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Teaching Children Who Have Difficulty Mastering Auditory Discriminations

Sarah Lichtenberger
Western Michigan University, sarah.lichtenberger@gmail.com

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TEACHING CHILDREN WHO HAVE DIFFICULTY MASTERING AUDITORY DISCRIMINATIONS

by

Sarah Lichtenberger

A dissertation submitted to the Graduate College in partial fulfillment of the requirements for the degree of Doctor of Philosophy Department of Psychology Western Michigan University April 2016

Doctoral Committee:

Richard, W. Malott, Ph.D, Chair
Jessica Frieder, Ph.D.
Steven Ragtozy, Ph. D.
Carmen Jonaitis, Ed.D.
TEACHING CHILDREN WHO HAVE DIFFICULTY MASTERING AUDITORY DISCRIMINATIONS

Sarah Lichtenberger, Ph.D.

Western Michigan University, 2016

Simple and conditional visual and auditory discrimination repertoires are critical components of many skills necessary for daily functioning, including communication, academic, and daily-living skills (Green, 2001). When auditory discrimination is not under instructional stimulus control, it can result in delayed acquisition of new skills and limit academic progress. The purpose of this study was to teach auditory discrimination to children with autism who had little to no progress on classroom procedures that required auditory discrimination, such as selecting an object from an array when given the name of the object as the direction. Auditory discrimination was taught starting with teaching a particular motor response in the presence of an environmental sound, then slowly introducing other sound and response pairings. We used a variety of teaching methods based on the learners’ progress (e.g., trial-and-error, shaping, and physical prompts). This set of interventions was implemented with three children enrolled in an early elementary special education classroom and were not demonstrating auditory discrimination under instructional stimulus control. Two children mastered the discrimination between a sound \( S^D \) and no-sound \( S^\Delta \) and the discrimination between a
sound $S^D$ and sound $S^A$. One child discriminated between three auditory $S^D$s, but did not maintain over time.
ACKNOWLEDGEMENTS

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Sarah Lichtenberger
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Early intensive behavioral intervention (EIBI), which typically involves discrete-trial training, is an effective treatment for children diagnosed with an Autism Spectrum Disorder (ASD; Weiss, 1999; Green, 1996; Lovaas, 1987). Previous studies have found that approximately 50% of children who receive EIBI achieve normal functioning and are able to return to mainstream education (Sallows & Graupner, 2005; Lovaas, 1987; Birnbrauer & Leach, 1993). Additionally, 40% make some progress and are able to move to less restrictive environments, while 10% show little to no improvement in skills (Lovaas, 1987). Two of the fundamental skills these children may have difficulty acquiring are discriminating auditory and visual stimuli (Green, 1996). Auditory discrimination is a necessary part of many other skills, including academic, daily living, and communication (Green, 2001).

Auditory discrimination is necessary for receptive language, giving children the ability to discriminate between words or sounds. Receptive language refers to the ability to respond to spoken language (Grow & LeBlanc, 2013). A deficit in receptive language may result in these children being unable to progress to less structured classrooms, to progress academically, and to acquire other language skills (Grow & LeBlanc, 2013; Hart & Risley 1992; Drash & Tudor, 1993; Lovaas, 1977). Approximately 10% of the children in our Early Childhood Special Education (ECSE) preschool classroom had been there for at least a year and either did not have the prerequisites for those procedures or had not
demonstrated success with the standard classroom procedures (e.g., receptive identification or direction-following), even with multiple interventions and prompting methods.\(^1\)

Though the discrimination skills needed in receptive identification and other receptive language tasks appear simple, they are actually composed of multiple discriminations, which may result in faulty stimulus control. First, there is the discrimination between the \(S^{D_i}\)s that is required in order to make a successive discrimination (Saunders & Spradlin, 1993). For example, with receptive identification, an array of objects is placed on the table (e.g., doll, car, and phone), and the direction “touch car” is given. The child must discriminate between the directions of “touch car”, “touch doll”, and “touch phone”, which are all presented in the session. Then there is a simultaneous discrimination between corresponding stimuli in the array (e.g., doll, car, and phone; Saunders & Spradlin, 1993). If either of these discriminations is faulty, it will affect responding in the procedure and the child’s progress toward acquisition of the skill.

A variety of methods for teaching receptive language have been examined, using both auditory-visual conditional discriminations (e.g., receptive identification), and simple-auditory discriminations (e.g., following directions; Geiger et al., 2012; Kodak, Clements, & LeBlanc, 2013; Grow, Carr, Kodak, Jostad, & Kisamore, 2011; Carp, Peterson, Arkel, & Petursdottir, 2012; Walker & Martin, 1994; Gutierrez Jr., Hale, O’Brien, Fisher, Durocher, Alessandri, 2009; Conyers, Martin, Yu, & Vause, 2000; Walker, Lin, & Martin, 1994; Greer & Ross 2007; Whitman, Zakara, Chardos, 1971; Dehaven, 1981). While the methods are usually effective, they may not be appropriate for

\(^1\) Based on the 33 children who were enrolled in the classroom between September and December 2015.
children with limited skills. One method frequently used to teach simple directions (e.g., sit down, stand up, clap your hands) involves a model prompt (Dehaven, 1981; Striefel, Bryan, & Aikins, 1974), however this method is difficult to use with children who do not have generalized imitation, and who do have limited attending skills.

In their recommendations for teaching receptive language, Grow and LeBlanc (2013) suggested requiring an observing response (e.g., echoing the vocal-verbal S\textsuperscript{D}). However, some of the children in the bottom 10% of performers do not demonstrate the most basic discrimination skills, making the teaching of an observing response difficult, as it may add to the complexity of the task. For example, they may be unable to vocally imitate, so teaching them to repeat the direction after it is given would not be possible.

Greer and Ross (2007) found using an auditory-matching procedure was successful for teaching auditory discriminations. However, this may be a difficult task for a child with inconsistent visual discrimination and scanning, and who has limited-attending skills, as the intervention requires an extended attending response to all of the sounds presented and a selection response between the two buttons.

