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Evaluation of a Wearable Activity Schedule for Promoting Independent Play in Children with Autism Spectrum Disorder

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Evaluation of a Wearable Activity Schedule for Promoting Independent Play in Children with Autism Spectrum Disorder

by

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Abstract

Title: Evaluation of a Wearable Activity Schedule for Promoting Independent Play in Children with Autism Spectrum Disorder

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Activity schedules are an antecedent intervention in which a series of visual cues, presented typically in booklets or binders, function as prompts for steps in a behavior chain (e.g., classroom routine, playing hide and seek). Although activity schedules are useful in getting individuals to manage their own behaviors, their typical presentation format can be cumbersome and stigmatizing for children placed in general education classrooms, placing additional barriers for independence and inclusion across environments for these children. Some researchers have used electronic devices such as tablets to display activity schedules, and although more socially acceptable, these are still cumbersome for young children and costly for most families. The purpose of this study was to evaluate the usefulness of a practical and affordable alternative, a wearable device functioning as an activity schedule, to promote independent play in young children diagnosed with Autism Spectrum Disorder (ASD) and whether the usefulness of this device will transfer outside the clinic context under the supervision of a caregiver. Results indicated that all three participants had higher levels of on-schedule responding under the watch condition compared to baseline condition. Two of the participants had minor levels of disruption in responding when generalization probes were first introduced but maintained responding at high levels for the remaining of the probes.

Keywords: Autism spectrum disorder (ASD), activity schedule, technology, stimulus control, generalization

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Dedication

I dedicate this thesis to my parents who made my dreams come true, to my sister who provided an immeasurable support and guidance, and to my boyfriend who emotionally supported me.

Evaluation of a Wearable Activity Schedule for Promoting Independent Play in Children with Autism Spectrum Disorder

Autism Spectrum Disorder

Manifestation of restrictive, repetitive behavior patterns, interests and/or activities, and deficits in reciprocal social communication and social interaction are all diagnostic features of Autism Spectrum Disorder (ASD; APA, 2013). According to a study conducted by Center for Disease Control and Prevention's (CDC) Autism and Developmental Disabilities Monitoring (ADDM) Network (2018), the prevalence of ASD between the years of 2000 and 2014 was estimated at 16.8 per 1,000 children. Reported frequencies for ASD have reached 1% of the population across U.S. and non-U.S. countries, and nearly 3% in some U.S. communities (DSM-V, 2013; CDC, 2018). Thus, ASD has become an urgent public health concern that requires early diagnosis, as well as developing instructional strategies to improve behavioral, educational, residential, and occupational needs of this population (CDC, 2018).

Effective Treatments

The National Research Council (2001) concluded that the most effective intervention for children with ASD is early and intensive education that specifically targets five core aspects: social, communication, play, life, and academic skills. The primary purpose of behavioral interventions is to generate functional and socially acceptable skills in people. For individuals with ASD, these skills are fundamental pre-requisites to engage in appropriate self-care, work, and leisure activities (MacDuff, Krantz, & McClannahan, 1993). However, extreme difficulties in planning, organization, and coping with change, as well as problems with transitioning between tasks can negatively impact performance of self-help skills and establishing independence (DSM-V, 2013; Russo et al., 2007). As a result, dependence on caregivers and lack of self-management are two of the primary stressors for the caretakers of individuals with ASD (Koegel et al., 1992), and should be the focus of behavioral interventions. Independence becomes a particularly critical issue when children shift from having one-on-one teaching services to having many teachers in large groups settings, as is common when children transfer to general education classrooms (Bryan & Gast, 2000; Charman, 2011).

Activity Schedules

Individuals with intellectual or developmental disabilities may develop a dependency to primary caregiver- or instructor-delivered prompts to initiate tasks or activities, and as a result their level of independence becomes restricted (Copeland & Hughes, 2000; Phillips & Vollmer, 2012). Prompts are essential parts of behavior analytic interventions during skill acquisition and can be easily associated with positive reinforcement, thereby acquiring stimulus control over the target response emitted by the learner (MacDuff et al.,1993). Most of the time this sequence of events leads learners to become unresponsive in the absence of prompting procedures and teachers. Lengthy response chains may require therapists to provide prompts for initiation of each component of the activity, which may be socially stigmatizing in a school environment (MacDuff et al., 1993). Typically developing individuals, respond to the natural cues to emit functional responses in a given context. For instance, hearing someone saying, "good morning" will serve as a natural cue for a child to respond by saying "hello." On the other hand, individuals with intellectual or developmental disabilities heavily rely on external cues that may come in the form of verbal instruction, modeling, physical prompting, and gestures from the instructor. Supporting these individuals to develop the skills to function independently in less restrictive environments is the ultimate goal of behavioral interventions, and to this end, external cues are gradually faded out in instruction until they can perform tasks independently (Mechling & Gast, 1997). One way in which independent functioning and reduction of dependency on a supervising adult can be promoted is by using a specific form of visual support: *activity schedules* (Kinney, & Taylor, 2006; Stromer, Kimball, Koyama & Wang, 2012).

Activity schedules are evidence-based practices (Knight, Sartini, & Spriggs, 2015), that is, there is ample empirical support for their usefulness in increasing independent use of skills. Activity schedules are comprised of various forms of visual cues (e.g., objects, photographs, pictures, symbols, drawings, and/or words) depicting a sequence of individual activities to guide the learner to complete predetermined set of tasks and/or complex behavior chains (Massey & Wheeler, 2000; McClannahan, & Krantz, 1999). Visual cues may depict the objects that should be used, actions that should be completed or a person who will accompany for that specific task (Massey & Wheeler, 2000). Activity schedules can curtail prompt dependency by transferring stimulus control from an instructor to a picture (Copeland & Hughes, 2000). Once the stimulus control is transferred to picture cues, the need to use verbal directions or physical guidance is diminished (Koyama & Wang, 2012). Activity schedules are traditionally presented as posters or in a three-ring binder (e.g., Betz, Higbee, & Reagon, 2008; Krantz, MacDuff, & McClannahan, 1993; MacDuff, Krantz, & McClannahan, 1993; Whatley, Gast, & Hammond, 2009). More recently, innovative forms such as power point presentation, iPod, or iPad also have been used (e.g., Brodhead, Courtney, & Thaxton, 2018; Burckley, Tincani, & Fisher, 2015; Carlile, Reeve, Reeve, & DeBar, 2013; Fage, Pommereau, Consel, Balland, & Sauzeon, 2016; McClannahan & Krantz, 1999). If activity schedules are shown to be effective in the absence of additional verbal prompts, reinforcement and/or adult supervision, they can be useful forms of intervention in settings such as schools (Blum-Dimaya, Reeve, Reeve, & Hoch, 2010).

The use of pictorial cues has a long history within behavioral research (e.g., Martin, Rusch, James, Decker, & Trtol, 1982; Schopler, Mesibov, & Hearsey, 1995; Thineson & Bryan, 1981; Wacker & Berg, 1983). A range of studies using activity schedules have found this intervention method led to successful outcomes in decreasing challenging behavior, as well as increasing social initiations, on-task, and on-schedule behaviors (Krantz & McClannahan, 2014). For instance, MacDuff et al. (1993) evaluated the effectiveness of photographic activity schedules, in combination with a graduated guidance procedure, on on-task and on-schedule behaviors in four boys with ASD living in a group home. The result of the intervention indicated that the participants learned to engage in a variety of recreational and home-living skills, and their schedule-following skills were generalized and maintained. Relatedly, Pierce and Schreibman (1994) investigated the efficacy of picture schedules on teaching active daily living skills. After the implementation of the pictorial self-management package, all three participants started engaging in previously defined daily living behaviors that were not in their repertoire previously and showed decreased levels of inappropriate behaviors. Importantly, participants continued completing scheduled tasks in the absence of therapists and across various settings. Similarly, Krantz and colleagues (1993) studied parents' use of photographic activity schedules on their children's home living skills. Results of this study showed increase in engagements with scheduled work or play activities and social initiations, and decrease in disruptive behavior (e.g., tantrums, aggression, disruptive behavior), all of which maintained at the ten-month follow-up session.

