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FURTHER EVALUATION OF METHODS TO IDENTIFY MATCHED STIMULATION

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The effects of preferred stimulation on the vocal stereotypy of 2 individuals were evaluated in two experiments. The results of Experiment 1 showed that (a) the vocal stereotypy of both participants persisted in the absence of social consequences, (b) 1 participant manipulated toys that did and did not produce auditory stimulation, but only sound-producing toys decreased his vocal stereotypy, and (c) only noncontingent music decreased vocal stereotypy for the other participant, but sterotypy paradoxically increased when toys were presented with music. Using a three-component multiple schedule, the results of Experiment 2 showed that the vocal stereotypy of both participants remained below preintervention levels following the removal of auditory stimulation and that 1 participant's vocal stereotypy increased following the removal of contingent reprimands. These patterns suggest that auditory stimulation functioned as an abolishing operation for vocal stereotypy and reprimands functioned as an establishing operation for vocal stereotypy. Together, the two experiments provide a method for identifying alternative stimulation that may substitute for automatically reinforced behavior.

DESCRIPTORS: automatic reinforcement, matched stimulation, noncontingent reinforcement, stereotypy, establishing operations, abolishing operations

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The primary difficulty in assessing automatically reinforced behavior is the relative inaccessibility of the sensory consequences thought to maintain behavior (e.g., LeBlanc, Patel, & Carr, 2000; Vollmer, 1994). Because the stimulation that supports such behavior is difficult to manipulate, assessment is often limited to demonstrating persistence of behavior in the absence of social reinforcement. Subsequent analyses are then conducted to identify preferred activities that compete for behavioral allocation with the problem behavior. The clinician can then evaluate the extent to which the problem behavior decreases during noncontingent access to these sources of preferred stimulation. If these procedures do not identify activities that compete effectively with problem behavior, treatment will often consist of punishment or a combination of noncontingent access to preferred items and punishment (LeBlanc et al.).

The effects of noncontingent reinforcement (NCR) on automatically reinforced behavior have been robustly demonstrated (e.g., Ahearn, Clark, DeBar, & Florentino, 2005; Higbee, Chang, & Endicott, 2005; Patel, Carr, Kim, Robles, & Eastridge, 2000; Piazza, Adelinis, Hanley, Goh, & Delia, 2000; Rapp, Vollmer, Dozier, St. Peter, & Cotnoir, 2004; Sidener, Carr, & Firth, 2005; Tang, Patterson, & Kennedy, 2003). For example, Piazza et al. found that providing access to preferred items that seemingly matched the overt sensory product produced by engaging in the automatically reinforced behavior produced substantial decreases in that behavior. However, access to unmatched stimuli (i.e., activities that produce stimulation dissimilar from that produced by engaging in the problem behavior) yielded less pronounced reduction. The results of Piazza et al. suggest that selecting competing stimulation based on the structural properties of the

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concurrently available stimulation is sufficient; however, Ahearn et al. found that both matched and unmatched preferred objects can produce comparable reductions in automatically reinforced behavior.

Studies that have evaluated sensory reinforcers using NCR procedures are limited in at least three ways. First, it is not clear whether reductions in automatically reinforced behavior are attributable to stimulus competition (i.e., alternative sensory reinforcement temporarily displaces the automatic sensory reinforcer) or stimulus substitution (i.e., the preferred item generates similar or identical stimulation; LeBlanc et al., 2000). Second, few studies of NCR have evaluated the extent to which the removal of matched or unmatched actitivies is followed by either continued behavioral suppression or a subsequent increase in automatically reinforced behavior. A handful of studies have shown that automatically reinforced behavior can increase following periods when the behavior was blocked or not permitted (e.g., Forehand & Baumeister, 1973; Rapp, 2006; Rapp et al., 2004), when the behavior was punished (e.g., Rollings & Baumeister, 1981), when a competing behavior was reinforced with edible items (e.g., Forehand & Baumeister, 1971), and when preferred objects were provided on a variable-time (VT) schedule (Ahearn, Clark, Gardenier, Chung, & Dube, 2003). These increases may indicate that deprivation for the sensory consequences of the behavior was imposed by the intervention. Finally, classification of matched or unmatched sensory stimulation has been based on the overt products of stereotypy rather than on the effect that the alternative stimulus has on the target behavior during and following access to the alternative stimulus (Rapp, 2006). Given these limitations, additional methods are needed to further evaluate the effects of preferred stimulation on automatically reinforced behavior.

The purpose of the following experiments was to evaluate a method for determining the extent to which stimulation provided during NCR is functionally matched to the sensory consequence produced by engaging in the automatically reinforced behavior. The response deprivation hypothesis states that restricting behavior (and consumption of the reinforcer) below its free-operant level of occurrence will produce a subsequent increase in behavior above its free-operant level when it is available (Timberlake & Allison, 1974). Extended to automatically reinforced behavior, the response deprivation hypothesis predicts that if behavioral reduction produced via NCR is a function of reinforcer substitution (i.e., alternative stimulation is functionally matched to the sensory consequence of the behavior), then the target behavior should not increase relative to preintervention level of occurrence following the removal of NCR. Conversely, if behavioral reductions are a function of reinforcer competition (i.e., the stimulation is functionally dissimilar), it is possible that NCR may impose deprivation for stimulation generated by the target behavior. In this scenario, the response deprivation hypothesis predicts that removal of the competing stimulation may set the occasion for increases in automatically reinforced behavior.

GENERAL METHOD

Participants and Target Behavior

Brian and Nevin were 9-year-old boys who had been diagnosed with autism and mental retardation. Brian and Nevin both engaged in vocal stereotypy, defined as acontextual audible sounds or words produced with an open or closed mouth. Vocal stereotypy included repetitions of words and phrases (e.g., "time for bed time for bed"), singing, and humming. Appropriate vocalizations (e.g., "bathroom please") were excluded. Both participants engaged in vocal stereotypy across a variety of activities including when in the classroom. Their teachers reported that their vocal stereotypy often interfered with training tasks and was disruptive to other students. Toy manipulation was defined as any contact of a participant's hand with a toy. Music interaction was defined as Nevin standing or sitting close enough to touch the CD player with either hand (see Experiment 1 below). Based on these definitions, it was possible to manipulate multiple toys simultaneously or to manipulate one or more toys while listening to music (Nevin only).

Setting

All sessions took place in a room (5 m by 6 m) located in a short-term residential facility for children with severe behavior disorders. A trainer was present for each session. Sessions were conducted 3 to 4 days per week. Three to six sessions were conducted per day (see below for duration of sessions within each experiment).

