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IDENTIFICATION OF ENVIRONMENTAL DETERMINANTS OF BEHAVIOR DISORDERS THROUGH FUNCTIONAL ANALYSIS OF PRECURSOR BEHAVIORS

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Experimental analysis procedures have been shown to be effective means for identifying the environmental determinants of problem behaviors. A potential limitation of these procedures is that it is necessary to produce and document patterns in the occurrence of the problem behavior during the assessment. In the case of severe behavior disorders, this may place the participant or therapist at such risk as to preclude the analysis. The current study arranged experimental analysis contingencies for precursor behaviors that had been observed to reliably precede the occurrence of problem behaviors targeted for reduction. For each of the 4 participants, it was possible to infer the maintaining variables for problem behaviors based on the outcomes of precursor analysis. These results suggest that the current procedures represent a promising alternative method for reducing risk during functional analysis of problem behaviors.

DESCRIPTORS: functional analysis, behavior disorders, response class hierarchies, precursor behaviors

Functional analysis has been demonstrated to be an effective means of identifying the environmental determinants of self-injurious behavior (SIB) and other behavior disorders. This information can then be used to develop treatments that correspond to the operant function of the problem behavior (Neef & Iwata, 1994). Experimental, or analogue, analysis methods for assessing problem behaviors involve systematic manipulation of antecedent and consequent variables that may evoke and maintain problem behaviors while eliminating or holding constant the "noise" (e.g., inconsistent contingencies, chaotic environments, and confounding variables) that makes such relations difficult to identify in natural settings. Thus, these methods permit direct observation of the effects of specific operant contingencies on problem behaviors.

A potential limitation of analogue analyses is that conditions are designed to systematically evoke and provide potentially reinforcing consequences for problem behavior. In fact, in order to produce outcomes that provide useful information about the variables associated with problem behavior, it is necessary to observe and document its occurrence during at least one functional analysis condition. Thus, risks associated with the behavior are present during the assessment. Furthermore, it may not be possible to conduct standard functional analyses when the problem behaviors simply cannot be allowed to occur. For example, if SIB is life threatening or aggression is severe, standard analogue procedures may be precluded. Several methodological variations of basic analogue analysis procedures might address this limitation.

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One general strategy for reducing risk during functional analysis procedures is abbreviated, or time-limited, assessment (e.g., Derby et al., 1992; Kahng & Iwata, 1999; Vollmer, Marcus, Ringdahl, & Roane, 1995). Results of studies using brief assessment procedures suggest that although they sometimes reveal the variables associated with problem behaviors, longer assessments are often necessary to clarify initial assessment results. For example, of 79 participants in the Derby et al. study, the variables maintaining problem behavior were identified for only 37 (46.8%) during the initial assessment. The remainder required additional assessments before the contingencies that maintained their problem behaviors could be identified. Similarly, data from only 6 of 20 participants differentiated during the initial phase of assessment in the Vollmer et al. study. Finally, outcomes of the two brief analysis procedures described by Kahng and Iwata corresponded to the outcomes of the extended analyses in 66% and 68% of the cases. Thus, for many participants, the additional protection afforded by brief analysis procedures is compromised because additional extended analyses are frequently necessary to produce orderly data. In addition, even brief procedures require that the problem behavior be produced and observed during the assessment, which may not be possible if the behavior is extremely dangerous.

Another potential method for reducing risk during functional analyses is to use protective equipment during sessions (e.g., helmets, arm splints, padded mittens). Le and Smith (in press) compared the outcomes of functional analyses of SIB of 3 participants with and without protective equipment. Outcomes of the analyses with protective equipment did not match those of the analyses without protective equipment and did not provide independent evidence about the variables associated with any participant's SIB. Thus, it appears that the use of protective equipment can confound the outcomes of assessment and does not represent a promising method to protect participants during functional analyses.

