Analyzing Stimulus-Stimulus Pairing Effects on Preferences for Speech Sounds

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Several studies have demonstrated effects of stimulus-stimulus pairing (SSP) on children's vocalizations, but numerous treatment failures have also been reported. The present study attempted to isolate procedural variables related to failures of SSP to condition speech sounds as reinforcers. Three boys diagnosed with autism-spectrum disorders participated. Phase 1 was designed to assess SSP effects on production of auditory stimuli via button pressing. When SSP failed to produce a preference for the target stimulus, we instituted a series of procedural manipulations intended to address potential reasons for failure. One participant preferred the target stimulus when given the opportunity to select preferred items for pairing prior to each session, but a subsequent reversal attempt produced ambiguous results. Two participants showed no consistent preference in Phase 1 and underwent a within-session reinforcer evaluation in Phase 2, in which alternative controlling variables were demonstrated by delivering preferred stimuli contingent on button pressing.

Key words: autism, conditioned reinforcement, stimulus-stimulus pairing, concurrent operants, vocalizations

Early behavioral intervention programs for nonverbal children diagnosed with autism typically attempt to establish vocal communication before considering alternative communication systems (Lovaas, 2003). However, efforts to shape recognizable speech sounds and establish functional speech may be complicated when children display a low frequency and limited variability of free-operant vocalizations. Early intervention texts based on Skinner's (1957) analysis of verbal behavior (Greer & Ross, 2008; Sundberg and Partington, 1998) have recommended the use of a stimulus-stimulus

pairing (SSP) procedure to increase the vocal play of children who do not communicate vocally. This procedure involves an adult's repeated presentations of a specific phoneme or syllable, each immediately followed by the presentation of a preferred item or activity, without any response requirement by the child.

Early research on SSP (Smith, Michael, & Sundberg, 1996; Sundberg, Michael, Partington, & Sundberg, 1996; Yoon & Bennett, 2000) demonstrated that SSP sessions were followed by temporary increases in rates of vocalizations that resembled the paired auditory stimuli, among children with and without developmental delays. Yoon and Bennett's data further suggested that SSP might be superior to direct reinforcement in terms of effects on free-operant vocalizations. Two of the studies (Smith et al; Yoon & Bennett) included conditions in which the auditory stimulus was presented in the absence of preferred stimuli, demonstrating that mere exposure to the stimulus was not sufficient to produce the effect. In addition, Smith et al. provided evidence that pairing an auditory stimulus with a presumed aversive stimulus might have the opposite effect of reducing the rate of target vocalizations, further underscoring the role of preferred

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stimuli in producing rate-increasing effects. None of the three studies, however, employed designs that permitted a rigorous demonstration of experimental control, and none took steps to prevent adventitious reinforcement of target vocalizations during pairing. In addition, none of the studies included control conditions in which the auditory and preferred stimuli were presented separately in time, to assess the role of temporal contiguity. Finally, an autism-spectrum diagnosis was reported for two of five participants in Sundberg *et al.*, but none of the participants in the other studies. As a result, these early studies may have provided limited support for clinical implementation with this population.

Two subsequent studies (Miguel, Carr, & Michael, 2002; B. E. Esch, Carr, & Grow, 2009) demonstrated SSP effects on free-operant vocalizations of children diagnosed with autism-spectrum disorders, and addressed some methodological limitations of previous studies. Both studies included omission contingencies to rule out adventitious reinforcement of vocalizations. In addition, both controlled for temporally noncontiguous presentation of auditory and preferred stimuli. Miguel *et al.* included a condition in which the presentations of auditory and preferred stimuli were separated in time, and B. E. Esch *et al.* interspersed presentations of the target auditory stimulus with presentations of a control auditory stimulus that was not contiguous with preferred stimuli. These studies provided more rigorous support for SSP. In spite of these positive results, however, numerous failures of SSP to increase vocalizations have also been reported in the literature. In the Miguel *et al.* study, SSP increased the vocalizations of only two out of three participants. In a direct replication of that study, B. E. Esch, Michael, and Carr (2005) found no effect on three children's free-operant vocalizations after an initial unsuccessful attempt to demonstrate an effect on echoic responding. In several other recent studies, some or all participants have failed to respond to SSP (Carroll & Klatt, 2008; Normand & Knoll, 2006; Stock, Schulze, & Mirenda, 2008; Yoon & Feliciano, 2007).

In sum, the literature to date suggests that SSP can increase rates of specific vocaliza-

tions, but does not produce this effect reliably. When the procedure works, it may be quite valuable, as it is easy to implement and may quickly increase the levels of specific vocalizations sufficiently that they can be reinforced and brought under stimulus control without the use of elaborate shaping procedures. However, if it is to be recommended as a clinical procedure, it is necessary to identify the conditions under which SSP produces an effect. So far, success does not appear correlated with any obvious participant characteristics, except possibly young age (for a review, see Stock *et al.*, 2008). Yoon and Feliciano (2007) reported that participants who responded to the procedure tended to have less functional verbal behavior but higher levels of vocal play than participants who did not respond. However, on the Behavioral Language Assessment (BLA; Sundberg & Partington, 1998), which has been the most commonly reported assessment in the SSP literature, profiles of participants who have responded to the procedure are quite similar to those of nonresponders. The BLA is a simple assessment procedure with limited psychometric information, and as a result, it is possible that it may have failed to capture important participant variables. However, in the absence of other information, procedural variables should be considered.

