8-2020

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

Clare Christe
Western Michigan University, ClareChriste123@gmail.com

ESTABLISHING AUDITORY DISCRIMINATION AND ECHOIC STIMULUS CONTROL WITH AN AUDITORY MATCHING PROCEDURE

by

Clare Christe

A dissertation submitted to the Graduate College
in partial fulfillment of the requirements
for the degree of Doctor of Philosophy
Psychology
Western Michigan University
August 2020

Doctoral Committee:

Richard W. Malott, Ph.D., Chair
Kelly Kohler, Ph.D.
Steven Ragotzy, Ph.D.
Alan Poling, Ph.D.
Carmen Jonaitis, Ed.D.

ESTABLISHING AUDITORY DISCRIMINATION AND ECHOIC STIMULUS CONTROL WITH AN AUDITORY MATCHING PROCEDURE

Clare Christe, Ph.D.

Western Michigan University, 2020

A generalized auditory matching repertoire is considered an early milestone in the development of verbal behavior (Greer & Keohane, 2006). Previous literature has demonstrated that the auditory matching (AM) protocol can improve echoics in individuals with developmental delays (Brown, 2005; Choi, Greer & Keohane, 2015; Du, Speckman, Medina, & Cole-Hatchard, 2017). However, some children experience difficulties with the match-to-sample (MTS) format of the AM protocol, if they are unable to perform delayed MTS tasks.

One alternative to MTS is the go/no-go procedure (Serna, Dube, & McIlvane, 1997), which requires the student to make a simple discrimination (i.e., same/different) between two stimuli that are presented simultaneously. Applying this format to auditory matching would eliminate the issue of the delay and allow for the almost-simultaneous presentation of two sounds—if they are continuously alternated until a response is made.

The purpose of this study, therefore, was to explore the effectiveness of this method for teaching auditory matching, and to evaluate whether mastery of this skill would improve six preschool children's echoic responses. We used a nonconcurrent multiple-probe design to assess each participant's performance on a list of echoics before, during, and after the intervention. Phases of the intervention began with simple sound discriminations that became successively more complex, until they involved word discriminations. Of the four students who achieved

generalized word matching, one demonstrated improved articulation and two acquired a generalized echoic repertoire.

ACKNOWLEDGMENTS

First, I would like to thank Dr. Malott for his supervision on this project—none of this would have been possible without him. From the very first day of 6100, your knowledge and passion for behavior analysis has been an inspiration to me. I am forever changed because of your guidance and the *Principles of Behavior.*[1] Thank you for paving the way for countless students, like myself, to continue saving the world with behavior analysis.

Second, I would like to express my gratitude to the other members of my committee: Dr. Kelly Kohler, Dr. Steven Ragotzy, Dr. Alan Poling, and Dr. Carmen Jonaitis. It has been a privilege learning from each of you, and I am sincerely grateful for the guidance you have provided over the course of my graduate career.

Third, I would like to thank all the Behavior Analysis Training System members who have supported me throughout this project. Specifically, thank you to my small group, for keeping me humble and making this experience worthwhile. And thank you to my research partners: Chelsie Morgan, Anne Nanninga, Marquin Evans, Molly Mattes, and Oina Akande—the success of this project is largely owed to you. And thank you to Dr. Kelly Kohler and my fellow PhD students, Dr. Sofia Peters, Dr. Kaylee Tomak, and Dr. Michael Tomak, for the advice and suggestions, among countless other things. And most importantly, thank you to Eddie Bobadilla, for being an outstanding performance manager and an even better friend.

Finally, I would like to thank my parents, Jennifer and Lawrence Christe. Mom, thank you for telling me to prioritize education over boys; and Dad, thank you for teaching me to

[1] Malott, R. (2014). *Principles of behavior* (7th ed.). Pearson.

prioritize faith and happiness above everything else. All my success is owed to you both. And thank you to Alexander Spinard, for being my person through it all. Your understanding and words of encouragement helped me through the most difficult moments of graduate school.

Clare Christe

TABLE OF CONTENTS

Table of Contents—continued

Table of Contents—continued

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

Imitation is one of the primary methods by which children learn from their environment; it allows for greater independence, facilitates skill acquisition, and is considered a key stage in the development of observational learning (Greer & Ross, 2008). Language also relies heavily on a child's ability to imitate vocal sounds, otherwise known as *echoics*. An echoic is a verbal operant that has point-to-point correspondence with the antecedent that controls it and results in generalized reinforcement, most often in the form of social praise (Skinner, 1957). The echoic is key to language development because it allows children to practice vocalizing and is a building block for other verbal operants (Du et al., 2017). However, while most children begin imitating speech at a young age, children with autism often have a difficult time acquiring this skill; and about 40% do not speak at all (Centers for Disease Control and Prevention, 2019). Yet the presence of communication deficits, regardless of severity, does not mean vocal verbal repertoires cannot be achieved; a specialized teaching approach may be all that is required to help these children make significant progress (Greer & Ross, 2008).

Verbal behavior analysis (VBA), which was founded on Skinner's (1957) theoretical analysis of verbal behavior, is a subfield of the basic and applied sciences of behavior that has been particularly effective in improving communicative repertoires in children with autism (Greer & Ross, 2008). While linguistic-based curricula focus on the form of language, VBA concentrates on the function and relies heavily on environmental interventions to establish verbal repertoires. Greer and Ross (2008) were among the first to develop a curriculum for teaching verbal behavior based on Skinner's theoretical analysis and over 20 years of research in VBA.

This curriculum is comprised of nine different stages, or milestones, considered critical in the development of verbal behavior. Each stage includes a list of prerequisite skills and *verbal capabilities* that, if missing, prevents the learner from advancing to more complex stages. The absence of any one of these skills could eventually lead to a plateau in learning that prevents further language development (Greer & Ross, 2008).

Prior research in VBA has focused on inducing *speaker* behavior in children with language delays. Several behavioral interventions have proved effective in this area, though a small portion of students still fail to make meaningful progress (Lovaas, 1987). Greer and Ross (2008) propose that an underdeveloped listener function could be responsible for this, as the listener stage directly precedes that of the speaker stage and is considered crucial to the development of echoics. Because listener behavior requires that the child be able to attend to vocal language, following directions and imitating speech becomes almost impossible when this skill is missing. Therefore, Greer and Ross (2008) recommend that students demonstrate proficiency in listener responding (also referred to as *listener literacy*) before beginning speaker instruction.

A *capacity for sameness* is critical to the acquisition of listener behavior (Greer & Ross, 2008). Students with this capability can recognize when two or more stimuli are the same, which is an important step towards learning simple discriminations. While most early intervention programs focus primarily on visual matching, Greer and Ross (2008) argue that a capacity for sameness should be taught across all five senses (e.g., sight, sound, touch, smell, and taste). Although more research is needed to support this theory, a capacity for sameness across sounds, also referred to as auditory matching, was first explored as a potential addition to the Assessment of Basic Learning Abilities (ABLA). The ABLA was developed by Kerr, Meyerson, and Flora in 1977 (as cited in Salem et al., 2014) to assess the ease or difficulty with which a student can learn various discriminations (i.e., imitation, positional discriminations, simple visual discriminations, conditional visual discriminations, simple auditory-visual discriminations, and conditional auditory-visual discriminations) (Salem et al., 2014). Pure auditory discriminations, however, were not included in the assessment. As a result, researchers have explored methods to assess conditional auditory discriminations, such as auditory matching, to determine if it should be included in the ABLA.

Harapiak, Martin, and Yu (1999) were among the first to evaluate an Auditory-Auditory Identity Matching Prototype Task (AAIM PT), which tested one's ability to match sounds (as cited in Salem et al., 2014). This task involved a tester saying a word (e.g., "pen" or "block"), and two assistants, placed on either side of the tester, repeating one of those two words; the participant should then point to the assistant whose word matched that of the tester's (as cited in Salem et al., 2014). Research on the AAIM PT shows that it has high predictive validity across similar auditory matching tasks and is more difficult than level six of the ABLA (i.e., conditional auditory-visual discriminations (Salem et al., 2014). Additionally, Marion et al. (2003) assessed the performance of a group of adults with developmental disabilities on the ABLA, the AAIM PT, and a test of echoics, mands, and tacts; they found that those who passed the auditory matching task scored the highest across all three verbal operant assessments, even above the group that had mastered level six of the ABLA, but not the AAIM PT. Altogether, these findings suggest that auditory matching plays a role in the development of early verbal operants, and may serve as a bridging task to vocalizations (Marion et al., 2003).

Although early researchers reported evidence of a link between language acquisition and auditory matching, none demonstrated that they were able to successfully teach the skill to participants who had initially failed the AAIM PT (Salem, 2012). Sewell (2006) was the first to attempt to teach auditory matching to individuals with disabilities using this format, yet her lack of success suggests that the AAIM PT may not be an effective teaching method. Salem (2012) was only able to teach the AAIM tasks after the training format was altered so that the participants, rather than the researchers, were actively involved in producing the sounds. As an alternative to the AAIM PT, Greer and Ross (2008) developed their own Auditory Matching (AM) Protocol, based off Brown (2005). In this protocol, three Big Mac® buttons are placed in a triangular formation on the table so that the top button (i.e., the sample stimulus) is in front of the teacher and the two bottom buttons (i.e., the comparison stimuli) are in front of the student; each button plays a prerecorded sound or word when pressed. The teacher first plays the sample sound, then the two comparison sounds (in a randomized order), before instructing the student to "match same." Similar to Salem et al.'s (2012, 2014) procedure, participants are then given the opportunity to actively produce the sounds by pressing any of the three buttons before selecting the comparison stimulus with the matching sound. Phases of the protocol begin with simple discriminations (e.g., sound vs. no sound) and become progressively more advanced (e.g., sound vs. white nose, sound vs. sound, non-word vs. word, word vs. word) until the student demonstrates generalized auditory matching.

The AM protocol has successfully induced echoics in nonvocal children and improved pronunciation in students whose articulation is poor (Brown, 2005; Choi et al., 2015; Du et al., 2017). It may also help children who have difficulties acquiring a capacity for sameness (Greer & Ross, 2008) or the listener component of naming (Speckman-Collins et al., 2007). These outcomes were a result of intense instruction in auditory matching, which may inadvertently condition adult voices as reinforcers (Speckman-Collins et al., 2007). In support of this theory are the findings of Choi et al. (2015), in which all three participants demonstrated conditioned reinforcement for listening to voices after mastering the protocol.

Mastery of the AM protocol can improve capabilities across multiple stages of verbal behavior, including echoics, listener responding, and conditioned reinforcement for adult voices. Although research on this topic is scarce, preliminary findings support the hypothesis that auditory matching is a behavioral cusp linked to both listener and speaker behavior. Results also suggest that the AM protocol is an effective method for teaching auditory matching, particularly when compared to the AAIM PT. However, the match-to-sample (MTS) format of the protocol does generate several inherent limitations, making it inappropriate for some learners. For example, unlike visual MTS programs, the sample and comparison stimuli in the AM protocol cannot be presented simultaneously at the beginning of each trial; instead, the instructor needs to present all three sounds in successive order, so that the learner has an opportunity to hear each one before selecting a match. This format mimics that of delayed MTS tasks, which involve an intentional delay between the removal of the sample stimulus and presentation of the comparison stimuli; unfortunately, the probability of a correct response decreases as a function of the delay between the sample and comparison stimuli (Thurman, 2009). Similar issues are likely to be encountered in the AM protocol. To avoid this issue in receptive identification programs (i.e., matching one of two visual stimuli to an auditory sample stimulus), Green (2001) recommends repeating the auditory sample stimulus every 2 seconds until the learner selects a comparison stimulus; doing so ensures that the student has a chance to hear the discriminative stimulus throughout the entire interval. Yet this is not a practical solution for auditory MTS programs, as the repetition of the sounds would over-complicate the procedure.

Match-to-sample programs have historically been the preferred method for teaching same/different discriminations. Students who struggle with this format, however, may have more success using the *yes/no* method, or *go/no-go* method for children who are nonverbal (Serna et al., 1997). Unlike typical MTS programs, this method does not incorporate an array of comparison stimuli to choose from. Instead, the student simply indicates whether two stimuli, presented simultaneously, are the same (e.g., stating “yes”) or different (e.g., stating “no”); learners who are nonvocal may make some arbitrary response when the stimuli are similar, but not make that response when they are dissimilar (Serna et al., 1997). A procedure like the go/no-go method could be used for auditory matching, if two sounds were continuously presented in an alternating fashion throughout the trial. If those two sounds were the same, the participant would indicate a match using some arbitrary response; and if the two sounds were different, the participant would refrain from making that response. This format would address the issues in the AM protocol, as the repeated presentations adheres to Green’s (2001) suggestion, while having one sound start immediately as the other sound ends (i.e., within a fraction of a second) reduces the delay between successive presentations.

