EFFECTS OF RESPONSE-CONTINGENT PAIRING ON VOCALIZATIONS OF NONVERBAL CHILDREN WITH AUTISM

by

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For typically developing children, language appears to be acquired effortlessly under natural caregiving arrangements. When children are around 2 months old they typically begin to make infrequent premature vocalizations, called coos. Between 3 and 8 months, infants begin to engage in babbling, which consists of more frequent speech-like vocalizations (Oller, 2000). Usually, around one year, infants will utter their first word (Fenson, Reznick, Bates, Thal, & Pethick, 1994), and by two years of age are able to successfully use short sentences to communicate with their caregivers and peers (Hoff, 2005). Evidence suggests that both socially mediated and response-produced consequences of vocalizing facilitate these changes in the early vocalizations of infants.

Increases in the frequencies and changes in patterns of vocalizations seen as infants progress from cooing to babbling to word production, have been partially accounted for through social reinforcement. A reinforcement contingency describes the behavior-environmental relationship that occurs when stimuli (e.g., smiles, attention, praise, etc.) are presented contingent on a specific behavior and the future probability of that specific behavior increases under similar conditions. Contingent presentations of stimuli, events, or conditions are classified as reinforcement when and only when they increase the future probability of behavior (Cooper, Heron, & Heward, 2007). It has been suggested that some social stimuli, such as mothers' voices may function as primary reinforcer for infants (Darcheville, Boyer, & Miossec, 2005). Early infant vocalizations appear to naturally engender social responses of caregivers (Gros-Luis, West, Goldstein, & King, 2006). The amount of social attention delivered contingent on infant vocalizations has been demonstrated to be influential in the vocal development of infants, in that infants whose mothers provide a dense schedule of contingent social attention reach early language milestones sooner than infants whose mothers provide less social attention contingent on vocalizations (Tamis-LeMonda, Bornstein, & Baumwell, 2001). Additionally, Goldstein, Schwade, and Bornstein (2009) demonstrated that contingent social attention can change the quality of infants' vocalizations, in that when parents of 9-month-old infants deliver social attention contingent on more advanced speech sounds, the rate and complexity of their infants' vocalizations increased. Taken together, these studies provide strong support for the role of social reinforcement in infants meeting early language-based milestones.

Response-produced auditory feedback has also been suggested to partially account for changes in the production of vocalizations as infants progress from one language-based milestone to the next (Bijou, & Baer, 1965; Skinner, 1957). According to this view, child vocalizations are likely to be repeated if they sound similar to speech sounds that child has heard in his or her environment. When response-produced stimuli increase the probability of the behavior that produces them, the definitional requirements of a reinforcement contingency are met. Reinforcement contingencies involving response-produced stimuli are often referred to as automatic reinforcement contingencies (e.g., Vaughan & Michael, 1982).

A number of findings suggest that response-produced auditory feedback may play a role in the development of vocal production. For example, it has been shown that for infants with hearing impairments, babbling is delayed, and the degree of impairment in hearing is correlated with the severity of the delay (Bass-Ringdahl, 2010). Furthermore, following cochlear implants, infants' hearing abilities dramatically increased and these increases correspond with increased use of words and canonical speech sounds. Goldstein and Swade (2008) provide further evidence that acoustic feedback plays a role in shaping vocal production by showing that when mothers' of 9.5-month-old infants provided social attention contingent on all infants' vocalizations, the phonological structure of the infants' vocalizations changed in accordance with the phonological structure delivered by parents during social attention. These studies suggest that auditory feedback from infants' self-produced vocal responses that match speech sounds in their environment can strengthen those responses. These studies provide some indirect support for the role of response-produced feedback in vocal development.

More direct evidence is difficult to produce in humans for ethical reasons, but research on vocal learning in songbirds has experimentally demonstrated the necessity of auditory feedback for song acquisition and maintenance. For example, several studies have shown that when songbirds (i.e., red-wing blackbirds and chaffinches) are raised from eggs or nestlings in acoustic isolation, their species-typical song does not match the song sung by the respective wild type (Marler, Krieth, & Tamura, 1962; Poulsen 1951; Thorpe 1954). This finding suggests the importance of hearing auditory stimuli that will be incorporated into the adult song. Furthermore, Waser and Marler (1977) demonstrated the importance of auditory feedback by deafening juvenile canaries following exposure to their species-typical song. Canaries do not practice their song until the onset of sexual maturity; therefore, the juveniles had not received prior auditory feedback from their own attempts to engage in song production. Findings demonstrated dramatic differences in songs produced by the juveniles that were deafened and the song produced by wild-type canaries. This finding highlights the importance of auditory feedback on the development of song. Woolley and Rubel (2002) demonstrated that for Bengalese Finches hearing self-produced songs is important for maintenance of their song. The experimenters deafened the birds after their song was stable by destroying the inner ear hair of the birds. Following deafening, the birds' songs differed in comparison to their pre-deafening songs.

Interestingly, as the hair cells of the Bengalese Finches regenerated their song recovered. Furthermore, feedback has been shown to shape or change stable songs of adult Bengalese Finch (Sober & Brainard, 2009). The experimenters put headphones on the birds while they sang. The pitch of the song was increased or decreased and delivered as auditory feedback through the headphones to the birds. The pitch of the birds' vocalizations while they sang compensated for the imposed shifts in the acoustic feedback in both directions. When the pitch was not manipulated, the pitch of the bird's song returned to the normal range. This finding suggests that feedback can shape the vocal production of some songbirds. It is unclear at this point what neural mechanisms allow for the feedback to facilitate, shape, or maintain vocalizations in songbirds or humans, but the automatic reinforcement account provides a functional explanation of the phenomenon.

Reinforcement by social and response-produced consequences provide a conceptual framework for the development of interventions for children who do not meet early language milestones under typical caregiving circumstances, such as some children with autism spectrum disorder (ASD). For these children, it is sometimes the case that social stimuli (i.e., those stimuli reported in the developmental literature on language acquisition to influence infant vocalizations, such as praise, smiles, nods, etc.), do not function as reinforcers (e.g., Dozier, Iwata, Thomason-Sassi, Worsdell, & Wilson, 2012). Thus, naturally occurring contingent delivery of social stimuli on vocalizations may not suffice to increase the behavior. This implies that one way to intervene is to create artificial reinforcement contingencies that provide the contingent delivery of known reinforcers (e.g., food items) on speech sounds to help these children meet their early language milestones. In addition, it is possible that the differential selection of vocalization occurring via auditory feedback is disrupted, perhaps due to speech sounds not functioning as conditioned reinforcers. If this is the case, it implies that alternatively, interventions can focus on establishing adult-delivered sounds as conditioned reinforcers. This has been the rationale for the development of stimulus-stimulus pairing (SSP) procedures to induce novel vocalizations in children with ASD. These procedures have been recommended in early behavioral intervention curricula to increase vocalizations of nonverbal children with ASD who engage in little vocal play (Greer, & Ross, 2008; Sundberg, & Partington, 1998) and their effects attributed to the establishment of speech sounds as conditioned reinforcers.

Stimulus-Stimulus Pairing

Stimulus-Stimulus Pairing Procedures

Stimulus-stimulus pairing procedures have been investigated extensively in the behavioral literature on early vocalizations. A SSP procedure involves repeated temporally contiguous presentations of a vocally presented speech sound with a preferred stimulus, such that the sound reliably predicts the immediate delivery of the preferred stimulus. For example, the therapist says, “bah, bah, bah”, and simultaneous with the third “bah” of the progression (i.e., “bah, bah, **bah**”), the experimenter delivers the preferred item. The delivery of the sound and the preferred item is independent of the participant’s behavior. The desired outcome is that when the child produces a vocalization that is similar to that of the adult model, the auditory feedback from those vocalizations will strengthen that response. Following successful SSP interventions, clinicians and parents have more vocal responses to reinforce and bring under stimulus control.

Applied Research on Stimulus-Stimulus Pairing

Several studies have provided support for the utility of SSP to increase novel vocalizations of typically developing children (Smith, Michael, & Sundberg, 1996), children with language delays (Sundberg, Michael, Partington, & Sundberg, 1996; Yoon & Bennett, 2000), and children with ASD (Esch, Carr, & Grow, 2009). Sundberg et al. (1996) first demonstrated the effects of the SSP procedure on vocalizations with four children with language delays and one typically developing child. The procedure consisted of pairing novel vocalizations (in many cases words or phrases) with stimuli or activities preferred by the participants. To evaluate the effects of the SSP procedure on target vocalizations, vocalizations were recorded during pre-pairing, pairing and post-pairing observations. Results showed that the target vocalizations of all participants increased following pairing relative to pre-pairing.

In addition to rate-increasing effects on vocalizations, Smith et al. (1996) demonstrated that through an SSP procedure, the rate of specific vocalizations decreased from pre-pairing observation sessions to post-pairing sessions when an adult's similar vocalizations had been paired with a mild punisher. In addition, pairing of vocalizations with neutral events had no effect on vocalizations.

Yoon and Bennett (2000) compared the effects on novel vocalizations of an SSP condition to an echoic condition with participants with developmental delays. First, the experimenters replicated earlier studies and found that vocally delivering target sounds paired with a preferred item produced increases in target vocalizations from pre-pairing to post-pairing observations for all three participants. Next, the experimenters attempted to use an echoic procedure to increase novel vocalizations. The echoic procedure consisted of the experimenter delivering the instruction, "say ___" and delivering a preferred item contingent on correct responses. None of the participants made the target sounds during echoic training. The experimenters conducted SSP following echoic training and SSP produced increased target vocalizations. These data suggest that for children who are not readily vocalizing, SSP is a more effective intervention than direct reinforcement of echoic responses, which lends further support to the clinical utility of the SSP to increase novel vocalizations.

Collectively, these early studies provided tentative support for the clinical utility of SSP to increase vocalizations of nonverbal children with ASD. However, they contained methodological limitations that prevent attributing the effects on vocalizations solely to SSP. One limitation is that they employed simple pretest-posttest designs that did not permit controlling for threats to internal validity (e.g., history). Another limitation includes not controlling for the effects of direct reinforcement of vocalizations (i.e., the possibility that vocalizations could have increased because a preferred item was delivered contiguously with a target vocalization of the participant). A third limitation is that these early studies did not assess the effects of modeling the speech sounds on participants' vocal behavior before introducing the pairing condition, as it is possible that simply modeling the speech sounds contributed or induced the noted increases in vocalizations. Lastly, these early studies did not assess the inclusion of preferred stimuli and adult delivered speech sounds in an unpaired arrangement to determine if the pairing was necessary.

Miguel, Carr, and Michael (2002) conducted a more rigorous evaluation of the effects of SSP on the target vocalizations of three participants with ASD. The experimenters corrected for the methodological issues in earlier studies by including an omission contingency placed on target responses that were made immediately prior to the delivery of the next pairing trial to rule out the possibility that adventitious reinforcement could occur under the pairing arrangement. The experimenters also employed a multiple baseline with an embedded reversal design across target vocalizations to control for threats to internal validity. The omission contingency consisted of incorporating a 20-s delay before the presentation of the next pairing trial. The delay was included to prevent direct reinforcement of target vocalizations. To control for the possibility that increases in target vocalizations could be attributed to modeling and/or the delivery of preferred items within the sessions, the experimenters included an unpaired condition prior to the pairing condition. The unpaired condition consisted of the experimenter vocally delivering the target sounds five times in a row. A 20-s interstimulus interval (ISI; the time between delivering the auditory stimulus and the preferred stimulus) began immediately following the target sounds. The preferred item was then delivered after the ISI elapsed. The SSP condition with the exception of the inclusion of the omission contingency was conducted similarly to the procedures described in the previous studies. Under these conditions, target vocalizations following SSP exceeded rates observed during baseline for two of the three participants.

Although some well-controlled studies have reported reliable effects of SSP on vocalizations for all or most participants (Esch et al., 2009; Miguel et al., 2002), other studies have completely failed to find the effect (Esch, Carr, & Michael, 2005; Normand & Knoll, 2006; Stock, Schulze, & Mirenda, 2008). For example, in an attempt to evaluate the clinical utility of SSP, Esch et al. (2005) used a multiple baseline design across response topographies to evaluate the effects of SSP on the target vocalizations of three children with ASD. The experimenters periodically conducted echoic probes to evaluate whether the vocalizations could be evoked as echoic responses. In the event that the target vocalizations occurred during the probes, the experimenters provided direct reinforcement contingent on the echoic responses. However, SSP failed to induce target vocalization of all three participants.

Several variables have been proposed as explanations for failures of SSP to affect vocalizations. For example, Miguel et al. (2002) suggested that conditioned reinforcement provided by auditory feedback may not adequately compete with reinforcers provided by others (e.g., preferred foods, social stimuli). Others have speculated that the preferred items delivered during pairings may not have been effective reinforcers (Esch et al., 2005). Yoon and Bennett (2007) hypothesized that some children may have negative pairing histories associated with attempts to produce speech sounds, in that the auditory products of their self-produced vocalizations may be automatically punishing. Petursdottir, Carp, Mathies and Esch (2011) evaluated procedural modifications to SSP, some intended to address issues known to affect conditioning, such as pre-exposure and blocking, and some intended to improve reinforcer identification for three nonverbal boys with ASD. Sound presentations consisted of pre-recorded speech sounds that were either presented with a preferred stimulus (target sound) or presented alone (i.e., the control sound). Following each session, participants had the opportunity produce identical pre-recorded speech sounds by pressing buttons, which made it possible to evaluate relative preference for the target sound and the control sound, irrespective of the participants' ability to articulate those sounds. Results indicated that no participant reliably preferred the paired sound over the control sound. These results were taken to suggest that the pairing procedures described in the literature on SSP effects on vocalizations may not reliably establish speech sounds as reinforcers for children with ASD.

Two recent studies have included efforts to enhance SSP (Esch et al., 2009; Rader et al., 2014). One procedural enhancement was the use of *motherese* when target sounds were presented, to differentiate them from other auditory stimuli in the environment. Another enhancement was the use of an observing prompt before each presentation (i.e., "look") to assure the participant was attending during the presentation of the target sounds. A variable intertrial interval (ITI; i.e., time between pairings) was used to reduce the predictability of stimulus presentation. Lastly, nontarget sounds that were not followed by a preferred stimulus were presented between target presentations in a semi-random fashion to promote discrimination of the specific sounds that are paired with a preferred stimulus. The investigators also departed from previous studies in their data collection methodology by recording within session vocalizations, as opposed to during pre- and post-pairing observation session. Across the two studies, enhanced SSP produced reliable effects on the vocalizations of four of five participants. However, it is unknown whether this success can be attributed to the enhancements of SSP or any aspect thereof, or whether it is related to participant characteristics.

In summary, the literature to date suggests that the particular SSP procedures used in these studies do not reliably affect the vocal production of children with ASD, perhaps because they do not reliably establish speech sounds as conditioned reinforcers. The exact procedural variables and/or participant characteristics that influence the effectiveness of the procedure have not been identified.

Potential Alternatives to Stimulus-Stimulus Pairing

Stimulus-stimulus pairing is hypothesized to establish speech sounds as conditioned reinforcers, however most basic research on establishing stimuli as conditioned reinforcers for children do not use response-independent pairing (RIP) procedures such as those typically reported in the SSP literature. More frequently, they employ response-contingent pairing (RCP) procedures (e.g., Leiman, Myers, &, Myers, 1961; Myers & Myers, 1963) or operant discrimination training (ODT) procedures (e.g., Sidowski, Kass, & Wilson, 1965). The main procedural difference across these conditioning procedures is in terms of whether or not there is a response requirement and when the response is required. In a typical ODT procedure, a discriminative stimulus (S^D) signals the opportunity for the individual to engage in a target response. Only responses in the presence of the S^D are reinforced. Target responses that occur under other conditions such as the S^{-delta} are extinguished. During RCP, the opportunity to respond is present whenever the manipulandum (e.g., a button) is present. Following each response a pairing of a neutral stimulus and a reinforcer is presented. These procedures differ from that of RIP, in that during RIP there is no response requirement placed on the participants as pairings are presented on a time-based schedule.

In an effort to demonstrate the establishment of conditioned reinforcers for children Leiman, Myers, and Myers (1961) divided 45 school-aged participants into three groups, one experimental group and two control groups. During the first phase, the experimental group and one of the control groups were required to respond correctly on an arbitrary discrimination task before receiving a pairing of the neutral stimulus (i.e., a buzzer) and unconditioned reinforcer (US; i.e., candy). The only difference for these two groups occurred during testing. The other control group was required to respond correctly on the same discrimination task but correct responses produced the US only. During testing, the experimental group received only the buzzer for correct responses. The control group that received only the US during the experimental phase did not receive a programmed consequence following correct responses. For the control group that received pairings during the experimental phase, correct responses did not produce a programmed consequence. For the control group that received only the US during the experimental phase, correct responses produced the buzzer alone. Results showed that persistence of correct responding was higher for the experimental group than for the control groups. This finding suggests that auditory stimuli can be established as conditioned reinforcers for children through this type of RCP procedure.

