An investigation of the effects of a parent delivered stimulus-stimulus pairing intervention on vocalizations of two children with Autism Spectrum Disorder

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Abstract Communication deficits in children with Autism Spectrum Disorder (ASD) can manifest in a myriad of lifelong social and educational challenges. Many children with ASD fail to learn vocal verbal behavior and may require intensive individualized intervention to learn early verbal operants. The current research aimed to evaluate the effects of a parent delivered stimulus-stimulus pairing (SSP) procedure on target vocalizations of two young children with ASD who did not present with vocal verbal behavior. Results indicated the intervention was successful in increasing the frequency of the target vocalizations for both participants. Social validity results indicated that parents were satisfied with the intervention and their own implementation of these procedures. These results are discussed in terms of their implications for parent delivered interventions.

Keywords stimulus-stimulus pairing (SSP) · verbal behavior · vocalizations · autism spectrum disorder (ASD) · parent training

Children diagnosed with autism spectrum disorder (ASD) present with a myriad of social communication deficits which vary across individuals. Such deficits are complex, and can range from insufficient speech and language skills (Charlop-Christy, Carpenter, Le, LeBlanc, & Kellet, 2002) to difficulties with more complex social communication skills, such as conversational reciprocity (Watkins et al., 2015). For children with ASD, development of vocal communication is often delayed and may never occur for some children (Kelley, Shillingsburg, Castro, Addison, & LaRue, 2007). In a longitudinal study of 206 children, researchers found that 30% of children did not acquire vocal language by the age of 9 (Anderson et al., 2007). Deficits in vocal communication are often associated with challenges across all stages of development

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and can present barriers to social, emotional, and cognitive development (Bellini, Peters, Benner, & Hopf, 2007). These barriers may impede later social, academic, and vocational success (Rao, Beidel, & Murray, 2008). Furthermore, deficits in communication are often associated with the development of challenging behavior and can have an impact on an individual's quality of life (Mulhern et al., 2016). Given the various challenges associated with failure to learn communication repertoires, and the empirical evidence that early intervention can ameliorate later challenges (Dunlap et al., 2006), empirical investigations of interventions to establish vocal verbal repertoires in children with ASD are extremely important.

In the typical developmental sequence, children begin to “babble” or produce phonetic sounds from the age of 3 to 6 months (Feldman, 2011). Over time, these sounds become more complex, and syllables are chained together to form more word-like structures. By the age of 6 months, children begin to babble in sounds that are associated with their native language (Feldman, 2011), with functional sounds and words being selected and reinforced by the individual's social community. According to Skinner's (1957) theory of verbal behavior, verbal operants (e.g., *mands* and *tacts*) are established through the mediation of reinforcement by listeners within the child's social community. Skinner (1957) posited that early verbal behavior (e.g., babbling, producing sounds) is shaped through automatic reinforcement, that is, babbling produces sounds that are automatically reinforced (auditorily). One process by which early verbal behavior develops is hypothesised to be the result of stimulus-stimulus pairing, whereby specific sounds become automatically reinforcing due to a history of being paired with the delivery of another established reinforcer.

The stimulus-stimulus pairing (SSP) procedure has been investigated with children with communication deficits (e.g., Esch, Carr, & Grow, 2009; Sundberg, Michael, Partington, & Sundberg, 1996; Yoon & Bennett, 2000). The SSP procedure employs the principles of classical conditioning to increase the conditioned reinforcing value of speech sounds through pairing with reinforcement. For example, an adult's production of the sound “bah” could be repeatedly paired with tickles (i.e., reinforcer) such that, the sound “bah” comes to acquire the same reinforcing properties as tickles. Sundberg et al. (1996) explored the SSP procedure with four children diagnosed with moderate to severe language delay. The procedure paired target sounds presented by an adult with the delivery of reinforcement. The results demonstrated that the children acquired and emitted the target sound (i.e., a novel word or sound) within the training sessions; however, maintenance of these outcomes were temporary and vocalization of the target word or sound ceased a few minutes after the procedure ended. Smith, Michael, and Sundberg (1996) further demonstrated the utility of the SSP procedure when implemented by parents with two typically developing infants. The target sounds included phonemes already in the children's repertoires but not yet under any stimulus control. The pairing procedure led to a 75% increase in the frequency of production of the target sounds by the children following the parent led intervention. As with other studies in this area, maintenance was limited.

