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RELATIVE INFLUENCES OF ESTABLISHING OPERATIONS AND REINFORCEMENT CONTINGENCIES ON SELF-INJURIOUS BEHAVIOR DURING FUNCTIONAL ANALYSES

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In the typical functional analysis in which the antecedent and consequent events associated with problem behavior are manipulated, the control condition involves elimination of both the relevant establishing operation (EO) and its associated contingency through a schedule of noncontingent reinforcement (usually fixed-time [FT] 30 s). In some functional analyses, however, antecedent events are manipulated in the absence of differential consequences, and a common test condition in such analyses also involves the delivery of reinforcement on an FT 30-s schedule. Thus, the same schedule of reinforcement (FT 30 s) is not considered to be an EO in the former type of analysis but is considered to be an EO in the latter. We examined the relative influences of EOs and reinforcement contingencies on problem behavior by exposing 6 individuals who engaged in self-injurious behavior (SIB) to four combinations of functional analysis conditions: EO present/contingency present, EO absent/contingency present, EO present/contingency absent, and EO absent/contingency absent. Results indicated that the only condition in which high rates of SIB were observed consistently was one in which the EO and the reinforcement contingency were both present. Implications of these results for the design of functional analysis test and control conditions are discussed.

DESCRIPTORS: establishing operation, functional analysis, self-injurious behavior

Much of the research on functional analysis methodology has consisted of procedural extension across problem behaviors, populations, and settings, with treatment being the major emphasis (e.g., see the special issue on functional analysis of the *Journal of Applied Behavior Analysis*, 1994), although some studies have focused primarily on procedural refinement (e.g., Iwata, Duncan, Zarcone, Lerman, & Shore, 1994; Northup et al., 1991; Vollmer, Marcus, Ringdahl, & Roane, 1995). Thus, either through necessity or by design, a number of variations in methodology have emerged over the past 15 years. Nevertheless, all experimental approaches to assessment contain common features that distinguish them from nonexperimental methods, including direct and objective measurement of ongoing behavior under predefined test and control conditions in which variables of interest are manipulated.

Most experimental research has utilized one of two general assessment models. In the antecedent-behavior-consequence model (hereafter called the A-B-C model) the test condition for a given behavioral function contains manipulation of both antecedent and consequent events to assess rates of behavior in the presence of a traditional three-term contingency (see examples by Hagopian, Fisher, & Legacy, 1994; Iwata, Dorsey, Slifer, Bauman, & Richman, 1982/1994; Mace & Lalli, 1991; Northup et al., 1991; Vollmer et al., 1995). The antecedent manipulation consists of an establishing opera-

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Table 1
Test and Control Conditions for Problem Behavior Maintained by Attention

Condition	A-B-C model	A-B model
Test		
Antecedent event	No attention	Attention (FT 30 s)
Consequent event	Attention (FR 1)	No attention
Control		
Antecedent event	Attention (FT 30 s)	Attention (FT 10 s)
Consequent event	No attention	No attention

tion (EO; see Michael, 1982, 1993) to evoke problem behavior maintained by a given reinforcer; the consequent manipulation consists of a reinforcement contingency for the problem behavior. For example, in the attention condition (test for maintenance by social-positive reinforcement) described by Iwata et al. (1982/1994), a therapist withholds attention as the antecedent event (EO) but delivers it contingent on the occurrence of problem behavior (reinforcement). In the play condition (control), by contrast, the EO and reinforcement are both absent: A therapist delivers noncontingent attention usually on a fixed-time (FT) 30-s schedule (EO absent) but does not deliver attention as a consequence for problem behavior (reinforcement absent).