The purpose of this study, therefore, was to explore whether auditory matching can be taught using this alternating format of the go/no-go method; and, if so, whether it still results in increased echoic responses in preschool children with language delays.

GENERAL METHODS

Participants

Five children were selected to participate in this study because they lacked an echoic repertoire (i.e., could not echo more than a few sounds/words). One student, Caleb[1], was also included due to his articulation issues and problem behavior during echoic procedures. The study was approved by the Human Subjects Institutional Review Board of Western Michigan University (see Appendix A). Each student's most recent performance on the Verbal Behavior Milestones Assessment and Placement Program (VB-MAPP) (Sundberg, 2008) was reviewed prior to being included in the study. Individual scores for each participant are reported in Table 1 for the following sections of the VB-MAPP; Listener Responding (LR), Visual Perceptual/Matching to Sample (VP/MTS), Imitation, and the Early Echoic Skills Assessment (EESA) developed by Barbara Esch (see Table 1). A more extensive report on the history of each participant can be found within their respective studies.

Setting

All six children were enrolled in an early childhood special education (ECSE) classroom, which specialized in providing behavioral services to preschool-aged children with developmental delays. Western Michigan University (WMU) undergraduate and graduate students provided up to 15 hours a week of discrete-trial training (DTT) instruction to each of the children, depending on their level of need.

[1] Pseudonyms used to protect the privacy of the participants.

Table 1

Participants' Demographic Information

Name	Age	Gender	Diagnosis	EESA	LR	VP/MTS	Imitation
Matt	3 years	Male	ASD	0	0	4	0
Hector	3 years	Male	ASD	0	1	9	1.5
Trevor	4 years	Male	ASD	0	.5	4.5	0
Christopher	4 years	Male	ASD	1.5	2.5	9	8
Neil	3 years	Male	N/A	0	1	5	0
Caleb	3 years	Male	ASD	N/A*	5	5	3.5

*Note.** Section terminated due to problem behavior.

Dependent Variable

We used a nonconcurrent multiple-probe design across participants to assess the effects of the go/no-go auditory matching procedure on echoic responses. The dependent variable was each student's performance on three echoic probes: one at the start of the intervention, one midway through the intervention, and one at the end of the intervention. Although Du et al. (2017) used the 100 English Words list by Choi et al. (2015) to probe echoic responses, we felt that the EESA would be more appropriate for our participants' skill level.

For the purposes of this study, words or phrases that the students echoed accurately were considered correct, while responses that were inaccurate, but still recognizable, were considered partial; an unrecognizable response, or a lack of response, was counted as incorrect. Targets could be repeated up to three times. No reinforcement was provided for any echoic response, to prevent the confounding of variables in subsequent probes. Reinforcers were intermittently provided to the students, contingent on their participation, to prevent responding from extinguishing.

Independent Variable

The independent variable was the go/no-go auditory matching procedure that we designed using Microsoft PowerPoint®. Individual slideshows were created for all phases of the intervention; each slideshow was duplicated to produce two versions: version A or B, that remained the same except for the order of the slides (see Appendix B for slide arrangement in both versions of Phase 2). This allowed us to systematically randomize the nonmatching and matching trials between sessions to prevent the student from acquiring a pattern of responding. Because there was a total of 12 trials per session, each slideshow consisted of six S^D (matching sounds) slides and six $S^{\triangle}$ (nonmatching sounds) slides. Both the S^D and $S^{\triangle}$ slides displayed a solid blue circle (i.e., “button”) at the bottom of the screen with a white line placed above it; a black background was used to make the circle more discriminable (see Figure 1).

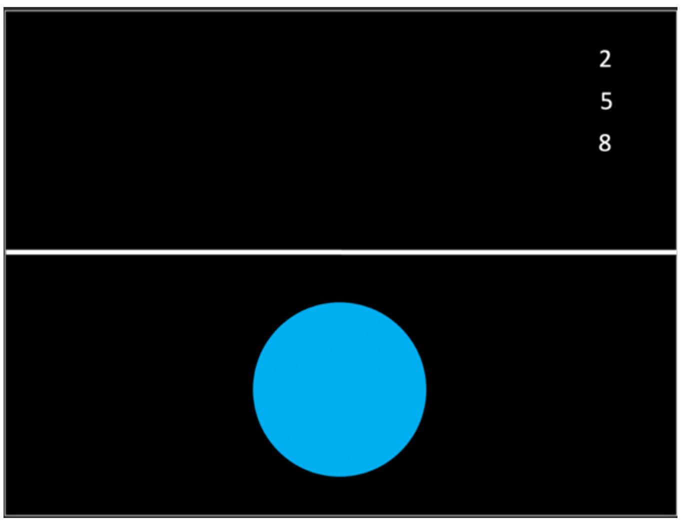

Figure 1. Example of a “trial” slide. Numbers would appear in the top-right corner of the screen after the corresponding number of seconds had passed since the start of the trial. Numbers varied across studies, depending on the prompting method.

Participants had 10 s to respond (i.e., touch the circle) before a trial slide automatically terminated and a “break” slide would appear. The break slide remained in place until the researcher was ready to start the next trial. This allowed the student time to consume a reinforcer if they had responded correctly, or, alternatively, signaled the end of a time-out if they had responded incorrectly (see Figure 2).

Figure 2. Example of a break slide. The number in the top-right corner of the screen refers to a 20 s time-out from attention; its appearance would cue the researchers that the time-out had ended.

Each PowerPoint presentation included 12 trial slides and 12 break slides, which were arranged in an alternating fashion.

Correct Response

S^D. A correct response was defined as touching any part of the blue circle within 8 s of the beginning of a matching trial (signaled by the appearance of the number eight on the screen). If a student responded independently within 8 s, the trial was immediately terminated and a reinforcer was provided. The next trial began when the student finished consuming the edible reinforcer, or after they had engaged with a tangible item for 15–20 s.

S^{Δ}. To respond correctly on a nonmatching trial, students had to refrain from touching the circle until the trial slide ended. If the student did not touch the circle, researchers would proceed through the break slide and immediately begin the next trial. No reinforcer was provided for correctly withholding the response, because we did not want to reinforce a nonresponse or pair nonmatching sounds with reinforcers.

Incorrect Response

S^D. An incorrect response occurred on a matching trial if the student failed to touch the circle within 8 s. Researchers would then physically prompt the response, before proceeding through the break slide to begin the next trial as quickly as possible (i.e., within a fraction of a second).

S^{Δ}. An incorrect response occurred if the student attempted to touch the circle at any point during a nonmatching trial. All attempts to touch the circle were immediately blocked, so that the student was not practicing an incorrect response. The nonmatching sounds continued to play until the trial slide ended and the break slide began. Researchers withheld attention from the student (e.g., no eye contact or verbal statements) until the number 20 appeared on the break slide, signaling that the time-out had ended, and the next trial could begin.

GENERAL PROCEDURE

Phases of the go/no-go auditory matching procedure were based off those in the original AM protocol (Greer & Ross, 2008) so that the two interventions remained as similar as possible. Doing so allowed for a more accurate comparison between the two interventions. Although sounds and phases varied across participants, overall mastery of the intervention occurred when students demonstrated generalized auditory matching with novel words (i.e., performed at 80% accuracy or better on a test with novel words). Mastery criteria for all phases was 80% accuracy across three consecutive sessions, 90% accuracy across two consecutive sessions, or 100% accuracy for one session.

Materials

PowerPoint presentations were downloaded onto a sixth-generation iPad before each session. Bluetooth® devices compatible with the Microsoft PowerPoint app were used to navigate between slides. The iPad was placed 10–12 in. away from the student to allow more time for the researchers to block an incorrect response. One researcher always sat beside the student to provide reinforcers, block incorrect responses, and prompt, as necessary. A research assistant was also seated behind the student to ensure that transitions between slides occurred as quickly as possible, without distracting the participants. Guided access on the iPad was activated before each session so that participants could not interrupt the slideshow or navigate outside of the app by touching the home button.

An informal preference assessment was conducted at the beginning of each session. Additional assessments were conducted if the student displayed a lack of motivation at any point during the session.

Interobserver Agreement and Treatment Integrity

Undergraduate and graduate research assistants were trained to collect interobserver agreement (IOA) data for both the EESA probes and intervention sessions. IOA data were collected for approximately 43% of intervention sessions and 63% of echoic probes. IOA data on the echoic probes was 88% for Matt, 82% for Neil, 92% for Hector, and 99% for Caleb. Scores above 80% were considered acceptable, as judgements between echoic responses were often subjective. No IOA data was taken for Christopher, due to problem behavior, and Trevor, who had no echoics. IOA data on intervention sessions was 100% for Matt, 99% for Neil, 98% for Hector, 99% for Trevor, 99% for Caleb, and 96% for Christopher.

Treatment Integrity

Treatment integrity was also taken during intervention sessions and echoic probes (see Appendix C for data sheets). If an individual score fell below 90%, feedback was provided to the researcher. Treatment integrity data for echoic probes was 100% for Matt, Neil, Hector, and Caleb. Treatment integrity data for intervention sessions was 100% for Matt, 100% for Neil, 100% for Hector, 100% for Trevor, 99% for Caleb, and 99% for Christopher.

Pilot Study: Matt

History

Matt's VB-MAPP assessment showed a score of zero on the EESA, Listener Responding, and Imitation sections. He did not demonstrate any echoics, although he would spontaneously emit at least 10 different speech sounds throughout the day (a few of which were whole-word approximations). He was able to visually attend to a book or toy for at least 30 s and could place three objects in a container on the VP/MTS section. He did not attend to voices in the environment or follow any vocal instructions. Although he continued working on the classroom's physical imitation and visual MTS programs while participating in this intervention, he did not receive instruction in echoics or listener responding.

Setting and Materials

To reduce noise level, sessions were conducted in a playroom adjacent to the student's classroom. A sign was placed on the door at the start of each session requesting that anyone using the playroom remain quiet. Within the room, a partition was placed around our work area to eliminate potential distractions from toys and other students.

Method and Results

Echoic Probe 1. Matt's baseline (BL) probe was conducted in a single day. We started with Group 1 of the EESA, which included 25 words with simple and reduplicated syllables. He correctly echoed two words and partially echoed 14 words (see Figure 3). Because he struggled to imitate most of the targets within Group 1, we did not think it necessary to test Groups 2 or 3 (two and three-syllable combinations, respectively).

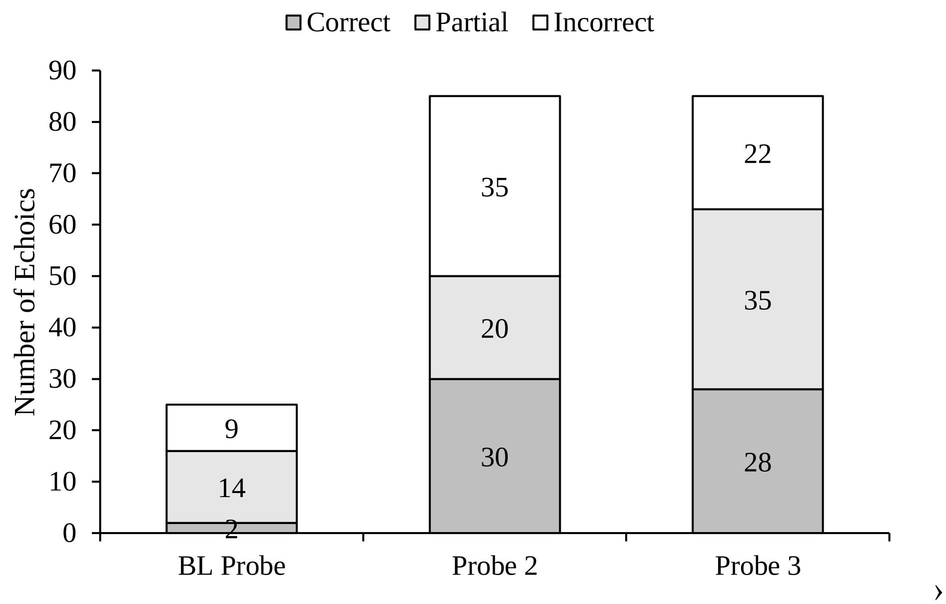

Figure 3. Matt's echoic responses on the EESA probes.

Phase 1. The first phase involved teaching the response in the presence of a single, repeating sound (i.e., a matching sound). This was the only phase that did not include a $S^{\triangle}$, so all twelve trials were of the same S^D (i.e., a tone). Each presentation of the tone was about a second long and began immediately after the previous tone ended (10 presentations per 10 s trial). We provided a physical prompt on the first trial to teach the response. Matt responded independently on the second trial and mastered this phase in only two sessions (see Figure 4 for this phase and subsequent phases).

Phase 2. Phase 2 included six trials of the tone from Phase 1, and six trials where no sound played. Any attempt to touch the circle during a no-sound trial was immediately blocked; a blocked response resulted in the termination of the trial (for this study only) and a 20 s time-out from attention. Matt attempted to touch the button twice in session one and once in session three during the no-sound condition; he mastered Phase 2 in three sessions.

