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Establishing Auditory Discrimination and Echoic Stimulus Control with an Auditory Matching Procedure

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Abstract

An echoic is a verbal operant which is controlled by a verbal discriminative stimulus and is characterized by the repetition of the verbal behavior of another speaker with point-to-point correspondence between the sound of the stimulus and the response (Skinner, 1957). These echoic responses are very important for children with developmental disorders because their language development is very unpredictable and may not appear at all, potentially causing difficulties in school and problems with social development (Reed, 2005). Teaching language acquisition skills can help offset these problems because it reinforces future echoic responses and helps develop advanced verbal operants such as mands and tacts (Du, Speckman, & Cole-Hatchard, 2017). Increasing future verbal behavior allows children to properly express their wants and needs. Previous research has shown that auditory matching protocols were effective in improving children's listener responding and pronunciation (Du, Speckman, & Cole-Hatchard, 2017; Choi, Greer, & Keohane, 2015: Speckman-Collins, Park, & Greer, 2007). The goal of this current study was to evaluate the effects of an auditory match-to-sample procedure on the echoic repertoire of a 3-year-old boy diagnosed with a developmental delay. The participant was taught to differentiate between progressively more difficult sounds, words, and multiple word phrases. Progress in this skill was monitored using the Early Echoic Skills Assessment which was probed four times over the study. It was expected that this procedure would result in an acquisition of more correct echoic responses.

Key Words: Echoic, Mand, Tact, Auditory Matching, & Listener Responding

Introduction

Many children that are diagnosed with autism or developmental delays experience problems with their language acquisition skills. According to a 2017 report by the Center for Disease Control, about 50% of children with autism do not develop useful language skills. Language skills are very important because they allow a person to express their wants and needs. Not having these skills to properly express their needs can cause frustration and result in problem behavior. Even with our current teaching methods, many children on the autism spectrum do not acquire a vocal verbal repertoire. One way we can increase these children's language skills is by increasing their phonetic awareness. Phonetic awareness is the ability to hear and manipulate the sounds that make up spoken words, and the understanding that spoken words and syllables are made up of sequences of speech sounds (Yopp, 1992). An example of this would be hearing the word "cat" and recognizing that the word is only one syllable and is made up of three different phonemes, two being consonants and one being a vowel. Auditory match-to-sample probes have been found to help facilitate phonemic awareness in children with language delays.

Researchers have also found auditory matching procedures to be effective in increasing the echoic repertoire of children diagnosed with autism. A study by Chavez-Brown (2005) implemented an auditory match-to-sample procedure and tested its effect on the echoic responses of two different groups of participants. The first group in this study were preschoolers who had some vocalizations, but experienced problems with articulation. The second group consisted of preschoolers who had no vocalizations. The procedure required students to press buttons that were the same as the sounds being made by the experimenter's buttons. This study found that the children in group one learned full echoic responses by the end of the study, while those in group two began emitting or approximating echoics (Chavez-Brown, 2005).

Additionally, similar studies have looked at the effects of the auditory match-to-sample procedure on the development of the listener component of naming. In one 2007 study Speckman, Park and Greer used the same procedure as Chavez-Brown, but instead tested their two participants' abilities to tact visual stimuli while also hearing auditory stimuli. The experimenter would show two pictures to the participant while also saying “Point to ___”. The researchers found that mastery of the auditory match-to-sample procedure was related to higher emergence of the listener component of naming.

Other research has looked at the effects that the auditory match-to-sample has on echoic responses and listener literacy. A 2015 study by Choi, Greer, and Keohane tested the effects of an auditory match-to-sample procedure on listener literacy and echoic responding using a computer program designed by the researchers. In experiment one and experiment two, researchers found that the participants, all ages seven or eight, had increased their full echoic responses for four syllable words in English and Korean (Choi, Greer, and Keohane, 2015). One important distinction between this study and ours is that the participants were much more advanced than the participants of our study based on their baseline echoic scores and also their age.

