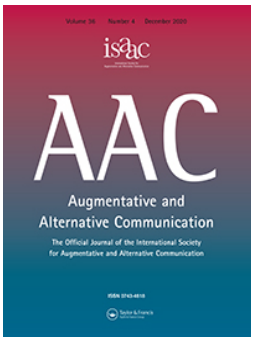

Augmentative and Alternative Communication

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/iaac20

Providing visual directives via a smart watch to a student with Autism Spectrum Disorder: an intervention note

Amanda M. O'Brien , Ralf W. Schlosser , Howard Shane , Oliver Wendt , Christina Yu , Anna A. Allen , Jacqueline Cullen , Andrea Benz & Lindsay O'Neill

AUGMENTATIVE AND ALTERNATIVE COMMUNICATION
2020, VOL. 36, NO. 4, 249–257
https://doi.org/10.1080/07434618.2020.1862299

INTERVENTION NOTE

Providing visual directives via a smart watch to a student with Autism Spectrum Disorder: an intervention note

Amanda M. O'Brien[a], Ralf W. Schlosser[b], Howard Shane[c], Oliver Wendt[d], Christina Yu[e], Anna A. Allen[e], Jacqueline Cullen[f], Andrea Benz[f] and Lindsay O'Neill[f]

[a]Speech Hearing Bioscience Technology, Harvard University, Boston, MA, USA; [b]Department of Communication Sciences and Disorders, Northeastern University, Boston, MA, USA; [c]Otolaryngology and Communication Enhancement, Boston Children's Hospital, Boston, MA, USA; [d]College of Health Professions and Sciences, University of Central Florida, Orlando, FL, USA; [e]Otolaryngology, Boston Children's Hospital, Waltham, MA, USA; [f]Fayetteville-Manlius Schools, Manlius, NY, USA

ABSTRACT

Smart watches are discreet and wearable tools that may be repurposed to improve directive-following for individuals with autism spectrum disorder (ASD). Specifically, a mentor can transmit just-in-time (JIT) visual supports (e.g., video clips, photographs, text) that depict an upcoming directive to a learner's smart watch to prompt the learner as needed from a distance. Using a single-case multiple probe design across settings, this investigation evaluated the effectiveness of providing text-based prompts on an Apple Watch[1] to a child with ASD within a school setting. A mentor transmitted 2-step written directives via text message to the participant's Apple Watch. The participant was instructed to attend to, read, and follow directives received on the watch. Results demonstrated that the intervention improved directive-following as well as increased the instructor's distance from the learner. It is proposed that JIT supports sent to a learner's smart watch may reduce the obtrusiveness of traditional prompting while also maintaining the naturalness of ongoing social or academic interactions. Clinical limitations and implications are discussed.

ARTICLE HISTORY
Received 13 April 2020
Revised 24 November 2020
Accepted 25 November 2020

KEYWORDS
Augmentative and alternative communication; Autism Spectrum Disorder; directive-following; just-in-time communication; wearable technology

Many individuals with moderate to severe autism spectrum disorder (ASD) demonstrate difficulties with receptive language skills, including directive-following (Hudry et al., 2010; Rice, Warren, & Betz, 2005). Directives are defined as "…verbal [or non-verbal, added by these authors] behaviors that communicate to the child the expectation that they do, say, or attend to something. This includes questions, commands, suggestions, and requests for both verbal and nonverbal behavior (McCathren, Yoder, & Warren, 1995, p. 91). Although there is limited research of receptive language interventions for children with ASD (Sevcik, 2006), the use of visual supports to augment spoken directives is a promising strategy for improving their ability to follow directives (Schlosser et al., 2013). Specifically, children with ASD may demonstrate improved directive-following when presented with visual supports paired with spoken input than when presented with the spoken directive alone (Schlosser et al., 2013).

Furthermore, O'Brien et al. (2016) provided initial feasibility data that a just-in-time (JIT) intervention approach may improve directive-following for individuals with ASD. JIT intervention refers to the "rapid creation and delivery of behavioral, organizational, and language supports including prompts, reminders, and rewards in a timely fashion" (O'Brien et al., 2017, p. 298). The JIT approach supports learning by reducing demands on working memory, focusing on teachable moments, and capitalizing on situated cognition (Schlosser et al., 2016). In the field of augmentative and alternative communication (AAC), a mentor can provide JIT supports to enhance a learner's expressive and receptive language skills (Caron, Light, & Drager, 2016; O'Brien et al., 2016; Schlosser et al., 2016).

Smart watches (e.g., an Apple Watch[1]) are increasingly utilized for both instruction and monitoring of individuals with ASD (Koumpouros & Kafazis, 2019). For the purposes of this study, smart watches may provide a naturalistic and unobtrusive wearable medium to provide JIT receptive language supports (e.g., visual directives) to individuals with ASD. Advances in the transmission of messages (e.g., via wi-fi, cellular connectivity, or Bluetooth) make it possible to deliver timely messages to a smart watch. For example, a mentor can send a directive (e.g., via photograph, video, or text) to a learner's smart watch thereby reducing the need for a mentor to be face-to-face with the learner. Increasing the distance between the mentor and learner may preserve the naturalness of a social or academic environment by minimizing potential negative social effects of teaching assistants hovering over the students that they support. The rationale for introducing visual supports via a smart watch is further strengthened by the observation that children with ASD

CONTACT Amanda Marie O'Brien amanda_obrien@g.harvard.edu Speech Hearing Bioscience Technology, Harvard University, 260 Longwood Avenue, Boston, MA 02115, USA

often demonstrate a preference for learning through technology in general (Lorah, Parnell, Whitby, & Hantula, 2015) and electronic screen media in particular (Shane & Albert, 2008).

