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Evaluating Stimulus-Stimulus Pairing and Direct Reinforcement in the Establishment of an Echoic Repertoire of Children Diagnosed with Autism

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Many children with autism do not imitate adult vocalizations, an important skill in learning to talk. Pairing adult vocalizations with preferred stimuli has been shown to increase free-operant vocalizations but effects are temporary; thus, direct reinforcement may be necessary to establish durable vocal behaviors. In Experiment 1, directly reinforced echoic responses did not increase following stimulus-stimulus pairings in three children with autism. Similarly, pairings did not increase free-operant vocalizations in Experiment 2, a replication of Miguel et al. (2002). Experiment 3 demonstrated that shaping increased vowel frequency for one participant. Results suggest that variables are yet to be delineated that influence effectiveness of a stimulus-stimulus pairing procedure on vocalization frequency and acquisition of a verbal operant following such pairings.

Key words: stimulus-stimulus pairing, automatic reinforcement, verbal behavior, autism, speech training.

Most humans seem to acquire a native language repertoire quite effortlessly even though characteristics (e.g., structure, usage rules, meaning) of the language may be quite complex. Moreover, for the most part, they do so in the absence of specific instruction (Bijou & Baer, 1965; Moerk, 1990; Schlinger, 1995). Skinner (1957) provides an explanation of this apparent phenomenon as a function of environmental variables operating according to behavioral principles (e.g., reinforcement). However, when one considers how rapidly young children learn their native language, it is logistically implausible that reinforcement of a direct nature (i.e., consequences deliberately arranged by another person) could be the sole explanation for such exponential language acquisition. Thus, we must consider how an infant manages to acquire much of the foundation for a robust language repertoire in the absence of direct reinforcement.[1]

To understand how this might come about, it is useful to consider a form of reinforcement that strengthens behavior without requiring the controlling contingencies to be deliberately arranged (i.e., mediated) by another person. Such a process, termed *automatic reinforcement* (Skinner, 1957; Vaughan & Michael, 1982), serves to strengthen a variety of behaviors that produce stimuli that, in themselves, constitute the reinforcing consequences for those behaviors. In other words, the strengthening effect is self-produced; thus, the reinforcement is "automatic."

In terms of early language acquisition, automatic reinforcement may occur through a process in which a neutral stimulus becomes conditioned as a reinforcer if it has been sufficiently paired with another stimulus that has already acquired reinforcing properties. For instance, during infant caregiving, parents typically vocalize[2] while delivering reinforcing stimuli to the child (e.g., talking to the baby while feeding, changing diapers, rocking). These caregiver vocalizations (initially neutral) may acquire reinforcing properties as a result of repeated pairings with unconditioned or conditioned reinforcers. To the degree the child

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[1]For a psycholinguistic treatment of this topic, see Brown, 1973; Chomsky, 1959; or Pinker, 1994.

[2]It is reasonable to surmise that sign language movements could function similarly.

produces similar sounds (i.e., a close match to "native" sounds produced by parents), these sounds, the auditory products of vocal musculature movements, may function as automatic reinforcers for those movements (Palmer, 1996; Schlinger, 1995). Thus, vocalizations could be shaped into speech components that resemble, and are directly reinforced by, those of the child's own verbal community.

Although automatic reinforcement may provide a plausible explanation for normal acquisition of early language, its role is less clear in explaining how a pairing process might be used to augment an inadequate repertoire or to facilitate acquisition of initial repertoires in those who have failed to acquire language. If language develops from vocalizing, imitating, and refining (i.e., through shaping) syllable units as the "building blocks" of one's language (Schlinger, 1995), it seems important to understand how those "raw materials" can be evoked in individuals who vocalize minimally or not at all.

Recent research has addressed this issue in children diagnosed with developmental disabilities as well as with typically developing children. Sundberg, Michael, Partington, and Sundberg (1996) were the first to investigate the effects of pairing a spoken sound with the delivery of a reinforcing stimulus on subsequent human vocal-verbal[3] behavior. Four children, ages 2 to 4, with severe to moderate language delays and one child, age 2.5, with typically developing language were presented with repeated pairings of adult sounds (e.g., "eee") with established reinforcers (e.g., tickles). Targets were chosen that were either novel or had not been emitted during a pre-pairing condition. Target and non-target vocal behaviors were observed before the procedure (pre-pairing) and afterward (post-pairing). The results showed that all of the children spontaneously emitted new vocal responses after pairings, although not all targeted sounds were emitted by all children. Because new responses appeared to be acquired without direct reinforcement, prompts, or direct echoic training, Sundberg et al. attributed the effects of the pairing procedure to automatic reinforcement. Although robust effects were achieved in this study, vocalizations decreased to pre-intervention rate within approximately 9 min.

Smith, Michael, and Sundberg (1996) evaluated the vocal-verbal behavior of two typically developing children (11 months, 14 months) using a procedure that paired a vocal stimulus with a reinforcing stimulus. One participant was also exposed to pairings of a vocal stimulus with neutral and aversive stimuli. Results showed that target sounds that already existed in the children's repertoires increased in frequency as a result of repeated pairings with a reinforcing stimulus and decreased when paired with an aversive stimulus (i.e., verbal reprimand). The neutral pairing condition, in which an auditory stimulus was not followed by a reinforcing event, did not result in emission of the target sound, ruling out the possibility that the child's target vocalizations were under imitative (echoic) control. In contrast to the Sundberg et al. (1996) results, no novel responses resulted from the pairing procedure.

Yoon and Bennett (2000) studied the effects of a stimulus-stimulus pairing procedure with four preschool children with severe language and communication delays. Three children in Experiment 1 were presented with a one-syllable stimulus followed immediately by physical interactions (e.g., tickles) that had been identified as established reinforcers. Vocalizations were observed during conditions of pre-pairing (baseline), pairing, and post-pairing. Targets were selected by identifying sounds that either did not exist in the child's vocal repertoire or occurred at a low frequency prior to the pairing procedure. Results showed that target vocalizations increased from a baseline rate of zero to a mean rate of 1.85 per min while non-targeted sounds did not increase. Consistent with previous studies, effects were temporary in that target vocalizations continued for a mean of less than 10 min (range, 3 to 16 min).