In one 2017 study, another auditory match-to-sample protocol was implemented with three preschoolers and resulted in a higher accuracy of the articulation of their echoics and their listener responding (Du, Speckman, Medina, & Cole-Hatchard, 2017). The procedure used involved three “buttons” in an app designed by the research team, each of which were programmed to make a different sound when pressed. Participants in the study would first listen to a target sound and were then required to press the button on the tablet in front of them that would make the same sound. This was a modified version of a 2007 study by Speckman-Collins, Park, and Greer which utilized the same procedures with an augmentative communication device. The results of this study also showed that the auditory stimulus became more likely than the visual stimulus to evoke responses in participants, which is otherwise known as advanced listener responding.

The purpose of the current study was to see how effective an auditory matching procedure could be in increasing language skills. Branching off from previous research, our participant was required to press a single button when he heard two of the same sound, or word, rather than having to select a corresponding sound from an array of three. This simplification allowed our procedure to be used for children with more severe language deficits. We also chose to implement more probes with the Early Echoic Skills Assessment than previous researchers in order to better assess the participants progression throughout the auditory matching procedure. There is also a significant lack of research in the area of echoics, especially research with echoics as the dependent variable (Raaymakers, et al, 2019). And thus, we also hoped to expand upon our existing pool of knowledge on echoics through these variations on previous research.

Methods

Participants and Setting

The current study was conducted at an Early Special Education Classroom. Trials were run in a small, private room with a few tables and chairs. The participant sat at a small table where a tablet was placed in front of him. A researcher sat right next to the participant with a keyboard by their feet in order to advance the slides while other researchers took data. Trials were conducted between the mid-morning and mid-afternoon every Monday, Wednesday, and Friday.

The participant was a three-year-old boy diagnosed with developmental delays. For the purposes of this study we will refer to him as C. At the time of this study, C was a student enrolled in the early childhood special education classroom. He was selected because of his preliminary scores on the Early Echoic Skills Assessment (EESA); scoring relatively high on the first two phases but showing deficits in the third phase of the assessment.

Materials

The procedure materials used in this study consisted of a tablet, Bluetooth keyboard, and a phone. Program materials used were Microsoft PowerPoint for running trials and Microsoft Excel to graph and track data. Materials used for data collection were a paper data sheet and a writing utensil. Reinforcers given to the child for correct responses were access to videos on a phone such as Peppa Pig or videos of trains. The participant was also given access to toy train tracks and toy trains. Food reinforcers consisted of Cheez-Its, Goldfish, Skittles, and M&Ms.

Research Design

A multiple probe design was implemented with the independent variable being the auditory matching procedure. The dependent variable was the number of correct echoic responses on the Early Echoic Skills Assessment.

Dependent Variable

The dependent variable of this study is the number of correct echoic responses on the EESA. A full score was given to responses that resembled the same sounds and the correct number of syllables of the emitted word. Partial scores were defined as recognizable responses, but incorrect or missing consonants or extra syllables. Incorrect responses were defined as no response, incorrect vowels, or missing syllables.

Because this study is an extension of an ongoing study conducted by a PhD student in the department, she conducted the initial training for data collection. The procedure was first explained, and then demonstrated for us before we began conduction sessions of our own. Treatment Integrity was collected for eight out of twenty-seven sessions and was on average 100%. Additionally, descriptive data were collected on problem behavior such as eloping, hitting, crying, and climbing.

Independent Variable

The independent variable for this study was the auditory matching procedure. Interobserver Agreement (IOA) was taken for 55% of all sessions for an average of 98.67%.

Baseline

The Early Echoic Skills Assessment was used in order to collect baseline data for this study. This was probed once over the course of three days before trials began. The Early Echoic Skills Assessment was probed again after phase five, eight, and after all phases were mastered.

Intervention

This study consisted of 11 total phases consisting of various discriminative stimuli (S^D) and S-deltas ($S^{\triangle}$). The researchers also employed various probes throughout the study alongside a generalization test. Mastery criterion for each phase of this study was three sessions at 80% or above, two sessions at 90% or above, or a single session at 100% accuracy. And each phase consisted of 10 to 15-minute long sessions three days a week with an average of three sessions per day. A description of these phases and the corresponding sounds used can be found in Figure 1 below. There were only two phases in which the participant was not required to discriminate between hearing the same and different sounds. Phase one only required the participant to touch the blue circle as a correct response. Phase two only required the participant to touch the blue circle when hearing the ding/ding but did not require them to discriminate between different sounds in the $S^{\triangle}$. The generalization test was conducted once, which tested our participant’s ability to discriminate between three words that he had not been tested on before: three, chair, and cook.