There is an increasing literature on using smart watches with children with ASD. Most of these studies explore using a smart watch to monitor physiological responses and movements of children with ASD (Sarker et al., 2018; Torrado, Gomez, & Montoro, 2017). A few studies have focused on the feasibility of using a smart watch to support receptive language skills for children with ASD; this research has shown that some children with ASD and limited functional speech can view scene cues (i.e., video clips and photographs that depict directives) on a smart watch screen and extract the necessary visual information to follow the depicted directives (O'Brien et al., 2016; Schlosser et al., 2017). Some individuals with ASD will also tolerate wearing the watch and follow directives depicted by scene-cue messages (i.e., photographs) received on the watch, within a structured clinical setting (O'Brien et al., 2020).

Given the promising outcomes of these case series design studies (O'Brien et al., 2016; Schlosser et al., 2017), it is a logical next step to use an experimental design to explore the functional relationship between providing visual supports on a smart watch and directive-following outcomes. The aim of the present study was to evaluate the effect of transmitting directives to a smart watch on directive-following by a learner with ASD with limited functional speech. Specifically, the following research questions were explored: What are the effects of a smartwatch intervention on (a) accuracy of directive-following; (b) anticipatory directive-following responses; and (c) accuracy of directive-following after a systematic increase in distance?

Method

Participants and setting

The participant, Sophie (pseudonym), met the following inclusion criteria: (a) primary diagnosis of ASD (as diagnosed by a pediatric psychiatrist); (b) hearing and vision within normal limits (based on school records); and (c) strong interest in screen media (per teacher observations). The participant was part of a larger AAC study (Schlosser et al., 2020). She was selected as a candidate for this study by her instructors based on a strong interest in technology, prompt-dependency during directive-following, and literacy skills. She was 9-years-old, used limited speech (1- 3-word utterances) to request and comment, and benefited from a range of low- and high-tech AAC strategies to expand communicative functions and utterance length. She received a score in the 0.3rd percentile (standard score of 58) on the Expressive Vocabulary Test, Second Edition (EVT-2; Williams, 2007) and a score in the 0.3rd percentile (standard score of 59) on the Peabody Picture Vocabulary Test, Fourth Edition, (PPVT-4; Dunn & Dunn, 2007). Regarding the participant's reading skills, her teacher reported that she read at the second-grade level at the time of the study. She read fluently at the sentence level and could match pictures to their representative sentences. Additionally, she answered who, what, and where questions in response to two to three sentence long texts, given a single picture prompt. Prior to the study, the participant had been exposed to the use of a paper-based written schedule presented by communication partners (i.e., teaching assistant (TA), teachers, etc.) to support her directive-following during transitions.

The study was performed in a public elementary school over 16 days across three environments: hallway, general education classroom, and special education classroom. Informed written consent was obtained by the participant's parent.

Materials

Materials were (a) an 8-item yes-no Tactile Sensitivity Survey developed by O'Brien et al. (2020), (b) an Apple Watch Series 3 GPS + Cellular, 38 mm (1.65 inch) OLED capacitive touchscreen, 390 × 312 pixels resolution, Space Gray aluminum case, (c) an iPhone[1] with the "messages" application used by the teaching assistant, (d) the text messages for each directive, and (e) the items required for the participant to carry out directives in each setting.

The participant was provided with JIT text messages to complete three directives per setting. A different set of directives was provided in each setting to prevent unwanted generalization in the untreated baseline settings (Horner & Baer, 1978). Each directive consisted of two related steps that were identified by the participant's teacher and therapists as directives that the participant had previously demonstrated difficulty completing independently when given a spoken and written schedule (e.g., *Get your paper and put it in your mailbox*; for the complete list of directives see Table 1). Text-based messages were used instead of photograph or video-based messages based on the participant's demonstrated literacy skills. Text-based messages transmitted more rapidly than photograph or video-based messages over the school's Wi-Fi network. The watch provided an auditory (i.e., beep) and haptic (i.e., vibrating) cue when the directive arrived.

Research design

A single-case experimental design was used in this study. Specifically, a multiple probe design across three settings within the elementary school (Horner & Baer, 1978) was employed. The start of intervention was staggered across settings. An a priori decision was made to have two overlapping data points between one setting and the next before beginning intervention in the next setting. Intervention began on Day 4 in setting one, on Day 6 in Setting 2, and on Day 10 in Setting 3. These a priori design decisions were made due to resource and time limitations inherent with conducting research during the school day in a school environment, and to increase the ease and accuracy of implementation for the school team by having a predictable schedule. A single post-probe design (Barrios & Hartmann, 1988; Schlosser & Lee, 2000) was used to assess maintenance in each setting.

Table 1. Directives by setting.

Setting	Directive
Hallway	Ride bike to the green line and stop.
	Stop at the rainbow line and turn around.
	Ride to the parking spot and get off the bike.
General education classroom	Walk to Ms. Lavoie's room and sit at your desk.
	Get snack and eat it.
	Walk to the bathroom and go in the bathroom.
Special education classroom	Walk to red table in Ocean and start your work.
	Get your paper and put it in your mailbox.
	Walk to the group table and sit down in the blue chair.

The study was approved by the relevant institutional review board.

Experimenters

A teaching assistant from the participant's classroom with introductory experience in using an Apple Watch was trained in the directive-following procedures by the school Speech-Language Pathologist (SLP). She delivered all directives in the study and was provided with weekly feedback from the first author based on video recorded sessions. One school SLP video recorded 25% of baseline and intervention sessions and a second SLP served as an independent observer to establish interobserver agreement with the teaching assistant.