Myers and Myers (1963) used RCP to demonstrate conditioned reinforcement effects with 96 typically developing children. The procedure was designed to increase attending during stimulus presentations. The general method consisted of allowing the participant to press a button (a clown nose) under a free-operant arrangement. Once the button was depressed, a light or buzzer followed by an M&M was presented. The effects of the buzzer or light as conditioned reinforcers were evaluated in terms of persistence of button pressing when edibles were no longer presented (i.e., the buzzer or light was still presented). Results indicated that responding during extinction (of the CS-US pairing) test was more persistent when the CS had been paired with a reward as opposed to being paired with a nonreward or neutral stimulus.

Sidowski et al. (1965) evaluated the effectiveness of several strategies to establish neutral stimuli as conditioned reinforcers. Participants included 140 school-age children, who were separated into one of four groups that were exposed to different contingencies for level pulls of a slot machine. The primary reinforcer group received a penny for each pull of the lever. The conditioned reinforcer group was presented with a light for .5 s prior to the delivery of a penny contingent on lever pulls. The contingency for the ODT group consisted of the light being presented before the lever could be pulled. The light turned off when the lever was pulled, and a penny was delivered. For the conditioned reinforcement and ODT group the light was presented before the lever could be pulled and did not turn off until the penny was delivered. Each group was then divided into different subgroups during the testing phase, a light and a no light group. The test phase consisted of withholding the delivery of pennies contingent on lever pulls (extinction of CS-US pairings). Participants in the light subgroups were presented with the light only, contingent on lever pulls during this phase. Participants in the no light condition did not receive pennies or a light contingent on lever pulls. The primary reinforcement group continued to receive pennies during the testing phase. The results suggest that the groups tested in extinction with the light responded significantly more than groups that did not receive the light in the extinction condition. This finding suggests that all three procedures were effective in establishing the light as a conditioned reinforcer. Additionally, more persistence was observed for the group who received pairing contingent on lever pulls. This finding suggests that RCP may be more effective than ODT when attempting to establish conditioned reinforcers for children.

These and other early studies provide evidence that it is possible to establish conditioned reinforcers for humans. Given that SSP interventions are hypothesized to exert their effects on vocalizations through conditioned reinforcement, this basic literature also suggests some alternatives to SSP procedures.

Applied Research on Operant Discrimination Training

Because early literature on establishing conditioned reinforcers in humans did not typically employ RIP to establish conditioned reinforcers, more recent literature sought to compare the effects of RIP to ODT (Holth, Vandbakk, Finstad, Gronnerud, & Akselsen-Sorensen, 2009; Lepper, Petursdottir, & Esch, 2013). Holth et al. demonstrated that ODT produced greater effects than RIP when establishing conditioned reinforcers for motor responses of children with and without ASD. Lepper et al. sought to identify whether ODT would increase vocalizations of children with ASD. The effects of ODT were compared to a RIP condition on target vocalizations of three nonverbal boys with ASD. The ODT condition consisted of 20 S^D trials in which the experimenter vocally presented an auditory stimulus three times (e.g., “bah, bah, bah”), and then delivered a preferred item contingent on a hand-raising response. In the presence of a second auditory stimulus, the S^{delta}, (as well as any time in the absence of the S^D), arm raises did not result in delivery of the preferred item. In SSP, each trial consisted of vocally presenting an auditory stimulus three times (e.g., “kah, kah, kah”) and a delivering a preferred item that overlapped with the auditory stimulus offset by 1 s. The S^{delta} sounds were interspersed between pairing trials and were not followed by preferred item delivery. The results indicate that both ODT and SSP produced higher rates of vocalizations compared to their respective control sounds. However, the effects of ODT were not greater than the effects of SSP on target vocalizations.

Applied Research on Response-Contingent Pairing

Greer, Pistoljevic, Cahill, and Du (2011) used RCP to establish adult-delivered vocalizations as conditioned reinforcers, rather than to increase target vocalizations. The participants were three children with ASD, for whom the speech of others did not appear to function as a reinforcer. The experimenters used a delayed pre-post probe design to evaluate the effects of a RCP on selection of stories, observing responses to adult voices, and the rate of acquisition on receptive language tasks. The RCP condition consisted of allowing the child to press a button on a cassette recorder under a free-operant arrangement. When the button was depressed, speech sounds were played. The experimenter also delivered a preferred edible (or soft touch) contingent on the button press response. Training continued until participants reliably depress the button during post-pairing test trials. To evaluate if RCP successfully established adult delivered sounds as conditioned reinforcers, the experimenters used a concurrent operants paradigm to assess preference for sounds. During these assessments, participants could chose to depress a button that produced adult-delivered speech sounds or a button that control button that did not produce sounds. Results demonstrated that during post training probes, participants depressed the button that produced the adults delivered sounds more frequently than they did during pre-intervention probes. However, because the response tested (i.e., selection of button presses that produced speech sounds) was directly reinforced during RCP, the effects of conditioned reinforcement cannot be separated from direct reinforcement. Additionally, the experimenters observed that this preference for sounds generalized to a new setting where participants selected listening to stories told by adults on cassette more frequently in an unstructured play session than they did prior to RCP. Additional data indicated that attending to adult sounds increased, and the number of trials needed to acquire language related skills in academic settings decreased following RCP. These findings suggest that RCP can be used to establish conditioned reinforcers for children with ASD. However, the use of the pre-post probe design for the secondary measures does not allow for history, maturation, or testing effects to be ruled out. For example, only one preference assessment probe was conducted with each participant in baseline, so it is possible the increase following RCP could be attributed to the participants having more experience with the testing conditions (i.e., button-pressing). Additionally, data were not presented on responses allocated to the control button preference assessment probes, which makes it difficult to identify if a true preference was obtained.

Despite the methodological issues, Greer et al. provides some initial support for the use of RCP to establish conditioned reinforcers for children with ASD. However, the effects of RCP on participants' vocalizations have yet to be evaluated. Additionally, it is unclear whether RCP is a more effective than other interventions such as, SSP or ODT, to establish speech sounds as conditioned reinforcers for children with ASD.

Dozier et al. (2012) evaluated the effects of RIP and RCP to establish praise as a conditioned reinforcer for 12 individuals with intellectual disabilities. During Experiment 1, four participants received 40 RIP trials per session. Each trial consisted of the experimenter delivering novel praise statements followed by the immediate delivery of a preferred edible on a fixed-time schedule. The effects of the contingent delivery of the previously paired praise statements on task completion were compared to baseline rates of task completion where praise was also delivered on task completion. The rate of task completion did not increase for any of the participants following the RIP intervention. During Experiment 2, eight participants received RCP trials that consisted of the experimenter delivering a novel praise statement followed by the immediate delivery of a preferred edible, contingent on a target response (e.g., arm raise). The results of Experiment 2 showed increased rates of task completion as compared to baseline task completion rates for four of the eight participants who were exposed to RCP. These findings tentatively suggest that RCP may be more effective when attempting to establish conditioned reinforcers for children with intellectual disabilities. However, even though Experiment 1 and Experiment 2 employed single-case experimental designs to evaluate the effects of each intervention relative to baseline, the two interventions were not compared directly between or within subjects. Because of this, it is possible that unknown participant variables account for the differential effects of the two interventions.

Purpose of Study

In summary, failures of RIP to produce an effect on the vocalizations of children diagnosed with ASD have frequently been reported in the literature (Carroll & Klatt, 2008; Normand & Knoll, 2006; Stock, Schulze, & Mirenda, 2008; Yoon & Feliciano, 2007). It is possible that these failures have occurred because the RIP interventions that have been employed in most studies are not optimal for establishing conditioned reinforcers for this population. Previous research suggests that RCP may produce more robust effects when attempting to establish stimuli as conditioned reinforcers for individuals with intellectual disabilities (e.g., Dozier et al., 2012); however, the effects of RCP on the vocalizations of children with ASD who engage in limited vocal play is unknown. Therefore, the purpose of Experiment 1 was to compare the effects of RCP and RIP interventions on vocalizations of nonverbal children with

ASD using a single-subject, alternating treatment design. Based on the preliminary findings of Dozier et al. it was predicted that RCP would produce greater effects than RIP. During Experiment 2 we sought to increase the rates of vocalizations induced during Experiment 1 through differential reinforcement. Additionally, during Experiment 3 we sought to determine whether or not induced vocalizations were functional for the participants.

General Method

Participants and Setting

Experiments 1, 2 and 3 were completed with three boys, Lee, Ken and Gabe. Lee was 4 years, 3 months old, Ken was 5 years, 4 months old, and Gabe was 6 years, 2 months old when the study began. The participants were recruited from local centers that provide early intensive behavioral intervention services to children with ASD. All three boys met participation eligibility for this study which included an existing diagnosis of ASD, severely delayed speech as indicated by a profile of 2.5 or below on the Behavioral Language Assessment (BLA; Sundberg & Partington, 1998), and a minimal echoic repertoire as indicated by a score of 5 or below on the Early Echoic Skills Assessment (EESA; Esch, 2008).

The BLA is an informant assessment that was conducted over the phone with the participants' parents. The assessment consists of 12 sections; each section assesses different language-related skills (e.g., motor imitation, labeling). Each section of the assessment is divided into five levels. Each level has a profile related to the specific language-related skill being assessed. Parents were asked to select the level that best represent their child's repertoire for each section. Results of the assessment were calculated by averaging scores across the 12 sections indicating an overall profile level for each participant. Lee's profile level was 2, with a score of 1.67. His BLA suggested he was able to imitate gross motor movements of others, match several pictures and objects, and follow a few simple directions. Ken's profile level was 2, with a score of 2.17. His BLA suggested that he could vocalize several speech sounds, imitate a few gross motor movements, match one or two pictures or objects, and follow a few instructions. Gabe's profile was 2, with a score of 2.3. His BLA suggested that he could identify several letters and numbers, match five to 10 pictures or objects to sample, and follow a few simple instructions. Additionally, all participants' BLA suggested that they were cooperative and could work at least 5 min without disruptive behavior. According to Sundberg and Partington (1998), children with a profile level of 2 or below are likely to require intensive language intervention.

The Early Echoic Skills Assessment (EESA; Esch, 2008) is a subtest of the Verbal Behavior Milestones Assessment and Placement Program (VB-MAPP; Sundberg, 2008). This is a direct assessment of the participants' echoic skills (i.e., the ability of the participant to imitate the speech sounds produced by others) conducted by the experimenter. The assessment evaluates the participant's ability to imitate simple and reduplicate syllables, 2-syllable combinations, 3-syllable combinations, prosody of spoken phrases and prosody in other contexts. The participant is presented with up to three opportunities to make an echoic response (i.e., make a response that imitates the sound delivered by the experimenter) to each sound presented by the experimenter. The best response of the three opportunities is scored as correct, which yields 1 point, or recognizable (i.e., response approximates the auditory stimulus but includes incorrect or missing consonants or extra syllables), which yields a score of .5. Failures to respond, unrecognizable responses, or responses with incorrect vowels or missing syllables are scored as 0. There are 112 points possible. Lee's EESA score was 1.5, as he approximated 3 simple syllables. Ken's EESA score was 2.0; he approximated two simple syllables and two, 2-syllable combinations. Gabe's EESA score was 1.0; he correctly imitated two simple syllables.

Sessions were conducted in a quiet room away from noise and other distractions. Contents of the room varied depending on room availability but always included a low table and chairs, and a video camera positioned on a tripod. Toys other than the preferred item selected by the participant were removed from the room or placed out of reach of the participant. Lee and Gabe were free to move around the room during sessions. Ken was instructed to sit in the child-sized chair during sessions, as he engaged in serious problem behaviors (i.e., pica, elopement, rumination, deliberate enuresis, self-injury and aggression) that required the experimenter to be in near proximity to block the behaviors for safety reasons. Visits were conducted two to five days per week and included one or two of the assessments or sessions described below. Visit duration varied but never exceeded 30 min. Total duration of participation ranged from four to eight months.

Manipulandum

The experimental manipulandum consisted of a blue plastic microswitch button (Big Red®) that measured 12.7 cm in diameter. The adapter cord was removed from the button.

Stimulus Preference Assessment

A paired-stimulus preference assessment (Fisher, Piazza, Bowman, Hagopian, Owens, & Slevin, 1992) was conducted with each participant in order to identify preferred stimuli to be used during the experimental sessions. The stimulus pool consisted of toys for Lee and foods for Ken and Gabe that were nominated by the participants' parents as preferred on the Reinforcer Assessment for Individuals with Severe Disabilities (RAISD; Fisher, Piazza, Bowman, & Amari, 1996). Parents nominated toys for Lee due to food selectivity issues (i.e., there were very few foods he would eat). Prior to conducting the assessment, participants were given the opportunity to sample the nominated items. During this time, the experimenter assessed whether the participant had the ability to engage with the items independently and in an appropriate manner (i.e., the item(s) did not evoke stereotypy). During the paired-stimulus assessment, two stimuli at a time were presented by placing them on a table in front of and equidistant from the participant. Food was presented in small quantities (e.g., one piece of cookie). The experimenter gave a prompt to scan both items (e.g., "look," while pointing to each of the two items). After the verifying that scanning had occurred, the experimenter instructed the participant to "pick one". The participant's selection of an item by pointing to it or grabbing it resulted in time to consume the selected edible or 20 s to engage with the toy. After consumption or the 20 s of engagement time elapsed, another pair of stimuli was presented in the same fashion. Each item in the stimulus pool was presented with every other stimulus twice, and the placement (i.e., right or left) of each item was counterbalanced across presentations.

During later experimental sessions, Ken exhibited behaviors (i.e., not consuming and/or rumination) that indicated that the paired-stimulus assessment had produced false-positive results (i.e., the most preferred item, banana slices, did not appear to be functioning as a reinforcer). Because problem behavior, rather than scanning issues, was suspected to have interfered with reinforcer identification through the use of the paired-stimulus assessment, we conducted an additional free-operant (Roane, Vollmer, Ringdahl, & Marcus, 1998) assessment based on the recommendations of Karsten, Carr, and Lepper (2011). A new stimulus pool consisting of toys was compiled based on therapist recommendations of items that Ken would work for during therapy. Also included in the assessment were the windows in the therapy room, based on informal observations suggesting that Ken would engage in problem behavior to access them. Prior to conducting the assessment, Ken was given the opportunity to sample the new set of nominated items. During this time, the experimenter assessed whether he had the ability to engage with the items independently and in an appropriate manner (i.e., the item(s) did not evoke problem behavior). Following the sampling period, almost all of the nominated toys were placed on a long, child-sized table against the west wall of the room. Along the north wall were the floor-to-ceiling windows that were included in the assessment. Before beginning the assessment, Ken was taken to the southeast corner of the therapy room and prompted by the experimenter to scan the available items in the room (i.e., the experimenter gave the verbal instruction to "look" while pointing to each item in the stimulus pool). After the experimenter verified that Ken had scanned the items (i.e., the direction of the participant's gaze was consistent with item locations), he was instructed to, "Go play." All items were freely available to Ken simultaneously and he could engage with as many or as few items as he wished during the 5 min session. Engagement was defined as Ken touching any item in the stimulus pool, including the window. Duration of engagement with each item was recorded. The cumulative duration of engagement with each item was divided by the total duration of the session which yielded a percentage of engagement for each stimulus available during the assessment. The item with the highest duration of engagement during the assessment was selected to use as the preferred item during experimental sessions for Ken.

Table 1 shows the selection percentage for each item included in the arrays for each participant. Selection percentages were calculated by dividing the number of times the item was selected by the number of times it was presented during the assessment. The resulting quotient was multiplied by 100. The stimulus with the highest selection percentage was used during the experimental sessions. The items identified during the paired-stimulus assessment included a glitter-filled wand for Lee, bananas for Ken, and Cheetos® for Gabe. For Ken, the free-operant assessment identified access to the window as the highest ranked stimulus. A small dinosaur was also identified as highly preferred for Lee. However, for each participant only one preferred item was used during sessions so that toy was not used.

