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An Experimental Analysis of Voice Volume for Children with Autism Spectrum Disorder

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Experimental Analysis of Voice Volume for Children with Autism Spectrum Disorder

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Abstract

Inappropriate prosodic production is an often observed, but rarely treated, communication skill deficit for individuals with autism. Expanding on previous literature, we conducted a functional analysis on the voice volume responses (VVR) of two children with ASD utilizing similar procedures to those from Edgerton and Wine (2017). Further, we evaluated the efficacy of using visual feedback from an app and a function-based treatment to decrease inappropriate VVR and increase appropriate VVR. Results of the functional analysis indicated loud VVR was maintained by social negative reinforcement (escape from demands) for one participant and by both social negative and automatic reinforcement for another participant. Results of the intervention demonstrated a decrease in the use of loud VVRs, and an increase in the use of appropriate VVRs, for one participant. The implications of the results with respect to conducting functional analysis on VVR are discussed.

Keywords: autism spectrum disorder, prosody, social communication, speech, visual prompt, voice volume

Introduction

Individuals diagnosed with autism spectrum disorder (ASD) often demonstrate difficulties with conversational speech, which may limit their communication and social interactions with peers (American Psychiatric Association, 2013). Children with ASD frequently struggle with prosodic production during conversation, such as difficulties with utterance duration, pitch range, and intensity (Diehl & Paul, 2013). Prosody refers to the suprasegmental characteristics of speech (duration, amplitude, and fundamental frequency of speech sounds) that we use to communicate (McCann & Peppe, 2007). If no adequate communication skills are learned, speech deficits persist over time and may become more severe as the individual gets older (Grosberg & Charlop, 2017). Also, some individuals might engage in stereotypic and repetitive motor mannerisms and use of language, such as noncontextual laughter, humming, repetitive noises, or vocalizations (American Psychiatric Association, 2013). A communication deficit not often evaluated but commonly observed in ASD is the use of inappropriate acoustic prosodic production (i.e., conversational volume; speaking too loudly or too quietly). Such deficits can profoundly impair the ability to form social interactions with the environment, such as developing and maintaining relationships, making social overtures, and having positive interactions with peers (Qualls & Corbett, 2018).

Some interventions commonly used to address social communication deficits among individuals with ASD include: using scripts to prompt conversation (Grosberg & Charlop, 2017); using speech-generating devices (SGD) to emit target vocalizations (Gervarter et al., 2016); teaching social perception through video modeling (video-based group instruction [VGI; Stauch et al., 2018]); or teaching communicative responses to replace problem behavior (functional communication training [FCT; Carr & Durand, 1985]). Such interventions have proven to be effective and efficient methods for teaching communicative responses, but seldom treat the receptive (responding to another person's speech features) or expressive (using affective and pragmatic speech) prosodic deficits associated with ASD (Diehl & Paul, 2013; Peppé et al, 2007).

Atypicalities in prosody production (rhythm, rate, and intonation patterns) are commonly observed communicative deficits associated with ASD (Diehl & Paul, 2013; McCann & Peppé, 2003; Qualls & Corbett, 2018). As the severity of the symptoms increases, individuals with ASD tend to speak less, have more variable prosody, engage in longer utterance durations, higher pitch ranges, and use fewer affect words (Bone et al., 2013; Diehl & Paul, 2013; Fusaroli et al., 2017; McCann & Peppé, 2003). Despite these results, no single acoustic feature (or prosodic deviance, such as monotonic speech) has been identified in the literature that could serve as a marker for prosody production in ASD. Nonetheless, the relevance of prosody to affective, nonlinguistic aspects of communication could suggest communication-related target behaviors that might improve social skills and communication for children with ASD (Peppé et al., 2007).

Few studies have evaluated the acoustic characteristics of prosody in children with ASD (Fusaroli et al., 2017; Muharib & Wood, 2018; Sng et al., 2018), and obtaining a measurement of conversational skills is typically limited to parent and teacher report measures (Paul et al., 2009). Additionally, the prosody of each response can be affected by environmental variables that are difficult to control or account for, such as rapport with the examiner, the task magnitude, the establishing operation for compliance with task demands, or the task difficulty (Tager-Flusberg & Kasari, 2013). As such, methods for assessing vocal responses should measure the acoustic prosody production (rhythm, rate, and intonation patterns). With the recent advancements in technology (e.g., portable tablet computers, multimedia players), phone application (apps) sound level meters (SLM) have become widely accessible for clinical use for voice and speech assessment. The use of apps for SLM readings are cost and time efficient, technologically advanced, portable, and engaging for patients and clinicians (Fava et al., 2016). Although a review of the literature supports the general effectiveness of using handheld technology as an augmentative and alternative communication (AAC) system for children with ASD (Gilroy et al., 2017; Goldsmith & LeBlanc, 2004; Lorah et al., 2015; Lorah et al., 2018), transportable technology has not often been evaluated with other aspects of communication such as prosody.

A few studies have used acoustic measures (e.g., voice volume, pitch recording) on electronic devices to treat problematic prosodic production in ASD (Diehl & Paul, 2013; Edgerton & Wine, 2017; Koegel & Frea, 1993). Edgerton and Wine (2017) implemented an intervention for shaping conversational speech volume for one intellectually disabled participant. Responses were measured using a voice meter application (Voice Meter Pro ™; EdTech Monster Limited) that provided visual feedback on the voice volume of the response emitted (e.g., speaking too loudly or too quietly). By differentially reinforcing appropriate volume in conjunction with the app, the researchers increased the conversational volume of the participant. However, no functional assessment was conducted for the prosodic production of the participant.

