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A Systematic Evaluation of Stimulus Preference, Response Effort, and Stimulus Control in the Treatment of Automatically Reinforced Self-Injury

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Environmental enrichment (EE) was evaluated as treatment for the automatically reinforced self-injurious behavior (SIB) of a 13-year-old male diagnosed with autism. First, a functional analysis determined that the participant's SIB persisted in the absence of social consequences. Next, EE was implemented as treatment and various components of the intervention were manipulated. The results suggested that three factors were correlated with increased EE efficacy: stimulus preference, response effort, and inhibitory stimulus control.

A recent experimental-epidemiological analysis indicated that approximately 25% of self-injurious behavior (SIB) cases were maintained by automatic reinforcement (Iwata et al., 1994). Automatically reinforced SIB is particularly challenging to treat because, unlike socially reinforced SIB, the reinforcers maintaining the behavior cannot be easily manipulated. One treatment that has been evaluated with automatically reinforced SIB is environmental enrichment (EE), which involves providing noncontingent access to various forms of appropriate stimulation (Horner, 1980). The rationale is that the alternative stimulation may compete with the stimulation produced by SIB (Vollmer, 1994).

Although EE is known to be an effective treatment package for automatically reinforced problem behavior (e.g., Ringdahl, Vollmer, Marcus, &

This study was conducted while the authors were at the Children's Seashore House and the University of Pennsylvania.

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Roane, 1997; Vollmer, Marcus, & LeBlanc, 1994), questions remain about the independent and combined effects of various treatment components. Research involving stimulus preference in the context of EE suggests that highly preferred stimuli produce larger decreases in problem behavior than nonpreferred stimuli (Ringdahl et al., 1997; Vollmer et al., 1994). Response effort may also influence the effectiveness of EE. Results of research suggest that increasing the effort required to engage in aberrant behavior (via wrist weights and arm restraints) may decrease aberrant behavior (but not appropriate play behavior) when EE with toys only is ineffective (Irvin, Thompson, Turner, & Williams, 1998; Van Houten, 1993). A third factor that may influence EE effects is inhibitory stimulus control. Problem behavior may be less likely to occur in the presence of other people (e.g., care providers) either because the behavior has been historically punished or because the behavior has been historically blocked and therefore extinguished (e.g., Ellingson et al., 2000).

In this study, a functional analysis showed that severe self-injury displayed by a boy with autism was automatically reinforced. Next, three component variables were evaluated within the context of EE: stimulus preference (Phase 1), response effort (Phase 2), and stimulus control (Phase 3). Although EE is typically presented as a treatment package with multiple (perhaps dozens of) components, the overall purpose of this study was to evaluate a method for elucidating the role of some of these components in isolation or in combination.

General Method

Participant and Setting

Dennis, a 13-year-old male diagnosed with autism and severe mental retardation, was referred to an inpatient unit for the treatment of severe SIB in the form of putting potentially dangerous substances into his eyes (e.g., hot sauce, toothpaste, perfume, lotions). His caregivers attempted to decrease the occurrence of SIB in his natural environment by eliminating Dennis's access to these substances; however, complete elimination of these substances in all settings was not feasible. In addition, his caregivers were unable to watch Dennis at all times, and thus were unable to block every instance of SIB. As such, it was necessary to identify ways to keep Dennis from seeking out these dangerous substances when his caregivers were not near him.

Sessions were conducted in domicile-style therapy rooms that contained a table, chairs, and other items necessary for sessions. Sessions were usually conducted four to six times per day, five days per week. Functional analyses and treatment sessions lasted 10 and 15 min, respectively.

Response Measurement and Reliability

Dennis's SIB was defined as contact between a bottle of shampoo or shampoo itself (harmless shampoo was planted in the therapy room) and Dennis's eye, or

contact between Dennis's hand to his eye (because he frequently put substances on his fingers, then rubbed his eyes). Data were collected on laptop computers through a one-way window and are expressed as responses per minute of SIB for the functional analysis, and percentage of 10-s intervals with SIB (partial interval) for the treatment analysis. The measure was converted to partial interval recording during the treatment analysis because it became increasingly difficult to detect or define the beginning and end of "one response" (i.e., he would continue to rub the substance in his eyes for extended durations).

