The Analysis of Verbal Behavior 2002, **18**, 3–13

The Effects of a Stimulus–Stimulus Pairing Procedure on the Vocal Behavior of Children Diagnosed with Autism

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Recent research suggests that the sound produced by a child's vocalization can become a conditioned reinforcer via the temporal pairing of an experimenter's vocal model with a preferred stimulus delivered to the child. The current study replicated and extended the findings of previous studies in this area. A multiple baseline design across vocal behaviors (combined with a reversal to baseline) was used to evaluate the effects of a stimulus–stimulus pairing procedure on one-syllable utterances of 3 boys who had been diagnosed with autism. Data were collected during presession and postsession observations across four conditions: baseline, control, pairing, and reversal. During baseline, the free-operant levels of target sounds were recorded in the absence of experimenter interaction. During the control condition, the experimenter presented a vocal model and, after a 20-s delay, presented a preferred stimulus to the child. During the pairing condition, the experimenter's vocal model was paired with the delivery of the preferred item. Results from postsession observations during the pairing condition showed an increase in target sounds for 2 participants. This outcome may suggest that the children's vocalizations were automatically reinforced, albeit only temporarily. Practical and theoretical implications of the results are discussed along with the specific methods employed in this literature.

Many children seem to acquire aspects of their parents' language without special instruction or direct (extrinsic) reinforcement (Bijou & Baer, 1965; Moerk, 1990; Mowrer, 1954; Novak, 1996; Schlinger, 1995). The process of automatic reinforcement has been used as an explanation for this outcome (Skinner, 1957; Vaughan & Michael, 1982). Bijou and Baer suggested that the sound produced by a child's vocal response could function as a form of conditioned reinforcement. The first step in the process of automatic reinforcement is the pairing of the sound (i.e., the sensory product of the response) with an established form of reinforcement. Schlinger suggests that typically developing children constantly hear the sounds produced by the verbal community while they are being fed and caressed, and during other interactions. Numerous pairings between adult vocal sounds and reinforcing stimuli might account for the development of these sounds as forms of conditioned reinforcement. The second step is the occurrence of behaviors (vocalizations) that produce these sounds; these behaviors are either strengthened or weakened, depending on the nature of the response product (either a conditioned reinforcer or a conditioned punisher). It is hypothesized that through this process the infant's own sound making is shaped into sounds similar to the ones produced by his or her verbal community (Bijou & Baer).

In the first attempt to demonstrate automatic reinforcement of vocal be-

This study is based on a thesis submitted by the first author, under the supervision of the third author, to the Department of Psychology at Western Michigan University in partial fulfillment of the requirements for the MA degree. We thank Carmen Jonaitis and Karol Peterson for their invaluable on-site support, and Dick Malott for his helpful comments on an earlier version of the manuscript. We also thank Angela Lebbon, Jennifer Baker, Kim Boven, Megan Coatley, Kris Krejci, Irene McGlynn, Kent Smallwood, Jessica Vore, Kristin Walther, and Amanda Worniak for their assistance with data collection.

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havior experimentally, Sundberg, Michael, Partington, and Sundberg (1996) evaluated the effect of a stimulus–stimulus pairing procedure with 5 children between the ages of 2 and 4 years. Four of the children had language delays, and 1 was a typically developing child. In the first experiment, the authors attempted to establish new sounds in the participants' vocal repertoires using the pairing procedure. Participants were exposed to three different conditions within each session (session length varied): prepairing, pairing, and postpairing. During the prepairing and postpairing conditions, the experimenter recorded target and nontarget vocalizations produced by the participants. During the pairing condition, a familiar adult emitted a target sound and, immediately after, delivered a preferred activity (e.g., tickles, praise, clapping). Approximately 15 pairings per minute during 1- to 2-min periods were conducted. The authors demonstrated an increased frequency of the targeted sound during almost all of the postpairing observations, which they attributed to automatic reinforcement.

