TEACHING SIMPLE AUDITORY DISCRIMINATIONS

TO STUDENTS WITH AUTISM

Kristine L. Marino, B.A.

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APPROVED:

Sigrid Glenn, Professor
Gina Green, Adjunct Professor
Janet Ellis, Professor
Manish Vaidya, Associate Professor
Richard G. Smith, Chair of the Department of
Behavior Analysis
Thomas Evenson, Dean of the College of
Public Affairs and Community Service
Sandra L. Terrell, Dean of the Robert B.
Toulouse School of Graduate Studies

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This study aimed to test the effectiveness of classroom translations of some laboratory procedures for teaching simple auditory discriminations to learners with developmental disabilities. Three participants with autism and mental retardation were trained to make topographically distinct responses in the presence of two different stimuli, either a pure tone and silence, or two tones. A portable electronic piano keyboard was used to produce tones. Delayed prompt and differential reinforcement procedures were used to teach the responses. None of the participants performed the discriminations accurately without prompting despite numerous revisions to the procedures.

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INTRODUCTION

The acquisition of auditory-visual conditional discrimination skills (often called “receptive vocabulary” or “receptive identification”) is a key component of language development. In conditional discriminations, which are often tested and trained with match-to-sample procedures, a response to one of two or more comparison stimuli is reinforced if, and only if, a particular sample stimulus is present. The sample stimulus varies from one trial to the next, while the same comparison stimuli are presented on every trial. For example, a series of trials to teach conditional discriminations involving dictated color names and colors might present squares colored red, yellow, and green as comparison stimuli on every trial. Each trial would begin with presentation of one dictated color name – either “red,” “yellow,” or “green” – as the sample. Each sample would be presented equally often within a set of trials, in unsystematic order. A response to the colored square that corresponds to the sample presented on a particular trial is reinforced; responses to the other comparisons are not reinforced in the presence of that sample. That is, the comparison that is discriminative for reinforcement depends, or is conditional on, the sample stimulus presented on each trial. If the learner comes to respond reliably to each colored square comparison in the presence of the corresponding dictated color name sample and not in the presence of the other samples, the inference can be drawn that the learner has acquired auditory-visual conditional discriminations, or conditional relations between each dictated color name and the corresponding color (Green, 2001; Green & R. Saunders, 1999; Sidman et al., 1982).

Many individuals with autism and related disorders have deficits in receptive language skills, and particular difficulty acquiring both visual-visual and auditory-visual conditional discriminations when the samples and their corresponding comparisons are not physically identical (arbitrary conditional discriminations; see Clark & Green, 2004; Green, 2001; Green, Mackay, McIlvane, Saunders, & Soraci, 1990; McIlvane, Dube, Kledaras, Iennaco, & Stoddard, 1990). Conditional discriminations are made up of two types of simple discriminations: successive discriminations among the sample stimuli presented across trials, and simultaneous discriminations among the comparison stimuli presented on every trial (K. Saunders & Spradlin, 1993; R. Saunders & Green, 1998). A simple discrimination is inferred when a learner is observed to respond differentially to two or more stimuli as a result of a particular reinforcement history. That might involve responding reliably in the presence of one stimulus (usually designated an S+) and not responding in the presence of a different stimulus (S-), or emitting one response in the presence of one stimulus (S1) and a topographically different response in the presence of another stimulus (S2). When learners with developmental disabilities fail to acquire conditional discriminations using standard teaching methods, one likely explanation is that they had not acquired the component simple discrimination skills. Some studies have shown that teaching the component simple discriminations can foster the subsequent development of conditional discriminations. For example, participants with mental retardation who had not acquired arbitrary conditional discriminations with standard training procedures were initially trained to respond on two different schedules of reinforcement to two visual stimuli (abstract figures) presented one at a time on a series of trials (a simple successive discrimination). They were also trained to touch one of two other abstract figures presented together, and to reverse that simple simultaneous discrimination. Both participants acquired both types of simple discriminations. Conditional discriminations with the first two figures serving as samples and the other two figures as comparisons were not demonstrated, however, until contingencies were arranged that maintained both types of component discriminations (K. Saunders & Spradlin, 1989, 1993).

Simple auditory discriminations are important not only as components of auditory-visual conditional discriminations, but also because they are involved in many other functional skills, such as attending and responding to various sounds in the environment, imitating vocal models, and comprehending spoken language. It is surprising, then, that most studies of simple discrimination training procedures published to date have used visual stimuli (e.g., Graff & Green, 2004; Sidman & Stoddard, 1967). There is a paucity of research on methods for teaching simple auditory discriminations. Serna, Stoddard, and McIlvane (1992) suggested one reason is that auditory stimuli like spoken words have complex characteristics and are therefore difficult to change using stimulus shaping or fading procedures like those that have proved effective for teaching simple visual discriminations. In addition, auditory stimuli must be presented successively vs. simultaneously, and successive simple discriminations have generally proved more difficult for learners with developmental disabilities to acquire than simultaneous simple discriminations (e.g., Stella & Etzel, 1986). Nonetheless, Serna et al. (1992) suggested that some procedures that have been used successfully to teach simple visual discriminations could be adapted for teaching simple auditory discriminations.

One set of investigators attempted to establish simple auditory discrimination performances by training three adults with mental retardation to respond in the presence of an auditory stimulus (spoken word) and visual stimulus (flashing light) presented together; however, the investigators were unable to transfer stimulus control from the visual to the auditory stimulus using a stimulus fading procedure. Additionally, one participant responded both in the presence of the spoken word and during intertrial intervals when the word was not spoken, suggesting that there was no stimulus control by the spoken word. The authors noted that it is especially difficult to establish control over responding by auditory stimuli because they tend to be fleeting (Stoddard & McIlvane, 1989).

Other researchers investigated the use of stimulus fading and shaping procedures similar to those that have proved effective with visual stimuli to train discriminations between two auditory stimuli (e.g., the dictated words “Touch” and “Wait”). The researchers used computer software to manipulate various dimensions of the auditory stimuli (e.g., decibel level, frequency) to make the words very distinctive initially, and then changed those dimensions systematically until they were the same for both words. Those procedures were effective for teaching one adult with mental retardation to touch a computer touchscreen in the presence of the dictated word “Touch,” and to refrain from touching the computer in the presence of “Wait.” Using the same computer software to gradually transform one dictated word into another, the investigators taught several synonyms to another participant with mental retardation (Serna, Stoddard, & McIlvane, 1992).

Another laboratory study also used computer technology to teach simple auditory and visual discriminations and reversals to students with autism and mental retardation. Auditory stimuli were pure tones of different frequencies, white noise, and dictated words. Specialized software and equipment allowed the auditory stimuli to be presented one at a time on successive trials, and to remain on until the participant responded or for a maximum of 5 s on each trial. Intensity (volume) of the auditory stimuli was manipulated directly in order to teach the auditory discriminations errorlessly; that is, the stimulus designated S+ or S1 was presented at full volume while the S- or S2 was presented at low volume on initial training trials. The difference in intensity served as a prompt for participants to respond to the S+/S1 by touching the computer screen, which was reinforced. Touching the screen in the presence of the S-/S2 was not reinforced. Over successive trials following correct responses, the intensity of S-/S2 was gradually and systematically increased, thereby fading the prompt. After an incorrect response to either S+/S1 or S-/S2, the computer backed up to the previous prompt level (i.e., greater intensity difference between S+/S1 and S-/S2) on the next trial. These prompt and prompt-fading procedures were implemented until the participant touched the computer screen reliably in the presence of the S+/S1 and not in the presence of the S-/S2 when both auditory stimuli were presented at equal intensity. Similar procedures were used to teach simple simultaneous discriminations among visual forms. All events – stimulus presentations, prompting and prompt fading, intertrial intervals, response recording, consequence delivery – were controlled precisely by the computer software. Six of 9 participants acquired simple auditory discriminations as readily as they acquired simple visual discriminations. The auditory discriminations involved the dictated word “Touch” (S+/S1) vs. no sound (S-/S2), “Touch” vs. white noise, a 950 Hz tone vs. no tone, and a 950 Hz tone vs. a 450 Hz tone, trained in that order. None of the participants reversed the simple discrimination between the 950 Hz and 450 Hz tones, whereas they did reverse simple visual discriminations between abstract black-on-white line drawings (Green, Albert, & Clark, 2001).