Interobserver agreement (IOA) was assessed during 35% of the functional analysis sessions and 15% of the treatment sessions. IOA was calculated by dividing each session into a series of 10-s bins. Agreement was scored if both observers agreed on the occurrence or nonoccurrence of SIB during that interval (for partial interval recording). For rate measures, the agreement was calculated for each 10-s bin by dividing the smaller number of responses by the larger number of responses, multiplied by 100. These values were then averaged for the entire session. Interval-by-interval agreement scores for entire sessions averaged 99% (range: 92% to 100%) for the functional analysis and 98% (range: 88% to 100%) for the treatment analysis (Phases 1 to 3).

Preference Assessment

A free operant preference assessment (Roane, Vollmer, Ringdahl, & Marcus, 1998) identified highly preferred items used in both the functional analysis and treatment analysis. An array of stimuli was presented concurrently for 5 min. Item manipulation was defined as contact between Dennis's hand and then item. Percentage of session time with item manipulation was calculated for each item, and items were ranked in order of preference. The most preferred item was a keyboard, and the least preferred item was a plastic block.

Functional Analysis

A functional analysis was conducted using methods described by Iwata et al. (1982/1994) and Vollmer et al. (1995). To ensure the participant's safety, harmless baby shampoo was available throughout the assessment (rather than dangerous substances), and a physician approved the sessions. For the purposes of this report, the most critical condition was one in which Dennis was watched through a one-way window when he was alone. Self-injury persisted at high levels even when Dennis was alone. This showed that Dennis was not engaging in self-injury for social reasons (e.g., attention). Because it occurred even when he was alone, the behavior was automatically reinforced (Iwata et al.). Functional analysis data are available from the authors upon request.

Treatment Phase 1: Stimulus Preference

Method

Partial EE was evaluated in a combined multielement and ABA design. At this stage, a therapist was present in all sessions. In baseline, the therapist did

not interact with Dennis and there was no social consequence for SIB. Next, two EE conditions were evaluated: EE with a preferred item (keyboard) and EE with a nonpreferred item (block). The keyboard and block were identified as high- and low-preference items in the preference assessment described previously. Dennis had continuous, noncontingent access to one of these stimuli and the therapist did not interact with him.

Results

Figure 1 displays the results of Phase 1. The figure depicts session-by-session results for all conditions (baseline, EE with low- and high-preference items, baseline). Self-injury occurred during an average of 16.4% of 10-s intervals and 13.8% of 10-s intervals during the first baseline and subsequent reversal to baseline, respectively. These baseline results confirm that Dennis engaged in SIB even when there were no social consequences for the behavior. The presence of a highly preferred item (M = 9.94% of intervals) resulted in a small overall decrease in SIB, whereas the presence of a nonpreferred item did not (M = 17.2% of intervals), although a downward trend was evident in both EE conditions. In addition, zero SIB was observed in 3 out of 11 sessions with the preferred item, whereas the nonpreferred item never produced zero SIB. These results suggest that EE with the highly preferred item modestly reduced SIB and that EE was only effective when the environment contained a preferred stimulus. The most likely explanation for the difference in levels of SIB during high- versus low-preference conditions (an overall 42% difference) is that Dennis spent more time engaged in a competing response (item engagement). In fact, the mean percentage of intervals with item engagement was 29% and 2% in the high- and low-preference conditions, respectively. These results should be interpreted with caution, however, as the levels of SIB during the last half of this phase were not clearly differentiated. In addition, only one preferred item was included in EE for the purposes of delineating the effects of item preference; however, it is possible that