In a follow-up study, Smith, Michael, and Sundberg (1996) evaluated the effects of the pairing procedure on the vocal behavior of 2 typically developing infants (11 and 14 months). The authors used procedures similar to those employed by Sundberg et al. (1996). In addition, the experimenters exposed 1 participant to neutral and negative pairing conditions. During the neutral condition, the experimenter emitted a sound but did not deliver a preferred item to the participant. During the negative pairing condition, the experimenter systematically correlated a sound with a verbal reprimand (e.g., "bad girl"). The neutral condition was designed to serve as a control for the possibility that the increase in participants' vocalizations was a function of imitation. The positive pairing condition resulted in an increase in target sounds during postpairing observations for both participants, whereas negative pairing resulted in a decrease in target sounds. However, all target sounds were already in the participants' repertoires. The authors reported failure in trying to teach the participants novel sounds through the pairing procedure. The neutral condition did not result in the participant's emission of that sound, ruling out the possibility that the target sound was under stimulus control of the sound produced by the model.

Recently, Yoon and Bennett (2000) evaluated the effects of a stimulus–stimulus pairing procedure with 4 preschool children with severe language delays. Vocal sounds were paired with physical interaction (e.g., tickles), and the frequency of the target sound during a postpairing observation was compared with its frequency during the prepairing observation using a multiple baseline design across participants. Participants had no oral-motor or vocal imitation skills. In their first experiment, the authors paired the target sound with what they stated was an established reinforcer approximately 36 times during a 3-min pairing session. The target sound was always a novel utterance. All participants showed an increase in the frequency of the target sound immediately after the pairing condition (i.e., during the postpairing observation). However, the authors suggest that the target sound could have occurred and been adventitiously reinforced during the pairing condition, which would threaten attributions to automatic reinforcement as the behavior-change mechanism. In a second experiment, the authors attempted to compare direct reinforcement and stimulus–stimulus pairing in training novel utterances. The study employed preechoic, echoic, postechoic, pairing, and postpairing conditions. During the preechoic, postechoic, and postpairing conditions, the experimenter assessed only the frequency of the target sound. During the echoic condition, the experimenter prompted and directly reinforced the target sound whenever it occurred. The sound was later simultaneously presented (i.e., paired) with a reinforcer during the pairing condition. For all participants, an immediate and significant increase in the target sound occurred only after the pairing condition, suggesting that automatic reinforcement (via stimulus–stimulus pairing) was more effective than direct reinforcement (i.e., echoic training) in generating or increasing vocal behavior that was not part of the participants' repertoires.

The outcomes of these three studies (Smith et al., 1996; Sundberg et al., 1996; Yoon & Bennett, 2000) are quite provocative in that the vocal responses of young children with and without language delays were increased without direct reinforcement. However, despite these findings, all of the studies contained common methodological limitations. First, in two of the studies (Smith et al., Sundberg et al.), the number of pairings was never constant across sessions or participants. Second, although Sundberg et al. employed a neutral condition to control for modeling effects, none of the studies controlled for the possibility of adventitious reinforcement during the pairing trials. Third, the Smith et al. and Sundberg et al. studies did not employ standard single-case design strategies (e.g., reversals) to demonstrate experimental control over the independent variable, nor did they replicate the effects across behaviors within participants. Finally, and perhaps most important, all of the studies demonstrated the effect only during a single session (in fact, the *x*-axis labels in all of these studies were scaled in minutes). Consequently, it is unclear whether the results of the stimulus–stimulus pairing procedure last beyond temporally proximate observations.

The current study was designed to extend the above studies on automatic reinforcement by (a) refining the methodology and (b) demonstrating the effect with children diagnosed with autism, for whom interventions for increasing existing and novel vocal behavior repertoires are relevant. There are three key methodological differences in the current study compared to previous ones. First, fluctuations in the efficacy of the procedure within participants were assessed by presenting a larger number of pairing sessions (with a consistent number of pairing trials per session), and by comparing the effectiveness of the procedure across larger units of time (i.e., days). Second, adventitious reinforcement of the target sounds by presentation of preferred items during the pairing procedure was controlled, along with the effects of modeling and an enriched environment.