When teaching auditory discriminations, Green (2014) recommended removing visual stimuli from the environment and teaching a motor response with each sound, as she suggested that would increase the probability that the child would attend to the relevant stimuli. This method may be helpful for children with limited repertoires as slow acquisition may be a result of not having the component simple discriminations (e.g., between sounds; Green, 2014). Green taught the discrimination between two sounds by training a different response in the presence of each sound using errorless learning (2014). However, the discrimination between two sounds is still complex, and may be
difficult for children with limited skills. Teaching the discrimination between sound and no sound may be easier and may facilitate the acquisition of later discriminations.

This study was an effort to find effective methods to teach the 10% of children who make minimal progress. We used a modification of the method described by Green (2014), with children who had difficulty with visual and auditory discriminations by starting with discrimination between sound and no sound, which is described in the following sections.

**General Method**

**Participants**

The three children who participated in the study were five years old and were enrolled in an early-elementary autism-spectrum-disorder classroom. They had been previously enrolled in the early childhood special education (ECSE) preschool classroom for three years, where they received discrete-trial training for three hours a day, five days a week. Eric² and Wendy had some minimal physical imitation, but not generalized imitation. Ariel had mastered visual matching-to-sample and had generalized matching, but did not have any physical imitation. Eric did not have success with any of the visual matching-to-sample procedures; Wendy had mastered the classroom three-dimensional matching-to-sample procedure, but the skills did not maintain or generalize to other objects or pictures. Their slow progress in the ECSE classroom resulted in minimal exposure to procedures requiring auditory discrimination skills (e.g., following directions, identifying objects).

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² Pseudonyms used to protect children’s privacy.
Settings and Materials

Sessions were conducted in a work area separate from the regular early childhood special education classroom. The sounds were recorded on a Learning Resources® Talk Point button or a BIGmack Communicator®. Each sound was recorded for 10 s. Edible reinforcers were selected using a paired-choice preference assessment for all three children (Fisher, et al., 1992).

Interobserver Agreement

Undergraduate research assistants collected interobserver-agreement data for 51.9% of all sessions with a mean agreement of 98.1% and a session range of 70% to 100%. Interobserver agreement for Eric was a mean agreement of 99.5% for 62.9.4% of sessions. For Wendy, the mean agreement was 97.6% for 37.1% of sessions. The mean agreement for Ariel was 97.3% for 57.1% of sessions.

Auditory-Visual Matching-to-Sample

When children in the ECSE classroom were unsuccessful with the regular receptive language training procedures (e.g., following directions or receptive identification), or were demonstrating slow progress, an auditory-visual matching-to-sample procedure that utilized environmental sounds was implemented (Chow, 2010). The procedure was used to facilitate receptive identification by first training sound discriminations. Children are taught to match sounds to objects. In the first phase two objects were placed on the table (a squeaky frog and tambourine). One of the corresponding sounds was played out of sight of the child (e.g., the tambourine). If the
child selected the corresponding comparison stimulus (e.g., the tambourine), the reinforcer was presented. If the child selected the incorrect stimulus (e.g., the squeaky frog), the stimuli were removed and the next trial was started.

If the child acquired four different sound/object pairs, words were introduced. One new object presented with the previously mastered objects and a word discriminative stimulus (S<sup>D</sup>) was intermixed with the previously mastered sounds. Ten sessions of the first phase of the procedure were conducted for all three children. If the child had demonstrated acquisition during the auditory-visual matching-to-sample procedure, he/she would have been excluded from the study and the procedure would have been implemented during his/her daily academic schedule.

All three children failed to discriminate to acquire the conditional auditory-visual discrimination, either showing a side bias (e.g., always selecting the item on the left side of the table) or an item bias (e.g., always selecting the frog). Because they did not master the conditional discrimination we started with a simpler discrimination between a sound S<sup>D</sup> and no-sound S<sup>A</sup>, to simplify the task even further, and remove the visual discrimination.

**PARTICIPANT 1: ERIC**

**Phases**

**Phase 1**

Eric’s highest score with the auditory-visual matching-to-sample procedure was 50%; he consistently selected the frog on each trial (see Figure 1 and Appendices A and B for this and all subsequent phases).
Figure 1. Number of sessions in each subphase within each phase with successful subphases (light gray patterned bar) and unsuccessful subphases (dark solid bar).
After the auditory-visual matching-to-sample training, we taught the discrimination between sound (piano sound) and no sound. The piano-sound S_D was presented for 10 s followed by 10 s without a sound presented, S_Δ (delta stimulus). The two conditions were alternated for a total of 20 trials per session (this method was used in all subsequent sound and no-sound conditions). The response of tapping the table was reinforced in the presence of the S_D. If Eric tapped the table in the S_Δ condition, the 10 s were restarted until he did not respond during the 10 s S_Δ. The phase change criteria were 80% or greater for three consecutive sessions and 90% or greater for two consecutive sessions for this phase of training, and all subsequent phases. Shaping was initially used to train the response of tapping the table in the presence of the piano sound. He had previously demonstrated physical prompt dependency with classroom procedures when least-to-most prompting was used and he did not have a reliable imitative repertoire. Any instance of touching the table was reinforced in the presence of the piano sound. However, his responding decreased to zero over seven sessions.

We then used physical prompting to train the response of tapping the table in the presence of the S_D, but used within-session prompt fading to reduce the chance of prompt dependency. Each prompt level was used for two trials within the session (i.e., two prompts at the hand, two at the wrist, two at the forearm, two at the back arm, and two trials without a prompt). Once independent responding was observed in the piano-sound condition, prompting was started at a less-intrusive prompt level (e.g., two prompts at the forearm, two at the back of the arm, and six trials without a prompt). This prompt-fading procedure was used to train all subsequent sounds. After three sessions with prompting, we tested independent responding, but responding in the piano-sound condition decreased
to zero after nine sessions. Within-session prompt fading was again introduced for three sessions. When prompts were removed, Eric responded 100% of the time in the piano-sound condition, and did not respond more than 30% of the time in the no-sound condition.