Yoon and Bennett (2000) compared traditional echoic training and SSP with four children with speech delays and no vocal verbal behavior prior to intervention. Results indicated that SSP was more effective at establishing and increasing the target sounds. Within this study, increases in the target vocalization were also only observed in the post-pairing condition which could suggest that the vocalizations had acquired automatically reinforcing properties and were not under echoic stimulus control. Miguel,

Carr, and Michael (2002) also demonstrated increases in target vocalizations for three children with ASD following an SSP intervention. However, examination of the maintenance of the positive results, demonstrated by both Yoon and Bennett (2000) and Miguel et al. (2002), indicated that the effects of the procedure were temporary.

Results of research investigating variations of the SSP procedure have been mixed (Carroll & Klatt, 2008; Esch, Carr, & Michael, 2005; Normand & Knoll, 2006; Stock, Schulze, & Mirenda, 2008; Yoon & Feliciano, 2007). In their respective studies, Esch et al. (2005), and Normand and Knoll (2006) found no effects for their SSP procedures. As outlined previously, many studies evaluating SSP procedures have failed to demonstrate lasting intervention effects (e.g., Carroll & Klatt, 2008; Esch et al., 2005; Miguel et al., 2002; Yoon & Bennett, 2000). In a systematic review of the literature, Petursdottir and Lepper (2015) reported that across 13 published studies included in their review, SSP produced vocalizations in 16 out of 25 participants (64%) with ASD diagnoses. In their review, Shillingsburg, Hollander, Yosick, Bowen, and Muskat (2015), concluded that SSP demonstrated positive effects for younger children and highlighted the need for further empirical evaluation of the procedure to improve clinical utility.

To date, the most promising SSP research conducted with children with ASD was conducted by Esch et al. (2009). This study included a number of procedural enhancements in comparison with previous research. The authors included both S+ and S- targets, the S+ being a sound that was paired with reinforcement, while the S- was not paired with reinforcement. The S- thus served as a control for the effects of the SSP procedure throughout the intervention. The SSP procedure was successful in increasing the frequency of the S+, while the frequency of the S- remained unchanged. Furthermore, a direct reinforcement condition was included, whereby reinforcement was delivered contingent upon participant production of the S+. This further strengthened SSP induced targets and a reversal indicated experimental control over the increases in vocalizations. The addition of direct reinforcement for target vocalizations appeared to support maintenance of intervention outcomes. Recent replications of the procedure demonstrated increases in the production of the target sounds for all participants (Miliotis et al., 2012) and for two out of three participants (Rader et al., 2014).

The earliest SSP procedures demonstrating positive outcomes employed familiar adults (Sundberg et al., 1996) and the participant's parents (Smith et al., 1996) to implement the procedures. Stock et al. (2008) have suggested the need for further empirical investigations of the outcomes associated with familiar adults delivering the SSP procedure. There is an established evidence base for parent-led interventions to achieve maintenance, generalization, and general improved outcomes across studies for children with ASD (Matson, Mahan, & LoVullo, 2009; McConachie & Diggle, 2007). The current study aimed to replicate and extend research by Esch et al. (2009) by evaluating the effects of the procedures when implemented by parents on vocalizations of two children with ASD.

Method

Participants and Setting

Two male participants were recruited for this study and assigned pseudonyms. Robert was aged 2 years, 8 months and Daniel was aged 4 years, 6 months at the onset of

intervention. Both children were diagnosed with ASD by two independent clinical psychologists using the Diagnostic and Statistical Manual of Mental Disorders (5th ed.; APA, 2013). Robert was receiving 10 hours per week of applied behavior analysis (ABA) intervention delivered within his home setting. His parents and tutor reported failed attempts at establishing an echoic repertoire. Robert was on Phase 1 of Picture Exchange Communication System (PECS; Bondy & Frost, 1994); however, his primary method of communication was to point and use physical gestures to mand for primary reinforcers. Daniel was attending a preschool for children with ASD that implemented an eclectic teaching model. He used PECS to mand for up to 15 items; however, this method of communication was reportedly inconsistently used within the home and school settings. Daniel also used pointing and physical gestures to mand for primary reinforcers. Both children were included in this study as they were non-vocal verbal and had no reliable echoic repertoire. Parental consent was obtained prior to the commencement of the intervention. The children's willingness to participate in the research was monitored throughout, by ensuring guidelines for ceasing the intervention were clearly outlined to all involved. No children were upset or demonstrated behavior to indicate they did not wish to participate at any time during the study.

Parents were deemed eligible to participate as the interventionist if they could commit to the six weeks required to complete the parent intervention, were willing to training with intervention, and were willing to participate in relevant assessments. Both parents of the children met these criteria and gave written consent to participate. Robert's parents were married, his mother worked in the home and his father worked full-time in a managerial role outside the home. Daniel's parents were also married. His mother worked part-time and father worked full-time in the retail industry, both outside the home.