Table 1

Participants' Stimulus Preference Assessment

Participant	Highly Preferred Stimuli		Moderately/Least Preferred Stimuli				
Lee	Wand (83%)	Dinosaur (83%)	Puppet (58%)	Snake (58%)	Bubbles (33%)	Pinball (17%)	Book (17%)
Ken PS	Bananas (100%)		Chips (67%)	Potatoes (17%)	Fries (17%)		
FO	Window (98%)		Puzzle (1%)	Books (0%)	Ramp (0%)	Frog (0%)	Dot Game (0%)
Gabe	Cheetos® (70%)		Cookies (60%)	Doritos (60%)	Bananas (50%)	Oreos (40%)	Oatmeal (20%)

Note. Selection (or duration of engagement) percentages rounded to the nearest whole number are indicated below the stimulus within the parentheses. For Ken, a paired-stimulus preference assessment (PS) and a free-operant (FO) stimulus preference assessment were conducted. Data from the free operant assessment are reported as the percentage of engagement across a 5 min session. The highly preferred stimulus for each participant was used as the putative reinforcer during experimental sessions. For Ken, the first eight sessions of Experiment 1 included only the highly preferred stimulus identified via the paired-stimulus assessment; all other sessions used only the highly preferred stimulus identified via the free-operant assessment.

Pre-experimental Observation

In order to ensure that each participant had the ability to vocalize the consonant and vowel sounds that made up the target and nontarget syllables presented in each experimental condition, these sounds were individually selected for each participant based on their vocalizations observed during free play observation sessions. During these observation sessions, participants were able to engage in activities (e.g., play with toys) and interact with experimenter; however the experimenter attempted to minimize interactions. For example, if a participant made some type of request for attention or help, the experimenter would deliver nonverbal reinforcement (e.g., turning on a toy, a smile or nod of the head). Each observation session was 10 min in duration. The number of sessions conducted with each participant ranged from three to six. The sessions were conducted across at least two days. During these sessions, the experimenter recorded the frequency and form of vocalizations. This information was used to select sounds for the experimental conditions. Each of these sounds consisted of a simple syllable, which exclude syllables that require consonant blends (e.g., “th”). Criteria for selection of syllables for the experiment included that the participant produced the consonant and vowel sounds during the observation, but did not produce the syllable as a single unit. For example, if the participant said “moo”, “bah”, and “ee”, during the observations, these syllables were excluded as syllables to be used during the experimental conditions, but the syllables “mah”, “boo”, “bee”, “oom”, “hab”, “hee”, and “mee” were eligible for selection. Four syllables were identified for each participant. After identification of each syllable, the experimenter verified that each sound selected had not previously been spoken by that participant during any of the previous assessments (EESA or preference assessment) by reviewing the videotaped sessions. Additionally, the experimenter verified that the sounds selected were not under echoic control by asking the participant to “say _____” three times for each syllable selected. If the participant approximated the syllable presented by the experimenter, that syllable was excluded and a replacement was identified through the same process described above. Following successful identification of sounds that met those criteria the experimenter randomly assigned two syllables to each experimental condition (i.e., RCP and RIP). Within each condition, one syllable served as a target sound the other syllable served as a nontarget sound. Table 2 provides a list of the auditory stimuli selected for each participant.

Table 2

Participants' Auditory Stimuli

Participants	Condition/ Target (T) or Nontarget (NT)	Auditory Stimuli
Lee	RIP T	Kuh
	RIP NT	Moe
	RCP T	Dah
	RCP NT	Mee
Ken	RIP T	Gee
	RIP NT	Hoo
	RCP T	Poo
	RCP NT	Nee
Gabe	RIP T	Moo
	RIP NT	Hum
	RCP T	Day
	RCP NT	Lah

Button-Press Training

The purpose of button-press training was to teach participants to press a button in order to receive the preferred item that was ranked highest during their stimulus preference assessment. Prior to the start of each training trial, the experimenter placed the participant's highest ranked preferred stimulus out of reach but within the participant's visual field and placed a button within reach of the participant. The participant initiated each trial by either reaching for the preferred item or reaching for the button. The experimenter physically blocked attempts to reach the preferred stimulus. The trials consisted of allowing 10 s for the participant to make an independent button-press response, a prompt to engage in the button press response (if needed), and the immediate delivery of the participant's preferred item contingent on the button press. Both independent and prompted responses resulted in the immediate delivery of the preferred item (a small piece of edible or approximately 15 s to engage with their preferred toy).

The experimenter used most-to-least prompting to train the button-press response if the participant did not engage in the response independently within the first 10 s of the trial. The most-to-least prompting hierarchy consisted of presenting the most intrusive prompt first, and gradually decreasing the level of intrusiveness across trials. The most intrusive prompt, full-physical guidance, consisted of the experimenter placing her hand over the participant's hand and physically guiding the button-press response. Partial guidance consisted of the experimenter prompting the button press response by guiding the elbow of the participant so that his hand moved toward the button. Gestural prompts were delivered by the experimenter pointing to the button. Criterion for progressing from a more intrusive prompt level to a less intrusive prompt level was three consecutive trials in which the prompt occasioned the button-press response. Criterion for progressing from a less intrusive level of prompt to a more intrusive level of prompt was one trial in which the prompt did not occasion the button-press response. In the event the prompt did not occasion the button-press response, the more intrusive prompt was implemented to ensure that all trials ended in delivery of the preferred item. Button-press training continued until the participant responded independently (without the aid of prompts) in 10 consecutive trials across two consecutive days of training. Sessions varied in duration but did not exceed 30 min. All participants met criterion within three sessions. Following button press training, the participant proceeded to the experimental evaluation portion of the study.

Experiment 1

The purpose of this experiment was to compare the effects of RCP to RIP on the vocalizations of nonverbal children with ASD.

Measurement

Dependent variables and data collection. In each experimental condition, frequency data were collected on participant vocalizations; one target sound and one nontarget sound. A target vocalization was defined as a vocalization that matched or approximated the target sound.

An exact match was scored if the participant produced the same syllable as the target sound. For example the target sound was "moo" and the participant said "moo". An approximation was scored if the participant made speech sounds that contained the exact vowel and a consonant that required similar tongue or lip placement to produce in the same order as presented by the experimenter. For example, if the participant's target vocalization was "moo", responses scored as occurrences included "moo" or "boo". For Gabe, only exact matches were scored as target sounds in Experiment 1. In session 30 of Experiment 2, the definition of a target response was expanded to include approximations for Gabe. This was done because it was observed that he began to make a specific vocalization which approximated the target sound at a high rate. Justification for broadening the definition was based on the fact that the goal of the intervention in Experiment 2, was to increase target vocalizations, not to shape them, and that several other published studies have included approximations as a part of the operational definition of a target response (e.g., Esch et al. 2005; Miguel et al., 2002; Yoon, & Feliciano, 2007). Nontarget vocalizations were defined in the same manner for all participants. Echoic responses were operationally defined as the participant vocalizing a sound that matched or approximated the sound presented by the experimenter anytime during the stimulus presentation or within 5 s of the offset. Within each session, the frequency of participant-produced vocalizations was recorded within ITIs and while the participant consumed or engaged with the preferred item during target trials. For each session, the frequency of target and nontarget vocalizations within a session was divided by the total duration of ITIs and consumption periods across the session which yielded a rate of vocalization per minute measure for target and nontarget responses.

Interobserver agreement. Two independent observers scored occurrence of target and nontarget vocalizations for at least 30% of all sessions, either live during the session or from videotape. Interobserver agreement scores were calculated separately for targets and nontargets using the frequency-within-trial agreement method. An agreement was scored if the two observers scored the exact number vocalizations within ITI, otherwise the ITI was scored as a disagreement. For each of these sessions, the number of ITIs and the respective consumption periods with disagreements was subtracted from the total number of ITIs and engagement periods. For each ITI and engagement period scored as a disagreement, the smaller frequency scored within that ITI and engagement period was divided by the larger frequency and quotient was added to the number of agreement trials. The sum was divided by the total number of ITIs and the quotient multiplied by 100. Agreement on target and nontarget vocalizations for all participants was calculated for at least 30% of all sessions in each condition.

For Lee, mean agreement across sessions was 99.0% (range, 95.0% to 100%) for target vocalizations of RCP, 100% for nontarget vocalizations of RCP, 100% for target vocalizations of RIP, and 100% for nontargets of RIP. For Ken, mean agreement was 98.8% (range, 95.0% to 100%) for target vocalizations RCP, 100% for nontarget vocalizations of RCP, 98.9% (range, 97.5% to 100%) for target vocalizations of RIP, and 99.7% (range, 97.5% to 100%) for nontargets of RIP. For Gabe, mean agreement was 96.9% (range, 84.3% to 100%) for target vocalizations of RCP, 99.0% (range, 95.0% to 100%) for nontarget vocalizations of RCP, 97.0% (range, 90.0% to 100%) for target vocalizations of RIP, and 100% for nontargets of RIP.

Procedure

Response-contingent pairing. Before each session, the experimenter placed a discrimination aid (i.e., colored poster boards) in view of the participant. The purpose of the discrimination aid was to help the participant discriminate between conditions, in order to reduce carryover effects due to multiple treatment interference (Conner et al., 2000).

Each RCP session consisted of 20 sound presentations, made up of 10 target and 10 nontarget sound presentations. The order of target and nontarget sounds was semi-randomized so that the same sound was presented no more than three times in a row.

During target sound presentations, the experimenter placed a button (the same one used during button press training) on the table in front of the participant. The experimenter waited for the participant to press the button. Immediately after the participant pressed the button, the experimenter vocally presented the target syllable three times with 1 s between presentations (e.g., "dah, dah, dah", see Table 2). Simultaneously with the third presentation of the target syllable (e.g., "moo, moo, **moo**"), the experimenter presented the participant's designated preferred item; that is, a small piece of food or 15 s of access to a non-food item. For Ken, when the window was used as the preferred item access to the window was blocked by a tri-fold poster board placed on a table in front of him. This prevented him from touching or seeing out the window. During target stimulus presentations, the experimenter removed the poster board simultaneously with the third presentation of the target syllable which allowed Ken to touch and see out the window. Upon presentation of the preferred item, the experimenter removed the button from the participant's reach, and the stimulus consumption period began. The consumption period consisted either of the 15 s of access to the preferred item or the amount of time that it took the participant to chew and swallow a food item. Following consumption, the ITI began. The button was represented by placing it within reach of the participant (or at a fixed location on a table for Ken) 10 s into the ITI. The ITI ended when the participant pressed the button, resulting in the presentation of either a target or a nontarget sound. Thus, the ITI was at least 10 s in duration but actual length varied depending on the latency of participant's button press response.

Nontarget sound presentations were included during RCP to promote discrimination of the target sounds, and to control for exposure to speech sounds. During nontarget sound presentations, the experimenter presented the button to the participant and waited for the participant to make a button-press response as described previously. Immediately after the participant pressed the button, the experimenter presented the nontarget sound. The nontarget sound presentation consisted of the experimenter vocalizing the nontarget syllable three times with 1 s between presentations (e.g., “hum, hum, hum” see Table 2). Immediately following the presentation of the nontarget sound, the ITI began (i.e., nontarget trials did not result in the delivery of a preferred stimulus) and the button was removed from the participant’s reach. Once 10 s of the ITI had elapsed, the button was placed back in reach of the participant, or on the table for Ken.

If the participant did not press the button within 1 min of the experimenter presenting the button, the experimenter lifted the button and replaced it in front of the participant (or on table). This was done to increase the likelihood that the participant noticed the button. No other prompts were used.

In order to prevent direct reinforcement of vocalizations, an omission contingency was in place for echoic responses and target or nontargets vocalizations that occurred immediately prior to a stimulus presentation. For example, the omission contingency was used if the participant made a target vocalization while pressing the button, or if he said the target during the stimulus presentation. The omission contingency resulted in the immediate termination of the target presentation and removal of the button. Once a 20-s interval elapsed without a target or a nontarget vocalization, the experimenter presented the button to the participant. Following the button-press response, the experimenter represented the terminated target or nontarget sounds in the manner described above.

Session duration varied due to variable rates of button-pressing but ranged between 10 and 75 minutes. If the participant could not be exposed to all 20 presentations during the originally scheduled maximum session time due to low rates of responding, the session was resumed on the next visit.

Response-independent pairing. Sessions of RIP were identical to RCP with the following exceptions. First, the button was not presented during RIP. Second, at the beginning of each trial, the experimenter delivered an observing prompt (e.g., “look”), waited for the participant to make eye contact, and then presented the target sounds (i.e., “day, day, day”) immediately followed by the preferred item (or just the nontarget control sounds). Third, the auditory stimuli differed from the ones used in RCP (see Table 2). Lastly, the timing of stimulus presentations was yoked to a previous RCP session. By yoking the timing of sound presentations timing effects are ruled out as a potential explanation for differential effects of the two conditions. This was important because differences in the timing of presentations across the conditions could have differential affected deprivation levels between stimulus presentations or made the stimulus presentations more or less predictable.

Experimental design. The experiment was conducted in two phases. In the first phase, an adapted alternating-treatments design was used to compared the effects of RCP and RIP on the target sounds assigned to each condition. The second phase was a “best-treatment” phase, in which the intervention that produced higher rates of target vocalizations in the first phase was applied to the target sound that occurred at lower rates in the first phase. In this phase, a multiple-baseline design across participants was used to evaluate the effects of the intervention.

An alternating-treatments design consists of rapid alternations of two or more experimental conditions (Barlow & Hersen, 1984). The alternating-treatments design controls for threats to internal validity by incorporating direct and repeated measures of the dependent variable coupled with the alternation of the treatment conditions. Data are typically collected on the same behavior under all of the experimental conditions. However, adapted versions of the alternating-treatments design for acquisition experiments permit randomly assigning different responses to conditions, followed by a within-subject replication of the comparison with a different set of responses (Gast & Wolery, 1988). Analysis is based on visual inspection of the data paths. A consistent separation between data paths from two conditions across repeated measure is taken to indicate an effect that cannot be attributed to history, maturation, or testing.

In the present study, different target and nontarget vocalizations were recorded during RCP and RIP for each participant (see Table 2). The sequence of experimental conditions was semi-randomized by assigning, via a coin flip, a block of four interventions (i.e., RCP, RIP, RCP, RIP or RCP, RCP, RIP, RIP) to the sequence. Heads lead to the RCP, RIP, RCP, RIP sequence, while tails lead to the RCP, RCP, RIP, RIP sequence in the following sessions. Blocking the sequence of interventions allowed for the conditions to be semi-randomized while taking into account the fact that due to yoking ITIs of RIP to RCP, RCP had to precede RIP.

Within the alternating-treatments design, the criterion for determining an effect of either intervention (RIP or RCP) was met when the participant’s vocalizations of the target sound exceeded vocalizations of the nontarget sound in at least three consecutive sessions. The effects of RIP and RCP were compared visually by looking for consistent differentiation between target sound vocalizations across multiple RIP and RCP sessions, and greater effects were evident if the rate of target responses in an intervention exceeded the rate of target response in the other condition across three consecutive sessions.

The multiple-baseline design across participants consists of repeated measures under baseline conditions for each participant, followed by the staggering of the intervention across baselines of differing lengths (Cooper, Heron, & Heward, 2007). The different baseline lengths serve to control for history, maturation, and amount of exposure to baseline conditions. An effect is demonstrated if changes in the level or trend of the behavior are observed, for each participant, when and only when the intervention is implemented. In the present study, the RCP *vs*. RIP comparison phase served as the baseline for the best-treatment phase. The intervention that produced a greater effect in the first phase was staggered across participants based on when the comparison between RCP and RIP was completed in the first phase; thus, the length of the baselines varied naturally. Specifically, the intervention that produced greater effects was applied to Lee's baseline following session 10, to Ken's baseline following session 16, and to Gabe's baseline following session 24. The purpose of this phase was to provide a within-subject replication of the differential effects of the two interventions. Criterion for completion of this phase was that within 10 sessions, rates of responding in at least 50% of the sessions exceeded the highest rate of responding observed for that sound in baseline, with the caveat that criterion could not be met before at least three sessions had been conducted.

Procedural fidelity. Procedural fidelity was assessed for at least 25% of sessions across all experimental conditions. Sessions used to assess procedural fidelity were selected randomly. Trials were scored as correct or incorrect based on the following experimenter behaviors: (a) delivery of the target sound, (b) delivery of the reinforcer, (c) conducting trials according to the specified ITI, and (d) implementation of the correction procedure. Procedural fidelity was calculated by dividing the total number of correctly implemented trials by the total number of correct and incorrect trials. The resulting quotient was multiplied by 100 in order to yield a percentage correct for each experimenter behavior. Mean fidelity scores for correct implementation of trials for Lee, Ken, and Gabe were 98.7% (range, 95.0% to100%), 100 %, and 97.5% (range, 90.0% to 100%), respectively.