Phase 2

An $S^\Delta$ (maraca sound) was presented in this phase. Trials alternated between the piano-sound $S^D$ and maraca-sound $S^\Delta$. Tapping the table was reinforced in the presence of the piano sound, but not in the presence of the maraca sound. Eric mastered the discrimination between the piano sound and maraca sound after five sessions.

Phase 3

The maraca sound was now an $S^D$ for the response of clapping, while the piano sound remained the $S^D$ for tapping the table. The two sounds were randomly alternated, with 10 trials of each sound. Physical prompting with within-session fading was used for the response of clapping for five sessions, as in Phase 1. When prompts were removed, Eric scrolled between the two responses of tapping the table and clapping hands when the maraca sound was playing, but continued to consistently tap the table in the presence of the piano sound.

Phase 4

We attempted to train the response of clapping hands by presenting the maraca sound with no sound as the $S^\Delta$, but had difficulty removing the physical prompts. The
difficulty gaining stimulus control may have been a result of using the maraca sound initially as an $S^\Delta$; therefore we introduced a new sound. Ten-trial maintenance sessions were conducted immediately after each training session for the piano-sound $S^D$.

**Phase 5**

A new response (waving) was reinforced in the presence of a new sound (drum). After 15 sessions, responding in the no-sound $S^\Delta$ remained at or below 30% and Eric waved in the presence of the drum sound 50-90% of trials. Responding may have varied because he would not immediately consume the edible, holding it in his mouth, and he would not respond until the edible had been consumed. The new $S^D$ was trained with a no-sound $S^\Delta$. While training this new discrimination, 10-trial maintenance sessions were conducted immediately after each training session, randomly alternating between the piano-sound $S^D$ and maraca-sound $S^\Delta$.

**Phase 6**

The two $S^D$s (piano and drum sounds) were presented in blocks of five trials each. One $S^D$ was presented for five trials with 10 s of a no-sound $S^\Delta$ between each $S^D$, and then the other $S^D$ was similarly presented.

**Phase 7**

After 12 sessions of Phase 6, we presented both $S^D$s in a randomly alternating order, and with five trials of each sound, with a no-sound $S^\Delta$ between each $S^D$. 
Phase 8

We reintroduced the maraca sound as an $S^D$ for the response of raising his arms up using the same method as used in Phases 1 and 4. The maraca sound gained stimulus control in 18 sessions. However, Eric would only raise one arm above his head. Ten trial maintenance sessions were conducted immediately after each training session for the piano- and drum-sound $S^D$s, with five randomly alternated trials of each sound.

Phase 9

We randomly rotated between the three $S^D$s (maraca, drum, and piano), with five trials per sound, in Phase 9. Accuracy ranged from 71-100% for each $S^D$.

Phase 10

A fourth $S^D$ (train horn) was introduced with the response of tapping the stomach. While we were introducing the fourth $S^D$, the maraca sound generator stopped producing sounds and the maraca had to be re-recorded. The recorded sound seemed the same to us, but when it was presented, Eric did not respond. Phase 10 was discontinued to retrain the maraca sound. Fifteen-trial maintenance sessions were conducted immediately after each training session for the piano-, drum-, and maraca-sound $S^D$s, with five randomly alternated trials of each sound.

Phase 11

However contrary to his performance in Phase 4, physical prompt fading was not successful for the response of raising his arms up. Instead, Eric would respond to a model
prompt of raising his arms up; therefore, we attempted to use a model prompt and within-
session fading. However, he still demonstrated prompt dependency. Responding in the
maintenance sessions for the two other $S^D$s (piano and drum) also decreased throughout
this phase. We continued to alternate between providing the model prompt and testing
independent responding, but his responding was inconsistent.

Discussion

Eric mastered the discrimination between a sound $S^D$ and no-sound $S^A$ in 25
sessions, and mastered the discrimination between a sound $S^D$ and sound $S^A$ in 5 sessions.
He also mastered the discrimination between three sound $S^D$s.

While Eric did not always engage in the target response in the presence of the
sound $S^D$ during training, he engaged in other behaviors that indicated he was
discriminating between the sound $S^D$ and no-sound $S^A$. At the start of training, in the
presence of the piano sound, he would smile, and when the sound stopped he would stop
smiling. In the presence of the drum sound, he would occasionally lean from side-to-side
in time with the beat of the drum and would sometimes close and open his mouth in time
with the drum.

During training, the sound generators would occasionally stop working or were
recorded over and had to be re-recorded. The piano sound was re-recorded three times,
but did not affect Eric’s performance. However, when the sound generator broke during
Phase 10, and was re-recorded, responding did not generalize to the new, seemingly
identical maraca sound. This may have been a result of the maraca $S^D$ just recently
gaining stimulus control over the response of raising an arm up, while the piano $S^D$ had maintained stimulus control over the response of tapping the table for over 50 sessions.

PARTICIPANT 2: WENDY

Phases

Phase 1

Wendy’s highest score with the auditory-visual matching-to-sample procedure was 50%; she randomly selected one of the two objects on the table (see Figure 2 and Appendices C and D for this and all subsequent phases).

Figure 2. Number of sessions in each subphase within each phase with successful subphases (light gray patterned bar) and unsuccessful subphases (dark solid bar). Phase 7: Dark gray row; one session with piano $S^D$ and no-sound $S^\Delta$, followed by one session with piano $S^D$ and maraca-sound $S^\Delta$. 

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The procedure in Phase 1 was the same as for Eric, including the use of physical prompting and within-session prompt fading to train the response of tapping the table in the presence of the piano sound ($S^D$). In Subphase 1, shaping failed to establish stimulus control by the $S^D$; therefore we began a series of subphases alternating between physical prompts and no prompts. After nine subphases, in the final subphase of 67 sessions, Wendy mastered the discrimination, with responding in the presence of the $S^D$ varying between 80 and 100% and responding in the $S^A$ varying between 20 and 40%. However, the stimulus control had become much stronger than this would suggest, because she would engage in incompatible behavior during the $S^A$ (e.g., getting up out of her chair or sitting on her hands) and immediately tapped the table when the $S^D$ started. After multiple sessions, she began to respond immediately after the $S^D$ was presented, but would also respond right before the 10 seconds of the $S^A$ ended.