Dependent measures

Directive-following was the primary dependent variable and was measured by the number of directives that the participant independently completed correctly. A directive was considered to be completed correctly if the participant independently attended to the watch, initiated completion of the directive within 10 s of receiving the message, and correctly followed both steps of the directive. A directive was considered to be completed incorrectly if the participant did not (a) independently attend to the watch upon receiving the message, (b) initiate completion of the directive within 10 s of receiving the message, or (c) correctly follow both steps of the directive.

Looking responses and anticipatory responses served as secondary dependent variables. A successful looking response was defined as the participant independently looking at the watch within 10 s of receiving a text message directive. The percentage of successful looking responses in baseline and intervention trials was calculated for each setting. Additionally, the number of anticipatory responses, or the number of trials that the participant began to complete a given directive prior to receiving the directive on her Apple Watch, was calculated for each setting. During baseline and intervention probes, if the participant demonstrated an anticipatory response (i.e., initiated directive following before receiving the text directive on the Apple Watch and then completed the directive after receiving the message), the response was marked as a correct "anticipatory response" (Slamecka, 1977), and was not included as a correct response in the probe data. If she did not anticipate the directive before receiving it, the response was coded as an incorrect anticipatory response.

Procedures

Tactile sensitivity survey

Prior to beginning the study, the participant's father completed the yes-no Tactile Sensitivity Survey. Each item had an option for a yes or no response. The participant's father wrote each response on the survey form. The total number of responses suggesting sensitivity was calculated to determine a sensitivity quotient (SQ) for the participant. A lower SQ suggests less sensory sensitivity, while a higher SQ suggests increased sensitivity. The mean response in a previous study with this population ($n = 10$) was 3.5 out of 8, with a standard deviation of 1.6 (O'Brien et al., 2020).

Baseline probes

During baseline, the participant wore the Apple Watch to prevent the possible novelty effects associated with wearing a watch during intervention only (Schlosser, 2003). The teaching assistant did not provide spoken instruction on how to look at, or respond to, the watch during baseline. When it was time in the participant's daily schedule to follow a given directive (e.g., when it was snack time), the teaching assistant used the messages application to send the appropriate directive to be followed (e.g., "Get snack and eat it") to the participant's Apple Watch from a distance of 5 ft. The teaching assistant recorded if the participant (a) looked at the watch, and (b) followed the directive. If she did not follow the directive after 10 s, the teaching assistant provided gestural (e.g., pointing to the participant's snack) and physical (e.g., gentle physical guidance toward the location of the snack) prompts to support her completion of the directive. These gestural prompts were provided because the directives were embedded within the participant's daily routine, and it was necessary for her to follow them regardless of her successful use of the Apple Watch.

Intervention procedures

Intervention differed from baseline in that the teaching assistant instructed the participant how to (a) look at and (b) respond to the directive received on the Apple Watch. Intervention was provided for a maximum of two out of the three directives, per setting, per day. The schedule of the two interventions to be targeted were chosen a priori so that the particular directive not targeted repeated every third intervention day. During the first intervention probe session, the teaching assistant stood 5 ft (1.5 m) from the participant. Every third intervention probe session, she increased her distance by 2 ft (0.6 m) until she was 9 ft (2.7 m) from the participant. During the intervention phase, probes were collected daily. A single maintenance probe was collected 2 weeks post-intervention completion, using the same procedures as baseline and intervention probes.

Intervention probes

As in baseline, the teaching assistant sent a text message to the participant's watch according to the participant's daily schedule without providing a spoken directive. Again, as in baseline, if the participant (a) looked at her watch within 10 s, and (b) correctly followed the directive, her response was marked as correct. If the participant did not complete (a) or (b), her response was marked as incorrect and intervention was provided. If the participant did not look at the watch within 10 s, and the directive was an intervention directive for that day, the participant's response was marked as incorrect and the teaching assistant provided gestural (e.g., pointing), spoken (e.g., *Check your watch, You do it, Ride to the green line and stop*) interventions, as well as physical prompts (e.g., tilting the watch to show the message) related to the steps of looking at the watch. After the participant looked at the watch, if she did not follow the directive after an additional 10 s, the teaching assistant provided spoken and gestural prompts as previously described to support her completion of the directive. If a directive was not identified as an intervention directive for a given day, and the participant did not independently complete that directive upon receiving the message, the teaching assistant used the same procedures as in baseline (e.g., gestural and physical prompts, no spoken prompts) to support directive following.

Social validation

The social validity of the intervention was examined following the treatment with relevant immediate community stakeholders (Schlosser, 1999); the two school-based SLPs, the classroom teacher, and the teaching assistant filled out a 10-item treatment acceptability survey, the modified Treatment Evaluation Inventory—Short Form (TEI–SF; Kelley, Heffer, Gresham, & Elliott, 1989). The wording of this instrument was minimally modified to reflect the acceptability of using the smart watch treatment to support directive- following. Additionally, one item was added to the original 9-item instrument to assess the acceptability of increasing distance between the student and teaching assistant. The original and the adapted TEI-SF feature a five-point Likert scale to quantify answers to each question, ranging from a score of 1 (*strongly disagree*) to 5 (*strongly agree*). For nine out of the 10 items, a score of 5 indicated the strongest positive reaction to the intervention. One item ("I believe the child will experience discomfort during the treatment") was reverse-scored, with an answer of 5 (*strongly disagree*) representing the most positive reaction to the intervention. According to Kelley et al. (1989), a score of 3 on each item would represent moderate acceptability. Thus, for the 10-item scale, a score of 30 represents moderate acceptability and a higher score indicates greater acceptability, with a maximum possible score of 50.