Banda and Grimmet (2008) conducted a review of the visual activity schedule literature published from 1993 to 2004 and found that visual activity schedules were effective in increasing social, functional, on-task, and transition behaviors in individuals with ASD, whereas some of the limitations included lack of generalization and social validity. Knight et al. (2015) extended the previous study by reviewing articles published between 1993 and 2013 and concluded that visual activity schedules, in combination with systematic instructional procedures, can be considered as evidence-based practice for individuals with ASD. Evaluation of generalization, maintenance, and social validity revealed that successive use of visual activity schedules to improve children's abilities in transitioning among activities, generalizing skills across settings, and maintaining skills from preschool through adulthood. These findings are supported by the National Autism Center and The National Professional Developmental Center on Autism Spectrum Disorder.

Activity schedules have other benefits for people with ASD who experience difficulties in receptive and expressive language. By visually preparing individuals for the next activity or step, activity schedules can minimize the occurrence of problem behaviors while increasing independence, easing transition between activities, and increasing the percentage of time engaged with the activity (Gena & Kymissis, 2001; Knight, Sartini, & Spriggs, 2015; Lequia, Machalicek, & Rispoli, 2012). Dooley, Wilczenski, and Torem (2001) used a schedule board embedded within a picture exchange communication system (PECS) of a student diagnosed with pervasive developmental disorder. Results showed a dramatic decrease in aggression and increase in cooperative behavior in the classroom setting. Similarly, Machalicek and colleagues (2009) studied the effects of activity schedules and task correspondence training on play and challenging behaviors. Three school-aged children with autism participated in the study and results indicated an increase in play activities while challenging behavior decreased for two participants. Besides decreasing challenging behaviors, visual activity schedules produce desirable outcomes in independent transitioning at school, home and community settings (e.g., Dettmer, Simpson, Myles, & Ganz, 2000; Whatley, Gast, & Hammond, 2009).

Krantz, MacDuff, and McClannahan (1993) studied the use of photographic activity schedules on stereotypic behavior during leisure, self-care, social interaction, and house-keeping activities. Common forms of stereotypic behavior observed in individuals with ASD include body rocking, verbal outbursts, echolalia, hand flipping, spinning, perseverative speech. Results indicated that when parents were trained to implement activity schedules, children engaged in stereotypic behaviors less frequently. These results are supported by a subsequent study conducted by Pierce and Schreibman (1994), in which they studied the effectiveness of a pictorial self-management intervention to teach daily living skills to children with ASD. Results indicated successful use of picture prompts to emit adaptive daily living skills (e.g. making the bed, doing laundry, making lunch, setting the table) and to decrease inappropriate behaviors.

By minimizing problem behavior associated with transitions, activity schedules support on-task and on-schedule behaviors. Transitioning between predetermined tasks or activities, visually attending, gathering or appropriately manipulating scheduled items, and visually attending to the visual activity schedule are considered on-task behaviors; engaging with corresponding task, item or activity on the visual activity schedule are on-schedule behaviors that are expected to be performed by the learner when following visual activity schedule (Zimmerman, Ledford, & Barton, 2017). Bryan and Gast (2000) evaluated the effectiveness of combined effects of graduated guidance and visual activity schedule with four students with ASD and concluded that teaching package promoted the independent functioning of students in the form of high-levels of on-task and on-schedule behavior. Similarly, Massey and Wheeler (2000) measured the efficacy of an activity schedule with a 4-year-old boy diagnosed with ASD.

Implementation of the activity schedule resulted in an increase of on-task behavior across work and leisure conditions.

Social Validity of Activity Schedules

Teaching individuals to independently engage in play and leisure activities using activity schedules comes with some unique challenges. The setting in which behaviors occur can be a barrier to implementing activity schedules, because leisure activities are mostly held in settings that are outside the center or school walls (e.g., playground) and may require the individual to move around (e.g., transitioning from assembling a train track to playing with trains). This makes it difficult to both engage in the target activity and carry the binder containing the visual activity schedule. Further, carrying a binder containing an activity schedule can be stigmatizing for the individual and can pose a barrier for inclusion in less restrictive environments such as school settings (Carlile et al., 2013). To circumvent this problem, researchers have sought other forms of presentation of the activity schedules (e.g., Blum-Dimaya, Reeve, Reeve, & Hoch, 2010; Brodhead, Courtney, & Thaxton, 2018; Carlile et al., 2013). For instance, Chan et al. (2014) successfully used a picture-based activity schedule presented on an iPad to teach a leisure activity (e.g., playing Angry Bird app) to three adults with mild intellectual disabilities.

Use of Technology

Carlile et al. (2013) used activity schedules presented on an iPod touch, which facilitated transportation of the activity schedule, and provided a discreet and socially acceptable alternative compered booklets, to study the effectiveness of the device to teach independent completion of leisure activities with four children with ASD. All four participants independently completed leisure activities when the iPod touch was introduced. According to Carlile et al. (2013), embedding prompts on an electronic device and reducing adults' proximity and verbal prompts to guide the learner to emit the desired response are benefits of using technology to display activity schedules. Smaller and portable handheld devices, such as iPods and tablets, that are programmed to provide auditory, visual or tactile prompts have been shown to be effective in creating a less restrictive environment and successful independent responding, and teaching skills to individuals with disabilities (Wu, Wheaton, & Canella-Malone, 2016). In addition, an activity schedule presented in technological format may possess additional benefits compared to traditional activity schedules, such as being more portable, less stigmatizing, and socially valid (Carlile et al., 2013). Devices such as iPods and tablets, however, are expensive and may be somewhat cumbersome when used with preschool-aged kids, and can in addition lead to decreased levels of interpersonal interaction (Goldsmith & LeBlanc, 2004).

Thus far, the use of a wearable activity schedules such as a watch has not been widely explored. Wearable devices specifically designed to be used with children, such as the Octopus watch (https://www.heyjoy.io), can be a promising alternative for presenting visual cues. This type of device is portable, commercially available, user-friendly, operable with little instruction, and economical compared to tablets or iPods. Recent work conducted by Jimenez-Gomez, Haggerty, and Topcuoglu (in preparation) evaluated the usefulness of using the Octopus watch as a visual activity schedule to support independent completion of self-care behavior chains in neurotypical children. In addition, Jimenez-Gomez et al. evaluated whether the Octopus watch would function as a visual activity schedule in children with ASD in a clinic setting to promote completion of independent play activities. Both neurotypical children and children with ASD were able to follow visual and tactile prompts delivered by the Octopus watch. In addition, participants demonstrated higher levels of independent completion of tasks and lower levels of off-task or problem behavior when wearing the watch compared to when the researchers delivered prompts.

These preliminary findings are promising regarding the usefulness of a wearable activity schedule in a clinic setting under the supervision of a trained behavioral therapist. The question remains, however, whether high levels of independent compliance with prompts and low levels of problem behavior also would be observed when the wearable device is used in more naturalistic environments (e.g., home setting). It is possible that when the target behavior (e.g., independent play) is addressed in one context (e.g., clinic setting with behavioral therapist), a return to the original context in which the behavior was not occurring independently and in the absence of problem behavior (e.g., home setting with caregiver) could result in loss of the therapeutic gains (Podlesnik, Kelley, Jimenez-Gomez, & Bouton, 2017; Wathen & Podlesnik, 2018). The purpose of this study was to further evaluate the utility of the Octopus watch to support independent play in children with ASD. More specifically, this study evaluated whether the treatment gains observed in a clinic context maintained once the child was asked by a caregiver to perform the same task (i.e., play independently) in a simulated home setting.

Method

Participants, Setting, and Materials

Three children ages 3-6 diagnosed with ASD were recruited for this study. Two of the participants were clients receiving behavior analytic services for 30 hours a week from a university-based autism clinic located in Florida. One participant was a client receiving behavior analytic services from an independent clinic located in Florida. All three participants had vocal-verbal repertoire to communicate with adults. All three participants scored at least Level 2 on the mand (asking for items), visual perceptual / matching to sample, and play domains of the *Verbal Behavior Milestones Assessment and Placement Program* (VB-MAPP; Sundberg, 2008), but did not test above Level 3, and had the ability to follow basic, one-step instruction, and did not display high rates of problem behavior that would interfere with performance. Pseudonyms are used below to protect the confidentiality of the clients.