For Robert, intervention took place in a room in the family home. This room contained a table, chair, and toys. Robert was allowed free access to the toys in this room. For Daniel, the intervention took place in the living room in the family home, which contained typical furnishings and Daniel also had free access to the toys within this room.

Pre Intervention Assessments

Pre-intervention assessments were conducted to establish the children's existing levels of verbal repertoires and pre-requisite skills necessary for teaching verbal behavior. As mentioned, a reinforcer assessment was also conducted to identify a hierarchy of preferred items for use within the study.

The first assessment conducted consisted of a 30 min free play observation session, in which the frequency and topography of each child's phoneme production were recorded using partial interval recording of 30 s time bins. From this, the target sounds (S+) "baboo" and "ahfoo", and non-target sounds (S-) "gah" and "ih" were chosen for Robert, and the target sounds (S+) "mah" and "whoo", and non-target sounds (S-) "dee" and "guh" were selected for Daniel. Consistent with previous research (Esch et al., 2009), the target and non-target sounds were chosen as they were emitted by the participants at low frequencies, that is, 20-25% of the timed sessions.

The Behavioral Language Assessment Form (BLAF; Sundberg & Partington, 1998) was administered by the researcher with the parents of both children. This assessment consists of a parent report questionnaire that addresses 12 different verbal behavior repertoires including, cooperation with adults, mands, motor imitation, vocal play, echoic, matching-to-sample, receptive, tacts, receptive by function, feature and class, intraverbals, letters and numbers, and social interaction. Both children scored between levels 1 and 2 across all 12 items on the assessment, with both receiving a score of 1 on the echoic subtest, indicating that they could not repeat sounds or words upon command.

The Preschool Language Scale 4 (PLS-4; Zimmerman, Steiner, & Pond, 2002) was also conducted with the children. This standardized assessment establishes the child's age equivalence language score. It is a comprehensive assessment assessing receptive and expressive language from the age equivalence of birth to 6 years 11 months. Pre-intervention results for the BLAF and PLS-4 are presented in Table 1.

Five items from the Comprehensive Application of Behavior Analysis to Schooling (CABAS) International Curriculum and Inventory of Repertoires for Preschool through Kindergarten (C-PIRK; Greer & McCorkle, 2003) were administered with both children to assess necessary pre-requisites to vocal verbal behavior. The five items tested included: the ability to visually track stimuli, a test for parent's voices

Table 1 Pre-Intervention Standardized Assessment Results

	Robert	Daniel
BLAF Scores		
A. Cooperation with Adults	3	3
B. Mands	2	4
C. Motor Imitation	1	3
D. Vocal Play	2	2
E. Vocal Imitation	1	1
F. Matching-to-Sample	3	4
G. Receptive	3	2
H. Labelling	1	1
I. Receptive by Function, Feature and Class	1	1
J. Conversational Skills	1	1
K. Letters and Numbers	1	1
L. Social Interaction	1	2
PLS Age Equivalence Language Score	12-16 months	12-16 months
C-PIRK Item Probes		
1. Visually track stimuli	100%	100%
2. Voices as conditioned reinforcers	100%	100%
3. Imitate gross motor behaviors	100%	100%
4. Match multiple exemplars	100%	100%
5. Discriminate multiple exemplars	100%	100%

as conditioned reinforcers, the ability to imitate gross motor behaviors, the ability to match multiple exemplars of stimuli, and the ability to discriminate multiple exemplars of stimuli (refer to Greer & McCorkle, 2003 for more detail).

The parents of both children completed the Reinforcer Assessment for Individuals with Severe Disability (RAISD; Fisher, Piazza, Bowman, & Amari, 1996). This assessment consists of a 10 item questionnaire which is completed with caregivers. Once preferred items were identified, a paired choice preference assessment was then conducted, whereby the child was offered a choice of two identified preferred items. The item the child approached or showed interest in was recorded as the preferred item. All items were rotated in pairs until each preferred item had been tested against every other preferred item to create a hierarchy of preferred items, with the most highly preferred items used during the intervention. Robert's preferred items included a balloon, pens, and a squeeze ball. Daniel's preferred items included foot rubs (assessed via picture presentation), chocolate buttons, and bubbles. For both children, items identified as less preferred were also available during intervention. This was to ensure that the environment was comparable to typical conditions for the child and was consistent with the environment descriptions from previous SSP literature (Esch et al., 2009; Miguel et al., 2002).