METHOD

Participants

Three boys whose behavior met diagnostic criteria for autism participated in the study. Leo, Rob, and Dave were ages 5, 3, and 5 years, respectively, at the beginning of the study. All of the children attended a public school classroom in which intensive behavioral treatment (based on Lovaas, 1981) was delivered for an average of 25 hr per week. Dave received an additional 25 hr per week of verbal-behavior training (Sundberg & Partington, 1998) at home, and Rob received an additional 20 hr per week of in-home therapy based on his school curriculum. Participants were referred to the study by their teacher because of their minimal vocal repertoires. That is, they could emit a few sounds, but could not exhibit more meaningful verbal behavior like mands, tacts, and intraverbals.

The Behavioral Language Assessment form developed by Sundberg and Partington (1998) was used to assess participants' verbal repertoires.[1] This in-

[1] The Behavioral Language Assessment is an informant assessment that contains 12 sections that assess a variety of basic language-related skills (e.g., cooperation, motor imitation, labeling, conversation). Each section is divided into five levels. Informants are asked to select a level that best represents the individual's repertoire in that area. In the current study, we averaged the scores from all 12 sections for our final classi-

formant assessment was conducted with one of the children's therapists at school prior to the study. Participants were given a classification profile from Levels 1 (low verbal repertoire) through 5 (high verbal repertoire) based on the informant report. Leo was classified with a Level 2 profile. He was very cooperative, and had good receptive and matching-to-sample skills. Leo did not have a generalized echoic repertoire. He had been heard to spontaneously vocalize the following sounds during baseline: "aya," "ee," "dah," "mm," "oo," and "uh." Rob was classified between Levels 1 and 2. Rob did not have a generalized echoic repertoire. He had been heard to spontaneously vocalize the sounds "mm," "dah," "mah," "oo," "gah," "bah," and "ee" during baseline. Dave was classified with a Level 3 profile. He was very cooperative and had generalized motor and vocal imitation (he could imitate over 100 words) as well as excellent matching-to-sample and receptive skills. Dave was able to request (mand) four to five items with no prompts. He had been heard to spontaneously vocalize the sounds "mm," "ee," "ka," "dah," "bah," and "pah."

Setting

Leo's sessions were conducted at his school in a small cubicle in his classroom. The cubicle was furnished with two small chairs and a table. Leo sat in one of the chairs and played with toys that were located on the table. The experimenter sat across from Leo. Sessions were conducted once each day, 5 days per week (Monday through Friday) at approximately the same time (0.5 hr before mealtime). Rob's sessions were conducted at home in his living room. The room contained two sofas, one end table, a television and videocassette recorder, a basket of toys, and two small chairs and a table (located in one of the corners). Only Rob and the experimenters were present in the living room during sessions. Rob was allowed to play with toys on the floor across from the experimenters. Sessions were conducted twice each day, 5 days per week, at approximately the same times (0.5 hr before or 2 hr after mealtime). Dave's sessions were conducted at his home in the room typically used for his therapy. The room contained two bookshelves with toys, a computer table and a personal computer, a television and videocassette recorder, two small chairs and a table (located in the center of the room). Only Dave and the experimenters remained in the therapy room during sessions. Dave was allowed to play with toys on the floor or on the table. The experimenters typically sat on the floor across from Dave. Sessions were conducted twice each day, 5 days per week, at approximately the same times (0.5 hr before or 2 hr after mealtime). For all participants, sessions were audiotaped for scoring purposes. The tape recorder was usually located next to the child. Although it was possible for participants to manipulate the tape recorder, this rarely occurred.

Target Behaviors and Interobserver Agreement

The target sounds were the two lowest frequency one-syllable utterances produced by each participant during baseline. Target sounds were "ee" and "uh" for Leo, "bah" and "oo" for Rob, and "dah" and "ee" for Dave. Close approximations to these sounds were also recorded as the target sounds (e.g., "aee" for "ee"). Response frequencies were recorded on site by trained undergraduate research assistants during 5-min presession and 5-min postsession observations in 30-s time bins. These observations were conducted immediately before (presession) and after (postsession) each baseline, control, and stimulus–stimulus pairing session.