In the second general model for conducting functional analyses (hereafter called the A-B model), antecedent events are varied across conditions but consequences are not (e.g., Carr & Durand, 1985; Durand & Carr, 1987, 1991, 1992; Durand & Crimmins, 1987, 1988). For example, in the "easy 33" condition (test for maintenance by social-positive reinforcement) described by Durand and Carr (1987), a therapist presents easy tasks and delivers attention in 33% of the intervals. In the "easy 100" condition (control), by contrast, a therapist presents easy tasks and delivers attention in 100% of the intervals. Occurrences of problem behavior produce differential consequences in neither the test nor control condition; thus, the major difference between conditions is the overall rate of attention. Because intervals are usually 10 s in duration, attention delivered in every third interval corresponds roughly to an FT 30-s schedule, whereas attention delivered in every interval corresponds to an FT 10-s schedule. The FT 30-s condition has been described as "discriminative for the emission of problem behavior" (Carr & Durand, p. 117); however, the low level of antecedent attention delivered in that condition relative to the FT 10-s condition seems to be more consistent with manipulation of an EO (deprivation).

Table 1 summarizes the differences noted above between the A-B-C and A-B models for assessment of problem behavior maintained by attention. In addition to highlighting the fact that the A-B model involves assessment under conditions of extinction, Table 1 shows that the control condition of the A-B-C model is virtually identical to the test condition of the A-B model. In other words, in the A-B-C model, it is assumed that delivery of attention according to an FT 30-s schedule *does not* function as an EO (i.e., there is no deprivation from attention) and therefore the condition should not evoke attention-maintained behavior. In the A-B model, however, it is assumed that the same schedule of attention *does* function as an EO (relative to an FT 10-s schedule) and should evoke attention-maintained behavior in spite of the fact that its occurrence is not rein-

forced. Thus, the typical A-B-C model predicts low rates of problem behavior under FT 30-s schedules of attention when extinction is in effect, whereas the typical A-B model predicts high rates of problem behavior.

Fischer, Iwata, and Worsdell (1997) summarized the results of A-B-C functional analyses for 36 individuals whose self-injurious behavior (SIB) was maintained by attention. In all cases, high rates of SIB were observed when attention was withheld (EO) except as a consequence for SIB, whereas low rates were observed when attention was delivered noncontingently (FT 30-s schedule) but was withheld as a consequence for SIB. Although these results provided some support for the practice of manipulating both antecedent and consequent events during functional analyses, the separate influences of these events were not evaluated fully. That is, the EO and the contingency were either present (test condition) or absent (control condition). Another condition (alone) contained the presence of the EO (no attention) in the absence of reinforcement; however, no condition was included in which the effects of reinforcement were evaluated in the absence of the EO (i.e., frequent attention delivered as both an antecedent and a consequent event).

The present study was designed to examine the separate and combined effects of antecedent and consequent events on SIB maintained by social-positive reinforcement. More specifically, we were interested in whether such behavior would be maintained in the presence and absence of an EO when reinforcement for SIB either was or was not available.

METHOD

Participants and Setting

Six individuals who had been diagnosed with profound mental retardation participated. All lived in a state residential facility for persons with developmental disabilities and had been referred to a day program for assessment and treatment of their SIB. Brenda was a 52-year-old woman with a limited communicative repertoire whose SIB consisted of head and body hitting and head banging. Dolly was a 38-year-old woman who displayed limited expressive and receptive language skills. She engaged in head banging that resulted in the use of a protective helmet to ensure her safety. Jenna was a 44-year-old woman who communicated using simple gestures (e.g., pointing to preferred items, leading caregivers to desired locations). Her SIB consisted of skin picking that often resulted in open sores. Beth was a 46-year-old woman who exhibited echolalia and could follow simple instructions. Her SIB consisted of hand mouthing that resulted in redness and tissue damage. Rich was a 33-year-old man with limited expressive and receptive language skills whose SIB consisted of head hitting, hand biting, and slamming his elbow into his torso. Sheila was a 29-year-old woman who communicated using simple gestures. Sheila engaged in SIB consisting of head and body hitting and hand biting.

Sessions were conducted in therapy rooms of the day program located on the grounds of the residential facility. All rooms contained a table, chairs, and other materials relevant to specific conditions (see below). Sessions were either 10 min (Brenda, Jenna, Rich, and Sheila) or 15 min (Dolly and Beth) in length, and two to four sessions were conducted per day, 4 to 5 days per week.