Data Collection and Interobserver Agreement

Data for both participants were collected through direct observation of the session using handheld computers that were equipped with a program that recorded the duration of each response. Each session was also videotaped. Interobserver agreement scores were obtained by having a second independent observer collect data either with the primary observer or from videotaped sessions. The primary observer was always seated behind a one-way window. The duration of vocal stereotypy and toy manipulation (music interaction included) was scored in real time and converted to percentage of time by dividing the number of seconds engaged in the event by the total number of seconds in the session and then multiplying by 100%. Interobserver agreement was calculated for 27% and 28% of sessions across experiments for Brian and Nevin, respectively, using the average agreement within 10-s intervals. That is, data that were collected by the primary and secondary observers were compared in 10-s bins. For each bin, the smaller number was divided by the larger number and then multiplied by 100%. Percentages for each bin were then totaled and divided by the total number of bins. For Brian, the mean agreement scores for vocal stereotypy and toy manipulation across experiments were 96% and 92%. For Nevin, the mean agreement scores for vocal stereotypy and toy manipulation (music interaction included) across experiments were 93% and 97%.

EXPERIMENT 1: NO INTERACTION VERSUS PREFERRED STIMULATION

The purposes of this experiment were (a) to evaluate the extent to which each participant's vocal stereotypy persisted in the absence of social consequences, (b) to identify preferred sources of alternative stimulation for each participant, and (c) to evaluate the effects of providing noncontingent access to highly preferred stimulation on each participant's vocal stereotypy. For both participants, the target behaviors were vocal stereotypy and toy manipulation.

Design and Procedure

A free-operant stimulus preference assessment (Roane, Vollmer, Ringdahl, & Marcus, 1998) was conducted to identify preferred objects that generated stimulation that was either matched or unmatched to stimulation generated by vocal stereotypy.

Stimulus preference assessment. Brian participated in two 10-min assessments and Brian participated in three 10-min assessments; each assessment was conducted on a separate day. For each session, the same seven (Brian) or eight (Nevin) items were available. Items that produced stimulation that matched the putative sensory product of vocal stereotypy (in that they produced sounds) included a musical keyboard, a letter board, a phonics board, a toy workbench, a toy radio, and music from a CD player (Nevin only). To access music, Nevin was required to sit or stand within reaching distance of a CD player, which was placed 2 m away from the other objects. When Nevin was in proximity, the trainer played the CD, which contained various nursery rhymes and brief songs. Items included in the preference assessments that generated stimulation that was not matched to the product of vocal stereotypy included building blocks and a figurine.

Based on the results of the preference assessment (Figure 1), vocal stereotypy was evaluated in the presence of highly preferred matched stimulation for Brian (toy workbench and letter board) and in the presence of matched (letter board, workbench, CD) and unmatched (building blocks and figurine) stimulation for Nevin. A reversal design was used for both participants, and the effects of music (from the CD player) and matched and unmatched toys were evaluated, separately and in combination, for Nevin. Each session was 5 min in duration. No social consequences were provided for the participants' behavior during any of the conditions.

Effects of preferred stimulation. Brian participated in three conditions. In the no-interaction condition, he was placed in the session room without access to preferred toys or training materials. A trainer was present, but no social consequences were provided. In the toys condition, Brian was provided the aforementioned toys. The toys no-audio condition was identical to the toys condition except that the batteries were removed from the toys, which prevented audio stimulation (similar to Taylor, Hoch, & Weissman, 2005). Brian could still obtain tactile (and possibly visual) stimulation by pushing buttons and manipulating parts. This condition evaluated the extent to which unmatched stimulation decreased Brian's vocal stereotypy.

Nevin participated in four conditions. The no-interaction condition was the same as described for Brian. In the music condition, the participant was placed in the session room and was provided with noncontingent access to music. The trainer was present and held the CD player so that Nevin could not adjust the volume or select the songs. Attempts by Nevin to press buttons on the CD player were gently blocked and no additional consequences were provided. Unlike the preference assessment sessions, music was provided regardless of where Nevin was located. The toys condition was the same as described for Brian, except that Nevin had access to two putatively matched objects and two unmatched objects. Nevin was given four toys because results from the stimulus preference assessment indicated that he tended to allocate his behavior to multiple toys simultaneously, rapidly alternate allocation across toys, or both. The music and toys condition combined the music condition and the toys condition (i.e., music was provided noncontingently, and the same four toys were available).

Results and Discussion

Figure 1 shows the results of the preference assessments for both participants. Brian allocated the highest percentage of time to the letter board and the toy workbench, both of which matched the product of vocal stereotypy. Therefore, the effect of providing access to both the letter board and the toy workbench was subsequently evaluated. Nevin engaged with many of the objects during each of the three sessions. Although Nevin allocated the highest percentage of time to the CD player (matched) and building blocks (unmatched), he typically manipulated multiple items simultaneously. (This is why the cumulative percentage of time manipulating objects exceeds 100%.) Therefore, the effects of matched and unmatched stimulation were evaluated for Nevin.

Figure 2 shows the results of the subsequent analyses for both participants. The level of Brian's vocal stereotypy during the toys, no-interaction, and toys no-audio conditions is displayed. In the first toys phase, a near-zero level of vocal stereotypy (M = 0.2%) was observed. In the ensuing no-interaction phase, a high to moderate level of vocal stereotypy (M = 66%) occurred. In the second toys phase, vocal stereotypy was again near zero (M = 0.4%). In the second no-interaction phase,