Zavier was five years five months while the project was in process and had been receiving applied behavior analytic (ABA) services for 24 months. He has multiple diagnosis of ASD, Avoidance/Restrictive Food Intake Disorder, and Accompanying Language Impairment. He scored 151 (out of a possible 170 points) on the most recent assessment of VB-MAPP, scored 15 (out of a possible 15 points) in Level 2 for mand (asking for items), visual perceptual / matching to sample, and play domains. Nevin, was six years and eleven months of old while the project was in process and had been receiving ABA services for two years and four months. He has a dual diagnosis of ASD and Avoidance/Restrictive Food Intake Disorder. He scored 137.5 (out of a possible 170 points) on the final assessment of the VB-MAPP, scored 15 (out of a possible 15 points) in Level 2 for mand (asking for items), visual perceptual / matching to sample, and play domains. Edith was four years six months while the project was in process and had been receiving ABA services for 5 months. She has diagnosis of ASD. She scored 107.5 (out of a possible 170 points) on the first assessment of the VB-MAPP, scored 14 (out of a possible 15 points) in Level 2 for mand (asking for items), visual perceptual / matching to sample, and play domains.

Sessions were conducted three to five days per week in a private session room that resembles a typical living room - that was named as home context at the legend of the graphs - or in a classroom at a university-based autism clinic. Each session lasted approximately 30 min, with breaks interspersed throughout. Session materials included the Octopus watch (https://www.heyjoy.io/products/octopus-watch), data sheets, pens, a motivator, a timer, clipboard, play materials, and a video camera.

The Octopus watch is an icon-based watch with a simple interface that was developed to promote independence in children. The device weighs 0.75 oz and has dimensions of 1.26 x 1.38 x 0.47 inches. An application specifically developed to remotely control the watch can be downloaded from application stores on smart phones. From this application, the researcher selected icons from the pool of over 700 icons depending on the activities targeted for each client (e.g., trains, dinosaur, blocks). All sessions were video recorded for scoring by a trained secondary observed for inter-observer agreement and treatment integrity.

Pre-experimental Interviews and Assessments

Prior to initiating the study, the researcher conducted interviews with caregivers and case managers to determine appropriate play targets. In addition, all activities chosen were probed to ensure participants could independently engage in the behaviors comprising the play behavior chain. For instance, if the behavior chain is playing with trains, the researcher probed whether the participant could independently connect tracks and place trains on the track.

Experimental Design

ABB design with an imbedded non-concurrent multiple probe across participants was used (Tawney & Gast, 1984). To evaluate whether participants maintain gains observed during the intervention in a context different than where the intervention was delivered, pre- and post-intervention multiple probe data was collected in the presence of primary caregivers both in a session room arranged to resemble the natural home environment and a clinical setting. Researcher probes in a session room arranged to resemble the natural home environment before and after intervention were also conducted to demonstrate the maintenance of the skill across different settings.

Dependent Variables and Data Collection

The two primary dependent variables were (1) percent of correct and independent completion of intervals for on-schedule responses in a behavior chain and (2) bids for attention per min. On-schedule responses were evaluated with whole interval recording. When the participant manipulated the scheduled item for the entire 1-min interval, it was recorded as plus (+). When the participant, (1) required a verbal prompt, (2) engaged in problem behavior, (3) moved 3 ft away from the scheduled item, or (4) discontinued manipulating the item for 5 s, it was recorded as minus (-) during that interval. Each interval was 60 s long, for a total of 900 to 1080 s in the 15 to 18 min session. On-schedule responses were calculated by dividing the number of intervals with correct responses by the number of total intervals to respond and multiplying by 100. Frequency of bids for attention were the number of instances of directed vocalizations towards the researcher (e.g., asks questions regarding the play task) and/or showing the play items to the researcher during the session. Rate of bids for attention were calculated by dividing the number of bids directed to the researcher or caregiver by the total session duration.

Three secondary dependent variables were also recorded: (1) percent of correct and independent completion of intervals for on-task responses, (2) verbal prompts provided by the researcher or caregiver during session, and (3) client-specific problem behaviors during activity transitions. On-task responses were evaluated with whole interval recording. When the participant manipulated any of the items picked during multiple stimuli without replacement (MSWO), for the entire 1-minute interval, it was recorded as plus (+). When the participant, (1) required a verbal prompt, (2) engaged in problem behavior, (3) moved 3 ft away from the scheduled item, or (4) discontinued manipulating any of the items for 5 s, it was recorded as minus (-) during that interval. Each interval was 60 s long, for a total of 900 to 1080 s in the 15 to 18 min session. Percentage of on-task responses was calculated by dividing the total number of independent correct responses by the total number of intervals.

Verbal prompt requirements were provided when: 1) the participant moved 3 ft away from the play items while discontinuing touching for 5 s, 2) the participant engaged in bids for attention without touching any of the items. Rate of verbal prompts was calculated by dividing the total number of verbal prompts provided by the therapist or caregiver by the total session duration. Problem behavior was evaluated according occurrence/nonoccurrence. When participants engaged in any problem behavior such as aggression, flopping, disruption and negative vocalization with 5 s onset during intervals or transition between activities, the researcher recorded the frequency of instances. Rate of problem behavior was calculated by dividing the number of problem behaviors by the total session duration.

Interobserver agreement. Interobserver agreement (IOA) data were collected by a second, independent observer who was trained on the operational definition of the target behaviors, and data collection procedures. IOA data were collected for at least 40% of sessions across all conditions and participants for both of the primary and secondary dependent measures. The IOA data were collected via video recording. Interval-by-interval IOA was used for percent correct and independent on-schedule and on-task responses within behavior chain. It was calculated by dividing the number of agreements by the total number of trials and multiplying by 100. Total count IOA was used for rate of verbal prompts, rate of problem behavior, and rate of bids for attention. In this case, IOA was calculated by dividing the smaller count by the larger count and multiplying by 100 (Cooper et al., 2007). For Nevin, IOA was collected for 47% of the sessions with an overall mean IOA of 99% (range of 86-100%). Mean IOA for primary dependent measures (i.e. on-schedule, bids for attention) was 99% (range of 99-100%). Similarly, mean IOA for secondary dependent measures (i.e. on-task, verbal prompts, problem behavior) was 99% (range of 95-100%). For Zavier, IOA was collected for 44% of the sessions with an overall mean IOA of 98% (range of 80-100%). Mean IOA for primary dependent measures (i.e. on-schedule, bids for attention) was 98% (range of 96-100%). Similarly, mean IOA for secondary dependent measures (i.e. on-task, verbal prompts, problem behavior) was 98% (range of 93-100%). For Edith, IOA was collected for 40% of the sessions with an overall mean IOA of 100%.

Treatment integrity. The primary observer trained four secondary observers on treatment procedures and provided a procedural integrity checklist. For each condition, a tailored checklist was provided to observers. The trained observers collected data on the accuracy of the primary instructor's (researcher or caregiver) implementation of the experimental procedures via video recording. Treatment integrity was calculated by dividing the number of correctly implemented components of the checklist by the total components and multiplying by 100. Treatment integrity was collected for 52% of the sessions for Nevin, with an average of 93% (range of 79-100%). Treatment integrity was collected for 50% of the sessions for Zavier, with an average of 93% (range of 75-100%). Treatment integrity was collected for 45% of the sessions for Edith, with an average of 99% (range of 94-100%).

Social validity. Two different satisfaction surveys were provided to primary caregivers and participants. Five-point Likert-scale provided to caregivers as a Post-intervention Social Validity measure (Appendix A) and statements were answered using the scale from 1 (strongly disagree) to 5 (strongly agree). A Satisfaction Survey (Appendix B) with five statements and two possible answer choices (i.e. liked, disliked) provided to participants. Choices made by pointing to a smiling face indicating "liked", and sad face indicating "disliked". Results of Post-intervention Social Validity measure (Appendix A) conducted on primary caregiver represented in the mean for each question across three caregivers and Satisfaction survey (Appendix B) conducted on participants represented with the preference for each statement, are shown in Table 1 and 2 respectively. Social validity measures conducted with participants indicated that all three answered 'liked' across five questions, except Zavier and Edith who answered question number two that asked about the comfort of the watch as "disliked". Additionally, Edith answered question number five that is asking if she would like to use the watch at home as "disliked". Overall, participants reported finding the watch useful reminders of what to do.