Interobserver agreement on procedural fidelity was calculated using the total agreement method by having two independent observers score at least 30% of the session across all conditions for which procedural fidelity data were calculated. Total agreement scores were calculated by each observer summing the number of correctly implemented trials across the session. The smaller number was divided by the larger number and the quotient multiplied by 100. Mean agreement scores on procedural fidelity were 97.5% (range, 90.0% to 100%) for Lee, 100% for Ken, and 90.0% (range, 80.0% to 100%) for Gabe.

Results and Discussion

Figure 1 shows rates of target and nontarget vocalizations for all participants across experimental conditions. All participants showed increases in target vocalizations over nontarget vocalizations in at least one experimental condition. For Ken, this effect was not observed until his preferred item was switched from bananas to window access in session nine.

In RCP, the criterion was met following the third session of RCP, for Lee, following session 13 of RCP for Ken, and following session 23 of RCP for Gabe. In RIP, Lee met criterion after session 10 of RIP. Ken and Gabe did not meet criterion. Gabe produced more target vocalizations than nontargets during RIP. Ken did as well, however those effects were only observed following the change in preferred items.

For all participants, higher rates of target vocalizations were observed in the RCP condition than the RIP condition. Mean target vocalizations for Ken, Lee, and Gabe induced through RCP were 0.25, 0.30, and 0.07 per min, and through RIP were 0.04, 0.04, and 0.02 per min, respectively. This was replicated for all participants in the second phase by intervening on the RIP target sounds using RCP. The multiple-baseline design across participants shows that rates of the vocalizations previously used during RIP immediately increased when and only when RCP was implemented for all participants.

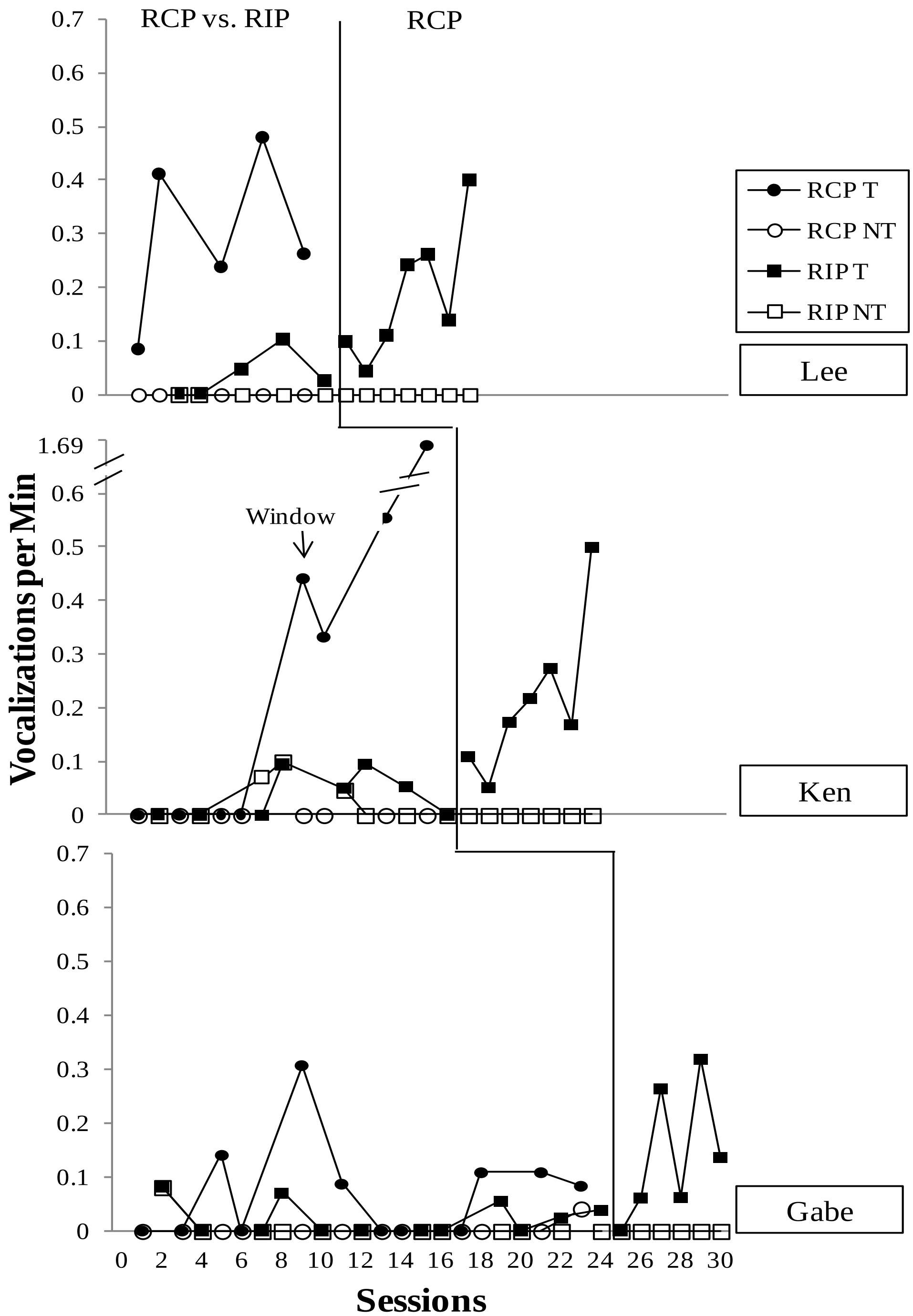

Figure 1. Rate of target (T) and nontarget (NT) vocalizations for Lee, Ken, and Gabe. In RCP vs. RIP, effects of response-contingent pairing (RCP) and response-independent pairing (RIP) were compared using an adapted alternating-treatments design. In RCP, effects of RCP on the T and NT vocalizations assigned to RIP, were evaluated using a multiple-baseline across participants design, where the T and NT of RIP in RCP vs. RIP, served as the baseline. The break in y-axis and data path for Ken was inserted to accommodate an outlier during RCP, session 15. Arrow indicates session that preferred item was changed for Ken.

In summary, RCP produced greater effects on target vocalizations than RIP for all participants. There are at least three possible reasons for RCP inducing more target vocalizations producing greater effect on target vocalizations than RIP. First, the value of the preferred stimulus may have played a role. The procedural arrangement of RCP allowed the participants to access their preferred item (delivered during the pairing) exactly at the time they desired it by engaging in the button-press response. In contrast, during RIP, preferred item delivery was yoked to a previous RCP session irrespective of the momentary incentive value of the preferred stimulus. Research in classical conditioning experiments have shown that when the magnitude of the reinforcer is greater there is faster conditioning (e.g., Rescorla, 1988), which suggests that the better reinforcers produce greater the effects on conditioning. Second, the data may be consistent with a contrafreeloading effect (for a review see Inglis, Forkman, & Lazarus, 1997), in that greater effects were demonstrated when participants were required to work for their preferred item during RCP. Contrafreeloading effects are typically demonstrated when subjects choose to engage in a response to access food rather than opting to eat the same food made freely available. This suggests that earned reinforcers are more valuable than free reinforcers. Consistent with that notion, children have been found to prefer contingent to noncontingent delivery of preferred stimuli (e.g., Luczynski & Hanley, 2009). From the contrafreeloading perspective, RCP should produce greater conditioning effects than RIP because the participants work for the preferred item in RCP, thus making the preferred stimulus more valued. Third, the button press may have functioned as an observing response that enhanced attention to the auditory stimulus presentations in the RCP condition. The RIP condition also contained an observing requirement (i.e., the participant was prompted to look at the experimenter) prior to the onset of each stimulus presentation; however, it is possible that the button press promoted greater attention than looking at the experimenter. The auditory prompt ("look") reliably occasioned the desired response for all three participants, but it is unclear what features of the prompt (e.g., auditory, mouth movement of the experimenter, etc.) the participants were attending to when they made eye contact. Although it has been hypothesized that observing prompts may enhance effects of RIP, their role has yet to be investigated. It is possible that attending to speech sounds of the observing prompt, could interfere with attending to other auditory stimuli that are presented shortly after (e.g., "look", "moo, moo, moo") for children with ASD. In fact, Esch et al. (2009) replaced the auditory observing prompt "look" with a clicker because one of the participants always repeated the statement prior to vocalizing the target response.

The failures of both RCP and RIP to produce an effect for Ken within the first few sessions are interesting. These failures likely occurred because the most highly preferred food did not function as a reinforcer, as suggested by his frequent failures to consume the food when it was delivered. Possible reasons why the paired-stimulus assessment failed to identify an effective reinforcer include problem behavior during the assessment and that none of the caregiver-nominated stimuli were effective reinforcers. Following recommendations by Karsten et al. (2011), a free-operant stimulus preference assessment was conducted using stimuli nominated by clinicians who worked with Ken frequently. Support for the assumption that bananas were not an effective reinforcer for Ken was provided by the fact that immediate increases in target vocalizations were evident in both conditions after the preferred item was exchanged for the one identified via the free-operant assessment.

Although RCP produced a sizeable effect on all participants' target vocalizations, the absolute rates of vocalizations remained low, ranging between 0 and 1.69 per min. On average participants produced less than one target vocalization every 2 minutes. At times several minutes would pass without a target vocalization. It is important to keep in mind that the desired outcome of a pairing intervention is a novel vocalization that can be reinforced and turned into functional communication. This requires target vocalizations to occur reliably so the clinician has ample behavior to reinforce. A possible limitation of the results of Experiment 1 is that it is unclear whether target vocalizations occurred at sufficiently high rates for a clinician to be able to reinforce the vocalizations and bring them under stimulus control. That is, the increases may not have been clinically significant. Experiment 2 was conducted to address this issue.

Experiment 2

In Experiment 1, we compared the effects of RCP to RIP on target vocalizations of three boys with ASD. The RCP condition produced higher and more consistent rates of target vocalizations for all three participants; however, the clinical relevance of those increases may be questionable. Therefore, in Experiment 2, we sought to increase the rate of RCP-induced target vocalizations through differential reinforcement while reducing the density of stimulus pairings during RCP by limiting access to the response button.

Measurement

Design and dependent variables. A multiple-baseline design across behaviors was used to evaluate the effects of differential reinforcement on target and nontarget vocalizations. In the multiple-baseline design across behaviors, repeated measures are collected under baseline conditions for two or more behaviors simultaneously. The initiation of the intervention is staggered across baselines of differing lengths. As in the multiple-baseline design across participants, the effects are analyzed using visual inspection to identify changes in level, trend or variability from the baseline to the intervention phase. Changes in level, trend or variability that are indicative of an effect should only be evident when the intervention is applied to the specific behavior.

The dependent measure was the same as in Experiment 1. However, the operational definitions of target and nontarget responses were expanded to include vocalizations that approximated the target and nontarget sounds presented in each condition. The expanded definitions included vocalizations that in which there was an error of placement in the first consonant. For example, an acceptable approximation of the target sound “moo” included “boo,” because the /m/ and /b/ sounds require similar lip placement. For Lee and Ken, the broader definitions were included from the start of the experiment. For Gabe, the broader definitions were applied following session 40, as he was not making errors of placement until session 30.

Interobserver agreement. Agreement scores were calculated for both target and nontarget sounds across baseline and experimental sessions as described in Experiment 1. Lee’s mean agreement was 81.7% (range, 75.0% to 100%) for the “dah” target vocalizations, 100% for “mee” nontarget vocalizations, 98.9% (range, 97.5% to 100%) for “kuh” target vocalizations, and 99.7% (range, 97.5% to 100%) for “moe” nontargets. Ken’s mean agreement was 85.6% (range, 71.4% to 100%) for “poo” target vocalizations, 100% for “nee” nontarget vocalizations, 98.9% (range, 97.5% to 100%) for “gee” target vocalizations, and 99.7% (range, 97.5% to 100%) for “hoo” nontarget vocalizations. For Gabe, the mean agreement for “day” target vocalizations was 98.6% (range, 90.0% to 100%), and 99.7% (range, 95.0% to 100%) for “lah” nontarget vocalizations. His mean agreement for “moo” target vocalizations was 90.9% (range, 56.0% to 100), and 100% for “hum” nontarget vocalizations.

Procedure

Baseline pairing. Baseline sessions were conducted identically to RCP sessions in Experiment 1, except that sessions were limited to 10 min in duration regardless of the number of stimulus presentations.

Differential reinforcement with thinning of RCP (DR). The purpose of this condition was to reinforce target vocalizations in an attempt to increase their rates above those seen in the RCP baseline. During this phase, RCP was conducted as described in Experiment 1 with the following exceptions: (a) all target vocalizations resulted in delivery of the preferred item, and (b) target vocalizations during the ITI resulted in resetting of the ITI, delaying the availability of the response button by 10 s, (c) if a target response was made during the consumption period for Lee and Ken, that period was extended an additional 15 s, and (d) session duration was limited to 10 min (this resulted in fewer pairings per session than described in Experiment 1). Resetting the ITI after a target vocalization reduced the number of pairings presented in the 10-min sessions, thus thinning the schedule of pairings presented. This arrangement allowed for participants' responses to dictate the how the schedule was thinned. The criterion for an effect of DR was determined through visual inspection with the additional requirement that at least 50% of the data points in the DR condition exceed the highest data point in baseline.

Procedural fidelity. Procedural fidelity was assessed for at least 25% of baseline and DR sessions for each participant. Sessions used to calculate procedural fidelity were selected randomly. Two procedural fidelity scores were calculated, one for stimulus presentations during RCP, and one for consequences delivered in DR. Stimulus presentations delivered by the experimenter were scored as correct or incorrect based on the following experimenter behaviors: (a) delivery of the target sound, (b) delivery of the reinforcer, and (c) presented the button or observing prompt following the correct ITI duration. Procedural fidelity for stimulus presentations was calculated by dividing the total number of correctly implemented stimulus presentations by the total number of correct and incorrect stimulus presentations. The resulting quotient was multiplied by 100 in order to yield a percentage correct for each experimenter behavior. An observer scored at least 25% of DR sessions to calculate a procedural fidelity score for consequence delivery. A correct consequence was defined as the experimenter delivering the preferred item within 3 s of a target vocalization. Procedural fidelity was calculated by dividing the total number of correct consequences by the total number of correct and incorrect consequences. The resulting quotient was multiplied by 100 in order to yield a percentage correct. Mean fidelity across participants for correct implementation of RCP was 100 % and correct delivery of consequences during DR was 91.2% (range, 75.0% to 100%).

Interobserver agreement on procedural fidelity was calculated using the total agreement method by having two independent observers score at least 30% of sessions for which procedural fidelity data were calculated. Total agreement scores were calculated by each observer summing the number of correctly implemented trials across the session. The smaller number was divided by the larger number and the quotient multiplied by 100. The mean procedural fidelity score for correct implementation of RCP was 100 % and for correct delivery of consequences during DR was 93.3% (range, 83.3% to 100%).

Results and Discussion

The DR with thinning of RCP pairings increased rates of target vocalizations relative to RCP alone for all three participants, whereas the rate of nontarget vocalizations was unaffected. For all participants, the effects were replicated across two target sounds. For Gabe, some procedural modifications were required before the effects of RCP were observed.

Figure 2 shows the rate of vocalizations across RCP baseline pairing and DR, for Lee. Lee's rate of target vocalizations during DR (*M* = 0.54 for "kuh" and for *M* = 1.00 "dah") increased from baseline (*M* = 0.10 for "kuh" and *M* = 0.42 for "dah"). Nontarget vocalizations were absent or occurred at lower rates than target vocalizations, and did not increase from baseline (*M* = 0.00 for "moe" and *M* = 0.00 for "mee") to DR (*M* = 0.00 for "moe" and *M* = 0.01 for "mee"). Lee met criterion following session 23, for "kuh", and following session 37 for the target "dah".

