The Use of Technology to Increase the Voice Volume of a Child with ASD

by

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Abstract

Autism spectrum disorder (ASD) is a pervasive developmental condition characterized by difficulties with social interaction and communication as well as restricted/repetitive behaviors. The communication difficulties experienced by children with ASD include atypical prosodic speech. When such difficulties are present, they become a major hinderance to social integration as well as education. This study evaluated the utility of the Voice Meter Pro application for increasing the voice volume of a 14-year-old girl with ASD who spoke in a low voice volume. A practice procedure, using modeling at an exaggerated volume, was also evaluated for its ability to increase the effectiveness of the feedback provided by the app. During this condition, the participant was provided with additional prompting as well as more opportunities to respond and have her increased voice volume reinforced. The present procedure was not effective for increasing the participant's voice volume. Limitations of the current study and considerations for the design of future applications and studies involving voice volume are identified.

Keywords: Autism, ASD, speech volume

Contents

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Autism spectrum disorder (ASD) is a pervasive developmental condition characterized by difficulties with social interaction and communication as well as restricted/repetitive behaviors (American Psychiatric Association, 2018). According to 2016 data collected by the Centers for Disease Control and Prevention (CDC), ASD affects 1 in 54 children in the United States (Maenner et al., 2020). The communication difficulties experienced by children with ASD may include atypical prosodic speech (patterns of stress, volume, intonation, tone, and rhythm) (Diehl & Paul, 2013; McCann & Peppé, 2003; Schriberg et al., 2001). When such difficulties are present, they can become a major hinderance to social integration (Schriberg et al., 2001) as well as education (Fleece, 1981).

Despite being associated with negative social and academic outcomes, the prosodic deficits of individuals with ASD are rarely addressed clinically (McCann & Peppé, 2003; Schriberg et al., 2001). This is unfortunate, as improvements in social communicative behavior have been shown to generalize to other members of that response class (Koegel & Frea, 1993). This class of behavior may have exceptional generality and function as a behavioral cusp.

One potential method for addressing the speech difficulties experienced by children with ASD is through differential reinforcement of appropriate speech volume (Edgerton & Wine, 2017; Fleece et al., 1981). The shaping of speech volume has infrequently been addressed in the scientific literature. This fact may be due, in part, to the difficulty of defining and measuring “appropriate speech volume” in a way that can

be understood by an exceptional learner. One way that this may be accomplished is through the use of technology.

The use of technology to prompt and reinforce socially appropriate speech volume was demonstrated by Fleece and colleagues in 1981. In that study, the authors used a system of lights and relays to successfully increase the voice volume of two preschool-age children. The children were able to recite nursery rhymes at a "normal" volume both during treatment and at 1- and 4-month follow-ups. Observers rated the children's volume levels on a scale from 0 to 20. Zero was "usually inaudible," five was "usually too soft," ten was "usually normal," fifteen was "usually too loud," and twenty was "usually screaming". The researchers gave performance feedback and tried to avoid providing social reinforcement. The system of lights had been designed to look like a Christmas tree and its lighting was intended to reinforce the speaker's increased speech volume. Results indicated that the participants' increased voice volumes were maintained following the study and generalized to their classrooms (Fleece et al., 1981).

More recently, Edgerton and Wine (2017) made use of a smartphone software application called Voice Meter Pro (EDTECH MONSTER LIMITED, 2013) to increase the speech volume of an 11-year-old student with ASD. The app uses a "thermometer" with blue, green, and red zones to indicate voice volume in real time. The sensitivity is adjustable by percentage. The researchers used an ABAB reversal design with phases similar to the baseline and treatment phases of the present study. At the start of baseline, their participant spoke "in the green" an average of 40% of the time. By the end of the study this was increased to 77%. This result was maintained after reinforcement was

thinned to the participants regular schedule at his school. The increase also generalized to the participant's classroom (Edgerton & Wine, 2017).

As mentioned, interventions to increase vocal volume can help autistic individuals communicate effectively and learn more efficiently but are rarely addressed in the literature. The present study sought to expand on previous literature on increasing voice volume. The current study used the ability of the Voice Meter Pro application to increase voice volume as in Edgerton & Wine, 2017, but with an adolescent female participant. A practice procedure, using modeling at an exaggerated volume, was also evaluated for its ability to increase the effectiveness of the feedback provided by the app.

Method

Participant

The participant in the current study was Robin, a 13-year-old female with a diagnosis of ASD. She received academic instruction at a center for autistic children which was affiliated with a state university in Northeast Ohio. Her vocal communication was limited to 1- to 2-word requests and responses. Consent was given by her mother for participation in this study. Because Robin was not able to read or write, assent was obtained using a developmentally appropriate script. She made few independent statements and spoke with a high pitch and at a low volume. Robin was cooperative throughout the study and appeared to enjoy interacting with the researchers.