The effects of SSP have typically been interpreted in terms of automatic reinforcement (Sundberg *et al.*, 1996; Sundberg & Partington, 1998). According to this interpretation, the pairing of an adult-emitted speech sound with a primary or other reinforcer establishes the speech sound as a conditioned reinforcer. Subsequently, when the child emits a sound that resembles the paired sound, the response-produced auditory stimulus serves to reinforce the vocal response and shape it to match the paired sound more precisely. Similar interpretations have long been applied to the shaping of infant babbling into speech sounds in the natural environment (Bijou & Baer, 1965; Skinner, 1957). The automatic reinforcement interpretation suggests that SSP might fail to increase vocalizations for two broad reasons. First, SSP may fail to establish the auditory stimulus as a conditioned reinforcer. Second, the child may rarely or never emit vocaliza-

tions that are sufficiently similar to the paired auditory stimulus to reinforce the vocal response (i.e., stimulus generalization may be an issue). When the dependent variable is vocalizations, however, it may be difficult to separate these two potential reasons for failure.

There are several possible reasons why the pairing of an auditory stimulus with a preferred stimulus might fail to condition the auditory stimulus as a reinforcer. First, the preferred stimulus with which the auditory stimulus is paired might not function as a reinforcer. Although several studies have reported the use of preference assessments to select preferred stimuli for pairing, only B. E. Esch et al. (2005) directly assessed the reinforcing effects of the stimuli following failures to produce a pairing effect. When preferred stimuli were delivered contingent on vocalizations, one child's target vocalizations failed to increase, suggesting that the stimuli did not function as reinforcers for that child's vocalizations. However, the other two participants' vocalizations increased, suggesting that ineffective identification of reinforcers could not account for their failure to respond to SSP. Second, effects analogous to overshadowing, blocking, and CS pre-exposure, all of which are known to affect respondent conditioning outcomes of stimulus pairing procedures (Mazur, 2006), may similarly affect the establishment of conditioned reinforcers via similar procedures. In respondent conditioning, overshadowing occurs when two neutral stimuli are simultaneously paired with an US, but only one acquires a CS function. In SSP, when a therapist vocally presents the auditory stimulus, the simultaneous sight of the therapist moving his or her lips might potentially overshadow the auditory stimulus. In B. E. Esch et al. (2009), it is possible that the interspersal of a control auditory stimulus may have served to prevent blocking by eliminating the correlation between lip movement and preferred stimuli. Blocking, in respondent conditioning, occurs when a neutral stimulus and a stimulus that has already acquired a CS function are presented simultaneously, followed by the US. The neutral stimulus may then fail to acquire a CS function. An analogous effect might occur in SSP if the therapist, simultaneously with

presenting a target speech sound, reaches for the preferred item that is to be paired with the speech sound. The sight of a person reaching for a preferred item might block the speech sounds if this stimulus already precedes delivery of preferred items reliably. CS pre-exposure refers to impaired acquisition of a conditioned response due to pre-exposure to the neutral stimulus that is subsequently paired with the US. In research on stimulus-stimulus pairing, lengthy exposure to the target auditory stimulus during baseline or control conditions might similarly impede conditioning. Third, the auditory stimulus may not be sufficiently salient to produce an effect (Dinsmoor, 1995). Only one stimulus-stimulus pairing study to date (B. E. Esch et al., 2009) has explicitly used procedures designed to enhance observation of the auditory stimulus. Fourth, parameters such as the number and temporal distribution of pairings, which have varied substantially across studies, may play a role in the outcome.

In the present study, effects of SSP on preference for a target auditory stimulus over a control auditory stimulus were evaluated in a concurrent-operant button-pressing preparation. This preparation was intended to separate conditioning failures from failures related to the child's vocal repertoire not including vocalizations sufficiently similar to the target stimulus. Thus, the purpose of the study was not to demonstrate clinically relevant behavior change, but rather, to identify variables that might influence the outcome of SSP in clinical or research settings. Variables hypothesized to influence the conditioning of reinforcers were manipulated. These variables included increasing the frequency of preference assessments (assuming that more frequent preference assessment might better serve to identify effective reinforcers, due to potential changes in the reinforcing value of stimuli over time), eliminating pre-exposure to the target auditory stimulus to prevent potential adverse effects of such pre-exposure, and increasing the number of pairings per session. An observing prompt (saying the child's name and waiting for eye contact) preceded stimulus presentation, and presentations of the target auditory stimulus were interspersed with presentations of a control stimulus in