The study reported here attempted to develop “tabletop” analogues of some of the computerized simple auditory discrimination procedures used in the study by Green, Albert, and Clark (2001). The aim was to evaluate the effectiveness of those procedures for teaching simple auditory discriminations to learners with autism and mental retardation, and the feasibility of implementing them in a school setting.

METHOD

Participants

Participants were selected from a pool of students attending the Connecticut Center for Child Development, a state-approved, applied behavior analytic special education school for children with autism and related disorders in Milford, CT. Criteria for selection included normal hearing; a basal age equivalent of 3 years or lower on the Peabody Picture Vocabulary Test-Revised (PPVT); reliably sitting at a desk and orienting toward a teacher and instructional materials for at least 10 min at a time; and a history of difficulties acquiring auditory discriminations (as reported by the behavior analytic and special education staff responsible for each prospective participant's educational programming). Participant 1 was a 14-year-old male with a primary diagnosis of autism and a secondary diagnosis of mental retardation. He had an age equivalent score of less than 1 year 9 months on the PPVT, an expressive vocabulary of approximately 25 words, and a receptive vocabulary of approximately 50 words. He reliably followed very simple 1-step directions related to body parts (e.g., "Touch your head" and "Clap your hands"), but did not follow complex directions, answer wh-questions, or engage in vocal verbal behavior except to make basic requests for items or activities. Participant 2 was a 13- year-old male with a primary diagnosis of autism and a secondary diagnosis of mental retardation. He had an age equivalent score of less than 1 year 9 months on the PPVT, and receptive and expressive vocabularies of approximately 50 words each. This participant reliably followed simple 1-step directions, but did not answer wh-questions, or discriminate shapes, letters, colors, or numbers. He had a very limited vocal verbal repertoire, mainly requesting items or activities. His primary mode of communication was a Dynavox MT4® augmentative and alternative communication device (DynaVox Mayer-Johnson, 2100 Wharton Street Suite 400, Pittsburgh, PA 15203), which he used to make requests for tangible items by touching icons on the device, producing the synthesized spoken names of the items. Participant 3 was a 13-year-old female with a primary diagnosis of autism and a secondary diagnosis of mental retardation. Her age equivalent score on the PPVT was 3 years. She had a more extensive vocabulary and more functional vocal verbal repertoire than Participants 1 and 2. Her primary mode of communication was vocal speech, although she used a DynaVox MT4® to compensate for articulation deficits. She had an extensive intraverbal repertoire, made comments and requests, and answered wh-questions about pictures and simple scenes, but did not reliably answer such questions within the context of conversation or follow complex spoken directions.

Setting and Sessions

All experimental sessions were conducted in a small tutorial room at the school that contained a small student desk, two chairs, and a video camera on a tripod. Participants sat at the desk across from the experimenter. Sessions were conducted 3 to 4 times per week on school days. In each session, a total of 24 trials were presented, with either a single tone or no tone presented for 5 s on each trial. There was an intertrial interval of 10 s. Session durations varied slightly across participants and target discriminations, but were generally approximately 10 min. Details are described in the Procedures section below.

Stimuli, Apparatus, and Materials

Stimuli to be discriminated were tones (musical notes) produced by pressing keys on a Little Tikes Carry Along Musical Keyboard with Teaching Lights ® (The Little Tikes Company, 2180 Barlow Rd. Hudson, OH 44236, United States). For each target discrimination, one tone was designated the S+ or S1, and either no tone (silence) or a different tone was designated the S- or S2. The keyboard was placed inside an open drawer built into the desk on the experimenter's side, out of the participant's view.

During initial training with Participant 1, a blank white 3 in. x 5 in. (7.62 cm x 12.7 cm) index card was placed on the desk; the participant was to touch it in the presence of the S+/S1 tone. Subsequently, a 3 in. x 5 in. (7.62 cm x 12.7 cm) piece of red laminated construction paper was propped on a business card holder in the center of the desk to signal the start and end of each trial. None of those materials were used with Participants 2 and 3.

A plastic cart of drawers holding the session materials was placed next to the desk on the experimenter's right-hand side, and data sheets specifying pre-arranged trials for each session were placed on top of the drawers. A cart holding a digital video camera was placed in the corner opposite the desk. Small pieces of edible reinforcers were kept inside the open desk drawer.

Dependent Variables and Measurement

The dependent variables were participants' responses in the presence of the stimuli designated S+ or S1 and the S- or S2 for each target discrimination. Those responses varied across discriminations and participants; details are described below. The experimenter (primary observer) recorded all responses during experimental sessions as correct or incorrect.

Interobserver Agreement (IOA)

Every session was video recorded; 33% of the recorded sessions were viewed and scored by a secondary observer who was trained on the response definitions and scoring criteria prior to assisting with the study. There was one exception: Due to technical difficulties, the videotaped sessions for the initial phase and first subphase for Participant 1, Discrimination 1 could not be viewed. Videotaped samples of all other procedural variations for all other participants were scored by the secondary observer. The secondary observer recorded the participant's responses in the same manner as the experimenter, as well as the experimenter's implementation of the experimental procedures on the first 9 pretest or training trials in the session. The data recorded by the two observers on each trial (participants' responses) or for each step of the procedures (experimenter's performance) were compared. If the data recorded by the two observers on a trial or step matched, an agreement was scored. Interobserver agreement (IOA) was calculated by dividing the number of agreements by the number of agreements plus disagreements and multiplying by 100%. For Participant 1's responses, the mean agreement was 97% (range: 88% - 100%). For Participant 2, the mean was 95% (range: 75% -100%). For Participant 3, agreement was 100% in all sessions. For the experimenter's implementation of the procedures, mean agreement for Participant 1 was 97% (range: 86% - 100%). The mean agreement for Participant 2 was 97% (range: 81% -100%). The mean agreement for Participant 3 was 98% (range: 92% - 100%). More details are available in Appendices A and B.

Preference Assessments

Preference assessments were conducted with each participant. Highly preferred stimuli identified through those assessments were delivered contingently on correct responding during experimental sessions. For Participant 1, the free-operant preference assessment procedure developed by Windsor, Piche, and Locke (1994) was conducted prior to each session. The most highly preferred item identified in each pre-session preference assessment was delivered contingent on correct responding in that session. This procedure was followed because Participant 1 preferred a wide range of edible reinforcers, and he was reported to satiate quickly on any one given edible reinforcer. Due to time constraints, the multiple stimulus without replacement preference assessment described by DeLeon and Iwata (1996) was conducted with Participants 2 and 3 prior to pre-testing. The most highly preferred edible identified in that assessment was delivered contingent on correct responses in all experimental sessions with those two participants (see Appendices C and D).

