JOURNAL OF APPLIED BEHAVIOR ANALYSIS 2009, **42,** 225–241 NUMBER 2 (SUMMER 2009)

EVALUATION OF AN ENHANCED STIMULUS–STIMULUS PAIRING PROCEDURE TO INCREASE EARLY VOCALIZATIONS OF CHILDREN WITH AUTISM

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Evidence to support stimulus–stimulus pairing (SSP) in speech acquisition is less than robust, calling into question the ability of SSP to reliably establish automatically reinforcing properties of speech and limiting the procedure's clinical utility for increasing vocalizations. We evaluated the effects of a modified SSP procedure on low-frequency within-session vocalizations that were further strengthened through programmed reinforcement. Procedural modifications (e.g., interspersed paired and unpaired trials) were designed to increase stimulus salience during SSP. All 3 participants, preschoolers with autism, showed differential increases of target over nontarget vocal responses during SSP. Results suggested an automatic reinforcement effect of SSP, although alternative interpretations are discussed, and suggestions are made for future research to determine the utility of SSP as a clinical intervention for speech-delayed children.

DESCRIPTORS: automatic reinforcement, autism, conditioned reinforcement, speech delay, stimulus–stimulus pairing

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Children with delayed speech have an instructional advantage if they emit frequent and varied vocal play and can repeat, even imprecisely, what they hear. Such fledgling speech can be shaped into accurate, complex topographies (e.g., Eikeseth & Nesset, 2003; Johnston & Johnston, 1972) that, taken together, characterize language when functional relations of these topographies and their controlling variables are established (see Sautter & LeBlanc, 2006). However, individuals who rarely vocalize or who do not readily imitate speech models have fewer opportunities to benefit from speech instruction because little behavior may be available for modification through reinforcement by a verbal community.

To create a larger pool of available vocal behavior that can come under appropriate stimulus control, researchers have recently begun to investigate the application of stimulus–stimulus pairing (SSP), an approach with wide support in the basic behavioral literature (see Williams, 2002). Aimed at increasing the conditioned reinforcing value of speech sounds (i.e., auditory stimuli as vocal response products), SSP is based on the rationale that early human vocal activity may develop, at least in part, from automatic reinforcement (Ahearn, Clark, MacDonald, & Chung, 2007; Vaughan & Michael, 1982) related to stimuli generated through speech behavior itself. In other words, early speech attempts may be self-strengthening in that these responses produce sounds that have value as reinforcers.

Systematically pairing a stimulus of weaker value with already-effective reinforcers (Catania, 1998) establishes the requisite history of contiguity (Michael, 2004) to condition it as a reinforcing stimulus in its own right. In the case of early speech acquisition, caregivers likely condition auditory stimuli by repeatedly pairing

This article is based on a dissertation by the first author and supervised by the second author that was submitted to Western Michigan University in partial fulfillment of the requirements for the doctoral degree in psychology. We thank Scott Gaynor, Jack Michael, David Palmer, and Mark Sundberg for inspiring this research and for helpful comments on an earlier version of this paper. We are also grateful to our many research assistants who helped throughout the study. James Carr is now affiliated with Auburn University.

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doi: 10.1901/jaba.2009.42-225

their own vocalizations with the delivery of important events (e.g., feeding, rocking). If a child subsequently produces similar sounds, these stimuli can function as automatic reinforcers for movements that produce them, thus allowing particular topographies to be selected into the speech repertoire (Bijou & Baer, 1965; Schlinger, 1995; Skinner, 1957). They then undergo further shaping into more complex syllabic units through social (Skinner) and automatic (Palmer, 1996) contingencies of reinforcement.

For children who engage in varied and frequent vocal play, the assumption is that the sounds produced have some value in the absolute sense (i.e., they sound good). Thus, early speech may be strengthened to some degree by its automatic consequences, irrespective of programmed (i.e., socially mediated) contingencies that also may operate on these vocalizations. However, in children with speech delays, auditory speech stimuli may not function as reinforcers for vocal behavior, as evidenced by a weak repertoire of few or inconsistent responses that result in such stimuli.

Applied studies using SSP to improve delayed speech have shown that, when an arbitrary syllable spoken by an adult is paired with a preferred stimulus,[1] children often subsequently emit the paired syllable, suggesting a procedural conditioning effect on the automatic reinforcing value of these auditory stimuli. Sundberg, Michael, Partington, and Sundberg (1996) paired novel syllables, words, or short phrases with known reinforcers for 4 preschoolers with severe to moderate language delays and 1 typically developing child. After brief pairings (e.g., 15 pairings per minute for a few minutes), all children emitted the novel vocal responses, although effects dissipated rapidly and not all pairing periods resulted in increased target responding.

In addition to influencing novel responses, SSP also has been shown to increase vocalizations that already exist in the repertoire. Smith, Michael, and Sundberg (1996) demonstrated postpairing increases with 2 typically developing infants (less than 18 months old) when acquired syllables were paired with reinforcer delivery. To address the possibility that observed increases in responding might be attributable to already-established echoic control, Smith et al. included a neutral condition in which the auditory stimulus was presented without reinforcer delivery. Because the target sound was not emitted, the authors concluded that increased vocalizations following positive reinforcer pairings were not under echoic control but, instead, were automatically reinforced.

Yoon and Bennett (2000) reported increased postpairing vocalizations with 4 speech-delayed preschoolers when speech sounds were paired with tickles for 3 min (12 pairings per minute) but, again, effects were temporary (3 to 16 min). Target responses were observed (with one exception) only after SSP and not when echoic contingences were in effect, thus underscoring Smith et al. (1996) in ruling out echoic control as a possible explanation for the results. Showing less robust and more variable SSP effects but using a more rigorous experimental design, Miguel, Carr, and Michael (2002) observed increased postpairing vocalizations across sessions in 2 of 3 speech-delayed preschool boys on at least one target syllable after establishing a pairing history of speech sounds with candy delivery.

In these studies and in others reporting absent or discrepant SSP effects (e.g., Esch, Carr, & Michael, 2005; Normand & Knoll, 2006; Stock, Schulze, & Mirenda, 2008; Yoon & Feliciano, 2007), variables responsible for these inconsistencies have not been delineated. Differential responding may be related to level of preexisting language skills. Yoon and Bennett

[1]In SSP studies of speech acquisition, speech stimuli are paired with preferred stimuli that may (or may not) have been shown to function as reinforcers for other responses. However, it should be noted that during SSP, no response is necessary for this "reinforcer" delivery to occur. Thus, the preferred stimulus does not function to strengthen a response but rather, through repeated pairings, to condition the speech stimulus as a reinforcer.