Two observers collected data independently during at least 25% of ran-

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fication. Information obtained from the Behavioral Language Assessment form is typically used to identify the initial curricular areas of a language intervention program.

domly selected sessions (distributed across conditions) for the assessment of interobserver agreement. Exact (block-by-block) agreement was calculated by dividing the smaller frequency of target sounds recorded in each 30-s interval by the larger frequency. These values were then averaged across sessions and multiplied by 100%. Mean agreement percentages (across sessions) were 91% (range, 75% to 100%) for Leo, 95% (range, 83% to 100%) for Rob, and 96% (range, 80% to 100%) for Dave.

Stimulus Preference Assessment

Prior to the study, a reinforcer assessment survey (Fisher, Piazza, Bowman, & Amari, 1996) was administered to the parents or caregivers of each participant. A list of five edible items was generated from the assessment. During each session, a single-array multiple-stimulus preference assessment (Higbee, Carr, & Harrison, 2000) was conducted. The experimenter placed the five items identified from the survey in front of the participant. The first item pointed to or touched by the child was selected for the subsequent session.

Procedure

Experimental design. A two-tiered multiple baseline design across vocal behaviors combined with a reversal to baseline was used to evaluate the effects of stimulus–stimulus pairing on target sounds. Phases consisted of baseline (A), control (A′), and pairing (B) conditions. A brief return to baseline was conducted as the final phase. During each phase, data were collected during presession and postsession observations (identical to baseline); these data are plotted on the figures.

Presession and postsession observations. Observations (5 min each) were conducted immediately before (presession) and after (postsession) each baseline, control, and stimulus–stimulus pairing session. During these observations, participants were allowed to play with toys while their vocal behaviors were recorded. During these observations, there was no or minimal interaction between the experimenter and participant.

Baseline. Baseline sessions were identical to the presession and postsession observations and lasted approximately 5 min. This condition was conducted to document participants' vocal repertoires in the absence of the independent variable.

Control. The experimenter repeated the target sound approximately five times, and after 20 s, presented the preferred edible item (i.e., a small piece of food). If the participant emitted the target sound during this 20-s interval, the timer was reset and the presentation of the preferred edible item was delayed 20 s. This correction procedure was used to control for adventitious reinforcement. After the participant was given 20 s to consume the edible item, a new trial was presented. Each session consisted of 20 trials. Session length varied, but never exceeded 20 min. The control condition was designed to control for the effects of modeling and an enriched environment (i.e., the emission of sounds and the delivery of preferred items) on vocal behavior.

Stimulus–stimulus pairing. During the session, the experimenter repeated the target sound approximately five times and presented the preferred edible item. The food item was presented after the first three but before the last sound was emitted by the experimenter. The participant was allowed to consume the item for at least 10 s, after which a new trial was presented. A correction procedure to control for adventitious reinforcement was also employed during this condition: The subsequent trial was delayed by 20 s if participants emitted the target sound. Each session consisted of 20 stimulus–stimulus pairing trials. Session length varied, but never exceeded 20 min.