Although atypicalities in speech volume in children with ASD could be a skill deficit for some, inappropriate prosody could also be maintained by operant contingencies. For example, inappropriate prosody may be reinforced by attention from caregivers (e.g., “please speak up!”) or by escape from aversive tasks. In these cases, the results of a functional analysis could be used to develop an effective treatment that weakens the relationship between problem behavior and its maintaining consequences and strengthens the relationship between appropriate behavior and those same consequences (Tiger et al., 2008). Additionally, teaching a function-based alternative communicative response can decrease the rate of problem behavior (Carr & Durand, 1985) and increase the speed of acquisition of new communicative responses (Plavnick & Ferreri, 2011).

The purpose of the current study was to conduct a functional analysis on the production of inappropriate voice volume (i.e., speaking too loudly or too quietly) with two participants diagnosed with ASD, and expand on previous literature (i.e., Edgerton & Wine, 2017) in utilizing new technology (i.e., smartphone application), in conjunction with a function-based intervention, for decreasing inappropriate voice volume and increasing appropriate voice volume.

Method

Participants and Settings

Participants were two children who had been diagnosed with ASD. Information about the participants is shown in Table 1. The participants were recruited from an in-home based behavior analytic company. Participants met the following inclusion criteria: (a) Participants could produce at least one distinguishable vocal response (e.g., one- to three-word utterances), (b) as measured by an assessment of verbal behavior (such as the *Assessment of Basic Language and Learning Skills, Revised* [ABLLS-R®; Partington, 2010]), participants possessed basic vocal mand and tact repertoires, and (c) as reported by caregivers, participants often spoke too quietly or too loudly. The participants were selected in order of recruitment and availability.

Sam was an 8-year-old boy diagnosed with ASD. As reported by his caregivers, Sam often engaged in loud communicative speech and loud vocal stereotypy. The topography of Sam’s vocal stereotypy included repetitive vowel sounds (i.e., “eee,”), non-contextual laugh or cackle (clearing throat noise), repetitive consonant sounds or humming (i.e., “mmm”), repetitive numbers, tongue “clicking” or ticking, and repetitive manding. Damien was a 7-year-old boy diagnosed with ASD. As reported by his parents, Damien often engaged in soft or whispered communicative speech and both loud and quiet vocal stereotypy. The topography of Damien's vocal stereotypy included repetitive consonant sounds and humming (i.e., "mmm"), noncontextual delayed echolalia (e.g., scripting), immediate echolalia (e.g., repeating command, task, word), forced clearing throat or cough (rasp sound), noncontextual laugh or cackle, and repetitive manding.

Sessions were conducted in the location where the participant received behavioral services. Sam's sessions were initially conducted in the dining room and later moved to a spare bedroom of the caregivers' home. The dining room contained a table, chairs, and the materials needed to conduct the session; the spare bedroom contained a bed, a carpet rug, shelves, and the materials needed to conduct the session. Damien's sessions were conducted in the dining room of the caregivers' home. The room contained a table, chairs, and the materials needed to conduct the session. All sessions were audio-recorded.

Materials

An iPhone installed with the latest operating system was utilized throughout the study to measure the voice volume emitted by the participants. We installed the latest version of the Voice Meter Pro app (Version 1.71; EdTech Monster Unlimited, 2013), available through the App Store. The app displayed the volume levels in a gauge that went up or down with the changes in volume (Figure 1). The display turned blue, red, or green when the participant spoke too quietly, too loudly, or at the appropriate volume, respectively. The app also contained adjustable settings. *Sensitivity* slider controlled how much the meter moved for a given response. *Dampening* slider controlled the responsiveness (or delay in movement) of the meter. *Upper* and *Lower Value* sliders set the maximum and minimum value of the acceptable volume. A laptop was used to mirror and record the iPhone's display. An external microphone (Sevenoak BY-DM1 lavalier microphone) was used to unobtrusively record responses in the natural environment.

Prior to the initiation of the study, the primary researcher conducted mock sessions with the participant's lead analyst to determine the upper and lower decibel (dB) value for appropriate voice volume responses. This was completed to establish a conversational volume that was deemed appropriate to the participant's natural environment (e.g., living room). Several steps were taken to ensure the equipment performed consistently throughout the study. An online noise generator was used to determine how to calibrate the app's settings, which helped to reduce variability occasioned by extraneous environmental noises (e.g., yard landscapers). Additionally, an app calibration task analysis was completed at the beginning of every session, which noted the location of the session, the percent of the sensitivity and dampening sliders, the upper- and lower-dB values, and ambient sounds that might have influenced the volume measurements.

Prior to each session, the recording equipment was set up discreetly within the environment. First, the iPhone was paired to the laptop (for screen recording and data collection), and the microphone was connected to the iPhone (for sound detection). Second, the microphone was placed at an approximately equal distance from the participant across all sessions (i.e., 0.30 to 1.22 m). When necessary, arrangements to the placement of the recording equipment (e.g., microphone, laptop) were made to account for the change of location. Third, during the FA sessions, both the iPhone's screen and the laptop's monitor were faced away from the participant; during the training and intervention sessions, the iPhone was placed in front of the participant with its screen visible to both the therapist and the participant.