General Procedures

Although the target discriminations and procedures varied across participants, most sessions were conducted as follows: For each discrimination, one tone was designated the S+ or S1 and either no tone or a different tone was designated the S- or S2. Each session consisted of 24 trials. Data sheets that prescribed the stimulus to be presented on each trial and the trial sequence, along with a space for recording the participant's response on each trial, were prepared in advance of each session (see Appendix E). Successive discrimination procedures were implemented. On each trial, either the S+/S1 or the S-/S2 was presented for 5 s; that is, the experimenter either pressed the designated key on the piano keyboard for 5 s, or did not press any key. Each stimulus was presented equally often within a session in random order, with the restriction that the same stimulus was never presented on more than two consecutive trials. Two topographically distinct responses were reinforced, one in the presence of the S+/S1 and the other in the presence of the S-/S2. Any other responses the participant made while the stimuli were presented were not reinforced. Correct responses were followed immediately by delivery of a preferred stimulus, and a 10 s intertrial interval (ITI). Incorrect responses were followed by the ITI.

The target discriminations were first pretested in sessions that started with 6 demonstration trials (3 each of the S+ or S1 and the S- or S2, in randomized order), followed by 18 test trials (9 of each stimulus, in unsystematic order). The purpose of the demonstration trials was to expose the participant to the successive discrimination procedures prior to administering either test or training trials. Responses on demonstration trials were not used to determine if performance met mastery criterion (described later). To start each demonstration trial, the experimenter presented the stimulus indicated on the data sheet and immediately prompted the participant to make the response designated as correct with that stimulus, using physical guidance or modeling. Correct prompted responses were reinforced. Test trials were exactly like demonstration trials, except that the experimenter did not prompt the participant to respond. Correct responses were reinforced. If the participant responded correctly on at least 8 of 9 pretest trials with both stimuli, the discrimination was considered mastered. This did not occur with any participant on any discrimination, so training ensued in the next session after the pretest.

Each training session consisted of 6 demonstration trials like those that started the pretest sessions, followed by 18 training trials (9 with each stimulus, in unsystematic order). Most-to-least prompting procedures were used to train the responses designated as correct in the presence of the S+/S1 and the S-/S2 for each discrimination. Prompts were either physical guidance or models, faded using a delay procedure. Training began at Prompt Step 0, where the experimenter provided the prompt immediately upon presentation of the stimulus on each trial (zero delay). When the participant responded correctly on at least 8 of the 9 S+/S1 trials and 8 of the 9 S-/S2 trials in a session, the prompt was faded in the next training session by delaying delivery of the prompt by 1 s relative to the onset of the stimulus on every trial (Prompt Step 1). Correct responses (either prompted or unprompted, i.e., made before the prompt was delivered) on at least 8 of 9 trials with each of the stimuli presented in a session resulted in the prompt being delayed by 2 s in the next session (Prompt Step 2). Prompt fading continued in that fashion, with the delay increasing in 1 s increments up to a 5 s maximum as long as the participant responded correctly on at least 8 of 9 trials with each of the stimuli. If the participant's performance did not meet that criterion, then in the next session the delay was decreased by 1 s; that is, the experimenter backed up to the preceding prompt step. Prompt fading then began again. Once the participant responded correctly (with or without prompting) on at least 8 of 9 S+/S1 trials and 8 of 9 S-/S2 trials at Prompt Step 5, a posttest was conducted. Posttest procedures were exactly like the pretests described previously (i.e., with 6 demonstration (prompted) trials followed by 18 unprompted test trials). Mastery was defined as responding correctly to the S+/S1 on at least 8 of 9 test trials and responding correctly to the S-/S2 on 8 of 9 test trials on the posttest.

Details and Variations per Participant

For Participant 1, Discrimination 1 had a high C note (labeled Tone 1) as the S+; the reinforced response was touching a 3 in. x 5 in. (7.62 cm x 12.7 cm) white index card placed on the table in front of the participant with his index finger at any time during the 5 s the tone was presented. The S- was no tone; touching the index card was not reinforced, and placing his hands on the desk or in his lap throughout the 5 s of each S- trial was reinforced. The procedures were revised when Participant 1 did not make progress on Discrimination 1, and often touched the index card on all trials. It seemed likely that his history of reinforcement for touching visual stimuli placed on a desk or table in front of him may have interfered with acquisition of the discrimination. Therefore, the response to S- (i.e., S2) was changed to touching his head rather than keeping his hands on the desk or in his lap, and the S+ tone (S1) was changed to a high F. When Participant 1 still made no progress, the procedures were revised again to address the possibility that the participant did not discriminate the nominal S- (no tone) from the ITI, which was also a period of silence. In an effort to differentiate trials from the ITI, a red laminated 3 in. x 5 in. (7.62 cm x 12.7 cm) index card was propped on a card holder on the desk facing the participant to indicate that a trial was starting. The red card was removed immediately after a reinforcer was delivered for a correct response, or after the participant made an incorrect response. The participant was not required to respond to the red card. The response to S+/S1 was changed to touching his stomach; touching head remained the target response to S-/S2. The participant still did not demonstrate progress. Therefore, training on Discrimination 1 was terminated, and training on Discrimination 2 began. The stimulus designated S1 was a middle C, in the presence of which the participant was to touch his stomach. S2 was a low F, in the presence of which waving one hand was reinforced. The red card was presented on each trial to cue its start and finish. Criterion for moving past Prompt Step 0 was revised to three consecutive sessions of correct responses on at least 8 of 9 S+/S1trials and at least 8 of 9 S2 trials. When Participant 1 still did not make progress, the procedures were revised such that no visual stimuli were presented; that is, there was no index card to be touched or red card to indicate onset and offset of a trial as in the preceding phases. Physical guidance procedures were used to prompt all target responses with Participant 1. They were faded using a delayed prompt procedure as described previously.

For Participants 2 and 3, initial procedures were identical to the revised procedures just described for Discrimination 2 training with Participant 1, except that model prompts were used rather than physical guidance. When Participants 2 and 3 did not demonstrate progress, a revision was implemented wherein prompted correct responses were followed by praise only, while independent (unprompted) correct responses were followed by praise and edible reinforcers. Additionally, criterion for advancing from Prompt Step 0 was changed to 3 consecutive sessions with at least 8 correct responses to both S+/S1 and S-/S2.

RESULTS

Figures 1 through 8 show the percentage of correct prompted responses and correct unprompted responses for the three participants. None of them acquired the auditory discriminations. Figure 1 indicates that during the initial phase of training of Discrimination 1, Participant 1 usually touched the index card every time it was presented; that is, he made the S+ response on all trials, suggesting that the index card controlled pointing responses. The delayed prompt procedure was ineffective for transferring stimulus control to the auditory stimuli. The variability in Participant 1's data is a result of moving from Prompt Step 0 (in which all responses were prompted immediately after onset of a trial) to Prompt Step 1, where the prompt was delayed slightly. In Subphase 1, this participant typically made the same response on all trials, often repeating the last response that was physically prompted. In Subphases 2 and 3, he typically made the response designated for the S-/S2 (touching his head for Subphase 2, waving for Subphase 3). He occasionally made the designated response for the S+/S1 as well (which was touching his head for both subphases), but not consistently during presentation of the S+/S1 tone. During the initial training of Discrimination 2, Participant 1 either did not respond prior to the prompt or lifted his hand slightly at the onset of either tone. It is unclear whether he lifted his hand in anticipation of receiving the edible reinforcer (which was always placed upon the desk), or in anticipation of receiving a prompt. He sometimes lifted his hand between trials as well, indicating that even this behavior was not under the control of the auditory stimuli. Also during this phase, the participant began to wait for the prompt more frequently. He continued to make errors when the prompt was faded. Participant 1 did not move beyond Prompt Step 1 until Subphase 1 (when the index card was removed entirely). At that point he began making fewer responses prior to the prompt at Prompt Step 1, and therefore fewer incorrect responses. These data suggested that the visual stimulus – the index card -- controlled the participant's responses, possibly due to a history of reinforcement in his educational program for touching stimuli presented to him on cards. Participant 1's participation in the experiment was terminated after the 46^{th} session due to increases in problem behaviors that were hypothesized to have had an escape function (see Figures 1-4).