**Phase 2**

Because there was still a relatively high rate of responding in the $S^A$ of the previous subphase with the piano-sound $S^D$, ten-trial maintenance sessions with this $S^D$ and the no-sound $S^A$ were continued. In addition, a new response (clapping hands) was reinforced in the presence of a new $S^D$ (maraca), with a no-sound $S^A$. One maintenance session followed each daily maraca $S^D$ training session. However, when the maraca $S^D$ was introduced, Wendy scrolled between the two responses, tapping the table and clapping, even though they were presented in two different sessions with a short break between each session. Responding also increased in the $S^A$ conditions and the new
discrimination was not established and the original piano-sound discrimination became less reliable.

Phase 3

We attempted to regain stimulus control of the tap table by presenting the piano-sound \( S^D \) with a no-sound \( S^\Delta \), as in Phase 1. Responding in the \( S^\Delta \) decreased and remained at 40% or lower, while tapping the table remained at 70% or greater in the \( S^D \).

Phase 4

We then attempted to retrain the clapping response in the presence of the maraca sound, and continued maintenance sessions with the piano sound, like in Phase 2. However, Wendy scrolled between the two responses in both sessions. We discontinued the training sessions with the maraca sound after four sessions and attempted to regain stimulus control of the table tapping response.

Phase 5

We introduced the maraca sound as an \( S^\Delta \) in this phase. Trials alternated between the piano-sound \( S^D \) and maraca-sound \( S^\Delta \). The tap table response maintained in the presence of the \( S^D \), however Wendy did not discriminate between the piano sound and maraca sound. She tapped the table in the presence of the maraca sound 20 to 70% of trials.
Phase 6

We returned to the piano-sound $S^D$ and no-sound $S^\Delta$, as in Phases 1 and 3. The rate of responding was low in the $S^\Delta$, but varied in the presence of the $S^D$, ranging from 40 to 80%.

Phase 7

In this phase, we divided each daily session into two sub-sessions. The first sub-session had a piano-sound $S^D$ and no-sound $S^\Delta$, and the immediately following sub-session had a piano-sound $S^D$ and maraca-sound $S^\Delta$. Wendy mastered the discrimination between the piano sound and maraca sound after three sets of the paired sub-sessions.

Phase 8

In Phase 7, each sub-session with a maraca-sound $S^\Delta$ was preceded by a sub-session with a no-sound $S^\Delta$. In this phase, we conducted sessions without no-sound $S^\Delta$ sessions interspersed (i.e., the $S^\Delta$ was only the maraca sound). After 10 sessions, Wendy reliably discriminated between the piano and maraca sounds.

Phase 9

A new response (waving) was reinforced in the presence of a new $S^D$ (drum). Training was the same as Phase 1, with physical prompting of the response. However, in both the $S^D$ and $S^\Delta$, Wendy engaged in stereotypy that had a similar topography to waving, showing no discrimination. Therefore, after four sessions, we changed the target
response to her touching her mouth, reinforcing that response in the presence of the drum-sound $S^D$.

In addition, a ten-trial maintenance session was also conducted for the piano vs. maraca discrimination, immediately after each drum $S^D$ session. The accuracy of responding varied in these maintenance sessions; she engaged in some scrolling between waving and tapping the desk and she no longer maintained the piano vs. maraca discrimination.

She scrolled between tapping the table and touching her mouth in both the training and maintenance sessions. After 17 sessions with physical prompting and fading the prompts within each session, we tested a session without any prompts, but she only touched her mouth once in the presence of the drum sound. We reintroduced physical prompts for five sessions before a testing session without prompts. However, while she touched her mouth on 90% of the trials in the presence of the drum sound, she scrolled between the two responses in the maintenance session, and the discrimination between the piano and maraca sounds still did not re-emerge.

**Discussion**

Wendy mastered the discrimination between a sound $S^D$ and no-sound $S^\Delta$ in 57 sessions, and mastered the discrimination between a sound $S^D$ and sound $S^\Delta$ in 23 sessions. However, she did not master the discrimination between two sound $S^D$s.

During training, Wendy started to engage in incompatible behavior in the no-sound $S^\Delta$. After the piano-sound $S^D$ ended, she would get out of her chair or sit on her hands; then once the $S^D$ was presented again, she would immediately tap the table,
demonstrating that she was discriminating between the $S^D$ and $S^\Delta$. When she was not engaging in incompatible behavior in the $S^\Delta$, she would begin tapping the table before the 10-seconds of the $S^\Delta$ had passed.

While Wendy’s response of tapping the table was under the stimulus control of the piano sound, other stimuli in the environment were also controlling the response. For instance, when we would sit down at the table, she would often begin tapping it. Or, when a reinforcer was in sight, she would frequently tap the table, even if the piano sound had not been presented. Varying the duration of the sound $S^D$ and no-sound $S^\Delta$ may have facilitated acquisition of the discrimination at a faster rate and decreased responding in the $S^\Delta$.

PARTICIPANT 3: ARIEL

Experiment 1

Phase 1

Ariel’s performance in the auditory-visual matching-to-sample procedure ranged from 0-60% (see Figure 3 and Appendix E for this and all subsequent phases).

Figure 3. Experiment 1: Number of sessions in each subphase within each phase with successful subphases (light gray patterned bar) and unsuccessful subphases (dark solid bar).
Phase 1 was the same for Ariel as it was for Eric and Wendy. Shaping was unsuccessful for training the tap table response in the presence of the piano-sound $S^D$; she infrequently touched the table and engaged in vocal and motor stereotypy. She would also sometimes sing “The Wheels on the Bus” or the “ABCs” with approximations of the words. After seven sessions, we implemented physical prompts and faded the prompts within each session. After three sessions of prompting, we tested responding without prompts, but it quickly decreased to only one response per session. We introduced physical prompts again but were unsuccessful at fading them out. She would tap the table with a light touch, but the response was not under the stimulus control of the piano sound.