Table 1
Auditory Stimuli

Participant	S1	S2	S3	S4
Brandon	<i>fluh-ich</i> (flaug)	<i>myuht-l</i> (mjöll)		
Brennan	<i>bruh-ith</i> (brauð)	<i>fuk-l</i> (fugl)	<i>h-reem</i> (hrím)	<i>stab-n</i> (stafn)
Dominick	<i>ooh</i>	<i>ee</i>	<i>ai</i>	<i>uh</i>

Note. For Brandon and Brennan, anglicized spelling based on pronunciation is presented in italics, and actual spelling of the foreign word in parentheses. The anglicized spelling may give the impression that all stimuli used for these participants contained two syllables; however, each of the six words contains only one syllable when properly pronounced by a native speaker.

order to prevent overshadowing and to control for stimulus exposure. In addition, we recorded the experimenter's behavior to ensure that the target sound was not presented simultaneously with the sight of the experimenter reaching for a preferred item, in an attempt to prevent blocking by this stimulus. The primary dependent variable was allocation of button presses to the button that produced the target auditory stimulus. However, vocalizations were also recorded to assess the possibility that the participants might prefer vocalizing the target sound to pressing buttons to produce it. If no preference was observed in any condition, a within-session reinforcer assessment was conducted to test whether allocation of button presses to the target stimulus could be altered via contingent presentation of preferred stimuli. This assessment tested whether the absence of a preference for the target stimulus could be attributed to failure to pair it with an effective reinforcer.

GENERAL METHOD

Participants and Setting

The participants were three boys who had received diagnoses of autism-spectrum disorders by qualified professionals, according to their parents. For each participant, 1–3 sessions were conducted per day, 1–2 days per week.

Brandon and Brennan were 4-year-old twins. The Behavioral Language Assessment form (BLA; Sundberg & Partington, 1998) indicated (based on information from their mother and informal observation) that both twins had high levels of vocal play, could echo many different words and phrases,

frequently manded for many different items and activities and could tact a large number of items, but had minimal intraverbal and receptive repertoires. Both twins were observed to engage in excessive echolalia. Brandon and Brennan's sessions were conducted in their living room at home, while they moved freely about the room.

Dominick was 3.5 years old. His BLA (based on information from parents) indicated infrequent vocal play, no echoic behavior and no other verbal operants. Dominick's sessions were conducted in a preschool classroom that was otherwise not in use during sessions. During sessions, Dominick was seated at a child-sized table, facing an experimenter who was seated on the other side. A second experimenter was usually seated behind Dominick.

Stimuli and Apparatus

Auditory stimuli consisted of prerecorded speech syllables in an adult, female voice, each 800 ms in duration. For Brandon and Brennan, the stimuli were one-syllable words from an unfamiliar foreign language (Icelandic). Each syllable contained at least one vowel or consonant-consonant combination that is nonexistent in English. The syllables used for Dominick were English vowel sounds. Table 1 shows the specific stimuli used for each participant. Stimuli 1 (S1) and 2 (S2) were used in baseline and in most of the subsequent conditions. For Dominick and Brennan, S1 and S2 were replaced with stimuli 3 (S3) and 4 (S4) in their final condition.

The experimental manipulandum consisted of two identical plastic microswitch response buttons (Big Red®) with an activation area

that measured 12.7 cm in diameter. The two buttons were identical in color (red for Dominick and green for Brandon and Brennan). Each button required 85 g of pressure to activate. The buttons were connected via a USB interface to a laptop computer running E-Prime software (Schneider, Eschman, & Zuccolotto, 2002) that was programmed to record button presses and to control the presentation of auditory stimuli. Activation of a response button resulted in immediate presentation of an auditory stimulus through the built-in computer speakers. When the response buttons were disconnected from the computer, the experimenter could present auditory stimuli by pressing keys on the keyboard.

PHASE 1: PAIRING

Measurement

Dependent variables. The primary dependent variable was the rate of button pressing to produce auditory stimuli during 2-min test periods. These data were recorded automatically by the experiment-running software. Data were also collected on vocalizations during test periods. Observers recorded these data from video using real-time recording on a laptop computer running the Behavioral Evaluation Strategy and Taxonomy (BEST) software application (Sharpe & Koperwas, 1999). For Dominick, the observer recorded all vocalizations that matched the vowel sounds listed in Table 1. Brandon and Brennan could not precisely articulate the syllables listed in Table 1. As a result, vocal approximations were recorded when these participants emitted one-syllable vocalizations in which the vowel and at least one consonant matched one of the syllables shown in Table 1.

Interobserver agreement. A second observer independently scored vocalizations from video in at least 25% of each participant's test periods. To calculate exact counter-interval (Cooper, Heron, & Heward, 2007) agreement, each session was divided into 10-s bins. An agreement was scored when the two observers recorded identical data on the frequency and type of vocalizations within a bin; otherwise, a disagreement was scored. Average agreement across ses-

sions was 94.5% (range, 83.3%–100.0%) for Brandon, 89.8% (range, 66.7%–100.0%) for Brennan, and 91.6% (range, 83.3%–100.0%) for Dominick.