Response Measurement and Reliability

Topographies of SIB were defined as follows: (a) *hand biting*: closure of upper and lower jaw on any part of the hand, (b) *head or body hitting*: forceful contact between a hand or elbow and the head or torso, (c)

head banging: forceful contact between the head and a stationary object, (d) *hand mouthing*: contact between the lips or mouth and the hand, and (e) *skin picking*: contact between a finger or fingernail and the skin. Trained graduate and undergraduate students recorded the frequency of SIB during each session on handheld computers (Assistant Model A 102).

All data on SIB were converted into number of responses per minute. Interobserver agreement was assessed during at least 36% of all sessions by having a second observer simultaneously but independently collect data with the primary observer. Sessions were partitioned into 10-s intervals, and observers' records were compared on an interval-by-interval basis. The smaller number of responses in each interval was divided by the larger number of responses; these proportions were averaged across intervals and multiplied by 100% to obtain a percentage agreement score. Mean agreement scores for SIB exceeded 93% in all cases. Observers also collected data on experimenters' implementation of assessment procedures (e.g., delivery of instructions, prompts, and consequences) as a means of assessing procedural integrity; these measures always exceeded 90% accuracy.

General Procedure

Prior to the study, all participants were exposed to multielement functional analyses (Iwata et al., 1982/1994) consisting of attention, tangible, demand, alone, and play conditions, as a screening procedure to identify individuals whose SIB was maintained by social-positive reinforcement. Results indicated that Brenda's, Dolly's, Jenna's, and Beth's SIB was maintained by contingent attention, and that Rich's and Sheila's SIB was maintained by access to edible items. Participants were then exposed to a second functional analysis consisting of the same conditions as in the first analysis, with one exception: An additional condition was included to evaluate the effects of reinforcement in the absence of an EO. Thus, across functional analysis conditions, the EO and the contingency for behavior maintained by positive reinforcement were present and absent in various combinations. Conditions were sequenced in a multielement design according to a fixed cycle (ignore → ignore/fixed-ratio [FR] 1 → FT/ignore → FT FR 1) based on procedures described by Iwata, Pace, et al. (1994), and each condition was conducted by a different experimenter in a different-colored room to enhance discrimination. (Data from conditions that were irrelevant to the purpose of the present study [demand condition for all participants, attention condition for Rich and Sheila] are not included in the figures.)

Ignore/FR 1 (EO present/contingency present). This condition assessed the influence of both the EO and the contingency on SIB and was based on the attention condition (Iwata et al., 1982/1994). The participant and the experimenter were present in a room. The experimenter ignored the participant throughout the session (EO) unless the participant engaged in SIB. Each occurrence of SIB resulted in delivery of either attention (Brenda, Dolly, Jenna, and Beth) or a tangible item (Rich and Sheila) by the experimenter. Attention consisted of a statement of concern (e.g., "Don't do that, you'll hurt yourself") that was usually combined with physical contact (e.g., a pat on the back); the tangible item consisted of a small piece of preferred food.

FT FR 1 (EO absent/contingency present). This condition assessed the influence of the contingency on SIB in the absence of the EO. The participant and the experimenter were present in a room, and the experimenter delivered noncontingent reinforcement according to an FT 30-s schedule: Pleasant comments (e.g., "I like the way you're playing," "That's a pretty shirt you