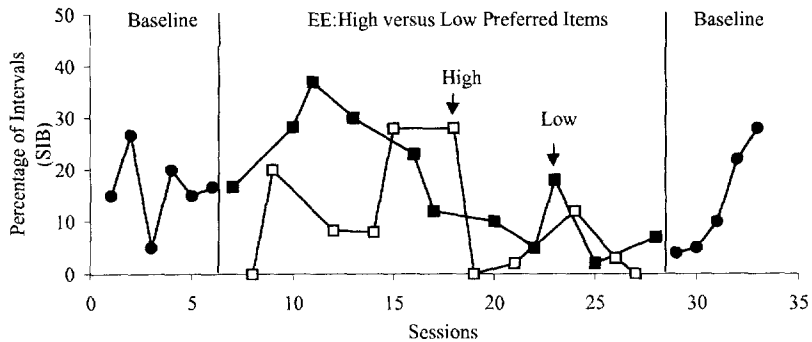

FIG. 1. Results of Phase 1. Session-by-session results are depicted, and SIB is expressed as percentage of 10-s intervals with SIB.

larger decreases in behavior could have been produced had numerous preferred items been concurrently available.

Treatment Phase 2: Response Effort

Method

The effects of response effort were evaluated in a combined multielement and reversal design. Again, a therapist was present in all sessions. The baseline was the reversal to baseline condition from Phase 1. During baseline, the preferred item (keyboard) was removed from the room and the shampoo bottle was always within Dennis's immediate reach (within 1 m). After baseline, EE with the preferred item (keyboard) and varying degrees of response effort for SIB was evaluated. Specifically, during the high response effort condition, the shampoo bottle was placed across the room (greater than 4 m) while the preferred item remained within Dennis's reach (less than 1 m). The therapist returned the shampoo bottle to the far side of the room after each occurrence of SIB. During the low response effort condition, both the shampoo bottle and the item were within his reach (less than 1 m). Next, high and low response effort were evaluated in the absence of EE (i.e., the preferred item was not available). Note that the low effort without EE condition was identical to the baseline condition (no preferred stimulus, shampoo bottle placed within 1 m). We then repeated the EE with the preferred item and high versus low response effort for SIB condition.

Results

Figure 2 displays the results of Phase 2. The upper panel depicts session-by-session results for each condition (baseline, effort comparison with EE, effort comparison in the absence of EE, effort comparison with EE). Following baseline, the first experimental comparison was between high-effort SIB and low-effort SIB while EE was in effect. Results indicated that increasing the response effort for SIB further decreased the levels of SIB during EE with the high-preference item (M = 3.03% of intervals during high effort and M = 10.4% of intervals during low effort). When the preferred item was removed (response effort only), the experimental comparison was between high-effort SIB and low-effort SIB without EE. High effort for SIB still produced lower levels of SIB (M = 5.5% of intervals) compared to low effort for SIB (M = 8.3% of intervals), although differences in responding became undifferentiated near the end of this phase. Subsequent reversal back to the response effort comparison with EE indicated that maximum reductions of SIB required both EE and high effort (M = 2% of intervals). These results should be interpreted with caution, however, as the levels of SIB during the latter portion of the second comparison were not clearly differentiated. These results show that both increased response effort for SIB and access to preferred stimuli influenced SIB levels; however, the combination of the two resulted in the most substantial reductions in SIB.