In attempting to explain the initial occurrence of the (new) target response following pairings, Yoon and Bennett (2000) speculated that the requisite relevant history might have involved direct reinforcement. That is, target responses may have occurred as a function of already-established echoic control of either the entire target sound stimulus (i.e., all phonemes presented in a syllable) or of individual phonemes

[3]The term vocal-verbal refers to vocalizations that are speech-related in contrast to non-speech vocalizations that may be emitted using the vocal musculature (e.g., coughing, crying, gagging, throat-clearing, humming, burping).

that were easily combined to match the simple target syllable presented through pairings. To evaluate this possible influence by direct reinforcement contingencies, the authors conducted a second experiment comparing differential effects on a novel vocal repertoire of stimulus-stimulus pairing with direct reinforcement for echoic responses. Participants included two children from Experiment 1 and one new participant who also had a limited vocal-verbal repertoire. Pre- and post-observation periods were scheduled around an echoic condition that was immediately followed by a pairing session and a subsequent post-pairing observation period. The target was a single syllable not in the participants' vocal repertoires. Results showed that for all three participants, the target syllable was not emitted during the echoic condition (with one exception) but was observed immediately after pairings, continuing for 8 to 20 minutes. Although occurrence of the first post-pairing response was not explained, Yoon and Bennett concluded that subsequent post-pairing vocalizations were attributable to automatic, not direct, reinforcement. That is, had responses been the under the control of direct reinforcement contingencies, they would have been observed during the echoic condition.

In the most recent study of automatically reinforced vocal behavior, Miguel, Carr, and Michael (2002) evaluated the effects of a pairing procedure on the verbal vocalizations of three children, ages 3 to 5, with a diagnosis of autism and limited vocal-verbal repertoires. Targets were selected from low-frequency syllables identified during an initial observation period. Multiple target presentations were made (e.g., ba ba ba) during which a preferred food item was delivered. Results from this study partially replicated earlier findings in that two of the participants demonstrated an immediate, although temporary, increase in at least one of the target sounds following the pairing procedure. For the remaining child, however, no effect was observed. Interestingly, this participant's initial vocal-verbal repertoire was more complex than others' in that it included independent mands, generalized motor and vocal imitation, and excellent receptive language skills. The authors speculated that, for children with more extensive verbal repertoires, reinforcers available through automatic reinforcement (i.e., auditory stimuli) might compete unsuccessfully with reinforcers delivered by others such as items produced through mand behavior.

The results of these studies show that speech vocalizations of children with communication delays can be strengthened through a pairing procedure whose mechanism of action suggests an automatic reinforcement function. That is, speech sounds are established as conditioned reinforcers for the sound-production behaviors that precede them. However, such improvement appears limited in duration, a problem that may be a function of unpairing (perhaps similar to respondent extinction) as a result of the conditioned reinforcer (i.e., self-produced sounds) occurring repeatedly in the absence of reinforcement. If this is so, presumably the positive effects of pairings could be extended through direct reinforcement to strengthen weak vocal behaviors temporarily induced by the pairing procedure.

The present study was concerned with the issue that seems to most limit the pairing procedure's utility as a clinically relevant tool—the apparent inability of the stimulus-stimulus pairing procedure to produce lasting effects. If extinction (i.e., unpairing) is a likely explanation for the elimination of newly emitted responses, and those responses are a function of the pairing procedure, it is possible that their decline could be prevented by direct reinforcement within some temporal "window of opportunity." It may be necessary to bring those weak responses under operant control maintained by contingencies of direct (i.e., non-automatic) reinforcement. Stability of the response would allow a more complex echoic repertoire to be strengthened so that fledgling speech responses could come under the influence of natural social contingencies and thereby flourish. This would require identifying the respective roles played by automatic reinforcement and direct reinforcement in strengthening speech vocalizations in individuals with limited repertoires. Since the research to date provides evidence for the role of the former, the next step is to more clearly delineate the latter.

The current study consisted of three experiments. The purpose of Experiment 1 was to demonstrate the clinical relevance of the pairing procedure by attempting to bring newly acquired, but potentially temporally unstable, responses under echoic control. Since this procedure proved ineffective, Experiment 2 was conducted to replicate the positive effects of increased post-pairing vocalizations reported by Miguel et al. (2002). However, this procedure did not produce increases in vocal behavior. Experiment 3 was therefore conducted to examine the degree to which specific vocal responses by these participants were sensitive to reinforcement via a simple shaping procedure.

EXPERIMENT 1

Method

Participants

Three children with diagnoses of autism participated in the study. Alexa was 6 years 10 months of age and had no history of behavioral instruction. David was 6 years 11 months of age and previously had received one school year of intensive behavioral instruction (based on Lovaas, 1981), approximately 25 hr per week. In addition, he had received 10 hr per week of parent-directed, after-school tutoring for the past 3 years. Jodi was 8 years 2 months of age and previously had been enrolled for 6 months in a classroom providing intensive behavioral instruction. All participants were currently attending a public school classroom for children with a diagnosis of autistic spectrum disorders.

A speech pathologist assessed the participants' speech and language skills. All participants had age-equivalent scores below 2 years of age on the Kaufman Speech Praxis Test (KSPT; Kaufman, 1995), an evaluation that requires an echoic response (i.e., imitating a vocal model) to identify which sounds or sound combinations are particularly difficult for a child. With the exception of two attempted oral-motor imitations (by David), none of the participants emitted any vocal-verbal or oral-motor imitative responses during the KSPT.

Echoic skills were also evaluated using the Behavioral Language Assessment (BLA; Sundberg & Partington, 1998), an informant assessment using a five-point scale to rate basic language-related skills. Informants gave participants a score of 1 on the vocal imitation (echoic) section of the BLA, indicating their observations that participants were unable to repeat any sounds or words upon command. Similarly, informants did not report occurrence of any other verbal operants such as mands, tacts, or intraverbals.

The Peabody Picture Vocabulary Test-III (PPVT; Dunn, Dunn, & Dunn, 1997) was administered to assess receptive language but basal levels could not be established for any participants. Thus, no language age scores could be derived. Since the PPVT did not yield information about the participants' receptive language function, the Receptive-Expressive Emergent Language Test, Third Edition (REEL; Bzoch, League, & Brown, 2003) was completed. Although designed for use with children under the age of 3, the REEL provided a reference point to compare derived expressive and receptive language ages of participants with those of typically developing children. Scores on the REEL were below 12 months of age for all participants on both receptive and expressive language measures.

Setting

The study was conducted in participants' homes after school or on weekends typically three days per week. Participants sat at a dining table (Jodi), in a highchair (Alexa), or at a small table in a designated therapy room (David). Baseline sessions (see ECH below) lasted not more than 2 min and duration of intervention sessions (see P-ECH below) was approximately 10 min; three to four contiguous sessions were typically presented each day. The materials consisted of a tripod-mounted video camera located next to the experimenter, recording data sheets, and a variety of preferred items on a tray, visible but out of the child's reach. The rooms also contained furniture (e.g., desk, chairs, bookcases) and other common household items (e.g., lamps, toys, phone).

Target Response

Target responses were selected from vocalizations observed during 30-min samples of free-operant vocal behavior videotaped within 1 week prior to the study. The samples revealed that all participants produced a few vowel sounds and one participant (David) occasionally emitted consonants in combination with vowels. Targets were /i/ and /u/ for Alexa and /i/, /a/, and /u/ for Jodi.[4] Consonant-vowel (CV) syllables (/si/, /bi/, /da/) were targeted for David whose free-operant sample included some consonant usage. In addition, one CV syllable (/ba/) was selected for Alexa since she was observed at times to approximate correct lip position for /b/.