Participant 2's results are displayed in Figures 5 and 6. He did not respond prior to the prompt on most trials. On occasions when he did respond before the prompt, the same topographical response was made on most trials (i.e. touching his stomach in the presence of both S1 and S2). There was a decrease in correct responding with prompts on S1 trials from sessions 8 through 17, and a decrease in correct prompted responses to S2 across those same sessions. After reinforcer delivery following prompted responses was discontinued (Subphase 1), this participant continued to respond only after the prompt was delivered on the majority of trials. There was an initial decrease in prompted correct responses in the presence of both S1 and S2 after the initial training session in Subphase 1, but then a steady increase in correct prompted responses to S1 and stable 100% correct responding to S2. At the same time, unprompted responses dropped to zero levels.

Participant 3, whose results are displayed in Figures 7 and 8, only responded prior to the prompt on three trials; two of these independent responses were incorrect. There was no change in her performance after Subphase 1 when reinforcer delivery following correct prompted responses was discontinued.

DISCUSSION

Participant 1 did not acquire the discrimination between a tone and no tone despite several procedural revisions, and none of the three participants acquired the discrimination between two tones. These results differ from those obtained by other investigators who successfully established simple auditory discriminations in some participants with autism and other developmental disorders (Green, Albert, & Clark, 2001; Serna, Stoddard, & McIlvane, 1992). In both previous studies, participants first acquired a discrimination between an auditory stimulus and absence of an auditory stimulus, then acquired discriminations between two different auditory stimuli (tones or words). Any of several procedural differences may account for the differences in the results of those studies and the present experiment. As noted previously, specially equipped computers using specialized software managed all experimental procedures as well as response recording in the studies by Green et al. (2001) and Serna et al. (1992). That technology made it possible for the investigators to manipulate features of the auditory stimuli so that researchers could use intensity fading and stimulus shaping techniques to teach the discriminations errorlessly. The researchers were also able to fade prompts within sessions because participant responses were detected and evaluated instantly by the computer, which was programmed to fade the prompt (i.e., increase the intensity of the S-/S2) after two consecutive correct responses. The present study also attempted to use errorless training procedures, but instead of differences in characteristics of the auditory stimuli themselves, the prompts were physical guidance or modeled responses provided by the experimenter, because those types of prompts are widely used in classroom instruction for learners with developmental disabilities. Delay procedures were used to fade the prompts, and instead of fading (i.e., increasing the delay to the prompt) the prompt within sessions after a small number of correct responses, the same prompt step was used throughout a session. If responding was highly accurate, the prompt was faded in the next session. Those procedures were selected because they readily lend themselves to classroom applications. Unfortunately, although they may be effective, delayed prompt procedures have been shown to produce prompt dependence in some learners who simply wait for the prompt, and do not come to make correct unprompted responses (for a review, see Oppenheimer, Saunders, & Spradlin, 1993; also see Clark & Green, 2004; Graff & Green, 2004). That occurred with all 3 participants in this study, and may have been exacerbated by the fact that prompts were faded across rather than within sessions. That is, if procedures designed to fade prompts more rapidly had been used here, transfer of stimulus control from the prompts and the index card to the auditory stimuli might have been more successful.

It is also possible that other types of prompt and prompt-fading procedures would have been more effective. The technology required for intensity fading and stimulus shaping procedures like those used by Green et al (2001) and Serna et al (1992) was not available for this study, and likely would not be available in most classrooms. Physical prompts could have been provided from behind the participants and faded via graduated guidance procedures, but it was impossible for the experimenter to do that while also managing all the other experimental procedures (i.e., stimulus presentations, timing, consequence delivery, data recording). A second adult would have been required to provide and fade physical prompts – not feasible in this study nor in many classrooms.

The type of stimuli used in this study may have been particularly difficult for the participants to discriminate, even with prompting and differential reinforcement procedures. Tones were selected because participants were less likely to have histories of reinforcement with those stimuli than with other auditory stimuli (e.g., spoken words and environmental sounds. When two tones were used, they were selected from the high and low ends of the musical scale, in an attempt to maximize their distinctiveness; however, they did not differ on other dimensions. As noted previously, had it been possible to present the stimuli at different intensities on initial training trials, the discriminations might have been established. Presenting stimuli that differed in other ways might also have fostered acquisition of the discriminations. For instance, instead of two tones, a spoken word and a tone or a tone and white noise might have been more discriminable because those stimuli have different acoustical characteristics. Future studies might train a discrimination between two sounds that are very dissimilar in several respects as an initial step for learners with auditory discrimination deficits.

The volume at which stimuli were presented in the current study might have hampered development of the target discriminations. Placing the portable piano keyboard inside the desk was necessary to prevent establishing stimulus control by some visual features of the keyboard, but it may have muffled the sound somewhat. Although the sounds were audible to the experimenter, they may not have been clearly audible to the participants. Since two of the three participants responded immediately after tone onset on many trials, albeit often incorrectly, it seems likely that the volume was adequate for the participants to hear the tones.

It is possible that acquiring a discrimination between an auditory stimulus and silence is necessary to develop further more complex auditory discrimination skills. That discrimination was not established with Participant 1 in this study, and was not presented to the other participants, because it was hypothesized that they might more readily learn to discriminate two different tones than a tone and silence, given that the ITI was also a period of silence. Investigators in previous studies succeeded in training a discrimination involving the spoken word, “Touch” and silence (Green et al., 2001; Serna et al., 1992). As discussed previously, the precisely controlled, automated procedures used in those studies probably contributed substantially to that success. It might also be the case, however, that participants in those studies had a history of responding to spoken instructions in general and, possibly, to the instruction, “Touch” specifically. If “Touch” already reliably controlled the response of touching, it might have been relatively easy for participants to learn to refrain from touching the computer screen in the absence of "Touch." That possibility was not examined in this study because non-speech stimuli were selected for reasons discussed previously.

Participant characteristics also might have influenced the results of this study. The participants were selected for their documented longstanding severe difficulties with auditory-visual conditional discriminations (as evaluated on the Peabody Picture Vocabulary Test-Revised) and other skills involving auditory discriminations. They were adolescents, so likely had long histories of relying on visual cues to access reinforcers. It was thought that such participants would provide an "acid test" of the training procedures used in this study, but perhaps it was not a fair test; younger participants might have acquired the simple auditory discriminations more readily than these older participants. That possibility should be examined in future studies.