(2000), for example, reported greater postpairing increases by a participant with a relatively stronger preintervention vocal repertoire. By contrast, Miguel et al. (2002) reported that their participant with the strongest preexisting language skills demonstrated fewer increases in vocalizations following pairing. It may be that, for some children with more advanced language skills (e.g., mands, intraverbals; Skinner, 1957), reinforcement available through verbal interactions with others, as well as that provided by achieving parity (Palmer, 1996) with the linguistic practices of one's verbal community, may supersede the effects of the SSP procedure on vocal play. However, Sundberg et al. (1996) observed postpairing increases in vocalizations by children with both strong and weak preintervention repertoires, whereas Esch et al. reported no vocalization increases after providing an extensive pairing history for 3 children (6 to 8 years old) with little preexisting vocal verbal behavior. Similarly, Normand and Knoll reported null SSP findings with a 3-year-old boy whose preintervention repertoire contained several vocal mands and tacts. Collectively, these results suggest that failure or success of SSP to produce effects cannot be attributed solely to idiosyncratic characteristics of existing language skills.

It is likely that factors related to conditioning procedures influence this process more directly, although no SSP studies to date have focused on specific variables (or their modification) that may affect stimulus conditioning. The behavioral literature is replete with examples (see Kelleher & Gollub, 1962; Williams, 2002) in which stimuli have been conditioned through pairing with either unconditioned or conditioned reinforcers and, thus established, have served to increase arbitrary nonvocal responding. In the case of automatically reinforced vocal responses, this conditioning process requires that speech stimuli become reinforcers themselves in order to strengthen the responses that produce them. With failures to condition or with discrepant performances, it may be that aspects of the pairing procedure impinge on the paired auditory stimulus in some way that constrains its sensitivity to the SSP process and to the durability of its effects. This suggests that procedures employed in SSP studies to date may not have been optimally arranged to produce conditioning. It is also possible that even if conditioning did occur, measurement systems may not have been sensitive enough to detect effects of SSP. In light of these possibilities, the current study was conducted to evaluate conditioning effects of SSP through various procedural modifications and post-SSP phases of socially mediated reinforcement.

In earlier studies, sessions consisted of a series of trials in which a syllable was paired with delivery of a putative reinforcer (e.g., *ba ba ba* plus candy). To the degree that these stimuli were salient, ability of the speech stimulus to acquire reinforcing properties through pairing would be more or less strong. Evidence from basic experimental research (see Dinsmoor, 1995a, 1995b) has shown that the effects of pairing can be enhanced by interspersing a stimulus that is not followed by a reinforcing stimulus (i.e., unpaired comparison S−) with trials in which a different stimulus (S+) is followed immediately by such an event. In the case of vocal responses, this advantage would arise for a self-produced auditory stimulus that resembles one with a pairing history over that of a nonpaired response product. In the current study, interspersal of S− trials with S+ trials was designed to maximize these pairing effects and provided additional benefit by controlling for elicitation effects of a nontarget auditory stimulus.[2]

Another change to the SSP procedure involved the addition of an observing prompt

[2]This use of the terms S+ and S− is unconventional in the sense that neither stimulus has discriminative properties (see Dinsmoor, 1995a, 1995b). These designations are used here to specify the degree of their conditioning potential in order to provide a contrast for the likelihood of either stimulus acquiring such discriminative properties.

(Dinsmoor, 1995b) prior to initiation of any trial. The purpose of this prompt (e.g., *look*) was to increase the likelihood that the succeeding auditory stimuli would be more salient as a result of the child's attending response immediately preceding SSP presentation. This prompt preceded all trials because it was important for S− and S+ to be equally observable. Next, experimenters used exaggerated prosodic patterns (*motherese*; Falk, 2004) when presenting stimuli of both S+ and S− to increase the likelihood that speech stimuli during sessions were different from nonrelevant speech stimuli occurring between formal sessions (e.g., incidental conversation during session breaks). Finally, varied intertrial intervals (ITIs; Catania, 1998; Gibbon & Balsam, 1981) were used during baseline and SSP to reduce fixed-time passage as a confounding effect to SSP effects in that target responses could more reliably be attributed to the conditioning procedure by eliminating temporal predictability while the relevant paired relation was held constant.

Further, this study assessed the effects of specific reinforcement of responses that produced a previously paired speech syllable. There is conceptual support for such an effect (Michael, 2004; Skinner, 1957, 1969), and of course, the clinical value for communication-impaired individuals is strong (e.g., Hall & Sundberg, 1987; Shafer, 1994).

METHOD

Participants and Setting

Three children with severely delayed speech-language skills who had been diagnosed with autism participated in the study. Joshua, 2 years 4 months old, had just been enrolled in school but classes had not yet begun. Madison, 2 years 8 months old, had been attending a behavior-analytic preschool classroom for 1 month at the time of her participation. Daniel, 5 years 7 months old, had previously received 1.5 years of school-based behavior-analytic instruction. None of the children displayed problem behavior (e.g., aggression, self-injury) or sensory loss (i.e., deafness, dysarthria), and all were from homes in which English was the primary language.

Sessions were conducted at each child's school 3 to 5 days per week and varied in duration from 5 to 15 min, depending on the condition. Sessions were typically conducted in a contiguous manner (several in a row) with brief play periods in between, and none were conducted immediately after lunch, recess, or playtime in order to maximize reinforcer value. Session rooms were carpeted and equipped with a small table, chairs, a video camera on a tripod, and low-preference toys (as identified by caregivers). Low-preference items remained present during sessions as part of the room's equipment. Interaction with these items was allowed, but it rarely occurred when higher quality reinforcers were available (during sessions). All sessions were videotaped. Reinforcers (edible items and highly preferred toys) were kept in closed, opaque containers and were not available to the child except during appropriate session conditions.

