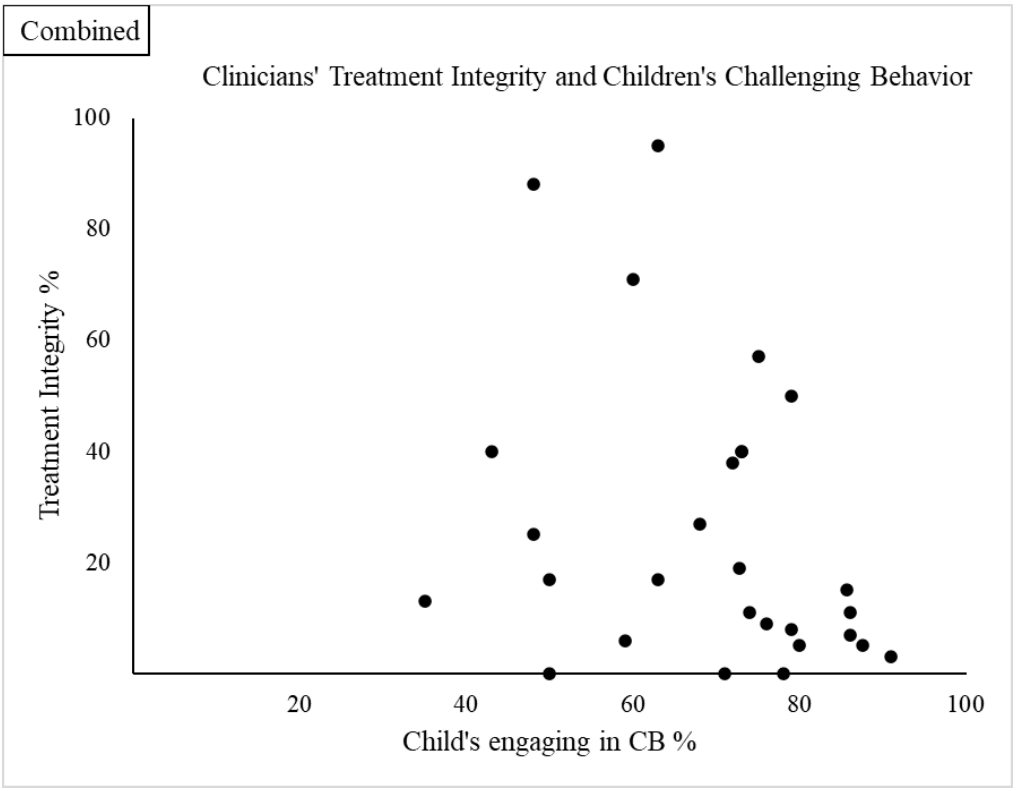
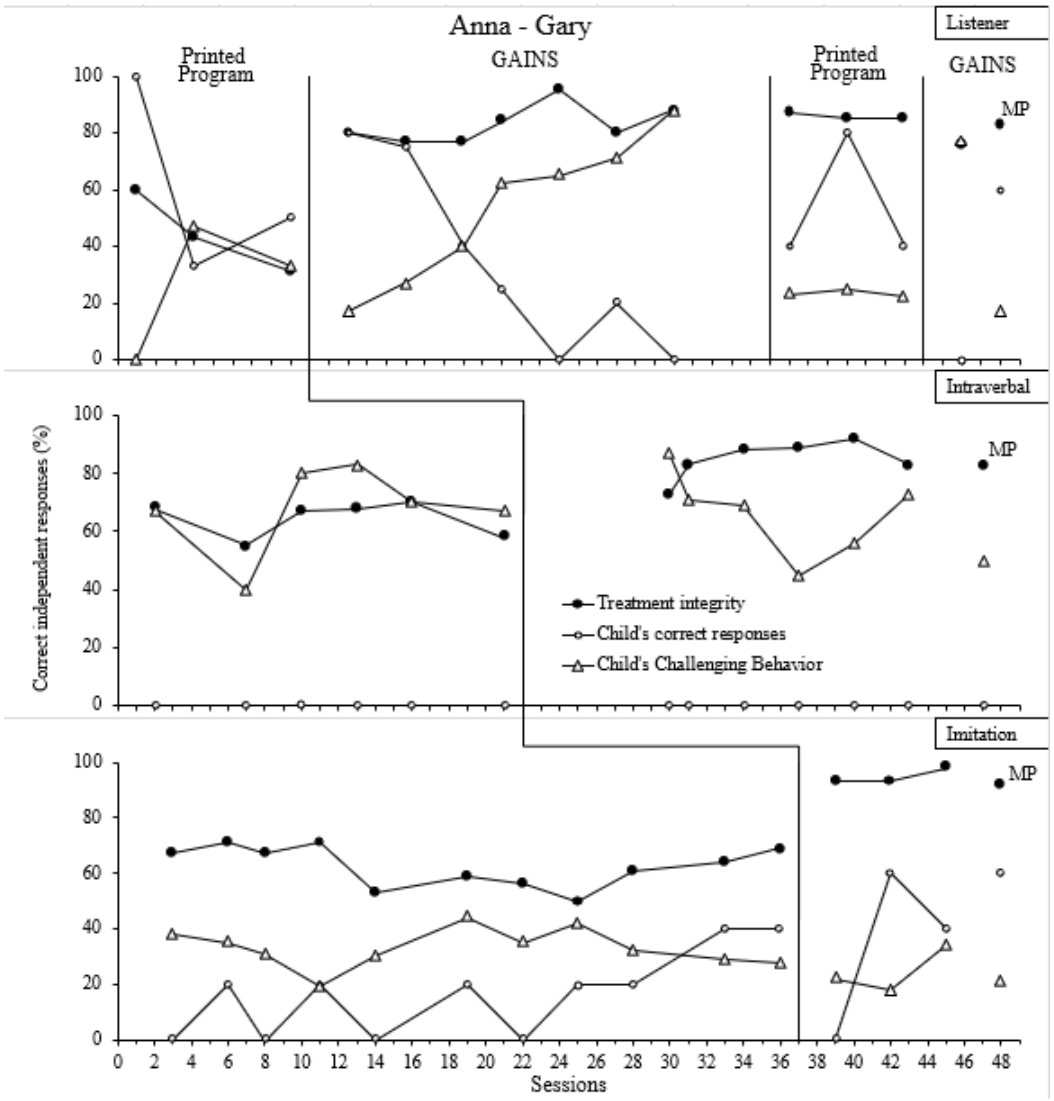


Figure 6

Treatment integrity, child's independent performance and challenging behavior for Anna in Experiment 2



Note. Closed circles represent the percentage of correct implementation of the behavioral protocol by participant Anna. Open circles represent the correct independent responding by the child during experimental sessions. Open triangles represent the percentage of child's engagement in challenging behavior during the session.