Integrity of the Independent Variable

Integrity of the independent variable was assessed by an independent observ-

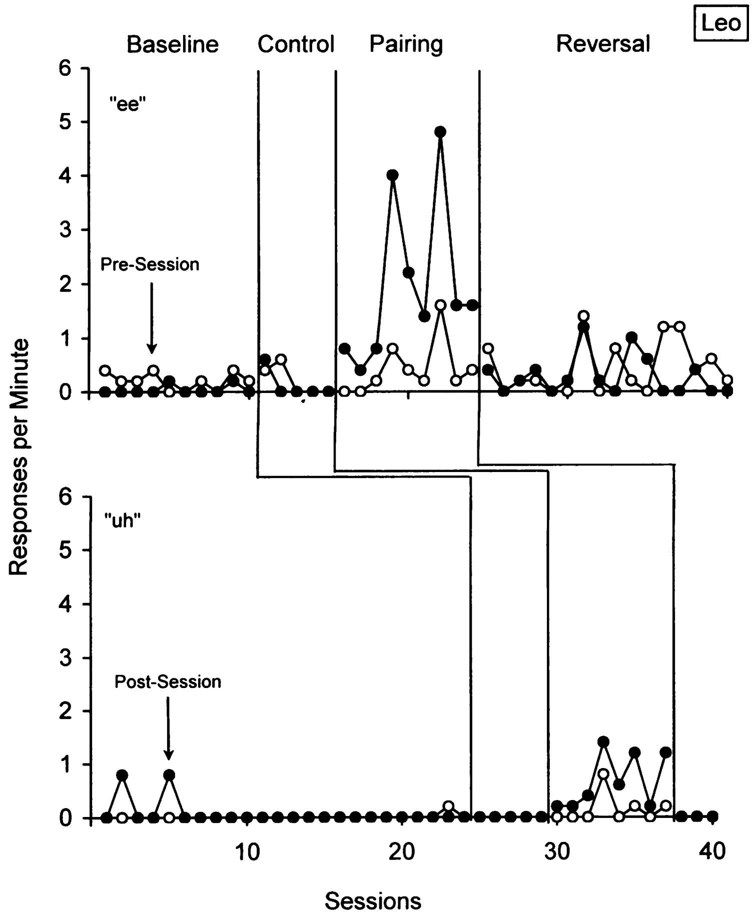

Fig. 1. Responses per minute during presession (open circles) and postsession (closed circles) observations during baseline, control, stimulus–stimulus pairing, and reversal conditions for both of Leo's vocalizations.

er for at least 25% of the control and pairing sessions for all participants. Sessions used in the calculation of integrity were randomly selected. Integrity was calculated by dividing the number of correctly implemented trials by the total number of trials. Trials were scored as entirely correct or incorrect based on the following categories: (a) Target sound: The target sound had to be produced by the experimenter and immediately followed by the delivery of the preferred edible item or presented alone (pairing and control conditions, respectively). (b) No contiguity: The preferred item had to be delivered 20 s after the emission of the sound by the experimenter during the control condition. (c) Intertrial interval (ITI): The ITI had to be at least 10 s during the pairing condition. (d) Correction: The onset of the trial had to be delayed by 20 s if the child responded during the ITI or within a trial (pairing and control conditions, respectively). Mean integrity percentages were 100% for Leo, 99% for Rob (range, 95% to 100%), and 98% for Dave (range, 95% to 100%).

RESULTS

Figure 1 shows the frequency of Leo's target sounds during presession and postsession observations. The first target sound was "ee" (upper panel). This sound occurred at a very low fre-