Preexperimental Assessments

A speech pathologist administered standardized and criterion-referenced speech-language assessments prior to the study, except when parents completed informant reports. The Kaufman Speech Praxis Test (KSPT; Kaufman, 1995) was given to determine participants' existing echoic repertoires with single phonemes (e.g., /*m*/) and more complex syllabic (e.g., /*ma*/) and multisyllabic (e.g., /*mama*/) constructions. Of 24 available echoic models, Joshua, Madison, and Daniel echoed 0, 3, and 2, respectively. None met basal level responding on the Peabody Picture Vocabulary Test–III (Dunn, Dunn, & Dunn, 1997), a measure of receptive picture identification. Thus an alternate inventory, the Receptive-Expressive Emergent Language Test (3rd ed.) (Bzoch, League, & Brown, 2003), was used to provide a reference point for comparing derived expressive and receptive language ages of participants. None of the participants scored over 12 months of age on this dichotomous (yes–no) measure of receptive and expressive language performance when observed in noninstructional settings. Additional speech-language information was obtained from informant observations of participants' verbal repertoires, including echoic function, using the Behavioral Language Assessment (BLA; Sundberg & Partington, 1998). Joshua's BLA indicated low-frequency vocal play, no echoic responses, and no other verbal operants. Madison's BLA showed frequent vocal play but no verbal functions. Daniel's BLA reported frequent vocal play and a few responses under mand, tact, or intraverbal control. He occasionally echoed simple sounds and words from the environment (e.g., television) but did not respond reliably to echoic prompts.

The topography and frequency of phonemes in the participants' vocal play repertoires were inventoried in a 30-min free-play observation period conducted during the week prior to the study. During this observation, Joshua emitted 12 (of 42 charted) English phonemes. Normative comparisons of spontaneous speech in typically developing peers have not been reported (see Smit, 1986), but phonetic transcription of speech samples from 520 typically developing children in California showed that by the age of 3 years, children could accurately emit all phonemes except /*l*/ and /*r*/ (Porter & Hodson, 2001), albeit under tact or echoic conditions. The 12 phonemes Joshua emitted were distributed over less than half (37%) of the 30-s recording intervals. By contrast, Madison emitted 29 phonemes across 93% of the intervals. Daniel demonstrated infrequent vocal behavior during free play, despite incipient verbal skills such as echoic, mand, and tact relations. He emitted 21 phonemes, but these were distributed over only 32% of intervals, a pattern similar to Joshua's (whose verbal repertoire, in contrast to Daniel's, contained no functional operants).

Stimulus Preference Assessment

Prior to the study, parents or teachers completed a preference assessment survey (Fisher, Piazza, Bowman, & Amari, 1996) that yielded a ranked list of each child's preferred edible items and toys. These items were further assessed (Carr, Nicolson, & Higbee, 2000) to verify preference ranking. The three highest ranked items in each assessment were selected for use as putative reinforcers during the study. To address the possibility of day-to-day changes in relative preference for various stimuli, the first daily session began with the experimenter presenting an array of items previously identified as preferred. Any items not touched, reached for, or accompanied by smiles when presented during a 1-min presession sampling period were eliminated, and remaining items were rotated randomly during that day's sessions. For simplicity of description, items identified through these assessments as preferred henceforth will be referred to as *reinforcers*.

Dependent Variables and Data Collection

Targets were selected from vocalizations made during the free-play observation period and consisted of combinations of phonemes that were not under echoic control (as evaluated by KSPT and BLA), yet occurred in 10% to 25% of 30-s intervals during the phoneme-inventory observation. This selection procedure ensured that topographies could be emitted by participants yet were under weak evocative control of an echoic stimulus. In cases in which fewer than 10% of intervals contained potential targets or phoneme units, targets were based on available (emitted) topographies. Targets (S+ responses) were *beh* and *oo* for Joshua, *aypayk* and *sheba* for Madison, and *reeklo* and *tebba* for Daniel. Interspersed S− responses were *sio* and *ee* for Joshua, *oro* and *yoit* for Madison, and *boosie* and *ammi* for Daniel.

Target responding was defined as any vocal response that matched or was similar to the paired training stimulus (S+). *Similarity* was defined as acoustic or phonologic approximation to a particular phoneme (e.g., same articulatory feature plus proximate placement). A *nontarget response* was defined as any response that was the same or similar to the unpaired comparison stimulus (S−). Vocalizations that did not meet the definition of target or nontarget responses were not counted. Nonspeech vocalizations (e.g., laughing, coughing) also were excluded. Any vocal response separated by a 1-s silent interval from any other vocal response was counted as one response.

Previous studies typically evaluated SSP effects on responding that occurred immediately preceding and following pairings (i.e., between sessions). However, these observation periods often yielded data that indicated weak, temporary, or absent effects of the independent variable. The current study was originally designed to similarly evaluate responding, but when pre- and postpairing observations failed to demonstrate SSP effects with the 1st participant (Joshua), and, concomitantly, experimenters observed responding during pairing sessions, within-session data were examined to capture more accurately the effects of SSP. Furthermore, analysis of within-session data allowed appropriate data comparison between conditions (SSP, programmed reinforcement) in which relevant stimuli were present, in contrast to postsession periods in which vocalizations produced the auditory stimulus but the paired reinforcer was absent.

Each occurrence of target and nontarget vocal responses was recorded when emitted during varied ITIs of baseline and SSP conditions. During the programmed reinforcement and withdrawal conditions, each instance of the target response was recorded during the 5-min session. Responses during programmed reinforcement were not counted if they occurred within 5 s of the adult vocal stimulus (see below).

Interobserver Agreement

Two independent observers manually recorded session data during randomly selected sessions (balanced across conditions) either during the session or from video recordings. Interobserver agreement on frequency of target and nontarget vocalizations was calculated separately by dividing the smaller frequency of vocalizations per session by the larger frequency per session and converting this ratio to a percentage. Target and nontarget interobserver agreement was assessed for sessions in which the relevant data were collected (target: baseline, SSP, programmed reinforcement, withdrawal; nontarget: baseline, SSP). For Daniel, all data were excluded for one session during which, when the school's public address system came on unexpectedly, he ran from the training area. No data were excluded from any other sessions.

For Joshua, Topography 1 (*beh*) agreement was calculated for 81% of sessions; mean interobserver agreement was 89% (range, 56% to 100%). Nontarget agreement was calculated for 86% of sessions and was 100%. On Topography 2 (*oo*), agreement was assessed in 73% of sessions, and mean agreement was 92% (range, 80% to 100%). Mean nontarget agreement for Topography 2, calculated in 63% of sessions, was 83% (range, 0% to 100%). For Madison, Topography 1 (*aypayk*) agreement was assessed across 35% of sessions, and mean agreement was 93% (range, 75% to 100%). Nontarget agreement was assessed in 40% of sessions, and mean agreement was 87% (range, 33% to 100%). Topography 2 (*sheba*) agreement for Madison was assessed in 35% of sessions, and mean agreement was 98% (range, 91% to 100%). Nontarget agreement was calculated in 38% of sessions and was 100%. For Daniel, Topography 1 (*reeklo*) agreement was calculated for 29% of sessions, and mean agreement was 96% (range, 85% to 100%). Nontarget agreement was assessed in 29% of sessions and was 100%. For Topography 2 (*tebba*), agreement was calculated for 38% of sessions, and mean agreement was 99.6% (range, 94% to 100%). Nontarget agreement was assessed in 33% of sessions, and mean agreement was 98% (range, 83% to 100%).