Dependent Variables and Inter-Observer Agreement

The dependent variable recorded was the frequency of production of the target sound (S+). The target sounds were identified using 30 s partial interval recordings from the inventory of phoneme vocalizations taken during the 30 min free play observation sessions for each child. These phonemes were heard during baseline but were not under any echoic control, as identified by BLAF and PLS-4 assessments. The target sounds occurred at low frequencies (between 20-25% of the 30 s time bins). This selection process ensured the children were able to emit the target sound. The target sounds (S+) chosen for Robert were "baboo" and "ahfoo." The target sounds (S+) chosen for Daniel were "ma" and "whoo." Non-target sounds (S-) were also chosen from these play observations and were chosen to provide an appropriate comparison as they had also occurred at low frequencies that were close in frequency to the S+ sounds. The non-target sounds (S-) chosen for Robert were "gah" and "ih." The non-target sounds (S-) chosen for Daniel were "dee" and "guh." Whilst the S- chosen for Robert in Set A was "gah" which could be deemed similar to the S+ chosen for Set B "ahfoo," they were differentiated by the S+ for Set B containing two syllables. More specifically, this meant that the sounds could not be incorrectly scored, as they did not occur as individual phonemes, in that "ah" was never heard in isolation, it occurred within "gah" or the two syllable sound of "ahfoo."

Target responding (S+) was operationally defined based on Esch et al.'s (2009) definition, "any vocal response that matched or was similar to the paired training stimulus" (p.229). As in Esch et al. (2009), similarity was defined as "acoustic or phonological approximation to a particular phoneme (e.g. same articulatory feature plus proximate placement)" (p. 229). More specifically, a target response consisted of a vocal production by the child that was the same as, or similar to (i.e., same articulatory

Table 2 Accepted Phonological Approximations for Robert and Daniel

	S+ (Target sound)	Acoustic/Phonological approximation		
Robert	Baboo	Ahboo	Buhboo	B-Boo
	Ahfoo	Uhfoo	Huhfoo	Ehfoo
Daniel	Ma	Mmmmah	Muh	
	Whoo	Hoo	Woo	
	S- (Non-target sound)	Acoustic/Phonological approximation		
Robert	Gah	Geh	Guh	
	Ih	Eh		
Daniel	Dee	Deee		
	Guh	Gih	Geh	

feature), the S+ target. Vocal responses that were produced more than 1 s of silence apart were defined as separate responses. See Table 2 for a list of approximations of the target sounds. For example, for the target sound “whee,” an appropriate approximation to this would have been “hee” or “wee” but not “wuh,” as the “ee” sound contained the same proximate placement of “ee” as “whee.”

The first author was present during all sessions for this study and recorded data on each session. Several sessions were audiotaped for inter-observer agreement (IOA). IOA was calculated by dividing the lower frequency of vocalizations recorded per session by the higher frequency of vocalizations recorded per session and multiplying this by 100 to attain a percentage. A second independent observer reviewed audiotapes for 41% of the intervention with the first target and 38% of the second target for Robert. Mean IOA on the first target (baboo) was 84% (range, 83–100%) and 99% (range, 88–100%) for the second target (ahfoo). For Daniel, 52% of sessions were scored by the second observer for the first target, with mean IOA scored at 98% (range, 83–100%). On the second target, 50% of sessions were scored for IOA, with mean IOA scored at 100%.

Experimental Design

The experimental design for this study was a non-concurrent multiple baseline design. This was conducted across two phoneme targets for each participant and was combined with a reversal to demonstrate experimental control.

Procedure

The study comprised of five phases which were delivered by the child’s parents and included: baseline, stimulus-stimulus pairing (SSP), direct reinforcement, noncontingent reinforcement (NCR), and a return to direct reinforcement phase. The procedure was delivered across two target phonemes per child. For Robert, a total of 39 sessions were conducted with Set A and 40 sessions were conducted with Set B. For Daniel, 29 sessions were conducted with Set A and 32 with Set B.

During the initial parent training, paired choice preference assessments were conducted prior to the beginning of each session using the three most highly ranked items. The procedure for these paired choice preference assessments was the same as the pre-intervention paired choice preference assessment. That is, the child was presented with a choice of two of the three most highly ranked items and the item the child approached or showed interest in was recorded as the preferred item. These items were presented in pairs until each preferred item had been tested against all other preferred items. Each preferred item was presented three times, with the preferred items that were chosen two or more times, selected for intervention. For Robert, the preferred items used across the sessions were a balloon and a squeeze ball, and across all sessions for Daniel, chocolate buttons were the most highly ranked item. All possible preferred items were kept out of the child's reach for at least one hour before the intervention.

Parent training Both sets of parents completed parent training on SSP prior to the implementation of intervention. The parents were exposed to a behavioral skills model for instruction, which included didactic instruction, modelling, rehearsal, and feedback. Parents performance on the implementation of the intervention was scored as frequency of correct trials on each condition, with mastery criterion of 90% accuracy to progress to the next intervention condition.