Response Definition and Recording System

The participants' vocal responses were recorded as they were emitted in two conditions of the intervention program: an echoic baseline condition (ECH) and an echoic condition preceded by antecedent pairings (P-ECH). In the P-ECH condition, massed presentations of auditory stimuli paired with immediate delivery of preferred stimuli preceded direct reinforcement of echoic responses. Target responses were defined as the production of any target syllable that matched or was topographically similar to the model presented. Non-target responses were defined as the production of any non-target syllable excluding non-speech vocalizations (e.g., laughing, burping, screaming, crying, coughing, grunting, gagging, sustained or repetitive humming). Repeated syllables (e.g., ba ba ba) occurring between presentations of the echoic model were counted as one response.

Interobserver Agreement

Two independent observers manually recorded session data during a minimum of 50% of randomly selected sessions (balanced across conditions) either *in vivo* or from video recordings.

Interobserver agreement (IOA) on frequency of target and non-target vocalizations was calculated using the point-by-point method by dividing agreements on response occurrence and non-occurrence recorded in each 10-trial session by agreements plus disagreements and multiplied by 100 to yield a percentage of agreement. Mean agreement percentages across ECH sessions were 98% (range, 75% to 100%) for Alexa, 99% (range, 90% to 100%) for David, and 100% for Jodi. Mean agreement percentages across P-ECH sessions were 96% (range, 75% to 100%) for Alexa, 99% (range, 90% to 100%) for David, and 100% for Jodi.

Stimulus Preference Assessment

Prior to the study, parents completed a preference assessment survey (Fisher, Piazza, Bowman, & Amari, 1996) that yielded a list of the child's preferred edibles and toy items. These items were then presented in separate assessments (i.e., toys, edibles) to the child three times in a multiple stimulus (without replacement) array (Carr, Nicolson, & Higbee, 2000) to verify preference ranking. At the beginning of each day's sessions, the experimenter presented an array of the five highest ranked items from the preference assessments. Any items not touched, reached for, or accompanied by smiles when presented during a 1-min pre-session sampling period were eliminated, and remaining items were randomly rotated during that day's sessions.

Procedure

Experimental design. This experiment observed the effects of 1) pairing a vocal stimulus with a reinforcing stimulus and 2) subsequent direct reinforcement of target vocal behavior upon an echoic operant. Auditory stimuli (i.e., syllables) were presented during each phase of an AB multiple-baseline design across topographies with a constant-series control (Hayes, Barlow, & Nelson-Gray, 1999) in which one measured response remains in baseline and does not undergo treatment. This experimental design represents typical clinical intervention in that massed presentations of paired stimuli do not usually precede echoic training. The multiple baseline diminished concerns regarding omission of a withdrawal condition that would have been presented following positive pairing effects (which did not occur).

Echoic condition (ECH). The experimenter presented the target vocal stimulus once (i.e., the syllable later repeated during pairings). When the participant approximated or matched the stimulus within 5 s, a preferred stimulus was delivered immediately. This stimulus (e.g., tickles) was terminated within 5 s or, in the case of edibles, when the item was consumed. If there was no response, no putative reinforcer

[4]Phonemes are written using the International Phonetic Alphabet (International Phonetic Association, 1999). For further information and to view a complete IPA chart, see http://www2.arts.org.gla.ac.uk/IPA/index.html.

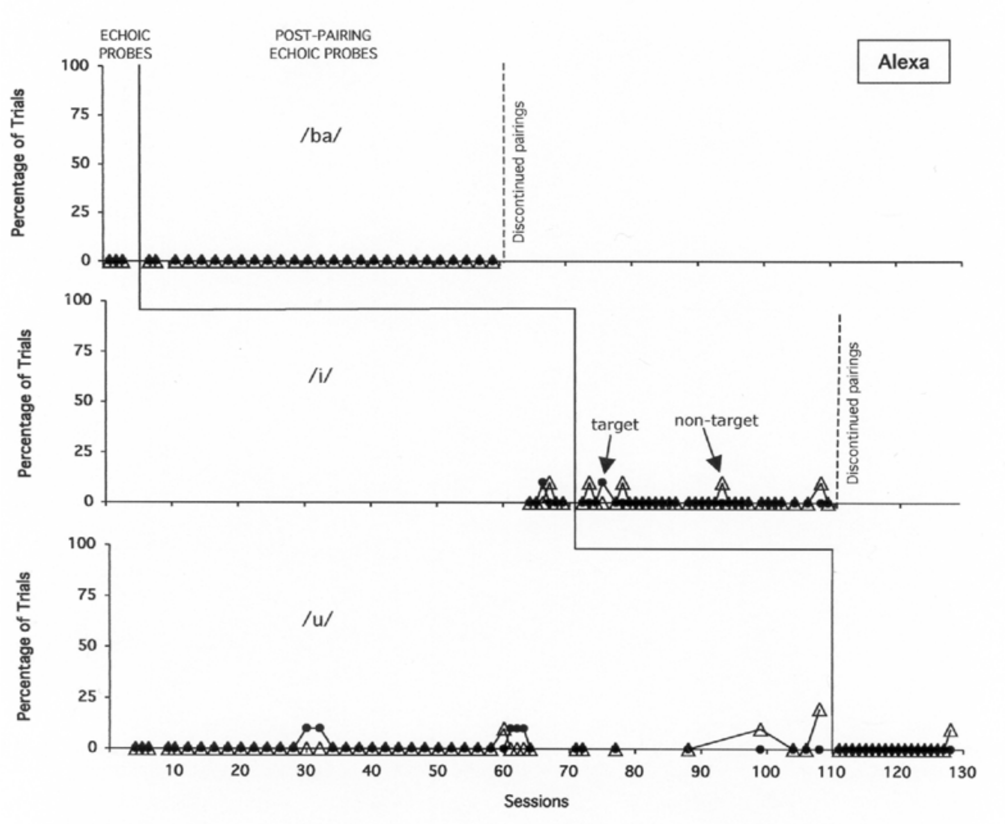

Figure 1. Percentage of trials during Experiment 1 in which target and non-target phonemes occurred during echoic probes in baseline and following stimulus-stimulus pairings with Alexa.

was delivered and the next trial was presented. Sessions consisted of 10 ECH trials; session length did not exceed 2 min.

Echoic with antecedent pairings condition (P-ECH). Sessions in this condition consisted of two segments: 1) 30 pairings of a vocal stimulus with a preferred stimulus and 2) direct reinforcement of echoic responses during 10 subsequent echoic probes. During the pairing (P) segment of P-ECH, targets were presented at the rate of one syllable per second for 3 s followed immediately by delivery of a preferred stimulus. The child had access to the preferred item for 5 s (or until consumed) after which the next pairing trial was presented. Immediately after the pairing segment of P-ECH, 10 echoic probes (ECH) were conducted in a procedure identical to that of the ECH condition. Responses on these probes provided data for the P-ECH condition.