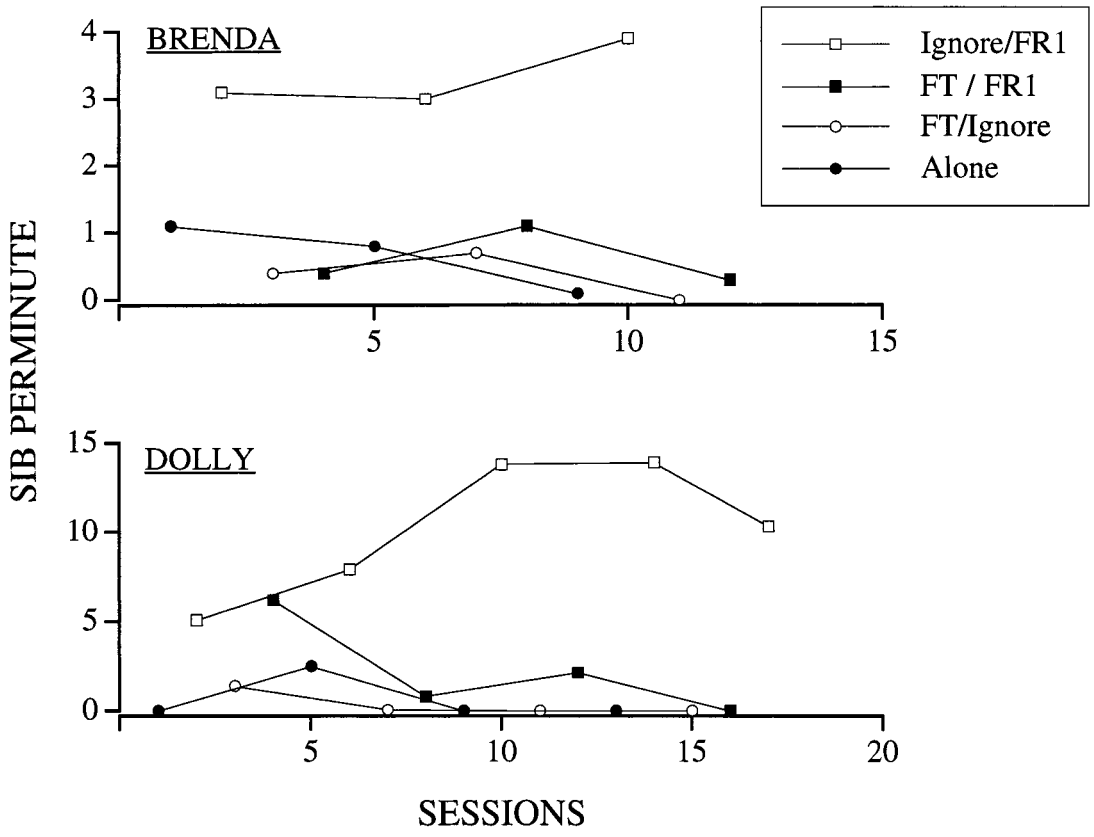

Figure 1. Number of responses per minute of SIB exhibited by Brenda and Dolly across functional analysis conditions.

have") were made to Brenda, Dolly, Jenna, and Beth; edible items were delivered to Rich and Sheila. In addition to the FT schedule of reinforcement, the experimenter delivered consequences for SIB as in the FR 1 condition.

Alone (EO present/contingency absent). This condition assessed the influence of the EO on SIB in the absence of the contingency. The participant was observed while he or she was alone in a room with no access to either attention or tangible reinforcers.

FT/ignore (EO absent/contingency absent). This condition was based on the play (Iwata et al., 1982/1994) and easy 33 (Durand & Carr, 1987) conditions. The participant and experimenter were in a room. The experimenter delivered noncontingent reinforcement (i.e., attention or tangible items) according to an FT 30-s schedule but delivered no consequences following occurrences of SIB. If SIB occurred at the end of an FT interval, reinforcement was delayed by 5 s to avoid accidental reinforcement of SIB.

RESULTS

Figure 1 shows the results of Brenda's and Dolly's functional analyses. Both individuals exhibited differentially high rates of SIB during the ignore/FR1 condition, in which reinforcement was withheld except as a consequence for SIB (EO present/contingency present). Their rates of SIB during the other conditions (FT FR 1 [EO absent/contingency present], FT/ignore [EO absent/contingency absent], and alone [EO present/con-

tingency absent]) were generally low and indistinguishable across conditions.

Figure 2 shows the results of Jenna's, Beth's, Rich's, and Sheila's functional analyses. Relative to other conditions, these 4 participants exhibited much higher rates of SIB during both the ignore/FR 1 and the FT FR 1 conditions, although SIB occurred somewhat more frequently during the ignore/FR 1 condition. Thus, increased rates of SIB were observed in the presence of a reinforcement contingency, regardless of whether access to reinforcers was withheld completely as an antecedent event (ignore/FR 1) or was provided on an FT 30-s schedule (FT FR 1). By contrast, all participants' SIB occurred at low rates during the FT/ignore and alone conditions, in which the reinforcement contingency for SIB was absent.