Procedure

Preference assessment. Each session started with a preference assessment to determine the preferred play activities. Activities to present during preference assessment were selected based on the initial interview and discussion with primary instructor, case manager, and/or primary caregivers. Related icons from the application were printed out (1x1 in) and laminated. MSWO assessment was conducted and the top three choices were used in a randomized order during the session (Cooper et al., 2007).

General procedures. Before every session, the instructor placed the Octopus watch on the preferred wrist of the participant. Icons selected from the MSWO were visually presented at the beginning of the session for the participant to visualize the choices made during the preference assessment. Materials related with each play skill were positioned by the instructor. For instance, if the participant chose to play with trains, blocks, and farm animals, these items were positioned in different areas of the room (e.g., classroom or simulated home setting). At the beginning of each session, the position of the play items was pointed out by the researcher.

Correspondence training of independent play. Participants were asked to tact each laminated visual stimuli depicting the play activity and a brief listener responding session was conducted with both pictures and actual items (e.g., "show me the picture that means time to play with …", "show me where the dinosaurs are"). Correspondence training was conducted at the beginning of each treatment session (i.e., watch condition). After completion of preference assessment, a brief listener responding session was implemented with the 3D play items (e.g. "show me where the cars are").

Baseline condition. During this phase, the Octopus watch did not provide any tactual or visual prompts. Verbal prompts were delivered once at the beginning of the 18 min play session (e.g., "Go play"). During the session, if the participant moved 3 ft away without touching any of the scheduled items, the instructor provided a verbal prompt to indicate they should be playing (e.g., "Go play"). When the participant engaged in bids for attention while he/she had contact with any of the items, no verbal prompt given. At the end of session, the watch was removed from the wrist of the participant. These sessions were conducted by the researcher in a clinic and a simulated home setting and by a caregiver in a clinic and a simulated home setting, all located at a university-based clinic.

Watch condition. An activity schedule was created on the Octopus watch application according to the randomized order of the play activities selected during the preference assessment. During this phase, the Octopus watch provided tactual and visual prompts regarding which activities should be completed. Visual and tactual cues scheduled to appear once at the beginning of each 5 min trial block of play skills and up to 3 times during ‘clean up’ time. At the beginning of the session, a correspondence training was conducted as described above. After correspondence training, a script was read by the researcher or by the caregiver to the participant. For instance, the researcher said, “Before, you were following what I was telling you to do. From now on, your watch is going to tell you what you should be doing. The watch will buzz and a picture will pop up that tells you what you are supposed to be playing with.” During the session, when the participant moved 3 ft away without touching any of the scheduled items, the instructor provided a scripted verbal prompt (i.e., **“**Follow what your watch is telling you to do.”). When the participant engaged in bids for attention while he/she has contact with any of the items, no verbal prompt was delivered. At the end of the session, the Octopus watch was removed from the wrist of the participant. The session was terminated, and feedback was provided by the instructor (e.g. “I like how you played with your cars, blocks, and trains.”). The watch condition was in place until participants reached the mastery criteria of three consecutive sessions at 90% or above of correct and independent completion of on-schedule steps in the play behavior chain.

Generalization probes. Immediately after the watch condition, caregiver and researcher probes were conducted both at clinic (caregiver only) and simulated home settings. The caregiver implemented the same procedures of the watch condition as described above. The purpose of these probes was to assess whether training with the watch conducted by the researcher in a clinic context would generalize to responding when the watch intervention was implemented in a different context by the researcher or by a caregiver both contexts.

Results

For all participants, the primary and secondary dependent variables are presented in separate figures. The percent correct and independent on-schedule responses in the behavior chain and bids for attention or assistance from Zavier are presented in the top and bottom panels of Figure 1, respectively. For on-schedule responses, the mean of percentage of correct and independent responses during baseline was 28% for both caregiver (range, 17-33%) and researcher (range, 28-39%) across contexts (i.e., simulated home context and clinic; top panel of Figure 1). During the watch condition implemented by the researcher, the percentage of intervals with on-schedule responses increased to a mean of 100%. Subsequently, implementation of the watch intervention in the simulated home environment and in the clinic by the primary caregiver, and in the simulated home environment by the researcher was evaluated. Results of this evaluation indicated a small decrease in Zavier's percentage of intervals with on-schedule responses when the caregiver implemented the intervention in the simulated home environment (94%). He reached to mastery criteria (90% or above for three consecutive sessions) within four sessions. Overall, generalization probes across people and contexts revealed a mean of 98% (range, 94-100%).

The rate of bids for attention showed an inverse relation to correct and independent on-schedule responses in the behavior chain (see bottom panel of Figure 1). That is, Zavier's mean of bids for attention or assistance directed at the caregiver or researcher was 0.09 per min during baseline and decreased to 0.04 per min, when the Octopus watch intervention was implemented by the researcher. During generalization probes conducted by the caregiver in the home and clinic contexts, and the researcher in the simulated home context, mean bids for attention or assistance increased to 0.06 per min.

Zavier's percent correct and independent on-task responses in the behavior chain and rate of verbal prompts provided by the researcher or primary caregiver are presented in the top and bottom panels of Figure 2, respectively. During the baseline condition, Zavier's mean percentage of intervals with correct and independent on-task responses was 97% (range, 83-100%; top panel of Fig. 2). During the watch intervention condition, mean rate of on-task behavior increased to 100%. During the final phase, when generalization probes were conducted by the caregiver in the home and clinic contexts, and the researcher in the simulated home context, behavior remained at similar level as during the watch condition with the mean of 99% (range, 94-100%).

The bottom panel of Figure 2 shows the rate of verbal prompts delivered to Zavier throughout the study. During the baseline condition, the rate of verbal prompts was 0.07 per min (range of 0.05-0.27) and decreased to 0.06 per min during the treatment condition. During generalization probes, mean rate of verbal probes increased to 0.18 per min (range of 0.06-0.35). The increase was due to treatment fidelity errors by the caregiver, which will be described in the discussion section.

Nevin's percent correct and independent on-schedule responses in the play behavior chain and bids for attention or assistance are presented in the top and bottom panels of Figure 3, respectively. For on-schedule responses, the mean of percentage correct and independent responses during baseline was 21% for both caregiver (range, 17-28%) and researcher (range, 11-28%) across contexts (i.e. simulated home context and clinic; see top panel of Fig. 3). During the watch condition implemented by the researcher, the percentage of intervals with on-schedule responses increased to a mean of 73% (range, 25-100%), with the last three sessions above 90%. Subsequently, implementation of the watch intervention in the home environment and in the clinic by the primary caregiver, and in the home environment by the researcher was evaluated during generalization probes. These indicated an initial disruption in Nevin's percentage of intervals with on-schedule responses compared to last three sessions of treatment condition and followed by a maintenance of skill.

Nevin's mean rate of bids for attention or assistance directed to the caregiver or researcher was 0.05 per min during baseline and slightly increased to 0.06 per min when the Octopus watch intervention was implemented by the researcher (see bottom panel of Figure 3). During generalization probes conducted by the caregiver in the home and clinic contexts, and the researcher in the simulated home context, mean rate of bids for attention or assistance decreased to 0.03 per min.

Nevin's percent correct and independent on-task responses in the behavior chain and rate of verbal prompts provided by the researcher or primary caregiver are presented in the top and bottom panels of Figure 4, respectively. During the baseline condition, Nevin's mean percentage of intervals with correct and independent on-task responses was 87% (range, 50-100%; see top panel of Fig. 4).

During the watch intervention condition, mean rate of on-task behavior increased to 97%. During the final phase, generalization probes were conducted by the caregiver in the home and clinic contexts, and the researcher in the simulated home context, a minor disruption in performance during the first two probes was observed, which was followed by a maintenance of the skill.

The bottom panel of Figure 4 shows the rate of verbal prompts delivered to Nevin throughout the study. During the baseline condition, the rate of verbal prompts was 0.45 per min (range of 0.05-2.27) and decreased to 0.07 per min during the treatment condition. During generalization probes, mean rate of verbal probes increased to 0.28 per min (range of 0.05-1.44).