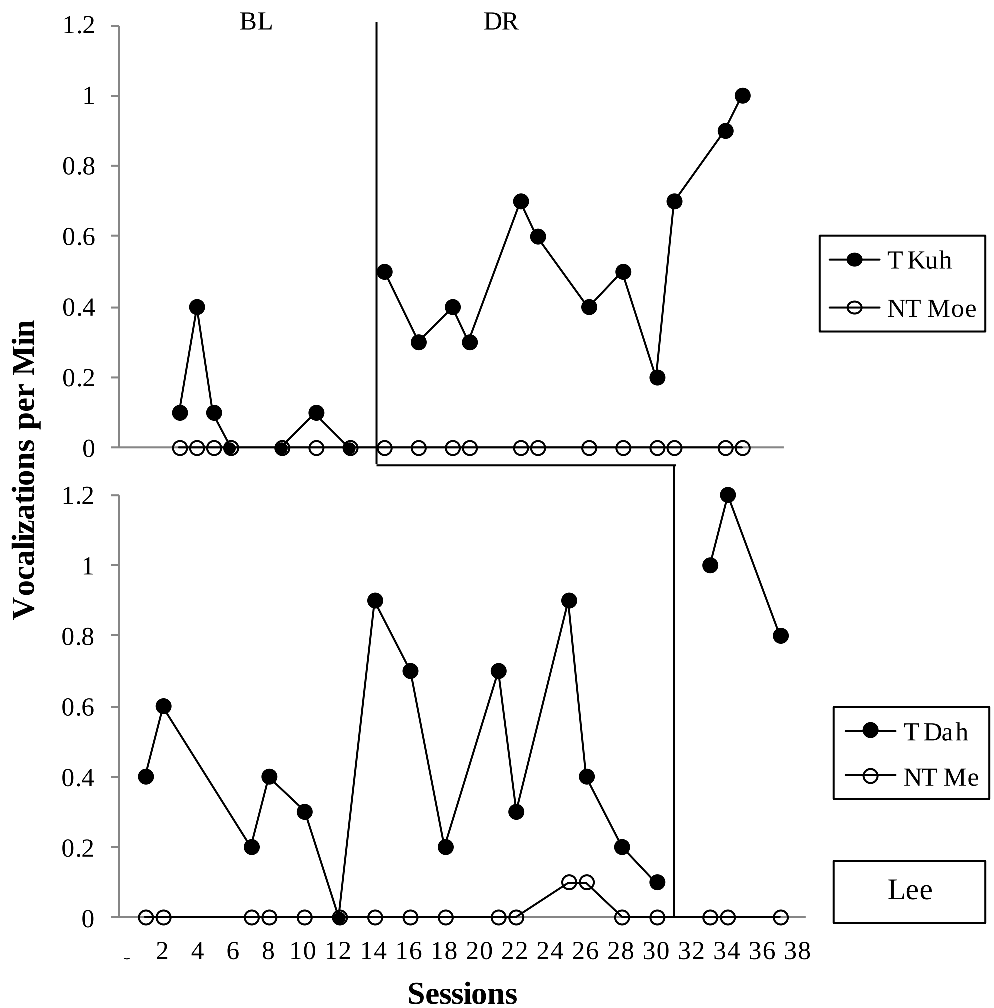

Figure 2. This multiple-baseline design across behaviors shows rates of two target (T) vocalizations ("kuh" and "dah") and two nontarget (NT) vocalizations ("moe" and "mee") for Lee during baseline pairing and differential reinforcement (DR).

Figure 3 shows the rate of vocalizations across RCP baseline pairing and DR, for Ken. Ken's rate of target vocalizations during DR (*M* = 0.94 for "poo" and for *M* = 0.57 "gee") increased from baseline (*M* = 0.43 for "poo" and *M* = 0.30 for "gee"). Nontarget vocalizations were absent or occurred at lower rates than target vocalizations, and did not increase from baseline (*M* = 0.00 for "nee" and *M* = 0.00 for "hoo") to DR (*M* = 0.03 for "nee" and *M* = 0.00 for "hoo"). Ken met criterion following session 10 for "poo", and following session 19 for "gee", which demonstrated an effect of the DR condition on both targets.

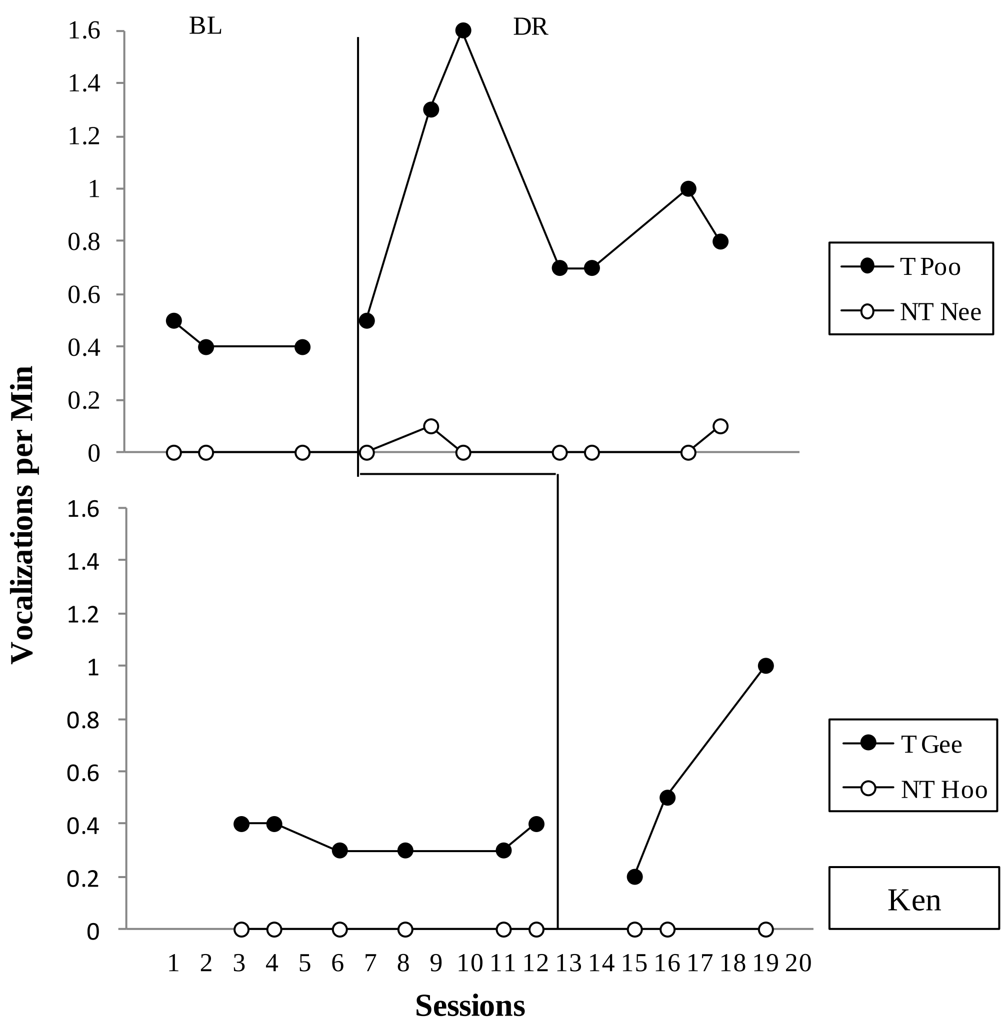

Figure 3. This multiple-baseline design across behaviors shows the rate of two target (T) vocalizations ("poo" and "gee") and two nontarget (NT) vocalizations ("nee" and "hoo") for Ken during baseline (BL) pairing and differential reinforcement (DR) with thinning.

Figure 4 shows Gabe's data. The top panel shows data for the target vocalization "moo" and nontarget vocalization "day" Gabe's rate of target vocalizations during DR when only the exact matches of the target sound was scored in the DR of target only condition (*M* = 0.20) increased from baseline (*M* = 0.10). Gabe met criterion following session 12 of DR of target only, but these effects diminished across future sessions. During the DR of target only sessions, Gabe frequently made a specific vocalization (i.e., "fuh") immediately prior to the delivery of the preferred item during pairing presentations. It was suspected that he had used this vocalization outside of sessions as a request for preferred stimuli. Because of this, an omission contingency was placed on "fuh". This addition of the omission contingency to the DR of target only condition occurred following session 30. As targets that fit the operational definition decreased across sessions of DR of target only, even with the omission contingency in place, it was observed that approximations of target sounds started to increase. These approximations consisted of Gabe saying "boo" repeatedly instead of "moo". This pattern of saying "boo" was suggestive of an extinction burst. The approximations were consistent with errors typical of early speakers. For example, two-year-olds frequently interchange /m/ and /b/ sounds. Because of this, DR was applied to both the target sounds and target approximations following session 40 in the DR of target and approximations condition. Rates of target vocalizations during the DR of target and approximations condition (*M* = 1.67) exceeded his RCP baseline pairing rates of target responses (*M* = 0.10).

Across DR conditions, nontarget vocalizations were absent or occurred at a lower rate than target vocalization, and did not increase from baseline (*M* = 0.01) to DR (*M* = 0.00).

The bottom panel of Figure 4 shows Gabe's data for the target vocalization "day" and the nontarget vocalization "lah". Gabe's DR of target only rates of target vocalizations (*M* = 0.20) exceeded his RCP baseline pairing rates of target responses (*M* = 0.16). Gabe met criterion during DR of target only following session 39; however these effects were minimal. The omission contingency placed on the "fuh" sound was added following session 30 and remained in place throughout the rest of the experiment. The differential reinforcement contingency was placed on both targets and target approximations following session 39 in the DR of target and approximations condition with Cheetos® condition. Rates of target vocalizations during the DR of target and approximations condition (*M* = 0.17) barely exceeded his RCP baseline pairing rates of target responses (*M* = 0.16). Gabe did not meet criterion during DR of target and approximations with Cheetos®. At this time, it was suspected that "moo" had been established as a request for Cheetos®, as this vocalization occurred frequently during "day" sessions of DR of target and approximations with Cheetos®, and when approximations were not reinforced during DR, his pattern of responding was consistent with an extinction burst. As a result, cookies, which ranked as his second/third most preferred item in the paired-stimulus preference assessment were used in place of Cheetos® following session 57 in the DR of target and approximations with cookies condition. Rates of target vocalizations during the DR of target and approximations condition w/ cookies (*M* = 1.70) exceeded his RCP baseline pairing rates of target responses (*M* = 0.16). Gabe met criterion in the DR of target and approximations with cookie condition following session 61. Rates of nontarget vocalization were absent or remained low across all conditions.

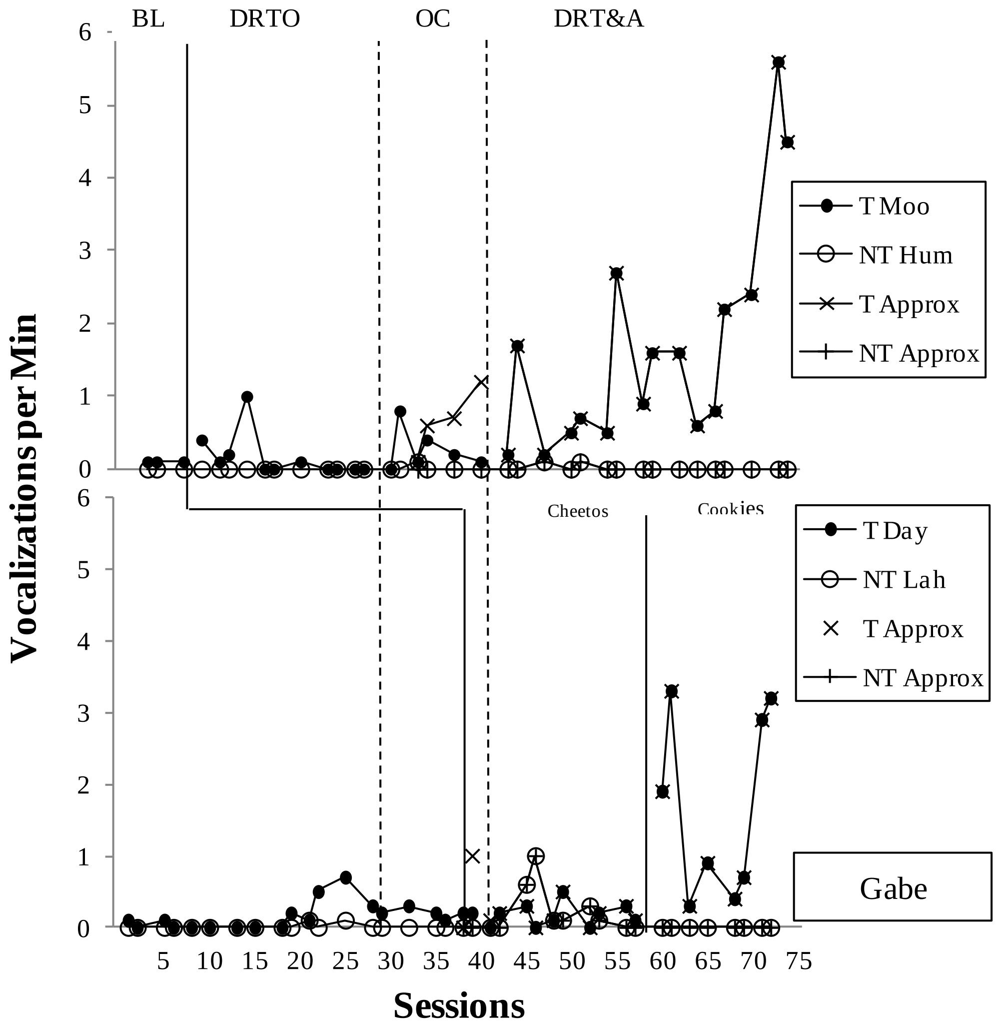

Figure 4. Gabe's data for Experiment 2. The multiple-baseline design across behaviors shows the rate of two target (T) vocalizations ("moo" and "day"), target approximations (T approx) for both these target sounds, two nontarget (NT) vocalizations ("hum" and "lah"), and nontarget approximations (NT Approx) for both these nontarget sounds. These vocalizations were recorded across baseline (BL), differential reinforcement with thinning target only (DR TO), and differential reinforcement with thinning target and approximations (DR T&A). The first dashed phase-change line indicates the addition of an omission contingency (OC), the second indicates the point at which differential reinforcement with target approximations began. Additionally, the phase-change line in the bottom panel indicates that the preferred item was switched from Cheetos® to cookies.

The purpose of thinning the schedule of pairings was not to eliminate the RCP condition entirely. Rather it was used to increase the probability that a target vocalization would occur in DR condition and to allow the schedule of pairings to be based on participant responding. The button was presented at the start of the session, and following a 10 s period of time during which the participant did not make a target response. Although, it was not an overall aim of the study, the reduction of the number of sound presentations across baseline and DR are noteworthy. For Lee, Ken and Gabe the mean number of sound presentations during baseline (M = 12.2, range 11 to 15; M = 10.4, range 13 to 9; M = 9.5, range 8 to 10, respectively) was greater than the mean number presented during DR (M = 10.2, range 6 to 14; M = 7.8, range 6 to 10; M = 5.3, range 1 to 13, respectively).

All three participants met or exceeded the criterion, which suggests that the rate of RCP-induced vocalizations can be increased via differential reinforcement. This is an important finding given the low rates of target vocalizations that were initially observed during RCP, before the application of differential reinforcement. Rates of vocalizations produced during DR condition exceeded baseline rates, exceeded rates observed in Experiment 1, and rates reported in other studies on vocalizations induced through procedures intended to establish speech sounds as conditioned reinforcers (e.g., Lepper et al., 2013).

For Gabe, it was suspected that “moo” was established as a request for the preferred item, as he began saying “moo” in both conditions. According to Skinner’s (1957) taxonomy of verbal behavior, a request is classified as a *mand* if it is occasioned by deprivation of a specific consequence that it has produced in the past (or alternatively, by aversive stimulation that it has terminated in the past). Essentially, mands are instances of verbal behavior that allow the speaker to access desired items, activities or conditions through the mediation of other people’s actions. Because they are highly useful for the speaker, early establishment of mand repertoires is emphasized in behavioral language interventions for children with ASD (e.g., Bondy & Frost, 1994; Sundberg & Partington, 1998).

Most mand training interventions (e.g., picture based exchange systems) include differential outcomes for each mand from the beginning of training. For example, if a child selects a picture of a cookie, the child receives a cookie. On the other hand, if the child selects a picture of chips, the child receives chips. The present study did not aim to establish mands, only to demonstrate that novel vocalizations could be induced through RCP and their rates increased further through differential reinforcement. In Experiment 1, it was necessary to use the same preferred item in both RCP and RIP to avoid confounds. In Experiment 2, we continued to use the same preferred item to reinforce both target sounds due to the history provided in Experiment 1. However, Gabe's behavior suggested that his vocalizations might function as mands occasioned by restricted access to Cheetos®, as the vocalization first reinforced with Cheetos® (i.e., "moo") persisted when the reinforcement contingency was placed on a different vocalization. When Cheetos® were replaced with cookies in the DR evaluation for the target "day", Gabe stopped saying "moo" during those sessions. He continued to say "moo" reliable in sessions that used Cheetos®. Experiment 3 was conducted to assess the possibility that the DR condition had established two separate mands for Gabe, for Cheetos® and cookies. Because Lee and Ken did not show the same patterns of responding in Experiment 2, we predicted that their vocalizations would not be found to function as mands for their preferred items.