Independent Variable Integrity

To assess independent variable integrity, an independent observer scored a minimum of 25% of sessions (selected randomly and balanced by condition) either during sessions or later from videotaped recordings of sessions. Trials were scored as completely correct or incorrect. The number of correct trials were counted, divided by the number of correct plus incorrect trials, and multiplied by 100 to yield a percentage of independent variable integrity (IVI). A pairing segment trial was correct if (a) three target syllables were presented per trial, (b) syllables were presented within 5 s, (c) a preferred stimulus was presented within 5 s after the auditory stimulus, and (d) no other stimulus was presented. An echoic segment trial was correct if (a) one target syllable was presented, (b) a preferred stimulus was given con-

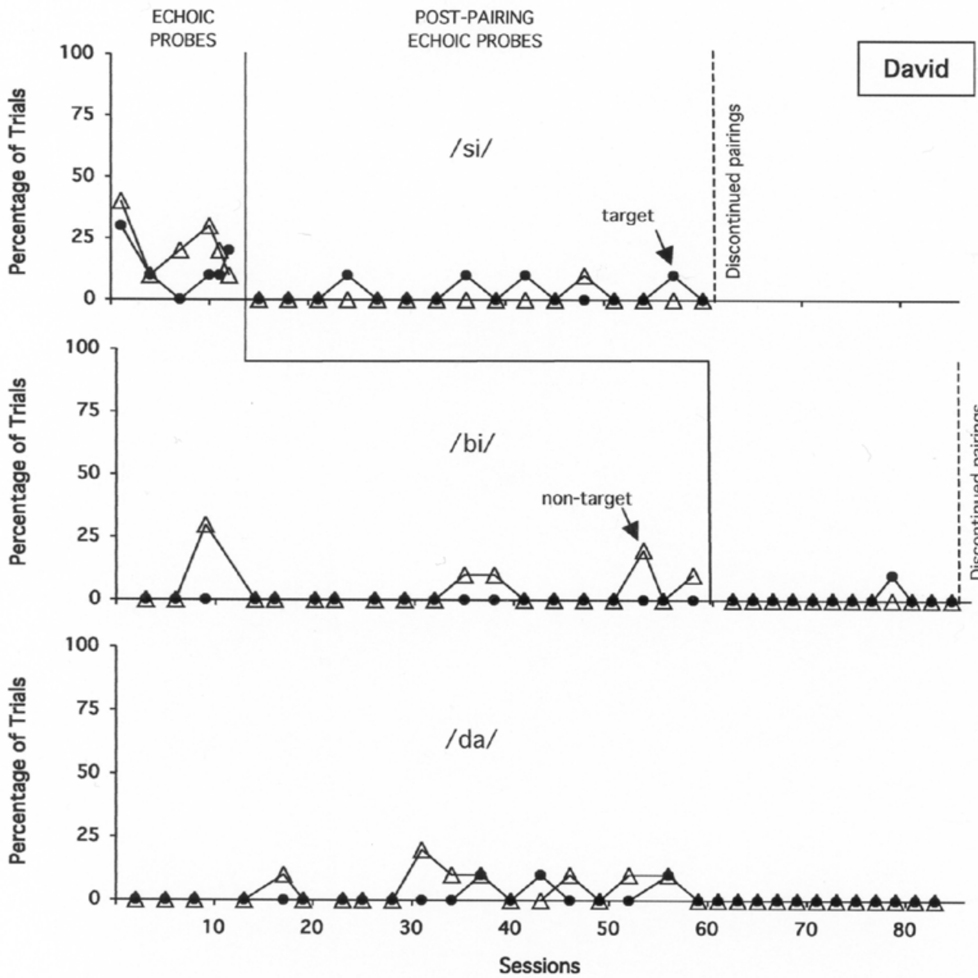

Figure 2. Percentage of trials during Experiment 1 in which target and non-target phonemes occurred during echoic probes in baseline and following stimulus-stimulus pairings with David.

tingently, and (c) the putative reinforcer was presented within 5 s. Mean integrity percentages were 99.5% (range, 97% to 100%) for Alexa, 99.9% (range, 99% to 100%) for David, and 100% for Jodi.

Results and Discussion

Figure 1 shows the frequency of Alexa's responses during ECH and P-ECH conditions. The upper panel shows no target (/ba/) or non-target responses in either condition, indicating that pairing an auditory stimulus with a preferred stimulus did not produce an increase in echoic responding following pairings. The second target sound (/i/; middle panel) was emitted once each during baseline (ECH) and P-ECH; thus, pairing the preferred stimulus with /i/ did not result in a higher frequency of a subsequent echoic response. The lower panel shows that the frequency of target and non-target responses remained low and infrequent throughout baseline and, with the exception of one non-target sound, no responses were emitted during P-ECH.

Figure 2 shows the frequency of David's responses during ECH and P-ECH conditions. The upper panel shows that echoic responding (/si/) did not increase over baseline levels following pairings (P-ECH), providing additional evidence that pairings failed to increase a subsequent echoic response. Also, non-target responding decreased over baseline levels during P-ECH while no increase in target respond-