Procedure

Paired-stimulus preference assessment. Prior to the experiment, paired-stimulus preference assessments (Fisher et al., 1992) were conducted to identify preferred toys and food items. Preferences for toys and food items were assessed separately. Eight items were selected for each assessment based on information from parents. The five items with the highest selection percentages were used in Brandon and Brennan's baseline and initial pairing phases (see Table 2). For Dominick, one of the five highest-ranking items was wooden blocks that repeatedly occasioned problem behavior during the preference assessment when he was asked to return them to the experimenter. As a result, the sixth highest-ranking item was used in place of blocks during baseline and the initial pairing phase.

Experimental sessions. Each session consisted of (a) a stimulus presentation period in which a predetermined number of stimuli were presented to the participant, and (b) a 2-min test period that immediately followed the stimulus presentation period. Experimental manipulations affected only the stimulus presentation period, whereas test period procedures remained constant throughout all conditions.

Baseline. During baseline sessions, a stimulus presentation period consisted of 10 presentations of S1, 10 presentations of S2, and 10 presentations of a preferred item. Five preferred items were used, with two presentations of each, except that if the participant failed to consume one or more items, only the remaining items were used for the remainder of that session.

During the stimulus presentation period, the response buttons were out of the participant's sight, and preferred items were out of reach except when they were presented to the participant. The experimenter presented the stimuli when prompted by the software program. Presentation order was randomized in blocks of three. The intertrial interval (ITI) was 10 s, and its timing began

Table 2
Preferred Stimuli in Experimental Conditions

Participant	Baseline and pairing	Pre-session selection condition ^a	Pre-session selection reversal ^a	Pre-session selection + extended pairing ^a	Pre-session selection + pairing without pre-exposure ^a	Phase 2
Brandon	Police truck, cell phone, plain potato chips, Ruffles®, chocolate teddy grahams	Keyboard (x2), music box (x1), shortbread cookies (x4)	Finger paint (x3), Picture book (x2), police truck (x2), music box (x2), keyboard (x1), cell phone (x1), shortbread cookies (x11)			
Brennan	Police truck, finger paint, picture book, chocolate chip cookies, cheese crackers	Music box (x3), police truck (x1), markers (x1), keyboard (x1), chocolate chip cookies (x4), cheese crackers (x1), graham crackers (x1)			Music box (x2), picture book (x1), chocolate chip cookies (x2), cheese crackers (x1)	Finger paint ^b , cheese crackers
Dominick	Playdough, spinning rod, spaghetti ball, goldfish crackers, saltine crackers	Blocks (x6), rubber ball (x1) fruit snacks (x5) saltine crackers (x2)		Blocks (x4), spaghetti ball (x1), playdough (x1), moon dust (x1), saltine crackers (x2), fruit snacks (x5)	Blocks (x2), spaghetti ball (x1), fruit snacks (x3)	Blocks, fruit snacks

^a Times selected in parentheses
^b Replaced with a picture book in minute 17

at the conclusion of the presentation of an auditory stimulus, or following the consumption of a preferred item.

Before presenting a stimulus, the experimenter said the participant's name to get his attention. Once the participant made eye contact with the experimenter, the experimenter presented the stimulus. An auditory stimulus was presented by pressing a key on the keyboard, which resulted in the auditory stimulus being played three times in succession, for a total stimulus duration of approximately 3000 ms. The stimuli were presented through the built-in computer speakers positioned directly in front of the experimenter. The presentation of a preferred item consisted of a small piece of food, or 10–20 s of access to a toy. The experimenter presented the preferred item by placing it in front of the participant.

Pairing. Pairing sessions were identical to baseline, except that during the stimulus presentation period, presentations of S1 (the target stimulus) and preferred items were temporally contiguous. After saying the participant's name and establishing eye contact, the experimenter first presented S1 by pressing the key on the keyboard, and waited until the stimulus had been presented twice. Upon the third presentation of the stimulus, the experimenter reached for and delivered a preferred item. The session contained 10 pairings of S1 and a preferred item, and 10 presentations of S2 (the control stimulus) alone.

Pre-session selection of preferred items. When no preference for the target stimulus was observed in the initial pairing condition, a pre-session stimulus selection procedure was implemented and included in all subsequent conditions. The procedure was implemented immediately before the beginning of each session and included the eight food items and eight toys that were included in the original paired-stimulus assessment. First, all eight food items were lined up in front of the participant. The participant was instructed to scan the array, and told to "Pick one." The participant received a small bite of the food he selected. Next, the procedure was repeated with toys, followed by approximately 20 s of access to the selected toy. The selected food item and toy were paired with the target auditory stimulus in the subsequent pairing

session. Each of the two items was thus scheduled for presentation five times in the session, but if a participant failed to consume one of the items, only the remaining item was used during the remainder of the session (no participant ever failed to consume both of the items). The items selected by each participant during this and subsequent conditions are shown in Table 2.

Extended pairing. During this condition, which was conducted with Dominick only, each session contained 20 pairings of S1 with preferred items, and 20 presentations of S2. Pre-session selection of preferred items continued during this condition.

