Speak Up: Increasing Conversational Volume in a Child with Autism Spectrum Disorder

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Abstract Deficits in social interactions are a hallmark of autism spectrum disorder. This study examined one relatively uncommon aspect of social interactions that has not received much attention from the literature: appropriate conversational volume. Conversational speech volume was measured using a commercially available application, and a package intervention was developed that consisted of feedback from the voice measuring application, signaling from a wrist bracelet, and differential reinforcement. The intervention was evaluated in an ABAB design and speaking at conversational volume was significantly increased when the intervention was in place and in probe conditions.

Keywords Autism spectrum disorder · Voice volume · Social interactions · Feedback

Autism spectrum disorder (ASD) is characterized by difficulties with social interaction, including difficulties in adjusting one's own behavior to suit the social context (American Psychiatric Association, 2013). Speaking either too loudly or too quietly is an example of failing to adjust one's behavior to social context, and it can likely represent difficulties to

successful social communication. Relatively few previous studies have evaluated this social skills deficit. Koegel and Frea (1993) addressed speaking below conversational volume in a participant diagnosed with ASD. Several participants were first taught to differentiate appropriate and inappropriate social skills (e.g., facial expression, eye gaze, perseveration of topic). During teaching, the researcher modeled social skills followed by the participant imitating the skills and identifying appropriate and inappropriate elements. Once participants could discriminate correct from incorrect social skills, a self-monitoring procedure was implemented that required the participants to record appropriate behavior when a timer sounded. Instances of appropriate behavior and self-monitoring were reinforced with the delivery of quarters which the participants used to play video games. Different social skills were targeted between participants and the results indicated that both targeted and untargeted social skills (including voice volume in one participant) improved as a result of the intervention. This study is one of the very few that have addressed conversational volume as a social skill.

An alternative or complementary approach to training discrimination of conversational volume may be to shape speech volume. However, voice volume might be difficult to shape without a mechanism to objectively identify when reinforcement should be delivered. Software applications (i.e., “apps”) are now ubiquitously available for a variety of uses in working with individuals with developmental disabilities (e.g., communication, recreation, telephone skills, to name a few). Little objective data on such applications have been published and therefore the rapid pace of development and commercialization of apps is far outstripping research. Some published studies have focused on speech-generating devices (Lorah, Parnell, Whitby, & Hantula, 2015) but few other apps have been empirically evaluated. The primary purpose of this study was to evaluate the use of a voice volume application used to

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- New technology can be evaluated in practice.
 - Voice volume can be shaped.
 - Voice volume apps can be used to provide feedback.
 - Generalization and maintenance may be aided by signaling when reinforcement is available.
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implement differential reinforcement of appropriate speech volume for a participant diagnosed with ASD. A secondary purpose was to demonstrate a method for evaluating technology within a clinical setting.

Method

Participant

The participant was an 11-year-old male diagnosed with ASD. He attended a private school serving children diagnosed with ASD. Both the classroom teacher and his guardians reported that he often spoke below conversational volume. He communicated vocally using primarily one- to three-word sentences. He had an extensive mand and tact repertoire and limited intraverbal skills.

Setting and Materials

Sessions took place in a secluded room in the school, with only the participant and investigators present. The room was cleared of all materials not related to the study. Sessions took place in the early afternoon. The participant and investigator sat at a table with an iPad 1 ft away and a second data collector was present while interobserver agreement (IOA) data were being collected.

The iPad contained an app, Voice Meter Pro™. The app displayed a thermometer gauge that went up and down with noise in the environment. Speaking too loudly or too softly was signaled by changing colors and an animated figure (Fig. 1). The Voice Meter Pro app was selected because it was purportedly developed to assist individuals diagnosed with ASD to monitor their own voice volume. The iPad displayed the Voice Meter Pro app during all sessions. The app contained adjustable settings and the investigators calibrated it by placing it 1 ft away and carrying on a conversation. At the outset of the study, the sensitivity (i.e., how likely the thermometer display was to register noise as too loud or soft) of the mic was adjusted so that during a conversation between the two investigators in a quiet room the thermometer was displayed as green (i.e., conversational); these settings were then used throughout the study. The rationale for using

adult conversation to set the sensitivity was that it was the approximate volume requested by the classroom teacher. The app was programmed to the following settings: sensitivity level of 55% and damping level of 32%. Dampening refers to the degree to which there is a delay in movement in the thermometer readings and was left at default settings.

Other items used in this study included a neon green rubber wristband approximately 3/4-in. wide and a stack of 50 3 × 5 index cards with pictures of items that were used in classroom instruction.

Response Measurement and Interobserver Agreement

During all sessions, each answer provided by the participant was coded as: Q (quiet), C (conversational), or L (loud), depending upon the measurement provided by the app (Fig. 1). At the end of each session, the data were converted to a percentage of questions where a conversational volume was used.

A second, independent observer collected data on voice volume on 34% of randomly selected sessions throughout the study to allow for IOA. During IOA, the second observer sat behind the primary data collector so that he could see the Voice Pro app but not the data sheet of the primary data collector. IOA was calculated by dividing the total number of sessions with agreements by the total number of trials multiplied by 100). Total IOA was 88% (range: 76–100).

Procedure

During each session in baseline and intervention, the investigator flipped through the deck of pictures and while the picture faced the participant, the investigator asked the participant to identify the picture or respond to a question related to the picture (e.g., is that a dog or a cat). Each session contained 30 questions (when the end of the deck was reached the investigator started back from the beginning). Most questions only required one-word responses. The deck was opened to a random location at the beginning of each session. The study used an ABAB design to evaluate the intervention.