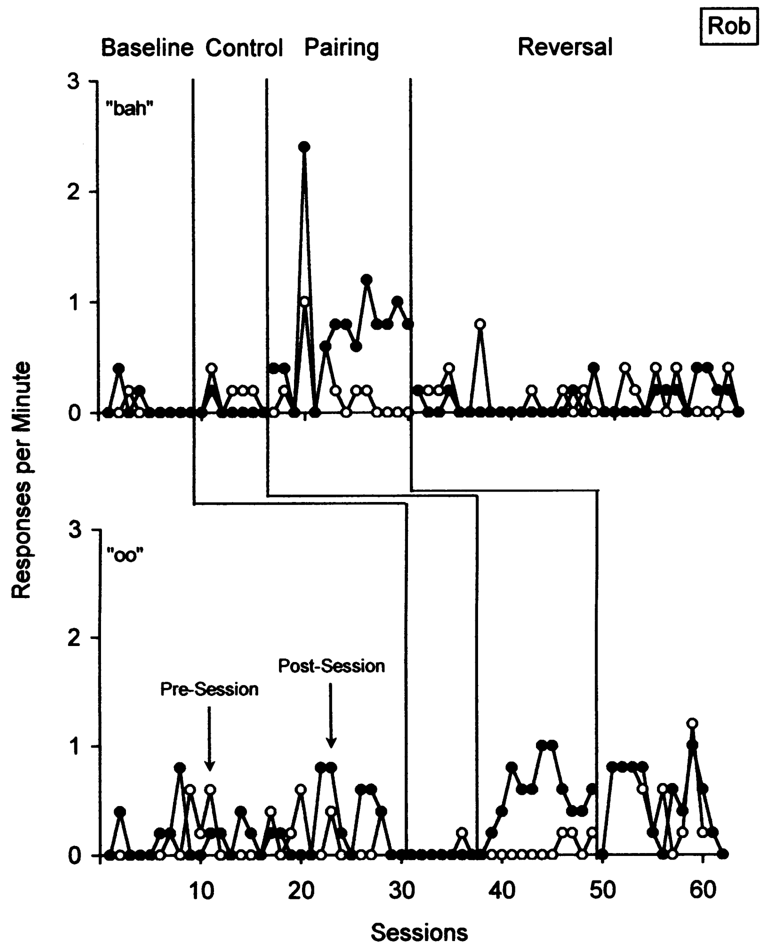

Fig. 2. Responses per minute during presession (open circles) and postsession (closed circles) observations during baseline, control, stimulus–stimulus pairing, and reversal conditions for both of Rob's vocalizations.

quency during presession and postsession observations in baseline. During the control condition, the target sound did not increase as a function of the noncontiguous presentation of the sound and the preferred edible item. However, the correction procedure (i.e., contingent postponement of the presentation of the preferred item) may have resulted in a reduction in the target sound. During the pairing condition, the target sound "ee" was more frequent during postsession than during presession observations. In addition, the overall frequency of the target sound was higher during the pairing condition than during baseline or control conditions. When the baseline condition was restored, the frequency of the target sound decreased, and no differentiation between presession and postsession was observed. Similar results were obtained with Leo's second target sound, "uh" (lower panel). It is noteworthy that the overall frequency of "uh" was not as high as the overall frequency of "ee" during the pairing condition. It is unclear what variables moderated the magnitude of the effect.

Figure 2 shows the frequency of Rob's target sounds during presession and postsession observations. The first target sound was "bah" (upper panel), which occurred infrequently during baseline. When the control procedure was introduced, no systematic differences between presession and postsession observations were noted. The pairing condition, however, did produce a clear differentiation between presession and postsession observations. The final reversal condition resulted in data similar to baseline (i.e., no difference). Rob's second target sound was "oo" (lower panel), which occurred at a higher rate than "bah" during baseline; however, there was no difference between presession and postsession observation data. During the control condition, responding in both the presession and postsession observations decreased to near zero, providing evidence that the control procedure may have suppressed responding. During the pairing condition, the frequency of the target sound was consistently higher during postsession than during presession observations. Although this difference was consistent throughout the phase, the overall frequency of responding was no higher than the overall frequency during the initial baseline condition. On the other hand, the frequency of the target sound during pairing was higher than the overall frequency during the immediately prior control condition. When the pairing procedure was withdrawn, the difference between presession and postsession data disappeared.

Figure 3 shows the frequency of Dave's target sounds during presession and postsession observations. The first and second target sounds were "dah" and "ee" (upper and lower panels, respectively). During baseline for both target sounds, there were no apparent differences between presession and postsession data. A similar pattern was observed in the subsequent control, pairing, and reversal conditions for both sounds. Interestingly, during some of the pairing sessions (Sessions 37, 42, and 45) for the sound "ee," Dave emitted the previously paired sound "dah" while attempting to reach for the food items. The sound "dah" appeared to be functioning as a form of request (mand), even though it was never explicitly trained as one.

DISCUSSION

The results of the current study partially replicate those from previous experiments (Smith et al., 1996; Sundberg et al., 1996; Yoon & Bennett, 2000). For Leo, the stimulus–stimulus pairing procedure produced an immediate and replicable increase in both target sounds without the need for direct reinforcement. For Rob, the pairing procedure produced an immediate increase in his first target sound ("bah"). Although the second sound occurred consistently more often during the postsession observation, the rates never exceeded those in the initial baseline phase. Further, the effect was temporary, in that (a) subsequent presession observations produced baseline-level responding, and (b) target sounds immediately returned to baseline levels after withdrawal of the intervention.