Figure 7

Simple linear regression for the Clinician's Correct Responding and the Child's Challenging Behavior for the Imitation program for participant Anna

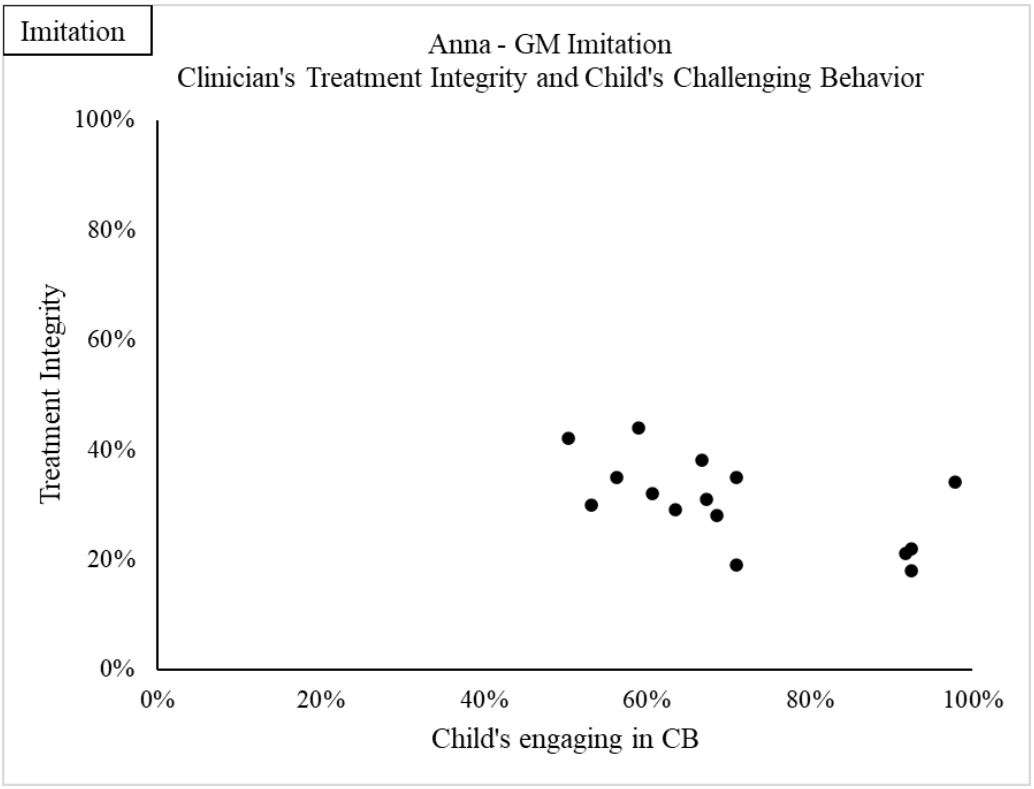


Figure 8

Simple linear regression for the Clinician's Correct Responding and the Child's Challenging Behavior for all three programs (Imitation, Intraverbal, and Listener response) for participant Anna