Procedure

Baseline. Each baseline session was approximately 12 to 15 min in duration and consisted of 10 trials each of S+ and S− (20 trials total), randomly arranged but with no more than two consecutive trials of either to reduce stimulus predictability (Catania, 1998). In S+ trials, the experimenter presented the target stimulus (e.g., said, "beh") without its paired stimulus. S− trials had no paired stimulus; thus, baseline S+ and S− trials were procedurally identical. Trials with Joshua were preceded with a prompt to attend (e.g., "look"). However, Madison often emitted the orienting prompt as part of the target response (e.g., "look! *sheba*"). Therefore, the auditory stimulus (*look*) was replaced with a clicker noise, effectively eliminating its inclusion in subsequent responses and possibly further distinguishing the target syllable as the more relevant stimulus from the orienting prompt. The clicker procedure was continued for the remaining participant (Daniel). Auditory stimuli were presented at the rate of one per second for 3 s (e.g., S+ *ba ba ba*; S− *dee dee dee*). To decrease temporal predictability, trials were separated by an ITI that varied between 5 s and 30 s. Between sessions, participants had access (in the session setting) to free play with low-preference toys. Interaction between participant and experimenter occurred only to the extent that it was necessary to ensure safety.

Stimulus–stimulus pairings. Pairing sessions were similar to those in baseline, with two exceptions. First, presentation of S+ trials included immediate delivery of a reinforcer following the vocal stimulus. During S+ trials, the child had access to the reinforcer for 10 s or, in the case of edible items, until consumed. Second, during S+ trials a 20-s correction delay was implemented if the participant emitted the target response between the experimenter's vocalization and delivery of the reinforcer. This delay controlled, to the extent possible, for adventitious reinforcement of responses through socially mediated contingencies. During this period, the experimenter did not look at or interact with the participant, and at the end of the delay a new trial began. If a reinforcer was already partially delivered, reinforcer delivery was completed but the response was not counted. Otherwise, reinforcer delivery was withheld and any responses during the delay were not counted. This procedure was designed to yield data reflective of SSP effects alone, insofar as possible. If the child emitted any other vocal response in the period between stimulus presentation and reinforcer delivery, no correction delay was imposed because target responding was the variable of experimental interest. Moreover, reinforcers only followed S+ stimuli, and the likelihood of a nontarget response occurring between S+ and reinforcer delivery was low. Furthermore, even if nontarget responses (or any other vocalizations) were emitted between S+ and reinforcer delivery, thus undergoing adventitious reinforcement, any subsequent target (over nontarget) rate increase would further support SSP effects on the dependent variable.

Programmed reinforcement. The purpose of the programmed reinforcement condition was to further strengthen SSP-induced target responses. During each 5-min session, the experimenter delivered a reinforcer within 5 s of a target vocalization. To maximize the likelihood of obtaining a reinforceable response, each session was preceded by SSP trials (S+ only) at the rate of one syllable per second (in triads) every 5 to 10 s until the child emitted a target response. These preliminary pairings were omitted if, when the session began, the child immediately emitted the target response. Data collection for these sessions began after the first target response and continued for 5 min. During this period, if 1 min elapsed with no target responding, another S+ pairing was provided.

Noncontingent reinforcement. The comparative effects of SSP and programmed reinforcement on target responding were further evaluated by conducting sessions in which noncontingent reinforcers were delivered for 5 min on a fixed-time (FT) 30-s schedule. If a target response occurred within 5 s of scheduled reinforcer delivery on the FT schedule, a 20-s correction delay was imposed. To the extent that responding occurred in the absence of programmed reinforcement during this condition, conclusions could be made regarding the source of reinforcement for post-SSP responding and the possible separate influence of automatic reinforcement on response maintenance.

Caregiver training. Caregivers for all participants received brief instruction in SSP and programmed reinforcement as part of the exit interview. This training was conducted to increase the likelihood that new vocal responses would be evoked and effectively maintained in the child's natural environment.

Experimental Design

A nonconcurrent multiple baseline design (Watson & Workman, 1981) across phoneme topographies was combined with a reversal design to evaluate effects of the SSP procedure and subsequent programmed reinforcement on the frequency of within-session vocalizations.

Treatment Integrity

A trained observer assessed treatment integrity from observations, balanced across conditions, during sessions or from videotapes. Trials were scored as completely correct or incorrect. The number of correct trials was divided by the number of correct plus incorrect trials, and this ratio was converted to a percentage to yield a mean integrity score across sessions. Baseline trials were correct if (a) the orientation prompt preceded each presentation of S+ or S−, (b) three scheduled syllables (either S+ or S−) were given within 5 s, and (c) no reinforcers followed S+ or S− presentations. An SSP trial was correct if (a) an attending prompt preceded each presentation of S+ or S−, (b) three scheduled syllables (either S+ or S−) were given within 5 s, (c) reinforcers followed S+ presentations within 5 s and no reinforcers followed S− presentations, (d) an ITI of 5 to 30 s occurred, and (e) a correction interval of 20 s followed any target response that occurred between presentations of S+ and reinforcer. Programmed reinforcement trials were correct if a reinforcer was presented within 5 s after the child vocalized any target syllable that was not preceded within 3 s by an echoic prompt from the experimenter. Withdrawal trials were correct if reinforcers were delivered on an FT 30-s schedule and a delay interval of 20 s occurred after any target behavior emitted within 5 s prior to scheduled reinforcer delivery. For Joshua, the mean integrity score was 99% for both evaluations across more than 50% of scored sessions. For Madison, the mean integrity score was at least 99% for both evaluations, calculated for 35% of sessions. Daniel's mean integrity score was 100% for both evaluations and was calculated for at least 29% of sessions.