DISCUSSION

Results of functional analyses indicated that the only condition in which high rates of SIB were observed consistently for 6 participants was the ignore/FR 1 condition, in which the antecedent EO (deprivation from reinforcement) and its associated contingency (reinforcement following SIB) were both present. None of the participants engaged in high rates of SIB in either the FT/ignore (EO absent/contingency absent) or alone (EO present/contingency absent) conditions. Finally, the FT FR 1 condition (EO absent/contingency present) produced mixed results: Low rates of SIB were observed for 2 participants (Brenda and Dolly) but high rates were observed for the other 4 (Jenna, Beth, Rich, and Sheila).

Results obtained during the ignore/FR 1 condition were generally consistent with those reported in previous studies based on the A-B-C model of functional analysis and therefore were not entirely surprising. When viewed from the perspective of a three-term contingency, the ignore/FR 1 condition would seem to be an ideal test condition: Given that a response is maintained by a particular reinforcer, its occurrence should be most likely when (a) an EO is present and (b) contingent reinforcement is available.

In contrast to the ignore/FR 1 condition, the FT/ignore condition contained neither the EO nor the reinforcement contingency. Therefore, it has been used frequently as a control condition in A-B-C functional analyses (e.g., Hagopian et al., 1994; Iwata et al., 1982/1994; Mace & Lalli, 1991; Northup et al., 1991; Vollmer et al., 1995). Results obtained during this condition were of particular interest in the present study because, as noted previously, a very similar condition has been used as a test condition in a number of studies in which antecedent but not consequent events were manipulated (i.e., A-B analyses, see Carr & Durand, 1985; Durand & Carr, 1987, 1991, 1992; Durand & Crimmins, 1987, 1988). All of our participants engaged in low rates of SIB during the FT/ignore condition. The consistency of this finding suggests that the FT/ignore condition may not serve as the best test condition for problem behavior maintained by social-positive reinforcement. Although this condition has evoked problem behavior in some studies, the explanation for such a finding remains unclear. Perhaps increases in problem behavior were a function of *relative* deprivation in the test condition (FT 30-s attention in easy 33) compared to its control (FT 10-s attention in easy 100). However, even if differential responding could be attributed to differences in the rate of noncontingent reinforcement, one might predict that responding would occur at low rates during both conditions due to the absence of contingent reinforcement. (Although only the FT 30-s condition was evaluated in this study, it seems unlikely that problem behavior would have occurred at higher rates during an FT 10-s condition.)