Pairing without pre-exposure. This condition was conducted with Dominick and Brennan. The procedures were the same as before, except that S3 (target) and S4 (control), to which the participant had no exposure in prior conditions, were substituted for S1 and S2. Pre-session selection of preferred items also continued during this condition.

Testing. A test period consisted of 2 min of free access to the response buttons that occurred immediately following each stimulus presentation period. For Dominick, the response buttons were placed 23 cm from the edge of the table, 140 cm apart, and equidistant from Dominick's midline. If Dominick got up from his seat during the session, he was redirected to sit. For Brandon and Brennan, the experimenter positioned herself in front of the participant, held each button at an arm's length, one to the left and one to the right, and looked down. If the participant moved around the room, the experimenter followed with the buttons. If the participant left the experimental area, he was redirected into the area by a second experimenter.

Activation of each button produced one of the two auditory stimuli that were used in the preceding stimulus presentation period. The left-right position of the target and the control stimuli alternated across sessions, such that the same stimulus was presented in the same location more in no more than two consecutive sessions. Before the beginning of each test period, the participant was prompted to press each button once, using a verbal ("press this one") and pointing prompt, followed by a physical prompt if the

participant did not press the button. The purpose of prompting was to ensure that the participant contacted the auditory consequences of pressing each button. The experimenter then instructed the participant to “press the buttons” while pointing to both buttons, and started the session timer. The experimenter did not interact with the participant during the test period, unless it was necessary to redirect the participant to the experimental area (this happened rarely).

Each participant underwent brief button training prior to baseline. During training, the placement of the buttons was the same as during test sessions, but button activation produced Windows® jingles instead of speech sounds. The participant was prompted to press each button, and prompts gradually withdrawn until the participant made at least one unprompted response on each button during a 2-min period.

Experimental design. Following baseline, different pairing conditions were presented sequentially to the participants and a reversal design used to evaluate effects of pairing. A preference for the target sound was defined as four consecutive sessions in which rates of pressing for the target sound were higher than for the control sound. If a participant demonstrated preference for the target sound in one of the pairing conditions, it was followed by a reversal condition. The reversal condition was identical to the preceding condition except that the previous control sound (e.g., S2) was paired with preferred items, while the previous target sound (e.g., S1) served as the unpaired control sound. In addition, a multiple-baseline design (concurrent) across participants was used for Brandon and Brennan’s observations.

Procedural fidelity. An observer scored at least 20% of all stimulus presentation periods with respect to the timing of the experimenter’s stimulus presentations. In baseline, the presentation of an auditory stimulus was scored as correct if it was not followed by the presentation of another stimulus (auditory or preferred item) within 10 s. Presentations of control stimuli were scored in the same manner during all conditions that involved pairing. Presentations of a target auditory stimulus were scored as correct if the experimenter initiated delivery of a preferred

item (defined as the beginning of any visible movement that resulted in handing over a preferred item) no earlier than the offset of the second presentation of the target stimulus, and no later than 1 s after the offset of the third presentation. The average percentage of correct stimulus presentations was 95.6% for Brandon, 98.3% for Brennan, and 97.9% for Dominick.

PHASE 2: REINFORCER ASSESSMENT

Dominick and Brennan participated in a brief within-session reinforcer assessment in Phase 2. Its purpose was to test whether preferred items, selected via the pre-session selection procedure from the pool of items used in Phase 1, would serve as reinforcers for pressing the response buttons.

Measurement

The primary dependent variable was the cumulative number of unprompted button presses. Two observers independently recorded prompted and unprompted presses on each response button from video, using a 1-min frequency-within-interval paper-and-pencil recording system. In each interval, percentage agreement for each button was calculated by dividing the lower number of responses by the higher number of responses and multiplying by 100. Average agreement was 91.2% for Brennan and 98.4% for Dominick.

Procedure

Pre-session selection of preferred items. A pre-session selection procedure identical to that used in Phase 1 was conducted to identify one food item and one toy for use in Phase 2. Brennan selected finger paint and cheese crackers and Dominick selected blocks and fruit snacks.

Baseline. During baseline, response buttons were arranged as in Experiment 1 test periods. Responses on the right button produced S1 and responses on the left button produced S2. At the beginning of baseline, the participant was instructed to “Press the buttons.” Every 20 s, the experimenter prompted a response on the right button, by pointing (Brennan) or physically (Dominick).

An unprompted response delayed the presentation of the next prompt by 20 s. Responses on either button did not produce any consequences other than the auditory stimuli.

FR1. The FR1 condition was identical to baseline except that all prompted and unprompted responses for S1 produced a bite of food or 10-s access to a toy in an alternating sequence. The timing of the 20-s prompt delay began at the conclusion of preferred item consumption. Dominick underwent two FR1 phases, and in the second, the left-right location of the auditory stimuli was reversed and prompts occurred on the left button.

Extinction. Extinction was identical to baseline, except the left-right location of the auditory stimuli was reversed from the previous phase, and prompts occurred on the left button. The purpose of switching locations was to use the extinction burst as an indicator of whether increased responding for the target sound in the previous phase reflected reinforcement of button pressing in a particular location, or reinforcement of the production of a particular auditory stimulus.