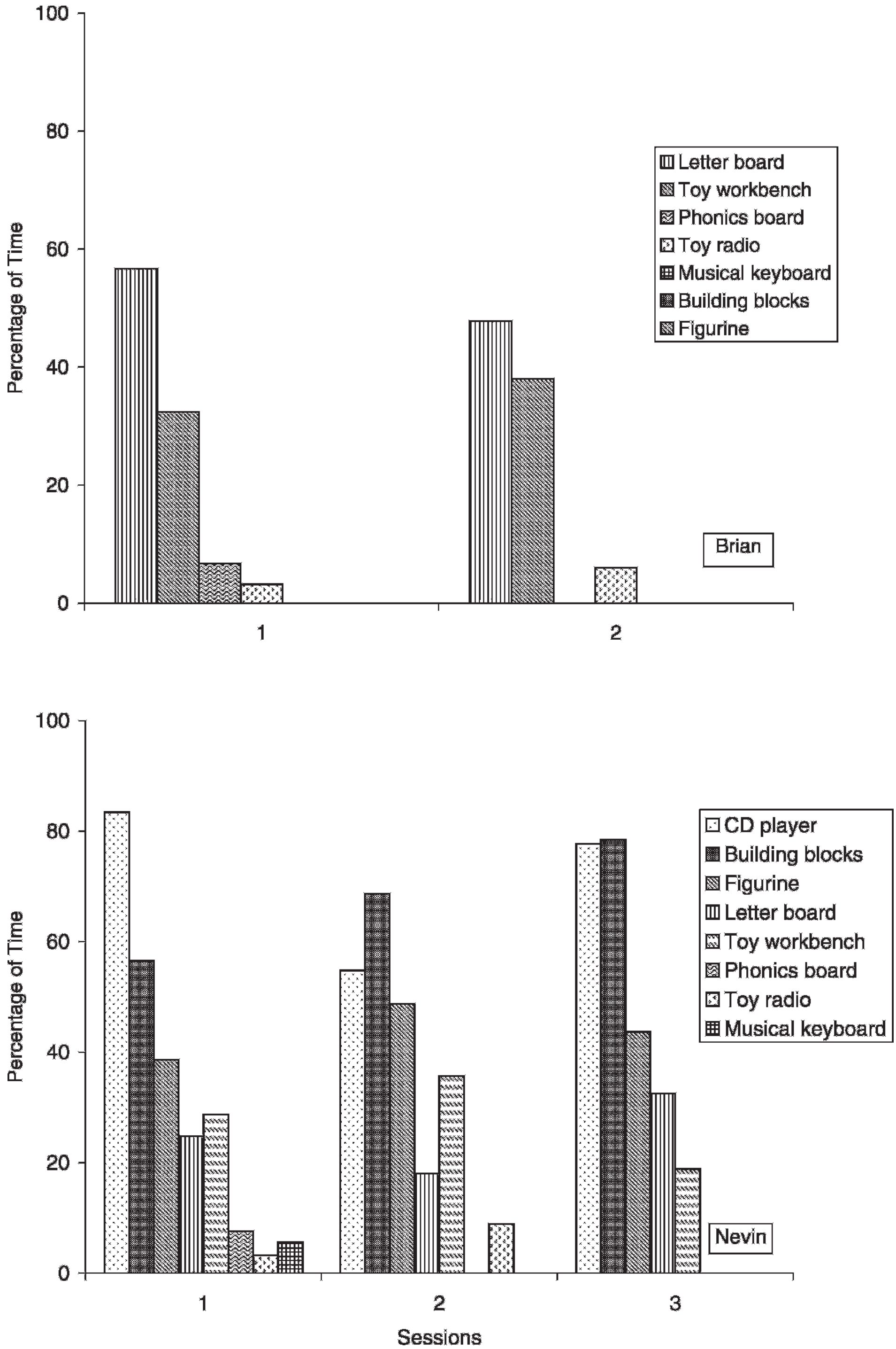


Figure 1. Percentage of time Brian engaged with objects during the first and second free-operant stimulus preference assessments (top). Percentage of time Nevin engaged with objects during the first, second, and third free-operant stimulus preference assessments (bottom).

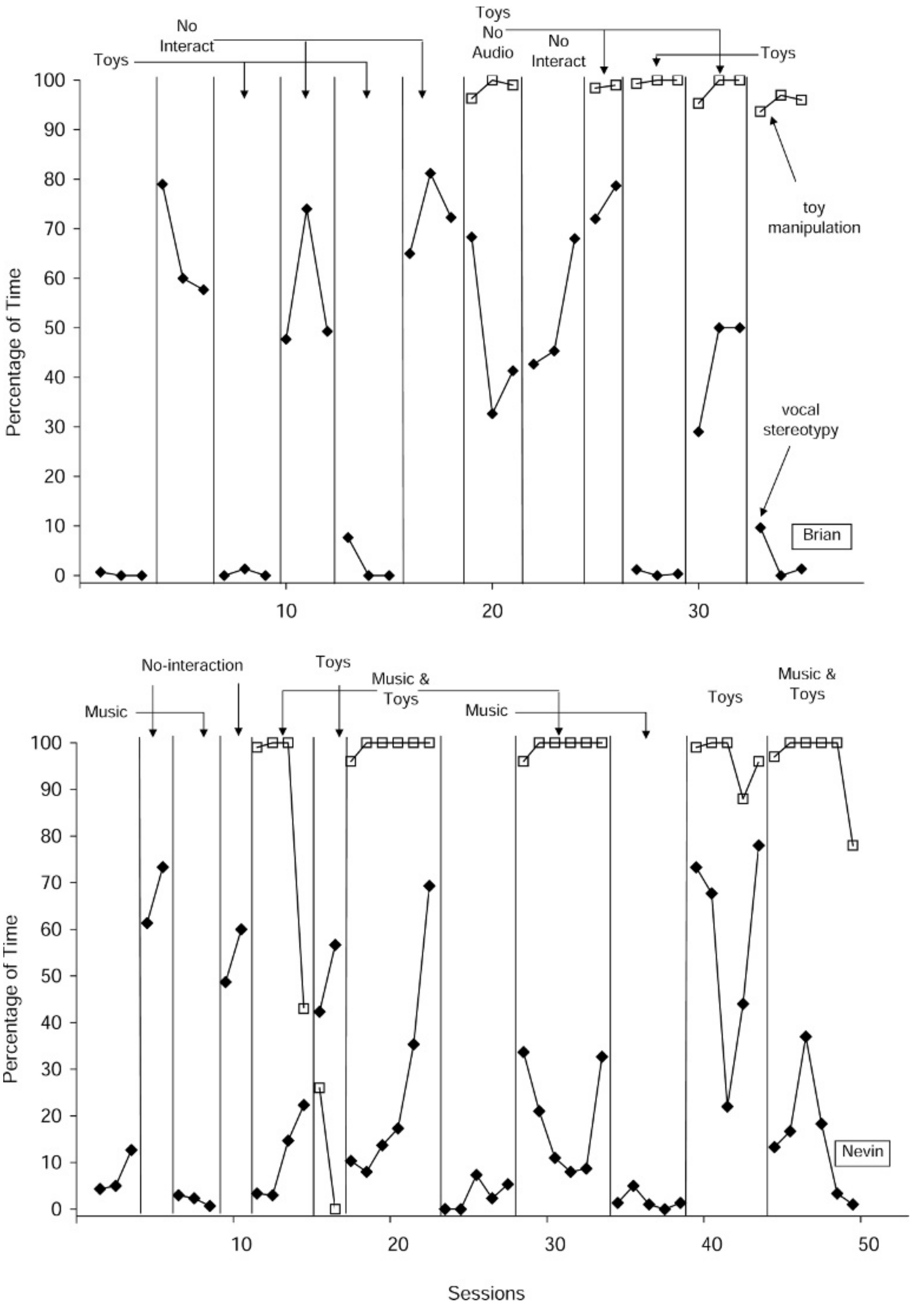


Figure 2. Percentage of time Brian engaged in vocal stereotypy and manipulated toys during no-interaction, toys no-audio, and toys conditions (top). Percentage of time Nevin engaged in vocal stereotypy and manipulated toys during no-interaction, music, music and toys, and toys conditions (bottom).

vocal stereotypy increased to a moderate level (M = 57%). In the third toys phase, vocal stereotypy was again at or near zero (M = 3%). As before, a high level of vocal stereotypy occurred in the third no-interaction phase (M = 73%). During the first toys no-audio phase, a high to moderate level of vocal stereotypy (M = 47%) and a high level of toy manipulation (M = 98%) were observed. In the fourth no-interaction phase, a moderate, increasing level of vocal stereotypy (M = 52%) occurred. During a return to toys no audio, again a moderate level of vocal stereotypy (M = 75%) and a high level of toy manipulation (M = 99%) were obtained. During the fourth toys phase, vocal stereotypy (M = 0.6%) decreased to near zero and toy manipulation remained high (M = 99.8%). During a third implementation of toys no audio, a moderate level of vocal stereotypy (M = 43%) and a high level of toy manipulation (M = 98%) occurred. In the final toys phase, again a lower level of vocal stereotypy (M = 4%) and a high level of toy manipulation (M = 95%) were observed.