`Experiment 3a

Experiment 2 demonstrated that RCP-induced vocalizations increased via DR while reducing the number of pairings presented. As the ultimate goal of language interventions for individuals with autism is to provide them with functional communication, it is important to assess whether novel vocalizations or words are functional (i.e., under stimulus control) for the participants or whether further intervention is needed.

An experimental functional analysis (Iwata, Dorsey, Slifer, Bauman, & Richman, 1982/1994) consists of rapid alterations of several highly controlled conditions in order to identify antecedents and consequences that influence a specific behavior (often problem behavior). During an experimental functional analysis, each test condition consists of the experimenter providing a specific consequence contingent on each instance of the behavior, or presenting an antecedent variable hypothesized to trigger the behavior. A function of the behavior of interest is identified when responding in a particular condition produces consistently higher rates than a control condition. Lerman et al. (2005) used the experimental functional analysis methodology to identify the function of speech (e.g., mand) for four children with developmental disabilities. To assess whether participant vocalizations functioned as mands for preferred items, two conditions were used. In one condition, participants received contingent access to a preferred item only following a specific vocal response. In the other condition, participants had continuous access to the preferred item, and vocal responses did not produce programmed consequences. Results indicated that the specific vocal response occurred more frequently in the condition in which the preferred item was delivered only following the specific vocal response. This pattern suggests that for the participants the vocalizations functioned as mands occasioned by restricted access to a reinforcer.

In Experiment 3a, we sought to assess whether participants had acquired RCP-induced target vocalizations as mands using procedures similar to those described by Lerman et al. (2005).

Measurement

Dependent variables. The rate of target vocalizations was recorded within each session for each participant. Target vocalizations were defined as in Experiment 2.

Interobserver agreement. Two independent observers scored occurrence of target and nontarget vocalizations for at least 30% of all sessions during the session or from videotape. The occurrence agreement was used to assess interobserver agreement. With this method, only sessions in which at least one observer scored an occurrence of the target behavior were included. For each session, the lower frequency of target vocalizations was divided by the higher frequency of target vocalizations and the resulting quotient was multiplied by 100. Lee's mean agreement score for the\ target vocalization "dah" was 88.7% (range, 66.6% to 100%), and 87.5% (range, 50.0% to 100%) for the target vocalization "kuh". Ken's mean agreement score for the target vocalization "poo" was 96.4% (range, 85.7% to 100%), and 100% for the target vocalization "gee". Gabe's mean agreement score for the target vocalization "day" was 87.5% (range, 66.7% to 100%), and 100 % for the target vocalization "moo".

Procedure

Overview. Two separate functional analyses were conducted with each participant, one for each of the target sounds induced through RCP and increased through DR in the previous experiments. The conditions in each functional analysis included a contingent access-condition and a free-access condition. All sessions were 3 min in duration to minimize satiation effects.

Contingent-access condition. Prior to each session, the participant was allowed to engage with his preferred stimulus (or a small bit of his preferred edible associated with the sound being evaluated) for 10 s (or allowed time to consume). At the start of the session, the preferred item was concealed by removing it from the participant's visual field. During the contingent condition, each target vocalization resulted in the experimenter delivering the preferred stimulus. The participant was allotted 10 s of engagement with the preferred stimulus or adequate time to consume the edible. For Lee and Ken, whose preferred stimuli were tangible items, the 10 s engagement period reset following any target vocalizations made while engaging with the preferred item, thus prolonging the engagement period contingent on target vocalizations.

Free-access condition. Prior to each session, the participant was allowed to engage with his preferred stimulus for 10 s or allowed to consume a small bit of his preferred edible. At the start of each session, the preferred item was presented to the participant by placing it in front of the participant's visual field, and within reach. For Gabe, edibles were broken into small bites and presented to him in the same manner. If Gabe consumed more than two thirds of the edibles in front of him within a session, more were presented before he ran out. During the free-access condition, participant's target vocalizations did not produce a programmed consequence.

Experimental design. An alternating-treatments design was used to compare vocalization rates in the contingent-access condition and the free-access condition.

Procedural fidelity. Procedural fidelity was assessed for at least 25% of sessions across all experimental conditions. Each session used to calculate procedural fidelity was randomly selected. The number of correct and incorrect consequences delivered by the experimenter following participants' target vocalizations was scored during these sessions. A correct consequence was defined as the experimenter delivering the preferred item within 3 s of a target vocalization in the contingent condition. A correct consequence in the free-access condition was defined as the experimenter actively ignoring target vocalizations. Procedural fidelity was calculated by dividing the total number of correct consequences by the total number of correct and incorrect consequences. The resulting quotient was multiplied by 100 in order to yield a percentage correct. The mean fidelity score for correct implementation of consequences was 91.1% (range, 89.1% to 96.7%).

Interobserver agreement on procedural fidelity was calculated using the total agreement method by having two independent observers score at least 30% of the session across for which procedural fidelity data were calculated. Total agreement scores were calculated by each observer summing the number of correctly implemented consequences across the session. The smaller number was divided by the larger number and the quotient multiplied by 100. The mean agreement score on procedural fidelity was 85.8% (range, 50.0% to 100%).

Results and Discussion

Figure 5 shows the result of Lee's functional analyses for the RCP-induced vocalization "dah" and "kuh". For "dah" (top panel) the rate of vocalizations in the contingent- *(M* = 0.33) and free-access (*M* = 0.33) conditions did not differ, in that there were no consistent differences across the data paths of the two conditions. Likewise, for his functional analysis of the RCP-induced vocalization "kuh" (bottom panel) his rate of vocalizations in the contingent- *(M* = 0.16) and free-access (*M* = 0.25) conditions were not differentiated, as the data paths for the two conditions showed no consistent differences across sessions.

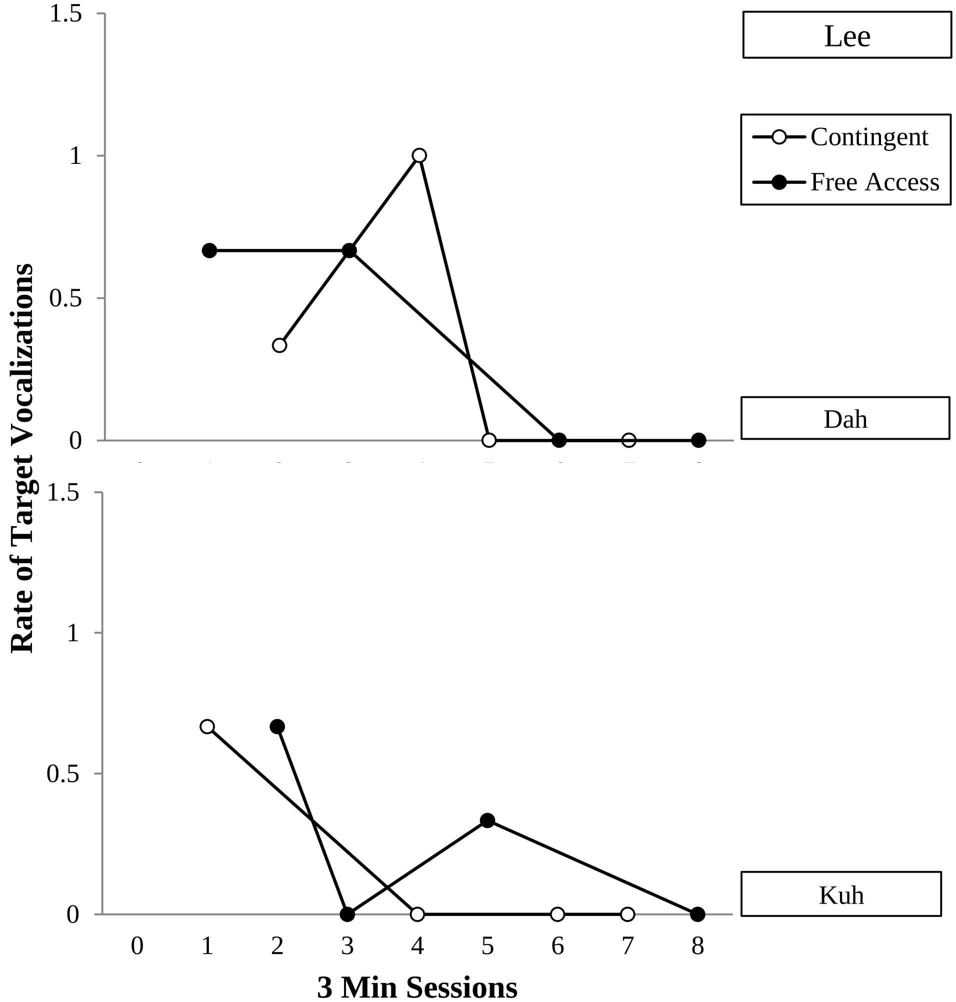

Figure 5. Shows Lee's functional analysis for "dah" (top panel) and "kuh" (bottom panel). The graph depicts the rate of vocalizations on the y-axis, across 3 min sessions on the x-axis. The open circles represent the contingent access condition, and the closed circles represent the free-access condition.

Figure 6 shows the result of both Ken's functional analyses for the RCP-induced vocalizations "poo" and "gee". For "poo" (top panel) the rate of vocalizations in the contingent- (M = 1.25) and free-access (M = 1.66) conditions did not differ in that through visual inspection the two data paths are not differentiated consistently across sessions. Likewise, "gee," the rate of vocalizations in the contingent- (M = 0.33) and free-access (M = 0.66) conditions did not differ consistently.

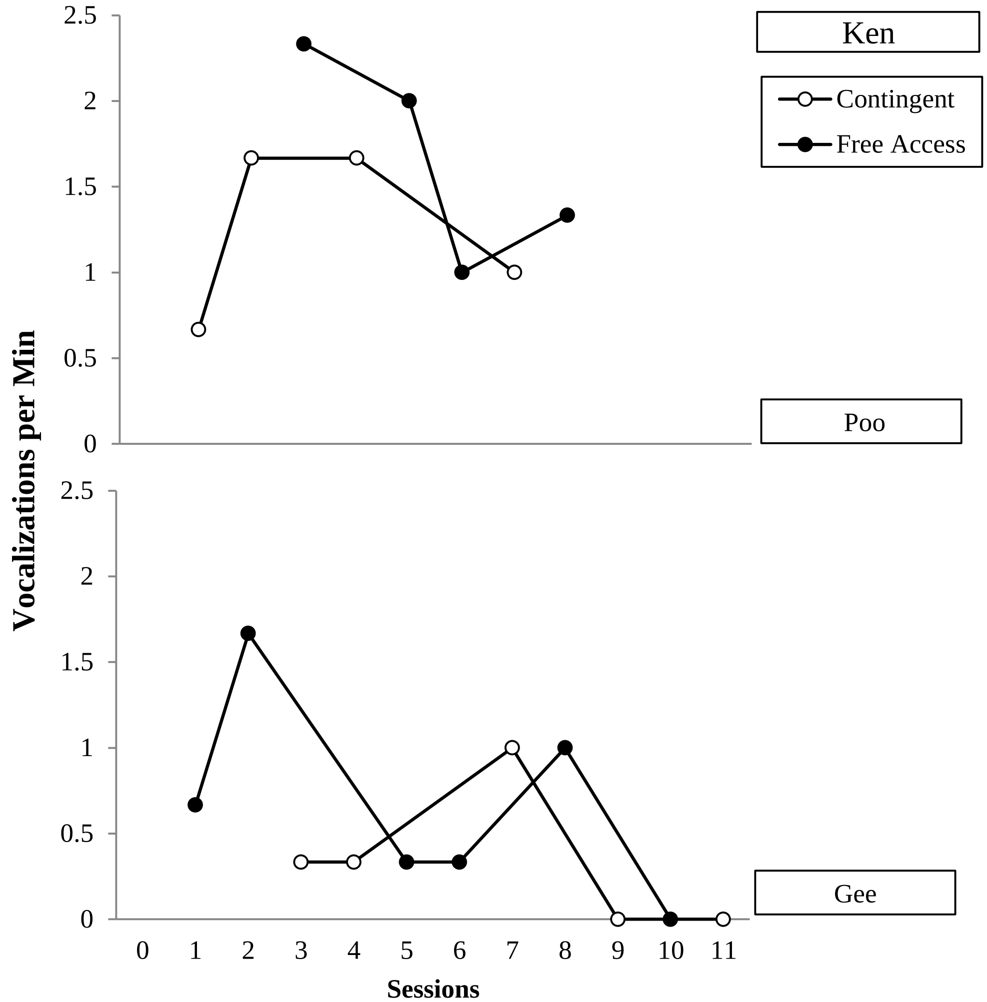

Figure 6. Shows Ken's functional analysis for "poo" (top panel) and "gee" (bottom panel). The graph depicts the rate of vocalizations are on the y-axis, across sessions on the x-axis. The open circles represent the contingent access condition, and the closed circles represent the free-access condition.

Lee and Ken's data suggest that DR with thinning of RCP pairings did not result in any of Lee or Ken's target vocalizations functioning as mands for their preferred items. In other words, none of their vocalizations seemed to be affected by whether or not access to the item was restricted.

Figure 7 shows the results of Gabe's two functional analyses for the RCP-induced vocalization "day" and "moo". For the "day" topography evaluation (top panel), higher rates of responding were evident in the contingent-access condition (*M* = 0.16) compared to the free-access condition (*M* = 0.01). This is evident by the two data paths being consistently separated with higher rates of responding associated with the contingent-access condition. Likewise, for his functional analysis of the RCP-induced vocalization "moo" (bottom panel) the data paths indicating the rate of vocalizations in the contingent- (*M* = 0.24) and free-access conditions (*M* = 0.03) were consistently differentiated from one another, with higher rates of responding in the contingent-access condition. In other words, Gabe said, "day" more frequently when access to cookies was restricted than when it was free, and "moo" more frequently when access to Cheetos® was restricted than when it was free. Thus, his data suggest that both target vocalizations were established as mands during the DR condition in Experiment 1.

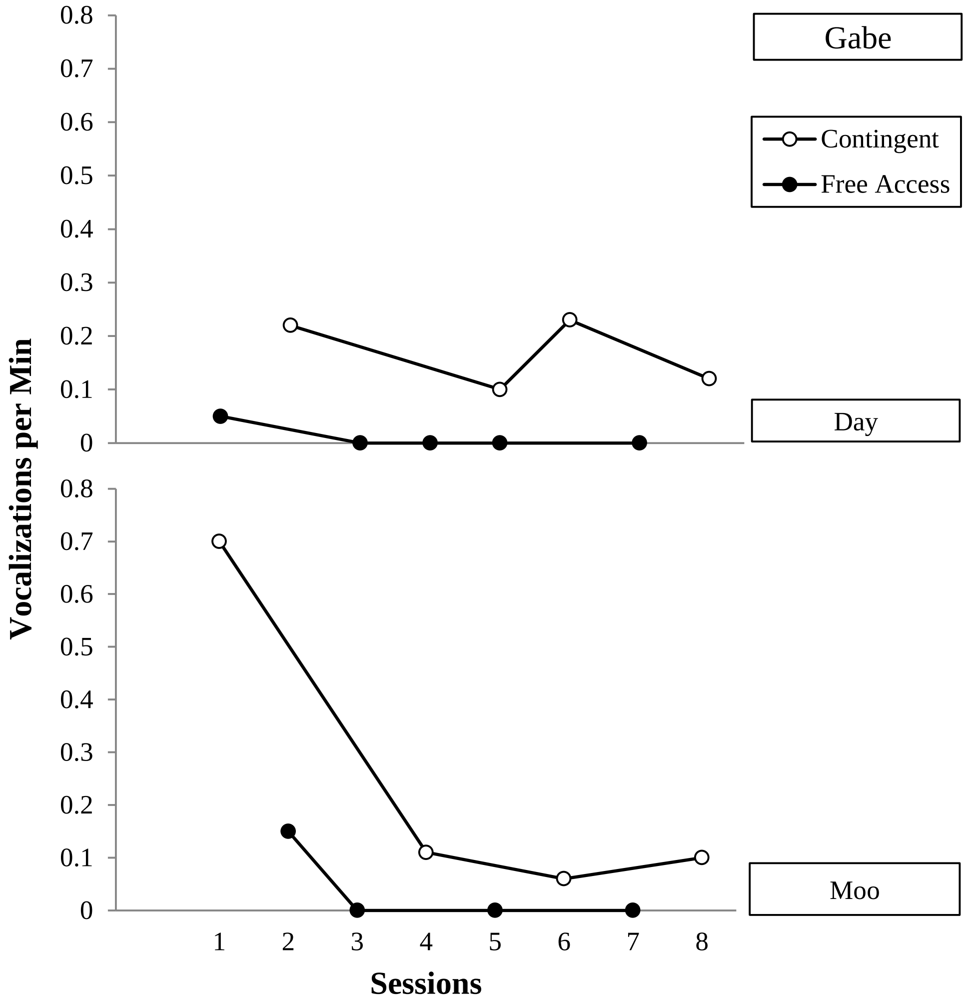

Figure 7. Shows Gabe's functional analysis for the "day" (top panel) and "moo" (bottom panel). The graph depicts the rate of vocalizations on the y-axis, across sessions on the x-axis. The open circles represent the contingent access condition, and the closed circles represent the free-access condition.