Another limitation of the current study was the amount of training the participants received. In the auditory discrimination portions of the study by Green et al. (2001), sessions consisting of 40 trials were run 4-5 days/week. Participants required an average of 6 sessions (240 trials) to acquire the initial discrimination between the presence and absence of the spoken word "Touch." In the current study, sessions consisted of only 18 trials, and because of the participants' school schedules it was only possible to conduct one session/day 3-4 times/week. Weekends and school vacations meant that there were long intervals between sessions for some participants. Had the participants received more frequent, continuous training and more trials per session, the results might have been different

Finally, aspects of the school setting in which this study was conducted may have had a deleterious effect on participants' acquisition of the auditory discriminations. Sounds from outside of the room in which the sessions were conducted could not be controlled. Sessions were terminated if the noise level seemed noticeably high to the experimenter, but external sounds might have competed with the tones that were used as experimental stimuli. This is likely true of most educational environments. One solution might be to present auditory stimuli via headphones if a quiet, soundproof room is not available. Pretraining would probably be required, however, to get some learners with autism to wear headphones and keep them in place throughout experimental sessions.

In summary, there are clearly some challenges to be overcome in translating laboratory procedures for teaching simple auditory discriminations into procedures that can be used effectively in typical classroom settings. This study may be seen as a first step toward addressing those challenges, as it identified some procedures that do not appear to be effective and several others that are good candidates for evaluation in future studies.

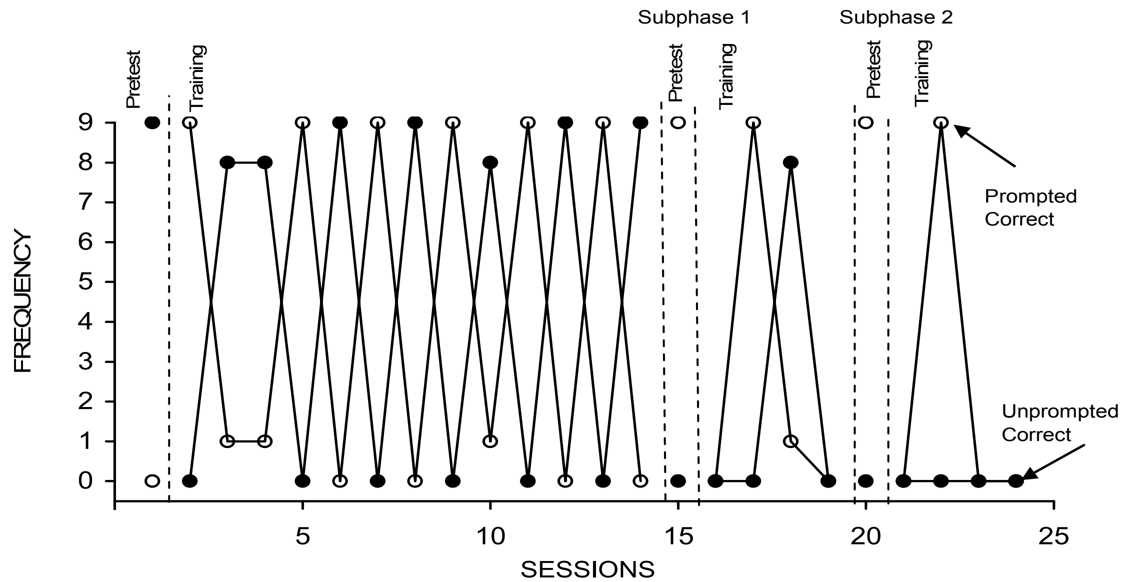

Figure 1. Frequency of prompted correct and unprompted correct responses to S+ for Participant 1, Discrimination 1 (Tone vs. Silence).

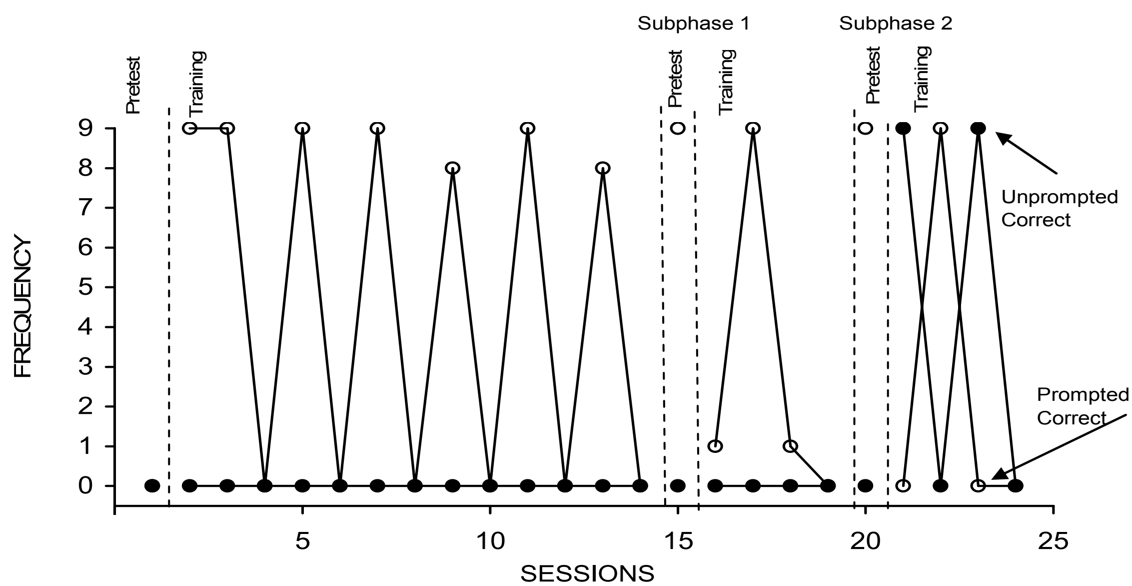

Figure 2. Frequency of prompted correct and unprompted correct responses to S- for Participant 1, Discrimination 1 (Tone vs. Silence).

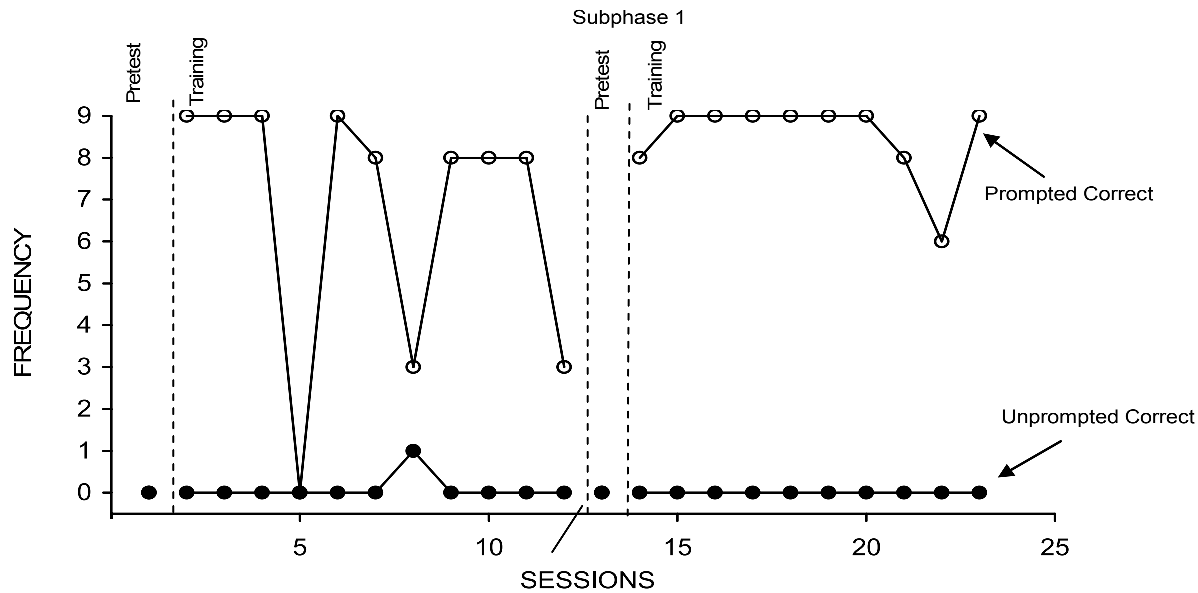

Figure 3. Frequency of prompted correct and unprompted correct responses to S+/S1 for Participant 1, Discrimination 2.