Another potential method to reduce risk during functional analysis is to infer the functional properties of problem behaviors based on outcomes of analyses of related behaviors. For example, if problem behaviors are members of functional response classes that include other, more benign behaviors, then placing functional analysis contingencies on benign members of the response class may indirectly produce information about the maintaining variables for the problem behavior. Furthermore, if the response class is hierarchically ordered and benign members of the class occur early in the response sequence, then little or no problem behavior may occur during the assessment. For example, when Lalli and colleagues applied contingencies for the first response in a response hierarchy, two subsequent responses were nearly eliminated (Lalli, Mace, Wohn, & Livezey, 1995). Other studies (Harding et al., 2001; Parrish, Cataldo, Kolko, Neef, & Egel, 1986; Sprague & Horner, 1992) demonstrated similar effects when both topographically similar and dissimilar behaviors within the same response class were manipulated. Thus, it may be possible to reduce risk during functional analyses by identifying and placing functional analysis contingencies on precursor behaviors (behaviors that are observed to frequently precede the problem behavior). In the current study, outcomes of standard functional analyses of problem behaviors were compared with outcomes of functional analyses of precursor behaviors to determine whether (a) the analyses identified a common maintaining contingency and (b) primary problem behaviors occurred less frequently during the functional analyses of precursor behaviors.

METHOD

Participants and Setting

The participants, Joan, Al, Fred, and Lula, lived at a residential facility for individuals with developmental disabilities. Each had received a diagnosis of profound mental retardation, none exhibited expressive language, and each appeared to have some limited receptive language skills. All participants had been referred for assessment and treatment of severe and chronic behavior disorders that placed the participants (Al, Joan, and Lula) or others (Fred) at risk for tissue damage. Participants were prescreened for the existence of precursor behaviors, but it was not necessary to exclude participants based on this criterion (i.e., 4 consecutive clients exhibited precursors during the prescreening process). Joan, whose problem behaviors included severe and chronic head banging, body hitting, and knee banging, was 41 years old at the time of the study. Al, whose problem behaviors included self-injurious wrist biting and body hitting, was 53 years old at the time of the study. Al took thioridazine HCl (150 mg/day) for behavior management during the study. Fred, whose primary problem behavior was aggression toward caregivers, was 35 years old at the time of the study. Lula, whose problem behaviors included self-injurious wrist biting, was 52 years old at the time of the study. All sessions were conducted at a day program for the assessment and treatment of severe behavior problems, located on the campus of the participants' residence. The experimental room in which sessions were conducted contained a table and chairs, a couch, and appropriate materials for each analogue session.

Target Behaviors

Problem behaviors. Operational definitions were developed for all participants' problem behaviors. Head banging (Joan) was defined as any audible contact of the head to any stationary surface. Body hitting (Joan and Al) was defined as audible contact of the open hand to any part of the body. Knee banging (Joan) was defined as any audible contact of the knees to a stationary surface. Aggression (Fred) included hitting and kicking others, and was defined as audible contact of the hand or foot to any part of another person. Wrist biting (Al and Lula) was defined as contact of the teeth with any part of the forearm.

Precursor behaviors. Operational definitions were developed for all participants' precursor behaviors. Precursor behaviors were identified via reports from caregivers and direct observation of participants in their residence prior to their participation in the study. No systematic procedures were used during these observations, but in each case it was possible to identify behaviors that frequently occurred just prior to the occurrence of problem behaviors (e.g., within 10 s). Screaming (Joan) was defined as any vocalization emitted above normal conversational volume. Grabbing (Joan) was defined as closure of the hand around any body part of another person. Falling (Joan) was defined as moving from a standing or sitting position to the floor. Vocalization (Al and Lula) was defined as any audible vocal sound other than laughter. Crying (Fred) was defined as audible whining at a volume exceeding that of normal conversation. Reaching (Fred) was defined as extending the arm toward another. Foot stomping (Fred and Joan) was defined as audible contact between the bottom of the foot and any stationary object.

Observation Procedures and Interobserver Agreement

Target behaviors were recorded by trained observers using handheld computers with software designed for behavioral data collection. Event recording was used to record all responses for Joan, Al, and Lula, and Fred's aggression. Rate (number of responses per

minute) was determined by dividing the total number of target responses scored by the session length in minutes. A partial-interval method was used to record Fred's precursor behaviors. Session time was divided into 10-s intervals, and observers scored the presence or absence of responses in each interval. Percentage scores were calculated by dividing the number of intervals containing target behavior by the number of intervals in the session and multiplying the result by 100%.