It is possible that with further training under the contingent- and free-access conditions present in the functional analysis, Lee and Ken could have acquired a functional mand. However, the purpose of the present study was only to verify whether or not mands were produced as a side-effect of the DR condition.

Gabe was the only participant whose vocalizations appeared to have acquired a mand function during differential reinforcement. Gabe was also the only participant whose preferred items were edibles. It is possible that a mand function develops more easily for edible stimuli.

Although Gabe's data appear to suggest that he was engaging in mands specifically for cookies and Cheetos®, it is possible that he was using both responses indiscriminately to request whatever items he did not have access to. Because data were recorded only on the target vocalizations in each assessment, it is unclear if Gabe was truly engaging in discriminated mands for cookies and Cheetos® in the present experiment. Experiment 3b was designed to address this issue.

`Experiment 3b

To determine if participants were using discriminated mands to access preferred items, Gutierrez et al. (2007) manipulated satiation following mand training for four participants with developmental disabilities. During mand training, participants were taught to select pictures that corresponded to two preferred items. Following mand training, participants were exposed to two conditions in a concurrent operants arrangement. During this assessment, the participant had access to both picture cards, as well as free access to one of the preferred items, while the other preferred item was restricted and delivered contingent on selecting the card that corresponded to that item. Selections of the card that corresponded to the item that was freely available resulted in removal of the picture cards. The free- and restricted-access items were alternated across sessions. A response was considered to function as a mand if it occurred at higher levels when access to it was restricted than when free access was provided. Gutierrez, Vollmer and Samaha (2010) systematically replicated Gutierrez et al. (2007) using representational items of preferred items rather than pictures for two participants with disabilities. Their findings were consistent with the previous study showing that the mand assessment could identify whether or not a response functioned as a mand for a specific preferred stimulus, and that training under the EO present and EO absent conditions of the mand assessment can further facilitate discriminated mands. The purpose of this experiment was to determine if Gabe's mands specified the reinforcer using procedures similar to those described by Gutierrez et al. (2007).

Measurement

Dependent variables. The number of each target vocalizations (i.e., "moo" and "day") was recorded across each minute of the evaluation.

Interobserver agreement. Two independent observers scored target vocalizations during both sessions. The overall agreement method was used to calculate agreement scores. With this method, the lower frequency of target vocalizations scored per min was divided by the higher frequency of target vocalizations scored per min and the quotient was multiplied by 100. For the first assessment, the mean agreement score was 100% for the both target vocalizations. For the second assessment, the mean agreement score for "day" was 96.0% (range, 80.0% to 100%), and 83.3% (range, 50.0% to 100%) for "moo".

Procedure

Overview. Prior to each evaluation, a paired-stimulus preference assessment was conducted to either identify which food was most preferred (for the first evaluation) or to induce satiation for the more preferred food if necessary for second evaluation. Only two edibles were included in each paired-stimulus preference assessment, Cheetos® and cookies. In the first paired-stimulus assessment, trials were presented until Gabe selected the same food across six consecutive trials. When criterion was met for one of the foods, it was restricted in the upcoming evaluation. This was done to increase the likelihood that Gabe would request the restricted food.

In the second paired-stimulus assessment, trials were presented until Gabe selected the food that would be restricted in the upcoming evaluation six consecutive times. This was done to be more assured that Gabe preferred the restricted food over the food that would be freely available in the second evaluation.

Two separate assessments were conducted with Gabe to determine if his mands were discriminated (i.e., whether the mand “moo” was occasioned by restricted access to Cheetos® only, and the mand “day” by restricted access to cookies only). Target vocalizations that corresponded to the restricted food produced a small bite of it. Vocalizations that were associated with the freely available items did not produce a programmed consequence. In the first evaluation, Cheetos® were delivered contingent on “moo” while cookies were freely available. In the second evaluation, cookies were delivered contingent on “day,” while Cheetos® were freely available. Each analysis was 5 min in duration to minimize satiation effects.

Concurrent operants evaluation. Prior to the start of each evaluation, Gabe was given a small bite of each of the two edibles used in the evaluation. The evaluation began by placing a small pile of one of the edibles (i.e., either cookies or Cheetos®, but not both together) broken into small bites in front and in reach of Gabe, and removing the other edible from his visual field. If Gabe produced a target response that was correlated with the freely available item, that response did not result in a programmed consequence. If Gabe produced a target response that was correlated with the stimulus that was not freely available, a small bite of that edible was delivered by the experimenter. If Gabe consumed more than two thirds of the freely available edibles within the session, more were presented before he ran out.

Experimental design. The effects of free access and contingent access to edible that had previously been correlated with target vocalizations were evaluated using a concurrent-operants design. The concurrent operants were the two RCP-induced target vocalizations of Experiment 1.

Procedural fidelity. Procedural fidelity was assessed for both 5 min sessions. Procedural fidelity was calculated by dividing the total number of correctly implemented contingencies by the total number of correct and incorrect contingencies for each session. The resulting quotient was multiplied by 100 in order to yield a percentage correct for each experimenter behavior. Each contingency was scored as correct or incorrect based on the following experimenter behaviors: (a) delivery of the preferred item only for target sounds associated with contingent-access condition, and (b) freely available edibles were placed in front and in reach of Gabe. Procedural fidelity scores across both assessments yielded a mean fidelity score for correct implementation of contingencies of 93.33% (range, 86.7% to 100%).

Interobserver agreement on procedural fidelity was calculated using the total agreement method by having two independent observers score both of the sessions for which procedural fidelity data were calculated. Total agreement scores were calculated by each observer summing the number of correctly implemented contingencies across the session. The smaller number was divided by the larger number and the quotient multiplied by 100. Mean agreement on procedural fidelity was 80.0% (range, (range, 73.3% to 100%).

Results and Discussion

The top panel of Figure 8 depicts the results of Gabe's first evaluation. During this evaluation he received Cheetos® contingent on vocalizing, "moo" and had free access to cookies. The figure shows that "moo" occurred at a higher rate (M = 2.80) than "day" (M =

0.00) under this arrangement, consistent with Gabe using the vocalization “moo” to specify a bite of Cheeto® as a reinforcer for that vocalization.

The bottom panel of Figure 8 depicts the results of Gabe’s second evaluation. During this evaluation Gabe received a small bite of cookie contingent on the vocalization, “day”, and had free access to Cheetos®. The results show that Gabe said, “day” more frequently under this arrangement (M = 2.40) than “moo” (M =0.60). Anecdotally, when Gabe said, “moo” during this evaluation it occurred immediately prior to him consuming the freely available Cheetos® which were correlated with that vocalization. These results are also consistent with Gabe using “day” functionally to specify cookies as his reinforcer.

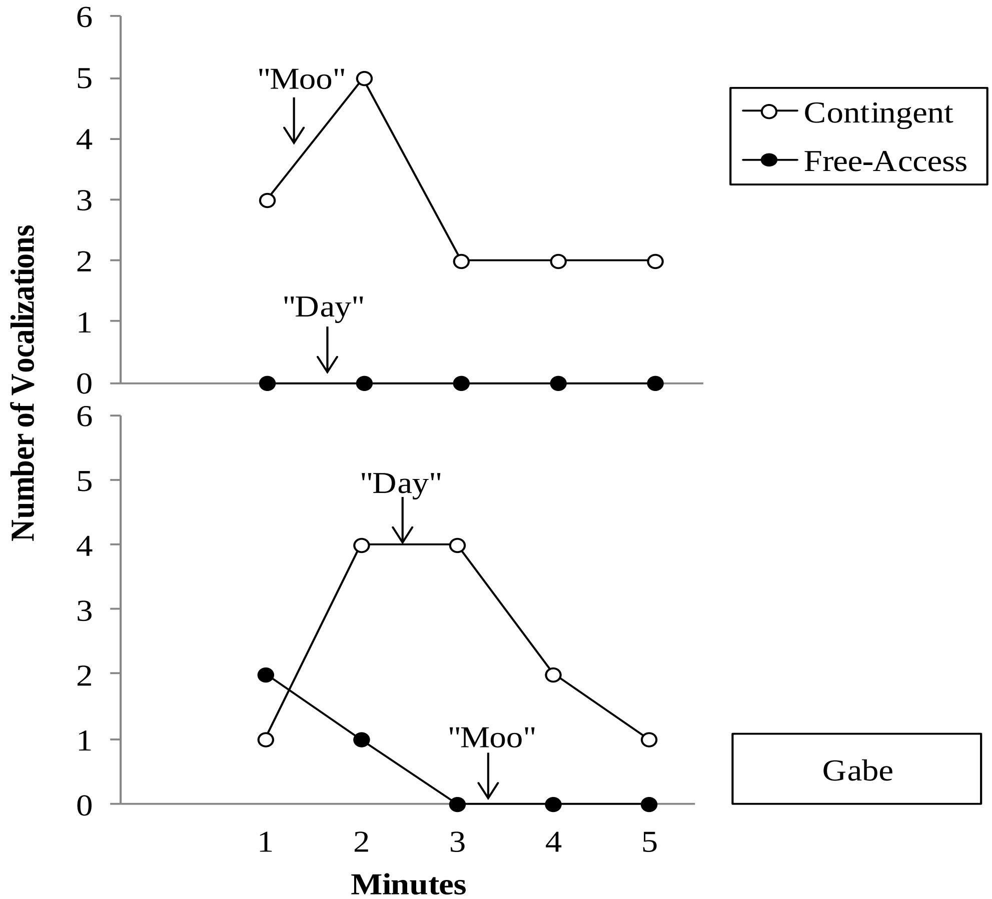

Figure 8. Shows the results of Gabe's discriminated mand assessment. The graph depicts the number of vocalizations on the y-axis, for the target sounds "moo" and "day", across minutes on the x-axis. The closed circles represent the rate of responding when Gabe had free access to the edible associated with the response. The open circles represent the rate of responding when the edible associated with that response was delivered contingent on the specific vocalization. In the top panel, Gabe had free access to cookies and Cheetos® were delivered contingent on "moo" vocalizations. In the bottom panel, Gabe had free access to Cheetos®, and cookies were delivered contingent on "day" vocalizations.

Collectively, the data suggest that Gabe acquired "moo" and "day" as functional and discriminated mands, in that when the conditions changed from Evaluation 1 to Evaluation 2, his verbal behavior changed too. The changes in his verbal behavior were consistent with the states of deprivation in both conditions, as he vocalized the target sound associated with the restricted item more frequently than he vocalized the target sound associated with the freely available item.

General Discussion

The RCP condition consistently produced greater increases in the target vocalizations of all participants compared to RIP. Target vocalizations induced through RCP increased further during DR and the number of pairings decreased for all participants. Additionally, Gabe acquired functional discriminated mands via DR. The capturing of a sound induced by stimulus-stimulus pairing as a mand has not been demonstrated previously in the literature.

These data are consistent with the findings of Dozier et al. (2013) that RCP is more likely than RIP to result in the establishment of conditioned reinforcers, and extend those findings to effects on vocalizations of children with ASD. Additionally, unlike Dozier et al., the present study used a single-subject experimental design to compare the effects of the two conditions. Because RCP reliably produced higher rates of responding for all participants, clinicians should consider using RCP in lieu of RIP when attempting to increase target vocalization of children with ASD. The intervention is easy to implement, and requires minimal effort from the participant, as well as minimal training of the interventionist. Additionally, this intervention takes into account the participant's choice of when to receive the preferred item, which may increase its social acceptability as an intervention for nonverbal children with ASD who have limited means to communicate their wants and needs. Although it is necessary to train the participants to engage in a response to access their preferred item before beginning RCP, the response was easy to establish for all participants in the present study. In the present study, a button press was arbitrarily chosen as the responses that produced pairings between speech sounds and preferred stimuli. However, a more clinically relevant response could also be used; for example, a non-vocal communication response such as a manual sign or picture exchange.

Interestingly, when manual sign training and picture exchange communication systems are used to teach mands to nonverbal children, they may already employ an RCP component. Specifically, when the therapist delivers a preferred item contingent on a manual sign or the selection of a picture, its delivery is usually accompanied by a vocal model. This systematic pairing of the name of the item with its delivery, contingent on a response, may be responsible for the fact that sign training and picture exchange training sometimes result in the learners beginning to vocalize the names of items that they learn to request (e.g., Bondy & Frost, 1994; Charlop-Christy, Carpenter, Le, LeBlanc, & Kellet, 2002; Tincani, 2004). Future investigators might consider explicitly combining sign or picture exchange training with the procedures described in the present study. For example, in the present study, the selection of target vocalizations was based on pre-experimental observation suggesting that the participant could articulate the component units of each selected syllable, even though they had not been observed to vocalize the syllable itself. Using a similar assessment to assist with the selection of intervention targets in sign or picture exchange training could possibly result in more reliable effects on speech sound production. It is also possible that greater effects of these alternative communication systems on vocalizations may be produced by incorporating nontarget trials, where, for example, the selection of some pictures produces only the vocal model of a word. This addition could serve to enhance the discrimination of the target sound.

A notable difference between how RCP was conducted in the present study and other interventions designed to teach children to mand for preferred items, is that in other interventions such as sign language and picture exchange systems, each response produces a differential outcome during mand training. For example, when teaching a child to use sign language to request water, the specific hand gesture for water is followed by the experimenter delivering a glass of water to the participant. Other hand gestures are followed by the delivery of the specific item that corresponded to it. Basic literature suggests that greater effects might be observed if each response produced a differential outcome (e.g., Williams, Butler, & Overmier, 1990), and conceptually, this practice should be more likely to result in the establishment of mands. Differential outcomes have not typically been used in RIP because the goal is to increase novel vocalizations, not to establish mands. Additionally, for some children with ASD there may be only a few items available that are likely to function as reinforcers. For these children, the number of novel speech sounds that could be targeted would be restricted to the number of available reinforcers. Several RIP studies have reported that preferred stimuli (or stimulus) used during sessions were identified through stimulus preference assessment conducted prior to sessions (e.g., Esch et al., 2009; Miguel et al., 2002; Petursdottir et al., 2011). Some studies reported to randomly alternate the identified preferred stimuli within stimulus presentations of RIP (e.g., Esch et al., 2009) and others reported to use only the highest ranked stimulus from the preceding stimulus preference assessment in sessions (e.g., Miguel et al., 2002). Other studies have used the same preferred stimulus for both sounds (e.g., Lepper et al., 2013) and Yoon and Feliciano (2007) reported that each target sound was correlated with a specific type of preferred item (i.e., social interactions or toys). Conceptually, the use of the nonspecific consequences for each target sound should not produce mands, which would allow for the nonspecific consequences to be used to establish a wider variety of novel speech sounds as conditioned reinforcers. This potential advantage of nonspecific reinforcement during pairing procedures could be evaluated in future research by comparing the effects of RCP interventions that produce differential outcomes for each target vocalization to RCP interventions that share the preferred stimulus or stimuli across target sounds.

Gabe acquired two discriminated mands during the course of this study. However, a potential limitation of the study was that the sounds targeted were not approximations of the conventional mands for the specific items. For example, “moo”, is not an approximation of the word “Cheeto”®. Identifying target sounds that were approximations of the specific items used during the intervention would have produced more clinically relevant results. However, the choice to use items identified via a stimulus preference assessment, and sounds that the participant could make but did not occur together, excluded this possibility, as “ch” and “kuh” were not identified as potential sounds during Gabe’s pre-experimental observation sessions. In addition, establishing mands was not an explicit goal of the intervention, but rather, an unanticipated side effect of RCP and DR in Experiments 1 and 2. Additional intervention (e.g., a shaping procedure) will be necessary before Gabe can request these specific items using their conventional names so that his requests may be understood by the general verbal community.