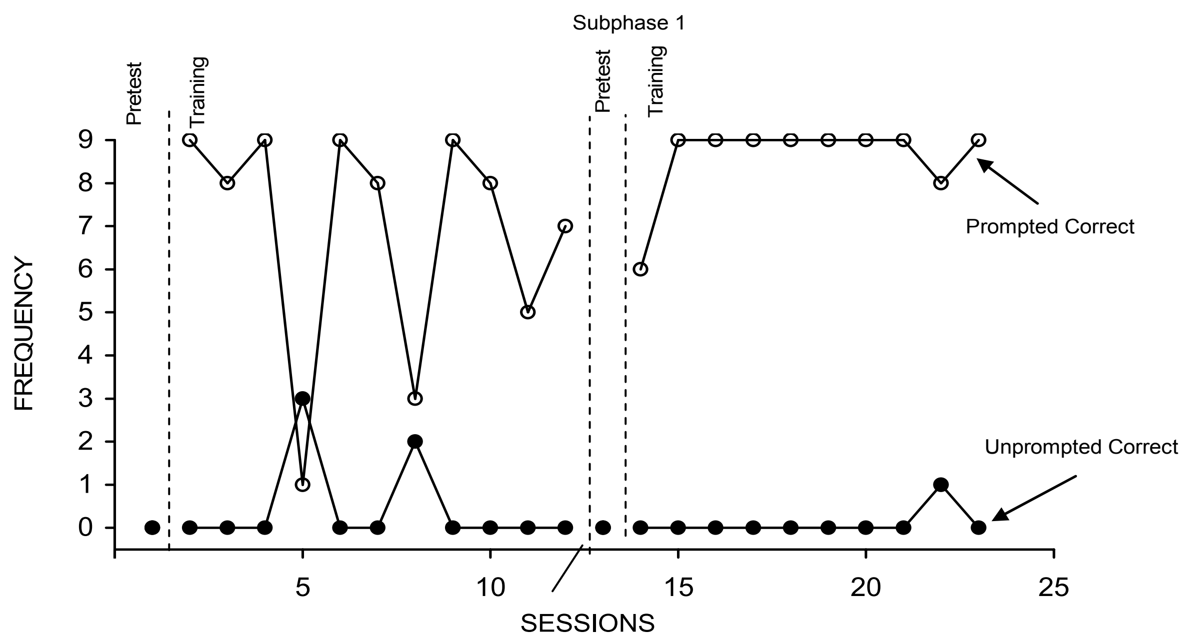

Figure 4. Frequency of prompted correct and unprompted correct responses to S-/S2 for Participant 1, Discrimination 2).

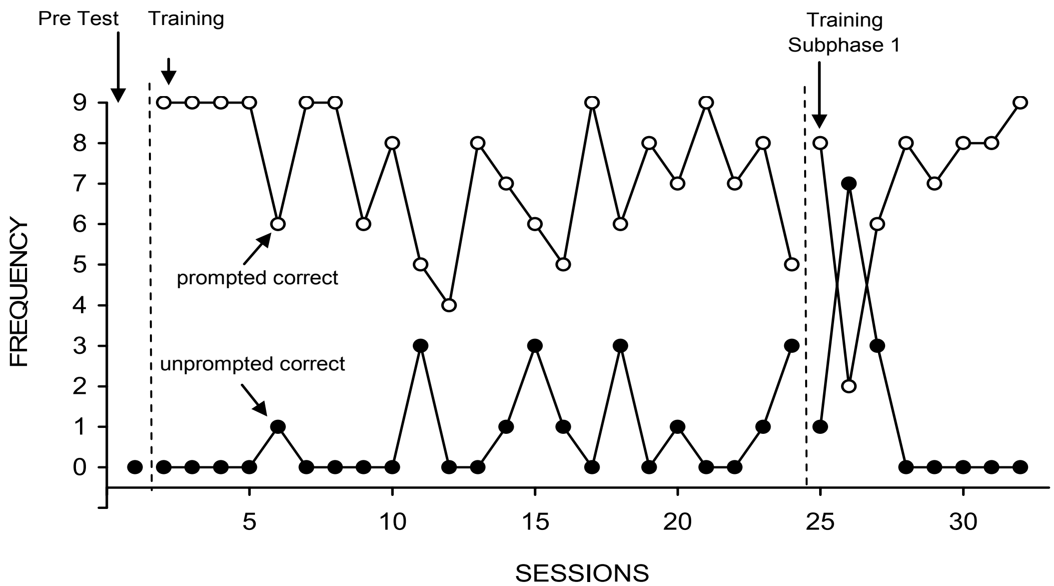

Figure 5. Frequency of prompted correct and unprompted correct responses to S+/S1 for Participant 2.

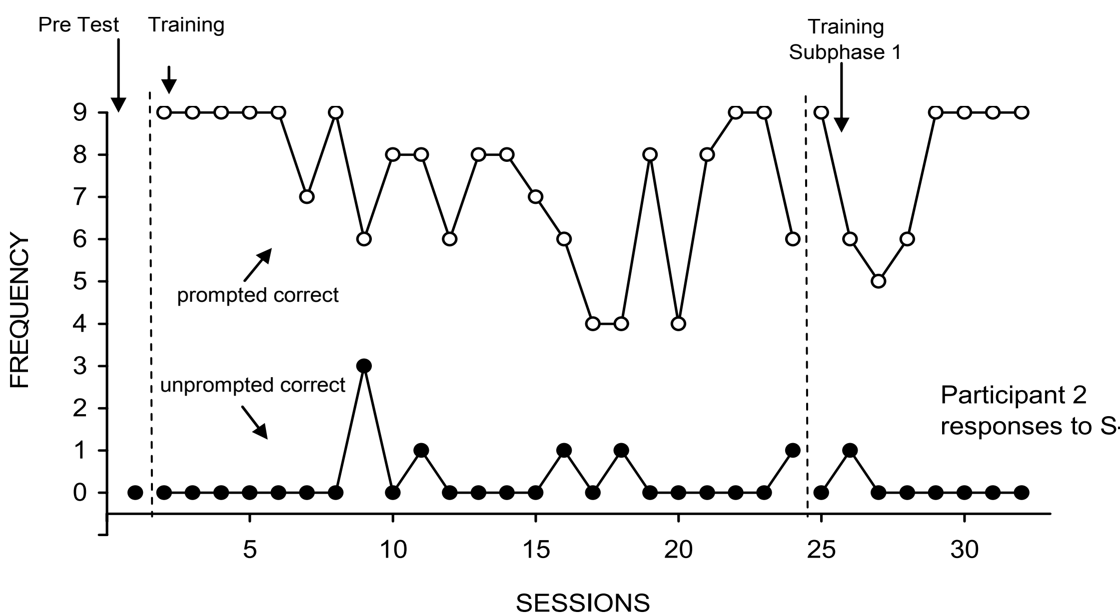

Figure 6. Frequency of prompted correct and unprompted correct responses to S-/S2 for Participant 2).