RESULTS

The upper two panels of Figure 1 show rates of button pressing for Brandon and Brennan in Phase I. In baseline, both participants pressed the buttons at moderate, variable rates (Brandon: $M = 5.57$ for S1 and $M = 6.79$ for S2; Brennan: $M = 7.45$ for S1 and $M = 7.80$ for S2). Both participants alternated frequently between buttons, and did not consistently press one button more than the other. During the initial pairing phase, both participants continued to press the buttons at similar rates (Brandon: $M = 6.0$ for S1 and $M = 6.16$ for S2; Brennan: $M = 7.50$ for S1 and $M = 6.70$ for S2). When the pre-session selection procedure was introduced, Brandon's response rates increased on both buttons, and he consistently produced the target sound at greater rates than the control sound ($M = 10.38$ for S1 and $M = 7.75$ for S2). However, this preference was not successfully reversed in the following reversal condition; instead, response rates on both buttons returned to baseline levels ($M = 5.45$ for S1 and $M = 5.18$ for S2). Further analysis could not be conducted as Brandon was enrolled in a full-time early

intervention program and became unavailable for additional sessions. Brennan continued to press at similar rates as before during the pre-session selection condition ($M = 8.08$ for S1 and $M = 7.50$ for S2). When S3 and S4 were introduced to the pairing sessions without prior exposure, no immediate preference was observed for either stimulus ($M = 9.17$ for S3 and $M = 8.50$ for S4).

The bottom panel of Figure 1 shows rates of button pressing for Dominick in Phase I. Dominick made only one unprompted button phase in baseline and none in the initial pairing phase. The introduction of pre-session selection coincided with a temporary increase in response rates, but button presses for the target and the control sound were overall undifferentiated ($M = .57$ for S1 and $M = .50$ for S2). During the extended pairing condition, response rates decreased on both buttons ($M = .36$ for S1 and $M = .21$ for S2), and Dominick did not make any button presses for S3 or S4 in the final condition.

Figure 2 shows the rate of vocalizations matching the target and control stimuli during test periods. Brandon (top panel) and Dominick (bottom panel) engaged in low rates of vocalizations throughout the experiment, with the exception of Dominick's Session 5 in which he matched S2 at a high rate. Brandon and Dominick did not show any changes in vocalization rates that coincided with phase changes, and they did not match target stimuli at higher rates than control stimuli. Brennan initially engaged in low rates of vocalizations approximating S1 and S2, but did not approximate S3 or S4. At the end of baseline, S1 and S2 approximations began to increase and continued at a higher level until the end of the pre-session selection condition. His vocalizations were mostly undifferentiated; however, he engaged in higher levels of S1 than S2 approximations for six consecutive sessions starting with the last data point in pairing without pre-session selection. In the last condition, when S3 and S4 were introduced, Brennan's vocalizations began to approximate those stimuli and no longer approximated S1 or S2.

Figure 3 shows the data from Phase 2 for Brennan (upper panel) and Dominick (lower panel). Brennan emitted unprompted responses on both buttons during baseline,

Figure 1. Participants' button pressing in Phase 1. Phase labels indicate (within parentheses) which stimulus was paired with a preferred item in each condition. PSP = Pre-session Selection of Preferred Items.

but during FR 1, a majority of his responses were on the button that produced S1. The per minute rate of unprompted responses on the S1 button was higher during baseline ($M = 6.75$) than during FR 1 ($M = 2.27$), but this was likely due to preferred item consumption time. During FR 1, Brennan stopped engag-

ing with the finger paint when it was presented, and made repeated attempts to access a picture book. As a result, the picture book replaced the finger paint in minute 17 and was used for the remainder of the phase. During extinction, when the left-right location of S1 and S2 was reversed, Brennan

Figure 2. Participants' vocalizations in Phase 1. In the upper two panels, data from session 5 and 14 (both Brennan) are missing due to technical issues.

responded on both buttons. Brennan continued to respond for 3 minutes before responding decreased to zero. Following extinction, the session was terminated, as Brennan refused to continue cooperating with the experimenters. He was unavailable for a second session due to full-time enrollment in an early intervention program.

Dominick did not make any unprompted responses during baseline in Phase 2. During FR 1, he gradually began to make unprompted responses on the S1 button, but not on the S2 button. During extinction, most of Dominick's responses were allocated to the S2 button in the previously reinforced location. FR 1 was re-instituted when responding on

Figure 3. Cumulative button presses for Brennan and Dominick in Phase 2.

the S2 button had slowed considerably. During the second FR 1 phase, Dominick immediately began to allocate all responses to S1 in the new location, and made no responses on the S2 button.