RESULTS

Results for Joshua are shown in Figure 1. The upper panel shows that rate of Topography 1 (*beh*) responding increased slowly during SSP over near-zero baseline rates to over 4 responses per minute, with interim responding stable but varied (range, 0 to 2.8 responses per minute) (Figure 1, top). When programmed reinforcement was implemented, responding initially decreased. However, responding during this condition recovered to SSP levels, indicating a learning effect, and continued in an upward trend to over 7 responses per minute. When reinforcers were available noncontingently, target responding immediately decreased, but then was maintained at rates between 3 and 6 responses per minute. Joshua did not emit any nontarget responses during the experiment for Topography 1, providing further support for positive SSP effects. Similar effects were observed in Joshua's second evaluation. Topography 2 (*oo*) responding (Figure 1, bottom) occurred at a mean rate of 0.6 responses per minute (range, 0 to 1.6) throughout baseline

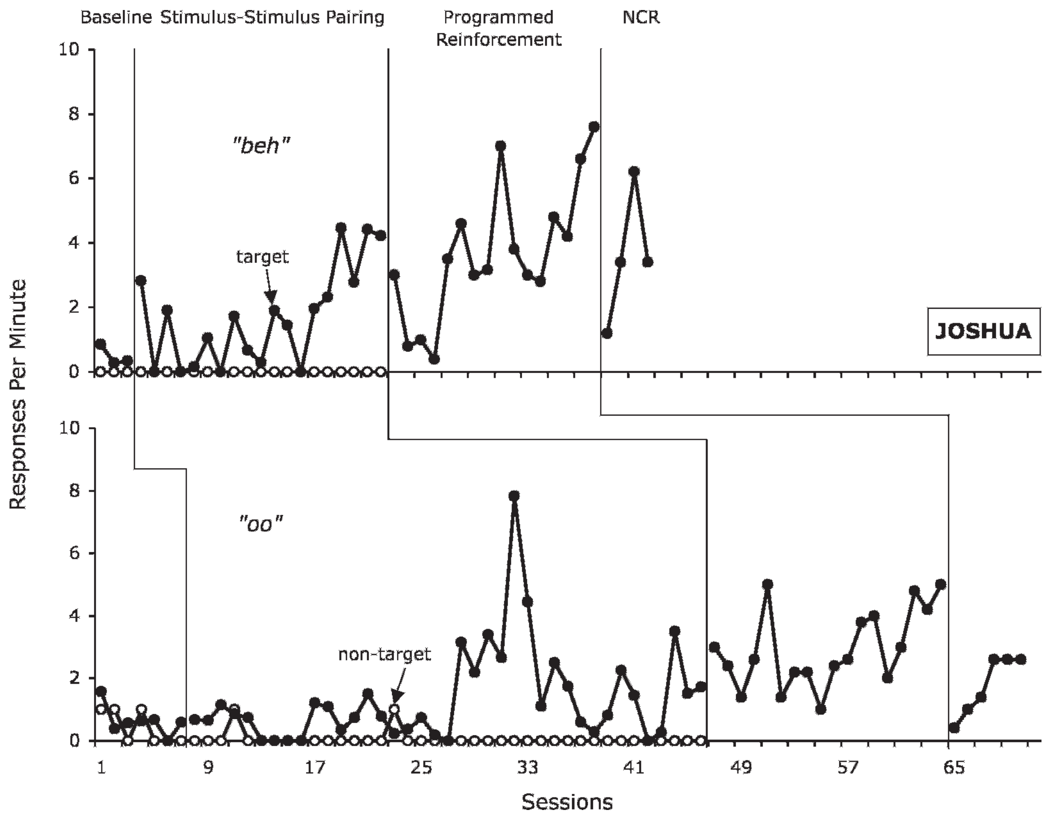

Figure 1. Rate of target and nontarget responses per session (20-trial blocks) for Joshua during within-session observations in baseline and stimulus–stimulus pairing (SSP) conditions and rate of target responses per 5-min session of programmed and noncontingent reinforcement.

and the first 20 SSP sessions. Over the next 19 SSP sessions, however, the mean rate increased to 2.2 (range, 0 to 7.8). When programmed reinforcement was implemented, responding was maintained at or above SSP levels, with a mean rate of 2.9 (range, 1 to 5). Responding was maintained during noncontingent reinforcement, after an initial decrease to zero following programmed reinforcement, with a mean rate of 1.8 (range, 0.4 to 2.6).

Results for Madison are shown in Figure 2. The upper panel shows Madison's vocalizations of Topography 1 (*aypayk*). Nontarget vocalizations were not emitted throughout the experiment. Baseline target responses were minimal, with a mean of 0.06 responses per minute (range, 0 to 0.5). Target responding steadily increased during SSP, showing modest differential pairing effects (levels did not exceed 2 responses per minute). When programmed reinforcement for target responses was instated, rate of vocalizations immediately increased to nearly 9 per minute, stabilizing at about 6. Target overall mean rate during programmed reinforcement was 6.4 (range, 5.4 to 8.8). The immediacy of change in response level during this condition suggests strong differential influence of social contingencies. During noncontingent reinforcement, responding decreased to near zero (0.6 rpm) within three sessions. After reinstating programmed reinforcement, responding was reestablished at previously high levels, with a mean rate of response of 5.1 (range, 0.5 to 7). In the second evaluation (Figure 2, bottom), baseline target (*sheba*) and nontarget topographies were emitted at low