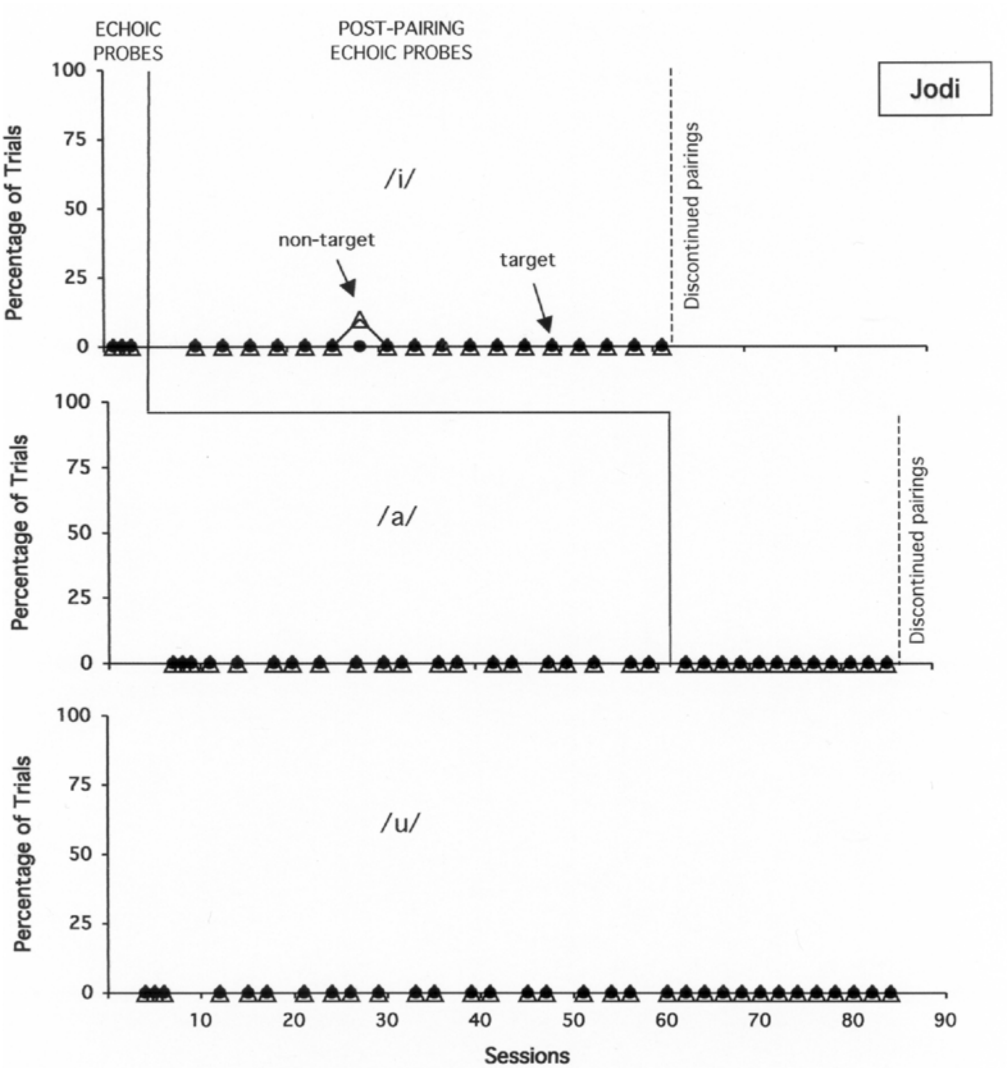

Figure 3. Percentage of trials during Experiment 1 in which target and non-target phonemes occurred during echoic probes in baseline and following stimulus-stimulus pairings with Jodi.

ing was observed. The second target sound (/bi/; middle panel) was not emitted during ECH and occurred only once during P-ECH. Thus, as seen with Alexa and similar to David's first target (/si/), pairing /bi/ with a preferred stimulus did not result in a higher frequency of subsequent echoic responses. Furthermore, as with /si/, when /bi/ was exposed to the pairing procedure, formerly low frequency non-target responding decreased to zero. Similarly, baseline echoic responding on both the untargeted /da/ (lower panel) and non-targets decreased to zero when /bi/ underwent pairing.

Figure 3 shows the frequency of Jodi's responses during ECH and P-ECH conditions. With the exception of one non-target response during P-ECH for /i/ (upper panel), no responses were observed during either ECH or P-ECH for any phonemes. This provides further evidence that, although all target responses existed or were closely approximated in each participant's pre-experimental phonetic repertoire, the stimulus-stimulus pairing procedure failed to increase frequency of these syllables during post-pairing echoic probes.

The results of Experiment 1 show that for three participants with autism and weak pre-intervention speech repertoires, echoic responding did not increase following a stimulus-stimulus pairing procedure. Presumably, if frequency of vocalizations increased following pairings, as occurred in previous studies, then direct reinforcement for these same vocalizations as echoic responses would establish operant control over such responses, thus increasing an echoic repertoire. Since such an increase was not observed in Experiment 1, it was important to determine whether, in fact, pairings did affect the frequency of post-pairing vocalizations, regardless of direct reinforcement for those responses as echoics. Therefore, we conducted Experiment 2 as a systematic replication of Miguel et al. (2002) to evaluate the effect of stimulus-stimulus pairings on the frequency of post-pairing free-operant vocalizations.

EXPERIMENT 2

Method

Participants, Setting, Materials

Experiment 2 was conducted with David and Jodi, participants from Experiment 1, in identical settings and using the same materials, preferred stimuli, and recording system as previously described.

Response Definition

Target responses were selected from those used in Experiment 1. For David, the syllable /bi/ was paired with preferred stimuli while /da/ served as a baseline control. Jodi's pairing target was /a/, while /u/ was observed as the control syllable.

Interobserver Agreement

Two independent observers manually recorded session data during a minimum of 27% of randomly selected sessions (balanced across conditions) either *in vivo* or from video recordings. IOA on frequency of pre- and post-session target vocalizations was calculated using the block-by-block method by dividing the smaller frequency of target sounds recorded in each 30-s interval by the larger frequency averaged across sessions and multiplied by 100 to yield a percentage of agreement. Mean agreement percentages across sessions were 100% for both David and Jodi.

Procedure

Experimental design. An AB design was combined with a second tier (non-paired syllable) that served as a constant-series control for the intervention to evaluate the effects of a stimulus-stimulus pairing procedure on the frequency of post-pairing free-operant vocalizations.

Baseline: Pre-session and post-session observations. Observations were conducted for 5 min (each) immediately before and after pairings. During these sessions, participants could play with toys while observers recorded the frequency of target vocalizations. Interactions between participants and observers either did not occur or occurred only to the extent minimally necessary to ensure participant safety (e.g., preventing the participant from climbing or leaving a supervised area).

Pairings. Sessions in this condition were identical to the pairings segment of the P-ECH condition in Experiment 1. In this condition, the experimenter presented 30 stimulus-stimulus pairings in which the target syllable was presented at the rate of one syllable per second for 3 s followed immediately by delivery of a preferred stimulus (e.g., tickles, sweet potatoes, book). The child had access to the preferred item for 5 s (or until consumed) after which the next pairing trial was immediately presented.

Independent Variable Integrity

To assess IVI, an independent observer scored a minimum of 25% of pairing sessions either during sessions or later from videotaped recordings of sessions. Trials were scored as completely correct or incorrect. The number of correct trials were counted, divided by the number of correct plus incorrect trials, and multiplied by 100 to yield an IVI percentage score. A pairing segment trial was correct if (a) 3 target syllables were presented per trial, (b) syllables were presented within 5 s, (c) a preferred stimulus was presented within 5 s after the auditory stimulus, and (d) no other stimulus was presented. Mean treatment integrity percentages were 100% for both David and Jodi.