Parent training was delivered by the first author and comprised of the following phases. Prior to the onset of the study, the parents were provided with an information sheet, which outlined the objectives of the intervention and the current SSP literature. Parents were then provided with a parent training protocol describing the stages of the intervention and the requirements of each condition in detail. This written protocol included information on, the baseline condition, the SSP condition, direct reinforcement condition, and noncontingent reinforcement condition. Within this protocol, parents were also provided with specific detailed information on presentation of trials (e.g., random alternation of sounds, presentation of the sounds, inter-trial intervals), corrective procedure, and delivery of preferred items. More specifically, parents were given information on the target (S+) and non-target (S-) sounds for their child and information on identification of acceptable approximations, the procedural elements of delivering a trial within the SSP procedure, and conditioned reinforcement conditions. The parents engaged in a didactic session, where the procedural elements were discussed in detail. The researcher asked the parents questions to ascertain the parents' understanding of all procedural elements and to determine progression to the next training phase. Examples of questions asked after each phase of parent-training included: "How do you run the target sound for this phase (e.g., SSP condition)?," "Do you understand how to implement the correction procedure?," "Explain how to present the non-target sound for this phase?," "Do you have any further questions?"

Following the didactic training session, parents began the modelling phase of the parent training. This was conducted in a stepwise manner whereby parents had to demonstrate mastery with each condition of the intervention before moving on to the next condition. The same steps were used for parent training of each intervention condition. The parents were shown a video model of the first author demonstrating the given procedure for the target condition. Questions arising from the video presentation were answered before the parents were asked to identify the procedural elements of the given condition. Parents were invited to watch the video multiple times and to ask as

many questions as they needed until all of the procedural elements were identified correctly by the parents. The parents then progressed to imitating the models in a role play condition. The researcher acted as the child within these sessions and provided prompts to parents where needed. The parents were provided with corrective feedback during and after each session. The parents were required to reach a mastery criterion of 90% accuracy of delivery of trials within the session, with the researcher, before progressing to the final stage of the parent training. The final stage involved the parents engaging in a role play of the target condition with each other. Again corrective feedback was provided by the researcher and frequency data for correct and incorrect trials were recorded. Parents were required to reach a mastery criterion of 90% accuracy with the procedure before completing the parent training on each condition. Robert and Daniel's parents reached mastery criterion during the first test session of each condition and so progressed to delivering the intervention to their own children.

All training sessions were completed during one training day, which lasted approximately two hours. The training was conducted in the family homes, in the designated areas in which the intervention was to be delivered. The children were not present during the parent training sessions.

Baseline The baseline condition consisted of the delivery of 10 probe trials of the target sound (S+) and 10 probe trials of the non-target sound (S-) (i.e., 20 probes in total), randomly interspersed using a random inter-trial interval of between 5 s and 30 s. The parents were prompted with a visual cue by the researcher to say the target or non-target sound. A probe consisted of the parent saying the target or non-target sound, not providing any further interaction, and recording the child's response. Target and non-target sounds were interspersed throughout the session. Probes for Set A were taken first, followed by probes for Set B. The child's production of the S+ and S- sounds were recorded throughout the baseline. The S+ and S- were delivered once by the parent per pairing trial (i.e., "baboo"), in contrast to the original procedure in which the sound was repeated 3 times (Esch et al., 2009). This was due to recent research (Miliotis et al., 2012) which found that one sound per pairing trial is more effective than triads of opportunities per pairing trial. The parents were instructed to deliver the S+ and S- in exaggerated tones (Motherese; Falk, 2004) to increase the salience of the sounds. For example, when saying "ahfoo," Robert's parent would speak in a higher tone and louder pitch than normal conversational speech. This type of "motherese" or "infant directed speech" has been found to increase infant's language development (Saint-Georges et al., 2013), and has previously been utilized within the SSP literature (Esch et al., 2009).

For Robert, Stimulus Set A consisted of the S+ "baboo" and the S- "gah." Stimulus Set B consisted of the S+ "ahfoo" and the S- "ih." Stimulus Set A for Daniel consisted of the S+ "mah" and S- "dee" and Stimulus Set B consisted of the S+ "whoo" and the S- "guh." For both participants, Set A began intervention before Set B was included. The baseline for Set B began when Set A had reached the final condition.