Edith's percent correct and independent on-schedule responses in the play behavior chain and bids for attention or assistance are presented in the top and bottom panels of Figure 5, respectively. For on-schedule responses, the mean percentage of correct and independent responses during baseline was 26% for both caregiver (range, 22-28%) and researcher (range, 0-33%) across contexts (i.e. simulated home context and clinic; see top panel of Figure 5). During the watch condition implemented by the researcher, the percentage of intervals with on-schedule responses increased to a mean of 95%. Subsequently, implementation of the watch intervention in the home environment and in the clinic by the primary caregiver, and in the home environment by the researcher was evaluated. Results of the evaluation indicated no disruption in the performance. Generalization probes across people and contexts revealed a mean of 100%.

Edith's mean of rate of bids for attention or assistance directed to the caregiver or researcher was 0.15 per min during baseline and slightly decreased to 0.08 per min when the Octopus watch intervention was implemented by the researcher (see bottom panel of Figure 5). During generalization probes conducted by the caregiver in the home and clinic contexts, and the researcher in the simulated home context, mean of rate for bids for attention or assistance were 0 per min. Results indicate no deterioration of the performance during generalization probes.

Edith's percent correct and independent on-task responses in the play behavior chain and rate of verbal prompts provided by the researcher or primary caregiver are presented in the top and bottom panels of Figure 6. During the baseline condition, Edith's mean percentage of intervals with correct and independent on-task responses was 92% (range, 44-100%). During the watch intervention condition, mean rate of on-task behavior increased to 95%. During final phase, generalization probes were conducted by the caregiver in the home and clinic contexts, and the researcher in the simulated home context, behavior remained at same level with the mean of 100%. These results indicate no disruption of the responding.

The bottom panel of Figure 6 shows the rate of verbal prompts delivered to Edith throughout the study. During the baseline condition, the mean rate of verbal prompts was 0.1 per min (range of 0.05-0.33) and decreased to 0.09 per min during the treatment condition. During treatment probes, mean rate of verbal probes increased to 0.09 per min (range of 0.19-0.06). During generalization probes conducted by the caregiver in the home and clinic contexts, and the researcher in the simulated home context participant did not require additional verbal prompts from a supervising adult and maintained the responding as seen at the last three sessions of the treatment phase.

Client-specific problem behaviors are only shown for Edith (Figure 7), as other participants did not display problem behavior during research sessions. Edith's problem behaviors consisted of aggression, disruption, and negative vocalization with 5 s onset. During baseline the mean rate of problem behavior was 0.72 per min and decreased to 0.03 per min during treatment condition and reached to zero levels during generalization probes. For other participants, these data are not shown due to absence of problem behavior during the study.

Discussion

To our knowledge, in addition to the work conducted by Jimenez-Gomez et al. (in preparation), the present study is the only other study to use an activity schedule in the form of a wearable device with the goal of teaching independent play skills to children with ASD. Further, it is the first study to evaluate whether the positive effects observed in the clinic are maintained when the watch intervention is implemented by a primary caregiver in a context that resembles the home environment. All participants correctly and independently completed steps in the play behavior chain and engaged in little to no bids for attention under the watch condition implemented by the researcher. In addition, when the watch condition was implemented by primary caregivers or by researchers in a novel context, participants maintained the skills with minor levels of disruption (i.e., high number of steps completed independently and low number of bids for attention). The results support the effectiveness of wearable activity schedules in promoting generalization of independent play skills across settings and across instructors without additional training.

It is important to note, however, that when the watch intervention was implemented by the caregivers, behavior was briefly disrupted. That is, target behaviors decreased compared to levels observed during the intervention implemented by the researcher. For instance, Zavier's on-schedule behavior decreased from 100% to 94% (see top panel of Figure 1). The same is true for Nevin's data on the mean rate of verbal prompts delivered by a supervising adult increased from 0.07 across treatment session to 0.28 across treatment probe sessions. For Edith neither of the dependent variables were disrupted. These findings are consistent with a renewal effect, in which a change in the context (e.g., person implementing treatment, location) can result in a decrease in therapeutic gains observed during the treatment condition (see Wathen & Podlesnik, 2018). Importantly, the small decreases in performance observed did not maintain over time, with behavior quickly returning to the same levels observed during last sessions of treatment.

Limitations

It is worth noting that Zavier's rate of bids for attention and rate of verbal prompts delivered by caregivers indicated a slight increase compared to the treatment condition. The increase in the mean rate was due to treatment fidelity errors which were committed by the primary caregiver. Delivery of verbal prompts that did not meet the procedural requirement evoked bids for attention by the participant. This caregiver required additional training to ensure treatment fidelity.

Another aspect worth noting regarding this study is that anecdotal data indicated all three participants had the independent play skills but did not engage in independent transitioning across different play activities. However, rigid engagement with certain activities is one of the maladaptive behaviors that children with ASD often engage in (Brodhead, et al., 2018) and was not necessarily captured by the data collected. Although the current study demonstrated the effectiveness of a wearable device to promote independent play skills and transitioning between activities, the appropriateness and variability of play was not evaluated. Future studies could assess the play topographies in which children engage while following prompts delivered by the Octopus watch.

Another important aspect to consider when designing interventions is how to ensure skills will be generalized to novel environments like home, community, and mainstream education settings. Including caregivers can result in improved outcomes and generalization of skills (Krants et al., 1993). Generalization of skills across setting, instructors, and tasks has been a widely studied area of research (e.g. Akers, Higbee, Pollard, Pellegrino, & Gerencser, 2016; Blum-Dimaya et al., 2010; Brodhead et al., 2018; Burckley, Tincani, & Fisher, 2015; Carlile et al., 2013; MacDuff et al., 1993; Massey & Wheeler, 2000; Pierce & Schreibman, 1994; Wacker et al., 1985; Wu, Wheaton, & Canella-Malone, 2016). For instance, Wacker and colleagues (1985) studied the generalization of the use of picture prompts to complete vocational or daily living tasks across settings without additional training and found that initial training was enough to acquire this generalization outcome. Beyond the effects on generalization post-intervention, parent involvement in interventions can result in positive social validity outcomes.

In the present study, social validity measures conducted with both primary caregivers and participants indicated high levels of social acceptance and satisfaction with the use of the Octopus watch. To our knowledge, this is the first study to assess the participant satisfaction in relation to the use of a wearable activity schedule. Participants' preference and positive attribute on the survey items may indicate that a technological device that includes an activity schedule feature can function as a reinforcer itself and contribute to the maintenance and generalization skills further without extensive training. Anecdotally, all three primary caregivers reported that they would like to purchase the device for their children to use at home for adaptive daily living skills or scheduling leisure activities during weekends.

The results of the current study are consistent previous findings in the activity schedule literature, which have reported increased level of independent appropriate attending (Akers et al, 2016), decreased level of problem behavior (Zimmerman, et al., 2017), and/or adult delivered prompts (Blum-Dimaya et al, 2010) during play activities. Akers and colleagues (2016) investigated the effectiveness of photographic activity schedules to increase independent playground skills of three participants with ASD. Results revealed that with the implementation of activity schedule, on-task behavior of the participants increased compared to baseline levels. Relatedly, Blum-Dimaya and colleagues (2010) found that by implementing activity schedule, the need of physical prompts by adults decreased, suggesting children could be more independent in performing tasks.

Researchers have explored various alternatives to the traditional binder presentation of the activity schedule to support children's independence in performing tasks (e.g., auditory timers, Coyle & Cole, 2004; tactile prompting devices, Shabani et al., 2002; Taylor & Levin, 1998). Recently, the use of technological advances to improve the implementation of activity schedules has been a topic of interest (Brodhead et al., 2018; Carlile et al., 2013; Chan et al., 2014; Grider, & Grider, 2009; Laarhoven, Johnson, Laarhoven-Myers, 2009). The current study supports the use of technology in the form of a wearable activity schedule to increase the independence of individuals with autism while limiting the need of the assistance of an adult. Furthermore, this study evaluated the usefulness of a less cumbersome and expensive technology than iPads or similar devices while providing a user-friendly and simple technology designed for children. Overall, findings of the present study are consistent with the activity schedule literature and extend the use of technology to present visual prompts to children with ASD. By using wearable devices, many of the obstacles present in traditional versions of activity schedules, such as stigma, can be easily circumvented. Technological aids such as wearable activity schedules may help children with ASD integrate into less restrictive learning environments, such as general education classrooms, more readily (Goldsmith & LeBlanc, 2004).