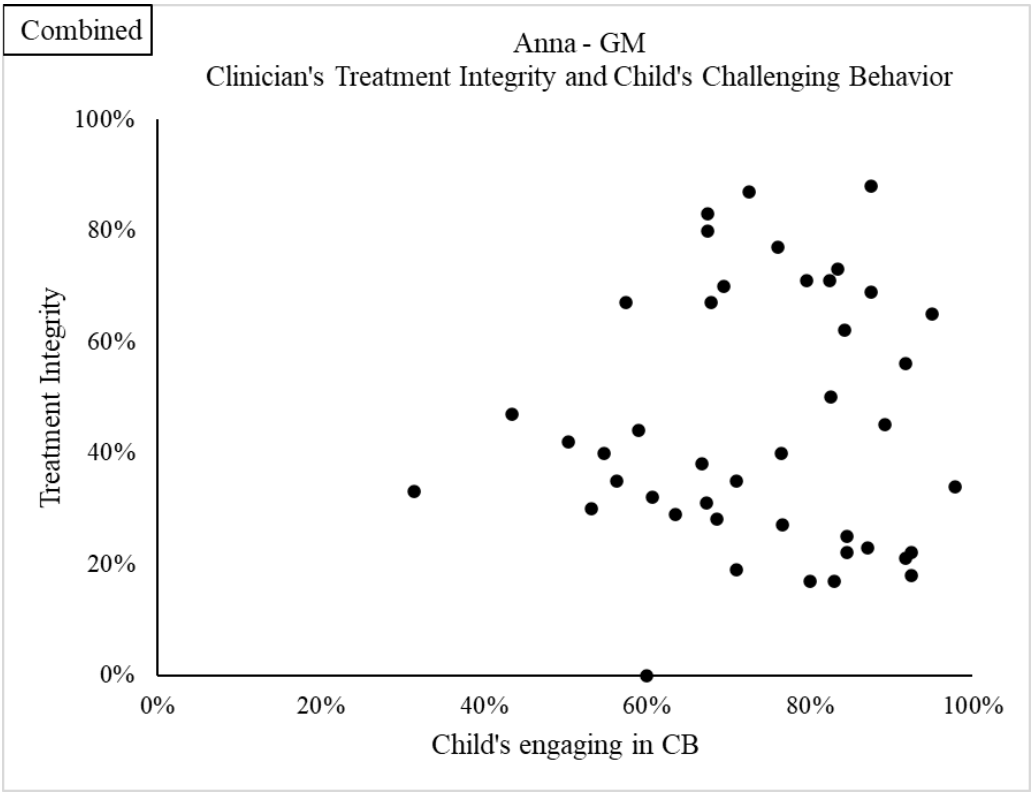
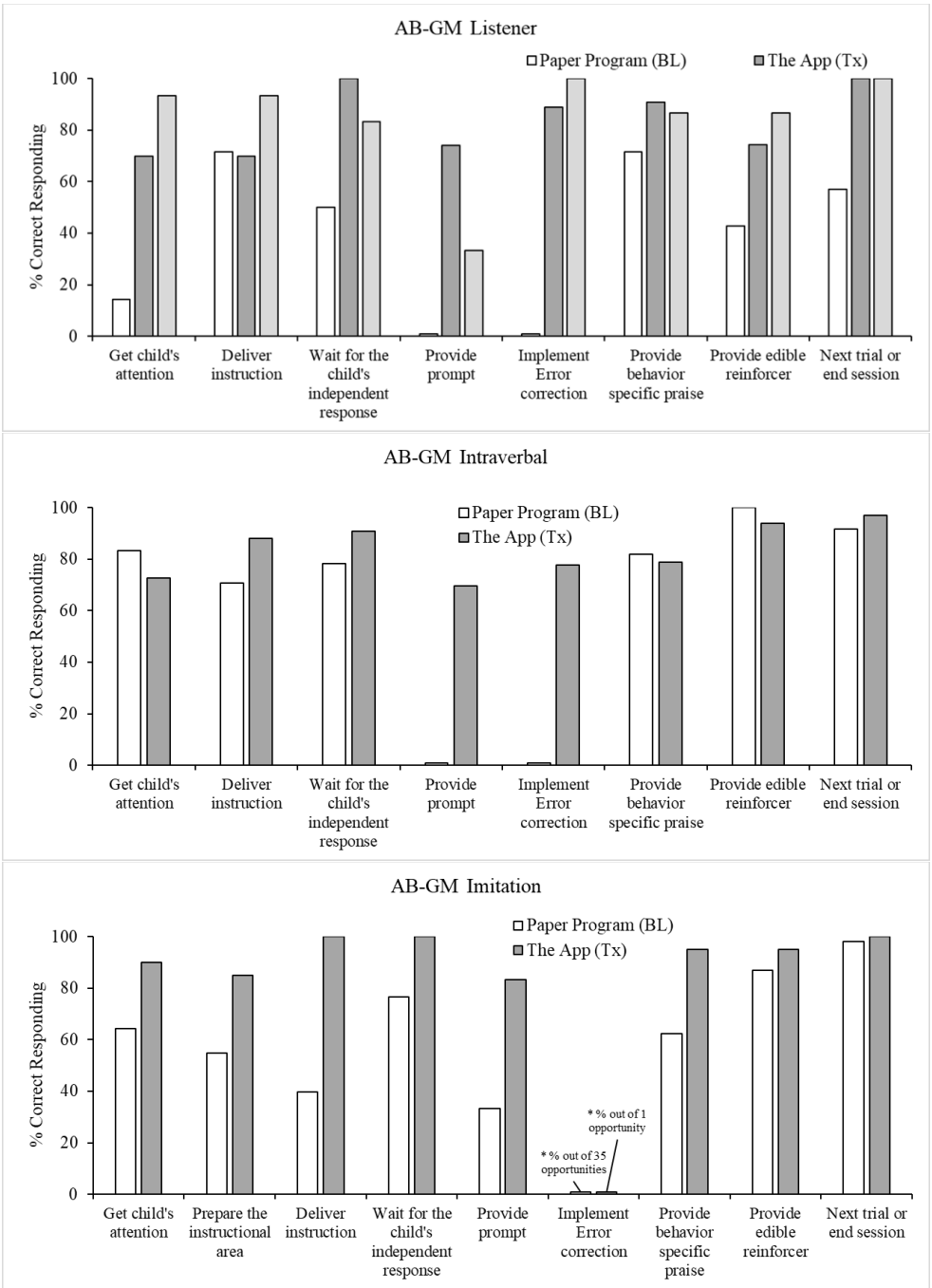