Correct trials were defined as touching the blue circle on the iPad screen when hearing the S^{D}, and incorrect trials were defined as any behavior other than touching the blue circle on the tablet screen when hearing the S^{D} or touching the circle on the screen when hearing the $S^{\triangle}$. Error correction consisted of physically prompting by gently taking the participants hand and guiding him until he touched the blue circle. The researchers would block the participant from touching the screen when the $S^{\triangle}$ was heard. If the participant did touch the screen in the presence of the $S^{\triangle}$, he was ignored for 20 seconds. If he did not touch the screen in the presence of the $S^{D,}$ the participant was physically prompted to touch the screen.

Phase Number	**S^{D}**	**Correct Response**	**$S^{\triangle}$**	**Incorrect Response**	**Error Correction**
EESA Probe 1					
Phase 1	N/A	Touches blue circle	N/A	Anything other than touching the blue circle or no response	Least-to-most physical prompting/ Blocking/ 20 Second Penalty
Phase 2	Ding/Ding	Touches blue circle in the presence of “Ding/Ding”	No Sound	Touching blue circle in the presence of no sound or not	Least-to-most physical prompting/ Blocking/ 20

				touching the circle in the presence of the S^{D}	Second Penalty
Phase 3	Ding/Ding	Touches blue circle in the presence of "Ding/Ding"	Ding/Beep	Touching blue circle in the presence of the S^{Δ} or not touching the circle in the presence of the S^{D}	Least-to-most physical prompting/ Blocking/ 20 Second Penalty
Phase 4	Beep/Beep	Touches blue circle in the presence of "Beep/Beep"	Ding/Beep	Touching blue circle in the presence of the S^{Δ} or not touching the circle in the presence of the S^{D}	Least-to-most physical prompting/ Blocking/ 20 Second Penalty
Phase 5	Beep/Beep & Ding/Ding	Touches blue circle in the presence of "Beep/Beep" or "Ding/Ding"	Beep/Ding	Touching blue circle in the presence of the S^{Δ} or not touching the circle in the presence of the S^{D}	Least-to-most physical prompting/ Blocking/ 20 Second Penalty
EESA Probe 2					
Phase 6	Juice/Juice & Ding/Ding	Touches blue circle in the presence of "Juice/Juice" or "Ding/Ding"	Juice/Ding	Touching blue circle in the presence of the S^{Δ} or not touching the circle in the presence of the S^{D}	Least-to-most physical prompting/ Blocking/ 20 Second Penalty
Phase 7	Book/Book & Ding/Ding	Touches blue circle in the presence of "Book/Book" or "Ding/Ding"	Book/Ding	Touching blue circle in the presence of the S^{Δ} or not touching the circle in the presence of the S^{D}	Least-to-most physical prompting/ Blocking/ 20 Second Penalty
Phase 8	Juice/Juice & Book/Book	Touches blue circle in the presence of "Juice/Juice" or "Book/Book"	Juice/Book	Touching blue circle in the presence of the S^{Δ} or not touching the circle in the presence of the S^{D}	Least-to-most physical prompting/ Blocking/ 20 Second Penalty

Generalization Test “Three/ Chair/ Cook”					
EESA Probe 3					
Phase 10	Jump/Jump & Lump/Lump	Touches blue circle in the presence of “Jump/Jump” or “Lump/Lump”	Jump/Lump	Touching blue circle in the presence of the S^{Δ} or not touching the circle in the presence of the S^D	Least-to-most physical prompting/ Blocking/ 20 Second Penalty
Phase 11	Sing/Sing & Ring/Ring	Touches blue circle in the presence of “Sing/Sing” or “Ring/Ring”	Sing/Ring	Touching blue circle in the presence of the S^{Δ} or not touching the circle in the presence of the S^D	Least-to-most physical prompting/ Blocking/ 20 Second Penalty
EESA Probe Final					

Figure 1: Figure one shows the sounds/words, correct responses, incorrect responses and error correction for each phase of the experiment.