**Experiment 2**

**Phase 1**

Ariel had demonstrated generalized visual matching-to-sample in an earlier project (Lichtenberger, Ouellette, & Malott, 2014). Because she had mastered this skill, for the second experiment we presented a visual stimulus (red square) and touching the stimulus was reinforced in the presence of the piano-sound $S^D$. The square was placed on the table for the entire session and no physical prompts were used because she had shown prompt dependency in the first experiment. The $S^D$ and $S^\Delta$ were presented as in Phase 1 of Experiment 1 for all three children. Touching the square in the presence of the piano sound was reinforced, but touching the square in the no-sound $S^\Delta$ extended the $S^\Delta$ until 10 seconds had elapsed without a response; then the $S^D$ was again presented.
Ariel continuously touched or picked up the square in both the $S^D$ and $S^\Delta$ except when engaging in stereotypy (see Figure 4 and Appendix F for this and all subsequent phases).

**Figure 4.** Experiment 2: Number of sessions in each subphase within each phase with successful subphases (light gray patterned bar) and unsuccessful subphases (dark solid bar).

Therefore, starting with Session Three the square was attached to a foam board for three sessions to prevent her from picking up and playing with the card. However, she still played with the square in both the piano-sound $S^D$ and no-sound $S^\Delta$.

**Phase 2**

We then attempted to train the discrimination between two different sounds by pairing each sound with a different color in a two-stimulus visual matching-to-sample procedure, by fading the colors of the sample stimuli to transfer stimulus control from the visual stimuli to the auditory stimuli (Pellegrino, Stone, & Malott, 2010; see Appendix K for materials).
First, we tested matching-to-sample by presenting the cards on the table, however Ariel’s attending to the stimuli was inconsistent. We then introduced a foam board to place the cards on, which was used when she mastered matching-to-sample (Lichtenberger, Ouellette, & Malott, 2014). Responding remained low, thus matching shapes was tested next. This also was unsuccessful. Based on information from the classroom teacher, we then tested matching colors using a file folder, which is commonly used in the classroom. She attended to the stimuli on the folder and matched the two colors with 100% accuracy over 10 trials, but would not demonstrate the skill with the same stimuli when placed on the foam board or on the table. We started discrimination training with the drum sound and maraca sound using the file folder.

Red and green cards were selected for the visual matching-to-sample procedure and the sample stimuli were faded to white over subsequent sessions. The cards were created in Microsoft® Word; the transparency of the cards was increased systematically until the last two cards were white, resulting in a set of seven sample stimuli from 0 to 100% transparency. A red card and a green card were placed on the table; the position of the cards was randomly alternated. The red sample stimulus was presented simultaneously with the drum sound and the green sample stimulus with the maraca sound. We presented both S^D’s in a randomly alternating order with five trials of each sound. The phase change criteria were two consecutive sessions at 80% or above and one session at 100%, with 10-trial sessions. Each sound and color pair was presented five times in each session in quasi-random order. Ariel met the phase change criterion in seven sessions.
Phase 3

The color of the sample stimuli was reduced to 33% transparency (slightly lighter than the comparison stimuli). Ariel responded with 100% accuracy; a second session was conducted before moving to the next phase to verify that responding maintained after two days without sessions, and a maintenance test session(s) was conducted after breaks and absences from school in all subsequent phases.

Phase 4-8

The color transparency of the sample stimuli was increased over subsequent phases. Incorrect responses resulted from inconsistent attending to the visual stimuli rather than the change in the transparency.

Phase 9

In this phase, the sample stimuli were both 100% transparent (i.e., white), to determine if the color identity matching-to-sample had shifted to auditory-visual matching-to-sample where the correct colored comparison card would be conditional on the auditory sample stimulus. Correct responding was at chance for all three sessions.

Phase 10

We then reverted back to colored sample stimuli with a 96% transparency, immediately followed by a session with the white sample stimuli. Ariel’s performance was 100% with the cards at 96% transparency, but again chance with the white cards and auditory sample stimuli; again the auditory stimuli had not gained stimulus control.
Discussion

Ariel did not master the discrimination between a sound $S^D$ and no-sound $S^\Delta$ after 45 sessions and started to show prompt dependency. She frequently engaged in vocal stereotypy and also sang during sessions, which may have prevented her from attending to the sound $S^D$s. Perhaps using reinforcing sounds would have increased attending to the $S^D$, or an intervention to decrease vocal stereotypy would have increased correct responding. When we initially started training in Experiment 1, she quickly demonstrated physical prompt dependency; with the lightest touch on the shoulder she would tap the table, but once the prompt was removed, she no longer responded in the presence of the auditory $S^D$.

In Experiment 2, she quickly moved through each transparency level of the sample stimuli until the sample stimuli were the same color (white), reaching the last phase in 33 sessions. We introduced Experiment 2 to utilize Ariel’s visual matching-to-sample skills; however, the vocal stereotypy seemed to decrease the probability that she was attending to the sound $S^D$s and thus stimulus control did not transfer from the visual stimuli to the auditory stimuli.

GENERAL DISCUSSION AND CONCLUSIONS

This study addressed the problem of teaching auditory discriminations to children who made little progress with typical discrete-trial training procedures, as a prerequisite for receptive language. While there is research that addresses some of the problems associated with teaching receptive language (Grow & LeBlanc, 2013), most do not focus on children who demonstrate such extensive skill deficits as the children in this study. Two of the three children mastered the discrimination between a sound $S^D$ and no-sound
S^\lambda$, as well as the discrimination between a sound S^D and sound S^\lambda. However, only Eric discriminated between multiple sound S^D's, and that performance did not maintain. Responding in the presence of the piano S^D did not maintain for Wendy once we started training a response to a new sound S^D; she engaged in scrolling in the presence of both sounds. Ariel did not master the discrimination between the sound S^D and no-sound S^\lambda and showed physical prompt dependency. In Experiment 2, stimulus control did not transfer from the visual stimuli (color cards) to the auditory stimuli (piano and drum sounds). She engaged in vocal stereotypy, which may have impeded acquisition of the discrimination in both experiments.