Figure 9

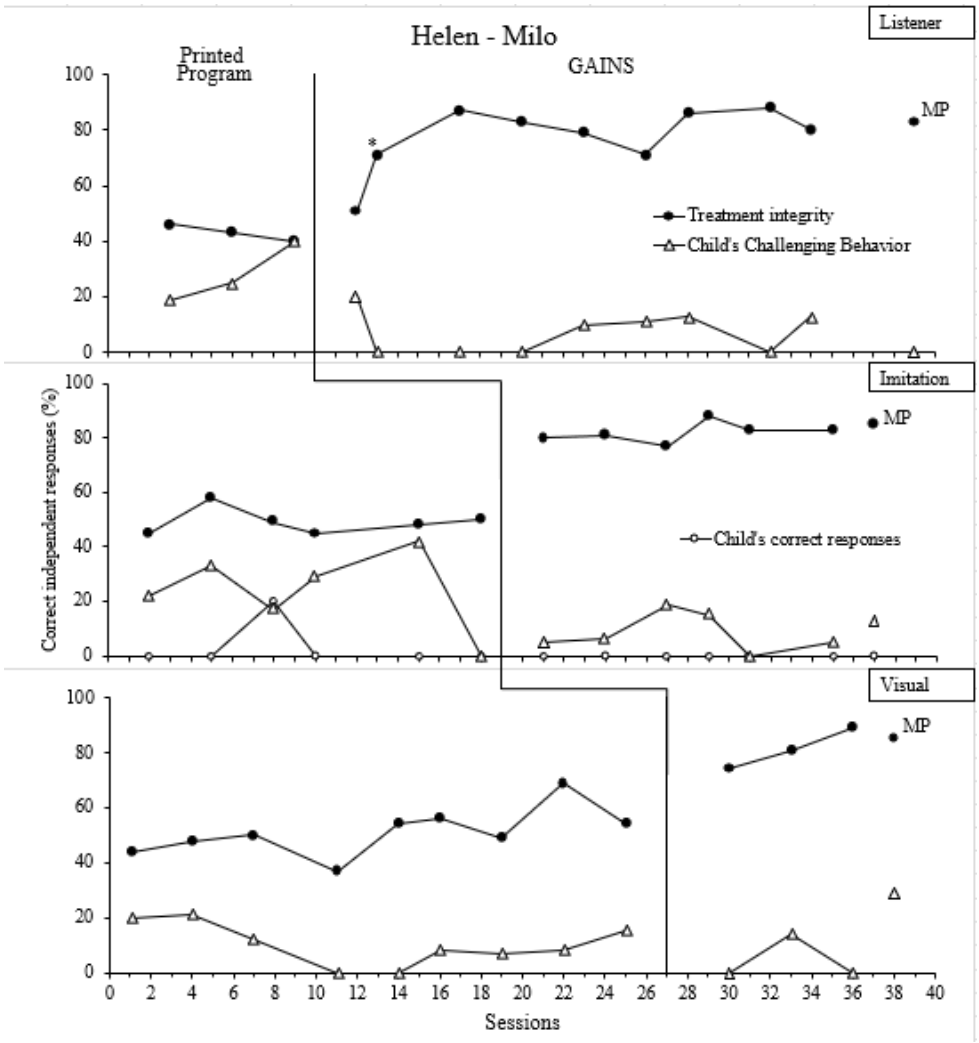
Treatment integrity error analysis for participant Anna



Note. On y-axes are the treatment integrity evaluation points for Anna's performance for three programs. The white bars represent Anna's treatment integrity during the baseline (paper program) condition, and the grey bars represent their performance during the treatment (the GAINS) condition.

Figure 10

Treatment integrity, child's independent performance and challenging behavior for participant Helen in Experiment 2



Note. Closed circles represent the percentage of correct implementation of the behavioral protocol by participant Helen. Open circles represent the correct independent responding by the child during experimental sessions. Open triangles represent the percentage of child's engagement in challenging behavior during the session.

Figure 11

Simple linear regression for the Clinician's Correct Responding and the Child's Challenging Behavior for all three programs (Imitation, Intraverbal, and Listener response) for participant Helen

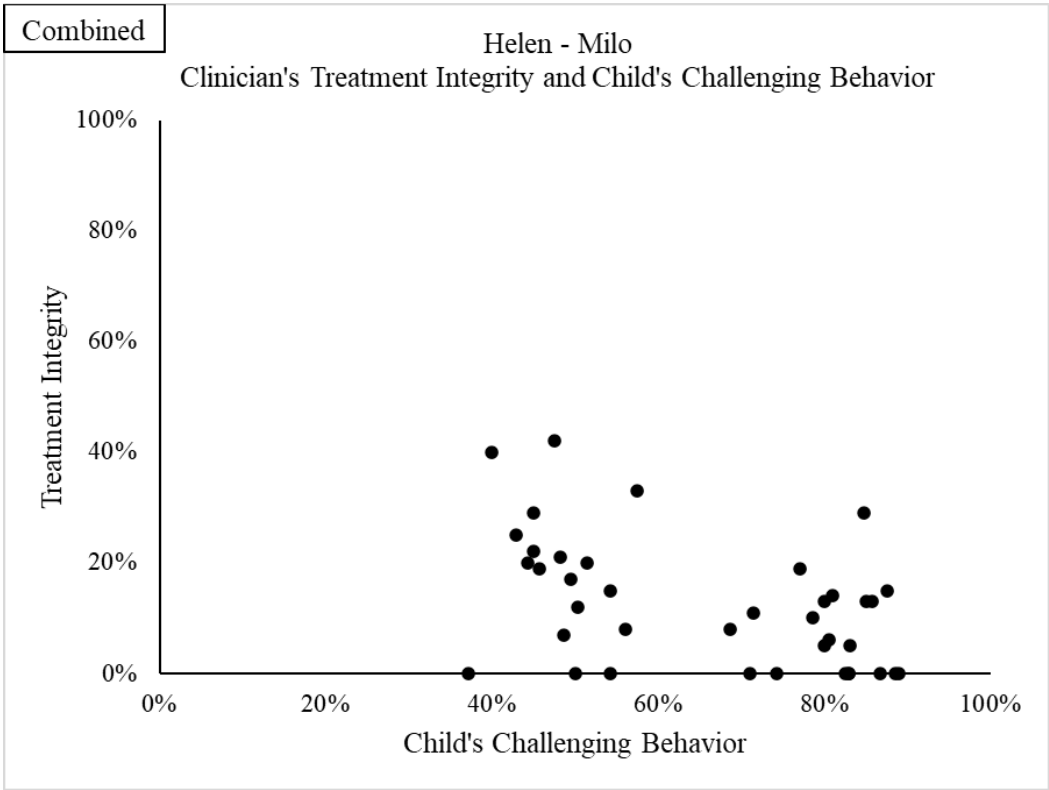
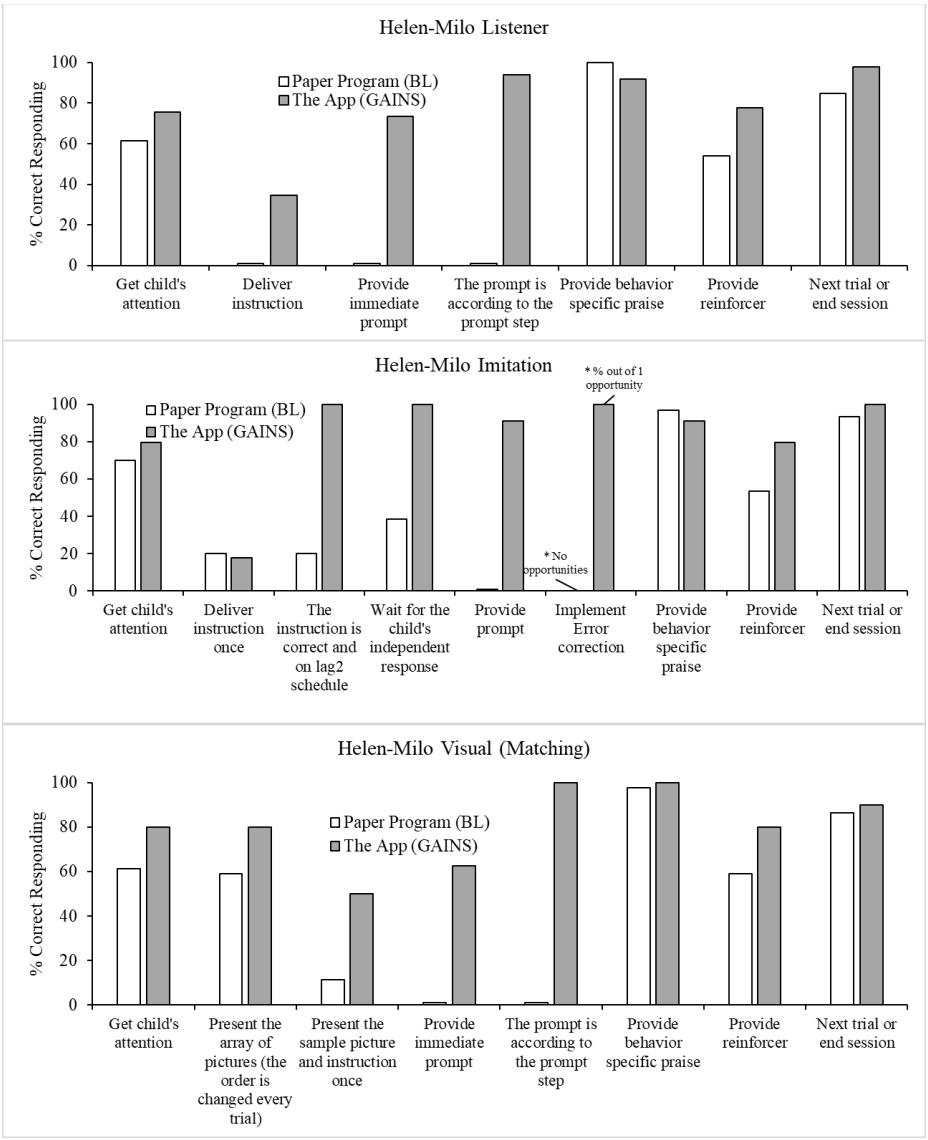