Future Research

Future research could investigate the usefulness of the Octopus watch or similar wearable devices with other populations (e.g., adolescence and adults), in other settings (e.g., school, residential group home), and across a range of different behavioral targets (e.g., self-care and adaptive daily living skills, social interaction with adults and//or peers, cooperative play, and bids for joint attention). Another interesting future avenue of research is the evaluation of transfer of the performance to untaught behavioral targets (e.g., Wacker and Berg, 1983). For instance, it is possible that after learning to follow prompts delivered by the watch to maintain independent play, children spontaneously will follow watch prompts for completing a different activity (e.g., getting ready for school in the morning).

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Figures

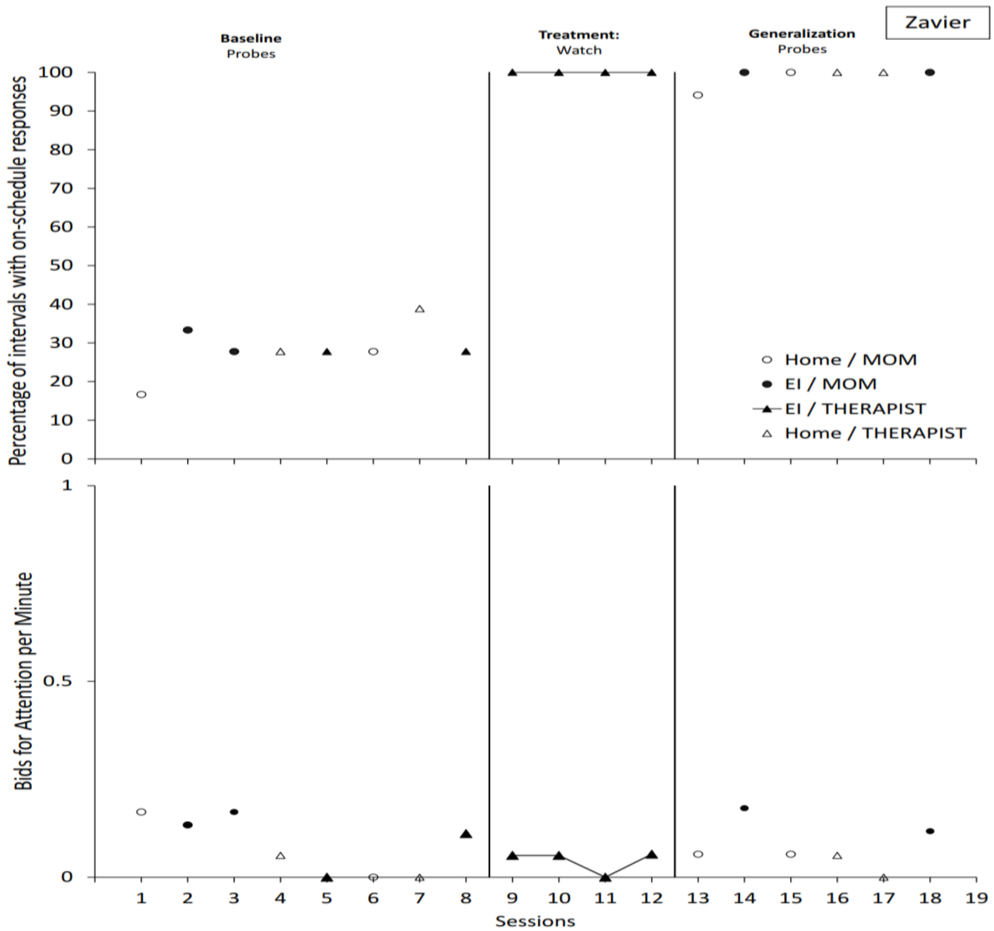

Figure 1. Top panel shows percentage of intervals with correct independent completion of on-schedule responses in the behavior chain across sessions. The open circles depict caregiver probes at a home setting, whereas the black circles depict caregiver probes at a clinic context. The black triangles depict researcher probes at a clinic setting and open triangles depict researcher probes at a home setting. Lower panel shows rate of bids for attention across sessions. Legend is same as top panel.

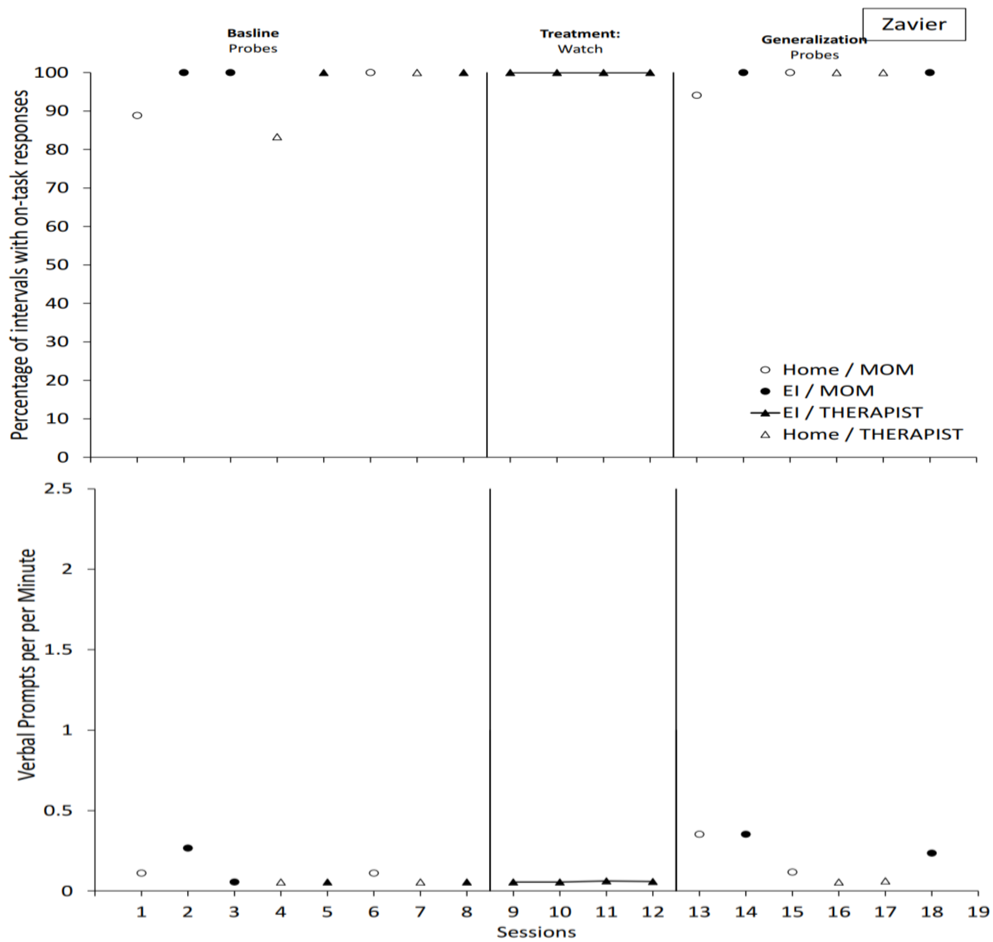

Figure 2. Top panel. Percentage of intervals with correct independent completion of on-task responses in the behavior chain across sessions. The open circles depict caregiver probes at a home setting, whereas the black circles depict caregiver probes at a clinic context. The black triangles depict researcher probes at a clinic setting and open triangles depict researcher probes at a home setting. Lower panel. Rate of verbal prompts across sessions. Legend is same as top panel.