Setting and Materials

The study was conducted in a quiet room at Robin's school with only the participant and the investigators present. An iPhone® 11 was placed on a stand attached to a desk and was in view of the participant and observers. The device was running Voice

Meter Pro, an application designed to help individuals monitor their voice volume. The application displays a "thermometer" with blue, green, and red zones and an animated emoji to indicate the volume level of sounds picked up by the microphone. The upper and lower bounds of the green zone are adjustable by percentages and were calibrated based on adult conversational speech volume. The app did not provide any quantitative measurement such as decibels. The phone was placed on the table approximately 20 inches away from Robin's mouth. After, the first two treatment sessions, the phone was attached to a drawer in order to move it approximately 4 inches closer.

Before the study began, the device and software were explained and demonstrated to Robin by the investigator speaking single words at each volume level. Before each session, she was prompted to "speak in the green" as she verbally labeled picture cards. Robin was offered a choice of preferred edible which was provided at the end of the session (baseline) or used to reinforce speaking at an appropriate volume level (treatment). Items offered included M&Ms, Skittles, and fruit snacks.

Interobserver Agreement

Data were collected by two observers during 24% of sessions. Agreement was 100% for each session. This is likely due to the use of an app to track the dependent variable. When a response caused the thermometer to reach the green zone the background color of the app changed from blue to green and an onscreen emoji changed its expression. The answer to whether or not each answer was "in the green" was clear and unambiguous.

Baseline

Robin was asked to label a series of 30 photographs of common objects or animals printed on cards. The cards were shuffled before each session. The task was similar to what she might be presented with during a typical direct instruction session. Only mastered stimuli were used, because the goal of the study was to increase speech volume, not to name common objects and animals. All labels consisted of a single word. Specific feedback was provided following each question. For correct answers, the investigator said, "That's right." The participant did not identify any items incorrectly during the study. The number of answers that caused the meter on the application to rise to the green zone was recorded and the number of answers occurring "in the green" was calculated as the dependent variable. The participants chosen snack item was offered following the session.

Treatment

Two treatment phases were conducted in a similar manner to baseline, but additional feedback and reinforcement were provided based on the Robin's speech volume. For example, "Yes, and you spoke in the green!" or "No, and you did not speak in the green." Reinforcement in the form of the chosen edible was provided for all answers that were "in the green." After two baseline sessions, Robin demonstrated a limited response to treatment. The app had been set to the highest sensitivity (100%), but it was hypothesized that it may be more sensitive to adult voices than those of adolescents. For all subsequent sessions, the phone was moved closer to Robin. This was done in an attempt to shape an increase in speech volume more gradually. As with baseline sessions, the number of answers that caused the meter on the application to rise

to the green zone were recorded and the number of answers occurring "in the green" was calculated.

Training

Following the first 3 treatment sessions, a training condition was implemented. During this condition, Robin was provided with additional prompting as well as more opportunities to respond and have her increased voice volume reinforced. During this condition, the labels for the first 10 (shuffled) cards were modeled by the trainer using a loud, enthusiastic voice (green or above on the app). Robin was given up to 3, prompted, opportunities to imitate the label "in the green." If she did so successfully, reinforcement was provided as during the treatment condition. The remaining 20 cards were then presented in the same manner as during treatment. After 9 training sessions the regular treatment sessions were resumed.

Experimental Design

An ABC design was utilized to assess the effectiveness of the smartphone application for increasing voice volume before and after the training sessions.

Results

Data for the baseline and treatment sessions are presented in Figure 1. Two baseline sessions were conducted with no responses occurring "in the green." Baseline sessions were followed by three pre-training treatment sessions. During the first session two responses reached the target level. During the second session no responses occurred "in the green." During the third pre-training treatment session, responding again remained below the target criterion.

The training and practice condition began following the third treatment session. When given an exaggerated model and up to three attempts, the Robin labeled an average of 3.44 out of 10 stimuli at the target volume level. For the remaining 20 (unprompted) stimuli she averaged only 1.22 out of 20 responses at the target volume level. Full results from the training sessions are listed in Table 1.

Following training, seven more sessions were conducted under the treatment condition. During these sessions, Robin averaged only 1.7 responses "in the green" per session. Also, no responses occurred "in the green" during the last two sessions.

Discussion

The present procedure was not effective for increasing the participant's voice volume. Neither the visual cues provided by the app or the practice and training sessions had a consistent effect on the participant's voice volume. These results are in contrast with those of Edgerton and Wine (2017) and Fleece et al. (1981). Several factors may have affected this outcome.