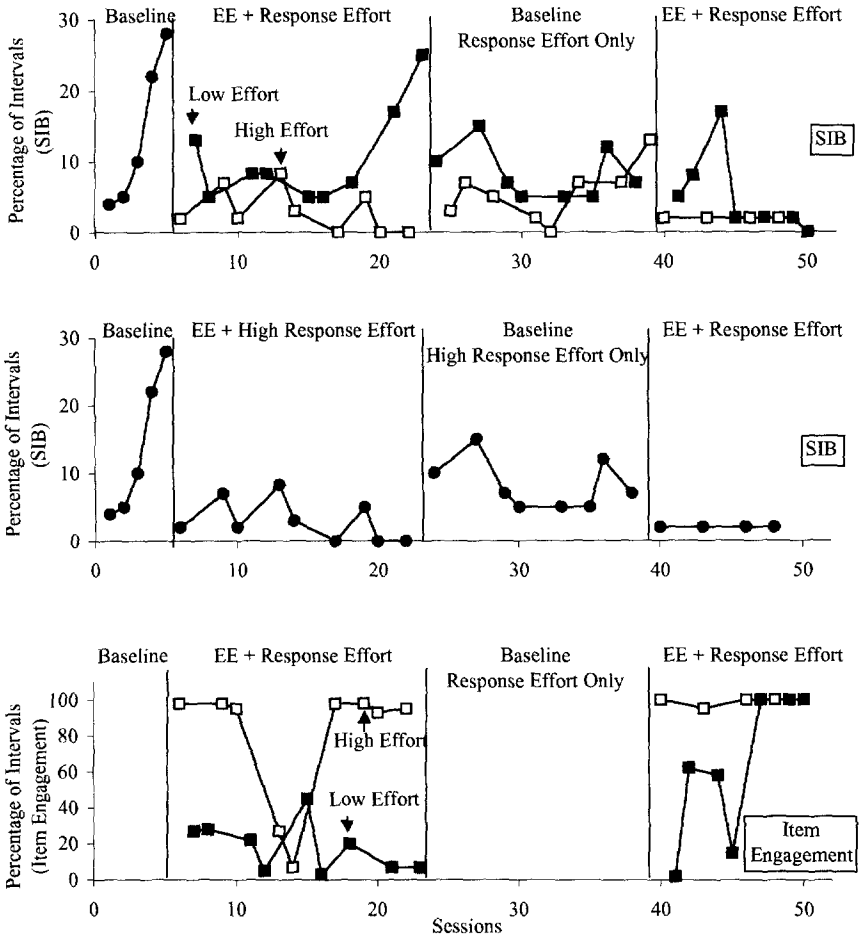

FIG. 2. Results of Phase 2. The upper panel depicts the session-by-session results for all conditions. The center panel isolates the comparison of EE with access to the preferred stimulus and high effort for SIB. The lower panel depicts the effects of high effort for SIB on item engagement. In all panels, SIB and item engagement are expressed as percentage of 10-s intervals.

Although the main comparison in Phase 2 was between high and low response effort, the center panel of Figure 2 isolates the effects of combining high effort and access to preferred stimuli in comparison to baseline. In this panel, the data paths for low response effort during EE are simply removed to highlight the effects of high response effort plus access to the preferred item (treatment) relative to low response effort plus no preferred item (baseline).

The lower panel of Figure 2 shows that the level of effort required to obtain access to the SIB material (shampoo) influenced the probability of Dennis's

interaction with the highly preferred stimulus (keyboard). In the first response effort comparison, the only difference in the environment was the amount of effort required to obtain access to the shampoo, yet clear differences in the percentage of intervals with engagement for the alternative item (preferred item) were obtained. The level of item interaction during the high-effort condition (M = 78.8% of intervals) exceeded the level of item interaction during the low-effort condition (M = 18.2% of intervals). In the second comparison, similar effects were obtained for item engagement during the first four sessions of high and low effort, but at the end of the comparison Dennis spent almost all of his time engaged with the preferred item in both conditions (and showed low levels of SIB; see upper panel). The level of item interaction during the high-effort condition (M = 98.8% of intervals) again exceeded the level of item interaction during the low-effort condition (M = 62.4% of intervals).

Phase 3: Inhibitory Stimulus Control

Method

The therapist noted that when she left the room following treatment sessions (thus leaving Dennis alone), Dennis was more likely to engage in SIB. He would stand up and walk across the room to where the shampoo was placed, and then he would place the shampoo in his eyes. We hypothesized that the presence of the therapist was exerting some inhibitory stimulus control over Dennis's behavior during the treatment sessions. We evaluated this hypothesis by comparing the effective intervention (preferred item plus high effort for SIB) with and without a therapist present, using a multielement design for six sessions of each condition (therapist in versus therapist out).