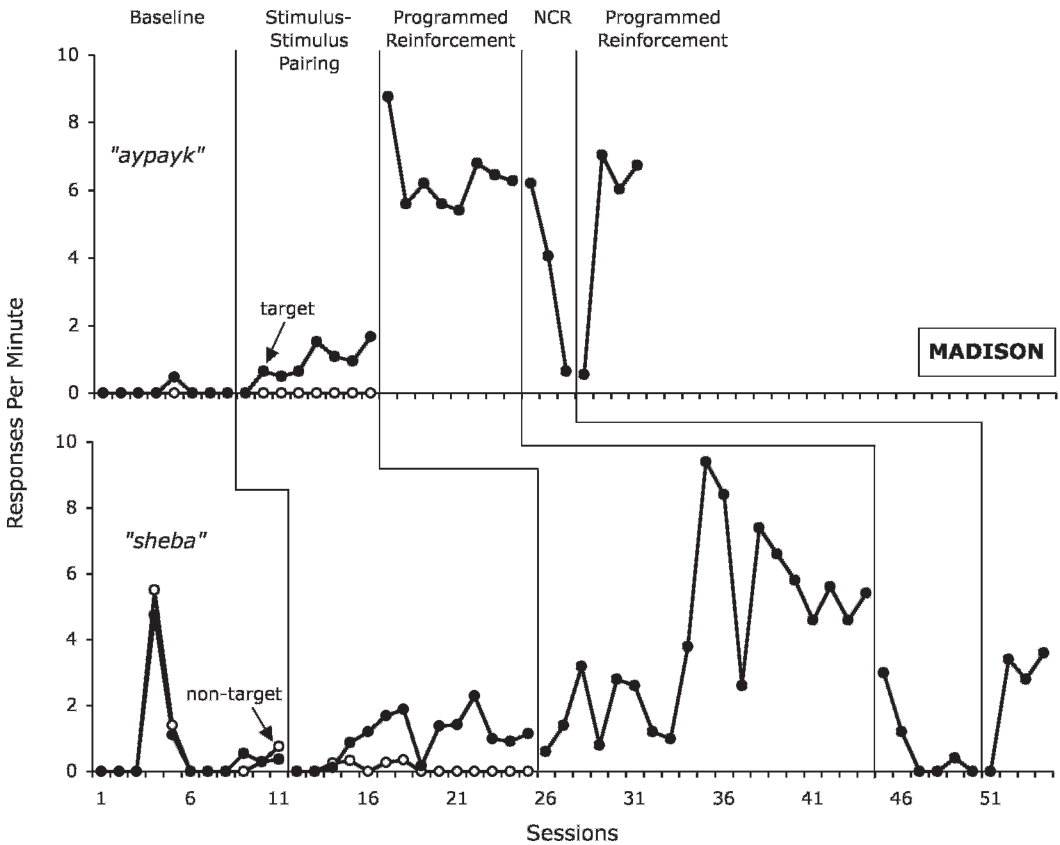

Figure 2. Rate of target and nontarget responses per session (20-trial blocks) for Madison during within-session observations in baseline and stimulus–stimulus pairing (SSP) conditions and rate of target responses per 5-min session of programmed and noncontingent reinforcement.

rates (except in Session 4 when both responses occurred approximately five times per minute). In SSP, there was a differential increase in target over nontarget vocalizations (which remained near zero throughout the SSP condition). Despite steady increases, the overall SSP mean target rate was 1 response per minute (range, 0 to 2.3) compared to a baseline rate of 0.6 (range, 0 to 4.8). During programmed reinforcement, Topography 2 responding was variable, with an upward trend over SSP levels and a mean target rate of 4.1 (range, 0.6 to 9.4). When reinforcement was available noncontingently, response level immediately decreased, dropping to zero by the third session and continuing at or near zero throughout. Mean target responding during the withdrawal condition was 0.7 (range, 0 to 3). To recover the target vocalization, programmed reinforcement was reinstated briefly. Responding immediately increased to 3.4 responses per minute and was maintained near this level (mean rate, 3.3; range, 2.8 to 3.6).

Daniel's results are shown in Figure 3. During the evaluation of Topography 1 (*reeklo*, top), no baseline responding occurred for either topography. During the first half of SSP, the differential effect of pairing on targets was evident, with a mean rate of 2.7 (range, 0.3 to 4.7) compared to the nontarget mean rate of 0.5 (range, 0 to 1.1). However, during the second half of SSP, both target and nontarget vocalizations decreased to less than 0.5 responses per minute, with one exception (Session 24).

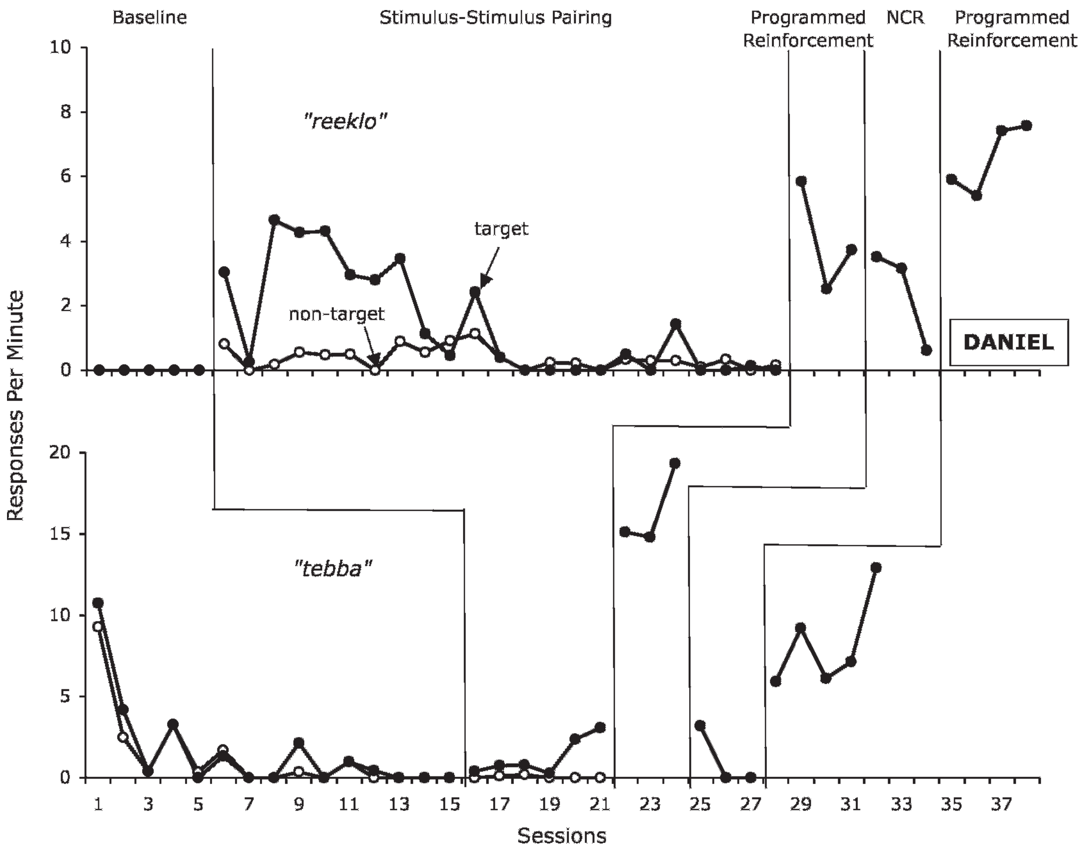

Figure 3. Rate of target and nontarget responses per session (20-trial blocks) for Daniel during within-session observations in baseline and stimulus–stimulus pairing conditions and rate of target responses per 5-min session of programmed and noncontingent reinforcement.

When programmed reinforcement was initiated, levels of target responding showed an immediate increase (5.8) then continued above 2.5 (mean rate, 4). Under noncontingent reinforcement, target responding decreased to 0.6 rpm. Programmed reinforcement was reinstated and target responding immediately increased to 5.9, higher than response levels during the first programmed condition. The mean target frequency during the second programmed reinforcement condition was 6.6 (range, 5.4 to 7.6).