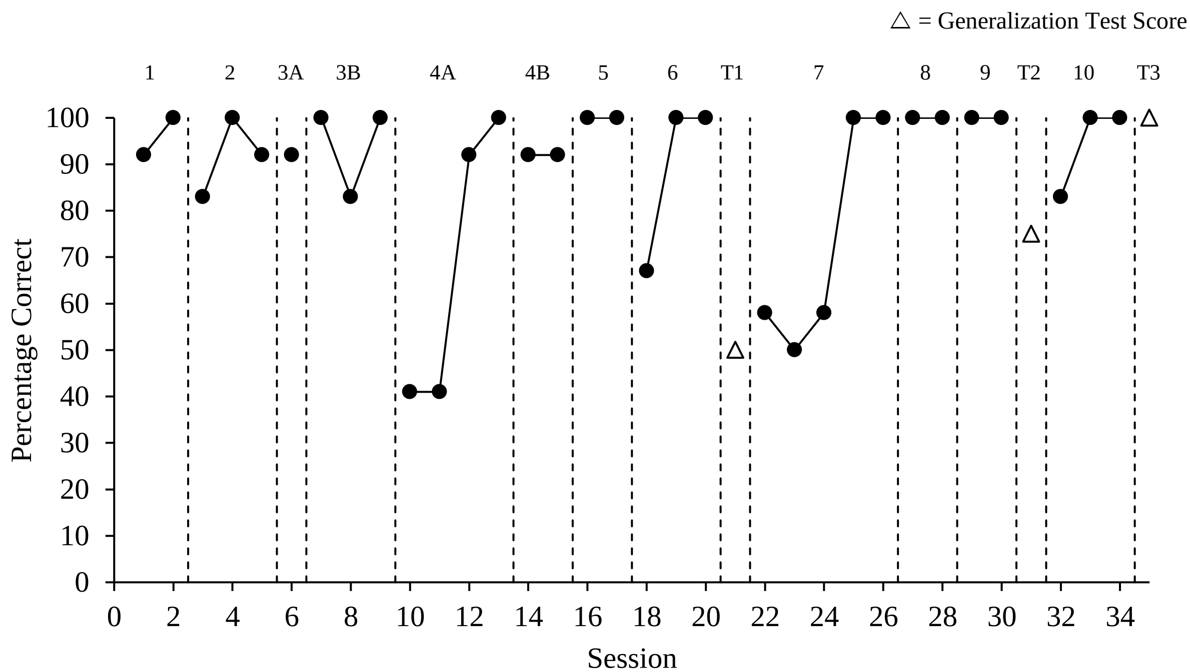

Figure 4. Matt's auditory matching data. He responded with 50%, 75%, and 100% accuracy on the three generalization tests (T1, T2, and T3, respectively), and mastered the intervention in 35 sessions.

Phase 3. Phase 3 was divided into two subphases, 3A and 3B (see Figure 4). Both subphases included six S^D trials of the tone from Phases 1 and 2, and six $S^{\triangle}$ trials with two alternating sounds: a car horn and the tone from the S^D. The order of the alternating sounds was randomized across trials. The duration of the car horn was slightly shorter than that of the tone, resulting in 11 presentations of the nonmatching sounds per trial. Subphase 3A included an auditory prompt that was embedded within the $S^{\triangle}$ trials; both the tone and the car horn were, subjectively, about a third the volume of the S^D sound. This helped make the transition from Phase 2 to Phase 3 slightly easier, given Matt's history of withholding a response in the presence of a no-sound trial. Because Matt only made one error in the first session of this subphase, we immediately moved to Subphase 3B, where the sounds were all of equal volume. He mastered this subphase in three sessions.

Phase 4. Phase 4 was the same as Phase 3, except that the car horn replaced the tone in the S^D trials. Because we wanted the pace of the repeating horn to resemble that of the repeating tone, only nine presentations occurred for the duration of the trial. Matt's history of withholding the response in the presence of the car horn was expected to cause difficulties in this phase. We therefore included the same subphases from Phase 3 in Phase 4, where the volume of the alter-nating tone and car horn was much lower in Subphase 4A. He mastered Subphase 4A in four sessions and Subphase 4B in two sessions.

Phase 5. Phase 5 combined the sounds from Phases 3 and 4. Three of the S^D trials were of the car horn and three were of the tone; the same $S^{\triangle}$ trials from the previous phase were included. No auditory prompts were used because Matt had already mastered these sounds. He responded perfectly across both sessions of Phase 5.

Phase 6. This phase was formatted in the same way as Phase 5, except that two novel sounds (a pig “oink” and a sheep “baa”) replaced the previous ones; the pacing of the sounds remained the same. He responded correctly on 67% of the trials in the first session and 100% of the trials in the following two sessions.

Generalization Test 1. The first generalization test included three novel sounds to assess whether Matt had acquired generalized auditory matching of sounds (see Appendix D for Sound Generalization Test data sheet). He responded incorrectly on all the nonmatching trials in the first session, indicating that the skill had not generalized.

Echoic Probe 2. The second echoic probe was conducted across two days. All three groups of the EESA were tested because of Matt's performance in Group 1. Of the 85 targets, 30 were echoed correctly and 20 were partially echoed (see Figure 3).

Phase 7. This phase combined word and sound discriminations. Three of the matching trials involved the tone, while the other three included a voice recording of the word "juice." The pace of the word repetitions were like that of the tone and the car (i.e., nine presentations per trial). The nonmatching trials included alternating presentations of the tone and the spoken word (e.g., "juice"). No auditory prompts were used, so all sounds were played at a normal volume. Matt responded incorrectly on most of the nonmatching trials in the first three sessions, but then mastered the phase in the following two sessions.

Phase 8. Phase 8 resembled the previous one, except that the word "book" replaced "juice" in the matching and nonmatching trials. The matching trials included 10 repetitions of each of the sounds. Matt responded perfectly in both sessions of this phase.

Phase 9. To teach word discriminations, matching trials varied between repetitions of the word "juice" and the word "book;" the nonmatching trials were alternations between those two words, at a pace of 9–10 words per trial. Matt again responded perfectly on the first two sessions.

Generalization Test 2. Now that Matt could discriminate between trials of matching and nonmatching words, the words "chair," "cook," and "three" were used to test for generalized auditory matching. The pacing of the words decreased to 5–6 repetitions per trial to allow for more naturalistic pauses between each word. He responded correctly on 50% of the nonmatching and 100% of the matching trials; he was one trial away from meeting mastery criteria for the second generalization test.

Phase 10. Phase 10 utilized the targets from the second generalization test to teach the words “three,” “chair,” and “cook” to mastery. This process was repeated for each subsequent generalization test until the student demonstrated generalized auditory matching. Matt mastered this phase in three sessions.

Generalization Test 3. The words “shoes,” “cup,” and “dog” were included in the third generalization test; the pacing remained at 5–6 word presentations per trial. Matt performed perfectly on the first session, indicating that he had acquired generalized auditory matching of words (see Figure 4). The intervention was terminated, and the final echoic probe was conducted.

Echoic Probe 3. All three groups of the EESA were probed across two consecutive days. The number of correct responses remained essentially the same across the second and third probes, with 30 in the second and 28 in the third; however, the number of partial echoics increased from 20 to 35. Unfortunately, Matt had a respiratory illness at the time of the third probe, which might explain why the number of correct echoic responses did not increase. Nonetheless, he demonstrated an overall increase of 47 echoic responses from the baseline probe (see Figure 3).

Discussion (Matt)

Matt achieved a generalized echoic repertoire after 20 sessions, and a generalized word-matching repertoire after 35 sessions (see Figure 4). Overall, these results were consistent with similar studies conducted on the AM protocol. This suggests that our go/no-go procedure may be an effective, alternative method for teaching auditory matching to students who lack the prerequisite skills for delayed MTS programs. Additionally, this study was the first to utilize auditory prompts to teach matching discriminations. Unlike physical prompts, an auditory cue requires the student to attend to the more relevant dimensions of the discriminative stimuli (i.e., the repetition of the sounds). Given that Matt was able to master difficult phases of this procedure (i.e., Phases 3 and 4) with relatively few errors, future research should explore the efficacy of this prompting method in similar situations.

Several anecdotal observations are worth noting. First, we noticed that Matt would often engage in superstitious behavior during the nonmatching trials. The behavior varied across phases and appeared to be highly correlated with a correct response. Furthermore, the absence of a superstitious behavior almost always preceded an incorrect response on a nonmatching trial. It may be that engaging in an alternative response during the nonmatching trial was easier than not responding at all. Future research should also explore this possibility, and whether teaching an alternative response during the S^{Δ} trials, rather than a non-response, produces faster skill acquisition.

Additionally, although we expected echoics to increase as Matt progressed through the intervention, anecdotal data suggests that he was acquiring a verbal repertoire much earlier than expected. After mastering Phase 2, both the researchers and classroom staff noticed a substantial increase in the rate and variety of his vocalizations. Moreover, within two weeks of mastering this phase, he began echoing words in the natural environment (even with the absence of reinforcement). This increase in vocalizations was surprising, given the fact that we had only reinforced responding in the presence of one sound (e.g., the tone). Training simple discriminations between sound vs. no sound, and sound vs. sound, may have been all that was required for him to attend to other sounds in the environment.

Matt’s performance on the VB-MAPP was reassessed two months after mastering this intervention. While substantial improvements were noted across each section, arguably the most impressive development occurred in listener responding. The graduate student responsible for his behavior programming reported that he could follow almost all the classroom's simple directions, although he never received explicit training on them. Furthermore, he required very few trials to master the object names in his receptive identification program, which was introduced shortly after he finished the auditory matching intervention. These findings align well with those of Du et al. (2017) and Choi et al. (2015), which also reported an increase in participants' listener responding skills after they mastered the AM protocol.

Study 2: Neil

History

Neil did not demonstrate any echoics or spontaneous vocalizations on his last VB-MAPP assessment. He could, however, match 10 identical objects on the VP/MTS portion. He could also respond to voices in the environment by making eye contact. While partaking in this study, Neil continued with his programming for physical imitation, simple direction following, and receptive identification of objects; he did not receive instruction for echoics.

Setting and Materials

Sessions for Neil and subsequent participants occurred in a room near the regular classroom. This room was sound-insulated and free of distractions. Neil received an edible reinforcer and 15–20 s of a preferred video or toy, contingent on a correct response.

Method

Procedure Modifications. The following modifications were made for this and the remaining studies: If a student attempted to respond on a nonmatching trial, the iPad was removed to facilitate the discrimination between a time-out following a response on a non-matching trial, and a failure to respond on a matching trial. Previously, the only difference between the two consequences was the duration in which the break slide remained in place before the next trial began (i.e., the intertrial interval).

Also, because the overall goal of the intervention was for the students to acquire auditory matching for words in as few sessions as possible, Phase 6 (the addition of two new sounds) and the Sound Generalization Test were eliminated, as they did not seem necessary for achieving that goal (see Table 2 for list of intervention phases).

Table 2

Basic Training Phases of the Intervention

Phase	S^D (Matching)	$S^{\triangle}$ (Nonmatching)
1	Tone	N/A
2	Tone	No sound
3	Tone	Tone/Beep
4	Beep	Tone/Beep
5	Tone & Beep	Tone/Beep
6	Tone & “Juice”	Tone/“Juice”
7	Tone & “Book”	Tone/“Book”
8	“Juice” & “Book”	“Juice”/“Book”
Generalization Test	Varies	Varies

Prompting. Because of Neil’s previous success with visual prompts, a visual, rather than an auditory prompt, was used for this study. For the first two sessions, the circle operandum was removed on the PowerPoint slides during the $S^{\triangle}$ trials, so that there was no opportunity for Neil to make an incorrect response. Using a decreasing time delay, we then faded the circle back into the $S^{\triangle}$ trials at 8 s, 5 s, and 2 s, across each session. If Neil attempted to touch the circle on more than two S$^{\triangle}$ trials within a session, we increased the delay in the following session; if he did not attempt to touch the circle for at least four of the six S$^{\triangle}$ trials within a session, we advanced to a shorter delay in the following session. The 2 s delay remained in place across both the S^{D} and S$^{\triangle}$ trials for the entire procedure, so he could not respond before hearing the first two sounds of the trial. For all phases, Neil was required to meet the mastery criteria in sessions where the delay had decreased to 2 s.

Results

Echoic Probe 1. Neil's first echoic probe was conducted in a single day. We ended the probe after Group 1 of the EESA, because he could echo only a few sounds and would not respond on the more difficult targets. He correctly echoed four words and partially echoed another four words (see Figure 5 for this and the subsequent probe).

Phase 1. In Phase 1, Neil required three physical prompts in the first session, and none in the second (see Figure 6).