The average length of the baseline sessions for Set A for Robert was 3.16 minutes and for Set B was 4.14 minutes. The average length of baseline sessions for Set A for Daniel was 3.2 minutes and the average length of baseline sessions for Set B was 3.3 minutes. Breaks of between 10 and 15 mins between each baseline session in both sets were given to the participants, whereby the participants had access to low preference

items for this period of time (as identified through the RAISD). No reinforcement was provided during these breaks. No notable interaction between the parents and participants took place during these break periods.

Stimulus-Stimulus Pairing The SSP sessions were identical to the baseline condition with the addition of the delivery of reinforcement. During SSP sessions, parents were prompted using visual cues to deliver the S+ or S- sounds on a random inter-trial interval between 5 s and 30 s, which was monitored by the researcher. Parents delivered the S+ or S- sound once per pairing trial. When delivering the S+, parents simultaneously delivered the selected reinforcer to the child. When delivering the S-, the parents did not deliver any reinforcement. If the participant emitted the S+ in the interval between the parent saying the S+ and the delivery of the reinforcer, the reinforcer was withheld for 20 s. For example, if the parent was in the process of saying the S+ and handing over the reinforcer and the child echoed the S+, the parent immediately withheld the delivery of the reinforcer and did not look at the child. This was to control for adventitious reinforcement. Of note, this correction procedure was never needed across any of the sessions for either child.

Direct Reinforcement This condition was initiated after the frequency of vocalizations in the SSP condition had shown five increasing data points. During this phase the vocal verbal model was given to prompt an echoic response from the child. The parent presented the S+, saying it once per second over three consecutive seconds (Esch et al., 2009). If the child emitted the S+ then the reinforcer was immediately delivered. This procedure was repeated every 5–10 s for a period of 5 min. This was in contrast to the SSP condition, in which reinforcement was presented regardless of the child echoing the S+. The parents were again prompted to deliver the S+ by the researcher holding a visual cue card. The researcher kept track of the timings on a stopwatch. During this condition, the S- was not presented by the parent, but the frequency of S- production by the child was still recorded.

Noncontingent Reinforcement This condition took place after vocalizations had increased in the direct reinforcement condition by five increasing data points. Each session lasted 5 min. The parent delivered reinforcement non-contingently every 30 s as prompted by the researcher who monitored timings using a stopwatch. This condition was conducted to ascertain if the vocalizations had acquired automatically reinforcing properties or if they were dependent on a vocal verbal model. In this condition, if the child continued to produce the S+ sounds at high rates it would be an indication that the sounds had become automatically reinforcing. During this condition there was no interaction between the parent and the child other than the delivery of reinforcement.

The parents did not deliver the S+ or S- sounds at any time during NCR. Eye contact was kept to a minimum and no verbal interaction took place. Similar to the SSP condition, a procedure to control for adventitious reinforcement was in place, whereby the parent withheld access to the reinforcer for 20 s contingent on the child producing the S+. Of note, this correction procedure was not needed across any of the sessions for either child.

Return to Direct Reinforcement This condition was identical to the previous direct reinforcement condition.

Social Validity

Social validity was assessed using a six item questionnaire. This questionnaire was completed by the parents following the completion of the study. The social validity measure was a measure of parents' experiences of the intervention package. It consisted of the following six statements relating to their experiences with the intervention: "I was confident in my ability to conduct the intervention," "It was difficult to find time to conduct the intervention," "I have noticed an increase in my child's babbling/verbal behavior since participating in the intervention," "This intervention provided me with meaningful one-on-one time with my child," "My child was less likely to engage in negative behaviors during the intervention," and "My child appeared to enjoy the intervention." Agreement with these statements were scored on a scale of 1 to 5, with 1 indicating strongly disagree and 5 indicating strongly agree. Item 2, "It was difficult to find time to conduct the intervention," was reverse-scored.

Fig. 1 Intervention results for target vocalizations for Robert

Fig. 2 Intervention results for target vocalizations for Daniel

Results

Intervention

The data for each child participant are presented in Figs. 1 and 2 and represent the vocalizations per min across each condition.

Results for Robert are shown in Fig. 1. The upper panel shows Set A (S+ “baboo”; S- “gah”) and the lower panel shows Set B (S+ “ah-foo”; S- “ih”). There was an increase in the mean production of “baboo” across the conditions. The production of “baboo” increased from a mean of 0.43 sounds per min in baseline ($SD = 0.23$) to a mean of 2.33 sounds per min in the SSP condition ($SD = 0.89$), showing an effect of the SSP condition on phoneme production. There was no change in the mean production of “gah” between baseline (0.13 sounds per min, $SD = 0.15$) and the SSP condition (0.15

sounds per min, $SD = 0.18$). Upon introduction of the direct reinforcement condition, the rate of “baboo” vocalizations immediately increased to a mean of 3.7 sounds per min ($SD = 0.66$). The production of “gah” increased slightly during the direct reinforcement condition ($M = 0.25$ sounds per min, $SD = 0.21$). Upon removal of direct reinforcement during the NCR condition, responding decreased to a mean of 1.22 responses per min ($SD = 0.22$) for “baboo” and production of “gah” remained unchanged ($M = 0.28$ sounds per min, $SD = 0.23$). When the direct reinforcement condition was reintroduced, production of “baboo” increased to a mean of 3.33 responses per min ($SD = 0.24$). Production of “gah” decreased to a mean of 0.13 responses per min during this phase ($SD = 0.15$).