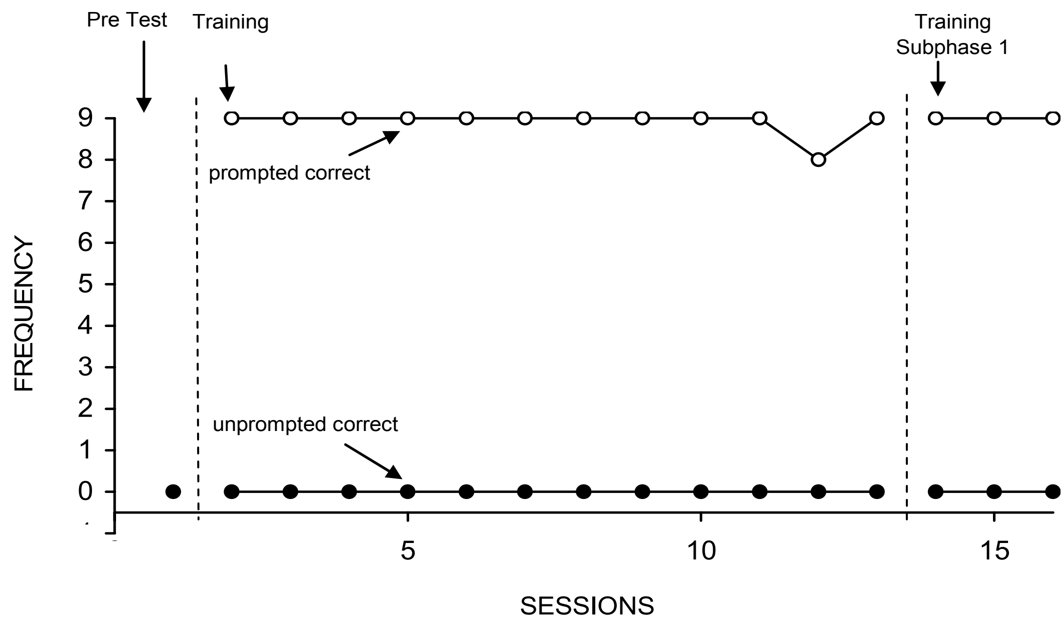

Figure 7. Frequency of prompted correct and unprompted correct responses to S+/S1 for Participant 3.

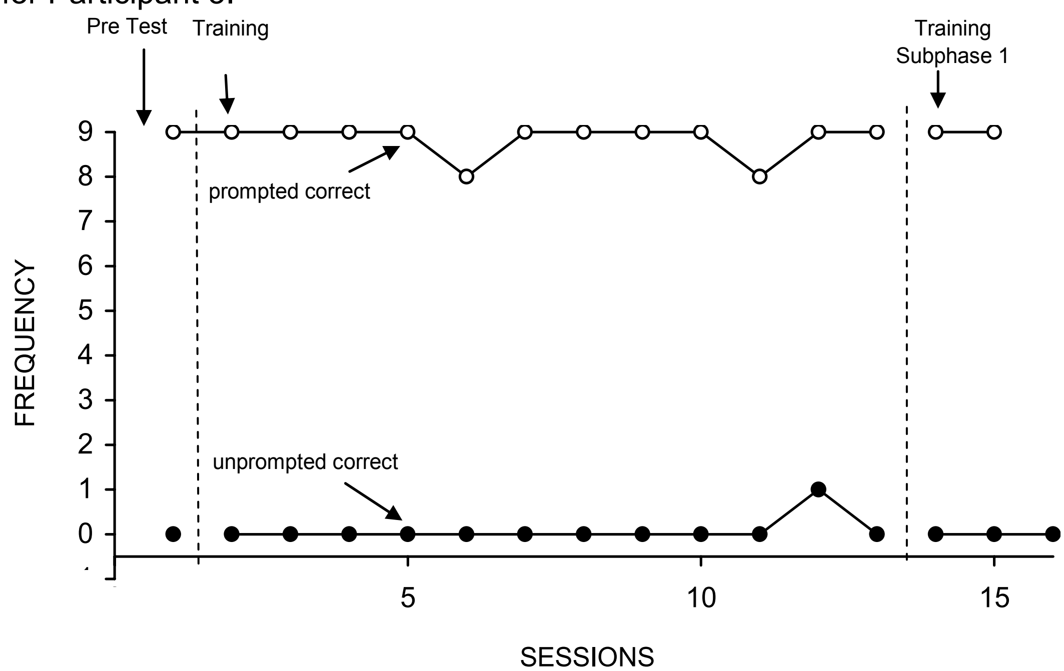

Figure 8. Frequency of prompted correct and unprompted correct responses to S-/S2 for Participant 3.

APPENDIX A

SAMPLE DATA SHEET FOR PARTICIPANT SESSIONS

STUDENT: ____________ Date: ____________ Staff: ____________ Pretest/ Training/ Posttest
Level: _________ Prompt Step: __________ S+: ________ S-: ________

Trial	Stim	+p,+,-p,-	Trial	Stim	+p,+,-p,-
D1	S+		7	S-	
D2	S-		8	S+	
D3	S+		9	S-	
D4	S+		10	S-	
D5	S+		11	S+	
D6	S-		12	S-	
1	S-		13	S+	
2	S+		14	S+	
3	S+		15	S-	
4	S-		16	S-	
5	S-		17	S+	
6	S+		18	S+	

IOA: Accuracy: S+: /9 S-: /9

STUDENT: ____________ Date: ____________ Staff: ____________ Pretest/ Training/ Posttest
Level: _________ Prompt Step: __________ S+: ________ S-: ________

Trial	Stim	+p,+,-p,-	Trial	Stim	+p,+,-p,-
D1	S+		7	S-	
D2	S-		8	S+	
D3	S-		9	S-	
D4	S+		10	S+	
D5	S+		11	S+	
D6	S-		12	S+	
1	S+		13	S-	
2	S+		14	S-	
3	S-		15	S+	
4	S-		16	S-	
5	S+		17	S-	
6	S-		18	S+	

IOA: Accuracy: S+: /9 S-: /9

APPENDIX B

SAMPLE DATA SHEET FOR INTEROBSERVER AGREEMENT (IOA):

PARTICIPANT RESPONSES

STUDENT: ____________ Date: ____________ Staff: ____________ Pretest/ Training/ Posttest
Level: _________ Prompt Step: __________ S+: ________ S-: ________

Trial	+p,+,-p,-	Trial	+p,+,-p,-
D1		7	
D2		8	
D3		9	
D4		10	
D5		11	
D6		12	
1		13	
2		14	
3		15	
4		16	
5		17	
6		18	

IOA: Accuracy: S+: /9 S-: /9

STUDENT: ____________ Date: ____________ Staff: ____________ Pretest/ Training/ Posttest
Level: _________ Prompt Step: __________ S+: ________ S-: ________

Trial	+p,+,-p,-	Trial	+p,+,-p,-
D1		7	
D2		8	
D3		9	
D4		10	
D5		11	
D6		12	
1		13	
2		14	
3		15	
4		16	
5		17	
6		18	

IOA: Accuracy: S+: /9 S-: /9

Directions for Completing Interobserver Agreement Data Sheet

Write one of the following for each trial:
P+ = correct response following prompt
P- = incorrect response following prompt
+ = correct response before prompt
- = incorrect response before prompt

Participant One Response Definitions:

<u>Discrimination 1: Initial phase:</u>
S+S1: Touch card with one or more fingers of one hand at any point while tone is sounding
S-:/S2 Refrain from touching card/keep hands on lap or on desk while tone is sounding