Response Measurement and Interobserver Agreement

Data were collected by trained observers on the volume of the vocalization, or voice volume response (VVR), emitted by the participant. Each vocalization (utterance) was measured by the app and coded as Q (quiet), C (conversational), or L (loud). *Q coded responses* was scored when the participant's response was below the lower dB value (i.e., quiet volume; Q-VVR). *C coded responses* was scored when participant emitted a response within the lower and higher dB range value (i.e., appropriate volume; A-VVR). *L coded responses* (L-VVR) was scored when the participant's response was above the high dB value. If any part of the utterance contained L-VVR, the consequence was delivered on the occurrence of L-VVR. However, both utterances were scored.

Data were collected by the observer from the recordings of the iPhone's mirrored display onto the laptop or the screen recording of the iPhone's display using a data collection program (Insight: Observation Timer [Version 1.3.2; Radloff, 2017]). A second independent observer collected data from the session recordings of the iPhone's display. Sessions were divided into 10-s time intervals. An agreement was recorded when both observers scored the same VVR as occurring during the interval. Interobserver agreement data were collected on 30% of randomly selected sessions throughout the study (range, 28% to 32%) across participants. Interobserver agreement for loud voice volume responses was calculated by dividing the number of intervals in which both observers agree on the occurrence or nonoccurrence of L-VVR by the total number of intervals in a session and multiplied by 100. Mean agreement across participants was 96.1% (range, 94.7% to 97.4%).

Preassessment

Prior to the initiation of the study, the participants' caregivers completed a Questions About Behavioral Function (QABF; Matson & Vollmer, 1995) assessment. Additionally, the caregivers were interviewed to identify: (a) idiosyncrasies that might occasion the occurrence of inappropriate voice volume, which was used to modify the test conditions; (b) mand and tact repertoire; (c) preferred leisure activities and items; and (d) physiological variables affecting speech production (e.g., oral impairment, ear infections). A brief paired-stimulus preference assessment (PSPA; Fisher et al., 1992) was conducted to identify the preference hierarchy of the leisure items.

Functional Analysis

Three to five sessions were conducted daily, one to five days per week. Each session lasted 5 min. Prior to starting each session, the researcher: (a) started screen mirroring the iPhone's display onto the laptop, or screen recording the display; (b) enabled the microphone to use with the voice volume meter while screen recording; (c) launched the app, calibrated the sound level meter, and adjusted recorder's settings (i.e., sensitivity, dampener, and threshold) as necessary; (d) turned the iPhone and the laptop away from the participant; and (e) started screen-recording the iPhone's display.

Using the procedures delineated by Iwata et al. (1982/1994), participants were exposed to no interaction, attention, tangible, play, and demand conditions. Sessions were conducted in a multielement design. Test conditions were modified to simulate environmental conditions likely to evoke L-VVR.

No Interaction

During this condition, all materials were removed; the participant did not have access to leisure items. No programmed consequences were delivered contingent on A-, Q-, or L-VVR. Additional no interaction sessions were conducted with Sam, as the initial results suggested L-VVR was maintained by automatic reinforcement.

Attention

During this condition, the participant was given access to a moderately preferred item (i.e., Legos for Sam, tablet for Damien). At the beginning of each session, the therapist directed the participant toward the preferred item, made a statement such as "I can't talk to you right now", and diverted their attention from the participant (e.g., turned to the side, gave no eye contact). Contingent on L-VVR, the therapist provided a brief statement (e.g., "you have to lower your voice"). All A- and Q-VVRs were ignored.

Tangible

During this condition, the participant was given brief access (e.g., 2 to 3 min) to the highly preferred item before the beginning of the session. The preferred item was removed at the start of the session. During the session, the therapist provided attention on a 30 s fixed-time (FT) schedule of reinforcement. Contingent on L-VVR, the participant was given 30 s access to the preferred item (i.e., tablet) for Sam, or preferred snack for Damien. All A- and Q-VVRs were ignored.

Play

The therapist and the participant were present in a room. The participant had free access to preferred items and activities. Attention was delivered continuously by the therapist. No demands were presented. No consequences were delivered for A-, Q-, or L-VVRs.

Demand

During this condition, demands were placed throughout the session. The therapist placed demands continuously using a three-step prompting sequence (i.e., verbal, gestural, and model). All task demands placed required a vocal response from the participant (i.e., tacting sight words for Sam; tacting actions or individuals for Damien). The participant was given a 30-s break contingent on L-VVR, regardless of response accuracy. For A- or Q-VVR, the therapist delivered feedback on the accuracy of each response (e.g., “that’s right” or “no, try again”) using a neutral tone of voice. Praise was provided contingent on correct responses.

Treatment Evaluation

Results of the FA were used to determine a function-based treatment for L-VVR. Treatment was assessed in a reversal design. Researchers used the same voice volume meter app to measure and code each response, and recording equipment was set up as described above. Three to five sessions were conducted daily, one to five days per week. Each session lasted 5 min.

Baseline

Data from the test condition of the FA with the highest rate of L-VVRs was used as the initial baseline. Procedures during all subsequent baseline phases were identical to the test condition. The iPhone’s screen and laptop monitor were facing away from the participant. No consequences were delivered contingent on A-VVRs.

Training

During the training sessions, the iPhone was placed in close proximity of the participants (i.e., 0.30 to 1.22 m) with the screen visible to the therapist and the participant. Prior to each training session, the participants were directed to attend to the voice volume recording app. The therapist made statements to signal the start of the session [e.g., “today, we are working on talking nicely; try to talk in (green)”]. The therapist modeled each voice volume response (quiet, conversational, and loud) by speaking three consecutive single-word utterances (e.g., cat, dog, bee) at each voice volume.