Figure 12

Treatment integrity error analysis for participant Helen



Appendix A

Requesting Item

Purpose: The purpose of this protocol is to teach your child to request items when they are present but not within their reach.

Set up (before session):

1. Select an area where you can interact with your child with minimal disruption (e.g., kitchen table, living room floor)
2. Set camera/phone pointing towards area where you will be sitting with your child
3. Have 3-5 items your child prefers (e.g., toys, activities). Try to limit access to these items outside of these sessions to maintain high motivation for these items
4. Invite your child to join you and start recording

General procedure (during session):

1. Place three preferred items (e.g., car, train, action figure) in front of your child and allow them to explore the items for a couple of minutes
    a. If they do not show interest in items, include other items they may be interested in
    b. If they attempt to leave area or show displeasure (e.g., whining), end session. Child needs to be motivated to interact with the items
2. After about one minute interacting with all items, remove them from the child's reach and wait for a vocal request (i.e., saying name of item they want)
    a. If child says name of one of the items, immediately give them the item *(record + below)*
        i. "Here's the train. Great job asking me for the train!"
    b. If a few seconds pass and child does not vocalize or if child attempts to grab item, say the name of the item with which they were last interacting (e.g., "train")
        i. "Say 'train'"
            1. If child repeats "train," give them the item and praise "I love how you said 'train'!" *(record 'p' below)*
            2. If child does not repeat the word, provide the prompt again and allow for another opportunity to repeat. If they do not repeat the second time, end session *(record - below)*
3. After 30 seconds interacting with the item, remove them from the child's reach and wait for a vocal request (i.e., saying name of item they want)
    a. If child says name of one of the items, immediately give them the item *(record + below)*
        i. "Here's the train. Great job asking me for the train!"
    b. If a few seconds pass and child does not vocalize or if child attempts to grab item, say the name of the item with which they were last interacting (e.g., "train")
        i. "Say 'train'"
            1. If child repeats "train," give them the item and praise "I love how you said 'train'!" *(record 'p' below)*
            2. If child does not repeat the word, provide the prompt again and allow for another opportunity to repeat. If they do not repeat the second time, end session *(record - below)*
4. Repeat # 3 until your child loses interest or 5 minutes have passed, whichever comes first

1. Place preferred items in front of your child    . [remember to record session]
2. Wait 1 minute, allow them to interact with items
3. Remove all items
4. Wait for independent request
    a. Child asks independently: circle a + below
    b. Child requests after you provide word: circle p below
    c. Child does not make request after 2 attempts: circle - below
5. Repeat from # 1 until child shows no interest (e.g., tries to leave, does not seem interested in items)

Date								
	1	2	3	4	5	6	7	8
Trial 1	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -
Trial 2	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -
Trial 3	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -
Trial 4	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -
Trial 5	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -
Trial 6	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -
Trial 7	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -
Trial 8	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -
Trial 9	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -
Trial 10	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -
Trial 11	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -
Trial 12	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -
Trial 13	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -
Trial 14	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -
Trial 15	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -

* Your clinician will provide instructions for how to submit video recordings and data *

Appendix B

Following Instructions

Purpose: The purpose of this protocol is to teach your child to follow simple instructions such as touch your nose, raise your hand, etc.
List: *(Is individualized for each participant)*

Set up (before session):

1. Select an area where you can interact with your child with minimal disruption (e.g., kitchen table, living room floor)
2. Set camera/phone pointing towards area where you will be sitting with your child
3. Have 1-3 items your child prefers (e.g., toys, snacks). Try to limit access to these items outside of these sessions to maintain high motivation for these items. These will be used to reward your child's behavior.
4. Invite your child to join you and start recording

General procedure (during session):

1. Ask your child to sit and provide praise for coming and sitting (e.g., "thanks for coming over!")
2. Deliver a verbal instruction (see list provided by your clinician) and wait for response (i.e., child touches head)
    a. If child responds within 5 sec, immediately praise ("that's touching your head!") and deliver preferred item or small snack *(record '+' below)*
        i. If using toy for reward, only provide access for about 20 sec and then remove the item before starting the next trial
    b. If a few seconds pass and child does not respond, model the response while saying "this is how we …. (e.g., touch head)"
        i. If child repeats your action, praise ("that's touching your head!") and deliver preferred item or small snack *(record 'p' below)*
        ii. If child does not repeat your action, provide the prompt again and allow for another opportunity to repeat. If they do not repeat or do incorrect action the second time *record '–' below* and move on to the next trial
    c. If child engages in incorrect response (e.g. clapping instead of touching their head), record '–' below and move on to the next trial
3. Repeat # 2 for 5 trials per session.

1. Get items you'll use for rewards and invite child to join you. [remember to record session]
2. Deliver verbal instruction (see list provided by clinician), no model
3. Wait 5 sec for independent response
    a. Child independently does action: circle a '+' below
    b. Child does action after you model: circle 'p' below
    c. Child does an incorrect action or does not respond correctly after 2 attempts: circle '-' below
4. Repeat from # 1 until you complete 5 trials

Date								
Sessions →	1	2	3	4	5	6	7	8
Trial 1	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -
Trial 2	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -
Trial 3	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -
Trial 4	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -
Trial 5	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -

Date								
Sessions →	1	2	3	4	5	6	7	8
Trial 1	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -
Trial 2	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -
Trial 3	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -
Trial 4	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -
Trial 5	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -

* Your clinician will provide instructions for how to submit video recordings and data *

Appendix C

Child Initials / Implementer: _____ / _____			DC:	*Grose Motor Imitation Treatment Integrity Data Sheet*								
Date and phase	Trial №	1.Get child's attention (child orienting toward the instructor and does not engage in other activities)	2. Deliver only model and verbal instruction once simultaneously	3. The verbal instruction is on lag 2 schedule and matches the protocol	4.Wait for at least 3 sec for independent response	5.Provide only physical prompt after 3 sec, if necessary	6.Deliver model prompt and instruction with the physical prompt immediately, if necessary	7.1.If correct **independent** or **prompted**, provide Behavior specific praise if incorrect, neutral confirmation statement	7.2.If correct **independent** or **prompted**, provide tangible reinforcer; If incorrect, no tangible	8. Next trial or end session (if 5 trials per session are done)	Treatment integrity %	Child's independent correct response %
Session 1		Note:										
	Trial 1	+ / - /na	+ / - /na	+ / - /na	+ / - /na	+ / - /na	+ / - /na	+ / - /na	+ / - /na	+ / - /na		+ / - /na
	Trial 2	+ / - /na	+ / - /na	+ / - /na	+ / - /na	+ / - /na	+ / - /na	+ / - /na	+ / - /na	+ / - /na		+ / - /na
	Trial 3	+ / - /na	+ / - /na	+ / - /na	+ / - /na	+ / - /na	+ / - /na	+ / - /na	+ / - /na	+ / - /na		+ / - /na
	Trial 4	+ / - /na	+ / - /na	+ / - /na	+ / - /na	+ / - /na	+ / - /na	+ / - /na	+ / - /na	+ / - /na		+ / - /na
	Trial 5	+ / - /na	+ / - /na	+ / - /na	+ / - /na	+ / - /na	+ / - /na	+ / - /na	+ / - /na	+ / - /na		+ / - /na
Session 2		Note:										
	Trial 1	+ / - /na	+ / - /na	+ / - /na	+ / - /na	+ / - /na	+ / - /na	+ / - /na	+ / - /na	+ / - /na		+ / - /na
	Trial 2	+ / - /na	+ / - /na	+ / - /na	+ / - /na	+ / - /na	+ / - /na	+ / - /na	+ / - /na	+ / - /na		+ / - /na
	Trial 3	+ / - /na	+ / - /na	+ / - /na	+ / - /na	+ / - /na	+ / - /na	+ / - /na	+ / - /na	+ / - /na		+ / - /na
	Trial 4	+ / - /na	+ / - /na	+ / - /na	+ / - /na	+ / - /na	+ / - /na	+ / - /na	+ / - /na	+ / - /na		+ / - /na
	Trial 5	+ / - /na	+ / - /na	+ / - /na	+ / - /na	+ / - /na	+ / - /na	+ / - /na	+ / - /na	+ / - /na		+ / - /na

Appendix D

GAINS Project
TA for clinicians and participant

A participant is going to come to the clinic for at least two hours once a week, to work on 3 programs for approximately two months with their assigned client.

Participant	Day	Time	Client	Programs	Working on programs start
X	X	X	X	X	X

Helen will come to the clinic **this and next week** on Wednesday during her scheduled time **to observe** the work with M and to join you for some fun activities during the client's free time. The main goal during those first two appointments is for Helen to:

- build a connection with M (**pairing**);
- identify M's potential **reinforcers**;
- observe and learn how to handle **non-compliance, elopement,** and **other minor problem behaviors (PBs)** (according to the M's Behavior Intervention Plan);

So that when Helen starts implementing the programs with the client independently, she feels comfortable giving instructions to the client.