A second observer simultaneously but independently scored 30%, 37.5%, 23%, and 26.6% of sessions for Joan, Al, Fred, and Lula, respectively. Interobserver agreement was calculated by dividing the session length into 10-s intervals. Within each interval, the smaller number of recorded responses was divided by the larger. The results were summed across the session, divided by the total number of intervals and multiplied by 100%. Agreement for Fred's precursor behaviors was calculated by dividing the session length into 10-s intervals, summing the number of intervals in which observers agreed about the presence or absence of precursors, dividing the sum by the number of intervals in the session, and multiplying the result by 100%. Mean agreement scores for Joan were 100% for SIB and 97.6% for precursor behaviors (range, 85% to 100%). Mean agreement scores for Al were 99.3% for SIB (range, 93.5% to 100%) and 97.3% for precursor behavior (range, 87% to 100%). Mean agreement scores for Fred were 99.9% for aggression (range, 98.8% to 100%) and 97.3% for precursor behaviors (range, 85.5% to 100%). Mean agreement scores for Lula were 99.2% for SIB (range, 95.1% to 100%) and 99% for precursor behavior (range, 95.8% to 100%).

General Procedure, Experimental Design, and Conditions

Experimental analysis conditions similar to those described by Iwata, Dorsey, Slifer, Bauman, and Richman (1982/1994) (alone, attention, tangible [Joan only], play, and demand) were presented using a multielement format. All sessions were 15 min in length (except for Lula, whose sessions were 10 min) and were conducted in the above order. One to four sessions were conducted per day, at the same time each day, 5 days per week. For Lula, one 1-hr alone session was conducted prior to her multielement analysis, and no alone sessions were conducted during the multielement analysis (staff had indicated that Lula was unlikely to emit SIB when she was alone, so the extended alone session was conducted to confirm this report before moving to extended analysis).

Each participant was exposed to the multielement analysis until the variables maintaining their problem behavior were apparent. Next, the multielement analysis was replicated, with the exception that experimental contingencies were placed on precursor behaviors rather than on problem behaviors. All other procedural variables (e.g., therapists, number and sequence of sessions) were identical to the original assessment. The following is a general description of the operative contingencies during the experimental conditions (see Iwata et al., 1982/1994, for a more complete description of these procedures).

Alone. The participant was seated in a room. No leisure materials were present, no therapist was present, and there were no programmed consequences for target behaviors. This condition was designed to evaluate whether target behaviors were maintained by nonsocial (automatic) reinforcement.

Attention. The participant was seated in a chair in the experimental room. Leisure materials (e.g., toys, games, and magazines) were scattered throughout the room. Occurrences of target behaviors produced approximately 5 s of attention from the therapist (e.g., the therapist approached the participant and delivered statements of concern or

reprimands). No other interaction between the participant and therapist occurred during these sessions. This condition was designed to evaluate whether target behaviors were maintained by positive reinforcement in the form of attention.

Play. The participant was seated in a chair in the experimental room. Leisure materials (e.g., toys, games, and magazines) were scattered throughout the room. No demands were given, but approximately every 30 s the therapist approached and interacted with the participant (e.g., "Fred, how are you doing today?") for approximately 5 s. There were no programmed consequences for target behaviors. This condition served as a control, against which test conditions were compared.

Demand. The participant was seated in the experimental room devoid of leisure materials. Every 30 s the therapist approached the participant and initiated a task trial (e.g., "Joan, stack these papers over here.") using a three-prompt sequence (verbal prompting, modeling, and physical guidance). Compliance prior to the third prompt resulted in statements of praise (e.g., "Great job stacking that paper, Joan.") and a break for the remainder of the 30-s trial. Target behaviors resulted in termination of the trial. Occurrences of target behaviors within 5 s before a scheduled trial delayed presentation of the trial until 5 s elapsed with no occurrence of target behavior. This condition was designed to evaluate whether target behaviors were maintained by negative reinforcement in the form of escape from task trials.