Data collection and analysis

Data collection was done in real time by the teaching assistant. A two-tiered data analysis approach was used to compare the participant's performance during baseline and intervention probes across the three settings. First, a visual analysis was conducted, which is currently the standard analysis used in-single case experimental design (Barton, Lloyd, Spriggs, & Gast, 2018). Because visual analyses tend to be subjective, we subsequently used a non-overlap effect size metric, Tau-U (Parker, Vannest, Davis, & Sauber, 2011), to confirm our visual analysis and quantify the magnitude of the treatment effect. Finally, we corroborated the effect size analysis with a second non-overlap effect-size metric, Improvement Rate Difference (IRD; Parker, Vannest, & Brown, 2009).

Visual analysis. A visual analysis was performed according to the guidelines established by Kratochwill et al. (2010). We analyzed the levels, trend, and variability of data within each condition and across adjacent conditions. We also analyzed the behavior changes across conditions in order to assess the existence of a functional relationship between the smartwatch intervention and directive-following performance.

Effect size estimates. The intervention effects were evaluated using a Tau-U metric because of evident trend in data patterns (see Figure 1). Tau-U is a non-overlap effect size statistic that is used to estimate the percentage of data improvement over time and that is sensitive to detecting and correcting for trend (Parker et al., 2011). The Tau-U metric by Parker et al. (2011) was selected after confirming the absence of a monotonic trend in all three tiers using the Baseline Corrected Tau Calculator, and thus ruling out the need for a baseline-corrected Tau-U (Tarlow, 2017). The Tau-U findings were corroborated with the IRD metric. The IRD is calculated by subtracting the improvement rate (i.e., number of improved data points divided by the total data points) of the baseline from the improvement rate of the treatment phase (Parker et al., 2009). Tau-U and IRD were calculated for each tier of the intervention, as well as for the omnibus of the three-tiered study. The calculations were completed using the Single Case Effect Size Calculator by Vannest, Parker, Gonen, and Adiguzel (2016).

Treatment integrity

An independent observer assessed treatment integrity of video recordings from 25% of the days that baseline and intervention directives were provided in each setting. The intervention procedure was broken down into the four steps to be completed by the teaching assistant: (a) send accurate message; (b) wait 10 s for completion; (c) instruct participant to look at watch, if needed; and (d) instruct participant to follow directive, if needed. The independent observer watched each video and recorded whether each of the four

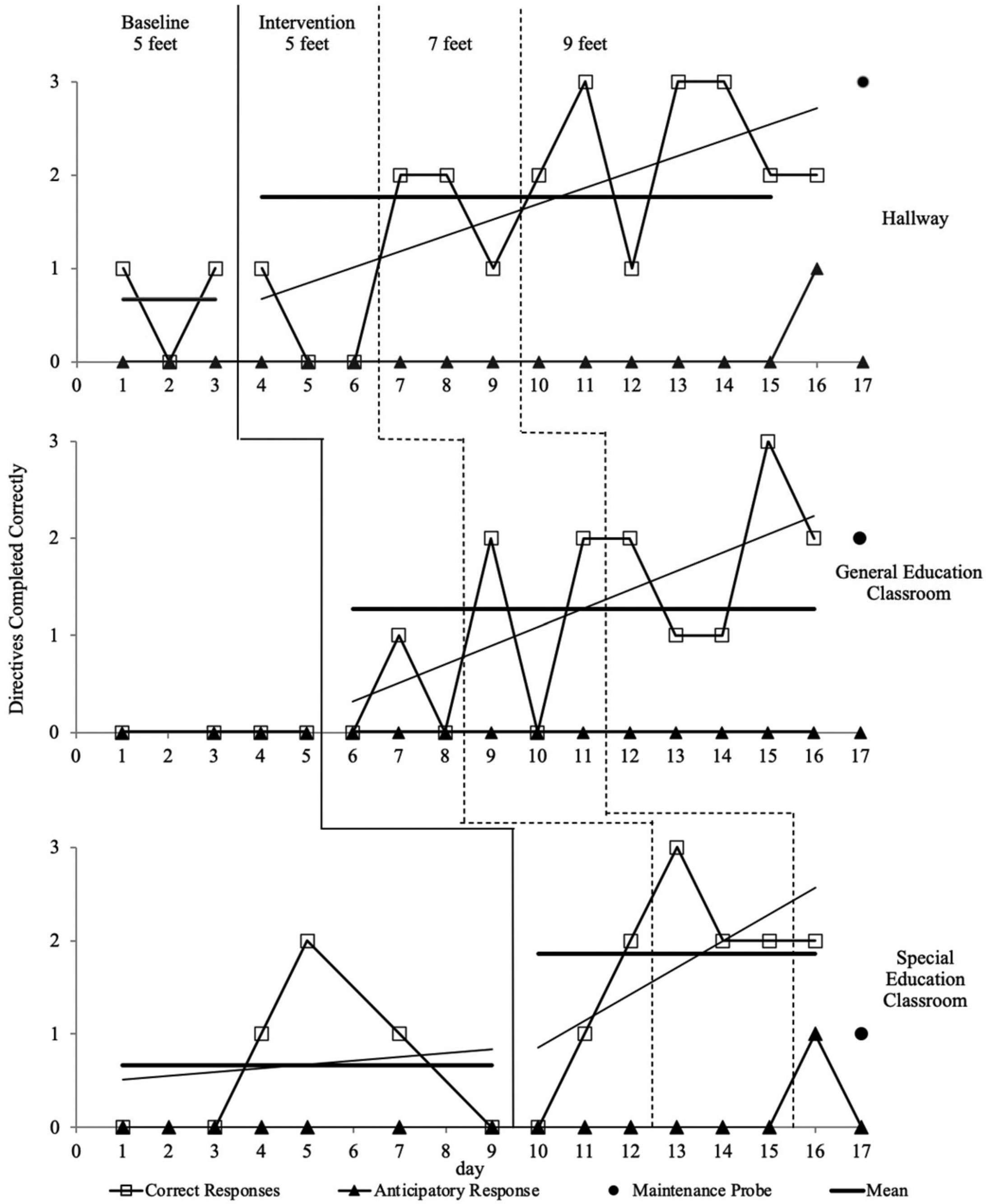

Figure 1. Accurate directive-following during baseline, intervention, and the maintenance probes.

steps was completed correctly, and in the correct order, for all video recorded directives. The number of steps coded as being completed accurately was divided by the total possible steps to obtain the percentage of steps that were completed correctly (Schlosser, 2002).