During those first two weeks, clinicians can tell anything they believe is relevant about the client (e.g., his preferences, challenging behaviors, and what are the procedures to handle those behaviors), just make sure **not to train** participants on any **teaching procedures** we use in ABA at the clinic (do not teach the participant to implement any skill-acquisition programs).

After February Xth

(Or as soon as the participant observed the sessions with the client for two days)

Pre-session criteria

Before Helen starts running a session with M at the table, make sure that:

1. M is calm and does not engage in any dangerous problem behavior (aggression, tantrum, SIB);
2. If previously during the session M engaged in dangerous PB:
   A. Wait for at least 10 min for M not to engage in any dangerous PBs.
   B. Run the 30 min pairing session for Helen and MM (e.g., Helen and M playing a game M prefers, Helen providing frequent praise to M for appropriate playing and engaging with her, etc.)
   C. Resume running the sessions with Helen and M.
   D. If the episode of the dangerous PB occurs again, repeat the procedure (points A to C).

Participant – Helen.

After two appointments of pairing with M, Helen will start to implement the assigned programs with M.

1. During **each appointment**, the participant runs **at least one session** (defined as 5 trials of one program) for each of the **assigned three programs.**
2. In the beginning, Helen runs all the programs using a paper version of the protocol and a data sheet.
3. Later (in a couple of weeks), I will introduce the App condition for one of the programs, while the other two programs are still run using the paper versions.

Clinician – Graduate students placed at the clinic.

During each appointment when the participant is working with the client:

1. You can prompt the participant on when is a good **time to start the session** and/or invite the client to the table (according to your normal work/break schedule with the client).
2. You can provide prompting on how to handle the client's problem behaviors or silently block the client's PBs (e.g., client eloping from the instructional setting).
3. Make sure **not to provide any instructions**, prompts, or feedback while the participant is **running the programs** with the child.
4. You can tell the participant something like: "*I'm going to video-record the session and I won't be able to say anything, please run the session as I'm not here*".
5. **Video record each session** for each program and upload them on Box:
    a. Place yourself and the tablet somewhere in the room to have the client's and the participant's **faces and reactions visible on the video**;
    b. Start recording as soon as the client and the participant **are seated at the table**;
    c. When the session is over (5 trials of one program run or the participant saying they are done), stop recording and **save the video**.
    d. Go to the CARTT → GAINS Project (Aliya's Thesis) → Video Recordings folder on Box and upload a video to the participant's folder ("Link to the folder");
6. Make sure **not to provide any feedback** on programs' implementation **after the session** or at any time **until the end of the project** (next semester). It is allowed to provide feedback on interactions with the child and handling his challenging behavior (e.g., how the child prefers to receive the reinforcement, what kind of reinforcement, how to play the child's preferred games, how to block the child from eloping and etc.)
7. If during the session, a client engages in **problem behavior**:
    a. Non-dangerous behaviors (such as noncompliance, whining, or disruptions), → keep recording and **do not provide any prompts**. You can block the child from eloping or disrupting.
    b. Dangerous behaviors (aggression, tantrum, SIB) → stop recording and act according to the client's **BIP** and the **clinic's protocols**.

Appendix E

Motor Imitation (Copying shapes)

Purpose: The purpose of this protocol is to teach the learner to independently copy shapes

Target Response: The learner will correctly copy shapes within 5 seconds of the SD.

SD: Therapist models motor movement saying, "Do this" (i.e., therapist drawing a square and says, "do this") or "Copy me" or "Do what I'm doing."

R: Learner responds with the corresponding motor response (e.g., draws a square).

SR+: Behavior specific praise (e.g., "Great job drawing square!") and access to preferred item on an VR1.

Mastery Criterion: 90% correct independent responding in three consecutive sessions.

Measurement Procedure: Data will be collected as a percent correct for 5-trial block session with each target. Correct responses (those matching the target response above) will be marked with a "+." Responses that do not correspond with the SD, including no response, will be marked with a "–." Prompted responses will be marked with "P+."

- Prompt Procedure: Full physical after 5s of no response or an incorrect response.
- Reinforcement Procedure: Provide praise and edible or tangible for correct responses on an VR1 schedule.

Phase: Teaching

- Run all the targets per every session (5 trials). Vary the verbal SDs with a lag 2 schedule (SD must be different than the previous 2 trials.)
- If the learner emits the target response on first attempt, provide edible or tangible reinforcer and behavior-specific praise.
- Prompt on a 5 second physical constant prompt delay (Give the SD and wait 5 seconds.) While delivering a neutral confirmation statement (e.g. "that's drawing a square").
    - Error Correction:
        - If the learner emitted incorrect response, or did not tolerate physical prompt, repeat the SD and represent the trial with the physical prompt while delivering a neutral confirmation statement (e.g. "that's drawing a square").
- Criteria for the learner to meet the mastery criteria. (90% correct across three consecutive sessions)

Targets:

1. Drawing a square
2. Drawing a triangle
3. Drawing a heart

Motor Imitation Datasheet

Date	Sessions	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5
	1	+ / p /-	+ / p /-	+ / p /-	+ / p /-	+ / p /-
	2	+ / p /-	+ / p /-	+ / p /-	+ / p /-	+ / p /-
	3	+ / p /-	+ / p /-	+ / p /-	+ / p /-	+ / p /-
	4	+ / p /-	+ / p /-	+ / p /-	+ / p /-	+ / p /-
	5	+ / p /-	+ / p /-	+ / p /-	+ / p /-	+ / p /-
	6	+ / p /-	+ / p /-	+ / p /-	+ / p /-	+ / p /-
	7	+ / p /-	+ / p /-	+ / p /-	+ / p /-	+ / p /-
	8	+ / p /-	+ / p /-	+ / p /-	+ / p /-	+ / p /-
	9	+ / p /-	+ / p /-	+ / p /-	+ / p /-	+ / p /-
	10	+ / p /-	+ / p /-	+ / p /-	+ / p /-	+ / p /-
	11	+ / p /-	+ / p /-	+ / p /-	+ / p /-	+ / p /-
	12	+ / p /-	+ / p /-	+ / p /-	+ / p /-	+ / p /-
	13	+ / p /-	+ / p /-	+ / p /-	+ / p /-	+ / p /-
	14	+ / p /-	+ / p /-	+ / p /-	+ / p /-	+ / p /-
	15	+ / p /-	+ / p /-	+ / p /-	+ / p /-	+ / p /-
	16	+ / p /-	+ / p /-	+ / p /-	+ / p /-	+ / p /-
	17	+ / p /-	+ / p /-	+ / p /-	+ / p /-	+ / p /-
	18	+ / p /-	+ / p /-	+ / p /-	+ / p /-	+ / p /-
	19	+ / p /-	+ / p /-	+ / p /-	+ / p /-	+ / p /-
	20	+ / p /-	+ / p /-	+ / p /-	+ / p /-	+ / p /-

Appendix F

Receptive Identification of Pictures: Matching

Purpose: The purpose of this protocol is to teach the learner to match identical 2D pictures in an array size of three pictures.

Target response: The learner will match a sample picture to an identical comparison picture in an array.

SD for matching: The clinician will present the learner with an array of various pictures on a picture board. The clinician will give the learner a sample picture that matches one of the comparison pictures in the array, while simultaneously saying, "match". After each trial, the clinician will reposition the comparison stimuli to avoid position bias.

Correct response: The learner will take the picture that the clinician presents to him, and place the sample picture on the Velcro strip next to the identical comparison picture within 10 seconds of receiving the SD. The learner will do this without emitting any problem behaviors.

Prompted response: The learner will take the picture that the clinician presents to him and place the sample picture on the Velcro strip next to the identical comparison picture on the corresponding prompt step, without emitting any problem behavior.

Incorrect response: Learner demonstrates one or more problem behaviors, and/or places a picture underneath a non-identical picture and/or does not match within 10 seconds of receiving the SD.

R+ correct response: Behavior specific praise (e.g., "Great job matching!") and access to preferred edible, tangible, or sensory social routine after each prompted or independent correct response.

Measurement Procedure: Data will be collected as correct, prompted, or incorrect for each trial. A "+" should be marked when a client independently emits a correct response. A "–" should be marked when a client emits an incorrect response with or without a prompt. A "P" should be marked when a client emits a correct response following a prompt.

Response Prompts: Most to Least with Physical Fading

- Full physical (hand over hand)
- Partial physical (wrist)
- Gestural
- Independent
    - Two consecutive trials of meeting current prompt step criteria, **increase** prompt step.
    - Two consecutive trials of failing to meet current prompt step criteria, **decrease** prompt step.

<u>Teaching</u>

- Provide 5 opportunities for the learner to engage in the target response per session and record responses accordingly.
- The comparison stimuli are presented before the target and verbal SD.
- Following each trial, rotate the position of the comparison stimuli randomly before beginning another trial.
- If the learner emits the correct response on the corresponding prompt step, provide edible, social, or tangible reinforcer and behavior-specific praise.
- If the learner does not emit the correct response after the prompt, move to another trial.

Targets:

1) Identical pictures of the Square
2) Identical pictures of the Triangle (only after the 1st target is mastered)
3) Identical pictures of the Circle (only after the 2nd target is mastered)

Matching Identical Pictures Datasheet

Date						
Sessions →	**1**	**2**	**3**	**4**	**5**	**6**
Trial 1	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -
Trial 2	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -
Trial 3	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -
Trial 4	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -
Trial 5	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -

Date						
Sessions →	**1**	**2**	**3**	**4**	**5**	**6**
Trial 1	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -
Trial 2	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -
Trial 3	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -
Trial 4	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -
Trial 5	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -	+ / p / -

Appendix G

GAINS Usability Survey (circle): 1 2

DSP for Dyad (circle): 1 2 3 4 Date: _____

We are interested in your thoughts about GAINS. As a professional who has used GAINS with a consumer, we value your input in helping us improve GAINS.

Please place an x in the cell for your response.

First, we have some questions about your experience with GAINS.	**Question Responses**				
	Strongly Disagree	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
The use of GAINS can enhance my job performance in helping consumers learn new skills.					
The use of GAINS can make me more effective in helping consumers learn new skills.					
The use of GAINS in helping consumers learn new skills enhances my productivity.					
Generally, I consider GAINS can be useful to me in helping consumers learn new skills.					
Learning to use GAINS would be easy for me.					
I find it easy to interact with GAINS.					
Interaction with GAINS is clear and easy to understand for me.					
Generally, I consider GAINS easy to use.					
If I have a choice, I intend to use GAINS in helping consumers learn new skills.					
I predict I will use GAINS in helping consumers learn new skills.					
If I have a choice, I plan to use GAINS in helping consumers learn new skills.					
I am able to integrate GAINS in helping consumers learn new skills.					
I can use GAINS even if there is no one to help me.					

Now, we have questions about some features of GAINS.	Question Responses				
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
It is easy to login into GAINS.					
It is easy to start instruction with the consumer.					
I can hear the audio assistance provided.					
It is easy to know what to do next.					
Audio assistance is easy to follow.					
Audio assistance is useful.					
The display is easy to read.					
Audio is enough. It is not necessary to read the display.					
It is easier than pen and paper to input data.					
Data recording is more accurate than pen and paper.					
It is useful to be provided the prompt level for a step.					
It is easy to tell what the prompt level is for a step.					
It is useful that GAINS tracks mastery of a step.					
GAINS makes it easy to track mastery of a step.					
Choosing Guidance Type (detailed, brief, etc.) is easy.					
Choosing Guidance Type (detailed, brief, etc.) is useful.					