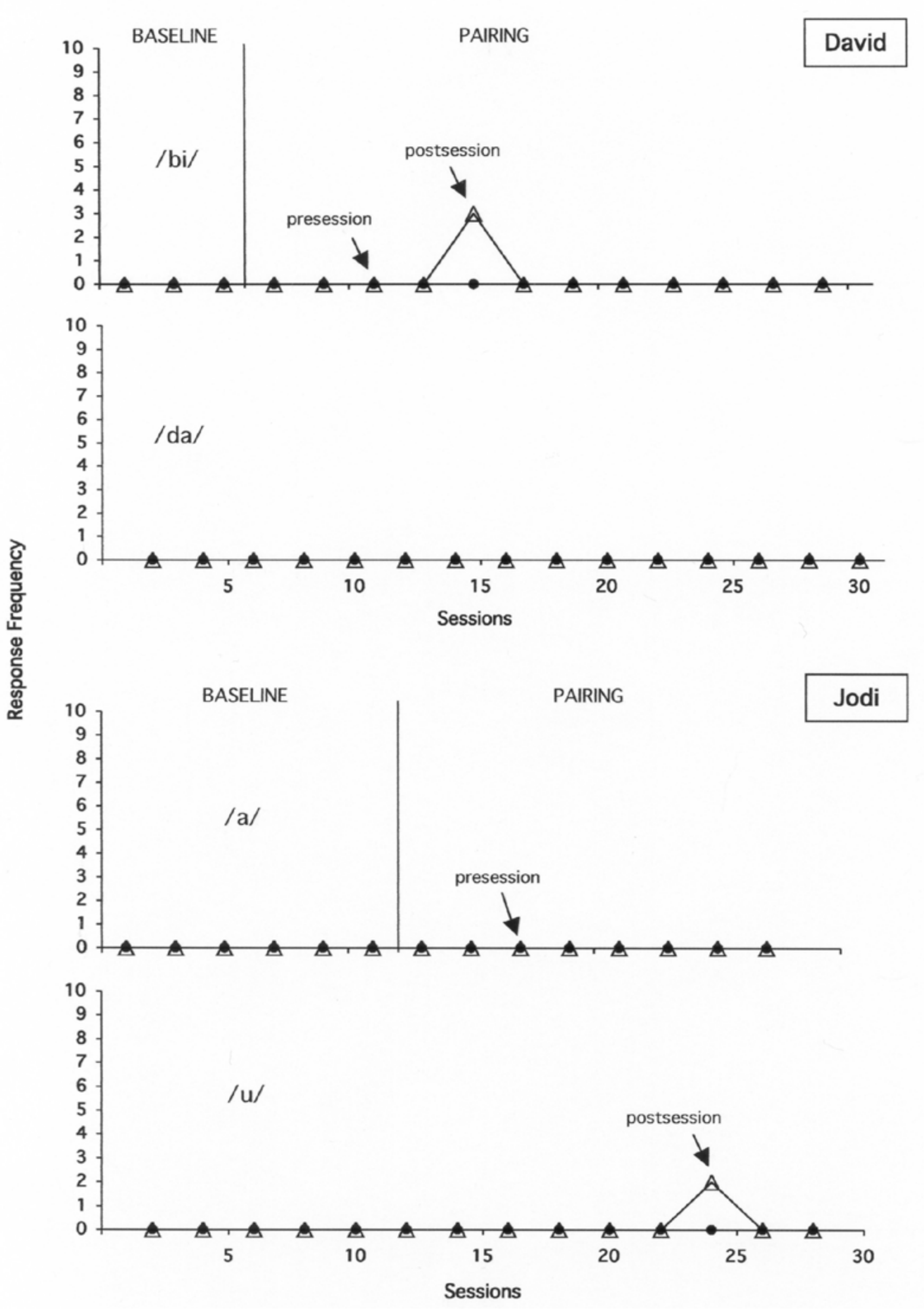

Figure 4. Target phoneme responses per minute during Experiment 2 for David (upper two panels) and Jodi (lower two panels) from observations occurring before and after stimulus-stimulus pairings.

Results and Discussion

Figure 4 shows that the vocalization rate for neither participant increased over baseline levels following pairings. Both the upper panels (David) and lower panels (Jodi) show similar patterns of non-responding during observations immediately preceding and subsequent to pairings.

For both participants, Experiment 2 failed to demonstrate an effect of pairings on the frequency of post-pairing target vocalizations. These results partially replicate the findings of Miguel et al. (2002) with respect to 1 of 3 participants whose target vocalizations did not increase following the pairing procedure. As Miguel et al. noted, variables affecting the reinforcing effectiveness of the auditory response product of vocalizations (i.e., hearing one's own voice) are yet to be identified. In the Miguel et al. study, the child with a stronger verbal repertoire (i.e., higher language scores, more vocalizations at baseline) showed lower rates of post-pairing vocalizations compared to children with weaker verbal repertoires. One explanation for this finding is that conditioned reinforcers produced by more complex verbal responses (i.e., mands, tacts, intraverbals) may effectively compete with (relatively weaker) automatic reinforcers that result from free-operant vocalizations. However, Yoon and Bennett (2000) found that greater pre-intervention vocal play skills were associated with higher cumulative rates of responding after pairing and Sundberg et al. (1996) demonstrated post-pairing increases in vocal behavior in children with low and high verbal repertoires alike. In the current study, participants demonstrated weak pre-intervention verbal repertoires, and yet post-pairing vocalizations rarely occurred. Thus, although there indeed may be a link between complexity of existing verbal repertoires and responsiveness to the pairing procedure, a conclusion of relative strength between direct and automatically reinforced vocal behavior would be premature.

Experiment 2 demonstrated that children with weak verbal skills did not benefit from a pairing procedure to increase vocalizations that could then be brought under the control of direct contingencies (Experiment 1). One limitation of both Experiment 1 and Experiment 2 was that the reinforcing effectiveness of stimuli identified as preferred was not specifically evaluated. It is possible that items and activities selected during stimulus preference assessments did not function as conditioned reinforcers to establish neutral stimuli (i.e., speech sounds) as effective reinforcers. However, this concern is diminished by the fact that children were observed to reach for, manipulate, consume, or otherwise actively engage with stimuli provided non-contingently during pairings and contingently during direct reinforcement of echoic responses. Furthermore, a number of studies have shown positive correlations between stimulus rankings from preference assessments and subsequent demonstrations of reinforcement effects (e.g., Carr et al., 2000).

Since a specific verbal operant (i.e., echoic) was not strengthened via a direct reinforcement contingency following a pairing procedure (Experiment 1), nor did this procedure result in increased target vocalizations (Experiment 2), it is possible that participants' vocal behavior was suppressed by unidentified variables or was in some way insensitive to reinforcement. Therefore, it was important to evaluate the degree to which specific vocal behavior was susceptible to direct reinforcement. Thus, Experiment 3 was conducted to evaluate the effects of a simple shaping procedure on frequency of vowel production.

EXPERIMENT 3

Method

Participants, Setting, Materials

The participants, setting, and materials were identical to those in Experiment 2.

Response Definition

The target response was defined as any orally resonated vocalic sound produced with an open mouth and larynx (i.e., vowels).[5] This excluded sounds that participants often produced such as nasopharyngeal and velopharyngeal vibrations (e.g., clicks, snorts, glottal plosives).