It is assumed that the target sound occurred after stimulus–stimulus pairing trials (during the postsession observation) because its response product (sound) functioned as a conditioned reinforcer. During postsession observations, the response product was not followed by or paired with any form of reinforcement, perhaps eventually resulting in the decrease of the reinforcing effectiveness of the sound, a process analogous to respondent extinction (of the stimulus–stimulus relation). Thereafter, a process analogous to operant extinction may also have occurred, because the emission of the target sound was no longer followed by a conditioned reinforcer. The only reason to expect the effects of the pairing procedure to last once pairing has ceased is if direct (extrinsic) reinforcement of such sounds had been implemented during postsession observations. Consequently, future research evaluating the effects of direct reinforcement as a follow-up adjunct to a stimulus–stimulus procedure is warranted.

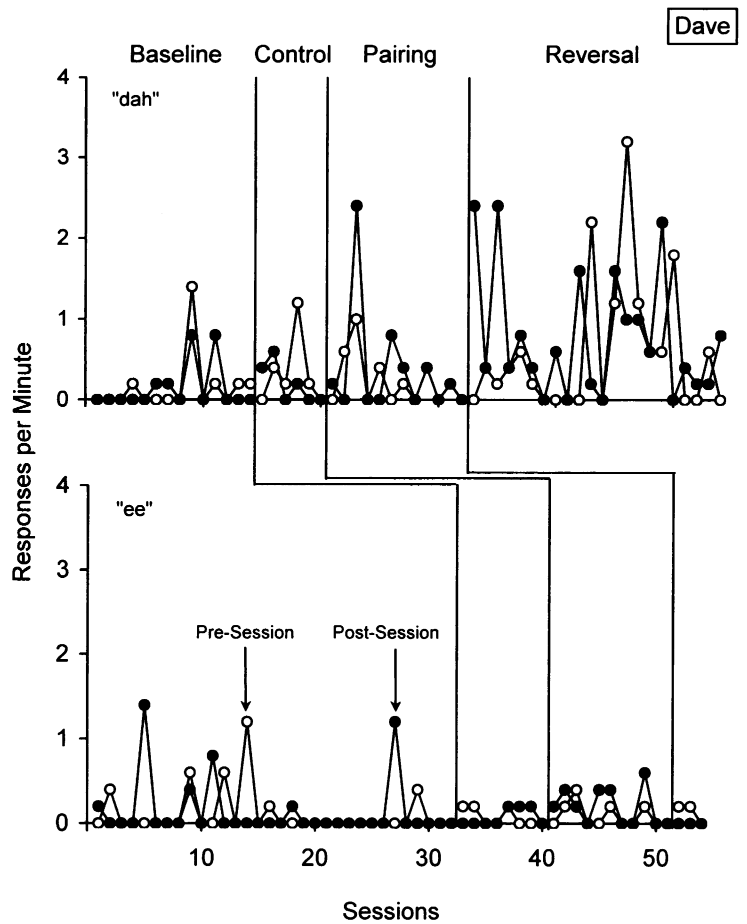

Fig. 3. Responses per minute during presession (open circles) and postsession (closed circles) observations during baseline, control, stimulus–stimulus pairing, and reversal conditions for both of Dave's vocalizations.