In summary, when no alternative stimulation was present (during the no-interaction condition) high levels of vocal stereotypy occurred. When Brian manipulated toys that generated auditory stimulation, vocal stereotypy decreased. Conversely, when he was given access to identical toys that did not generate auditory stimulation, vocal stereotypy occurred frequently.

The lower panel of Figure 2 shows the levels of Nevin's vocal stereotypy and toy manipulation during the music, no-interaction, music and toys, and toys conditions. In the first music phase, a low but slightly increasing level of vocalizing (M = 7%) occurred. In the first no-interaction phase, a moderate to high level of vocal stereotypy (M = 67%) was observed. In the second music phase, a low level of vocal stereotypy (M = 2%) was obtained. A return to the no-interaction phase again produced an increase in vocal stereotypy (M = 54%). In the first music and toys phase, a low to moderate but increasing level of vocal stereotypy (M = 11%) and a high level of toy manipulation (M = 85%) occurred. In the first toys phase, vocal stereotypy increased to a moderate level (M = 49%) and toy manipulation decreased to zero (M = 13%). In the second music and toys phase, toy manipulation was high (M = 99%) and vocal stereotypy increased across sessions (M = 26%). In the third music phase (toys were absent), vocal stereotypy was at or near zero (M = 3%). In the third music and toys phase, vocal stereotypy became variable (M = 19%) and toy manipulation was again high (M = 99%). In the fourth music phase, the level of vocal stereotypy was again low (M = 2%). In the second toys condition, vocal stereotypy increased but was variable (M = 57%) and toy manipulation was high (M = 97%). In the fourth music and toys phase, vocal stereotypy decreased but was again variable (M = 15%) and toy manipulation was high (M = 96%).

The results for Nevin show that stimulation from matched and unmatched toys was not as effective as auditory stimulation from the CD player for decreasing his vocal stereotypy. In general, levels of vocal stereotypy were low during music, moderate during music and toys, and high during no-interaction and toys conditions. Because levels of vocal stereotypy in the toys phases appeared to be comparable to the levels observed in the no-interaction phases, it is likely that toys exerted little or no effect on Nevin's vocal stereotypy. Although vocal stereotypy was consistently low only when auditory stimulation (music) was provided, the addition of toys (in the music and toys phase) appeared to increase vocal stereotypy. It is noteworthy that during this evaluation Nevin typically manipulated the nonauditory (unmatched) toys or manipulated the auditory toys without activating the auditory stimulation.

The results of Experiment 1 demonstrated that (a) auditory stimulation decreased vocal stereotypy for both participants, (b) other forms of stimulation (e.g., tactile, visual) did not decrease vocal stereotypy for either participant, and (c) Nevin's vocal stereotypy increased when toys (i.e., other modalities of stimulation) were added to music. For both participants, high levels of vocal stereotypy occurred in the no-interaction condition, suggesting that each participant's vocal stereotypy was maintained by a source of automatic reinforcement; however, the results from this experiment cannot be used to rule out the effect of social consequences (e.g., attention, escape from demands) on vocal stereotypy. By contrast, both participants displayed low levels of vocal stereotypy when auditory stimulation was available, suggesting that such stimulation competed with or substituted for the sensory stimulation generated by vocal stereotypy.

Further analyses were required to determine to whether decreases in Brian's and Nevin's vocal stereotypy were a function of reinforcer competition or substitution. If auditory stimulation is functionally matched to the sensory product of vocal stereotypy, then removal of such stimulation should not set the occasion for increases in vocal stereotypy compared to the preintervention or free-operant level of occurrence. Conversely, if auditory stimulation is not functionally matched to the product of vocal stereotypy, then its removal should occasion an increased level of vocal stereotypy.

EXPERIMENT 2: ASSESSMENT OF MOTIVATING OPERATIONS

The results of some recent studies suggest that some forms of automatically reinforced behavior may be sensitive to motivational operations (e.g., Rapp, 2004, 2005, 2006; Rapp et al., 2004; Van Camp et al., 2000). For example, Rapp et al. showed that stereotypy often increased above prior baseline levels following periods when access to stereotypy was restricted. This pattern suggests that a functionally dissimilar intervention might serve as an establishing operation (EO) for automatically reinforced behavior. Rapp (2006) described a method to evaluate this possibility using a multiple schedule wherein behavior is measured during three successive components: preintervention, intervention, and postintervention. It was found that the component that followed an intervention providing continuous access to matched toys always produced a lower level of stereotypy than the preintervention component (Rapp, 2006). However, when the intervention was response blocking, the component that followed intervention (no alternative and presumably unmatched stimulation) always contained higher levels of stereotypy than the preintervention component.

Based on the response deprivation hypothesis and the pattern described above, a functionally matched intervention may serve as an abolishing operation (AO) for stimulation generated by problem behavior. This functional match should be reflected in decreased or unchanged levels of behavior, relative to preintervention, in the component that follows intervention with matched stimulation. Conversely, a functionally unmatched intervention may decrease the level of target behavior but may actually serve as an EO for stimulation generated by the target behavior. The EO effect should be reflected in an increased level of the target behavior in the component that follows intervention.

In this experiment, the effect of access to the letter board and toy workbench, both of which produced audio stimulation, was evaluated for Brian. For Nevin, the effect of access to music from the CD player was evaluated. To examine the sensitivity of the three-component method, the effects of gum and contingent verbal reprimands were also evaluated for Nevin. The reprimand sequence was conducted with Nevin because his mother reported that she frequently used verbal reprimands to interrupt his vocal stereotypy.

Design and Procedure

Changes in each participant's vocal stereotypy from pre- to postintervention were evaluated using a combination of a reversal design with a multiple schedule (Brian) and a brief reversal with a multiple schedule (Nevin). For Brian, preferred stimulation involved access to two toys (letter board and toy workbench). For Nevin, preferred stimulation involved independent access to music and chewing gum. The effect of access to chewing gum on vocal stereotypy was evaluated because it appeared to be highly preferred (i.e., he frequently requested gum). The overt stimulation produced by chewing gum did not match that of vocal stereotypy, and the act of chewing would potentially compete with vocal stereotypy. To evaluate an intervention that provided no explicit alternative stimulation, the effect of contingent verbal reprimands (e.g., "Nevin, stop it") on vocal stereotypy were also evaluated.

Brian's vocal stereotypy was evaluated using two sequences. Each sequence contained three 15-min components (45 min total per session). One sequence was conducted per day. In the no-interaction sequence, the first, second, and third components were the same. During each component, the procedures were identical to the no-interaction condition used in Experiment 1. This sequence evaluated natural changes in levels of vocal stereotypy across the 45-min session. In addition, the third component of the no-interaction sequence served as a control for the third component of the other two sequences. In the toys sequence, the procedures in the first and third components were identical to the no-interaction condition and the second component was identical to the toys condition used in Experiment 1. This sequence evaluated Brian's behavior prior to and immediately following an intervention that had been previously shown to decrease his vocal stereotypy. An AO effect for vocal stereotypy would be identified if responding in the third component of the toys sequence was lower than responding in the first component; an EO effect would be identified if responding in the third component of the toys sequence was higher than responding in the first component of the toys sequence and higher than responding in the third component of the no-interaction sequence.