Some additional limitations of the study should be noted. Yoking the timing of sound presentations across RCP and RIP was necessary to control for timing effects and keep the duration of exposure to each condition equal; however, it introduced potential sequence effects. Participants were always exposed to RCP first, as the subsequent ITIs of RIP were yoked to ITIs in a corresponding RCP condition. Efforts were made to randomize the order in which the conditions were presented through random alterations of the two, four block sequences to minimize potential sequence effects. However, it is possible that RIP was disadvantaged by always being the second treatment introduced.

Another potential limitation of is that the effects of conditioning were not directly assessed following RCP, but rather inferred due to the increase in target vocalizations over the nontarget vocalization. That is, the hypothesized mechanism by which pairing procedures increase target vocalizations increased was not directly demonstrated. This is a limitation of most research to date on the use of pairing procedures to increase target vocalizations. To extend these findings researchers should evaluate the extent to which target sounds function as conditioned reinforcers for children with ASD following successful pairing interventions, by using methods commonly reported when evaluating the effects of conditioned reinforcement. For example, investigators could use the new-response method, by delivering adult-delivered speech sounds contingent on behaviors other than vocalizations.

Despite these limitations, this study extends the literature on the use of pairing interventions to increase vocalizations of nonverbal children with ASD in several important ways. First, it suggests that the effects of pairing procedures on vocalizations may be enhanced by making stimulus presentations contingent on a response. This information could lead to more efficient clinical use. Second, it addressed the issue of tenuous durability cited in previous literature by demonstrating that the effects of RCP can be increased via differential reinforcement with thinning of RCP pairings. Lastly, it is the first study in this area that has sought to empirically evaluate the function of pairing-induced vocalizations following direct reinforcement; an evaluation that showed that reinforcement of RCP-induced vocalizations can produce meaningful speech.

REFERENCES

Barlow, D. H., & Hersen, M. (1984). *Single case experimental designs: Strategies for studying behavior change* (2nd ed.). New York: Pergman.

Bass-Ringdahl, S. M. (2010). The relationship of audibility and the development of canonical babbling in young children with hearing impairments. *The Journal of Deaf Studies and Deaf Education, 15,* 287-310. doi:10.1093/deafed/enq013

Bijou, S. W., & Baer, D. M. (1965). *Child development II: Universal stage of infancy.* New York:Appleton-Century-Crofts.

Bondy, A. S., & Frost, L. A.(1994). The picture exchange communication system. *Focus on Autistic Behavior, 9,* 1–19.

Carroll, R. A., & Klatt, K. P. (2008). Using stimulus-stimulus pairing and direct reinforcement to teach vocal verbal behavior to young children with autism. *The Analysis of Verbal Behavior, 24,* 2008.

Charlop-Christy, M. H., Carpenter, M., Le, L., LeBlanc, L. A., & Kellet, K. (2002). Using the picture exchange communication system (PECS) with children with autism: Assessment of PECS acquisition, speech, social-communicative behavior, and problem behavior. *Journal of Applied Behavior Analysis, 35,* 213–231. doi: 10.1901/jaba.2002.35-213

Conner, J., Iwata, B. A., Kahng, S. W., Hanley, G. P., Worsdell, A. S., & Thompson, R. H. (2000). Differential responding in the presence and absence of discriminative stimuli during multielement functional analyses. *Journal of Applied Behavior Analysis, 33,* 299-308. doi: 199.1901/jaba.2000.33-299

Cooper, T. O., Heron, T. E., & Heward, W. L., (2007). *Applied Behavior Analysis* (2nd ed). Upper Saddle River, NJ: Pearson.

Darcheville, J. C., Boyer, C., & Miossec Y. (2005). Training infant reaching using mothers' voice as reinforcer. *European Journal of Behavior Analysis, 5,* 43-51.

Dorow, L. G. (1980). Generalized effects of newly conditioned reinforcers. *Education and Training of the Mentally Retarded, 15,* 8-14.

Dozier, C. L., Iwata, B. A., Thomason-Sassi, J., Worsdell, A. S., & Wilson, D. M. (2012). A comparison of two pairing procedures to establish praise as a reinforcer. *Journal of Applied Behavior Analysis, 45,* 721-735.

Drennen, W. Gallman, W., &Sausser, G. (1969). Verbal operant conditioning of hospitalized psychiatric pattients. *Journal of Abnormal Psychology, 74,* 454-458. doi: 10.1037/h0027829

Esch, B. E. (2008). EESA: Early echoic skills assessment. In M. L. Sundberg VB-MAPP: Verbal behavior milestones assessment and placement program (pp. 62-63). Concord, CA: AVB Press.

Esch, B. E., Carr, J. E., & Michael, J. (2005). Evaluation stimulus-stimulus pairing and direct reinforcement in the establishment of an echoic repertoire of children diagnosed with autism. *The Analysis of Verbal Behavior, 21,* 43-58.

Esch, B. E., Carr, J. E., & Grow, L. L. (2009). Evaluation of an enhanced stimulus-stimulus pairing procedure to increase early vocalizations of children with autism. *Journal of Applied Behavior Analysis, 42,* 225-241. doi: 10.1901/jaba.2009.42-225

Fenson, L., Dale, P.S., Reznick, J.S., Bates, E., Thal, D.J., & Pethick, S.J. (1994). Variability in early communicative development. *Monographs of the Society for Research in Child Development, 59,* 1–173.

Fisher, W. W., Piazza, C. C., Bowman, L. G., & Amari, A. (1996). Integrating caregiver report with a systematic choice assessment to enhance reinforcer identification. *American Journal on Mental Retardation, 101,* 15-25.

Fisher, W. W., Piazza, C. C., Bowman, L. G., Hagopian, L. P., Owens, J. C., & Slevin, I. (1992). A comparison of two approaches for identifying reinforcers for persons with server and profound disabilities. *Journal of Applied Behavior Analysis, 25,* 491-498.

Gast, D. L., & Wolery, M. (1988). Parallel treatments design: A nested single subject design for comparing instructional procedures. *Education and Treatment of Children, 11*, 270-285.

Goldstein, M. H., King, A. P., & West, M. J. (2003). Social interaction shapes babbling: Testing parallels between birdsong and speech. *Proceedings of the National Academy of Sciences*, *100*, 3030–3035.

Goldstein, M. H., & Schwade, J. A. (2008). Social feedback to infants' babbling facilitates rapid phonological learning. *Psychology Science,* 19, 515-523.

Goldstein, M. H., Schwade, J. A., & Bornstein, M. H. (2009). The value of vocalizing: Five month-old infants associate their own noncry vocalizations with responses from caregivers. *Child Development*, *80,* 636-644.

Greer, R. D., Pistoljevic, N., Cahill, C., & Du, L. (2011). Effects of conditioning voices as reinforcers for listener responses on rate of learning, awareness, and preference for listening to stories in preschoolers with autism. *The Analysis of Verbal Behavior, 27,* 103-124.

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

Gros-Louis, J., Goldstein, M. H., King. A. P., & West, M. (2006). Mothers provide differential feedback to infants' prelinguistic sounds. *International Journal of Behavioral Development, 30,*112-119.

Gutierrez, A., Jr., Vollmer, T. R., Dozier, C. L., Borrero, J. C., Rapp, J. T., Bourret, J. C., Gadaire, D. (2007). Manipulating establishing operations to verify and establish stimulus control during mand training. *Journal of Applied Behavior Analysis, 40,* 645–658.

Gutierrez, A., Jr., Vollmer , T. R., & Samaha, A. L. (2010). Developing and assessing stimulus control based on establishing operations during mand training using representative objects. *Behavioral Interventions, 25,* 169-182. doi: 10.1002/bin.302

Hoff, E. (2005). *Language development (3rd ed.)*. Belmont,CA: Wadsworth.

Holth, P., Vandbakk, M., Finstad, J., Gronnerud, E. M., & Akselsen-Sorensen, J. M. (2008). An operant analysis of joint attention and the establishment of conditioned social reinforcers. *European Journal of Behavior Analysis, 10,* 143-158.

Inglis, I. R., Forkman, B., & Lazarus, J. (1997). Free food or earned food? A review and fuzzy model of contrafreeloading. *Animal Behavior, 53,* 1171-1191.

Iwata, B. A., Dorsey, M. F., Slifer, K. J., Bauman, K. E.,& Richman, G. S. (1994). Toward a functional analysis of self-injury. *Journal of Applied Behavior Analysis, 27,* 197–209. (Reprinted from *Analysis and Intervention in Developmental Disabilities, 2*, 3–20,1982)

Karsten, A. M., Carr, J. E., & Lepper, T. L. (2011). Description of a practitioner model for identifying preferred stimuli with individuals with autism spectrum disorders. *Behavior Modification,* 35, 347-369. doi: 10.1177/0145445511405184

King, A. P., West, M. J., & Goldstein, M. H. (2005). Non-vocal shaping of avian song development: Parallels to human speech development. *Ethology, 111,* 101-117.

Leiman, A. H., Myers, J. L., & Myers, N. A. (1961). Secondary reinforcement in a discrimination problem with children. *Child Development, 32,* 349-353.

Lepper, T. L., Petursdottir, A. I., & Esch, B. E. (2013). Effects of an operant discrimination training procedure on the vocalizations of nonverbal children with autism. *Journal of Applied Behavior Analysis, 46,* 656-661.

Lerman, D. C., Parten, M. Addison, L. R., Vorndran, C. M., Volkert, V. M., & Kodak, T. (2005). A methodology for assessing the function of emerging speech in children with developmental disabilities. *Journal of Applied Behavior Analysis, 38,* 303-316.

Lucyznski, K. C., & Hanley, G. P. (2009). Do children prefer contingencies? An evaluation of the efficacy of and preference for contingent versus noncontingent social attention. *Journal of Applied Behavior Analysis*, *42*, 511-525. doi: 10.1901/jaba.2010.43-397

Marler, P., & Tamura, M. (1964). Culturally transmitted patterns of vocal behaviour in sparrows. *Science, 146,* 1483-1486.

Michael, J. (1993). Establishing operations. *The Behavior Analyst, 16,* 149-155.

Miguel, C. F., Carr, J. E., & Michael, J. (2002). The effects of a stimulus-stimulus pairing procedure on the vocal behavior of children diagnosed with autism. *The Analysis of Verbal Behavior, 18,* 3-13.

Myers, N. A., & Myers, J. L. (1963b). Secondary reinforcement in children as a function of conditioning associations, extinction percentages, and stimulus types. *Journal of Experimental Psychology, 65,* 455-459.

Normand, M. P., & Knoll, M. L. (2006). The effects of a stimulus-stimulus pairing procedure on the unprompted vocalizations of a young child diagnosed with autism. *The Analysis of Verbal Behavior, 22,* 81-85.

Oller, D. K. (2000). *The emergence of speech capacity*. Mahwah, NJ: Erlbaum.

Petursdottir, A. I., Carp, C. L., Matthies, D. W., & Esch, B. E. (2011). Analyzing stimulus-stimulus pairing effects on preferences for speech sounds. *The Analysis of Verbal Behavior, 27,* 45-60.

Ploog, B. O. (2010). Stimulus overselectivity four decades later: A review of the literature and its implications for current research in autism spectrum disorder. *Journal of Autism and Developmental Disorders, 40,* 1332-1349.

Poulsen, H. (1951). Inheritance and learning in the song of the chaffinch, *Fringilla coelebs*. *Behaviour, 3,* 216-228.

Rader, L., Sidener, T. M., Reeve, K. F., Sidener, D. W., Delmolino, L., Miliotis, A., Carbone, V. (2014). Stimulus-stimulus pairing of vocalizations: A systematic replication. *The Analysis of Verbal Behavior, 30,* 69-74. doi: 10.1007/s40616-014-0012-0

Rescorla, R. A. (1988). Pavlovian conditioning: It's not what you think it is. *American Psychologist, 43,* 151-160.

Roane, H. S., Vollmer, T. R., Ringdahl, J. E., & Marcus, B. A. (1998). Evaluation of a brief stimulus preference assessment. *Journal of Applied Behavior Analysis, 31*, 605-620.

Sidowski, J. B., Kass, N., & Wilson, H. (1965). Cue and secondary reinforcement effects with children. *Journal of Experimental Psychology, 69,* 340-342.

Skinner, B. F. (1957). *Verbal behavior.* New York: Appleton-Century-Crofts.

Smith, R., Michael, J., & Sundberg, M. L. (1996). Automatic reinforcement and automatic punishment in infant vocal behavior. *The Analysis of Verbal Behavior, 13,* 39-48.

Sober, S. J., & Brainard, M. S. (2009). Adult birdsong is actively maintained by error correction. *Nature Neuroscience, 12,* 927-931. doi:10.1038/nn.2336

Stock, R. A., Schulze, K. A., & Mirenda, P. (2008). A comparison of stimulus-stimulus pairing, standard echoic training and control procedures on the vocal behavior of children with autism. *The Analysis of Verbal Behavior, 24,* 123-133.

Sundberg, M. L. (2008). *VB-MAPP: Verbal behavior milestones assessment and placement program.* Concord, CA: AVB Press.

Sundberg, M. L., Michael, J., Partington, J. W., & Sundberg, C. A. (1996). The role of automatic reinforcement in early language acquisition. *The Analysis of Verbal Behavior, 13,* 21-37.

Sundberg, M. L., & Partington, J. W. (1998). *Teaching language to children with autism or other developmental disabilities.* Pleasant Hill. CA: Behavior Analysts.

Tamis-LeMonda, C. S., Bornstein, M. H., & Baumwell, L. (2001). Maternal responsiveness and children's achievement of language milestones, *Child Development, 72*, 748-767.

Theobold, D. E., & Paul, G. L. (1976). Reinforcing value of praise for chronic mental patients as a function of historical pairing with tangible reinforcers. *Behavior Therapy, 7,* 192–197.

Thorpe, W. H. (1954). The process of song-learning in the chaffinch as studied by means of the sound spectrograph. *Nature, 173,* 465-469.

Tincani, M. (2004). Comparing the picture exchange communication system and sign language training for children with autism. *Focus on Autism and Other Developmental Disabilities, 19*, 152-163. doi: 10.1177/10883576040190030301

Vaughan, M. E., & Michael, J. L. (1982). Automatic reinforcement: An important but ignored concept. *Behaviorism, 10*, 217-227.

Waser, M. S., & Marler, P. (1977). The role of auditory feedback in canary song development. *Journal of Comparative and Physiological Psychology, 91*, 8-16.

Williams, D. A., Butler, M. M., & Overmier, J. B. (1990). Expectancies of reinforcer location and quality as a cue for a conditional discrimination in pigeons. *Journal of Experimental Psychology: Animal Behavior Processes, 16,* 3–13.

Woolley, S. M. N., & Rubel, E. W. (2002). Vocal memory and learning in adult Bengalese Finches with regenerated hair cells. *The Journal of Neuroscience, 22,* 7774-7787.

Yoon, S., & Bennett, G. M. (2000). Effects of a stimulus-stimulus pairing procedure on conditioning vocal sounds as reinforcers. *The Analysis of Verbal Behavior*, *17,* 75-88.

Yoon, S., & Feliciano, G. M. (2007). Stimulus-stimulus pairing and subsequent mand acquisition of children with various levels of verbal repertoires. *The Analysis of Verbal Behavior, 23,* 3-16.

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ABSTRACT

EFFECTS OF RESPONSE-CONTINGENT PAIRING ON VOCALIZATIONS OF NONVERBAL CHILDREN WITH AUTISM

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In Experiment 1, an adapted alternating treatment design was used to compare the effects of a response-contingent pairing (RCP) and a response-independent pairing (RIP) procedure on the vocalizations of 3 nonverbal boys with autism spectrum disorder (ASD). During RCP, adult-delivered sounds that were either paired with a preferred item (target sounds) or not followed by a programmed consequence (nontarget sounds), were presented contingent on the participant making a button-press response. During RIP, the timing of sound presentations (either target or nontarget) was determined by yoking the interstimulus interval (ISI) to the corresponding ISI in a preceding RCP session. Experiment 2 used a multiple baseline design across behaviors to evaluate the effects of differential reinforcement of target vocalizations while thinning the number of presentations during RCP. Experiments 3a and 3b consisted of functional analyses of pairing-induced speech sounds. All participants' data suggested that RCP had greater effects on target vocalizations than RIP, and that the rate of target sounds induced through RCP could be increased through differential reinforcement while thinning pairings. Results of Studies 3a and 3b indicate that target vocalizations were functioning as requests for 1 of the 3 participants following differential reinforcement.