Interobserver agreement

Video recordings of 25% of the baseline and intervention sessions were analyzed for interobserver agreement. For each video-recorded directive, the independent observer recorded whether the participant (a) looked at the watch and (b) correctly followed the directive. The observer's responses were compared to those of the teaching assistant. For both dependent variables, the number of agreements was divided by the total number of agreements plus disagreements and multiplied by 100 to obtain the percent agreement.

Results

Tactile sensitivity survey

Responses suggesting tactile sensitivity were summed to determine the participant's sensory quotient (SQ). She received an SQ of 2 out of 8, based on her sensitivity responses to the following items: "Is your child especially ticklish" (Sensory sensitivity response: Yes) and "Does your child wear a bracelet, watch, wrist ware or ankle ware?" (Sensitivity response: No).

Inter-observer agreement and treatment integrity

IOA for directive-following across settings was 97% with a range from 92% to 100%. IOA for looking at the watch across settings was 93% with a range from 78% to 100%. Treatment integrity for the steps of intervention was 94% with a range from 88% to 100%.

Directive-following acquisition

Baseline

A graphic display of the participant's performance is presented in Figure 1 and descriptive statistics are included in Table 2. A within-condition visual analysis of the baseline conditions reveals a zero-celerating low-level of performance in the hallway, a completely stable baseline at zero in the general education classroom, and a more variable baseline in the special education classroom that featured an initial upward trend but then returned to zero prior to intervention (see Figure 1).

Intervention

A within-condition visual analysis of the intervention conditions reveals moderately steep, accelerating trends, as evident by the trend lines, across all settings. An adjacent-condition analysis from baseline to intervention reveals that the participant's performance not only indicates a change in the trajectory of the trend lines in the desired direction across settings but also a clear level shift across settings. Moreover, there were no changes in the desired direction in the as-of-yet untreated baseline while the intervention occurred in the earlier tier/s (setting/s).

The non-overlap metric, Tau-U, confirmed the trends observed in the visual analysis and established an effect size of moderate or large for each setting and the intervention overall (Table 2). There was a moderate effect size in the hallway (0.5897) and special education classroom (0.5952) settings, and a large effect size for the general education classroom (0.7273). The omnibus effect size (0.6388) was also large. These effect sizes were corroborated with the IRD, which showed a moderate effect size for the hallway (0.6154), special education classroom (0.5476), and omnibus (0.6301), and a very large effect size for the general education classroom (0.7273).

In terms of means, during baseline in the hallway, the participant correctly completed an average of .67 directives out of 3 (range 0–1). During probing in the intervention phase, she correctly completed an average of 1.77 directives (range 0–3) out of 3 (Figure 1).

Anticipatory responses

Within-condition analyses of the baselines revealed a flat zero baseline across all settings for anticipatory responses. Within-condition analyses of the intervention phases revealed one anticipatory response in the last probe out of a total of 13 probes in the hallway, no anticipatory responses in the general education classroom, and one anticipatory response during the last probe of the special education classroom.

Directive-following maintenance

During the maintenance probe in the hallway, the participant correctly followed three out of three directives. In the general education classroom, she maintained two out of three directives. In the special education classroom, she maintained one out of three directives.

Looking responses

In the hallway, the participant looked at the watch upon receiving a text message in 88.9% (8/9) of trials during baseline, and 97.4 (38/39) of trials during the intervention. In the general education classroom, she looked at the watch in 75% (9/12) of trials during baseline, and in 93.9% (31/33) of trials during intervention. In the special education classroom, she looked at the watch in 85.7% (18/21) of trials during baseline, and 85.7% (18/21) of trials during intervention.

Treatment acceptability survey

Treatment acceptability scores from the modified TEI-SF were as follows: 39 (teaching assistant), 41 (special education teacher), 43 (SLP1), and 48 (SLP2), with an average score of 42.75 out of a maximum score of 50. The survey-takers generally strongly agreed, agreed, or were neutral in their response to the intervention. All survey takers strongly agreed with the statement: "I find this treatment to be an acceptable way for the teaching assistant to provide directives from a distance." Two of the four disagreed with the statement: "I believe this treatment is likely to result in permanent improvement" (Figure 2).

Discussion

The present study is the first to employ an experimental design to study the effect of teaching a learner with ASD to respond to visual supports via a smart watch. The smart watch intervention was effective in providing modest gains in directive-following across three environments within a school setting. The intervention was also effective in increasing the distance between the learner and the teaching assistant across all three settings. All instructors involved in the study rated the intervention as more than moderately acceptable, with greatest agreement that the intervention was successful in providing directives from a distance.

Table 2. Effect size indicator scores for each tier and omnibus of the multiple probe design.