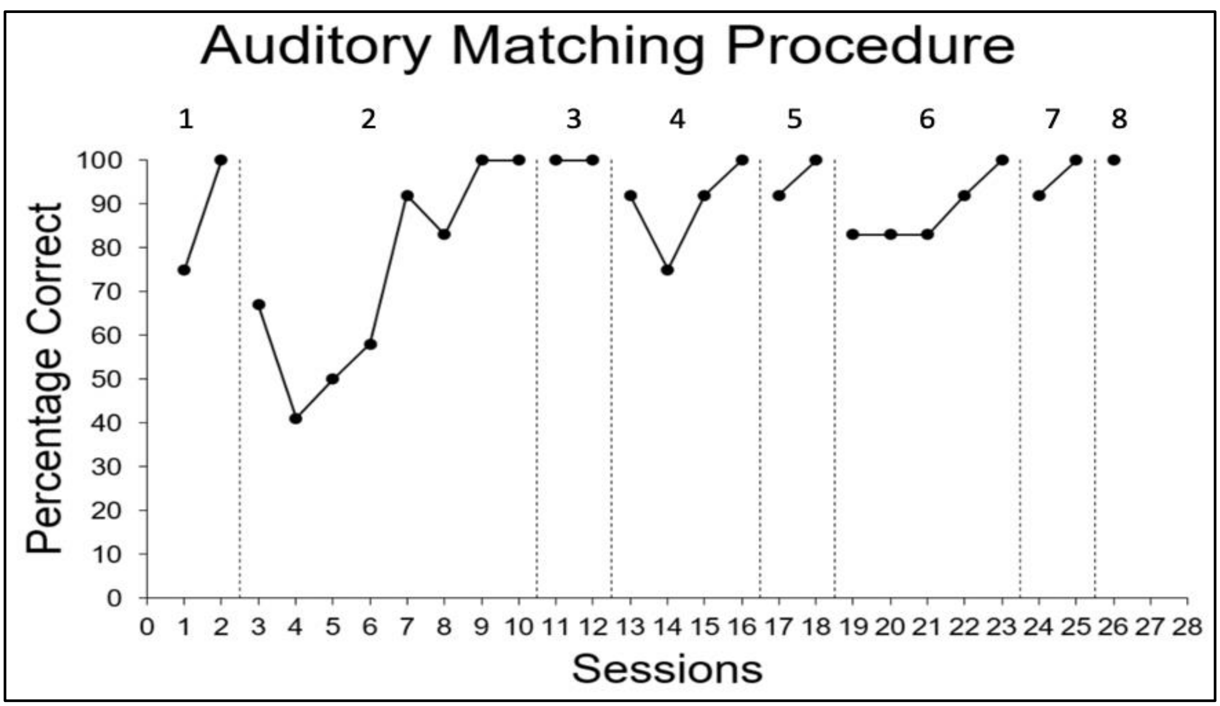
Results

The original hypothesis of this study is that implementing an auditory matching procedure (AMP) will result in increases in the participants' scores in the Early Echoic Skills Assessment (EESA). The reason we intervened in the first place was because of our participant’s original score on the EESA. While he did have some echoic ability, he struggled with certain pronunciations and had many partial echoics. Implementing the AMP resulted in an increase in full and incorrect echoic responses and a decrease in partial responses from the baseline EESA probe to the second. Unfortunately, this study had to be stopped prematurely because of the Covid-19 pandemic. The closure of the early special education classroom where our study took place forced us to stop our study after our participant mastered phase eight of the experiment.

As mentioned above, our participant reached mastery criteria for eight of the 11 phases of the intervention in 26 sessions total. On average, it took our participant three and a half sessions to reach mastery criteria for each phase. As shown in Figure one, there was a large drop in correct responding during phase two that can be attributed to problem behavior. In this phase, it took our participant the most sessions of any phase, eight sessions total, to reach mastery criteria and advance to phase three.

If you remove the data from phase two, the average number of sessions it took our participant to master through each phase was about two and a half sessions compared to the total average of three and a half sessions. Had our research continued, the next step would have been probing the generalized test which would test our participant's auditory matching ability on three novel words, "three", "chair", and "cook". It would be safe to assume based on his prior scores that if given the opportunity, he would have passed the generalized test probe which would test his ability to discriminate between three new words that he had never seen before.