Function-Based Intervention

In conjunction with differential reinforcement of alternative behavior, the researchers evaluated the effectiveness of the voice volume recording app for decreasing L-VVRs. During the treatment phase, sessions were conducted in a manner identical to baseline, except a functional reinforcer was delivered contingent on A-VVRs. For both participants, the functional reinforcer was a 30 s break from demands. L-VVRs were placed on extinction.

Results

Results of Sam's FA for loud voice volume responses are shown in Figure 2. Sam engaged in variable levels of L-VVR in the multielement phase of the FA across all conditions, though L-VVR occurred at a generally higher level during the demand condition relative to the play condition. In the extended no interaction phase, levels of L-VVR maintained across several sessions. These results indicate that Sam's loud VVR was maintained by both social negative (escape from demands) and automatic reinforcement. For Sam, the QABF identified automatic as the most likely function maintaining VVR, with escape and tangible also receiving high scores; this partially corresponded with the results of the FA.

Results of Damien's FA for loud voice volume responses are shown in Figure 3. Damien engaged in higher levels of L-VVR during the demand condition relative to the play condition in the multielement phase of the FA. In the pairwise phase, Damien continued to engage in higher levels of L-VVR during the demand condition relative to the play condition. Damien engaged in very low levels of L-VVR during the last two play conditions. These results indicate that Damien's L-VVR was maintained by social negative reinforcement in the form of escape from demands. For Damien, the QABF identified attention as the most likely function, which did not correspond with the results of the FA.

Results of Sam's intervention are shown in Figure 4. For the first 7 sessions of the intervention phase, Sam engaged in high rate of L-VVR, similar to that during baseline. During these sessions, the therapist accidentally placed both loud VVR and quiet VVRs on extinction and only reinforced the occurrence of appropriate VVR, which deviated from the initial treatment goal (decrease L-VVR). As treatment adherence was modified, Sam exhibited lower levels of L-VVR compared to the initial baseline phase. Results of Damien's intervention are shown in Figure 5. When the intervention was implemented, Damien engaged in low rate of L-VVR compared to baseline data. During the return to the baseline phase, L-VVR occurred at a similar rate as that during the initial baseline phase. When intervention was reinstated, the rate of L-VVR did not decrease to previous intervention levels.

Discussion

The purpose of the present study was to expand the methodology for assessing and treating deficits in prosody and social communication of children with ASD. Results from this study indicate that VVR could be maintained by operant contingencies. Results of the FA demonstrated that loud VVR was maintained by both social negative (escape from demands) and automatic reinforcement for one participant and social negative reinforcement for another participant. Using the results of the FA, the experimenters implemented a function-based intervention for decreasing L-VVR. The function-based intervention, in conjunction with the app, decreased the rate of L-VVR for one participant. It is unclear whether or not the function-based intervention would be successful for the second participant with high treatment fidelity in place; this will be evaluated in the future. In summary, results indicate that function-based interventions (e.g., differential negative reinforcement of alternative behavior) may be used to reduce inappropriate VVRs.

Although atypicalities in speech volume in children with ASD could be maintained by operant contingencies, inappropriate prosody could also be a skill deficit for some. For example, Edgerton and Wine (2017) treated speech volume as a skill deficit, which suggest an inability to produce conversational speech volume by the participant. The app was utilized as a visual feedback for shaping responses at an appropriate voice volume. However, in the current study, speech volume was treated as a performance deficit, and not a skill deficits, as no physiological variables affecting voice production were noted by the caregivers and the participants had been observed engaging in conversational speech volume. In this case, the visual feedback stimulus was utilized as an initial step towards measuring and quantifying prosody of speech.

Several preventative measures were completed to ensure the materials (i.e., laptop, iPhone, lavalier microphone) performed consistently across sessions. First, the experimenter created a task analysis that delineated the steps to set up the equipment. Additionally, a troubleshooting guide was created to problem solve equipment issues. For example, when the iPhone could not be paired to the laptop, the screen recording function of the phone was utilized. This did not affect the app's measurement of the sounds; however, a slight difference could be heard (clear and/or louder) when scoring iPhone's screen recording, compared to the mirrored displayed.

Despite these preventative measures, the use of the recording equipment had some limitations. First, the recording app could not measure the participant's VVR in isolation of the ambient level of sound. Environmental noises that were in close proximity (e.g., family's pet, plastic bag's crinkle), or were high noise volume (e.g., doorbell, a conversation held by people present), would affect the noise measurement of the app. During data collection, the observer would score loud, conversational, or quiet VVR if the participant's voice could be heard in isolation of other environmental noises or the voice of the participant exceeded the noises in the environment. When the ambient level of sound could not be regulated or maintained consistent across sessions, the session location was changed for Sam. For example, the wood floors echoed walking steps as L-VVR, regardless of the speed or force of each step. As such, the initial location of Sam’s assessment was changed from the dining room to a spare bedroom that contained a bed and a rug carpet, which muffled the sound produced while walking or moving around.

Second, the current study was conducted in the location where the individual receives behavioral services, which may hinder the participant's ability to generalize across settings that require different VVRs. As the location and ambient level of sound changes, the participant must adjust his VVR to meet those of the environment. The use of mobile apps permits the therapist to conduct generalization sessions with minimal disruption to the natural environment. Future studies should assess the generalization and maintenance of the intervention across settings where the ambient level of sound varies from the training setting (e.g., library, park).