Phase 2. A visual prompt was not included in the first four sessions of this phase. However, Neil would engage in significant problem behavior whenever we would block his attempts to touch the circle during a no-sound trial. Therefore, we removed the circle on the seventh session and incorporated the visual-prompting method to avoid problem behavior. He responded correctly on 67% of the no-sound trials in session eight, where the circle appeared at 5 s, so we progressed to a 2 s delay in sessions nine and ten. No problem behavior occurred after the visual prompt was introduced.

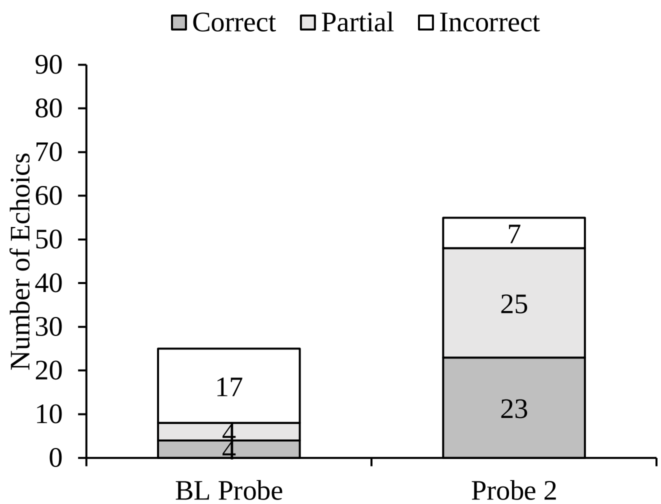

Figure 5. Neil's echoic responses on the EESA probes.

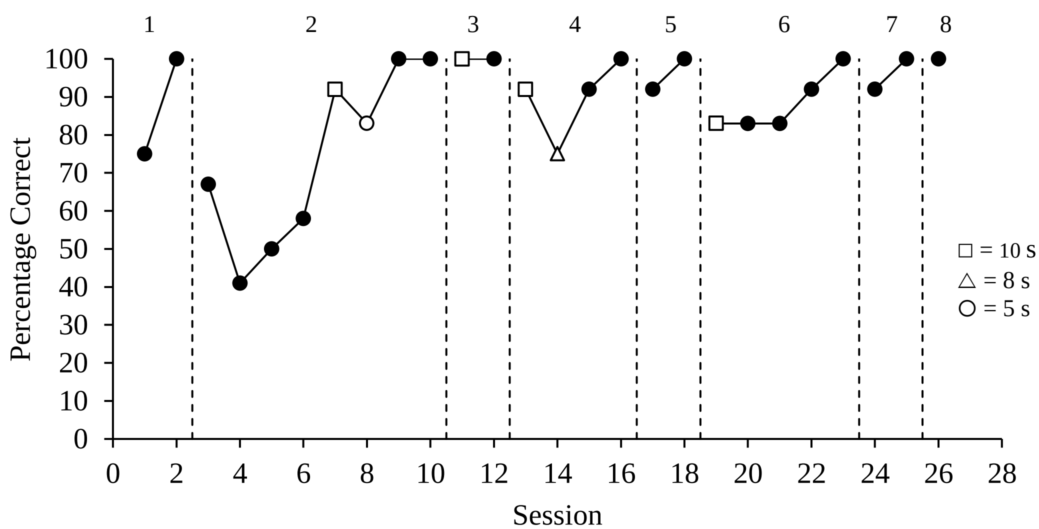

Figure 6. Neil's auditory matching data. The different symbols refer to the delay of the visual prompt.

Phase 3. Session 11 in Phase 3 included a 10 s delay, so no circle was present in the nonmatching trials with the car horn and the tone. By the end of the session, Neil would look away from the screen immediately after hearing the horn, indicating that the sounds were now controlling his behavior. We therefore probed session 12 at 2 s, and he responded with 100% accuracy.

Phase 4. Phase 4 began with a 10 s delay in session 13, which decreased to an 8 s and a 2 s delay in the following three sessions. He responded correctly across all trials at the 2 s delay.

Phase 5. We did not include a visual prompt in this phase, as Neil had previously mastered each of the sounds. Like Matt, he completed Phase 5 within two sessions.

Echoic Probe 2. The second echoic probe was conducted in a single day and covered Groups 1 and 2 of the EESA. Of the 55 total words, Neil correctly echoed 23 and partially echoed 25 (see Figure 5). This was an overall increase of 40 echoics from the baseline probe. We did not probe Group 3, as the majority of his echoics in Group 2 were only partially correct.

Phase 6. Phase 6 was the same as Phase 7 in the pilot study (i.e., "juice" & tone). Although Neil was demonstrating auditory discrimination at this point, we still included an 8 s delay in the first session of this phase to avoid problem behavior related to errors. After observing that he would look away from the screen when hearing a nonmatching sound, we moved to a 2 s delay in the following session; and he performed at mastery criteria across the next three sessions.

Phase 7. Neil mastered this phase in two sessions, without the inclusion of a visual prompt.

Phase 8. Neil responded perfectly on the first session of Phase 8, indicating that he was able to discriminate between at least one set of matching and nonmatching words. Unfortunately, we were unable to conduct the generalization test, or the third echoic probe, due to the COVID-19 pandemic.

Discussion (Neil)

Neil achieved a generalized echoic repertoire after 18 sessions of the auditory matching intervention, and he mastered Phases 1-8 within 26 sessions (see Figure 6). However, his performance of 92% accuracy on the first session of Phase 7, which included one novel word, suggests that he may have acquired some generalized word-matching.

The visual prompt used within this study reduced errors, and, as a result, eliminated problem behavior during our sessions. Furthermore, the visual prompts appear to be just as effective as the auditory prompts used in the pilot study. In fact, Neil mastered Phases 3 and 4, arguably the most difficult phases of the intervention, in one less session than did Matt. Future research should explore both methods further.

Like Matt, Neil showed a substantial increase in the rate and variety of his vocalizations in the early phases of this procedure (i.e., Phase 4). It remains unclear why mastering non-matching and matching discriminations for only two sounds would result in such large improvements across both participants. Future research should explore whether a similar phenomenon is observed within the AM protocol, as well as explanations of why it occurs.

Study 3: Caleb

History

Caleb could vocalize eight whole words or phrases, with appropriate intonation and rhythm, on his last VB-MAPP assessment; most of these words were mands for preferred reinforcers. He did not demonstrate echoics at the time of the assessment, although he would frequently engage in echolalia throughout the day. Additionally, many of the words and phrases that he emitted were missing syllables (e.g., “skittles” sounded like “ski-lles”), making it difficult to understand him. However, he was missing some of his top front teeth (permanently), which may have contributed to these articulation issues. A week after the VB-MAPP assessment was conducted, and before this study began, he emitted a few echoics, which were immediately reinforced by his technician. Soon after that, he demonstrated a generalized echoic repertoire, although articulation was still an issue.

Caleb was able to imitate two physical actions and match 10 identical objects. He demonstrated some listener responding skills by selecting the correct object from an array of four, for 20 different items, when the object's name was spoken. Additionally, he could follow four simple directions without a visual prompt. He did not receive instruction on echoics while participating in the intervention.

Setting and Materials

All sessions were conducted in the sound-insulated room discussed in Study 2. Caleb received an edible reinforcer and 15–20 s of a preferred video, or toy, for a correct response.

Method

Procedure Modifications. Only Phase 4 was modified in this study (see Results of Phase 4 for further explanation).

Prompting. We did not implement a specialized prompting method for Caleb, as error correction was all that was needed for him to acquire most skills. Consequences for a correct or incorrect response were implemented as described in the General Methods section.

Results

Echoic Probe 1. Caleb's baseline probe was conducted across three days. We tested all three groups of the EESA, as he already had a generalized echoic repertoire. While testing Group 3, we observed a substantial amount of problem behavior, perhaps due to a combination of difficult targets and poor articulation. Because we were unable to deliver reinforcers for correct responses, we terminated the probe to avoid making echoics more aversive. Out of 64 targets, he correctly echoed 33 words and partially echoed 25 words (see Figure 7).

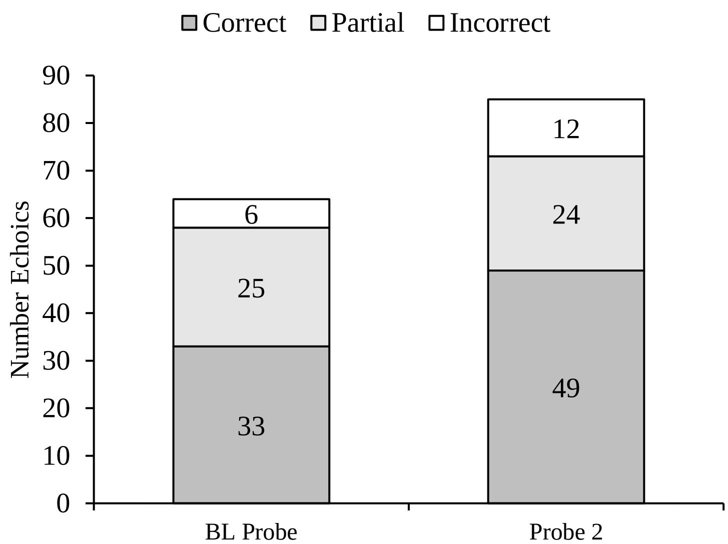

Figure 7. Caleb's echoic responses on the EESA probes.

Phase 1. Caleb immediately touched the circle on the first trial of session one, before we had the opportunity to teach the response. He continued to respond correctly across the remaining trials, mastering this phase in one session (see Figure 8).

Phase 2. He responded incorrectly on four of the no-sound trials in the first session of Phase 2. However, he mastered this phase in the following two sessions.

Phase 3. Caleb only emitted one incorrect response across both sessions of this phase.

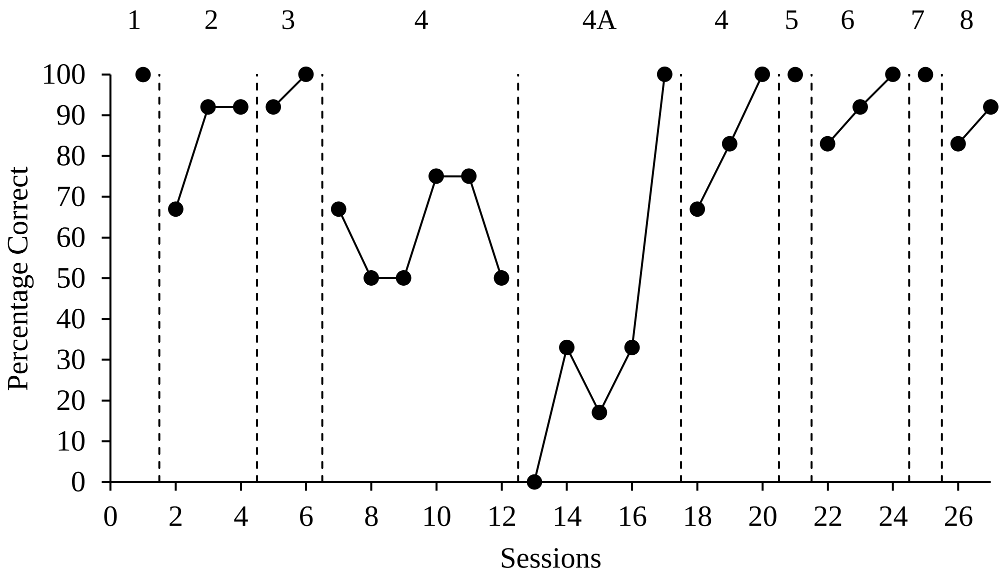

Figure 8. Caleb's auditory matching data. 4A refers to the subphase where the nonmatching sounds were removed.

Phase 4. In the first four sessions of this phase, Caleb failed to respond across most of the trials, probably because the sound of the car horn (now in both the S^D and $S^\triangle$) had signaled a nonresponse in the previous phase. His performance increased to 75% correct across the next two sessions. However, we did not attribute this increase to learning, as he was responding randomly across the matching and nonmatching trials. His responding decreased to 50% in session 12, where we also noticed a decrease in his attending to the stimuli. Therefore, two additional subphases were included.

Subphase 4A. We removed the nonmatching trials in this subphase, so that only the S^D trials with the car horn remained. We hoped that repeating Phase 1 with the car horn, instead of the tone, would establish the response in the presence of the horn. Caleb responded below 50% on the first four sessions of this subphase and attending remained low; additional reinforcers were therefore included at session 17. He could now earn an edible, a phone video, and the toy trains for each correct response; and we also increased the amount of praise he received. He responded correctly on 100% of the trials after implementing this change, so we returned to Phase 4.

Return to Phase 4. Caleb responded incorrectly on three of the nonmatching trials and one of the matching trials in session 18. His performance increased to 83% accuracy in session 19, and he mastered this phase in the following session. It remains unclear whether mastery of Phase 4 was due to the previous subphase, a change in reinforcers, or a combination of both.