[5]It was rationalized that vowel sounds occur earlier and are easier to produce compared to consonants (Ling, 1976; Schlinger, 1995) and convey more important semantic information than consonants by delineating prosodic features such as intonation, stress, and rhythm of an utterance (Ling, 1989).

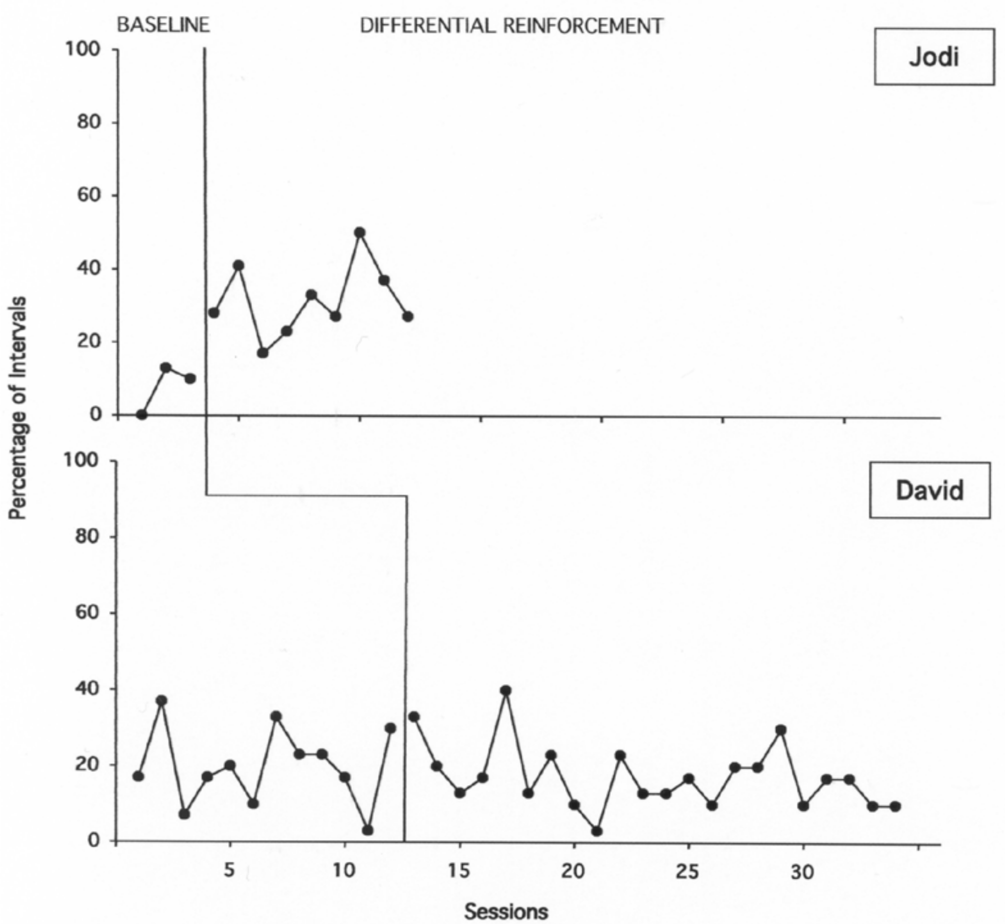

Figure 5. Results of differential reinforcement of vowel frequency during Experiment 3 for Jodi (top panel) and David (lower panel) graphically depicted using a nonconcurrent baseline design.

Interobserver Agreement

Two independent observers manually recorded session data during a minimum of 33% of randomly selected sessions either *in vivo* or from video recordings. IOA on frequency of target vocalizations was calculated using the block-by-block method by dividing the smaller frequency of target sounds recorded in each 30 s interval by the larger frequency averaged across sessions and multiplied by 100 to yield a percentage of agreement. Mean agreement percentages across sessions were 91% (range, 80% to 100%) for David and 97% (range, 93% to 100%) for Jodi.

Procedure

Experimental design. A nonconcurrent multiple baseline design across participants was used to evaluate the effects of differential reinforcement on frequency of vowel vocalizations. Graphs for the 2 participants were combined (see Figure 5) to aid in visual inspection and provide support for the interpretation of treatment effects.

Baseline. Baseline consisted of 5-min sessions during which participants played with toys while observers recorded frequency of target vocalizations. Interactions between participants and observers either did not occur or occurred only to the extent minimally necessary to ensure participant safety (e.g., preventing the participant from climbing or leaving a supervised area).

Differential reinforcement. During the 5-min sessions in this condition, the experimenter delivered a preferred stimulus (e.g., hugs, ball) immediately after the child vocalized a vowel sound. Putative reinforcers were delivered on a continuous reinforcement schedule.

Independent Variable Integrity

To assess IVI, an independent observer scored a minimum of 32% of the sessions either during sessions or later from videotaped recordings of sessions. Trials were scored as completely correct or incorrect. The number of correct trials were counted, divided by the number of correct plus incorrect trials, and multiplied by 100 to yield an IVI percentage score. A trial was correct if a preferred stimulus was presented within 5 s after the child vocalized a target vowel. Mean treatment integrity percentages were 98% (range, 88% to 100%) for David and 100% for Jodi.

Results and Discussion

Figure 5 shows the results of a differential reinforcement procedure on vowel frequency for David and Jodi. The frequency of Jodi's vowel production (upper panel) increased immediately over baseline levels ($M = 7.67\%$ of intervals) to an average of 31.4% of intervals during which preferred stimuli were delivered. In contrast, the lower panel of Figure 5 shows that David's vowel production did not respond to direct reinforcement. Vowel frequency remained low and stable throughout both baseline and intervention.

Experiment 3 shows equivocal results of differential reinforcement on frequency of participants' vowel production, although conclusions regarding treatment effects are necessarily weakened due to lack of within-subject verification for both participants. For Jodi, items identified as preferred appeared to function as reinforcers to strengthen her vocal repertoire, whereas preferred items did not have a similar strengthening effect on David's vocal behavior.

That stimuli previously identified as preferred were effectively demonstrated to have a strengthening effect on target responding with Jodi supports the assumption that, for at least one participant, these preferred stimuli functioned as reinforcers. However, the inability to shape the frequency of David's vocalizations may indicate that items identified as preferred did not function as reinforcers. Although he usually engaged with the identified items, at times he returned them to the experimenter, shaking his head "no." This underscores the importance of identifying the reinforcing strength of stimuli selected as preferred during preference assessments and supports previous calls to include reinforcer assessments in protocol designs (Galensky, Miltenberger, Stricker, & Garlinghouse, 2001).