DISCUSSION

SSP did not reliably alter preferences for speech sounds, as assessed with a concurrent-operant procedure. Brandon was the only participant who showed evidence that the pairing procedure produced a consistent preference for a target stimulus. Following introduction of the pre-session selection procedure, Brandon reliably allocated more responding to the button that produced S1 than the button that produced S2. His selections during this condition differed substantially from the preferred items presented in the previous conditions (see Table 2); specifically, he never chose any

of the toys or food items used in the previous conditions. Thus, it is possible that the effect observed in this condition reflected a shift in Brandon's preferences from the pre-experimental preference assessment. Unfortunately, an attempt at reversing this effect in the subsequent condition was only partially successful, because although preference for S1 was eliminated, preference did not shift to S2. It is possible that in the reversal condition, the prior history of S2 being correlated with the absence of reinforcement impeded its acquisition of reinforcing value. Another possibility is that by this time, none of the items in the stimulus pool were effective reinforcers for Brandon's behavior. However, because the absence of a preference reversal precluded a convincing demonstration of experimental control, an alternative explanation is that the pattern of responding observed in the first pre-session selection condition was simply due to

extraneous factors and not functionally related to the pre-session selection procedure. Indeed, the pre-session selection effect was not replicated convincingly with the other two participants. Dominick pressed the S1 button at a higher rate than the S2 button in the first two pre-session selection sessions, and in addition, his overall rate of responding increased. However, this pattern did not persist, and thus, it is unknown if it was related to the experimental manipulation.

Brennan and Dominick never showed a consistent preference for a target stimulus, in spite of a number of procedural manipulations. Brennan's mean level of responding for the target stimulus was slightly higher than for the control stimulus in all conditions that involved SSP, but preference for the target stimulus was not observed consistently across sessions. The results of Phase 2 suggest that in Phase 1, the auditory stimuli had been paired with effective reinforcers, but they still failed to acquire sufficient reinforcing value to alter the distribution of button presses by themselves. However, Brennan's data may be limited in this regard, as responding for S1 was already higher than responding for S2 in baseline, and it was not possible to conduct a second FR1 phase following extinction. For Dominick, button location appeared to be a more salient stimulus than the auditory stimuli that the buttons produced, as he continued to respond in the previously reinforced location during extinction, as opposed to responding on the button that produced the sound previously correlated with reinforcer delivery. This pattern may suggest that the failure to observe a preference during Phase 1 was not likely due to a problem with discriminating which button location produced a more favorable consequence. For Brennan, this was less clear, as he made almost as many responses for S1 in the new location as for S2 in the previously reinforced location during extinction.

No clear effects were observed on vocalizations resembling the target auditory stimuli, suggesting that the absence of an effect on button-pressing was not likely due to displacement of button-pressing by a vocalization that produced a similar stimulus. Brennan engaged in more frequent vocaliza-

tions than the other participants. Most of his vocalizations, as well as most of Brandon's, occurred in close temporal proximity with button pressing and thus may have been under echoic control. His higher rates of vocalizations approximating S1 than S2 in sessions 31 through 40, which were not accompanied by consistently higher rates of button-pressing, might suggest that approximations of S1 were more reinforcing than approximations of S2 during this time. However, the difference was small and transient, and it was not observed with S3 and S4 in the subsequent condition.

Given the numerous failures of SSP to affect vocalization rates that have been reported in the literature (Carroll & Klatt, 2008; B. E. Esch et al., 2005; Miguel et al., 2002; Normand & Knoll, 2006; Stock et al., 2008; Yoon & Feliciano, 2007), these results are perhaps not surprising. In the present study, we assessed the hypothesized conditioning effect of stimulus-stimulus pairing in isolation from its hypothesized reinforcing effects on vocalizations. Thus, a piece of information that it contributes is the suggestion that failure of SSP to increase vocalizations may, at least in some cases, be attributed to failure of the procedure to condition auditory stimuli as reinforcers. However, the results are discouraging in that they do not shed much light on procedural variables that reliably moderate or enhance the effects of SSP on the reinforcing value of auditory stimuli. While they tentatively suggest that frequent preference assessments may be beneficial, the effects of this variable were not reliable. Eliminating pre-exposure to the target stimulus did not result in preference for the target stimulus, and neither did an increase in the number of pairings. In addition, careful attempts were made to prevent blocking and overshadowing at the procedural level. By presenting auditory stimuli through the computer speakers and including a control stimulus in all conditions, we attempted to ensure that no stimulus other than the target stimulus was uniquely correlated with reinforcer delivery. In addition, the experimenter reliably waited until the end of the target sound presentation to visibly reach for a preferred item to deliver to the participants. Thus, it seems

unlikely that any of these variables were related to the failure to observe an effect with Brennan and Dominick.

Some aspect of the concurrent-operants procedure may have contributed to the absence of an effect on button-pressing for Brennan and Dominick and the absence of a reversal effect for Brandon. For example, it is possible that a concurrent-chains procedure would have been more sensitive to preference, or that an intermittent schedule of stimulus presentation on the buttons would have resulted in response differentiation. It is also possible that the presence of the response buttons during test periods made them too easily discriminable from stimulus presentation periods. Thus, it is possible that the procedure did alter the reinforcing value of the target stimuli, but that our test procedures failed to detect it. Nevertheless, the absence of an effect, not only on button-pressing but also on vocalizations, is in agreement with prior research suggesting that SSP effects on vocalizations are not obtained reliably.