When conducting the auditory discrimination training, it was not possible to remove all of the extraneous sounds from the environment, though sessions were conducted in a more secluded area of the classroom. This may have made it difficult to attend to the auditory stimuli and slowed acquisition. Visual stimuli were not used with Eric and Wendy during training, but we were not able to remove all visual stimuli from the environment. Other stimuli could have gained stimulus control over the response. For example, Wendy would tap the table immediately after the piano-sound S^D was presented, but would also tap the table whenever she initially sat down at the table where sessions were conducted or in the presence of the researcher, even in a different classroom.

Typically, EIBI is recommended for 30-40 hours per week, and even then 10% of children do not make substantial progress (Green 1996; Lovaas, 1987). In our classroom, children only received discrete-trial training for 15 hours a week, however it is possible that even with 40 hours a week with the standard curriculum, these children might not
have acquired receptive language skills. According to Greer & Song-A Han (2015),
generalized visual matching-to-sample may be a prerequisite skill for learning to
receptively identify objects. Simple discrimination between auditory stimuli is also
crucial for the acquisition of receptive identification and other receptive language skills.
In our classroom, the first formal procedures these children were exposed to that involved
receptive language were designed to teach orienting to their name, “sit down”, “quiet
hands”, and “come here”. This initial auditory direction following training used a
combination of auditory and visual stimuli, either of which might have dominated
stimulus control when we taught the directions. We were presenting both an auditory and
visual S\textsuperscript{D}, as the primary function was to get the child’s behavior under instructional
stimulus control, and not necessarily to gain auditory stimulus control over the child’s
behavior. Then, when we started formal auditory stimulus control training (with a
direction-following or receptive-identification procedure) they already had an extensive
learning history in which they possibly did not have to attend to auditory stimuli; we may
be extinguishing attending to the auditory stimuli (i.e., the auditory direction).

With the possibility that we may inadvertently be extinguishing attending to
auditory stimuli, it may be crucial to teach auditory discrimination when we start teaching
visual discrimination. The children with slow acquisition of skills are already at risk of
not mastering receptive language and more time with formal auditory discrimination
training may be necessary for them to succeed. All three of the children had been in the
classroom for at least two years before we started formal auditory discrimination training
and sessions consisted of only twenty trials a day, five times a week. More time with
formal auditory discrimination training and starting it earlier in their curriculum might
have resulted in more success and maintenance of not only sound but also word
discrimination. Even though the acquisition of visual stimulus control was very slow and
working on auditory stimulus control might have interfered with visual stimulus control,
auditory stimulus control is equally, if not more, important and starting formal training
earlier might have been more successful. It may even be necessary to only use auditory
stimuli when they are functional (e.g., when giving direction) rather than in all S^D_s (e.g.,
saying “match same” during visual matching-to-sample).

Future research should also assess the use of reinforcing auditory stimuli for
training auditory discriminations. Reinforcing or even familiar auditory stimuli might
increase the probability that the child attends to the sound and might gain discriminative
stimulus control more quickly.
REFERENCES


presented at the Israeli Association for Behavior Analysis Conference, Tel Aviv, Israel.


Appendix A

Auditory Discrimination Graph for Eric: Auditory-Visual Matching-to-Sample and Phases 1-7
Figure 5. Percentage of trials with responses for Auditory-Visual Matching-to-Sample and Phases 1-7 of auditory discrimination training for Eric.
Appendix B

Auditory Discrimination Graph for Eric: Phases 8-11
**Figure 6.** Percentage of trials with responses for Phases 8-11 of auditory discrimination training for Eric.
Appendix C

Auditory Discrimination Graph for Wendy: Auditory-Visual Matching-to-Sample and Phases 1-4
Figure 7. Percentage of trials with responses for Auditory-Visual Matching-to-Sample and Phases 1-4 of auditory discrimination training for Wendy.
Appendix D

Auditory Discrimination Graph for Wendy: Phases 5-9
Figure 8. Percentage of trials with responses for Phases 5-9 of auditory discrimination training for Wendy.
Appendix E

Auditory Discrimination Graph for Ariel: Auditory-Visual Matching-to-Sample and Experiment 1
**Figure 9.** Percentage of trials with responses for Auditory-Visual Matching-to-Sample and Phase 1 of auditory discrimination training (Experiment 1) for Ariel.
Appendix F

Auditory Discrimination Graph for Ariel: Experiment 2
Figure 10. Percentage of trials with responses for Experiment 2 for Ariel.
Appendix G

Experiment 1 Procedure Write-Up
### Simple Auditory Discrimination Training Part 1 – Movement