Tangible (Joan). Anecdotal reports from direct care staff suggested that Joan sometimes appeared to engage in SIB to gain access to preferred items. Therefore, a fifth condition was conducted. Immediately before each tangible session, she was allowed access to highly preferred items for approximately 10 s. Next, she was seated in the experimental room with the therapist who held the items in plain view. Target behaviors resulted in access to the items for approximately 10 s. This condition tested whether her behavior was maintained by positive reinforcement in the form of presentation of tangible items.

RESULTS

Results for all participants are presented in Figures 1 through 4. To provide a clearer visual depiction of response differentiation across test conditions, *Y*-axis scales for problem behaviors are different from those for precursor behaviors.

Joan's results are shown in Figure 1. During the first phase of the assessment (contingencies on SIB), SIB occurred almost exclusively in the demand condition, indicating that it was sensitive to negative reinforcement in the form of termination of task trials. Precursor behaviors occurred at the highest levels during demand and tangible sessions. During the second phase of assessment (contingencies on precursors), precursor behaviors occurred almost exclusively during demand sessions. Thus, results of the experimental analyses of SIB and precursor behaviors identified a common maintaining contingency. In addition, SIB rarely occurred during the second phase of assessment, showing a reduction during demand sessions from a mean rate of 1.3 responses per minute during the first phase to 0.01.

Al's results are shown in Figure 2. During the first phase of the assessment (contingencies on SIB), SIB occurred almost exclusively in the demand condition, indicating that it was sensitive to negative reinforcement in the form of termination of task trials. Precursor behaviors also occurred at the highest levels during demand sessions. During the second phase of assessment (contingencies on vocalizations), vocalizations occurred almost exclusively during demand sessions. Thus, outcomes of the experimental analyses

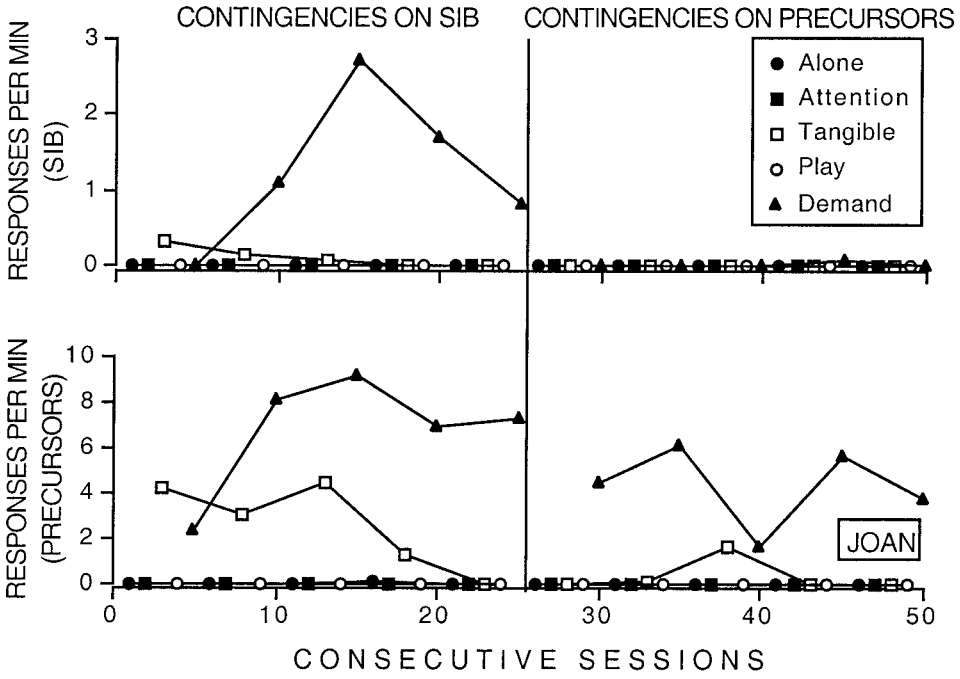

Figure 1. Rates (number of responses per minute) of SIB (top panel) and precursor behaviors (bottom panel) for Joan.