The 1981 study by Fleece and colleagues was conducted with preschool-age participants. It is possible that their prosodic speech patterns were still in the process of becoming established and reinforced. The Edgerton and Wine (2017) study used an older participant (11). However, their participant was speaking "in the green" 40% of the time at the start of baseline. Edgerton and Wine also reported that the iPad® used in their study was placed 1 foot away from the participant. They did not report how this was measured or how the iPad® was oriented. If it was from the closest part of the participant, the device was likely closer in the present study. If it was from the participants mouth, the present study had it placed farther away. In either case, they set

the app sensitivity at 55% while the present study used a setting of 100%. The participant in the Edgerton and Wine (2017) study certainly appears to have begun the study speaking at a higher volume level than the one in the present study.

Restricted Interests and Possible Imitation

Robin had a well-established history of atypical prosodic speech. It had also been reported and observed that she enjoyed watching online videos designed to elicit an autonomous sensory meridian response (ASMR). "ASMR is a . . . sensory phenomenon, in which individuals experience a tingling, static-like sensation across the scalp, back of the neck and at times further areas in response to specific triggering audio and visual stimuli" (Barratt & Davis, 2015). The creators of these videos often whisper or speak very quietly into a microphone when making them. It is possible that the Robin was imitating an atypical style of speech that she enjoys hearing and listens to on a regular basis.

Study Design

One issue with the study design is that the microphone was moved after the baseline phase had already ended. Had the intervention resulted in a meaningful change in the dependent variable this would have weakened the result. However, this change did not appear to have any effect on the dependent variable in this case. The change was made because the sensitivity of the app could not be set low enough to shape the participant's behavior to the target level. This and other issues involving the app will be discussed further in the next section.

Another possible issue with the study is the amount and duration of the training given to the participant. Despite instruction and prompting, the participant did not appear

to maintain attention to the app throughout the study. Further training on the use of the app and assessment of the participant's understanding may have made the app more efficacious. The duration of the study may also have been a limiting factor on its own. It is possible that simply increasing the duration of the training and practice period would have given the participant a better understanding of the app and a greater ability to attend to its cues and access more reinforcement.

The App

Over the course of the study, several questions arose regarding the use of the app. The first question was whether it should be used with an external microphone. During the initial planning for the study, a cardioid microphone was tested which would have been attached to the same stand as the phone. It was not used, because it did not appear to have any effect on the responsiveness of the app versus using the phone's built-in microphone. It is possible that there is a type or quality of microphone which would be more suited for use with the Voice Meter Pro app. To make this determination would require further consultation and experimentation.

A second question which arose regarding the app was whether it differentially responds to different tones of voice. Observer's noted anecdotally that the app appeared to respond more dramatically to the researcher's voice than Robin's, even when speaking at similar volume levels. As previously noted, Robin was an adolescent female and tended to speak in an exceptionally high voice. It is possible that this is a limitation of the hardware which could be remedied through the use of an external microphone. To address this question would require additional recording hardware (decibel meter, spectrum analyzer, etc.) and expertise.

These questions are made more complex by a design limitation of the app. It provides no record or quantitative measure of voice volume. As mentioned previously, the sensitivity of the app is adjustable. However, it only indicates voice volume using the three colors. There are unlabeled tick marks on the thermometer. However, they are of limited utility without labels or a convenient way to create a synchronized recording of the device's display and the participant's responses. Quantitative feedback would allow the app to measure smaller changes in participant behavior. The addition of a numerical value to the feedback displayed by the app would increase its usefulness for empirical research. This would be true even if the number only represented the percentage of the "thermometer" filled. The observers in the present study noted anecdotally, that some of the participants responses were subjectively louder than others despite not meeting the criterion for reinforcement. If we had an objective way to measure these responses, we may have been able to provide differential reinforcement for them and produce a more gradual increase in the participant's speech volume.

Future Directions

Though the present procedure failed to produce a socially significant change in the Robin's behavior it did raise several questions for examination in future research. Future studies should assess microphones of various types and in different orientations. The sensitivity and range of the devices should be considered as well as their practicality in various settings. It is possible that a lavalier (clip-on or lapel) microphone might be ideal for this use case. However, a microphone of this type may not be tolerated well by all potential participants.

The Voice Meter Pro app might also be compared against other apps and devices. The app's sensitivity should be assessed using a decibel meter and possibly a frequency analyzer. If the app or microphone is more sensitive to some frequencies, that should be taken into consideration when calibrating it. Future studies might also use multiple devices for monitoring and recording. However, this would likely require additional observers in addition to the increase in cost for the equipment.