Nevin's vocal stereotypy was evaluated during four sequences. Each sequence contained three 10-min components (30 min total per session). One sequence was conducted per day. In the toys sequence, the procedures were the same as in Experiment 1. The toys sequence was used as the control because comparable levels of vocal stereotypy occurred during the toys and no-interaction conditions. In the toys and music sequence, the first and third components were the same as in the toys condition described above. The second component also contained the four toys and continuous access to music from the CD player. This sequence evaluated Nevin's behavior prior to, during, and immediately following a matched intervention that had been previously shown to decrease vocal stereotypy.

In the toys and gum sequence, the first and third components were the same as in the toys condition. During the second component, Nevin was given one piece of chewing gum and the same toys were available. This sequence evaluated his behavior prior to, during, and immediately following an intervention that was hypothesized (based on informal observation) to decrease vocal stereotypy but was not matched to the product of vocal stereotypy.

In the toys and reprimand sequence, the first and third components were the same as the toys condition. During the second component, brief verbal reprimands (e.g., "stop that Nevin") were delivered on a continuous schedule following instances of vocal stereotypy and the same toys were available. To minimize potential carryover (i.e., inhibitory stimulus control) into other components, a specific trainer was used exclusively for the reprimand component. This sequence evaluated Nevin's behavior prior to, during, and immediately following an unmatched intervention.

An AO effect for Nevin's vocal stereotypy would be identified if responding in the third component of the toys and gum sequence was lower than responding in the first component of the toys and gum sequence and lower than responding in the third component of the toys sequence. By contrast, an EO effect would be identified if responding in the third component of the toys and gum sequence was higher than responding in the first component of the toys and gum sequence and higher than responding in the third component of the toys sequence.

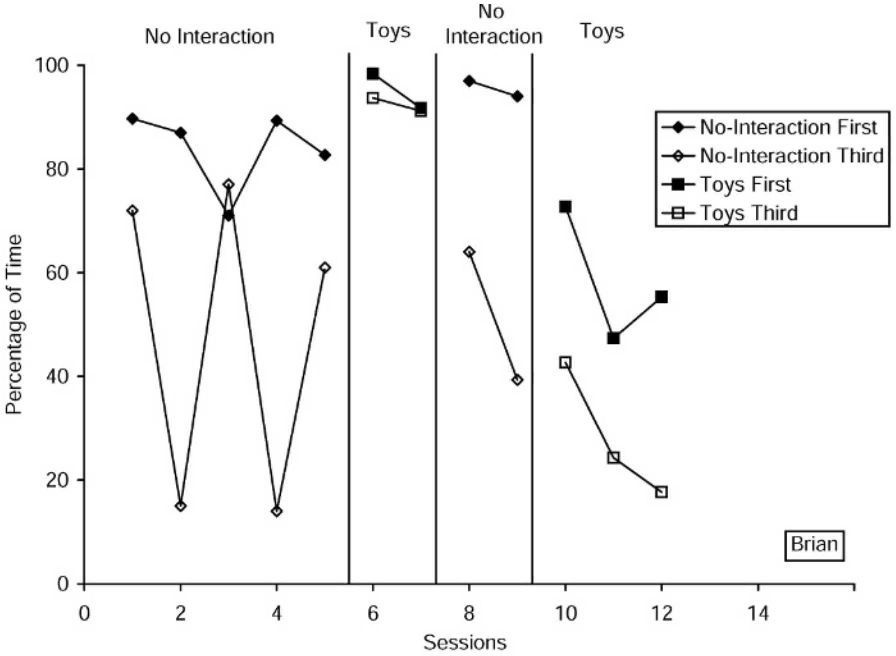
Results and Discussion

Figure 3 shows the results of the multiple-schedule analysis for Brian. To aid in the visual comparison of first and third components, data from the second component are not shown (data are available from the author and are described below). In the first no-interaction phase, relatively high levels of vocal stereotypy occurred during the first (M = 84%) and second (M = 83%) components, with a variable level of vocal stereotypy occurring during the third component (M = 48%). In the next phase, vocal stereotypy was low in the second component (M = 11%) and high during the first (M = 95%) and third (M = 92%) components of the toys sequence. In the following no-interaction phase, vocal stereotypy was high in the first component (M = 95%), lower in the second component (M = 72%), and substantially lower in the third component (M = 52%). In the final phase, vocal stereotypy was moderate in the first component (M = 58%), lower in the second component (M = 14%), and moderate to low in the third component (M = 28%) of the toys sequence.

There was a lower level of vocal stereotypy in the third component than in the first component of the no-interaction sequence for six of seven sessions. This pattern indicates that Brian's vocal stereotypy decreased across time without intervention (i.e., access to vocal stereotypy may function as an AO for subsequent vocal stereotypy). In the toys sequence, the level of vocal stereotypy in the third component was lower than or equivalent to levels in the first component for three of four sessions. Because the level of Brian's vocal stereotypy did not, relative to the first component, increase during the third component of the toys sequence and was comparable to the third component of the no-interaction sequence, it may be reasonable to conclude that the auditory stimulation produced from manipulating toys did not function as an EO for subsequent vocal stereotypy (i.e., deprivation from the product of vocal stereotypy was not imposed by manipulating toys). If access to toys did function as an AO for Brian's vocal stereotypy, the effects were no greater than those produced by prior access to vocal stereotypy alone, as seen in the no-interaction sequence.

Figure 3 also shows the effects of the toys and toys and music sequences on Nevin's vocal stereotypy. In the toys sequences, vocal stereotypy was always highest in the first component (M = 79%), slightly lower in the second component (M = 77%), and lowest in the third component (M = 73%). These results are consistent with those obtained with Brian during the no-interaction sequence. In the toys and music sequence, vocal stereotypy was always highest in the first component (M = 75%), lowest in the second component (M = 10%), and moderate in the third component (M = 54%). Comparing the two sequences, the level of vocal stereotypy in the third component of the toys and music sequence was substantially lower than in the third component of the toys sequence during two of the three sessions. Thus, the decrease in vocal stereotypy when music was present and the subsequent lower levels in the ensuing component, relative to the third component of the toys sequence, suggest that music was functionally matched to the product of vocal stereotypy and thereby functioned as an AO for Nevin's vocal stereotypy.