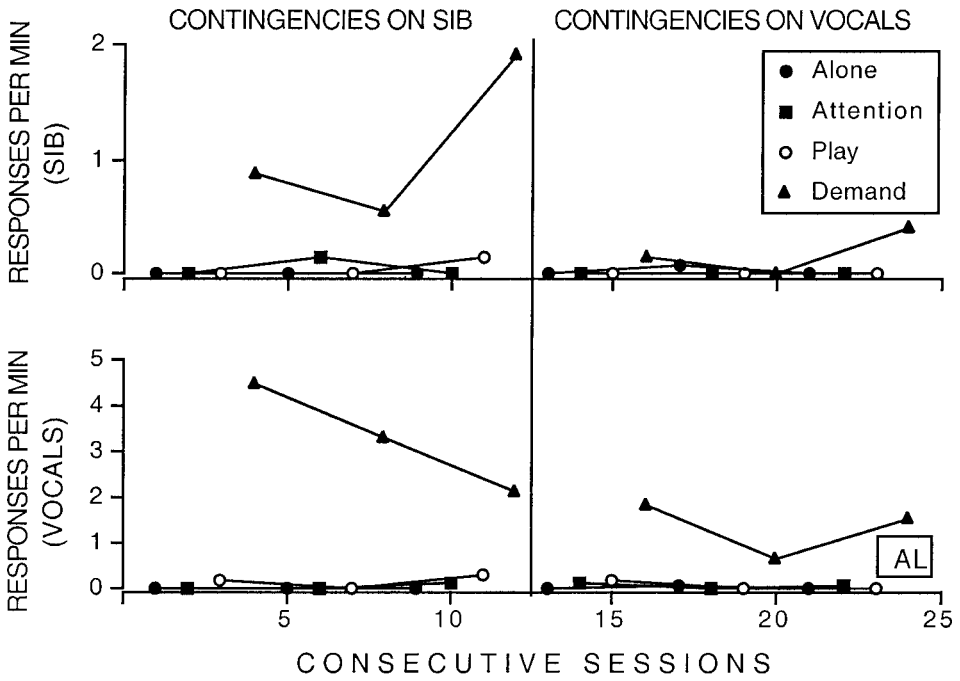

Figure 2. Rates of SIB (top panel) and vocalizations (bottom panel) for Al.

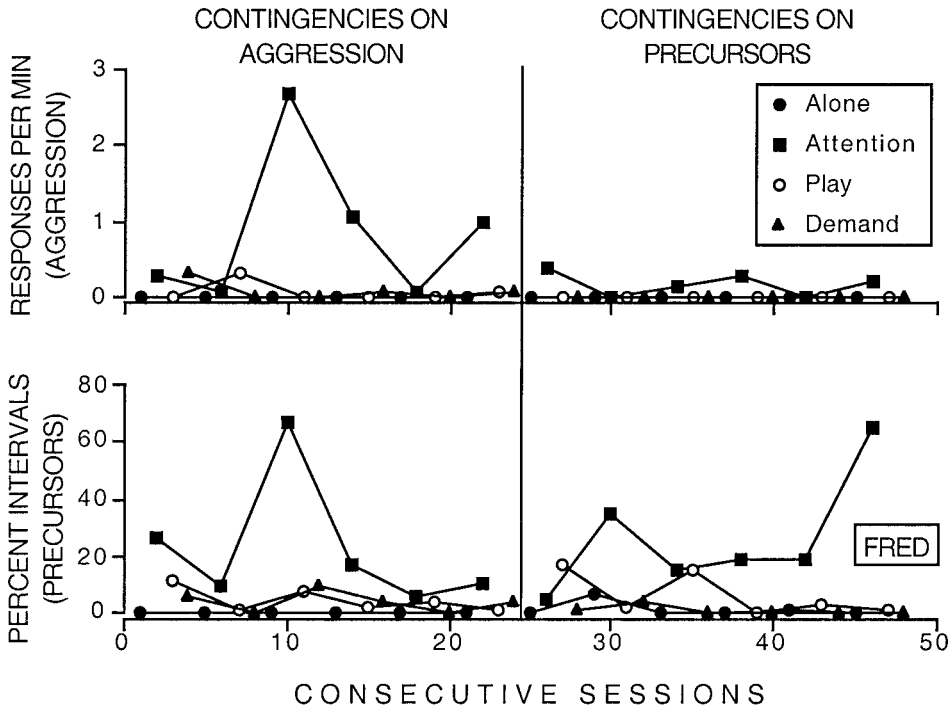

Figure 3. Rates of aggression (top panel) and percentage of intervals containing precursor behaviors (bottom panel) for Fred.