The final stage of treatment was evaluated in a combined multielement and concurrent operant arrangement. Initially, we conducted repeated sessions with the therapist either in the room or out of the room. These initial sessions did not differ procedurally from the brief assessment of inhibitory stimulus control described above. The purpose of conducting these sessions was to test the possibility that the inhibitory stimulus control might eventually transfer to sessions in which the therapist was out of the room. This was considered possible (if unlikely) because the therapist always returned to the room immediately after each 15-min session, which represents a fixed-time (FT) schedule of "checking on" Dennis. Thus, although the therapist leaving the room set the occasion for SIB in the prior assessment, repeated exposure to these conditions might eventually reduce the likelihood of SIB in the absence of a therapist.

Finally, because some SIB was still occurring when the therapist was not in the room, a gradual fading procedure was implemented. The purpose of this final treatment phase was to eventually eliminate the therapist from the room for an extended period while maintaining low rates of SIB. Thus, a fading procedure was used and no attempt was made to reverse the effects: Given

that the independent and combined effects of treatment components had already been evaluated, a demonstration of experimental control was not the objective of the final stage. Nonetheless, a degree of experimental control was demonstrated by treating the item engagement and SIB as concurrently available operants, with response allocation to each alternative used as the dependent measure. The therapist gradually increased the FT interval for "checking on" Dennis. In the first session of therapist fading, the therapist entered the room and pointed to a "poison" sticker every 30 s. The FT interval was subsequently increased very gradually across sessions when low levels of SIB and high levels of engagement were obtained. In addition, two sessions were conducted with Dennis's mother using variable monitoring intervals (with intervals ranging from 30 s to 120 s within a single session).

Results

Figure 3 displays the results of Phase 3. The left upper panel shows the results of the initial comparison between "therapist in" versus "therapist out" (the test for inhibitory stimulus control). There was a clear difference in the level of SIB depending on whether the therapist was in (M = 1.5% of intervals) or out (M = 8.8% of intervals) of the room. The right upper panel shows the results of the initial comparison between "therapist in" versus "therapist out" on preferred item engagement. More item engagement occurred when the therapist was in the room (M = 98.0% of intervals) compared to when the therapist was out of the room (M = 63.3% of intervals).

The lower panel of Figure 3 depicts the results of the subphase designed to reduce SIB levels when the therapist was not in the room. Unexpectedly, during therapist-out, Dennis gradually engaged in less SIB, even though these sessions were identical to the therapist-out sessions in the initial assessment (see upper panel). When the therapist was in the room, preferred item engagement remained high and SIB remained low throughout. Combined with the first stage of this phase (upper panel of Figure 3), the results suggested that the presence of a therapist in the room was initially necessary to maintain lower levels of SIB, but eventually SIB rates were somewhat inhibited, even when the therapist was out of the room. One interpretation of these results is that SIB levels were reduced because Dennis was exposed to the presence of the therapist on a FT 15-min schedule. These conclusions are tempered by two factors: (a) we did not test whether the SIB would return to high levels in the absence of an adult if the adult stopped returning every 15 min, and (b) some level of SIB was still occurring near the end of the evaluation.

Because some SIB still occurred when the therapist was out of the room and because his hospital discharge was impending, we completed Dennis's treatment by gradually increasing the interval during which the therapist was out of the room. Specifically, the FT interval was reduced initially to 30 s. During the final phase, the therapist came in the room once every 30 s (beginning of fade) to once every 900 s (end of fade) while maintaining low levels of SIB. Levels of engagement with the preferred item remained high through-