Figure 3 (bottom) shows Daniel's vocalizations during Topography 2 (*tebba*) training. During baseline, after an initial period when both target and nontarget topographies were emitted at fairly high rates (approximately 10 rpm during Session 1), vocalizations varied in a downward trend between 0 and approximately 4 responses per minute, and then stabilized at zero. Target responding remained below 1 for the first four sessions of SSP but then increased to approximately 3. At this point, given the prior results with Topography 1, programmed reinforcement was initiated to avoid response loss and maximize clinical benefit by strengthening this topography. The target behavior immediately responded to the contingency with an initial frequency of 15 responses per minute, increasing to 19 by the third session of this condition. The response level decreased to zero when reinforcement was available noncontingently, and reinstatement of the programmed contingency again resulted in immediate increases in responding to 5.9, increasing to a mean overall rate of 8.2.

DISCUSSION

This study investigated the effects of an enhanced stimulus–stimulus pairing procedure on vocal responses of children with autism and the subsequent effects of programmed reinforcement on pairing-induced speech responses. Results showed that target vocalizations increased during SSP to acceptable but moderate levels over baseline and that these increases occurred in the absence of programmed reinforcement. Moreover, in all cases, topographies were further strengthened at or above SSP levels through subsequent programmed reinforcement. However, when reinforcement was available noncontingently, only the participant with the lowest preexperimental vocal repertoire (Joshua) demonstrated target maintenance. Thus, the current study offers only modest evidence that SSP-induced speech is strengthened by its absolute conditioned reinforcing value, particularly in speech-delayed children with existing moderate vocal play. Rather, social contingencies of reinforcement may play a greater role in strengthening incipient vocalizations for these and other early speech learners.

The clinical utility of SSP may have varied for individual participants. Except for Daniel's Topography 1 (*reeklo*), all targets occurred at least once during baseline. It is possible that vocalizations could have been increased without SSP but, instead, through programmed reinforcement alone. However, this study was not designed to evaluate the separate effects of this variable but rather to employ more optimal SSP procedures to augment low-frequency vocalizations in children who were not readily responsive to verbal operant contingencies. This potential clinical benefit of SSP is most evident for Daniel, whose target response (*reeklo*) did not occur at all during baseline but occurred during SSP and was strengthened differentially over a nontarget response. To a lesser extent, this may also be true for Madison's target *aypayk* and Joshua's target *beh*; both were observed during baseline, but occurred only weakly compared to the more robust and differential performance during SSP.

The clinical value of SSP is to establish or increase incipient vocal responses not currently under operant control so that speech training can proceed by arranging social contingencies (e.g., mand) that will strengthen and maintain functional language. With all 3 participants in this study, preexperimental vocalizations in general occurred at low frequencies, and previous efforts to establish echoic or mand control over the existing vocal repertoire had largely failed, thus underscoring SSP as a viable alternative for initial speech training. However, in this study, as in several previous SSP investigations, performances varied across participants, and this may be due to multiple factors.

Differential increases in target over nontarget responding during SSP suggest that paired speech stimuli became conditioned such that similar response-produced stimuli functioned to strengthen those responses. The strongest evidence for this is Joshua's response maintenance during noncontingent reinforcement (NCR) when socially mediated reinforcement was not contingent on target responding and, thus, continued vocal behavior may be attributable, at least in part, to automatic reinforcement contingencies. However, the brevity of this phase makes it difficult to rule out control by social contingencies and, particularly for Madison and Daniel, response decreases during NCR may simply point to the relative strength of these contingencies on vocal behavior.

Daniel's data in the first SSP evaluation (see Figure 3, top) merit further analysis. Early target responding suggests that the S+ *reeklo* was initially conditioned to some degree, only to lose its value in the latter half of the phase. Competing contingencies may have influenced response strength. Daniel had a stronger history of reinforcement for verbal behavior than

Joshua and Madison did. Thus, responding that occurred possibly under partial influence of this history may have decreased, because these contingencies were not currently active and, concomitantly, an omission contingency (the correction delay) was in place. In the current study, as in Miguel et al. (2002), a 20-s delay was imposed during SSP if target responding occurred between presentations of the two stimuli being paired. This procedure was an attempt to control for adventitious reinforcement of responses under socially mediated contingencies (e.g., echoic), but, it is possible that this correction delay functioned to suppress responding overall. This would explain the decreasing trend during SSP in target vocalizations for Daniel and, perhaps, the sometimes variable and sluggish responding by the other 2 participants.

In addition to the SSP correction, Miguel et al. (2002) also imposed a correction delay after responding that occurred during the ITI. The purpose was to control for selection of these responses through social contingencies available in the next scheduled SSP (e.g., tangible items). No such delay was employed in the current study because suppression of responding during the variable ITI was undesirable because this interval yielded the actual within-session experimental data (unlike Miguel et al., in which data were collected during pre- and postsession observations). Because no ITI delay was used, it is possible that any responses, target and nontarget alike, that occurred contiguously with the next pairing were susceptible to adventitious reinforcement. Certainly, both responses had equal opportunity to occur based solely on occurrence of programmed auditory stimuli (i.e., S+ and S− syllables). However, to the extent that SSP increased target responding differentially, more target responses would be available for incidental reinforcement. However, other factors make it difficult to attribute increased target responding during SSP to the absence of an ITI correction. First, the S− control (not previously used in SSP studies) ensured that nonpairing trials were as likely to follow the ITI as were trials of SSP, thus eliminating availability of reinforcing stimuli during these periods. In addition, reinforcers in SSP occurred after the variable ITI, regardless of response occurrence during ITI, thus further disrupting any contingent relation between ITI response and SSP reinforcer.