Effect size indicator	MPD phases: Tier 1 (Hallway)	Tier 2 (General Ed. Classroom)	Tier 3 (Special Ed. Classroom)	Omnibus
Tau-U	0.5897 (moderate)	0.7273 (large)	0.5952 (moderate)	0.6388 (large)
IRD	0.6154 (moderate)	0.7273 (very large)	0.5476 (moderate)	0.6301 (moderate)

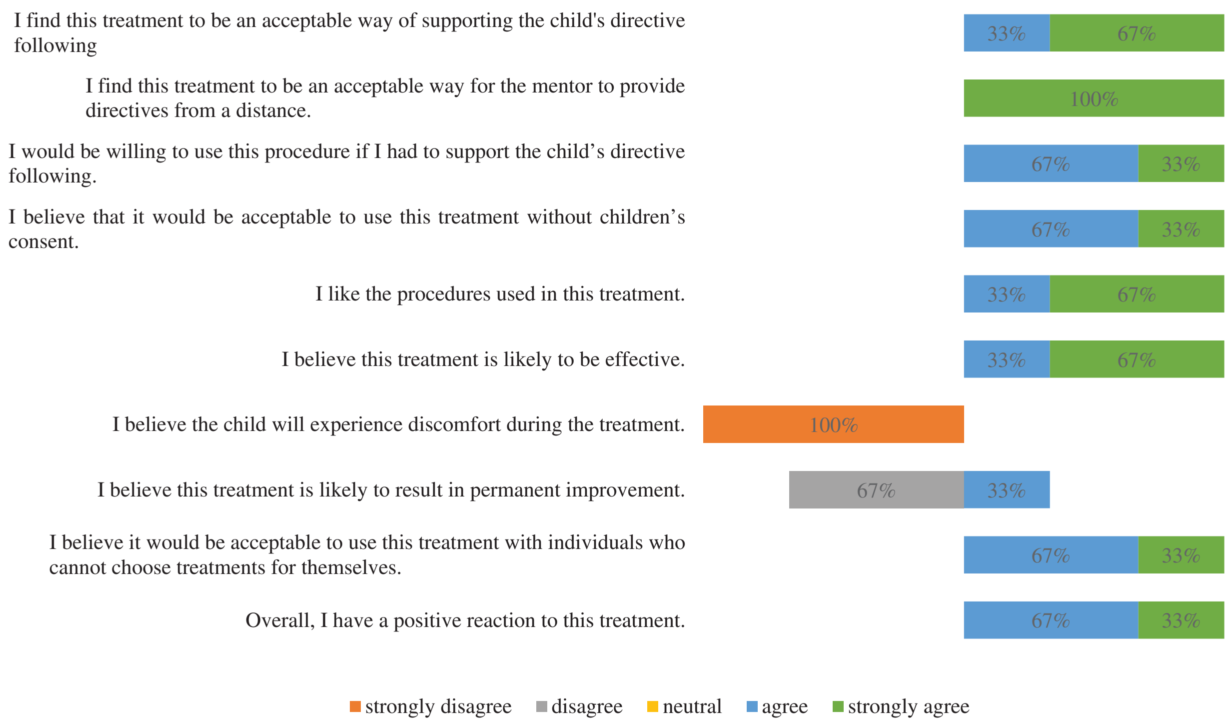

Figure 2. School speech-language pathologists, classroom teacher, and teaching assistant responses to the acceptability of the smartwatch intervention.

Tolerance wearing the smart watch

This study was consistent with a previous case series design study suggesting that some children with ASD will tolerate wearing a smart watch despite the known sensory sensitivities associated with ASD (O'Brien et al., 2020). Importantly, this was the first study of directive-following in which a participant wore the Apple Watch during an extended period of time in a natural environment. The Tactile Sensitivity Survey results continue to suggest that the exploratory survey may provide helpful information related to a child's tolerance of the watch. A larger sample size is needed to determine the predictive value of the survey in a statistical sense.

Responsiveness to auditory and haptic prompts

As indicated by the "looking" data in baseline, the participant generally appeared to understand intuitively that she should look at the watch upon receiving an auditory and haptic prompt. While we anticipated that the teaching assistant would need to instruct the participant to look at the watch upon receiving a message, she independently viewed the watch during baseline (i.e., pre-instruction). Post-intervention, the participant demonstrated a small improvement in the percentage of trials in which she looked at the watch in two of the three settings (Figure 1). Generally, the haptic and auditory cues provided sufficient and self-evident notification of the arrival of a directive for the participant.

Reading and following the messages

In contrast to viewing the watch, however, the participant required intervention to follow the messages received on the watch. A visual analysis of the outcomes suggests improvements in directive-following across all three settings, with the most variable success in the special education classroom. Of note, the participant followed one-to-two of the directives in the special education classroom during baseline. This improvement during baseline could possibly be explained by the familiarity, structure, and reduced distractibility of the special education setting (e.g., fewer students). Importantly, the participant's performance in the special education classroom returned to zero before introduction of the intervention.

Anticipatory responses

By the conclusion of the study, the participant began to demonstrate anticipatory responses in two settings (hallway, special education classroom). In other words, she initiated the forthcoming directive before receiving the text-message directive to do so, suggesting a paired association between the two successive tasks (Slamecka, 1977). The participant's anticipatory responses suggest that the smart watch intervention may have enhanced serial learning of sequential directives within a routine. Notably, the participant did not demonstrate any anticipatory responses prior to the smart watch intervention, or during baseline, despite previous exposure to the targeted directives.

Smart watch intervention as a JIT support

The participant's improvements in directive-following as a function of the smart watch intervention provide another example of how JIT supports may be used to enhance receptive language in the field of AAC (O'Brien et al., 2016; Schlosser et al., 2016). As JIT-based interventions continue to be expanded in the field of AAC, clear classification of the JIT prompts according to the taxonomy will support clinician and researcher comprehension of the range of JIT supports. The JIT prompts utilized in the present study can be classified by the JIT schema described by Schlosser et al. (2016) as follows: (a) directive (intended purpose); (b) auditory and tactile alert, visual prompt (modality); (c) mentor (source); and (d) wireless transfer (delivery method).