Baseline At the beginning of each baseline session, the investigator opened the Voice Meter Pro app on the iPad and placed the iPad 1 ft away from the participant. The investigator

Fig. 1 “Voice Meter Pro” app thermometer readings

oriented the participant to the app and demonstrated each of the three voices (quiet, conversational, and loud by speaking three consecutive single-word utterances) and then told the participant it was “time to talk in the green.” The investigator then administered 30 questions to the participant. If the participant correctly answered a question, the investigator said “that’s right,” and if he answered incorrectly the investigator said “no” and then provided the answer. The participant answered most questions correctly throughout the study and no single question was consistently missed. The green bracelet was placed on the wrist of the participant’s dominant hand during the first baseline session only, in order to assess whether the bracelet alone would affect the volume of the participant’s voice.

Intervention Sessions in the intervention phase were similar to baseline, with the following exceptions. During intervention, the investigator delivered high energy praise and a small reinforcer following each participant response that occurred in a conversational volume (i.e., for which the app did not register too loud or too quiet) and delivered specific feedback (e.g., “that’s right and you spoke in the green”). If the participant’s volume was “quiet” or “loud,” no reinforcer was provided and the investigator provided specific feedback, appropriate to the response (e.g., “that’s right but you did not speak in the green,” “no and you did not speak in the green”). As in baseline, the investigator also provided the correct answer whenever the participant made an error. Reinforcers were determined via a forced choice preference assessment conducted before the intervention condition.

Probes In the first probe phase (P1), reinforcers were thinned closer to his naturally occurring reinforcement schedule at the school (one potato chip for every four correct answers), and the volume screen was turned around such that the investigators could see the screen but the participant could not. The

next probe phase (P2) was identical to the first but was conducted in the participant’s classroom.

Results and Discussion

Figure 2 presents the results of the intervention. During the initial phase of baseline, conversational speech occurred relatively infrequently across sessions ($M = 40\%$ of responses). When the intervention was implemented, an increasing trend was observed in the data, and an increase in level was observed by the end of the condition ($M = 64\%$). When baseline was reinstated, there was an immediate drop in the percentage of responses with conversational speech, similar to levels observed in the first baseline condition ($M = 48\%$). When the final intervention condition was reinstated, conversational speech volume immediately increased to percentages similar to the last few sessions of the first intervention phase ($M = 77\%$). During both probe phases, responding was maintained at levels comparable to intervention.

This study demonstrated a method to increase speech volume by providing visual feedback on speech volume and differentially reinforcing appropriate volume. Without mechanical or electronic measurement, voice volume is a highly challenging behavior to measure objectively and differentially reinforcing appropriate voice volume in the current study would therefore have been difficult without the use of the app.

For clinicians, a logical next step would be to program for reinforcement to be delivered only when the client speaks in a conversational volume outside of contrived practice formats. Experimenter questions followed by client answers, repeatedly cycling through the same 50 questions, do not resemble everyday verbal behavior in real life. Future studies should evaluate the degree to which these procedures promote response generalization outside of contrived practice situations and evaluate methods for programming for such generalization, as needed.

Fig. 2 Percentage of vocal responses with appropriate conversational volume across baseline (Bl), intervention (Int), treatment thinning probes (P1), and generalization across settings probes (P2)

Another contribution of the current study is that it provides a model for how clinicians can empirically evaluate the numerous apps being developed to assist in the treatment of individuals diagnosed with ASD. Since it is clear that the developers of such apps are not taking the responsibility of evaluating their own apps, it is incumbent upon clinicians to empirically evaluate any apps that they hope may be effective. The experimental design used in the current study is likely feasible for most behavioral clinicians to implement with apps in their daily practice.

A limitation of the current is that no functional assessment was conducted of the participant's behavior of speaking too softly. It was assumed that speaking below conversational volume was a skill deficit; however, it could be that speaking softly was shaped and maintained by social contingencies. For example, if a client answers too softly to be heard, an adult may decrease the rate of initiating conversation over time and if conversations are non-preferred, that may negatively reinforce quiet speaking. Future investigations on conversational volume should consider assessing the function of the behavior before treating it as a skill deficit.

It is worth noting that multiple treatment components, including reinforcement, visual feedback from the Voice Pro app, and a signaling procedure (green bracelet) were introduced together. It is possible that differential reinforcement of appropriate volume would have shaped volume without the need for the app or the bracelet. The app was included because of the immediate visual feedback it provided to the participant and the bracelet was included to aid in generalization but, since a component analysis was not conducted, it is not possible to be certain what contribution, if any, each component made.

The Voice Volume Pro app, itself, was not without limitations. The iPad tracked both the investigator's and the participant's responses. Although rare, when the participant responded quickly following the investigator's question, it was difficult to determine if the app was tracking only the participant's voice or both voices. For clients who consistently respond quickly, practitioners may need to implement

headphones with microphones (although caution is warranted as these devices could be stigmatizing) in order to allow for accurate data collection and feedback. Headphones and microphones may also allow future investigators to evaluate the procedure in loud environments (the training and probes were conducted in quiet environments but this is almost certainly not the case in most classrooms). Additionally, it is possible the sensitivity settings on the application could be decreased to allow for data collection in noisy classrooms but this was not evaluated in the current study. Also, during probes, when the iPad was turned away, it could have changed the volume readings from the app.

The current study lends support for the potential effectiveness of a voice meter app, combined with differential reinforcement, for changing an individual's voice speech to an appropriate conversational level. Additionally, this study demonstrated how new technology can be evaluated within a clinical context. Future research should continue to evaluate commercially available apps that may aid in addressing subtle or difficult to measure behaviors.

Compliance with Ethical Standards This study was not externally funded. The authors declare that they have no conflicts of interest. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Informed consent was obtained from all individual participants included in the study.

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