Figure 4 shows the effects of the toys and gum and toys sequences on Nevin's vocal stereotypy. In the toys and gum sequence, vocal stereotypy was always highest in the first



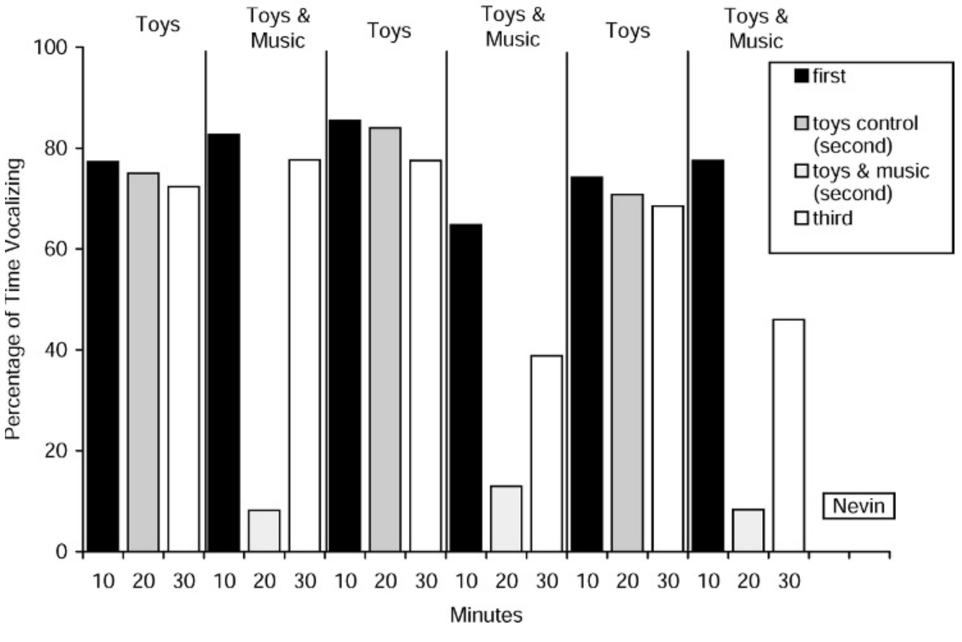


Figure 3. Percentage of time Brian engaged in vocal stereotypy during the no-interaction and toys sequences (top). Percentage of time Nevin engaged in vocal stereotypy during the toys and toys and music sequences (bottom).

component (M = 77%), lower in the second component (M = 21%), and during the third component was higher than the second component (two of three sessions) but lower than the first component (M = 42%). Again, in the toys sequences, vocal stereotypy was always highest in the first component (M = 83%), followed by the second (M = 66%) and third

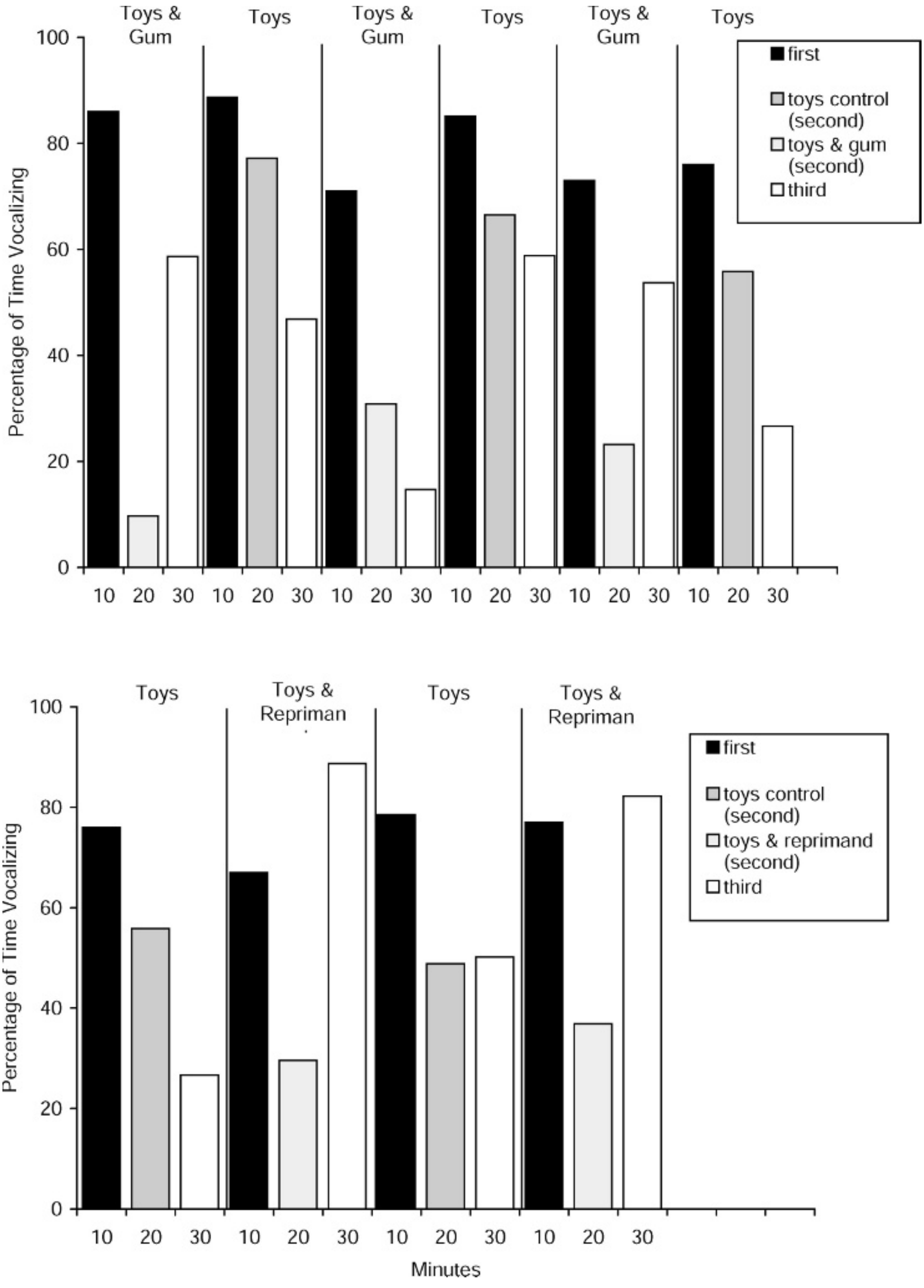


Figure 4. Percentage of time Nevin engaged in vocal stereotypy during the toys and toys and gum sequences (top). Percentage of time Nevin engaged in vocal stereotypy during the toys and toys and reprimand sequences (bottom).

(M = 44%) components. Although the level of vocal stereotypy in the third component of the toys and gum sequence was lower than it was in the first component of the toys and gum sequence, it was comparable to the level of vocal stereotypy in the third component of the toys sequence. Thus, the extent to which gum functioned as an AO for Nevin's vocal stereotypy was unclear; however, the pattern of Nevin's behavior in the toys and gum sequence was consistent with Brian's in the toys sequence insofar as it suggests that gum did not function as an EO.