#### PROCEDURE SHEET

**Pupil:**

**Teacher:** DM/MN

**Procedure Writer:** SL

**Date Written:** 10/16/14

**IEPC Goal:**

**Objective:**

**Materials:** Two sound buttons.

**Reinforcer:** See student’s reinforcer list.

**Data collection:** 20 trials, + for correct, - for incorrect

<table>
<thead>
<tr>
<th>Phase</th>
<th>Tutor Presentation/Preparation</th>
<th>Correct Response</th>
<th>Incorrect Response</th>
<th>Criteria for Change</th>
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<tbody>
<tr>
<td></td>
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<td>Pupil Behavior</td>
<td>Tutor Behavior</td>
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<tr>
<td>1</td>
<td>Tutor sits behind student with two sound buttons on the floor out of the student’s sight. DO NOT PROVIDE ANY VOCAL S’s. For Red Button (drum sound): Tutor taps button with foot to start sound. For Green Button (no sound): Tutor taps button with foot to start sound condition and prompts student to place hands in lap. Prompting: Trials 1-4: Hand-over-hand prompt Trials 5-8: Prompt at wrist Trials 9-12: Prompt at forearm Trials 13-16: Prompt at back of the arm Trials 17-20: NO PHYSICAL PROMPT</td>
<td>Red Button: Student taps table within the 10 seconds of sound Green Button: Student does not tap table</td>
<td>Red Button: Student does not tap table within the 10 seconds of sound Green Button: Start next trial</td>
<td>100% for 2 consecutive sessions</td>
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<tr>
<td>2</td>
<td>Tutor sits behind student with two sound buttons on the floor out of the student’s sight. DO NOT PROVIDE ANY VOCAL S’s. For Red Button (drum sound): Tutor taps button with foot to start sound. For Green Button (No sound): Tutor taps button with foot to start sound condition</td>
<td>Red Button: Student taps table within the 10 seconds of sound Green Button: Student does not tap table</td>
<td>Red Button: Student does not tap table within the 10 seconds of sound Green Button: Start next trial</td>
<td>80% or &gt; for 3 consecutive sessions, or 90% or &gt; for 2 consecutive sessions</td>
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<td>3</td>
<td>Tutor sits behind student with two sound buttons on the floor out of the student’s sight. DO NOT PROVIDE ANY VOCAL S’s. For Red Button (drum sound): Tutor taps button with foot to start sound. For Green Button (BELL sound): Tutor taps button with foot to start sound</td>
<td>Red Button: Student taps table within the 10 seconds of sound Green Button: Student does not tap table</td>
<td>Red Button: Student does not tap table within the 10 seconds of sound Green Button: Start next trial</td>
<td>80% or &gt; for 3 consecutive sessions, or 90% or &gt; for 2 consecutive sessions</td>
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<td>4</td>
<td>Tutor sits behind student with two sound buttons on the floor out of the student’s sight. DO NOT PROVIDE ANY VOCAL S’s. For Red Button (drum sound): Tutor taps button with foot to start sound. For Green Button (BELL sound): Tutor taps button with foot to start sound and prompts student to raise both arms at designated prompt level. Prompting FOR GREEN BUTTON ONLY: Trials 1-4: Hand-over-hand prompt Trials 5-8: Prompt at wrist Trials 9-12: Prompt at forearm Trials 13-16: Prompt at back of the arm Trials 17-20: NO PHYSICAL PROMPT</td>
<td>Red Button: Student taps table within the 10 seconds of sound Green Button: Student raises arms within the 10 seconds of sound</td>
<td>Red Button: Student does not tap table within the 10 seconds of sound and/or taps table</td>
<td>80% or &gt; for 3 consecutive sessions, or 90% or &gt; for 2 consecutive sessions</td>
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<td>Tutor sits behind student with two sound buttons on the floor out of the student’s sight. DO NOT PROVIDE ANY VOCAL S’s. For Red Button (drum sound): Tutor taps button with foot to start sound. For Green Button (bell sound): Tutor taps button with foot to start sound.</td>
<td>Red Button: Student taps table within the 10 seconds of sound. Green Button: Student raises arms within the 10 seconds of sound.</td>
<td>Red Button: Highly preferred edible/tangible. DO NOT SAY ANYTHING. Green Button: Highly preferred edible/tangible. DO NOT SAY ANYTHING.</td>
<td>Red Button: Student does not tap table within the 10 seconds of sound and/or raises arms. Green Button: Student does not raise arms within 10 seconds of sound and/or taps table. Red Button: Wait 3 seconds before starting next trial. Green Button: Wait 3 seconds before starting next trial.</td>
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Appendix H

Phase 1 Data Sheet
## Auditory Discrimination Training Data Sheet

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Appendix I

Experiment 2 Procedure Write Up
Auditory Discrimination with Matching

**PROCEDURE SHEET**

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<th>Pupil:</th>
<th>Teacher:</th>
<th><strong>DM/MN</strong></th>
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<td>Procedure Writer:</td>
<td>SL</td>
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<tr>
<td>Date Written:</td>
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**IEPC Goal:**

**Objective:**

**Materials:** Sound buttons and color cards with faded steps (1-7) with corresponding color written on back. (F7 should be white)