Phase 5. He responded with 100% accuracy on the first session of Phase 5.

Echoic Probe 2. The second echoic probe was conducted across three days and covered all three groups of the EESA. Unlike the first probe, no problem behavior occurred, so we tested all 85 targets (compared to 64 in the first probe). Caleb correctly echoed 49 words and partially echoed 24 words, for an overall increase of 15 words (see Figure 7). Additionally, taking into account only the first 64 targets across both of the probes, his correct echoics still increased by 15, while his partial echoics decreased by 13—a strong indication that his articulation had improved.

Phase 6. He performed at or above 83% accuracy across all three sessions of Phase 6.

Phase 7. He mastered Phase 7 in a single session.

Phase 8. Caleb responded at 83% and 92% accuracy on the first two sessions of Phase 8. Unfortunately, we were unable to continue with the rest of this phase, along with the generalization test and third echoic probe, because of the COVID-19 pandemic.

Discussion (Caleb)

Caleb already had a generalized echoic repertoire before starting this intervention. However, his pronunciation made him difficult to understand; and we encountered high levels of problem behavior whenever we attempted to work on his articulation using echoics. The present intervention allowed us to continue working on his speech with a procedure that generated essentially no problem behavior. Although we were unable to conduct the third echoic probe, Caleb's number of correct echoics increased by 16 words, and his number of partial echoics decreased by one. This suggests that our go/no-go auditory matching intervention, like the AM protocol, may improve students' articulation (Brown, 2005; Du et al., 2017).

In keeping with his relatively advanced listener skills demonstrated in the VB-MAPP assessment, Caleb performed the best across the procedure (apart from Phase 4, which may have been due to a motivational issue). In fact, during Phase 3cof this study, he would stomp his feet according to the rhythm of the $S^{\triangle}$, but not the S^{D}. This supplemental behavior may have helped him master this difficult phase in only two sessions. Future research should explore whether similar behaviors can be used to help students discriminate between complex auditory stimuli.

Study 4: Trevor

History

On his last VB-MAPP assessment, Trevor could spontaneously emit at least five different speech sounds; these sounds were not functional, however, but merely vocal stereotypy that occurred throughout the day. He could not imitate any sounds or words. This assessment also showed that he had no imitation skills, although he had acquired generalized physical imitation by the time of this study. Additionally, his VP/MTS score indicated that he could match 5 identical objects, though at the time of this intervention, he was matching 10 objects, 10 pictures, and 10 objects-to-pictures. Overall, he had excellent visual attending skills, but very poor auditory discrimination. He could not follow vocal instructions, and often relied on visual cues to compensate for this weakness. For example, when working on the directions “arms up” and “clap hands,” he initially appeared to have acquired these targets. However, we eventually realized that he was attending to the shape of the technician’s mouth, rather than the vocal instruction. After continuing to work on these targets for several months, and requiring the technician to wear a face mask, he still could not follow those two directions.

During this study, Trevor was receiving instruction in facial imitation for the sounds “mmm,” “oh,” “puh,” and “duh.” Although this created a confounding variable for the present intervention, it was decided that it was best to continue with that training.

Settings and Materials

For Phases 1 through 5, sessions were conducted in the playroom that was used in the pilot study. However, during Phase 6, we moved to the sound-insulated room discussed in Study 2. Trevor received an edible, along with 15–20 s of a preferred video, for each correct response.

Method

Procedure Modifications. No modifications were made to the procedure, outside of those that were required for the prompting method.

Prompting Method. After fourteen sessions in Phase 2, Trevor was still responding across both the S^D and S^{Δ} trials almost 100% of the time. Additionally, he would engage in problem behavior whenever we attempted to block the response on a no-sound trial. We therefore implemented a within-session, most-to-least prompting method, because of his previous success with physical prompting in other procedures. The duration of the S^D and S^{Δ} trials were also shortened to 5 s instead of 10 s, to reduce the aversiveness of having to engage in a nonresponse over a longer period.

We began by gently placing Trevor's hands in a folded position (i.e., a "quiet hands" position) before every trial. We then hovered our hands above his own for 2 s on the S^D trials (allowing him to hear the first two sounds before responding) and 5 s on the S^{Δ} trials. If he remained in the quiet hands position for the entire duration of the S^{Δ} trial, we considered this a correct response; any attempt to touch the circle during the S^{Δ} trial was treated as an incorrect response. To fade the prompt, we removed our hands at 4 s, 3 s, and 2 s, until he was allowed 3 s to respond across all trials. The numbers 2, 3, 4, and 5 would appear in the top-right corner of the screen, across both the S^D and the S^{Δ} trials, as a cue for the researcher to remove their hands. If Trevor responded correctly across two consecutive S^{Δ} trials, we decreased the duration of our prompt by one second. If he responded incorrectly across two consecutive S^{Δ} trials, we increased our prompt by one second, or kept it at 5 s if he was already at that level. Mastery criteria needed to be met at 2 s for all phases of the procedure.

Results

Echoic Probe 1. We only probed the first column in Group 1 of the EESA, as we had previously worked on echoics, but had not yet observed a vocal response. Trevor would often scroll through previously mastered responses when an echoic target was delivered. He did not attempt to echo any words in the baseline probe (see Figure 9).

Phase 1. Trevor required eight prompts to touch the circle in the first session, responding independently only 33% of the time. He mastered this phase in the following two sessions, however (see Figure 10).

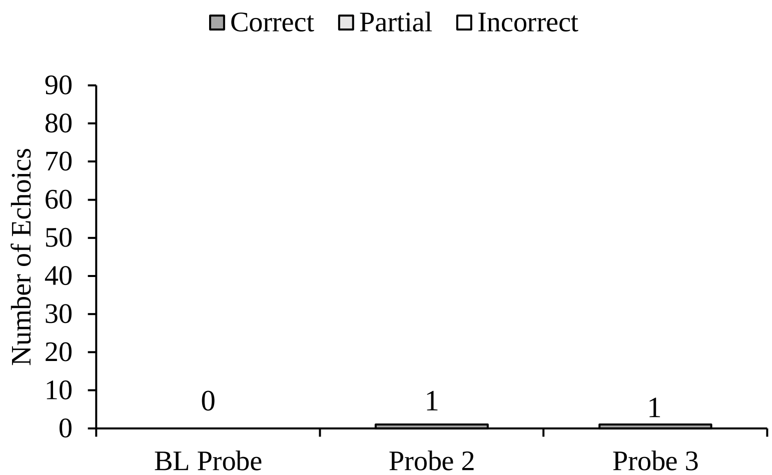

Figure 9. Trevor's echoic responses on the EESA probes.

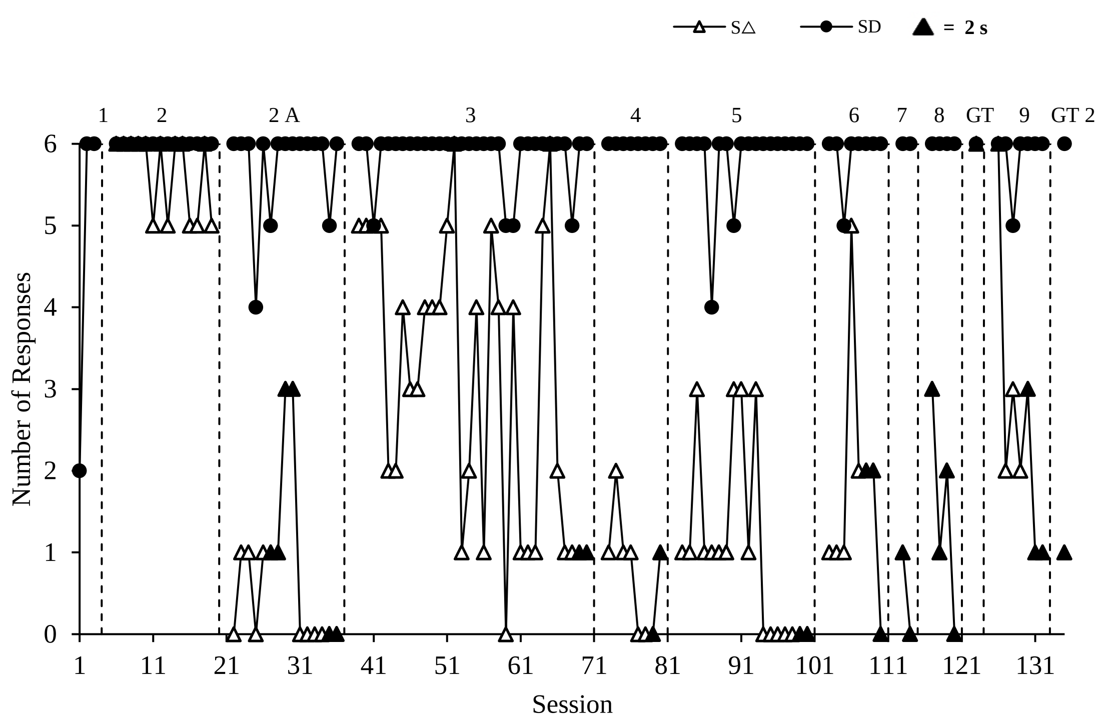

Figure 10. Trevor's auditory matching data. The most-to-least prompting method was introduced in Phase 2A and continued for the remaining phases. The black triangle symbols refer to the removal of the physical prompt on a S$^{\triangle}$ trial. Greater disparities between the circle and triangle symbols indicate better performance; to perform at mastery criteria for any given session, the black triangle symbols needed to be fall below three responses, and the circle symbols needed to remain above three responses. (The format of this figure differs from that of the other comparable figures because of the use of most-to-least prompting.)

Phases 2 and 2A. As stated in the methods section of this study, Trevor never responded above 58% accuracy in Phase 2. Therefore, we proceeded to Phase 2A at session 18, which introduced the most-to-least prompting. After eight sessions in this phase, he responded with 92% accuracy at 2 s, but then performed at 75% accuracy in the following two sessions. He mastered Phase 2A in 15 sessions.

Phase 3. Phase 3 took the longest for Trevor to complete. Except for one session, the prompting level never fell below 4 s until session 57, and then took an additional eight sessions for him to master this phase.

Phase 4. He mastered Phase 4 in only 8 sessions, in contrast to Phase 3 which required 31 sessions.

Phase 5. Trevor was the first participant to spend more than two sessions in Phase 5, which was a combination of the two previous phases. It took 18 sessions for him to reach mastery criterion.

Echoic Probe 2. During the last sessions of Phase 3, one of the behavior technicians working with Trevor reported that he echoed the words “ah” and “buh.” When we probed through the targets of Group 1 in the second EESA probe, he correctly echoed the word “ah” again (see Figure 9).

Phase 6. The second part of this intervention required, on average, fewer trials to mastery. He completed Phase 6 in eight sessions.

Phase 7. Based on Trevor’s performance in the previous phase, we removed the most-to-least prompting in Phase 7; he responded incorrectly only once across the two sessions.

Phase 8. We continued without the prompts again for Phase 8. He responded incorrectly on three of the nonmatching trials in the first session, but then mastered this phase in the following three sessions.

Generalization Test 1. The first generalization test consisted of two novel words, “cup” and “dog.” Although we originally included three words in the pilot study generalization tests, the addition of the third word may have increased the difficulty of those tests. Trevor touched the circle across all twelve trials of the test, indicating that he had not yet acquired generalized auditory matching for words.

Phase 9. Like the pilot study, Phase 9 simply involved teaching the words “cup” and “dog” to mastery. Because Trevor performed at 50% accuracy on the generalization test, we reinstated the most-to-least prompting. He mastered this phase in seven sessions.

Generalization Test 2. The second generalization test included the words “three” and “chair.” Trevor responded incorrectly on only one of the matching trials, meeting the mastery criterion with 92% correct.

Echoic Probe 3. Aside from the words “ah” and “buh,” we did not observe any further increase in echoics across the remaining phases. Therefore, we again stopped the probe after Group 1 of the EESA. Trevor’s performance maintained with one correct echoic for the word “ah” (see Figure 9).

Discussion (Trevor)

Although Trevor did not achieve a generalized echoic repertoire, he did acquire four echoic sounds. Two of those echoics, “ah” and “buh,” were demonstrated before he had begun his facial imitation training. Additionally, they occurred in the early phases of the auditory matching intervention (between Phases 2 and 4), like the previous three studies. This may have contributed to his performance in his other procedure, where he also acquired the sounds “mmm” and “oh.”

Trevor acquired a generalized word-matching repertoire in 113 sessions, spending a significantly longer amount of time in the intervention than the previous participants. This may be due to his poor auditory discrimination skills discussed at the beginning of this study. Yet despite the length of time that it took for him to complete the intervention, he still acquired the ability to discriminate sounds and words. Hopefully, this will advance his progress in future listener responding programs, as he began responding to his name towards the end of this intervention.