Figure 4 also shows the effects of the toys and toys and reprimand sequences on Nevin's vocal stereotypy. As in prior toys sequences, vocal stereotypy was highest in the first component (M = 77%) and lower in the second (M = 52%) and third (M = 38%) components; however, unlike prior sessions, the level of vocal stereotypy in the third component was slightly higher than in the second component during the last toys sequence. In the toys and reprimand sequence, vocal stereotypy was highest during the third component (M = 85%), followed by the first (M = 72%) and the second (M = 33%) components. The decrease in vocal stereotypy in the second component compared to the first suggests that reprimands exerted a suppressive effect on vocal stereotypy; however, the subsequent increase in vocal stereotypy during the third component, relative to the first component of the toys and reprimand sequence and the third component of the toys sequence, suggests that reprimands imposed deprivation for the stimulation generated by vocal stereotypy. Thus, in the toys and reprimand sequence, the delivery of contingent reprimands during the second component may have functioned as an EO for vocal stereotypy in the third component.

GENERAL DISCUSSION

The results from Experiment 1 showed that both participants' vocal stereotypy persisted in the absence of social consequences and that access to auditory stimulation from toys (Brian) and music (Nevin) decreased vocal stereotypy. These results suggest that vocal stereotypy was automatically reinforced and that auditory stimulation competed with or substituted for the sensory consequence produced by vocal stereotypy. Unlike Brian, access to toys did not decrease Nevin's vocal stereotypy and the combination of toys and music also did not produce consistent reductions. Using a three-component multiple schedule, Experiment 2 showed that each participant's vocal stereotypy typically decreased across successive components during the no-interaction (Brian) or toys (Nevin) sequence. A similar pattern was reported in an earlier study that showed decreased levels in stereotypy when prior access to stereotypy was provided earlier in a given day (Rapp, 2004). These results suggest that prior access to vocal stereotypy in the first component, second component, or both may have served as an AO for vocal stereotypy in subsequent components. This observation highlights the need for no-intervention sequences to control for natural changes in motivating operations when evaluating the effects of competing or substitutable reinforcement.

On the whole, the results of the present study are consistent with prior studies that decreased automatically reinforced behavior using NCR (e.g., Higbee et al., 2005; Patel et al., 2000; Piazza et al., 2000; Rapp et al., 2004; Sidener et al., 2005). Although it is not clear why Nevin's vocal stereotypy increased when toys were combined with music, prior studies have shown that automatically reinforced behavior may be occasioned by ambient stimulation (Carter, Devlin, Doggett, Harber, & Barr, 2004; Rapp, 2005; Van Camp et al., 2000). However, it should be noted that the effects of access to matched, unmatched, or combined stimulation may be idiosyncratic and related to relative preference for activities (Ahearn et al., 2005).

The results of the evaluation to determine whether preferred items provided competing or functionally substitutable (i.e., matched) stimulation for vocal stereotypy were less clear. For Nevin, reduced levels of vocal stereotypy in the third component of the toys and music sequence, relative to the first component of this sequence and the third component of the toys sequence, suggest that music functioned as an

AO for the sensory consequence produced by his vocal stereotypy. By contrast, increased vocal stereotypy in the third component of the toys and reprimand sequence, relative to both the first component of this sequence and the third component of the toys sequence, suggests that reprimands functioned as an EO for his vocal stereotypy. The motivational effects of toys for Brian and gum for Nevin were not clear; however, neither stimulus appeared to function as an EO for vocal stereotypy.

The results of the present study replicate those of Simmons, Smith, and Kliethermes (2003) and Rapp (2006) by showing persistent reductions in automatically reinforced behavior following access to matched stimulation. The current study also extends the methodology proposed by Rapp insofar as multiple control conditions were employed to assess the effects of matched and unmatched stimulation. In addition, the increase in Nevin's vocal stereotypy following the reprimand component is consistent with prior studies involving punishment of automatically reinforced behavior (Rapp et al., 2004; Rollings & Baumeister, 1981). Thus, interventions that do not involve alternative reinforcing stimulation may function as EOs for automatically reinforced behavior.

The purpose of this study was to evaluate a method for empirically determining whether an alternative form of stimulation provides a functional match to the sensory consequences generated by automatically reinforced behavior. In this sense, this investigation evaluated the extent to which intervention with noncontingent stimulation functioned as an AO or EO for subsequent exhibition of the target behavior. For Brian, vocal stereotypy was lower in the third component than in the first component in nearly every session for both the no-interaction and toys sequences. This pattern suggests that the stimulation provided in the second component of each sequence (the product of vocal stereotypy and toys with audio stimulation, respectively) functioned as an AO for vocal stereotypy. In this case, determining what constitutes a matched intervention was made based on postintervention levels of behavior within and across sequences.

For Nevin, levels of vocal stereotypy in the third component of the toys and music sequence were always lower in the first component of the sequence and were typically lower than in the third component of the toys sequence. That is, levels of vocal stereotypy in the third component of the toys and music sequence were below the level that was expected without additional intervention. Thus, toys that generate auditory stimulation appeared to function as an AO for vocal stereotypy and were thereby functionally matched to vocal stereotypy. Conversely, although contingent reprimands decreased vocal stereotypy, the removal of reprimands was correlated with increased vocal stereotypy in the third component when compared to the first component of the toys and reprimand sequence and the third component of the toys sequence. This pattern suggests that contingent verbal reprimands may have functioned as an EO for subsequent vocal stereotypy. It is not clear why the music component decreased Nevin's vocal stereotypy in the third component beyond that observed in the third component of the toys sequence. It is possible that the amount of reinforcement generated by vocal stereotypy is physically limited by the behavior itself. For example, the stimulation provided by music may have exceeded the level provided by vocal stereotypy and thereby exerted a more durable value-altering effect.

Although the three-component approach may be useful for examining the direct effects of competing sources of stimulation, the present results are subject to alternative interpretations. For example, it is possible that Nevin's vocal stereotypy decreased in the third component of the gum sequence as a function of fatigue from chewing during the prior 10 min rather than decreased motivation to vocalize. However, fatigue would not account for decreased vocal stereotypy in the third component of the music sequence, because audio stimulation was provided independent of responding. Similarly, it is possible that 15 min of manipulating toys (i.e., the second component of the toys sequence) was not of sufficient duration to impose deprivation for the product of Brian's vocal stereotypy.

It is also possible that reduction in vocal stereotypy during the third component of the no-interaction (Brian), toys (Nevin), and toys and music (Nevin) sequences was a function of habituation for the sensory product of vocal stereotypy (see Murphy, McSweeney, Smith, & McComas, 2003). If the gradual reduction in vocal stereotypy observed across the first, second, and third components was a function of habituation to the sensory consequence of vocal stereotypy, then the addition of an intervention should have produced dishabituation for the product of vocal stereotypy in the second component of the toys and music sequence (i.e., when music was provided). This pattern was not typically observed.