of SIB and vocalizations identified a common maintaining contingency. In addition, SIB rarely occurred during the second phase of assessment, showing a reduction during demand sessions from a mean rate of 1.1 during the first phase to 0.05.

Fred's results are shown in Figure 3. During the first phase of the assessment (contingencies on aggression), aggression occurred almost exclusively in the attention condition, indicating that it was sensitive to positive reinforcement in the form of attention from the therapist. Precursor behaviors occurred across all conditions but at their highest levels during attention sessions. During the second phase of the assessment (contingencies on precursor behaviors), precursor behaviors occurred at the highest levels during attention sessions. Thus, outcomes of the experimental analyses of aggression and precursor behaviors identified a common maintaining contingency. In addition, aggression rarely occurred during the second phase of assessment, showing a reduction during attention sessions from a mean rate of 0.86 during the first phase to 0.13.

Lula's results are shown in Figure 4. During the first phase of assessment (contingencies on SIB), SIB occurred almost exclusively during demand sessions, with the exception of one attention session (Session 7) when SIB occurred at a rate of 10.5 responses per minute. These results suggest that Lula's SIB was maintained primarily by negative reinforcement in the form of termination of task trials. Vocalizations also occurred almost exclusively during demand sessions with the exception of Session 7 when vocalizations occurred at a rate of 1.5. During the second phase of the assessment (contingencies on vocalizations), vocalizations occurred exclusively during demand sessions. Thus, outcomes of the experimental analyses of SIB and vocalizations identified a common

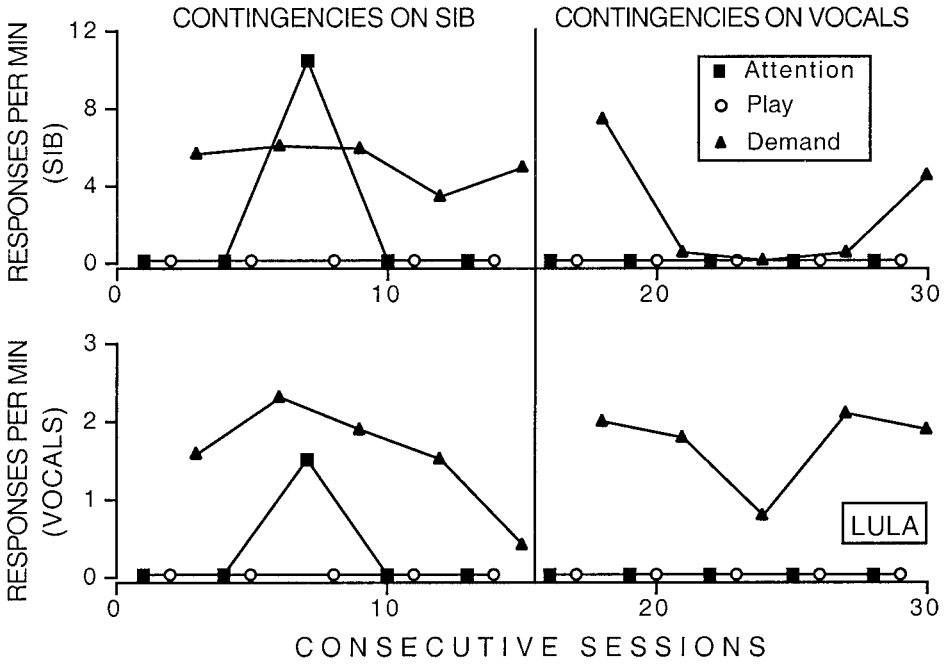

Figure 4. Rates of SIB (top panel) and vocalizations (bottom panel) for Lula.

maintaining contingency. Although SIB occurred at high levels during Sessions 18 and 30, the mean rate of SIB showed a decrease from 5.2 during the first phase of assessment to 2.68 during the second phase.