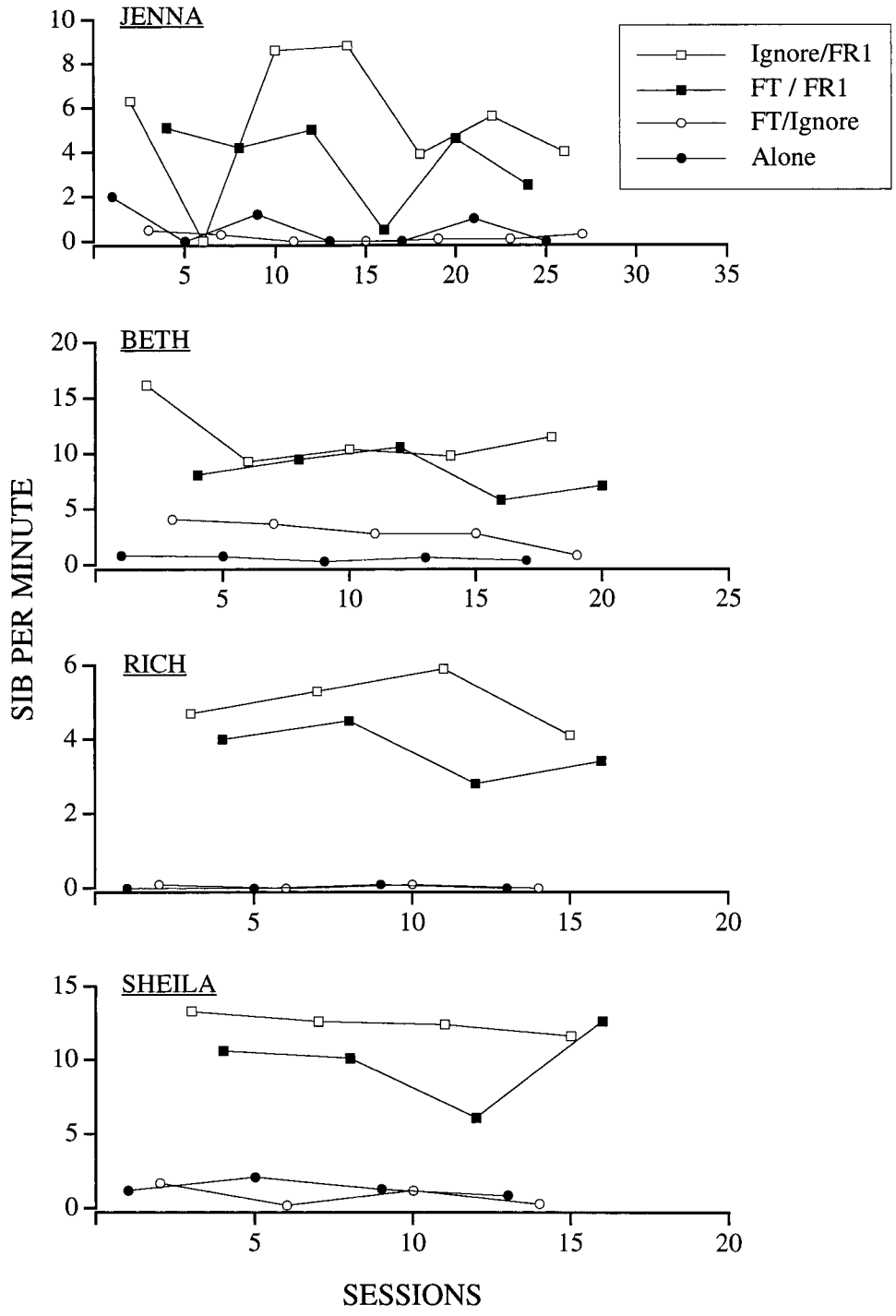

Figure 2. Number of responses per minute of SIB exhibited by Jenna, Beth, Rich, and Sheila across functional analysis conditions.

The alone condition also was associated with low rates of SIB for all participants. Even though an EO was present in this condition, contingent reinforcement was unavailable. Thus, any problem behavior evoked as a result of deprivation would be extinguished, which might be reflected as a decrease in response rate across successive exposures to the condition. Some evidence of this type of pattern can be seen in Brenda's data (Figure 1, top panel, alone condition). The other 5 participants, however, exhibited uniformly low rates of SIB in the alone condition, perhaps because it was the one condition in which the absence of reinforcement was most easily discriminated (no experimenter was present). It should be noted that the absence of the experimenter was a limitation because a potentially salient discriminative stimulus for SIB was missing during the alone condition that was present during all other conditions. An alternative way to conduct the alone condition would have been to include a therapist who ignored all occurrences of SIB.