Third, the consequence delivered contingent on the occurrence of L-VVR during the functional analysis could have functioned as a punisher. During some of the sessions, the therapist’s response (e.g., “you have to keep it down”) often resulted in lower rates of L-VVR for the remainder of the session. When presenting the discriminative stimulus the therapist had to mitigate their own prosody (i.e., speed, volume, intonation) as their verbal statement often elicited a communicative response from the participants. For example, when the therapist removed the tasks and made statement (e.g., “ok, you don’t have to” or “you can have a break”), the participant would leave the work area (often to the other side of the room) or make comments on having tasks removed (e.g., “but why?” or “why don’t I have to?”). This was also observed during the no interaction condition (e.g., “earth to Mr. Arturo”), as well as during the attention condition, when the therapist made a comment of the L-VVR (e.g., “sorry”). The change in the rate of L-VVR suggests that the therapist’s response (e.g., “you have to keep it down”) may function as a punisher, instead of a reinforcer. As previous literature suggest (i.e., Kodak et al., 2007), the type of attention provided contingent on problem behavior (L-VVR) could influence the occurrence of the behavior. Future studies should assess the effects of using different types of attention on the occurrence of L-VVR.

References

American Psychiatric Association (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). American Psychiatric Association.

Bone, D., Lee, C. C., Chaspari, T., Black, M. P., Williams, M. E., Lee, S., Levitt, P., & Narayanan, S. (2013). Acoustic-prosodic, turn-taking, and language cues in child-psychologist interactions for varying social demand. *Proceedings of Interspeech*, 2400-2404.

Carr, E. G., & Durand, V. M. (1985). Reducing problem behaviors through functional communication training. *Journal of Applied Behavior Analysis*, *18*, 111–126. https://doi.org/10.1901/jaba.1985.18-111

Diehl, J. J., & Paul, R. (2013). Acoustic and perceptual measurements of prosody production on the profiling elements of prosodic systems in children by children with autism spectrum disorders. *Applied Psycholinguistics, Firstview, 34*, 125-161. https://doi.org/10.1017/S0142716411000646

Edgerton, L., & Wine, B. (2017). Speak up: Increasing conversational volume in a child with autism spectrum disorder. *Behavior Analysis in Practice*, *10*, 407-410. https://doi.org/10.1007/s40617-016-0168-2

EDTECH MONSTER LIMITED. (2013). *Voice Meter Pro* (Version 1.71) [Mobile app]. App Store. https://apps.apple.com/us/app/voice-meter-pro/id686934049?mt=8%2C8%3Futm_source%3Ddf-vmp-landing&utm_medium=vmp-sales-fun&utm_campaign=vmpfeb2016&utm_content=prod-image&ign-mpt=uo%3D4

Fava, G., Oliveira, G., Baglione, M., Pimpinella, M., & Spitzer, J. B. (2016). The use of sound level meter apps in the clinical setting. *American Journal of Speech-Language Pathology*, *25*, 14-28. https://doi.org/10.1044/2015_AJSLP-13-0137

Fisher, W., Piazza, C. C., Bowman, L. G., Hagopian, L. P., Owens, J. C., & Slevin, I. (1992). A comparison of two approaches for identifying reinforcers for persons with severe and profound disabilities. *Journal of Applied Behavior Analysis*, *25*, 491–498. https://doi.org/10.1901/jaba.1992.25-491

Fusaroli, R., Lambrechts, A., Bang, D., Bowler, D. M., & Gaigg, S. B. (2017). Is voice a marker for autism spectrum disorder? A systematic review and meta-analysis. *Autism Research*, *10*, 384-407. https://doi.org/10.1002/aur.1678

Gevarter, C., O'Reilly, M. F., Kuhn, M., Mills, K., Ferguson, R., Watkins, L., Sigafoos, J., Lang, R., Rojeski, L., & Lancioni, G. E. (2016). Increasing the vocalizations of individuals with autism during intervention with speech-generating device. *Journal of Applied Behavior Analysis*, *49*, 17-33. https://doi.org/10.1002/jaba.270

Gilroy, S. P., McCleery, J. P., & Leader, G. (2017). Systematic review of methods of teaching social and communicative behavior with high-tech augmentative and alternative communication modalities. *Review Journal of Autism and Developmental Disorders*, *4*, 307-320. https://doi.org/10.1007/s40489-017-0115-3

Goldsmith, T. R., & LeBlanc, L. A. (2004). Use of technology in interventions for children with autism. *Journal of Early and Intensive Behavior Intervention*, *1*, 166-178. https://doi.org/10.1037/h0100287

Grosberg, D., & Charlop, M. H. (2017). Teaching conversational speech to children with autism spectrum disorder using text-message prompting. *Journal of Applied Behavior Analysis*, *50*, 789-804. https://doi.org/10.1002/jaba.403

Iwata, B. A., Dorsey, M. F., Slifer, K. J., Bauman, K. E., & Richman, G. S. (1994). Toward a functional analysis of self-injury. *Journal of Applied Behavior Analysis*, *27*, 197–209. https://doi.org/10.1901/jaba.1994.27-197 (Reprinted from *Analysis and Intervention in Developmental Disabilities*, *2*, 3-20, 1982)

Kodak, T., Northup, J., & Kelley, M. E. (2007). An evaluation of the types of attention that maintain problem behavior. *Journal of Applied Behavior Analysis, 40*, 167-171. https://doi.org/10.1901/jaba.2007.43-06

Koegel, R. L., & Frea, W. D. (1993). Treatment of social behavior in autism through the modification of pivotal social skills. *Journal of Applied Behavior Analysis*, *26*, 369-377. https://doi.org/10.1901/jaba.1993.26-369

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 Disorder*, *45*, 3792-3804. https://doi.org/10.1007/s10803-014-2314-4

Lorah, E. R., Tincani, M., & Parnell, A. (2018). Current trends in the use of handheld technology as a speech-generating device for children with autism. *Behavior Analysis: Research and Practice*, *18*, 317-327. https://doi.org/10.1037/bar0000125

Matson, J. L., & Vollmer, T. R. (1995). *User's guide: Questions About Behavioral Function* (*QABF*). Scientific Publishers.