<u>Subphase 1:</u>
S+/S1: Same (touch card at any point while tone is sounding)
S-/S2: Touch head with one or more fingers or with palm of one hand
<u>Subphase 2:</u>
S+/S1: Touch on or near stomach (e.g. above stomach on chest ok) with one or more fingers or with any part of one hand
S-/S2: Same (touch head)

<u>Discrimination 2 Initial Phase:</u>
S+/S1: Same (touch stomach)
S-/S2: Wave by lifting one hand off of lap or desk and moving at wrist up and down at least once

<u>Subphase 1:</u>
S+/S1: Same (touch stomach)
S-/S2: Same (wave)

Participants 2 and 3 Response Definitions:
S+/S1: Touch on or near stomach (e.g. above stomach on chest ok) with one or more fingers or with any part of one hand
S-/S2: Wave by lifting one hand off of lap or desk and moving at wrist up and down at least once

APPENDIX C

SAMPLE DATA SHEET FOR INTEROBSERVER AGREEMENT –

PROCEDURAL INTEGRITY

Participants 2 & 3 Initial Training Scorer: ______________________________

Participant: __________ Date of Video: ________

S+/S1 = High Tone S-/S2 = Low Tone
S+/S1 Response = Touch Stomach S-/S2 Response = Wave

H = High Tone L = Low Tone S = Touch Stomach (high tone) H = Touch Head (Low Tone)

	1	2	3	4	5	6	7	8	9
Present tone for 5 s. OR until student makes response	H L	H L	H L	H L	H L	H L	H L	H L	H L
Prompted Response *IF PRE-TEST, NO PROMPT	S W	S W	S W	S W	S W	S W	S W	S W	S W
Correct Prompted Response EDIBLE IMMEDIATELY									
Correct Independent Response EDIBLE IMMEDIATELY									
Incorrect Response: NO REINFORCER (end trial immediately)									
Wait 10 sec. (intertrial interval)									

Directions: For the first 9 training trials presented in the video, circle the appropriate letter or mark +/- as appropriate for each step of the procedure. Refer to response definitions provided within instructions on IOA for participant responses.

APPENDIX D

FREE-OPERANT PREFERENCE ASSESSMENT DATA SHEET FOR

PARTICIPANT 1

Items used:

1. ______________________ 6. ______________________
2. ______________________ 7. ______________________
3. ______________________ 8. ______________________
4. ______________________ 9. ______________________
5. ______________________ 10. ______________________

Date: ___________________

Interval:	Item:	Interval:	Item:
1:50		0:50	
1:40		0:40	
1:30		0:30	
1:10		0:20	
1:00		0:00	

Directions:

1. Conduct assessment at the start of each session.
2. Assign each edible item a number in the spaces provided.
3. Place equal amounts of edible reinforcers (bite-sizes pieces) on plate.
4. Begin timer counting down from 2 minutes.
5. At each 10-second interval, record which edible(s) the participant is selecting or consuming (if none, note that). Replenish as needed.
6. Use the edible that is scored during the highest number of intervals as a reinforcer during subsequent training trials.

APPENDIX E

MULTIPLE STIMULUS WITHOUT REPLACEMENT PREFERENCE

ASSESSMENT DATA SHEET FOR PARTICIPANTS 2 & 3

Trial # ______________________

Items	Order Selected
1.	
2.	
3.	
4.	
5.	
6.	
7.	
8.	
9.	
10.	

Directions:

1. List all edibles in order presented in first column.
2. Place all edibles equal distance apart in front of participant.
3. Tell participant “choose one”.
4. Write a “1” next to the first edible selected, and so on.
5. When the participate finishes consuming, do not replace the selected item. Rotate all remaining items and again say “choose one”.
6. Continue until all items are selected.
7. If the participant does not select a particular edible, note that.
8. Conduct 5 trials in this fashion; use the edible that was selected the highest number of times as a reinforcer for subsequent training trials.

REFERENCE LIST

Clark, K.M., & Green, G. (2004). Comparison of two procedures for teaching dictated word/symbol relations to learners with autism. *Journal of Applied Behavior Analysis, 37,* 503-507.

DeLeon, I.G., & Iwata, B.A. (1996) Evaluation of a multiple-stimulus presentation format for assessing reinforcer preferences. *Journal of Applied Behavior Analysis, 29,* 513-533.

Graff, B., & Green, G. (2004). Two methods for teaching simple visual discriminations to learners with severe disabilities. *Research in Developmental Disabilities*, *25,* 295-307.

Green, G. (2001). Behavior analytic instruction for learners with autism: Advances in stimulus control technology. *Focus on Autism and Other Developmental Disabilities*, *16*, 72-85.

Green, G., Albert, A., & Clark, K. (May 2001). *Auditory and visual discrimination learning by students with autism and mental retardation.* Paper presented at the annual meeting of the Association for Behavior Analysis, New Orleans.

Green, G., Mackay, H.A., McIlvane, W.J., Saunders, R.R., & Soraci, S.A., Jr. (1990). Perspectives on relational learning in mental retardation. *American Journal on Mental Retardation, 95*, 249-259.

Green, G., & Saunders, R.R. (1998). Stimulus equivalence. In K. A. Lattal & M. Perone (Eds.), *Handbook of research methods in human operant behavior* (pp. 229-262). New York: Plenum.

McIlvane, W.J., Dube, W.V., Kledaras, J.B., Iennaco, F.M., & Stoddard, L.T. (1990). Teaching relational discrimination to individuals with mental retardation: Some problems and possible solutions. *American Journal on Mental Retardation, 95,* 283-296.

Oppenheimer, M., Saunders, R.R, & Spradlin, J.E. (1993). Investigating the generality of the delayed-prompt effect. *Research in Developmental Disabilities, 14,* 425–444.

Saunders, K.J., & Spradlin, J.E. (1989). Conditional discrimination in mentally retarded adults: The effect of training the component simple discriminations. *Journal of the Experimental Analysis of Behavior, 52*, 1-12.

Saunders, K.J., & Spradlin, J.E. (1993). Conditional discrimination in mentally retarded subjects: Programming acquisition and learning set. *Journal of the Experimental Analysis of Behavior, 60*, 571-585.

Saunders, R.R., & Green, G. (1999). A discrimination analysis of training structure effects on stimulus equivalence outcomes. *Journal of the Experimental Analysis of Behavior, 72,* 117-137.

Serna R.W., Stoddard, L.T., & McIlvane, W.J. (1992). Developing auditory stimulus control: A note on methodology. *Journal of Behavioral Education, 2*, 391-403.

Sidman, M., Rauzin, R., Lazar, R., Cunningham, S., Tailby, W., & Carrigan, P. (1982). A search for symmetry in the conditional discriminations of Rhesus monkeys, baboons, and children. *Journal of the Experimental Analysis of Behavior, 37,* 23-44.

Sidman, M., & Stoddard, L.T. (1967). The effectiveness of fading in programming a simultaneous form discrimination for retarded children. *Journal of the Experimental Analysis of Behavior, 10,* 3-15.

Stella, M.E., & Etzel, B.C. (1986). Stimulus control of eye orientations: Shaping S+ only versus shaping S- only. *Analysis and Intervention in Developmental Disabilities, 6*, 137-153.

Stoddard, L.T., & McIlvane, W.J. (1989). Establishing control by spoken words with profoundly mentally retarded individuals. *Research in Developmental Disabilities, 10*, 141-151.

Windsor, J., Piche, L.M., & Locke, P.A. (1994) Preference testing: A comparison of two presentation methods. *Research in Developmental Disabilities, 15*, 439-455.