DISCUSSION

For all participants in this study, experimental analyses of problem and precursor behaviors "matched," in the sense that each pair of assessments identified a common maintaining contingency. This suggests that it is possible to infer the environmental determinants of problem behaviors by placing experimental analysis contingencies on behaviors that are observed to occur just prior to the problem behaviors. The current outcomes also show that problem behaviors occurred at greatly reduced levels during the assessments of precursor behaviors. Taken in combination, these outcomes suggest that experimental analysis of precursor behaviors represents a promising method to decrease risk to participants or caregivers during functional analyses of dangerous behaviors.

Whereas standard functional analysis procedures identify maintaining contingencies through evocation of and application of consequences to the behavior targeted for reduction, the current procedures represent an indirect assessment method in which the functional properties of the primary problem behavior are inferred via patterns of a behavior that is correlated with the primary problem behavior. It is important to note that this was usually accomplished without evoking or reinforcing the problem behavior itself. Thus, the results of the current study suggest that these procedures may represent an alternative functional analysis method when the behavior targeted for reduction is too dangerous to the participant or therapist to be allowed to occur. However, the current results are not sufficiently general to warrant a recommendation that clinicians replace functional analyses of problem behaviors with precursor analyses; replications of these

procedures with additional participants are needed to determine the general utility of this method.

It is important to note that no participant in the current study engaged in problem behavior maintained independent of social contingencies. A limitation of this type of assessment is that it would not be possible to assess behavior so maintained because it is not possible to differentially withhold or present the automatically occurring consequences presumed to be operative in such cases. Thus, the current procedures do not provide a means of protection for participants whose behavior disorders are maintained independent of social contingencies.

A recommended strategy for providing protection for clients whose problem behaviors are suspected to be maintained automatically (e.g., clients with profound developmental disabilities, sensory deficits, or who present with certain topographies of SIB such as eye poking or hand mouthing) is to begin assessment with an extended alone condition, as was done with Lula in the current study. If responding persists during this condition, treatment for automatically maintained problem behavior could be initiated. If the behavior was not observed or showed signs of extinction during this condition (e.g., bursting, followed by a decrease in rate), then an assessment of precursor behaviors could be initiated. This sequence of assessment procedures would allow rapid identification of behavior maintained independent of social contingencies without requiring initial exposure to irrelevant assessment conditions.

In the current study, precursor behaviors appeared to be functionally related to primary problem behaviors in that both problem and precursor behaviors were sensitive to the same reinforcement contingencies (i.e., they were members of common functional classes). In addition, precursor behaviors were typically emitted just prior to the more problematic responses. Such orderly relations have been referred to as response hierarchies (Lalli et al., 1995). Lalli et al. conducted a functional analysis showing that three problem behaviors displayed by a 15-year-old girl were each maintained by escape and that they typically occurred in a predictable sequence. When reinforcement contingencies were applied to the first of these responses to occur in this response hierarchy sequence, later responses in the sequence were suppressed. The authors speculated that the earlier responses were possibly less effortful, less likely to be punished, and produced a shorter latency to reinforcement than later members of the hierarchy. In addition, one may speculate that in the natural environment earlier responses frequently produce reinforcement, making engaging in responses that otherwise occurred later in the hierarchy unnecessary.

Magee and Ellis (2000) observed that when continuous reinforcement was available for the first problem behavior observed during assessment, additional problem behaviors did not occur. However, when extinction was systematically applied to first-occurring responses, subsequent members of the response class increased in rate. Apparently, applying extinction to initial members of hierarchically ordered response classes can increase the likelihood of occurrence of other class members. This arrangement may be analogous to standard functional analysis procedures in which experimental contingencies are operative only for behaviors targeted for reduction while other potential members of the response class are functionally placed on extinction. Thus, by placing contingencies on other responses that are likely to occur early in a hierarchical sequence (precursor behaviors), the likelihood of observing more problematic, subsequently occurring responses can be decreased. These findings emphasize the importance of selecting behaviors for assessment that reliably

precede the problem behavior rather than behaviors that are merely *correlated with* the problem behavior, thus not only permitting accurate inferences about the problem behaviors but also reducing the likelihood of their occurrence.