Some limitations to the current study should be noted. First, the effects of alternative stimulation that did not overtly match the product of vocal stereotypy were not explicitly evaluated. This absence is based on the fact that neither participant's vocal stereotypy decreased when they manipulated unmatched stimuli (see Figure 2). As an alternative to unmatched stimulation, contingent reprimands were used because there was informal evidence that Nevin's vocal stereotypy decreased following reprimands. This intervention contained a minimal source of alternative stimulation (the verbal reprimand), and Nevin's mother frequently provided reprimands contingent on vocal stereotypy. Given that Nevin vocalized in the presence of toys but not during access to music in the absence of toys, it would have been interesting to evaluate the effects of contingent music loss on vocal stereotypy (see Falcomata, Roane, Hovanetz, & Kettering, 2004).

Second, the results of two evaluations, the effects of toys for Brian and gum for Nevin, may be considered equivocal because the level of vocal stereotypy in the third component of the test sequence was similar to the level in the third component of the control sequence. Nonetheless, the pattern observed in the control sequence was not unexpected (see Rapp, 2004), and the results of the two evaluations suggest that the intervention did not function as an EO for vocal stereotypy. Finally, the same sequences and experimental designs were not employed for both participants. The design employed for Nevin was adopted only after discovering that the approach used for Brian required a protracted number of sessions and extensive time (8 hr to evaluate one stimulus for Brian vs. 8 hr to evaluate three stimuli for Nevin). Future research will likely determine the utility of either approach.

The results of this study suggest that it may be possible to identify empirically stimulation that is substitutable for sensory reinforcers. If supported by subsequent research, this method could help to bring the assessment of automatically reinforced behavior into closer alignment with the vast behavioral technology for assessing socially reinforced behavior. Future research should evaluate this method using a wider array of alternative stimulation. Of more immediate relevance, the observation that some automatically reinforced behavior decreases across time may have particular use for individuals whose behavior is insensitive to potential sources of competing stimulation. For example, introducing alternative sources of stimulation following prior access to automatically reinforced behavior may increase the probability that competing reinforcement will be contacted.

REFERENCES

Ahearn, W. H., Clark, K. M., DeBar, R., & Florentino, C. (2005). On the role of preference in response competition. *Journal of Applied Behavior Analysis*, *38*, 247–250.

Ahearn, W. H., Clark, K. M., Gardenier, N. C., Chung, B. I., & Dube, W. V. (2003). Persistence of stereotypic behavior: Examining the effects of external reinforcers. *Journal of Applied Behavior Analysis*, *36*, 439–448.

Carter, S. L., Devlin, S. R., Doggett, A., Harber, M. M., & Barr, C. (2004). Determining the influence of tangible items on screaming and handmouthing following an inconclusive functional analysis. *Behavioral Interventions*, *19*, 51–58.

Falcomata, T. S., Roane, H. S., Hovanetz, A. N., & Kettering, T. L. (2004). An evaluation of response cost in the treatment of inappropriate vocalizations maintained by automatic reinforcement. *Journal of Applied Behavior Analysis*, *37*, 83–87.

Forehand, R., & Baumeister, A. A. (1971). Rate of stereotyped body rocking of severe retardates as a function of frustration of goal-directed behavior. *Journal of Abnormal Psychology*, *78*, 34–42.

Forehand, R., & Baumeister, A. A. (1973). Body rocking and activity level as a function of prior movement restraint. *American Journal of Mental Deficiency*, *74*, 608–610.

Higbee, T. S., Chang, S., & Endicott, K. (2005). Noncontingent access to preferred sensory stimuli as a treatment for automatically reinforced behavior. *Behavioral Interventions*, *20*, 177–184.

LeBlanc, L. A., Patel, M. R., & Carr, J. E. (2000). Recent advances in the assessment of aberrant behavior maintained by automatic reinforcement in individuals with developmental disabilities. *Journal of Behavior Therapy and Experimental Psychiatry*, *31*, 137–154.

Murphy, E. S., McSweeney, F. K., Smith, R. G., & McComas, J. J. (2003). Dynamic changes in reinforcer effectiveness: Theoretical, methodological, and practical implications for applied research. *Journal of Applied Behavior Analysis*, *36*, 421–438.

Patel, M. R., Carr, J. E., Kim, C., Robles, A., & Eastridge, D. (2000). Functional analysis of aberrant behavior maintained by automatic reinforcement: Assessment of specific sensory reinforcers. *Research in Developmental Disabilities*, *21*, 393–407.

Piazza, C. C., Adelinis, J. D., Hanley, G. P., Goh, H. L., & Delia, M. D. (2000). An evaluation of the effects of matched stimuli on behaviors maintained by automatic reinforcement. *Journal of Applied Behavior Analysis*, *33*, 13–27.

Rapp, J. T. (2004). Effects of prior access and environmental enrichment on stereotypy. *Behavioral Interventions*, *19*, 287–295.

Rapp, J. T. (2005). Some effects of audio and visual stimulation on multiple forms of stereotypy. *Behavioral Interventions*, *20*, 255–272.

Rapp, J. T. (2006). Toward an empirical method for identifying matched stimulation: A preliminary investigation. *Journal of Applied Behavior Analysis*, *39*, 137–140.

Rapp, J. T., Vollmer, T. R., Dozier, C. L., St. Peter, C., & Cotnoir, N. (2004). Analysis of response reallocation in individuals with multiple forms of stereotyped behavior. *Journal of Applied Behavior Analysis*, *37*, 481–501.

Roane, H. S., Vollmer, T. R., Ringdahl, J. E., & Marcus, B. A. (1998). Evaluation of a brief stimulus preference assessment. *Journal of Applied Behavior Analysis*, *31*, 605–620.

Rollings, J. P., & Baumeister, A. A. (1981). Stimulus control of stereotypic responding: Effects on target and collateral behavior. *American Journal of Mental Deficiency*, *86*, 67–77.

Sidener, T. M., Carr, J. E., & Firth, A. M. (2005). Superimposition and withholding of edible consequences as treatment for automatically reinforced stereotypy. *Journal of Applied Behavior Analysis*, *38*, 121–124.

Simmons, J. N., Smith, R. G., & Kliethermes, L. (2003). A multiple-schedule evaluation of immediate and subsequent effects of fixed-time food presentation on automatically maintained mouthing. *Journal of Applied Behavior Analysis*, *36*, 541–544.

Tang, J., Patterson, T. G., & Kennedy, C. H. (2003). Identifying specific sensory modalities maintaining the stereotypy of students with multiple profound disabilities. *Research in Developmental Disabilities*, *24*, 433–451.

Taylor, B. A., Hoch, H., & Weissman, M. (2005). The analysis and treatment of vocal stereotypy in a child with autism. *Behavioral Interventions*, *20*, 239–253.

Timberlake, W., & Allison, J. (1974). Response deprivation: An empirical approach to instrumental performance. *Psychological Review*, *81*, 146–164.

Van Camp, C. M., Lerman, D. C., Kelley, M. E., Roane, H. S., Contrucci, S. A., & Vorndran, C. M. (2000). Further analysis of idiosyncratic antecedent influences during the assessment and treatment of problem behavior. *Journal of Applied Behavior Analysis*, *33*, 207–221.

Vollmer, T. R. (1994). The concept of automatic reinforcement: Implications for behavioral research in developmental disabilities. *Research in Developmental Disabilities*, *15*, 187–207.

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