Future research might explore the contribution of additional procedural variables to SSP effects on the conditioned reinforcing value of stimuli. Based on a review of the existing SSP literature, Stock *et al.* (2008) tentatively concluded that SSP effects might be more likely with procedures that included a greater number of pairings per minute, fewer presentations of the target sound per pairing, and social reinforcers, such as tickles. In the present study, the density of pairings, number of presentations of the target sound per pairing, and the selection of preferred stimuli were highly similar to a study by B. E. Esch *et al.* (2009), in which SSP successfully increased vocalizations. However, none of these variables were manipulated, and as a result, it is unknown if they would have made a difference.

Additional limitations of the study should be noted. First, Dominick was the only participant who was representative of individuals for whom SSP might be considered clinically. Brandon and Brennan had extensive vocal repertoires and were not in need of intervention for enhancing their level of vocal play or establishing prerequisites for echoic responding. While the purpose of the study was not to demonstrate effects on

clinically relevant behavior, the inclusion of other nonvocal participants might have strengthened external validity. Second, we recorded vocalizations only during the 2-min test periods that followed stimulus-presentation periods, and not during the stimulus-presentation periods themselves. Most studies on SSP, including the majority of studies that have successfully reported effects on vocalizations (Miguel *et al.*, 2002; Sundberg *et al.*, 1996; Yoon & Bennett, 2000), have similarly assessed the dependent variable during brief periods immediately following SSP, in the absence of any stimulus presentation by the experimenters, in order to rule out echoic control over vocalizations. However, in the most successful SSP demonstration to date with participants diagnosed with autism, B. E. Esch *et al.* (2009) departed from this convention by recording vocalizations during stimulus-presentation periods, after pilot data indicated that an effect was more likely to be detected at this time. It is possible that in the present study, an effect on vocalizations that could have been observed during stimulus presentation periods dissipated quickly when pairing was discontinued. This possibility was not evaluated due to inconsistent video quality for Brandon and Brennan, who moved frequently around the experimental area during stimulus presentation periods. Third, we used a fixed rather than a variable ITI. In B. E. Esch *et al.* (2009), it is possible that a variable ITI contributed to the successful demonstration of an effect, and the potential contributions of ITI and pairing density should be evaluated further. Fourth, a minimal number of sessions were conducted in Brennan and Dominick's final condition with stimuli S3 and S4, as well as in Dominick's extended pairing condition. It is possible that an effect would have been observed with prolonged exposure to these conditions. Finally, in Phase 2, Brennan's data would have benefited from a more extended baseline, as well as greater exposure to FR 1.

SSP is easy to implement and requires little therapist training compared to other procedures for increasing specific vocalizations, such as shaping. However, given its unreliable effects in the literature to date and the lack of information on participant or procedural variables that contribute to its

effects, it may be premature to recommend the procedure clinically. Future research might explore other procedures that might increase the frequency or variability of vocal play without a need for shaping, for example, lag schedules of reinforcement (see J. W. Esch, Esch, & Love, 2009). With regard to SSP, the present results suggest that more research may be needed specifically on the conditions under which the auditory stimulus may acquire a reinforcing function. In addition, future research should further develop methods for assessing the reinforcing value of auditory stimuli in isolation from their effects on vocalizations.

In general, there is a paucity of research on conditioned reinforcement in children diagnosed with autism. This is surprising, given that a common suggestion in the early intervention literature is that social stimuli (e.g., praise) may fail to function as reinforcers for children with autism and must be established as such by association with primary reinforcers (e.g., Greer & Ross, 2008; Lovaas, 2003). A few studies have investigated token reinforcement (e.g., Charlop-Christy & Haymes, 1998; Moher, Gould, Hegg, & Mahoney, 2008; Tarbox, Ghezzi, & Wilson, 2006) or other nonsocial conditioned reinforcers (e.g., Greer & Singer-Dudek, 2008; Holth, Vandbakk, Finstad, Gronnerud, & Sorensen, 2009) in this population. However, we are aware of only two studies (Greer, Singer-Dudek, Longano, & Zrinzo, 2008; Isaksen & Holth, 2009) that have successfully demonstrated establishment of verbal or social reinforcers in children with autism diagnoses. Interestingly, neither study employed a contiguous pairing procedure similar to those employed in the SSP literature; Greer et al. employed an observation learning protocol, whereas Isaksen and Holth employed an operant discrimination training procedure. Indeed, Holth et al. (2009) found that discrimination training was more effective than contiguous pairing with preferred items at establishing arbitrary neutral stimuli as conditioned reinforcers for children with and without autism diagnoses. The authors offered no particular explanation for this finding; however, it may be speculated that an operant response requirement offers the advantage of providing the therapist with evidence that the relevant stimuli

are observed or attended to. In an SSP procedure, by contrast, there is no way of verifying that the stimuli are observed or that they are sufficiently discriminable for the participant. Future research might evaluate the effects on vocalizations of speech stimuli's acquisition of discriminative function.

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