One potential account of the mechanism responsible for the decrease in problem behaviors during the precursor assessment is that the establishing operation (EO) for the problem behaviors was decreased due to delivery of the maintaining consequence following precursor behaviors (i.e., satiation). However, there are at least three limitations to this account. First, there were no programmed consequences for problem behaviors during the precursor assessment and, thus, problem behaviors would be expected to be extinguished in this condition. A second and related issue is that the original response–consequence contingency must be maintained when evaluating EOs (see Smith, Iwata, Shore, & Goh, 1995, for explication of this strategy). Third, precursor behaviors persisted at relatively high levels across participants during the precursor assessment. If EOs for the *classes of behaviors* maintained by the consequence of interest had been manipulated, then *all* behaviors in those classes should have decreased. Thus, the decreases in problem behaviors observed during this study do not appear to be the result of changes in EOs.

The etiology of these hierarchically ordered response classes remains unknown, although at least one tenable account can be articulated. In natural settings, caregivers may occasionally provide potentially reinforcing consequences when behaviors that covary with problem behaviors are observed in an attempt to avoid or "head off" more severe problem behavior. That is, if a caregiver "senses" that a client is becoming agitated or upset, he or she may take action to calm the person down before an escalation to more severe problem behavior occurs. These actions may include such potentially reinforcing events as the provision of attention or termination of task trials. Such arrangements might represent inadvertent differential reinforcement of alternative behavior (DRA), and may result in an uneven distribution of responses in the class in favor of precursor behaviors (Sprague & Horner, 1992), especially if these behaviors are less effortful, less painful, and equally likely to be followed by reinforcement (Lalli et al., 1995).

A limitation of the current study is that no systematic procedure for identifying precursors was used. Precursor behaviors were identified based on verbal reports by attending staff and casual observations by experimenters. Thus, more systematic methods for identifying precursor behaviors are needed. However, for each of the 4 participants in this study, staff reports and informal observation (i.e., clinical judgment) effectively and efficiently identified responses that, when entered into functional analysis contingencies, produced valid assessment results and reduced occurrences of related problem behaviors. Subsequent investigations might focus on more systematic and replicable methods for identifying precursor behaviors. For example, conditional probabilities obtained via descriptive assessment could be used to determine whether potential precursors (a) reliably precede problem behaviors and (b) are unlikely to occur at other times (Thompson & Iwata, 2001; Vollmer, Borrero, Wright, Van Camp, & Lalli, 2001).

Other areas for future investigation may include the etiology of precursor behaviors and how they become related to other, more detrimental behavior; and how members of hierarchically ordered response classes relate to each other and to environmental contingencies. In addition, studies showing direct progression from precursor analyses to treatment should be conducted. Such investigations may lead not only to the development

of safer and more efficient assessment methods but also to more direct integration of treatment with assessment, in which elucidation of the functional properties of behavior disorders and initiation of effective treatments may be accomplished simultaneously.

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STUDY QUESTIONS

1. What were the participants' precursor behaviors, and how were the precursors identified?

2. What was the procedural difference between the two functional analyses?

3. What was the purpose of Lula's extended alone session?

4. Briefly summarize the results obtained in the two functional analyses.

5. Results of the study suggested that it is possible to "infer the environmental determinants of problem behaviors by placing experimental analysis contingencies on behaviors that are observed to occur just prior to the problem behaviors." What is the potential danger of making this type of inference?

6. Why is it that functional analyses of precursor behaviors may be relevant only for behaviors maintained by social reinforcement?

7. The authors suggested that the current procedures may be helpful when problem behaviors are too dangerous to be allowed to occur. For what other kinds of behaviors might precursor analyses be useful?

8. What are the implications of the results for treatments consisting of differential reinforcement versus exinction?

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