**Reinforcer:** See student’s reinforcer list.

**Data collection:** 20 trials, + for correct, - for incorrect

<table>
<thead>
<tr>
<th>Phase</th>
<th>Tutor Presentation/Preparation</th>
<th>Correct Response</th>
<th>Incorrect Response</th>
<th>Criteria for Change</th>
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<tbody>
<tr>
<td><strong>1</strong></td>
<td>Tutor sits across from student with two sound buttons on the floor. Tutor places red and green cards on table in front of the student. DO NOT PROVIDE ANY VOCAL S’s. Present one of the cards to the student and simultaneously press the corresponding sound button (Red: Sound 1; Green: Sound 2). Randomly rotate position of the cards.</td>
<td>Student places sample stimulus with corresponding comparison stimulus or touches corresponding comparison stimulus within 3 seconds.</td>
<td>Student does not place sample stimulus within 3 seconds.</td>
<td>Use prompt hierarchy, presenting new sound every 2 seconds. If sound ends before prompt hierarchy is finished, physically prompt correct response and then prepare for next trial.</td>
</tr>
<tr>
<td><strong>2</strong></td>
<td>Tutor sits across from student with two sound buttons on the floor. Tutor places red and green cards on table in front of the child. DO NOT PROVIDE ANY VOCAL S’s. Present one of the F1 cards to the student and simultaneously press the corresponding sound button (Red: Sound 1; Green: Sound 2). Randomly rotate position of the cards.</td>
<td>Student places sample stimulus with corresponding comparison stimulus or touches corresponding comparison stimulus within 3 seconds.</td>
<td>Student does not place sample stimulus within 3 seconds.</td>
<td>Wait for sound to finish then prepare for next trial.</td>
</tr>
<tr>
<td><strong>3</strong></td>
<td>Tutor sits across from student with two sound buttons on the floor. Tutor places red and green cards on table in front of the child. DO NOT PROVIDE ANY VOCAL S’s. Present one of the F2 cards to the student and simultaneously press the corresponding sound button (Red: Sound 1; Green: Sound 2). Randomly rotate position of the cards.</td>
<td>Student places sample stimulus with corresponding comparison stimulus or touches corresponding comparison stimulus within 3 seconds.</td>
<td>Student does not place sample stimulus within 3 seconds.</td>
<td>Wait for sound to finish then prepare for next trial.</td>
</tr>
<tr>
<td><strong>4</strong></td>
<td>Tutor sits across from student with two sound buttons on the floor. Tutor places red and green cards on table in front of the child. DO NOT PROVIDE ANY VOCAL S’s. Present one of the F3 cards to the student and simultaneously press the corresponding sound button (Red: Sound 1; Green: Sound 2). Randomly rotate position of the cards.</td>
<td>Student places sample stimulus with corresponding comparison stimulus or touches corresponding comparison stimulus within 3 seconds.</td>
<td>Student does not place sample stimulus within 3 seconds.</td>
<td>Wait for sound to finish then prepare for next trial.</td>
</tr>
<tr>
<td>Phase</td>
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<td>Correct Response</td>
<td>Incorrect Response</td>
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<td>Pupil Behavior</td>
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<td>Student places sample stimulus with corresponding comparison stimulus or touches corresponding comparison stimulus within 3 seconds.</td>
<td>Provide reinforce and wait for sound to end before preparing for the next trial.</td>
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<td>5</td>
<td>Tutor sits across from student with two sound buttons on the floor. Tutor places red and green cards on table in front of the child. DO NOT PROVIDE ANY VOCAL S’s. Present one of the F4 cards to the student and simultaneously press the corresponding sound button (Red: Sound 1; Green: Sound 2). Randomly rotate position of the cards.</td>
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<td>Student does not place sample stimulus with corresponding comparison stimulus or does not touch corresponding stimulus within 3 seconds.</td>
<td>Wait for sound to finish then prepare for next trial.</td>
<td>90% or greater for 2 consecutive sessions or 80% or greater for 3 consecutive sessions.</td>
</tr>
<tr>
<td>6</td>
<td>Tutor sits across from student with two sound buttons on the floor. Tutor places red and green cards on table in front of the child. DO NOT PROVIDE ANY VOCAL S’s. Present one of the F5 cards to the student and simultaneously press the corresponding sound button (Red: Sound 1; Green: Sound 2). Randomly rotate position of the cards.</td>
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<td>Student places sample stimulus with corresponding comparison stimulus or touches corresponding comparison stimulus within 3 seconds.</td>
<td>Provide reinforce and wait for sound to end before preparing for the next trial.</td>
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<td>Student does not place sample stimulus with corresponding comparison stimulus or does not touch corresponding stimulus within 3 seconds.</td>
<td>Wait for sound to finish then prepare for next trial.</td>
<td>90% or greater for 2 consecutive sessions or 80% or greater for 3 consecutive sessions.</td>
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<td>7</td>
<td>Tutor sits across from student with two sound buttons on the floor. Tutor places red and green cards on table in front of the child. DO NOT PROVIDE ANY VOCAL S’s. Present one of the F6 cards to the student and simultaneously press the corresponding sound button (Red: Sound 1; Green: Sound 2). Randomly rotate position of the cards.</td>
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<td>Student places sample stimulus with corresponding comparison stimulus or touches corresponding comparison stimulus within 3 seconds.</td>
<td>Provide reinforce and wait for sound to end before preparing for the next trial.</td>
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<td>Student does not place sample stimulus with corresponding comparison stimulus or does not touch corresponding stimulus within 3 seconds.</td>
<td>Wait for sound to finish then prepare for next trial.</td>
<td>90% or greater for 2 consecutive sessions or 80% or greater for 3 consecutive sessions.</td>
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<td>Tutor sits across from student with two sound buttons on the floor. Tutor places red and green cards on table in front of the child. DO NOT PROVIDE ANY VOCAL S’s. Present one of the F7 cards to the student and simultaneously press the corresponding sound button (Red: Sound 1; Green: Sound 2). Randomly rotate position of the cards.</td>
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<td>Student places sample stimulus with corresponding comparison stimulus or touches corresponding comparison stimulus within 3 seconds.</td>
<td>Provide reinforce and wait for sound to end before preparing for the next trial.</td>
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<td>Student does not place sample stimulus with corresponding comparison stimulus or does not touch corresponding stimulus within 3 seconds.</td>
<td>Wait for sound to finish then prepare for next trial.</td>
<td>90% or greater for 2 consecutive sessions or 80% or greater for 3 consecutive sessions.</td>
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Appendix J

Experiment 2 Data Sheet
# MTS and Auditory Discrimination Data Sheet

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Appendix K

Experiment 2 Materials
Appendix L

HSIRB Approval
Date: February 16, 2016

To: Richard Malott, Principal Investigator
    Sarah Lichtenberger, Student Investigator for dissertation
    Student Investigators: Heriberto Bobadilla, Melanie Coon, Amelia Fonger,
    Jonathan Fujii, Jacqueline Helton, Haley Hughes,
    Stephanie Johnson, Dustin Kelly, Natalie Mann, Jennifer Petree,
    Abigail Trotz

From: Amy Naugle, Ph.D., Chair

Re: HSIRB Project Number 14-03-28

This letter will serve as confirmation that the changes to your research project titled “Teaching Children with Autism Who Have Difficulty Mastering Auditory Discriminations” requested in your memo received February 16, 2016 (to add student investigators Jacqueline Helton, Dustin Kelly, Jonathan Fujii, Melanie Coon, and Abigail Trotz) has been approved by the Human Subjects Institutional Review Board.

The conditions and the duration of this approval are specified in the Policies of Western Michigan University.

Please note that you may only conduct this research exactly in the form it was approved. You must seek specific board approval for any changes in this project. You must also seek reapproval if the project extends beyond the termination date noted below. 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 HSIRB for consultation.

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

Approval Termination: March 19, 2016
Date: March 20, 2014

To: Richard Malott, Principal Investigator
    Sarah Lichtenberger, Student Investigator for dissertation
    Trevor Charbonneau, Student Investigator
    Kelsey Rothermel, Student Investigator

From: Amy Naugle, Ph.D., Chair

Re: HSIRB Project Number 14-03-28

This letter will serve as confirmation that your research project titled “Match-to-Sample and Auditory Discrimination Training for Children with Autism” has been approved under the exempt category of review by the Human Subjects Institutional Review Board. 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 in this project (e.g., you must request a post approval change to enroll subjects beyond the number stated in your application under “Number of subjects you want to complete the study.”) 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 HSIRB for consultation.

Reapproval of the project is required if it extends beyond the termination date stated below.

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

Approval Termination: March 19, 2015