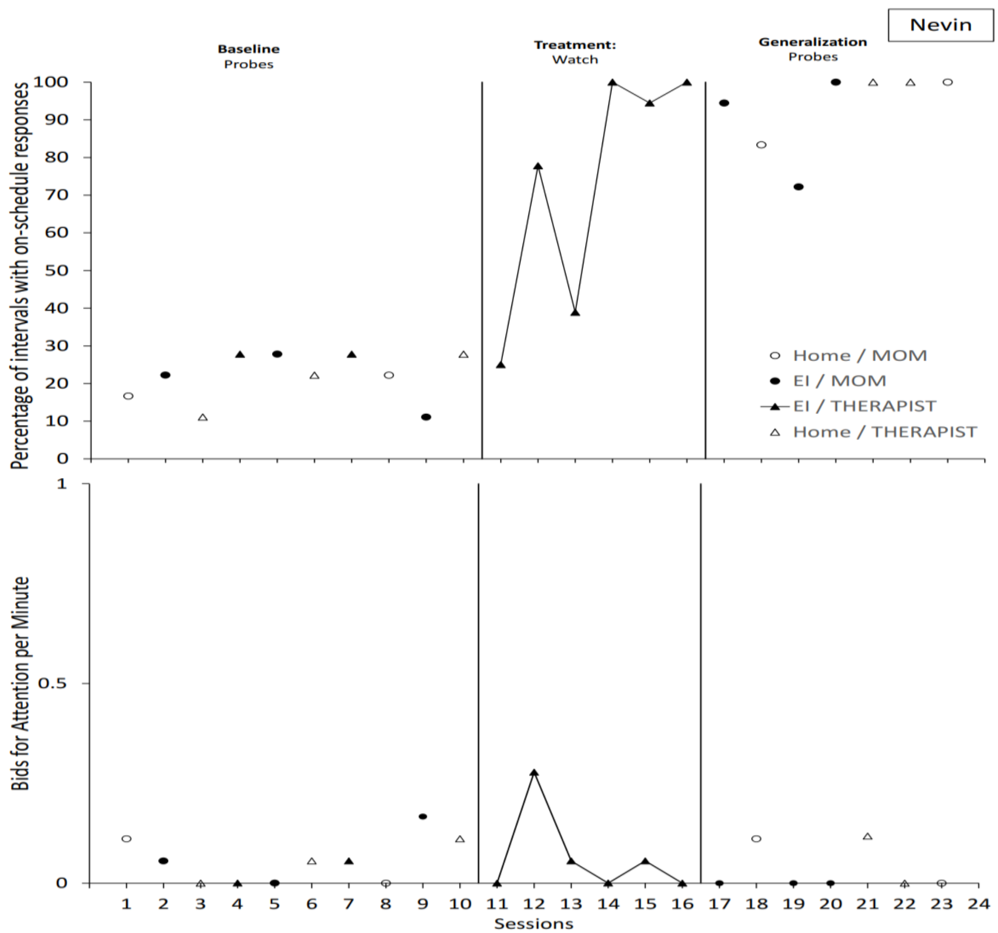

Figure 3. Top panel shows percentage of intervals with correct independent completion of on-schedule responses in the behavior chain across sessions. The open circles depict caregiver probes at a home setting, whereas the black circles depict caregiver probes at a clinic context. The black triangles depict researcher probes at a clinic setting and open triangles depict researcher probes at a home setting. Lower panel shows rate of bids for attention across sessions. Legend is same as top panel.

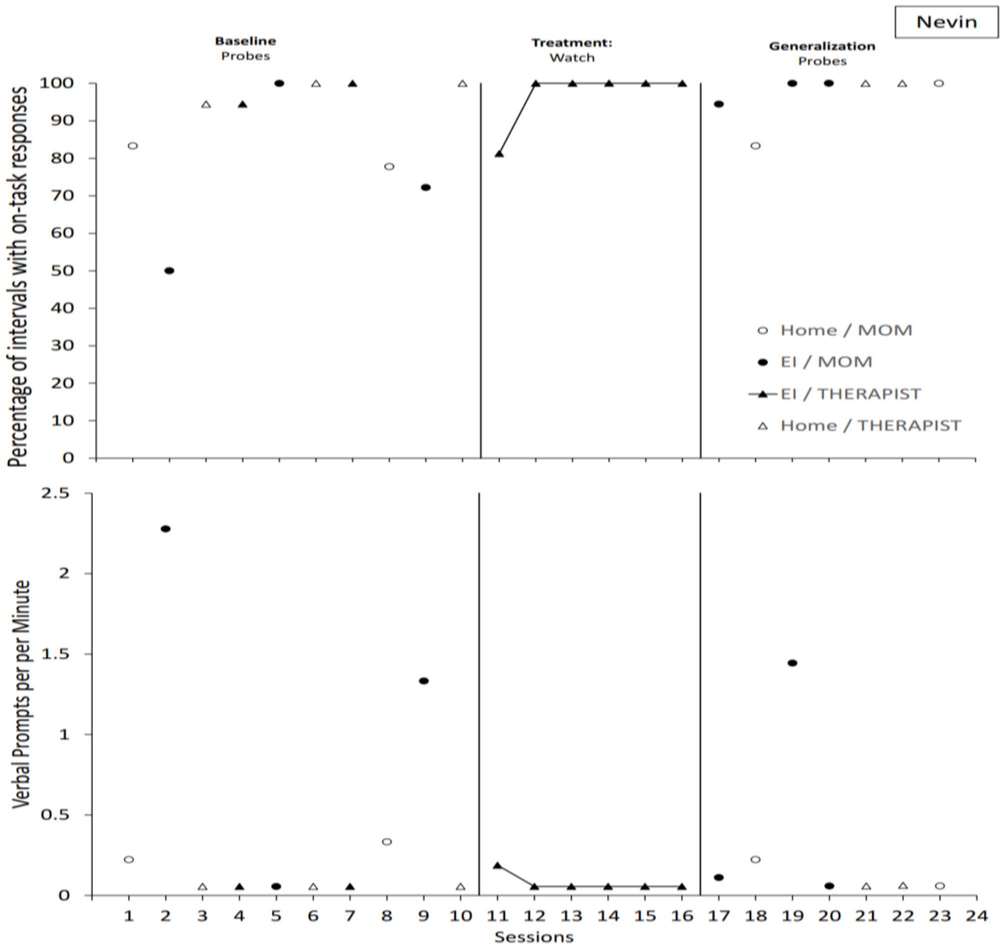

Figure 4. Top panel. Percentage of intervals with correct independent completion of on-task responses in the behavior chain across sessions. The open circles depict caregiver probes at a home setting, whereas the black circles depict caregiver probes at a clinic context. The black triangles depict researcher probes at a clinic setting and open triangles depict researcher probes at a home setting. Lower panel. Rate of verbal prompts across sessions. Legend is same as top panel.

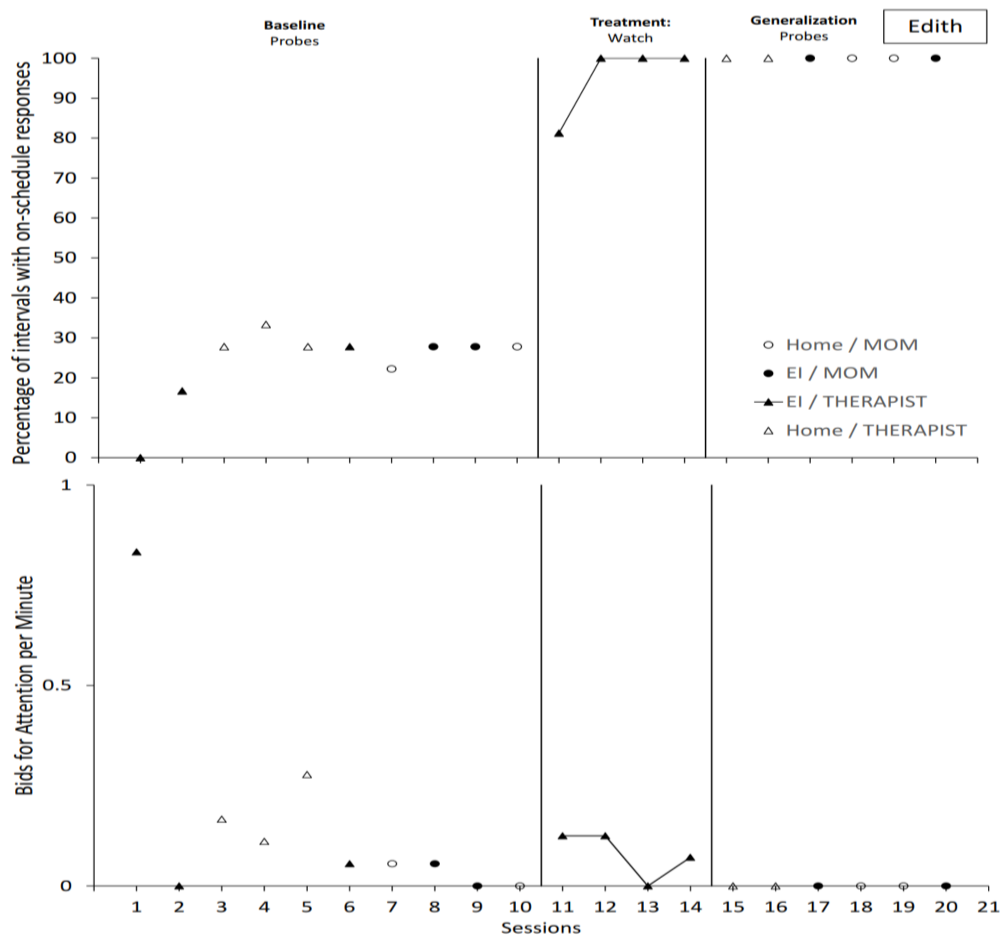

Figure 5. Top panel shows percentage of intervals with correct independent completion of on-schedule responses in the behavior chain across sessions. The open circles depict caregiver probes at a home setting, whereas the black circles depict caregiver probes at a clinic context. The black triangles depict researcher probes at a clinic setting and open triangles depict researcher probes at a home setting. Lower panel shows rate of bids for attention across sessions. Legend is same as top panel.