This study failed to achieve its goal of increasing Robin's voice volume. However, several considerations for future studies involving voice volume were identified. Applications for measuring and monitoring voice volume should also take voice tone into account. Researchers may also want to consider tone along with volume when calibrating their equipment. This study also identified factors that can increase the usefulness of Voice Meter Pro and similar applications and devices. Quantitative feedback is invaluable for detecting small incremental changes in voice volume which may be socially significant for exceptional learners. The type and quality of the microphone that is to be used should also be considered by researchers and app designers. Though it had limited utility in this case, further study and development may increase the efficacy of this and similar technologies.

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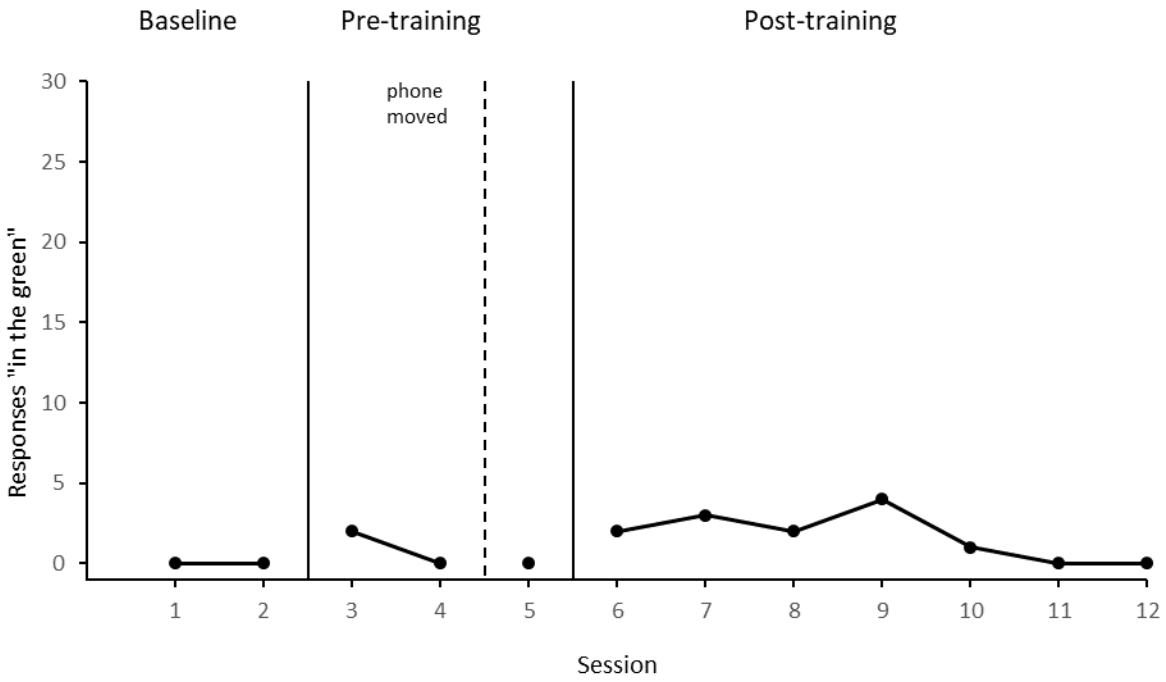
Figure 1

Responses at Target Level



Note. Between sessions 5 and 6, 9 practice sessions were conducted. See text for explanation and Table 1 for practice session data.

Table 1

Data from Practice Sessions

Session	Prompted at Target Level (first 10)	Unprompted at Target Level (remaining 20)
1	0	1
2	4	0
3	5	0
4	2	0
5	5	3
6	4	1
7	7	3
8	1	1
9	3	2
Average	3.44	1.22

IRB Approval

Dear Investigators,

Your protocol entitled The Use of Technology to Increase Voice Volume of a Child with Autism Spectrum Disorder has been reviewed and is deemed to meet the criteria of an expedited protocol, category 7. This data is collected in the regular educational setting using an intervention that is common for students needing this type of support. You will be comparing the effectiveness of interventions for increasing the voice volume of a current student using an app and candy incentives. This process is consistent with activities used to support the social development of children in the educational setting of the RICH center. You will not report any students name or information with their data. You will ask the student for verbal assent once you have their parents' permission to have the child in the research guided activity. The student can exit the study at any time without consequence. You will be getting parent consent before recruiting your student. The student must provide assent to participate and can withdraw at any time.

You may begin the investigation immediately. Please note that it is the responsibility of the principal investigator to report immediately to the YSU IRB any deviations from the protocol and/or any adverse events that occur. Please reference your protocol number 069-21 in all correspondence about the research associated with this protocol.

Good luck on your research.
Karen

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"If you can't explain it simply, you don't understand it well enough." -Einstein

Leadership is not about titles, positions or flowcharts. It is about one life influencing another."
— John C. Maxwell