GENERAL DISCUSSION

This study attempted to temporally extend the positive, yet temporary, effects on vocalizations previously demonstrated by a stimulus-stimulus pairing procedure through direct reinforcement for post-pairing echoic responses. However, since pairings did not increase the frequency of free-operant vocalizations, there were no increased vocalizations to be brought under the contingencies of direct reinforcement to establish a stronger echoic repertoire. Moreover, there is some evidence to suggest that pairings may have had a suppressive effect on frequency of non-target syllables (e.g., David's performance in Experiment 1). The current study is the first in this line of research to report failure to demonstrate positive effects of the pairing procedure with all participants, although it is not the only one to report negative results (see Miguel et al., 2002). At present, the literature is inconsistent in demonstrating the strength of the pairing procedure's ability to increase free-operant speech vocalizations.

Several issues should be considered in future research. It is possible that strength of existing repertoires somehow influences, or is related to, sensitivity to reinforcement. Certainly, weak repertoires (i.e., infrequent vocal play) may influence the effectiveness of the pairing procedure in establishing auditory stimuli as conditioned reinforcers (as might result when an environment provides few "natural" or unscheduled pairings). Similarly, weak or ineffective verbal repertoires (i.e., few mands or tacts) might presage difficulty establishing further such contingent relations. If so, this would lend credence to increased efforts to survey the strength of existing repertoires prior to a pairing procedure. However, research has shown that the pairing procedure positively affected both weak repertoires (Miguel et al., 2002; Yoon & Bennett, 2000) and those that were more extensive (Sundberg et al., 1996).

These findings notwithstanding, it is possible that evaluation of these or other variables may inform the relation between the pairing procedure and its impact on speech acquisition. Researchers should consider existing topographies (e.g., different vowel/consonant phonemes), complexity (e.g., phonemes per syllable, use of blends), existing response form (e.g., PECS,[6] sign), history of non-responding, or strength of related repertoires (e.g., motor imitation).

If failure to establish the auditory stimulus as a conditioned reinforcer accounts for the effects (i.e., lack of) seen in the current study, it may be possible to strengthen the reinforcing value of the auditory stimulus by altering the temporal context in which it occurs in relation to primary (or other conditioned) reinforcer presentation. In discussing extension of the delay-reduction hypothesis to elicited responding, Fantino (1981) suggests that by varying inter-trial intervals (in autoshaping studies with pigeons) changes in acquisition rates are possible, since stimulus strength (i.e., reinforcing value) is a function of the reduction in time to reinforcement correlated with the onset of that stimulus. In terms of the current study with humans, by interspersing non-reinforced trials (of non-targeted syllables) during stimulus-stimulus pairings, the resulting spacing of targeted syllables followed by a preferred stimulus (i.e., ideally a conditioned reinforcer) would signal a greater reduction in the delay to reinforcer presentation compared to the overall context of trial presentations. This should strengthen the relation between the auditory stimulus and its paired reinforcer, thus establishing the auditory stimulus as a conditioned reinforcer. It is ultimately an empirical question whether the delay-reduction hypothesis can be appropriately extended to the current preparation.

In addition to the issue of reinforcer strength, the number of pairings required to produce positive effects is unknown. In the current study, several thousand pairings failed to increase vocalizations that had occurred (albeit weakly) in pre-intervention observations. In contrast, Yoon and Bennett (2000) provided one session of 36 pairings and observed immediate increases in vocalizations not observed prior to intervention. It is possible that such robust effects with so few pairings resulted from the use of more powerful stimuli (as reinforcers). The current study may have been limited by its use of a brief stimulus preference assessment in that it failed to identify effective reinforcers (David's results support this possibility). In contrast, Yoon and Bennett used stimuli (i.e., tickles) that had been shown previously to function as reinforcers.

Thus, several variables deserve careful consideration in future research: differential response to pairings of precisely defined pre-invention repertoires, the quantity of pairings in differentially affecting absolute and relative response rates, and the identification of effective reinforcers (in contrast to stimuli identified as simply "preferred") in establishing auditory (speech) stimuli as conditioned reinforcers.

Another area to consider is the advantage of a less structured (i.e., clinical) setting in which to investigate pairing effects. More playful sessions would likely offset any inhibitory effects of a formal presentation of auditory stimuli, particularly important if participants have negative histories of attempts to emit speech on command or to precisely match auditory targets.

Investigations of independent variables upon behavior that produces its own reinforcing stimuli have not been widely conducted by behavior analysts (Vaughan & Michael, 1982). This is not surprising given the difficulty of identifying and analyzing contingencies that control complex verbal behavior, much of which may be covert. In contrast, non-verbal human behavior maintained by automatic reinforcement is often readily observable (e.g., scratching an itch) and thus the controlling variables may themselves be more easily identified. Therefore, investigations into the role of automatic reinforcement in strengthening a weak speech repertoire might be facilitated by selecting non-vocal targets as analogs for speech responses. For example, one might pair a non-vocal auditory stimulus (e.g., clicker noise) with delivery of candy such that the clicker noise becomes a conditioned reinforcer. To the extent a child continues to depress the device (after the initial random response), and absent any mediating influence by another person, one could conclude the behavior was maintained by automatic reinforcement. The device could then be altered such that it no

[6]Picture Exchange Communication System (Frost & Bondy, 1994).

longer produced the noise and any behavioral change (i.e., reversal) could be observed.

Although such analog investigations are just that, they may provide a useful framework for prediction and verification of behavioral change by dealing with observable stimuli that may be more familiar to experimenters.[7] For example, one could quite easily hypothesize (and subsequently adjust) variables that influence rate or accuracy of depressing the clicker device, whereas variables affecting the behavioral analog to clicker pressing (i.e., vocal tract movements) may elude speculation. This approach may be particularly useful in identifying parameters related to speech acquisition such as topographical parity (e.g., phoneme matching), vocal musculature control (e.g., latency, intensity), or integrity of sensory feedback (e.g., transient signals) that may affect emission (thus reinforcement) of vocalizations following pairings.

In summary, the stimulus-stimulus pairing procedure is inconsistent in producing increased vocalizations in children with developmental disabilities. Although previous findings demonstrated the utility of this procedure to strengthen vocal behavior in some children, the current study found no effect on targeted syllables and there is some evidence that pairings may have a suppressive effect as well. Preexisting vocal-verbal repertoires may provide clues into variables affecting the mechanisms of automatic and direct reinforcement. Children respond differentially to the pairing procedure (i.e., automatic reinforcement), but not consistently differentially according to their similar repertoires (e.g., Yoon & Bennett, 2000 vs. Miguel et al., 2002). Thus, it is unclear when and for whom this procedure is clinically relevant. It will be important for future investigations to identify the specific variables contributing to both positive and negative effects in order to more clearly explain the role of automatic reinforcement in augmenting speech acquisition in those individuals whose vocal-verbal repertoires are deficient.

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[7]Of course, replication of these changes should be extended to verbal behavior applications to strengthen conclusions about experimental control.

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