Several SSP procedural modifications were made, although not separately evaluated, to overcome the transience and variability of the procedure's typical effects under the assumption that strong stimulus salience during pairing is likely to produce robust conditioning. An orienting prompt that initiated all baseline and SSP trials may have increased the impact of ensuing stimuli, contributing to differential effects observed in SSP. However, the role of orienting responses to the prompt was not evaluated. To differentially establish paired stimuli as conditioned reinforcers for responses that produced these stimuli, nonpaired stimuli (S−) were randomly, but equally, interspersed during baseline and SSP sessions. This modification may have facilitated salience of the paired stimulus by changing the ratio of reinforcer probability (Gibbon & Balsam, 1981) and thus increased the likelihood that important stimuli would be more potent (Dinsmoor, 1995a) and that participants would disregard, relative to S+, the unimportant stimuli (i.e., those that were not followed by reinforcers). (The term *reinforcer*, in this instance, refers to the paired stimulus and is not used in the typical sense, because no response is required for this stimulus to be delivered.) The added experimental control offered by the S− feature supports the interpretation of a differential conditioning effect of SSP on paired stimuli, because nontarget responses that produced unpaired stimuli failed to increase commensurately with target responses. It should be noted, however, that, initially, S+ and S− might have been equally salient for all participants (see baseline for Daniel's, Joshua's, and Madison's Topography 2). Finally, an ITI varying in duration from 5 s to 30 s was used to highlight the unpredictability of trial stimuli and thus to increase attending responses to these stimuli (Gibbon & Balsam). In addition to earlier comments regarding the ITI, it should be noted that shorter (variable) durations may have been insufficient to make stimuli optimally salient and thus discriminable. For instance, with certain edible reinforcers, it is possible that even with maximum interval values, food taste dissipated slowly and remained available as a reinforcing stimulus during nonpaired trials, making the difference between S+ and S− less observable.

The study also may have been limited by the method used to calculate interobserver agreement. Although observations of target and nontarget responses were calculated separately, comparing all responses in briefer time bins (e.g., 10 s) would increase confidence in response occurrence. Finally, there was a practical challenge in delivering some types of reinforcers (e.g., bubbles) between one response and the next, which may have maintained a triadic response pattern (e.g., *beh beh beh*) that children often emitted. Although there is little reason to expect an altered topography (i.e., a single response) because the paired stimulus was triadic, the triadic response form often persisted during programmed reinforcement even when reinforcer delivery followed a single response (e.g., *beh*). Such idiosyncratic responding emphasizes the need, in applied settings, to manage the influence of stimuli that are prominent, yet irrelevant, to the learning task.

In SSP research, two issues seem most important to investigate. First, reliable effects have been elusive. The transience of speech as an environmental stimulus may render it too obscure to become easily conditioned as a reinforcer for individuals who unreliably respond to stimulus changes in general. Thus, future researchers might focus on evaluating SSP procedural components designed to increase stimulus salience to determine which are necessary and sufficient to produce the most reliable effects. Modifications such as those used collectively in the current study are examples of components whose contributions could be separately evaluated, one of the most important being the S− feature, to inform treatment effects on both target and nontarget responses. More frequent preference sampling could also be employed to inform shifts in motivating operations (Laraway, Snycerski, Michael, & Poling, 2003) that affect the value of stimuli used as reinforcers in the pairing process.

The other important concern is isolation of the role of automatic reinforcement in producing SSP effects. Controls typically used to demonstrate a programmed reinforcement effect (Thompson, Iwata, Hanley, Dozier, & Samaha, 2003) would be appropriate to evaluate the effect of automatically produced stimuli on target behaviors. In particular, response maintenance could be evaluated during extinction, which, in the case of SSP studies, would require the vocal response to occur without being followed by its putative reinforcer (the auditory stimulus). Masking the stimulus to prevent auditory detection would be one way to accomplish this. A more rigorous control would be achieved through NCR, which allows the necessary elements of both the contingent relation and the presence of the auditory stimulus to be evaluated. It should be noted that the NCR condition in the current study controlled more directly for the effects of programmed (vs. automatic) reinforcement on the target response because the reinforcer delivered during NCR was not the auditory stimulus conditioned during SSP; rather, it was the item delivered in the programmed reinforcement condition. Therefore, any response decrease from the programmed reinforcement condition to NCR would suggest influence by programmed contingencies; this, indeed, was the case with Daniel and Madison. However, Joshua's target response maintenance during NCR suggested indirectly that the auditory stimulus retained some conditioned value as an automatic reinforcer. To evaluate more directly the effects of automatic reinforcement using an NCR control, a post-SSP condition might provide the target syllable played periodically through speakers, thus eliminating the contingency between the target response and the reinforcing stimulus. Hence, any subsequent response decrease might be attributable to the noncontingent availability of the stimulus that, indeed, functioned as a reinforcer for the response. Researchers might also evaluate the strength of previously paired auditory stimuli to reinforce nonvocal arbitrary responses such as a button press (see Esch et al., 2005), although it could be argued that this type of procedure involves contingencies that are more appropriately termed *programmed* than *automatic*.

Evaluation of the role of conditioned automatic reinforcement in SSP will require future researchers to consider the separate functions that result in novel response generation (the first response), response strengthening, and maintenance of targeted topographies. Some have suggested that the first response in SSP may be a type of echoic reflex (Tonneau, 2005) potentiated by SSP, with subsequent vocalizations maintained by the conditioned reinforcing stimuli they produce. This suggests that differential effects of SSP may be dependent on some level of an echoic or perhaps another facilitative duplic (i.e., nonvocal imitation) repertoire. However, if auditory speech stimuli could elicit a type of echoic reflex, it is unclear why vocalizations in general would be resistant to echoic operant contingencies, as is the case with many early speech learners with autism.

SSP research to date has often shown transient conditioning effects. However, to the extent that automatic reinforcement plays a role in strengthening SSP responding, temporary effects are not unexpected, nor are they undesirable. The goal of SSP is to generate sufficient vocal behavior such that it can come under the control of naturally occurring contingencies that are adaptive for the speaker. Some of these are social contingencies (Skinner, 1957), but certain contingencies of automatic reinforcement (such as achieving parity with the practices of a verbal community; Palmer, 1996) may be equally requisite for development of a complex repertoire. Therefore, practitioners should anticipate transient SSP effects and proactively engineer social contingencies to promote long-term maintenance of new responses.

Finally, failures or equivocal SSP findings (e.g., Esch et al., 2005; Miguel et al., 2002), further illustrated in performance differences in the current study, may suggest some yet undefined, but requisite, learner repertoire that is optimally responsive to the SSP conditioning process. One such possibility is the learner's history of responding to environmental stimuli, particularly verbal stimuli, whether self-generated or produced by others. In the case of automatically reinforced verbal behavior, the speaker also necessarily functions as his own listener (Palmer, 1996). Thus, deficits in a listener repertoire would preclude benefit from these contingencies. In SSP research to date, most participant speaker–listener repertoires have been described as largely nonfunctional. Therefore, it may be necessary not only to evaluate but also to teach prerequisite listener skills that support attending to verbal stimuli (e.g., orienting, following simple instructions). One corollary benefit of such training might be increased vocal play whose frequency and topographic diversity may be supportive to the SSP conditioning process.

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Received November 19, 2007
Final acceptance June 17, 2008
Action Editor, Rachel Thompson