Responding was similar with Set B. The production of the target sound in Set B (S+ “ahfoo”; S- “ih”) increased from a mean of 0.74 sounds per min ($SD = 0.23$) in baseline to a mean of 1.41 sounds per min ($SD = 0.37$) in the SSP condition, showing an effect of the SSP condition on vocalizations. The mean production of “ih” did not change significantly between baseline ($M = 0.73$ sounds per min, $SD = 0.22$) and the SSP condition ($M = 0.65$ sounds per min, $SD = 0.18$). Upon introduction of the direct reinforcement condition, the target sound increased further to a mean of 2.04 sounds per min ($SD = 0.26$). This effect was not demonstrated for the S- with mean responding remaining unchanged ($M = 0.72$ sounds per min, $SD = 0.3$). Upon removal of direct reinforcement during the NCR condition, “ahfoo” responding decreased to a mean of 1.45 responses per min ($SD = 0.25$). During this condition, production of “ih” decreased slightly to a mean of 0.5 sounds per min ($SD = 0.26$). Responding for “ahfoo” increased again upon the re-introduction of the direct reinforcement condition to a mean of 1.9 responses per min ($SD = 0.25$). When the direct reinforcement condition was reintroduced, production of “ih” remained unchanged at a mean of 0.55 responses per min ($SD = 0.19$).

Results for Daniel are presented in Fig. 2. The upper panel represents Set A and the bottom panel shows Set B. The production of S+ “ma” increased from a mean of 0.73 vocalizations per min in baseline ($SD = 0.10$) to a mean of 1.97 sounds per min in the SSP condition ($SD = 0.61$). The production of the S- (“dee”) remained unchanged between baseline ($M = 0.45$ sounds per min, $SD = 0.06$) and the SSP condition ($M = 0.42$ sounds per min, $SD = 0.24$). Upon introduction of the direct reinforcement condition, mean rate of “ma” vocalizations were 3.25 responses per min ($SD = 0.19$) and mean rate of “dee” vocalizations increased slightly to 0.85 responses per min ($SD = 0.34$). During the NCR condition, mean responding for “ma” decreased to 1.96 vocalizations per min ($SD = 0.24$) and mean production of “dee” remained unchanged ($M = 0.86$ sounds per min, $SD = 0.26$). Responding for “ma” increased once the direct reinforcement condition was implemented to a mean of 2.75 responses per min ($SD = 0.19$). During this condition, mean production of “dee” did not change, remaining at 0.85 sounds per min ($SD = 0.25$).

For Set B the production of S+ “whoo” increased from a mean of 0.98 sounds per min in baseline ($SD = 0.35$) to a mean of 1.95 sounds per min in the SSP condition ($SD = 0.82$). Mean production of the S- (“guh”) did not change significantly between baseline ($M = 0.85$ sounds per min, $SD = 0.24$) and the SSP condition ($M = 0.79$ sounds per min, $SD = 0.2$). Upon introduction of the direct reinforcement condition, rate of “whoo” vocalizations increased to a mean of 2.85 responses per min ($SD = 0.34$). Mean production of “guh” increased slightly to 0.9 sounds per min ($SD = 0.2$) in

the direct reinforcement condition. During the NCR condition, “whoo” responding decreased slightly to a mean of 2.49 vocalizations per min ($SD = 0.18$) and “guh” responding decreased slightly to a mean of 0.54 sounds per min ($SD = 0.19$). There was a further increase in mean responding for “whoo” with the reintroduction of the direct reinforcement condition ($M = 3.1$, $SD = 0.26$). During this condition, production of “guh” increased slightly to a mean of 0.95 responses per min ($SD = 0.19$).

Social Validity

The social validity items were scored on a scale between 1 and 5, with higher scores indicating higher social validity. Mean scores for both Robert’s and Daniel’s parents were 4.3. Social validity measures demonstrated that the parents did not find it difficult to find time to implement the intervention and that both children appeared to enjoy the intervention. The parents reported they were confident in their ability to conduct the procedure and they agreed that the intervention gave them meaningful one-on-one time with their children. Both parents reported an increase in their child’s babbling/verbal behavior after the intervention.