McCann, J., & Peppé, S. (2003). Prosody in autism spectrum disorders: A critical review. *International Journal of Language & Communication Disorders*, *38*, 325-350. https://doi.org/10.1080/1368282031000154204

Muharib, R., & Wood, C. L. (2018). Evaluation of the empirical support of functional communication training for children with autism spectrum disorder. *Review Journal of*

Autism and Developmental Disorders, *5*, 360-369. https://doi.org/10.1007/s40489-018-0145-5

Partington, J. W. (2010). *The Assessment of Basic Language and Learning Skills-Revised (ABLLS-R): ABLLS-R protocol.* Behavior Analysts, Inc.

Paul, R., Orlovski, S. M., Marcinko, H. C., & Volkmar, F. (2009). Conversational behaviors in youth with high-functioning ASD and Asperger Syndrome. *Journal of Autism and Developmental Disorders*, *39*, 115-125. https://doi.org/10.1007/s10803-008-0607-1

Peppé, S., McCann, J., Gibbon, F., O'Hare, A., & Rutherford, M. (2007). Receptive and expressive prosodic ability in children with high-functioning autism. *Journal of Speech, Language, and Hearing Research*, *50*, 1015–1028. https://doi.org/10.1044/1092-4388(2007/071)

Plavnick, J. B., & Ferreri, S. J. (2011). Establishing verbal repertoires in children with autism using function-based video modeling. *Journal of Applied Behavior Analysis*, *44*, 747-66. https://doi.org/10.1901/jaba.2011.44-747

Qualls, L. R., & Corbett, B. A. (2017). Examining the relationship between social communication on the ADOS and real-world reciprocal social communication in children with ASD. *Research in Autism Spectrum Disorder*, *33*, 1-9. https://doi.org/10.1016/j.rasd.2016.10.003

Radloff, L. (2017). *Insight: Observation Timer* (Version 1.3.2) [Mobile app]. App Store. https://apps.apple.com/us/app/insight-observation-timer/id1212950867

Sng, C. Y., Carter, M., & Stephenson, J. (2018). A systematic review of the comparative pragmatic differences in conversational skills of individuals with autism. *Autism and Developmental Language Impairments*, *3*, 1-24.

https://doi.org/10.1177/2396941518803806

Stauch, T. A., Plavnick, J. B., Sankar, S., & Gallagher, A. C. (2018). Teaching social perception skills to adolescents with autism and intellectual disabilities using video-based group instruction. *Journal of Applied Behavior Analysis*, *51*, 647-666. https://doi.org/10.1002/jaba.473

Tager-Flusberg, H., & Kasari, C. (2013). Minimally verbal school-aged children with autism spectrum disorder: The neglected end of the spectrum. *Autism Research*, *6*, 468–478. https://doi.org/10.1002/aur.1329

Tiger, J. H., Hanley, G. P., & Bruzek, J. (2008). Functional communication training: A review and practical guide. *Behavior Analysis in Practice*, *1*, 16-23. https://doi.org/10.1007/BF03391716

Table 1

Demographic Information of Participants

Name	Age	Gender	DSM-V Diagnosis	Target Behavior	QABF	Physiological Variables
Sam	8	M	ASD	Communicative Speech	Automatic, Escape, and Tangible	None
Damien	7	M	ASD	Vocalizations and Communicative Speech	Attention	None

Note. Participants' descriptive characteristics. M = male; DSM-V = Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition; QABF = Questions About Behavioral Function; ASD = autism spectrum disorder.

Figure 1

*Figure 1***.** App-level and display changes contingent on volume recorded. *Blue* background when the participant is speaking too quietly. *Green* background when the participant is speaking at an appropriate volume. *Red* background when the participant is speaking too loudly.