This fourth study offered an alternative prompting method to Studies 1 and 2, although it remains unclear as to which is most effective. Physical prompting, along with visual prompts, may be the more appropriate option for students like Neil and Trevor, who have trouble inhibiting a response on the $S^{\triangle}$ trials. However, we also noticed that Trevor, like Matt, would engage in superstitious behavior upon hearing a nonmatching sound. This again appeared to be correlated with the inhibition of an incorrect response, though the superstitious behavior did not occur as reliably as it did with Matt. Why superstitious behavior improves students’ performance remains unclear.

Study 5: Christopher

History

Christopher received a score of 1.5 on the echoics section of the VB-MAPP; he correctly echoed the word “ah” and partially echoed the word “wow.” He could also spontaneously emit at least 10 different speech sounds, some of which were whole-word approximations. His strengths included physical imitation and VP/MTS, as he could imitate novel actions and could match 15 identical objects or pictures in a disordered array of eight. However, one of his key weaknesses was listener responding. He could not follow vocal directions or receptively identify objects; two graduate students within the classroom had previously attempted to teach these skills, without success. Christopher could reliably respond to his name and attend to a speaker's voice, however. He did not receive instruction in echoics while participating in this intervention.

Setting and Materials

Sessions with Christopher occurred in the hallway outside of his general classroom. Given that his preferred reinforcers were in this location, conducting sessions within the same area was much easier for the researchers. He was provided with an edible reinforcer and a 1 min break after each correct response, where he would engage in various activities, such as riding a bike or playing tag.

In Phases 4 and 5 of this procedure, we used a 2nd Generation Amazon Echo speaker to increase the volume of the sounds.

Method

Procedure Modifications. Initially, no procedure modifications were implemented for this study. However, we made several changes in Phase 4 to troubleshoot Christopher's lack of progress (see Figure 11). These changes included reinforcing compliance with blocked responses and the addition of a speaker in Phase 4 (see Phases 3 and 4 in Results section for further explanation).

Prompting. On session 53, we implemented the visual-prompting method that was used in Study 2 (see Figure 11). This method was eventually removed in the next phase, as it was not effective for Christopher.

Results

Echoic Probe 1. Christopher's baseline echoic probe was conducted in a single day. Due to high levels of problem behavior while testing Group 1, we terminated the probe after five targets. He correctly echoed one word, "ah".

Phase 1. Christopher only required one initial prompt during the first session of Phase 1 (see Figure 11).

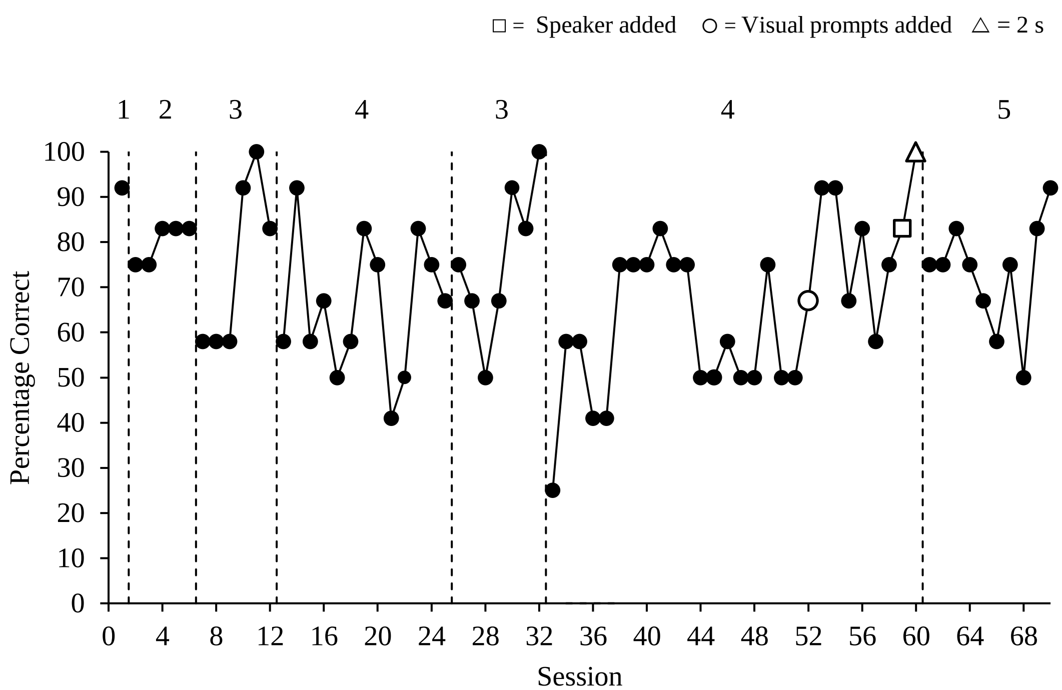

Figure 11. Christopher's auditory matching data. The different symbols refer to modifications in the intervention to help him progress through Phase 4.

Phase 2. Christopher responded with 75% accuracy across the first two sessions of Phase 2, incorrectly touching the circle on three of the no-sound trials. His performance improved by one response in the following three sessions, however, and he mastered the phase with 83% accuracy.

Phase 3. On the first three sessions of Phase 3, Christopher performed with 58% accuracy, responding across most of the nonmatching sounds. His percentage increased to 92% in the following session, and he completed this phase in six sessions.

Phase 4. Although he achieved a 92% on the second session of Phase 4, Christopher's performance dropped to 58% in the third session; then his responding fluctuated between 58% and 83% over the next ten sessions. Most of the incorrect responses within this phase occurred in the presence of the nonmatching sounds. After 13 sessions with no progress, we returned to Phase 3 to reteach the nonresponse in the presence of nonmatching sounds.

Return to Phase 3. Christopher mastered this phase again, after seven sessions.

Return to Phase 4, with modifications. Upon returning to Phase 4, Christopher responded correctly on only three of the trials in the first session. We also encountered problem behavior whenever we attempted to block an incorrect response—presumably because blocking the response had become paired with a 20 s time-out at the end of the trial. To avoid future problem behavior and increase compliance with the response block, we only delivered a time-out when he touched the circle in the presence of the $S^{\triangle}$. However, if he complied with the response block that we provided and did not touch the circle, we continued to the next trial with no time-out. But we still recorded this as an incorrect response on the data sheet.

After eleven sessions with no progress, we implemented the visual-prompting method used with Neil, as both students struggled with inhibiting a response in the presence of the nonmatching sounds. Unfortunately, even with these modifications, Christopher was still not making progress after an additional 15 sessions. We implemented one additional change by linking an Amazon speaker to the iPad to increase the volume of the sounds (see session 60 in Figure 12). He responded with 83% accuracy on the first session with the speaker, and 100% accuracy on the next session. Upon completing that session, Christopher also said “bye” to us when he returned to the classroom. This was the first vocalization that we had heard since beginning the intervention.

Phase 5. We removed the visual prompts in Phase 5, as they did not improve responding in Phase 4. In the last two sessions of this phase, he performed at 83% and 92% accuracy. Unfortunately, he did not have the opportunity to master Phase 5 and continue with the intervention because of the COVID-19 pandemic.

Discussion (Christopher)

Although we were not able to conduct a second echoic probe, we anecdotally observed an increase in echoics since Christopher’s vocalizations in the last session of Phase 4 (where he said “bye” for the first time). And anecdotally, after that, he would echo an average of 5–10 words across most sessions of Phase 5. While we did not provide tangible or edible reinforcers for these vocalizations, we did deliver social praise and attention. Although this could have compromised the internal validity of the study (had we finished it), it was considered more important to prioritize a functional vocal repertoire. Moreover, much of Christopher’s problem behavior was reportedly maintained by adult attention; as many of his echoics within our sessions were heavily praised, this provided an alternative way for him to obtain that attention.

Like Caleb, Christopher experienced difficulties in Phase 4. This phase was arguably the most difficult of the intervention, possibly because it was the first to require a conditional discrimination from the student. Although the tone appears in both the S^D and $S^{\triangle}$ trials in Phase 3, students need only attend to the car horn in the $S^{\triangle}$ to correctly withhold the response. This may have been the case for Caleb and Christopher, both of whom acquired the simple discrimination between the tone (making a response) and the car horn (withholding a response) with relatively few issues. However, Phase 4 required them to make a conditional discrimination based on whether the sound was repeated, rather than the sound itself. Combining this with their history of withholding a response in the presence of the horn made this even more difficult. Although both students eventually mastered this phase, future replications should examine different ways to troubleshoot Phase 4 when students experience difficulties.

Across the three different variables added to Phase 4 (i.e., reinforcing blocking, incorporating a visual prompt, and using a speaker), the addition of the speaker produced the most rapid improvement in performance. Therefore, future replications might use a speaker to make the sounds more salient.

Study 6: Hector

History

Hector had received a zero on the echoic portion of his VB-MAPP assessment. However, he could spontaneously emit at least 5 different speech sounds and would attend to voices by making eye contact with the speaker. Additionally, he could imitate 15 different motor movements and matched at least 25 non-identical objects or pictures in a disordered array of 10. Like Trevor, he demonstrated very strong visual skills, but experienced difficulties with listener responding. He did not respond to his name or follow any vocal instructions.

Hector was also working on facial imitation with echoics at the time of this intervention. Given that this program was developed by his Speech-Language Pathologist, we decided to continue with the programming, despite the confounding variable. Our hope was that at least one of the interventions, if not both, would increase his echoics.

Setting and Materials

Like Trevor, sessions for Hector were originally conducted in the playroom, but were moved to the sound-insulated room during Phase 3A. Hector received an edible reinforcer, along with 15–20 s of a preferred video, for a correct response.

Method

Procedure Modifications. Procedure modifications were made in Phase 3 of this study (see Subphases 3A and 3B in Results section).

Prompting. The auditory prompting method of the pilot study was briefly introduced at the beginning of Phase 3, and then later removed within that same phase.

Results

Echoic Probe 1. Hector's baseline probe was conducted in a single day. We did not probe Groups 2 or 3 because he correctly echoed one word, and partially echoed eleven words in Group 1.

Phase 1. Hector failed to respond on four of the trials in the first session of Phase 1. He mastered the phase in the following two sessions (see Figure 12).

Phase 2. Hector responded across all of the no-sound and sound trials in the first two sessions. His performance increased to 92% accuracy in the following session, though it decreased again in sessions five and six. After a total of 11 sessions, he mastered Phase 2 with 83% accuracy across three consecutive sessions.

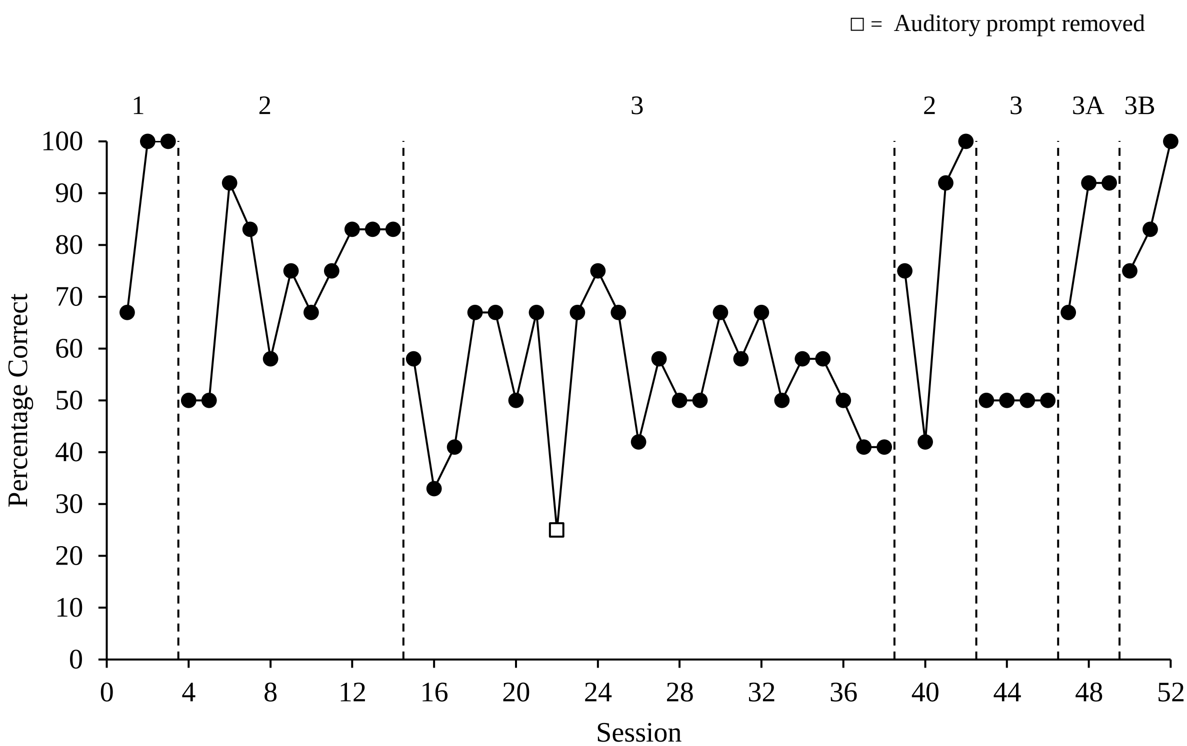

Figure 12. Hector's auditory matching data. The square symbol refers to the session where the auditory prompts were removed in Phase 3.