Clinical implications

The results of this study may have implications for the provision of unobtrusive supports from a distance within an inclusive school environment. Throughout the study the teaching assistant increased her amount of distance from the participant from 5 to 9 ft (1.5–2.7 m), which may allow for increased naturalness in a school environment. Teaching assistants who support children with ASD have sometimes been described as hovering instead of helping due to their consistently close proximity (e.g., Giangreco, Edelman, Luiselli, & MacFarland, 1997). If a mentor provides JIT support from a distance via a smart watch, the child with ASD may experience a less intrusive and more mainstream social and classroom experience. Increasing the distance between the mentor and the learner may also serve to increase actual independence through the emergence of anticipatory responses and perceived independence by peers for learners with ASD.

Limitations and future directions

The results of this preliminary study must be interpreted in light of a few limitations. Firstly, although experimental, this study included only one participant. Given the heterogeneity of children with ASD, the results may not generalize to other individuals with ASD. It is important to replicate this research with a larger sample of children with ASD. Additionally, because we chose directives that occurred only once each day, we were unable to collect probe and intervention data for every directive during intervention. Rather, we provided intervention using an "as needed" (i.e., JIT) approach, for a maximum of two directives per setting, per day. In this way, we maintained the integrity of the participant's schedule, while still collecting probe and intervention data. A follow-up study in which temporally nonspecific directives are used may prove useful in collecting both intervention and probe data for each directive, each day.

Two additional design limitations include the a priori decisions about when to begin intervention in each setting, and when to increase the distance between the teaching assistant and the student, rather than using the participant's performance to guide intervention. Finally, related to the watch, technological (e.g., speed of wireless connection) and financial (e.g., cost of the watch) factors may reduce the intervention feasibility in some school settings.

Additional research is required to explore the benefits of a smart watch intervention in increasing actual and perceived independence for learners with ASD. In terms of perceived independence, peers of the participants should be included in social validity assessments. Finally, the potential of a smart watch intervention to offer unobtrusive, non-stigmatizing, and discreet supports may be most critical in inclusive classroom and community-based environments. Hence, future research should be directed in these settings.

Conclusions

This intervention note describes the first study to use an experimental design to investigate the effectiveness of repurposing a general consumer-level smart watch as part of an intervention that supports directive-following for a child with ASD. The results suggest that this child with ASD demonstrated modest improvements in directive-following, and an increased distance from her mentor, after receiving the smart watch intervention. This smart watch intervention may result in improved independence through remote support and the acquisition of anticipatory responses as well as improved independence as perceived by peers.

End notes

ORCID

Amanda M. O'Brien http://orcid.org/0000-0001-5350-5457
Ralf W. Schlosser http://orcid.org/0000-0002-2069-3911
Oliver Wendt http://orcid.org/0000-0002-7363-3779

References

Barrios, B. A., & Hartmann, D. P. (1988). Recent developments in single-subject methodology: Methods for analyzing generalization, maintenance, and multicomponent treatments. In M. Hersen, R. M. Eisler, & P. M. Miller (Eds.), *Progress in behavior modification* (Vol. 22, pp. 11–47). Newbury Park, CA: Sage Publications.

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

Caron, J., Light, J., & Drager, K. (2016). Operational demands of AAC mobile technology applications on programming vocabulary and engagement during professional and child interactions. *Augmentative and Alternative Communication (Baltimore, Md. : 1985)*, *32*(1), 12–24. doi:10.3109/07434618.2015.1126636

Dunn, L. M., & Dunn, D. M. (2007). *Peabody picture vocabulary test, Fourth edition (PPVT-4)*. Bloomington, MN: NCS Pearson, Inc.

Giangreco, M. F., Edelman, S. W., Luiselli, T. E., & MacFarland, S. Z. C. (1997). Helping or hovering? Effects of instructional assistant proximity on students with disabilities. *Exceptional Children*, *64*(1), 7–18. doi: 10.1177/001440299706400101

Horner, R. B., & Baer, D. M. (1978). Multiple-probe technique: A variation on the multiple baseline. *Journal of Applied Behavior Analysis*, *11*(1), 189–196. doi:10.1901/jaba.1978.11-189

Hudry, K., Leadbitter, K., Temple, K., Slonims, V., McConachie, H., Aldred, C., … Charman, T., PACT Consortium (2010). Preschoolers with autism show greater impairment in receptive compared with expressive language abilities. *International Journal of Language & Communication Disorders*, *45*(6), 681–690. doi:10.3109/13682820903461493

Kelley, M., Heffer, R. W., Gresham, F. M., & Elliott, S. N. (1989). Development of a modified treatment evaluation inventory. *Journal of Psychopathology and Behavioral Assessment*, *11*(3), 235–247. doi:10.1007/BF00960495

Koumpouros, Y., & Kafazis, T. (2019). Wearables and mobile technologies in Autism Spectrum Disorder interventions: A systematic literature review. *Research in Autism Spectrum Disorders*, *66*, 101405. doi:10.1016/j.rasd.2019.05.005

Kratochwill, T. R., Hitchcock, J., Horner, R. H., Levin, J. R., Odom, S. L., Rindskopf, D. M., & Shadish, W. R. (2010). *Single-case designs technical documentation*. Retrieved from What Works Clearinghouse website: http://ies.ed.gov/ncee/wwc/pdf/wwc_scd.pdf

Lorah, E. R., Parnell, A., Whitby, P. S., & Hantula, D. (2015). A systematic review of tablet computers and portable media players as speech generating devices for individuals with autism spectrum disorder. *Journal of Autism and Developmental Disorders*, *45*(12), 3792–3804. doi:10.1007/s10803-014-2314-4

McCathren, R. B., Yoder, P. J., & Warren, S. F. (1995). The role of directives in early language intervention. *Journal of Early Intervention*, *19*(2), 91–101. doi:10.1177/105381519501900201

O'Brien, A., O'Brien, M., Schlosser, R. W., Yu, C., Allen, A., Flynn, S., … Shane, H. C. (2017). Repurposing consumer products as a gateway to just-in-time communication. *Seminars in Speech and Language*, *38*, 297–312. doi:10.1055/s-0037-1604277.