Unfortunately, the pairing procedure proved to be ineffective in increasing Dave's target sounds. As reported by Sundberg et al. (1996), we also observed that during some sessions the participants vocalized less often, perhaps as a function of specific variables that affected the effectiveness of "hearing one's own voice" as a form of reinforcement (i.e., establishing operations). The identification of such variables may also help us to understand the variability in responses across sessions. Yoon and Bennett (2000) suggested that there might be a relationship between a child's baseline verbal behavior repertoire and the effectiveness of the pairing procedure. In an unpublished study, Bennett and Yoon (2000) found that the less advanced a child's verbal behavior repertoire was, the more responsive he or she was to the pairing procedure. The authors defined *verbal repertoire* based on the number of vocalizations per second and the number of functional response forms (i.e., echoics, mands, tacts, and intraverbals) produced by the child. Leo and Rob scored lower than Dave did on the prestudy Behavioral Language Assessment. For the children with a strong verbal repertoire, the conditioned reinforcer produced by the emission of the target sound may have competed with other reinforcers that could be produced by the child's verbal behavior. These other reinforcers may have been more powerful (e.g., a mand would produce a desired item), thus decreasing the probability of the target sound, whose automatic reinforcer was relatively weaker. Because the results of the current study, as well as those of Yoon and Bennett (2000), are somewhat inconsistent with those obtained by Sundberg et al. (1996), who were able to use the pairing procedure to increase vocal behavior in children with extensive verbal repertoires, further investigation of the correlation between preexisting verbal repertoires and sensitivity to the stimulus–stimulus pairing procedure is warranted.

Despite the generally positive outcome demonstrated in 2 of the 3 participants and the methodological improvements made compared to previous studies, two limitations of the current study are worth noting. First, the reinforcing value of the preferred items used during pairing was never directly tested. Although a brief multiple-stimulus preference assessment was conducted before each session, the extent to which the selected items actually functioned as reinforcers for behaviors other than selection was unknown. Recent studies (e.g., Higbee et al., 2000) have shown that the most preferred stimulus in a multiple-stimulus preference assessment generally produces the strongest reinforcement effects. However, no attempt was made to present the preferred item contingent on another behavior to verify its reinforcing properties. Second, no data were collected regarding other potential sources of differential reinforcement that could have accidentally followed the target behavior during sessions. These sources could potentially include subtle smiles, head nods, eye contact, and so forth. Although observers were explicitly trained to avoid interaction, future research might monitor more closely these possible sources.

There is much to be explored in the area of automatic reinforcement and language development. It is still unknown why some children's vocal behaviors do not change as a function of the pairing procedure. It is also unclear whether the degree of difficulty in producing a certain sound affects a child's response to the procedure. In the current study, vocal responses that the children could already produce were used as targets. This decision was made to avoid the possibility that a failure to respond to the procedure was due to articulation deficits. A question that future researchers might attempt to answer more directly is whether the pairing procedure produces differential effects with already existing compared to novel sounds.

Another possible area of research would be to evaluate whether the pairing procedure can result in untrained mand responses. In the current study, the only participant whose behavior did not change as a function of the pairing procedure (Dave) began to use one of the paired sounds as a mand (similar to what was reported by Sundberg et al., 1996). It is possible that the 20-s correction procedure was insufficient in preventing adventitious reinforcement. The participants could have also been covertly producing the target sound immediately before the experimenter provided the preferred item, which would be analogous to a mand contingency.

In summary, the results of the current study contribute more support to the notion that automatic reinforcement can be used to increase the vocal behavior of children. The findings from the current and previous studies appear to support the use of a stimulus–stimulus pairing procedure as a supplement to direct reinforcement as a method for strengthening vocal responses of children with language delays who are undergoing verbal-vocal behavior training. In application, the pairing procedure would involve taking every opportunity to associate adult vocalizations with preferred stimuli. If the product of these vocalizations acquired reinforcing properties, the vocalizations should be strengthened (Sundberg & Partington, 1998). Such a procedure would be especially relevant for children who lack an echoic repertoire. It is important to note, however, that the current study is not "applied" according to the conventions of the discipline (e.g., Baer, Wolf, & Risley, 1968), in that the participants' vocal repertoires were not significantly improved. Because the purpose of the study was primarily to evaluate the effect with a relevant population, perhaps it can best be characterized as a bridge study (Carr, Coriaty, & Dozier, 2000; Wacker, 1996). Thus, before dissemination of the stimulus–stimulus pairing procedure into practical arenas, it is crucial to better demonstrate its utility, especially with respect to its integration with direct-reinforcement strategies.

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