Phase 3. For Phase 3, we introduced the auditory prompts that were previously used in the pilot study. The first seven sessions included nonmatching sounds that were about a third of the volume of the tone. However, after noticing a lack of attending across most of the trials, we removed the auditory prompt in session 22 (see Figure 12). Responding maintained at the same level, even after the increase in volume. After 24 sessions without improvement and intermittent responding in presence of the S^D, we returned to Phase 2.

Return to Phase 2. Responding immediately increased after returning to Phase 2, except for session 40, where he responded correctly on only 42% of the trials. This decrease was attributed to a lack of attending, as his performance increased considerably in the following session. Within four sessions, Hector had mastered Phase 2 again; therefore, we returned to Phase 3.

Return to Phase 3. Hector responded on all of the trials, both the S^{D} as well as the $S^{\triangle}$, for four consecutive sessions. Assuming the tone, not the horn, was controlling his response in the nonmatching trials, we included an additional subphase without the tone in the $S^{\triangle}$.

Subphase 3A. This subphase continued with the tone for the matching trials, while the sound of the car horn and the sound of a train alternated in the nonmatching trials. Everything but the nonmatching sounds remained the same as Phase 3. Hector mastered this subphase in three sessions.

Subphase 3B. This subphase replaced the car horn with the tone in the nonmatching trials, so that the $S^{\triangle}$ consisted of the alternating tone/train sound. The tone continued as the matching sound. He again mastered this subphase in three sessions. Unfortunately, we could not continue with this intervention due to the COVID-19 pandemic.

Discussion (Hector)

Of the six participants, Hector and Trevor struggled the most with Phase 3; they were also the two students with the weakest auditory discrimination skills. Given that we did not observe a significant increase in Hector's—or Trevor's—vocalizations, auditory matching may not be an effective intervention for students with similar skill levels, at least regarding echoics. However, had we continued with the intervention, Hector's echoics might have increased after completing Phases 4 and 5. It is worth noting that both students relied heavily on visual cues within their environment to perform daily tasks; concentrating heavily on visual cues may make it less likely that the student will attend to auditory cues. But while this may not be an effective intervention for echoics, auditory matching could still be used to help students acquire simple and conditional auditory discriminations. One benefit to this intervention is that it removes visual cues from the environment and allows the practitioner more control over the volume and consistency of the sounds being trained. Additionally, the subphases in Phase 3 helped Hector acquire simple discriminations between two different sounds. Future research should explore ways to utilize the auditory matching procedure to help train basic and conditional sound discriminations for learners who struggle in this area.

GENERAL DISCUSSION

Preliminary results suggest that the go/no-go procedure is an effective method for teaching auditory matching, as well as improving echoic responses. Two students achieved a generalized echoic repertoire, one improved his articulation, and two additional students acquired at least some vocal imitation skills. However, it is difficult to compare our intervention with the AM protocol (Greer & Ross, 2008), given that we altered the variety and frequency of sound presentations within each phase, in addition to using a different word list to probe echoic responses. Future replications should explore a more direct comparison between the two methods, along with identifying prerequisite skills that may be needed for either intervention to be successful.

While we anticipated that echoics would increase as students progressed through the phases, we did not expect this to occur as early as it did for the participants. By Phase 5, and sometimes as early as Phase 3, there was an increase in echoics for five of the six children; and the one child whose echoics did not increase had only completed Phase 3 when the intervention ended. Although previous research on the AM protocol also reported an increase in echoics after training sound/word discriminations (Du et al., 2017), our intervention had only trained one matching discrimination by the time this occurred. It is somewhat encouraging that we observed functional improvements early in the procedure, especially for students like Christopher, who was unable to proceed to the word-training phases. Though it remains unclear why mastering one or two matching sounds would generalize to echoics, it nevertheless provides social validity for students who spend more time in the initial phases.

Across the six studies, there appears to be a negative relationship between the average number of sessions needed in each phase, and the number of echoics each student gained across the first two EESA probes (see Table 3). While this does not take into account different prompting methods or the early termination of the intervention in three of the studies, there does appear to be a noticeable difference between the students who spent an average of four sessions in each phase, and those who spent 14–17 sessions in a phase. Both Neil and Matt required the fewest number of sessions per phase, and both experienced the most substantial increase in their echoics. Christopher, Hector, and Trevor, on the other hand, required more than 13 sessions within each phase, and only reported an increase of one echoic, in Trevor's case (though it is difficult to estimate Christopher's increase, as we were unable to conduct the second EESA probe). Future replications should explore whether students like Neil, Matt, and Caleb have the prerequisite abilities that facilitate quicker mastery of auditory matching and greater improvements to their echoic repertoires, as a result.

Table 3

Comparison of Average Sessions per Phase and Number of Echoics Gained

	Neil	Matt	Caleb	Trevor	Christopher	Hector
Avg. sessions per phase	3	3.25*	3.5	13.88	14	17.333
Echoics Gained across 1st and 2nd probe	40	34	13	1	N/A	N/A

**Does not include Phase Six of the Pilot Study*

Several noteworthy observations occurred that future replications should explore. First, Trevor, Neil, Christopher, and Hector all had difficulty inhibiting the response on the $S^{\triangle}$ trials, even to the point that blocking a response often resulted in problem behavior (or ignoring the block altogether). With Christopher, there was, anecdotally, a 3–6 s difference in latency between the matching and nonmatching responses of touching the circle (the latter being the slower); this suggests that he was discriminating between the S^D and $S^{\triangle}$ trials, but perhaps had difficulty inhibiting the response in the $S^{\triangle}$. Serna et al. (1997) reported that one complication with the go/no-go method is that it "may introduce a response bias, typically towards 'going'" (p. 358). On the other hand, engaging in an alternative behavior, rather than a non-behavior, appeared to improve responding during the $S^{\triangle}$ trials; and both Matt and Trevor engaged in superstitious behaviors that almost always resulted in their abstaining from a response during the $S^{\triangle}$. With Caleb, tapping his feet to the $S^{\triangle}$ sounds also appeared to be correlated with abstaining from responding. Future replications, therefore, should explore teaching an alternative response for the $S^{\triangle}$.

Another area to explore is prompting methods and procedure modifications that can help students achieve success in the early phases of auditory matching. For example, the auditory prompts used in the pilot study worked well for Matt on Phases 3 and 4, though they were not effective for Hector; and the visual prompts that were effective for Neil in Study 2 were not helpful for Christopher in Study 4. As auditory prompts have rarely been utilized in other listener programs (perhaps because of the difficulty with keeping the sounds/words consistent across sessions), future studies should explore the use of technology to control and manipulate the presentation of those sounds. However, methods outside of prompting can also be used to facilitate progress on difficult phases; procedure modifications, such as those used with Hector, were effective in troubleshooting performance. One suggestion might be to utilize three sounds in either Phase 3 or Phase 4, as we did with Hector, so that the sound in the S^D does not also appear in the $S^{\triangle}$. The S^D can be reintroduced later to the $S^{\triangle}$, as it was with Hector, or it could be systematically faded into the S^{Δ} along some other dimension. The go/no-go auditory matching procedure offers many opportunities for future research.

Summary

The go/no-go procedure was found to be an effective method for teaching auditory matching, as well as inducing echoics and improving articulation in preschool children with language delays. Future research should compare the efficacy of this method to the AM protocol, to determine which will have the most significant impact for children with varying prerequisite abilities. Additionally, future research could examine the predictive value of an auditory matching task on future auditory discrimination skills.

REFERENCES

Brown, M. C. (2005). *The effects of the acquisition of a generalized auditory word match-to-sample repertoire on the echoic repertoire under mand and tact conditions* [Unpublished doctoral dissertation]. Columbia University.

Centers for Disease Control and Prevention, National Center on Birth Defects and Developmental Disabilities. (2019, August 27). *Signs and symptoms of autism spectrum disorders.* https://www.cdc.gov/ncbddd/autism/signs.html

Choi, J., Greer, R. D., & Keohane, D.-D. (2015). The effects of an auditory match-to-sample procedure on listener literacy and echoic responses. *Behavioral Developmental Bulletin, 20*(2), 186–206. https://psycnet.apa.org/fulltext/2015-46463-001.pdf

Debert, P., Matos, M. A., & McIlvane, W. (2007). Conditional relations with compound abstract stimuli using a go/no-go procedure. *Journal of the Experimental Analysis of Behavior, 87*(1), 89–96. https://doi.org/10.1901/jeab.2007.46-05

Du, L., Speckman, J., Medina, M., & Cole-Hatchard, M. (2017). The effects of an auditory matching iPad app on three preschoolers' echoic and listener responses. *Behavior Analysis in Practice, 10*(2), 118–130. https://doi.org/10.1007/s40617-017-0174-z

Green, G. (2001). Behavior analytic instruction for learners with autism: Advances in stimulus control technology. *Focus on Autism and Other Developmental Disabilities, 16*(2), 72–85. https://psycnet.apa.org/doi/10.1177/108835760101600203

Greer, R. D., & Keohane, D.-D. (2006). The evolution of verbal behavior in children. *The Journal of Speech and Language Pathology –Applied Behavior Analysis, 1*(2), 111–140. http://dx.doi.org/10.1037/h0100194

Greer, R. D., & Ross, D. (2004). Verbal behavior analysis: A program of research in the induction and expansion of complex verbal behavior. *Journal of Early and Intensive Behavior Intervention, 1*(2), 141–165. https://pdfs.semanticscholar.org/041c/3c93c3a09168680cbd1e4a17aa4b2d543442.pdf

Greer, R. D., & Ross, D. E. (2008). *Verbal behavior analysis: Inducing and expanding new verbal capabilities in children with language delays.* Pearson Education.

Harapiak, S., Martin, G., & Yu, D. (1999). Hierarchical ordering of auditory discriminations and the Assessment of Basic Learning Abilities test. *Journal on Developmental Disabilities, 6*(2), 32–50.

Lovaas, O. I. (1987). Behavioral treatment and normal educational and intellectual functioning in young autistic children. *American Psychological Association*, *55*(1), 3–9. https://www.beca-aba.com/articles-and-forms/lovaas-1987.pdf

Marion, C., Vause, T., Harapiak, S., Martin, G. L., Yu, C. T., Sakko, G., & Walters, K. L. (2003). The hierarchical relationship between several visual and auditory discriminations and three verbal operants among individuals with developmental disabilities. *The Analysis of Verbal Behavior, 19*, 91–105. https://doi.org/10.1007/bf03392983

Salem, S. (2012). *Teaching auditory-auditory identity matching to persons with developmental disabilities and children with autism* (Publication No. 1316931403) [Doctoral dissertation, University of Manitoba]. ProQuest Dissertations and Theses Global.

Salem, S., Martin, T., Martin, G., Yu, C. T., Dodson, L., & Wightman, J. (2014). Teaching auditory-auditory identity matching to persons with intellectual disabilities and children with autism: A pilot study. *Journal on Developmental Disabilities*, *20*(3), 57–70. http://oadd.org/wp-content/uploads/2014/01/41019_JoDD_57-70_v13f_Salem_et_al.pdf

Serna, R. W., Dube, W. V., & McIlvane, W. J. (1997). Assessing same/different judgments in individuals with severe intellectual disabilities: A status report. *Research in Developmental Disabilities*, *18*(5), 343–368. https://doi.org/10.1016/s0891-4222(97)00015-2

Sewell, T. (2006). *A comparison of methods to teach auditory-auditory identity matching to persons with developmental disabilities* (Publication No. 621570311) [Doctoral dissertation, University of Manitoba]. ProQuest Dissertations and Theses Global.

Skinner, B. F. (1957). *Verbal behavior.* Copley.

Speckman-Collins, J. M., Lee Park, H.-S., & Greer, R. D. (2007). Generalized selection-based auditory matching and the emergence of the listener component of naming. *Journal of Early and Intensive Behavioral Intervention*, *4*(2), 412–429. http://dx.doi.org/10.1037/h0100382

Sundberg, M. L. (2014). *The verbal behavior milestones assessment and placement program: The VB-MAPP* (2nd ed.). AVB Press.

Thurman, H. O. (2009). *Assessment of delayed matching in preschoolers with autism* (Publication No. 1489238) [Master's thesis, Northeastern University]. ProQuest Dissertations and Theses Global.

Vause, T., Harapiak, S. M., Martin, G. L., & Yu, C. T. (2003). Predictive validity of auditory discriminations in persons with intellectual disabilities: Extending the ABLA test. *Journal on Developmental Disabilities*, *10*(1), 21–34.