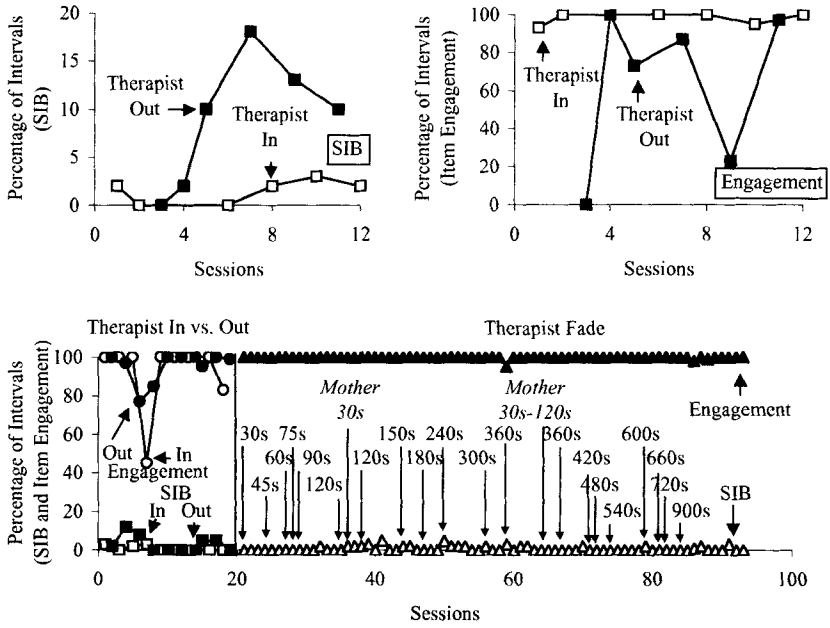

FIG. 3. Results of Phase 3. The upper left panel depicts the evaluation of inhibitory stimulus control for SIB (therapist in versus therapist out of room). The upper right panel shows the effects of therapist in versus out of the room on item engagement. The lower panel shows the results of the therapist fade. In all panels, item engagement and SIB are expressed as percentage of 10-s intervals.

out this stage and levels of SIB remained low, although SIB did occur on occasion. Finally, in the sessions conducted by Dennis's mother, zero SIB occurred and engagement with the preferred item was 100%.

Discussion

This study provides another example of EE as a potentially effective treatment for automatically reinforced SIB. In this case, EE with a high-preference item, increased response effort for SIB, and a transfer of stimulus control from an adult in the room to no adult in the room, were used in combination to decrease SIB to clinically significant levels. Although the effects of EE components are likely to be idiosyncratic across individuals, the procedures used in this study provide a method for evaluating independent and combined effects of treatment components. The results of this study are particularly relevant to the treatment of automatically reinforced problem behavior because the consequences for automatically reinforced behavior can rarely be eliminated. As such, it is necessary to identify variables that promote the allocation of responding to competing behaviors (i.e., item engagement) rather than

problem behavior. The data presented here provided further support for the utility of preference assessments prior to implementing EE, the use of increased response effort in cases when EE alone does not produce significant reductions in aberrant behavior, and the need for evaluating the effects of adult presence. In addition, the method used for the systematic identification of effective treatment components may be utilized with a variety of other behavior problems and treatments.

From a clinical standpoint, the treatment package involving high-preference items, high effort for SIB, and "spot checks" of supervision was viewed as successful and manageable. Because it was likely that Dennis would be left alone during short intervals of time (e.g., when a care provider used the rest room or answered a telephone), it was deemed important to maintain low levels of SIB in the absence of an adult. By the end of the study, he was rarely engaging in SIB during 15-min alone intervals. After completion of the study, his mother conducted several successful 15-min sessions. She reported that the 15-min interval was about as long as she would ever leave him unsupervised, except at night. Upon returning home, she reported that the intervention was both acceptable and effective during daytime hours; however, formal follow-up data were not collected. Although the experimental control demonstrated during the treatment analysis would suggest that the resulting treatment package should maintain low levels of SIB, the relatively brief treatment phases (compared to the presumably long history of SIB) and the lack of follow-up data are notable limitations.

Although effects within any given condition were subtle in this study, different levels of responding were observed as a function of three factors: stimulus preference, response effort, and therapist presence/absence. In addition, the factors seemed to be symbiotic insofar as the effect of any single component in isolation was negligible. These subtle component effects, nonetheless, could add up to a large amount of potentially dangerous SIB over an extended period of time. Future research on the treatment of automatically reinforced behavior could further evaluate the effects of these and other factors within the context of EE and other treatments for severe behavior disorders.

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