Figure 2

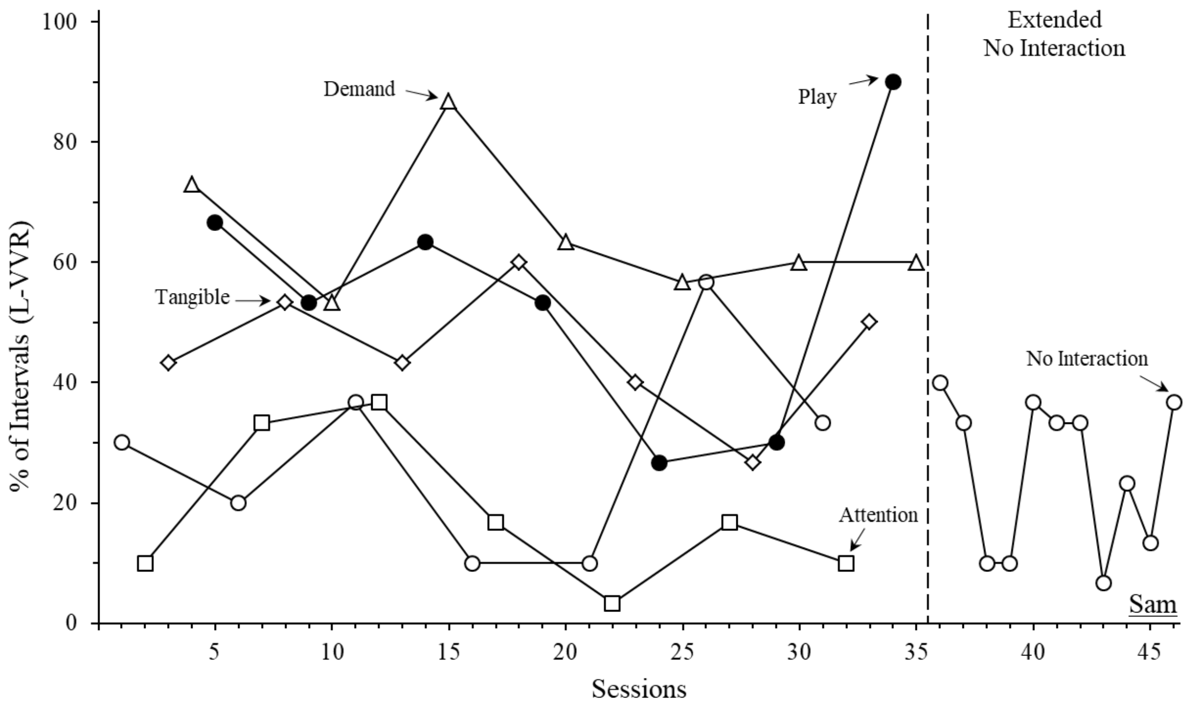

*Figure 2***.** Percent of 10-s intervals with loud voice volume responses (L-VVR) for Sam across all FA conditions and extended no interaction phase.

Figure 3

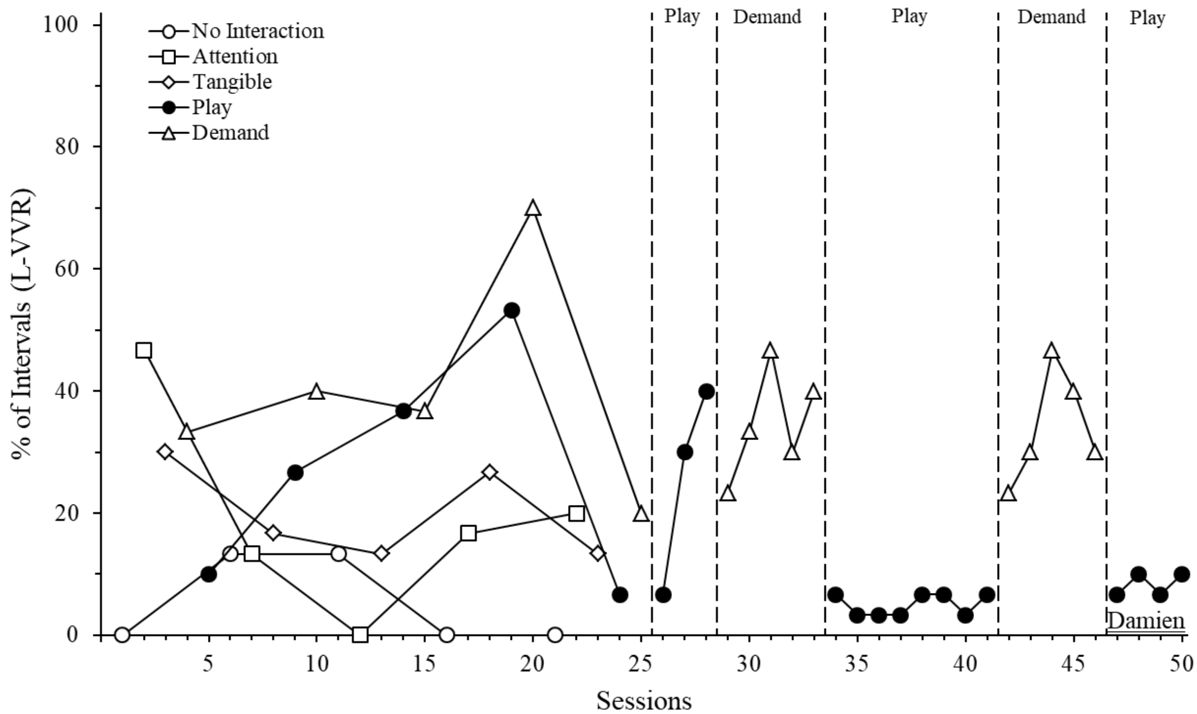

Figure 3. Percent of 10-s intervals with loud voice volume responses (L-VVR) for Damien across all FA conditions and pairwise (play and demand) conditions.