Discussion

This study investigated the effects of a parent implemented SSP procedure on the vocalizations of two children with ASD and results demonstrated positive outcomes of increased frequency of target sound production across both children. For both participants, the target responses (S+) were higher in frequency across all conditions relative to baseline while the non-target (S-) responses remained relatively unchanged. Although the current research was based on an intervention designed by Esch et al. (2009), it was also adapted based on recommendations from other research (Miliotis et al., 2012) to include the use of one pairing sound per trial and the addition of parents as interventionists. Our findings are in line with previous research utilizing a similar SSP procedure (Esch et al., 2009; Miliotis et al., 2012; Rader et al., 2014); however, the current study is the first to demonstrate such effects with this particular procedure with parents as interventionists.

Both Robert and Daniel showed increases of over 50% in the frequency of vocalizations across all target phonemes. This is notable given that both participants had previously been receiving intervention with minimal benefit to their vocal verbal behavior. The results suggest that the SSP condition was responsible for initial increases in vocal responding, with further increases in responding observed when direct reinforcement was implemented. Although a drop in responding was observed in the NCR condition, responding remained higher than baseline levels. The overall results provide support for the contention that the SSP procedure works to condition speech sounds as positive reinforcers. This may explain why target responses reduced during NCR but did not diminish entirely. In other words, hearing the target speech sounds automatically reinforced sound production, which was not the case in the baseline condition. Future researchers might consider presenting the NCR condition immediately following the SSP condition to further evaluate the role of automatic

reinforcement in target sound production in the absence of a history of direct reinforcement.

It is important to note that this study focused on increases in sound production and not necessarily echoic responding. Although a model of the target sound was provided by the parents, imitation of the sounds (i.e., sound production only following the model) was not a target of this procedure and was not explicitly measured. Increasing vocalizations is an important outcome but next steps, clinically, would likely include demonstrating echoic control of responding and then transferring responding to other verbal operants. Future research should examine what procedure, if any, would be required to develop echoic once vocalizations have increased via SSP.

It is pertinent to acknowledge a number of limitations in the current research. Although data were collected on the parent training responses within each intervention condition, there were no procedural integrity checks conducted of the parent implemented SSP procedure. The researcher was present during all sessions and provided prompts for parent implementation of the procedure; however, data regarding correct implementation were not collected. Future research should employ more rigorous measures of procedural integrity. Furthermore, the parents in this study were not trained to proficiency in independent implementation. Future research could examine whether parents can independently implement SSP with fidelity. Another limitation to consider is the reinforcement schedule across conditions. During the NCR condition, reinforcement was delivered at 30 s intervals; thus, it is possible that reinforcement may have been delivered more often in this condition than in the SSP or differential reinforcement conditions. Future research could examine whether variations in reinforcement delivery across conditions effects results.

An important element of the study includes the attempt to ensure prerequisites to language were present by testing participants using some items from the C-PIRK (Greer & McCorkle, 2003) before intervention. However, the prerequisites needed for vocal verbal communication are not clearly identified within the literature. While previous papers in the SSP literature (Esch et al., 2005; Esch et al., 2009; Stock et al., 2008) have used the BLAF (Sundberg & Partington, 1998) as a measure of verbal behavior, more research is needed to determine what, if any, prerequisites are necessary for SSP to be effective with a particular individual.

While earlier SSP research used a familiar adult or parent to deliver the intervention (Sundberg et al., 1996; Smith et al., 1996), the current study is the first since then to examine the outcomes of parent-led SSP procedures on increasing speech sounds of children with ASD. These preliminary findings are promising, with increases in vocalizations observed in the two children. The social validity measures highlight that parents were happy with the intervention and indicated their children appeared to enjoy the intervention. Additionally, the parents noted an increase in their child's babbling as a result of participating.

The current study demonstrated positive outcomes of a parent implemented SSP procedure on increasing the frequency of vocalizations in two children with ASD. Apart from adding to the SSP literature base on the importance of such interventions, the study also provides preliminary support for teaching these skills to parents to promote early speech sounds in their children. Including parents within interventions can increase learning opportunities for children, as well as support better generalization and maintenance outcomes.

Compliance with Ethical Standards

Conflict of Interest The authors declare that we have no conflict of interest. There are no potential conflicts of interest pertaining to this research. The authors confirm there are no relationships or interests that had a direct or potential influence or impart bias on this work.

Ethical Approval All procedures performed in this research were in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed Consent Informed consent was obtained from all individual participants included in the study.

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