Vause, T., Martin, G. L., & Yu, D. C. T. (2000). ABLA test performance, auditory matching, and communication ability. *Journal on Developmental Disabilities*, *7*(2), 123–141.

Williams, G., & Greer, R. D. (1993). A comparison of verbal-behavior and linguistic-communication curricula for training developmentally delayed adolescents to acquire and maintain vocal speech. *Behaviorology*, *1*, 31–46.

Appendix A

Approval from WMU Human Subjects Institutional Review Board

WESTERN MICHIGAN UNIVERSITY

Institutional Review Board
FWA00007042
IRB00000254

Date: November 20, 2019

To: Kelly Kohler, Principal Investigator
Richard Malott, Co-Principal Investigator
Clare Christe, Student Investigator
Marquin Evans, Student Investigator

From: Amy Naugle, Ph.D., Chair

Re: IRB Project Number 19-11-06

This letter will serve as confirmation that your research project titled "Establishing Auditory Discrimination and Echoic Stimulus Control with an Auditory Matching Procedure" has been **approved** under the **exempt** category of review by the Western Michigan University Institutional Review Board (IRB). The conditions and duration of this approval are specified in the policies of Western Michigan University. You may now begin to implement the research as described in the application.

Please note: This research may **only** be conducted exactly in the form it was approved. You must seek specific board approval for any changes to this project (e.g., ***add an investigator, increase number of subjects beyond the number stated in your application, etc.***). Failure to obtain approval for changes will result in a protocol deviation.

In addition, if there are any unanticipated adverse reactions or unanticipated events associated with the conduct of this research, you should immediately suspend the project and contact the Chair of the IRB for consultation.

The Board wishes you success in the pursuit of your research goals.

A status report is required on or prior to (no more than 30 days) November 19, 2020 and each year thereafter until closing of the study. The IRB will send a request.

When this study closes, submit the required Final Report found at https://wmich.edu/research/forms.

Note: All research data must be kept in a secure location on the WMU campus for at least three (3) years after the study closes.

Office of the Vice President for Research
Western Michigan University
1903 W. Michigan Ave., Kalamazoo, MI 49008-5456
PHONE: (269) 387-8293 FAX: (269) 387-8276
WEBSITE: wmich.edu/research/compliance/hsirb

Appendix B

Phase Two Data Sheet (Versions A and B)

Name: **Procedure: Auditory Matching** **Mastery criteria: 80% for 3. 90% for 2**

Phase: __2A__ Prompt: ____________________

Trial	Target	Data	Correction	Date
1	No sound			
2	Sound		P F	Initials
3	No sound			
4	No sound			WB / MC
5	Sound			N/A
6	No sound		P F	PC?
7	Sound		P F	Y / N
8	No sound			Code:
9	Sound		P F	
10	No sound			
11	Sound		P F	
12	Sound		P F	
	%:		WB:	MC:

Phase: __2B__ Prompt: ____________________

Trial	Target	Data	Correction	Date
1	Sound		P F	
2	No sound			Initials
3	Sound		P F	
4	No sound			WB / MC
5	Sound		P F	N/A
6	No sound			PC?
7	No sound			Y / N
8	Sound		P F	Code:
9	No sound			
10	Sound		P F	
11	No sound			
12	Sound		P F	
	%:		WB:	MC:

Phase: __2B__ Prompt: ____________________

Trial	Target	Data	Correction	Date
1	Sound		P F	
2	No sound			Initials
3	Sound		P F	
4	No sound			WB / MC
5	Sound		P F	N/A
6	No sound			PC?
7	No sound			Y / N
8	Sound		P F	Code:
9	No sound			
10	Sound		P F	
11	No sound			
12	Sound		P F	
	%:		WB:	MC:

Phase: __2A__ Prompt: ____________________

Trial	Target	Data	Correction	Date
1	No sound			
2	Sound		P F	Initials
3	No sound			
4	No sound			WB / MC
5	Sound			N/A
6	No sound		P F	PC?
7	Sound		P F	Y / N
8	No sound			Code:
9	Sound		P F	
10	No sound			
11	Sound		P F	
12	Sound		P F	
				MC:

Phase: __2B__ Prompt: ____________________

Trial	Target	Data	Correction	Date
1	Sound		P F	
2	No sound			Initials
3	Sound		P F	
4	No sound			WB / MC
5	Sound		P F	N/A
6	No sound			PC?
7	No sound			Y / N
8	Sound		P F	Code:
9	No sound			
10	Sound		P F	
11	No sound			
12	Sound		P F	
	%:		WB:	MC:

Phase: __2A__ Prompt: ____________________

Trial	Target	Data	Correction	Date
1	No sound			
2	Sound		P F	Initials
3	No sound			
4	No sound			WB / MC
5	Sound			N/A
6	No sound		P F	PC?
7	Sound		P F	Y / N
8	No sound			Code:
9	Sound		P F	
10	No sound			
11	Sound		P F	
12	Sound		P F	
	%:		WB:	MC:

Phase: __2B__ Prompt: ____________________

Trial	Target	Data	Correction	Date
1	Sound		P F	
2	No sound			Initials
3	Sound		P F	
4	No sound			WB / MC
5	Sound		P F	N/A
6	No sound			PC?
7	No sound			Y / N
8	Sound		P F	Code:
9	No sound			
10	Sound		P F	
11	No sound			
12	Sound		P F	
	%:		WB:	MC:

Phase: __2B__ Prompt: ____________________

Trial	Target	Data	Correction	Date
1	Sound		P F	
2	No sound			Initials
3	Sound		P F	
4	No sound			WB / MC
5	Sound		P F	N/A
6	No sound			PC?
7	No sound			Y / N
8	Sound		P F	Code:
9	No sound			
10	Sound		P F	
11	No sound			
12	Sound		P F	
	%:		WB:	MC:

Phase: __2A__ Prompt: ____________________

Trial	Target	Data	Correction	Date
1	No sound			
2	Sound		P F	Initials
3	No sound			
4	No sound			WB / MC
5	Sound			N/A
6	No sound		P F	PC?
7	Sound		P F	Y / N
8	No sound			Code:
9	Sound		P F	
10	No sound			
11	Sound		P F	
12	Sound		P F	
	%:		WB:	MC:

1/12 = .08% 2/12=17% 3/12 = 25% 4/14= 33% 5/12 = 41%. 6/12 = 50%. 7/12 = 58% 8/12 = 67& 9/12 = 75%. 10/12 =

Appendix C

Treatment Integrity Data Sheets

Auditory Matching Treatment Integrity

Portion	Task	1	2	3	4	5	6	7
Before	Booth is clear of toys/clutter							
	Ipad is placed on desk in front of student							
	Tutor establishes attending							
Correct	**Sd:** Edible/tanglble reinforcer is delivered immediately after student presses button in presence of sound							
	S-delta: No reinforcer is delivered if student does not respond to s-delta; tutor proceeds to next trial							
Incorrect	**Sd**: Student is physically prompted to touch button after 8 seconds and no reinforcer is provided during 20 s timeout							
	S-delta: Student's responses are blocked for entire trial and no reinforcer/attention is provided during 20 s timeout							
Data	Collects Data on every trial (doesn't try to remember)							
	Records designated prompt level during session							

EESA Probes Treatment Integrity (All Phases)

Portion	Task	Treratme
Before	Booth is clear of toys/clutter	
	Tutor conducts forced choice preference assessment (edibles & tangibles) before session	
	Tutor conducts additional preference assessments as needed throughout session	
	Tutor establishes attending (eye contact)	
Sd	Tutor delivers Sd in neutral tone	
	Tutor only conducts echoic trials	
After	**Correct, incorrect or no response:** No reinforcer (edible/tangible/social praise) is delivered	
	Tutor implements mixed trialing (provides reinforcement contingent on correct responding for FLOs)	
Data	Collects Data on every trial (doesn't try to remember)	

Notes:

Appendix D

Data Sheet for Matt's Sound Generalization Test

Name: ____________ **Procedure: Auditory Matching** **Mastery criteria: 80% for 3. 90% for 2**

Phase: __Generalized Sound Test				
Trial	Target	Data	Correction	Date
1	Horn/Train		P F	
2	Train/Train			Initials
3	Train/Horn		P F	
4	Horn/Horn			WB / MC
5	Train/Phone		P F	N/A
6	Train/Train			PC?
7	Phone/Horn		P F	Y / N
8	Phone/Phone			Code:
9	Horn/Horn			
10	Phone/Train		P F	
11	Phone/Phone		P F	
12	Horn/Phone			
	%:		WB:	MC:

Phase: __Generalized Sound Test				
Trial	Target	Data	Correction	Date
1	Horn/Train		P F	
2	Train/Train			Initials
3	Train/Horn		P F	
4	Horn/Horn			WB / MC
5	Train/Phone		P F	N/A
6	Train/Train			PC?
7	Phone/Horn		P F	Y / N
8	Phone/Phone			Code:
9	Horn/Horn			
10	Phone/Train		P F	
11	Phone/Phone		P F	
12	Horn/Phone			
	%:		WB:	MC:

Phase: __Generalized Sound Test				
Trial	Target	Data	Correction	Date
1	Horn/Train		P F	
2	Train/Train			Initials
3	Train/Horn		P F	
4	Horn/Horn			WB / MC
5	Train/Phone		P F	N/A
6	Train/Train			PC?
7	Phone/Horn		P F	Y / N
8	Phone/Phone			Code:
9	Horn/Horn			
10	Phone/Train		P F	
11	Phone/Phone		P F	
12	Horn/Phone			
	%:		WB:	MC:

Phase: __Generalized Sound Test				
Trial	Target	Data	Correction	Date
1	Horn/Train		P F	
2	Train/Train			Initials
3	Train/Horn		P F	
4	Horn/Horn			WB / MC
5	Train/Phone		P F	N/A
6	Train/Train			PC?
7	Phone/Horn		P F	Y / N
8	Phone/Phone			Code:
9	Horn/Horn			
10	Phone/Train		P F	
11	Phone/Phone		P F	
12	Horn/Phone			
	%:		WB:	MC:

Phase: __Generalized Sound Test				
Trial	Target	Data	Correction	Date
1	Horn/Train		P F	
2	Train/Train			Initials
3	Train/Horn		P F	
4	Horn/Horn			WB / MC
5	Train/Phone		P F	N/A
6	Train/Train			PC?
7	Phone/Horn		P F	Y / N
8	Phone/Phone			Code:
9	Horn/Horn			
10	Phone/Train		P F	
11	Phone/Phone		P F	
12	Horn/Phone			
	%:		WB:	MC:

Phase: __Generalized Sound Test				
Trial	Target	Data	Correction	Date
1	Horn/Train		P F	
2	Train/Train			Initials
3	Train/Horn		P F	
4	Horn/Horn			WB / MC
5	Train/Phone		P F	N/A
6	Train/Train			PC?
7	Phone/Horn		P F	Y / N
8	Phone/Phone			Code:
9	Horn/Horn			
10	Phone/Train		P F	
11	Phone/Phone		P F	
12	Horn/Phone			
	%:		WB:	MC:

Phase: __Generalized Sound Test				
Trial	Target	Data	Correction	Date
1	Horn/Train		P F	
2	Train/Train			Initials
3	Train/Horn		P F	
4	Horn/Horn			WB / MC
5	Train/Phone		P F	N/A
6	Train/Train			PC?
7	Phone/Horn		P F	Y / N
8	Phone/Phone			Code:
9	Horn/Horn			
10	Phone/Train		P F	
11	Phone/Phone		P F	
12	Horn/Phone			
	%:		WB:	MC:

Phase: __Generalized Sound Test				
Trial	Target	Data	Correction	Date
1	Horn/Train		P F	
2	Train/Train			Initials
3	Train/Horn		P F	
4	Horn/Horn			WB / MC
5	Train/Phone		P F	N/A
6	Train/Train			PC?
7	Phone/Horn		P F	Y / N
8	Phone/Phone			Code:
9	Horn/Horn			
10	Phone/Train		P F	
11	Phone/Phone		P F	
12	Horn/Phone			
	%:		WB:	MC:

Phase: __Generalized Sound Test				
Trial	Target	Data	Correction	Date
1	Horn/Train		P F	
2	Train/Train			Initials
3	Train/Horn		P F	
4	Horn/Horn			WB / MC
5	Train/Phone		P F	N/A
6	Train/Train			PC?
7	Phone/Horn		P F	Y / N
8	Phone/Phone			Code:
9	Horn/Horn			
10	Phone/Train		P F	
11	Phone/Phone		P F	
12	Horn/Phone			
	%:		WB:	MC:

1/12 = .08% 2/12=17% 3/12 = 25% 4/14= 33% 5/12 = 41% 6/12 = 50%. 7/12 = 58% 8/12 = 67& 9/12 = 75%. 10/12 = 83% 11/12 = 92%