In addition to the auditory matching procedure and generalization test probes, we also probed the Early Echoic Skills Assessment (EESA) in order to measure our participants baseline scores before implementing the AMP. The EESA was then probed a second time after phase five



was mastered. Figure two shows the number of full, partial, and incorrect echoic responses to the first two EESA probes. In the first EESA, our participant scored a 33 on his full echoic responses. When the EESA was probed the second time, he increased his full echoic responses to 49. Our participant's full echoic responses increased by 16 from the baseline probe to the second probe and his partial echoic responses decreased by one. His incorrect responses increased from six to 12 from the baseline probe to the second probe.

Figure 2: Figure two shows the percentage of the participant's correct responses for each session of the auditory matching procedure

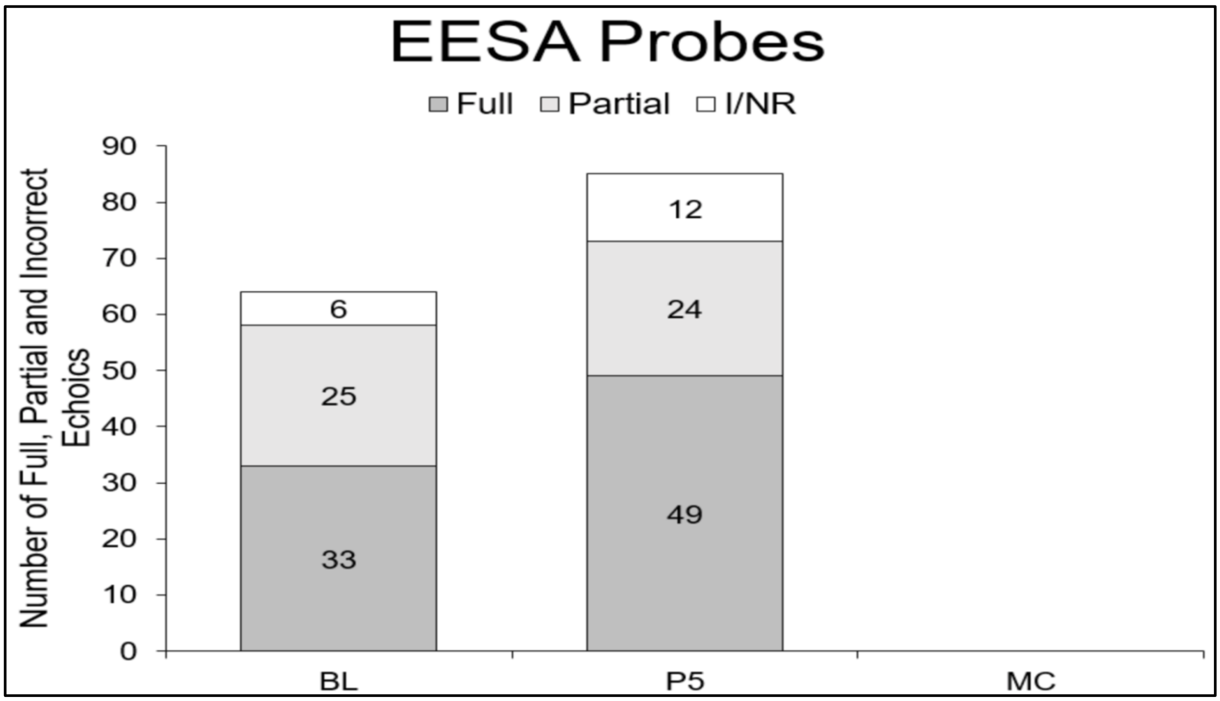


Figure 3: Figure three shows the number of Full, Partial, and Incorrect echoic responses emitted by our participant during the Early Echoic Skills Assessment (EESA) probes

Discussion

Our hypothesis was that the participant's completion of the auditory matching procedure (AMP) would result in higher scores on the Early Echoic Skills Assessment (EESA). Even though our participant's full echoic responses did increase, our hypothesis was only partially supported by the results of our study. Our participant did not reach mastery criteria for all 11 phases due to the Covid-19 pandemic postponing the study. However, he was able to reach mastery criteria for the first eight phases within 26 total sessions. We believe that we obtained these results because our participant's pronunciation abilities were increased due to the auditory matching procedure (AMP). This experiment was not altered after starting.