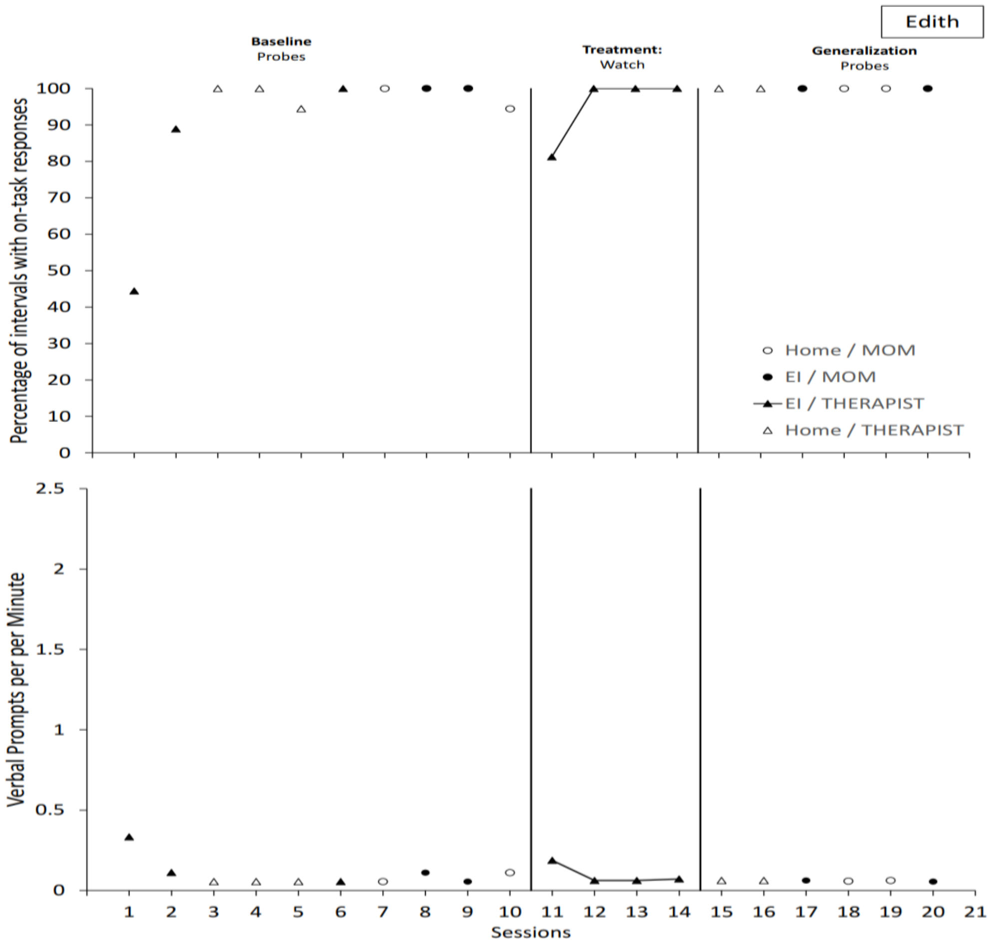

Figure 6. Top panel. Percentage of intervals with correct independent completion of on-task responses in the behavior chain across sessions. The open circles depict caregiver probes at a home setting, whereas the black circles depict caregiver probes at a clinic context. The black triangles depict researcher probes at a clinic setting and open triangles depict researcher probes at a home setting. Lower panel. Rate of verbal prompts across sessions. Legend is same as top panel.

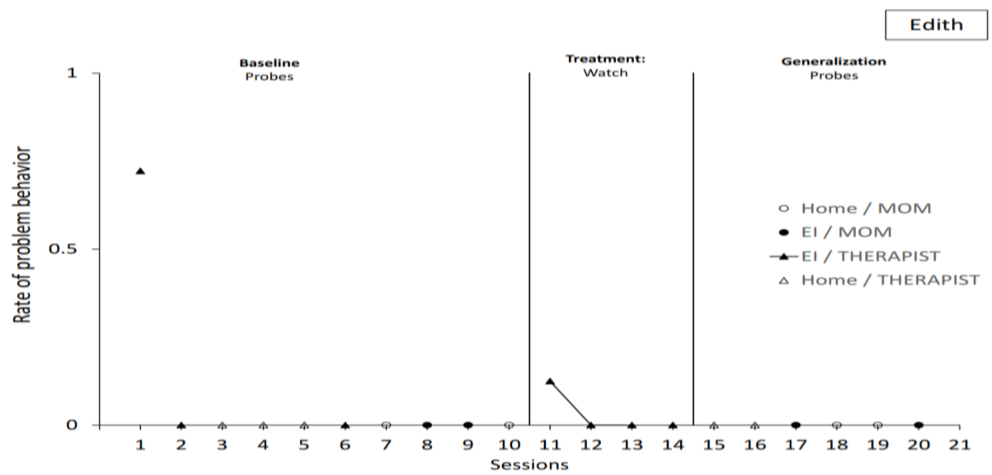

Figure 7. Rate of problem behaviors across sessions. The open circles depict caregiver probes at a home setting, whereas the black circles depict caregiver probes at a clinic context. The black triangles depict researcher probes at a clinic setting and open triangles depict researcher probes at a home setting.

Tables

Table 1

Post-Intervention Social Validity Measure

Statements	Mean	Range
I would use the wearable activity schedule at our home setting.	5	5
Participant engage in the activity as a typical 3 to 12-year-old would be.	3.3	3-4
Overall, the learner was appropriately structuring his/her play time without adult prompts.	4.7	4-5
There was a component that may have a stigmatizing effect on participant's involvement in the community.	1.7	1-2
I would recommend the use of the watch to others (parents, caregivers, children).	4.7	4-5

Note: 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree

Table 2
Satisfaction Survey

Statements	Children		
	Zavier	Nevin	Edith
The watch was easy to use	Liked	Liked	Liked
The watch was comfortable to wear	Liked	Liked	Disliked
I saw the pictures and felt the buzzing (vibration) of the watch	Disliked	Liked	Liked
The pictures and buzzing of the watch were good reminders of what I needed to do. / I moved from one toy to another when I saw the picture and felt the vibration.	Liked	Liked	Liked
I would like to use the watch for other activities (e.g. getting ready for school in the morning).	Liked	Liked	Disliked

Appendices

APPENDIX A

Post-Intervention Social Validity Measure

Name: ________________________________ Date:

1. I would use the wearable activity schedule at our home setting.

Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

2. Participant engaged in the activity as a typical 3 to 12-year-old would be.

Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

3. Overall, the learner was appropriately structuring his/her play time without adult prompts.

Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

4. There was a component that may have a stigmatizing effect on participants involvement in community.

Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

5. I would recommend the use of the watch to others (parents, caregivers, children).

Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

6. Please list any further comments or suggestions.

APPENDIX B

Satisfaction Survey

Name: ______________________________ Date:

1. The watch was easy to use.


2. The watch was comfortable to wear.


3. I saw the pictures and felt the buzzing (vibration) of the watch.


4. The pictures and buzzing of the watch were good reminders of what I needed to do. / I moved from one toy to another when I saw the picture and felt the vibration.

 

5. I would like to use the watch for other activities (e.g., getting ready for school in the morning).