O'Brien, A., Schlosser, R. W., Shane, H. C., Abramson, J., Allen, A. A., Flynn, S., … Dimery, K. (2016). Brief report: Just-in-time visual supports to children with autism via the Apple Watch:® A Pilot Feasibility Study. *Journal of Autism and Developmental Disorders*, *46*(12), 3818–3823. doi:10.1007/s10803-016-2891-5

O'Brien, A. M., Schlosser, R., Yu, C., Allen, A. A., & Shane, H. C. (2020). Repurposing a smartwatch to support individuals with autism spectrum disorder: Sensory and operational considerations. *Journal of Special Education Technology*. https://doi.org/10.1177/0162643420904001

Parker, R. I., Vannest, K. J., & Brown, L. (2009). The improvement rate difference for single-case research. *Exceptional Children*, *75*(2), 135–150. doi:10.1177/001440290907500201

Parker, R. I., Vannest, K. J., Davis, J. L., & Sauber, S. B. (2011). Combining nonoverlap and trend for single-case research: Tau-U. *Behavior Therapy*, *42*(2), 284–299. doi:10.1016/j.beth.2010.08.006

Rice, M. L., Warren, S. F., & Betz, S. K. (2005). Language symptoms of developmental language disorders: An overview of autism Down syndrome, fragile X, specific language impairment, and Williams syndrome. *Applied Psycholinguistics*, *26*(1), 7–27. doi:10.1044/2015_JSLHR-L-15-0255

Sarker, H., Tam, A., Foreman, M., Fay, N., Dhuliawala, M., & Das, A. (2018). Detection of stereotypical motor movements in autism using a smart watch-based system. *AMIA Annual Symposium Proceedings*, *2018*, 952–960.

Schlosser, R. W. (1999). Social validation of interventions in augmentative and alternative communication. *Augmentative and Alternative Communication*, *15*(4), 234–247. doi:10.1080/07434619912331278775

Schlosser, R. W. (2002). On the importance of being earnest about treatment integrity. *Augmentative and Alternative Communication*, *18*(1), 36–44. doi:10.1080/714043395

Schlosser, R. W. (2003). *The efficacy of augmentative and alternative communication: Toward evidence-based practice*. San Diego, CA: Academic Press.

Schlosser, R. W., Laubscher, E., Sorce, J., Koul, R., Flynn, S., Hotz, L., … Shane, H. (2013). Implementing directives that involve prepositions with children with autism: A comparison of spoken cues with two types of augmented input. *Augmentative and Alternative Communication (Baltimore, Md. : 1985)*, *29*(2), 132–145. doi:10.3109/07434618.2013.784928

Schlosser, R. W., & Lee, D. (2000). Promoting generalization and maintenance in augmentative and alternative communication: A meta-analysis of 20 years of effectiveness research. *Augmentative and Alternative Communication*, *16*(4), 208–227. doi:10.1080/07434610012331279074

Schlosser, R. W., O'Brien, A., Yu, C., Abramson, J., Allen, A., Flynn, S., & Shane, H. C. (2017). Repurposing everyday technologies to provide just-in-time visual supports to children with intellectual disability and autism: A pilot feasibility study with the Apple Watch®. *International Journal of Developmental Disabilities*, *63*(4), 221–227. doi:10.1080/20473869.2017.1305138

Schlosser, R. W., Shane, H. C., Allen, A. A., Abramson, J., Laubscher, E., & Dimery, K. (2016). Just-in-time supports in augmentative and alternative communication. *Journal of Developmental and Physical Disabilities*, *28*(1), 177–193. doi:10.1007/s10882-015-9452-2

Schlosser, R. W., Shane, H. C., Allen, A. A., Benz, A., Cullen, J., O'Neill, L., … Pasupathy, R. (2020). Coaching a school team to implement the visual immersion system tm in a classroom for children with autism spectrum disorder: A mixed methods proof of concept study. *Advances in Neurodevelopmental Disorders*, *4*(4), 447–470. doi:10.1007/s41252-020-00176-5

Sevcik, R. A. (2006). Comprehension: An overlooked component in augmented language development. *Disability and Rehabilitation*, *28*(3), 159–167. doi:10.1080/09638280500077804

Shane, H. C., & Albert, P. D. (2008). Electronic screen media for persons with autism spectrum disorders: Results of a survey. *Journal of Autism and Developmental Disorders*, *38*(8), 1499–1508. doi:10.1007/s10803-007-0527-5

Slamecka, N. J. (1977). A case for response-produced cues in serial learning. *Journal of Experimental Psychology: Human Learning & Memory*, *3*(2), 222–232. doi:10.1037/0278-7393.3.2.222

Tarlow, K. R. (2017). *Baseline corrected tau calculator*. http://www.ktarlow.com/stats/tau

Torrado, J. C., Gomez, J., & Montoro, G. (2017). Emotional self-regulation of individuals with autism spectrum disorders: Smart watches for monitoring and interaction. *Sensors*, *17*(6), 1359, 1–29. doi:10.3390/s17061359

Vannest, K. J., Parker, R. I., Gonen, O., & Adiguzel, T. (2016). *Single Case Research: Web based calculators for SCR analysis. (Version 2.0) [Web-based application]*. College Station, TX: Texas a&M University. Retrieved from singlecaseresearch.org

Williams, K. T. (2007). *Expressive vocabulary test* (2nd ed.). Minneapolis, MN: NCS Pearson.