Our results are very similar to other studies in that implementation of the AMP resulted in increases in pronunciation and echoics. (Chavez-Brown, 2005; Choi, Greer, & Keohane, 2015; Du, Speckman, Medina, & Hatchard 2017; Speckman-Collins, Park, & Greer, 2007). One of the main reasons we believe we saw these results is because our study follows a similar pattern to the research done by Chavez-Brown in that our phases progress from discriminating between sound versus no sound, sound versus word, word versus word, and then testing our participants ability to match novel words. There are key procedural differences, however, between our study and other previous research. One example of these differences is past research done by Chavez-Brown (2005) and Speckman-Collins, Park, and Greer (2007) used an augmentative communication device in order to implement the AMP. This device had three buttons, each programmed to make a different sound. The researcher would first press a button activating the target sound or word the participant was being tested on. Then, other researchers pressed each of the three buttons and then the participant would press the button he thought was the same as the target sound or word. One of the problems of using this type of communication device was that not only was it expensive, but since it had limited memory, the researcher would have to go through and record the new sounds every time there was a phase change (Du, Speckman, Medina, & Hatchard (2017). In the study done by Du, Speckman, Medina, & Hatchard (2017), the researchers used the same three button system, but instead of using the communicative device, they used a tablet with an app they designed themselves. Our study contributed to existing literature because of the differences in our procedure. In previous research, the participant was required to hear the sound and press the button that directly corresponded to the target sound. Our procedure used a single button system and required the participant to hit the button when he heard the same sounds.

One of the possible confounding variables in this study was that the participant was still receiving behavioral therapy alongside this study. This could have affected the research because the results we obtained could be partially attributed to his behavioral programs and not the auditory matching procedure. Another possible confounding variable was the possibility that our participant was receiving extra help with vocalizations from his parents at home. A possible solution to this problem could be asking the parents if they are working with him at home on his language skills.

One limitation of the study was that the entirety of phase three of the baseline EESA was not probed. This was due to problem behavior that was occurring before the start of the experiment. Our participant was sometimes non-compliant when faced with a difficult task for longer than five minutes. Our solution to this problem was to spread out the EESA over multiple days in order to minimize the non-compliant behavior. One of the biggest limitations was the problem behavior that occurred when conducting this study (See Figure four for all operational definitions of occurring problem behavior). One example of problem behavior that occurred during this study was when we were conducting the EESA. As we would say the word that our participant was supposed to say back, he would repeat it as the researcher was talking. This would make it harder for the researcher to make accurate assessments. Another limitation of this study was we did not take interobserver agreement (IOA) for the entirety of the first EESA probe. This was due to time conflicts between the researchers of this study. Better planning for the second EESA probe allowed us to take IOA data its entirety.

Our findings suggest that if our participant would have completed the AMP and if he remained on the same track, he would have likely scored higher in his echoic responses. Because of the skills associated with the AMP, other aspects of his language may have improved as well. One behavior that began occurring more frequently since starting the auditory matching procedure was tacting. As our participant progressed farther into our study, his tacting of items in his environment did appear to increase. Further research could look at the impact the auditory matching procedure could have on other aspects of language such as tacting. It could also potentially explore not only adding more participants but looking at participants of different academic levels. Another possibility for future research could be to assess listener responding with probes along with the EESA. The implications of this research show that auditory matching procedures can be used to improve the language ability of others. Our research could be incorporated into special education classrooms as an effective method in increasing students' language abilities.

Problem Behavior	**Operational Definition**
Climbing on Table	Any instance of one or both knees touching the top of a table or other raised surface unless part of an appropriate activity
Climbing on Booth Wall	Any instance of reaching with one or both hands touching the top of the booth wall with one or both feet not touching the floor
Crying/Whining	Any vocalization (sounds or words) accompanied by facial contraction with or without tears for any period of time
Flopping	Any time the stomach, or forearms and knees touch the floor when doing so is not a part of an appropriate activity
Hitting	Using hands (open or closed fist) or arms to forcibly strike another person/self/or object

Eloping	Moving or attempting to move away from the tutor from one location to another without a signaled transition or exchange unless an appropriate activity calls for it
Overlapping Speech	Any instance of speaking while currently being spoken too

Figure 4: Table of all problem behavior that occurred during this study with its corresponding operational definition

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