Figure 4

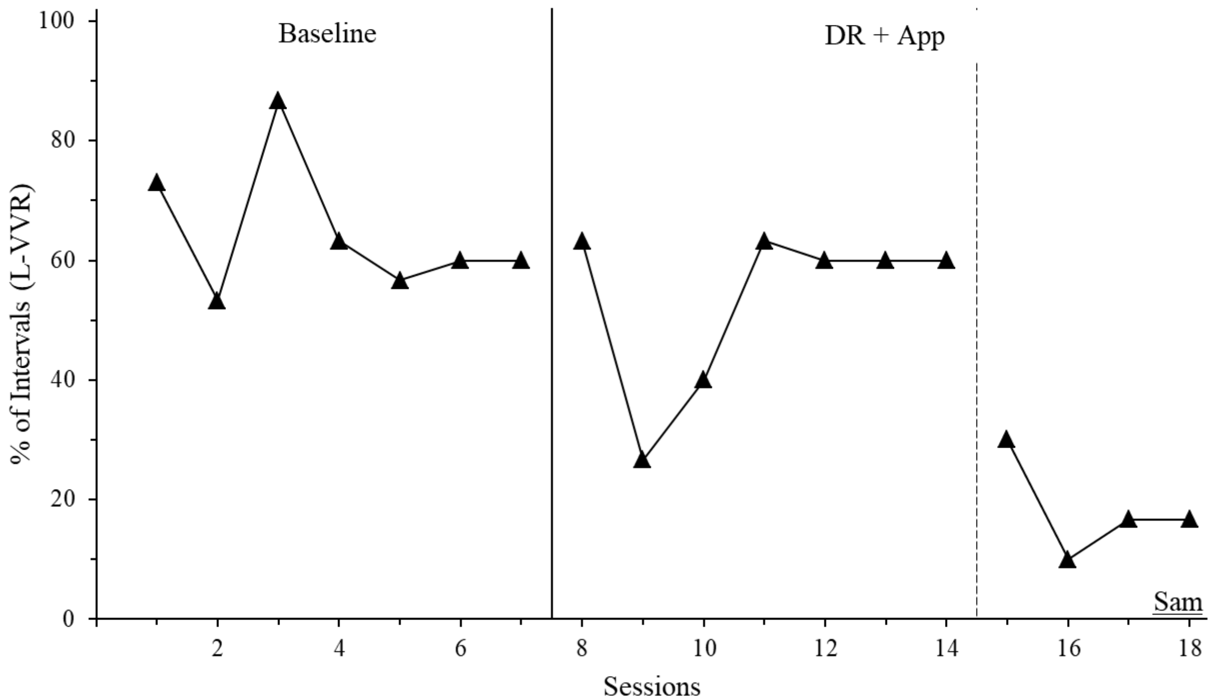

Figure 4. The percent of intervals that Sam engaged in loud voice volume responses (L-VVR) across sessions. The dashed line shows a change in intervention procedure (from L-VVR and Q-VVR on extinction to L-VVR only). DR + App = Differential Reinforcement plus the App.

Figure 5

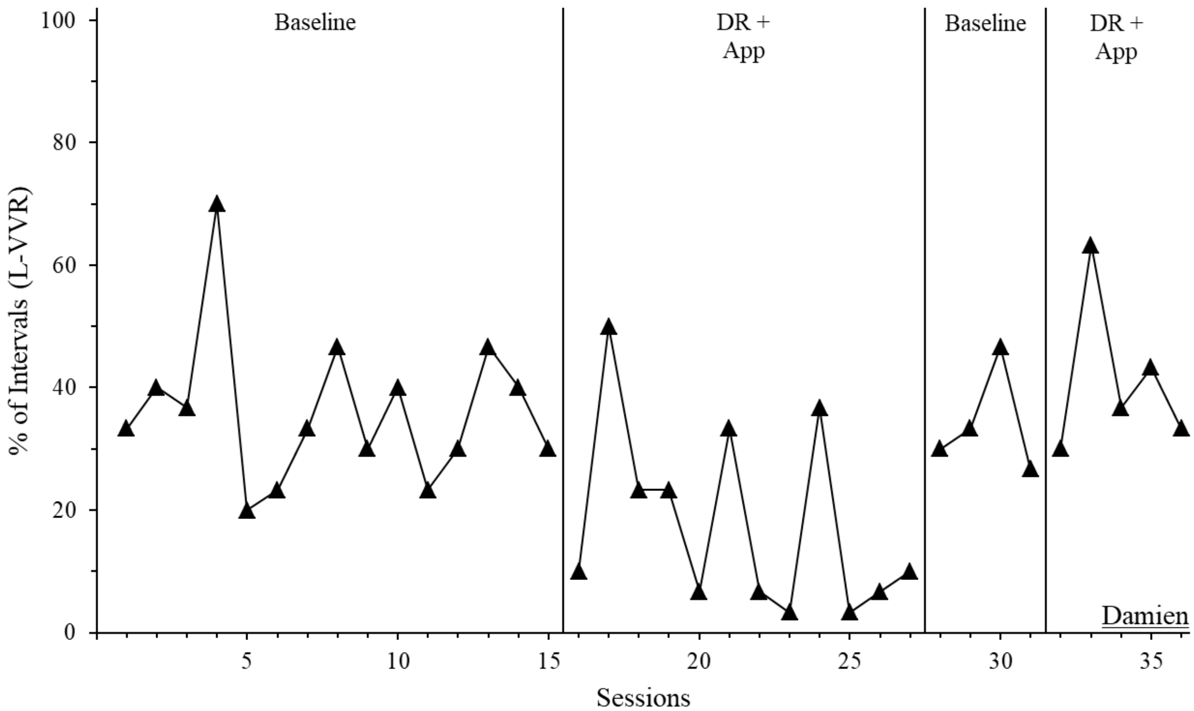

Figure 5. The percent of intervals that Damien engaged in loud voice volume responses (L-VVR) across sessions. DR + App = Differential Reinforcement plus the App.