The FT FR 1 (EO absent/contingency present) condition used in the present study is not included in a typical functional analysis. In fact, results of several recent studies have shown that schedules of noncontingent reinforcement superimposed over schedules of contingent reinforcement are associated with response suppression (Fischer, Iwata, & Mazaleski, 1997; Lalli, Casey, & Kates, 1997). We included the FT FR 1 condition to evaluate all possible combinations of reinforcement withheld and delivered as antecedent and consequent events. The results obtained in this condition provide perhaps the best illustration of the relative influence of EOs on responding in the presence of reinforcement and suggest that those effects may be somewhat idiosyncratic. Brenda and Dolly engaged in low rates of SIB under FT FR 1, suggesting that the FT 30-s schedule of noncontingent reinforcement eliminated deprivation as an EO and, as a result, compromised the effects of the FR 1 schedule of contingent reinforcement. These results were consistent with those reported by by Fischer, Iwata, and Mazaleski and by Lalli et al. By contrast, Jenna, Beth, Rich, and Sheila exhibited relatively high rates of SIB under FT FR 1; that is, they continued to engage in SIB for reinforcement even though reinforcement was freely available. The results obtained for these 4 participants were somewhat unusual but suggest that the FT 30-s schedule of noncontingent reinforcement simply did not compete effectively with the FR 1 schedule of contingent reinforcement. In most therapeutic applications of noncontingent reinforcement, initial schedules of reinforcer delivery were continuous (e.g., Hagopian et al., 1994; Hanley, Piazza, & Fisher, 1997; Vollmer, Iwata, Zarcone, Smith, & Mazaleski, 1993) or resulted in rates of reinforcement greater than those experienced under baseline conditions (Goh, Iwata, & DeLeon, 2000; Marcus & Vollmer, 1996). Thus, it is possible that low rates of SIB would have been observed more consistently in the FT FR 1 condition under a richer schedule of noncontingent reinforcement.

It is also possible that the high rates of SIB observed during Jenna's and Beth's FT FR 1 conditions were due to the fact that the forms of noncontingent and contingent attention were dissimilar. The FT attention delivered as an antecedent event consisted of general social statements, whereas the FR attention delivered as a consequence consisted of statements of concern and disapproval. Results of two recent studies (Fisher, Ninness, Piazza, & Owen-DeSchryver, 1996; Piazza et al., 1999) have shown that different forms of attention may not always have similar reinforcing effects. Thus, the possibility exists that the forms of attention provided during the FT FR 1 condition were not functionally equivalent, leading to unsuccessful competition between the noncontin-

gent and contingent schedules of reinforcement.

In summary, results of the present study have several implications for the design of functional analysis test and control conditions. First, the most consistent effects were observed when both the EO and reinforcement contingency were present, suggesting control over both antecedent and consequent events as a preferred strategy in the development of a test condition. Second, although low rates of problem behavior were observed under extinction regardless of whether the EO was present (alone) or absent (FT/ignore), we believe that the latter condition would be a preferred control because it seems less likely to evoke problem behavior. Third, results obtained during the FT FR 1 condition suggest that the manipulation of EOs may affect functional analysis outcomes even when test conditions contain positive reinforcement contingencies. Smith, Iwata, Goh, and Shore (1995) showed a similar influence of EOs during functional analyses of problem behavior maintained by negative reinforcement. Finally, it is important to emphasize the fact that the influences of antecedent and consequent events were examined only on a within-session basis. It is entirely possible that historical variables prior to an assessment session may affect behavior during a session (see O'Reilly, 1999, as an example), which may require more careful consideration of presession conditions.

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STUDY QUESTIONS

1. Describe the two general models for conducting functional analyses of problem behavior and note the main difference between them.

2. The authors describe the establishing operation (EO) for behavior maintained by social-positive reinforcement. In a typical functional analysis, what would be the EO for behavior maintained by (a) social-negative reinforcement and (b) automatic reinforcement?

3. Construct a table showing the antecedent and consequent manipulations for the four functional analysis conditions of interest in this study.

4. Summarize the results obtained for all participants under the four assessment conditions.

5. Given the results observed under the FT FR 1 condition, how might this condition be altered to increase or decrease the likelihood of problem behavior?

6. Describe the relative strengths and limitations of the alone (ignore) and play (FT/ignore) conditions as control conditions for behavioral sensitivity to social-positive reinforcement. Ultimately, what feature of both conditions makes either one at least adequate as a control condition?

7. According to the authors, what factors may have produced high rates of problem behavior under the FT FR 1 condition for some participants?

8. Based on the findings of the current study, what is the authors' general recommendation for the development of test conditions in a functional analysis?

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