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DESCRIPTIVE AND EXPERIMENTAL ANALYSES OF POTENTIAL PRECURSORS TO PROBLEM BEHAVIOR

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We conducted descriptive observations of severe problem behavior for 2 individuals with autism to identify precursors to problem behavior. Several comparative probability analyses were conducted in addition to lag-sequential analyses using the descriptive data. Results of the descriptive analyses showed that the probability of the potential precursor was greater given problem behavior compared to the unconditional probability of the potential precursor. Results of the lag-sequential analyses showed a marked increase in the probability of a potential precursor in the 1-s intervals immediately preceding an instance of problem behavior, and that the probability of problem behavior was highest in the 1-s intervals immediately following an instance of the precursor. We then conducted separate functional analyses of problem behavior and the precursor to identify respective operant functions. Results of the functional analyses showed that both problem behavior and the precursor served the same operant functions. These results replicate prior experimental analyses on the relation between problem behavior and precursors and extend prior research by illustrating a quantitative method to identify precursors to more severe problem behavior.

DESCRIPTORS: descriptive assessment, functional analysis, lag-sequential analysis, precursors, problem behavior, response-class hierarchies

Iwata, Dorsey, Slifer, Bauman, and Richman (1982/1994) designed a series of experimental conditions based on the conceptual model described by Carr (1977) to identify the operant function of self-injurious behavior (SIB). Subsequently, functional analyses have been shown to be effective in identifying the functions of a variety of response forms and across a variety of settings (see Hanley, Iwata, & McCord, 2003, for an extensive review). However, as suggested by Iwata (1994), there are some circumstances under which the traditional functional analysis methods may be difficult to carry out. For example, when the severity of behavior (e.g., intense SIB) places the participant at risk, functional analysis may be applied more appropriately to response forms that are potentially equivalent in function to severe problem behavior but are of less danger to the participant. Similarly, when the response topography (e.g., aggression) places the therapist or experimenter at risk, assessing response topographies that are correlated with more severe behavior may be indicated. Notably, this highlights the malleability of the functional analysis and not a limitation of the procedure.

Lalli, Mace, Wohn, and Livezey (1995) demonstrated that less severe problem behavior frequently cooccurs with more severe problem behavior and that the two could share func-

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tional similarities. Lalli et al. conducted a functional analysis of SIB and aggression exhibited by a young woman with developmental disabilities in which either topography produced the programmed reinforcer across test conditions. In addition, the researchers collected data on a third topography (screaming) while contingencies were in place for SIB and aggression. Next, the researchers systematically exposed two of the three responses to extinction while delivering the reinforcer following occurrences of only one topography. For example, one analysis involved reinforcement for SIB while aggression and screams were placed on extinction. A second analysis involved reinforcement for screams while SIB and aggression were placed on extinction. Lalli et al. used latency to response as the dependent variable and showed that the participant exhibited an orderly sequence of response topographies, depending on which response produced the reinforcer. Richman, Wacker, Asmus, Casey, and Adelman (1999) reported a similar finding.

Magee and Ellis (2000) conducted a related study in which they implemented extinction systematically across multiple topographies of problem behavior. Functional analyses were conducted with 2 young boys to identify the function of problem behavior. Next, the behavior observed most frequently during the functional analysis was exposed to extinction while other topographies of behavior (e.g., yelling, property destruction) continued to produce the reinforcer identified via functional analysis. Magee and Ellis noted a relative increase in levels of the problem behavior that continued to produce the reinforcer. This finding was observed for both participants and suggests that the nonoccurrence of multiple forms of problem behavior during functional analyses may result from other members of the response class producing functionally similar reinforcers.

Smith and Churchill (2002) assessed the functional similarities between more and less severe topographies of problem behavior. Smith and Churchill conducted functional analyses of severe problem behavior and events that were reported (or observed) to occur prior to instances of severe problem behavior with 4 participants. The researchers referred to these latter response topographies as *precursors*. By systematically applying contingencies to either severe problem behavior or precursors, Smith and Churchill were able (a) to identify the operant function of severe problem behavior, (b) to identify the operant function of the precursor, and (c) to assess levels of precursors and severe problem behavior during conditions in which contingencies were not explicitly arranged for either response (i.e., assess levels of the presumed precursor when contingencies were arranged for problem behavior but not precursors, and vice versa). Results of the functional analyses of severe problem behavior matched those obtained for functional analyses of precursors for all participants. For example, for 1 participant, escape from demands reinforced SIB. When the contingencies were applied to precursors and no programmed contingencies were in place for SIB, levels of SIB were low while levels of the precursor (vocalizations) were elevated in the escape condition. Based on these results, Smith and Churchill concluded that precursors and problem behavior were members of the same response class. This finding is encouraging in that it suggests that, in some situations, effective treatments could be developed based on functional analyses that target less dangerous response topographies, thereby possibly reducing the previously described risks associated with functional analyses of severe problem behavior. One potential limitation of the study by Smith and Churchill is that no systematic methods of direct observation were applied to assess the relation between precursors and severe problem behavior.

An alternative strategy to the assessment of dangerous problem behavior is descriptive assessment, which involves the direct observation

of behavior under naturally occurring environmental conditions (Iwata, Kahng, Wallace, & Lindberg, 2000). For example, prior descriptive behavioral assessment research has attempted to develop hypotheses about the operant function of problem behavior by gathering data on events that occur antecedent and subsequent to instances of problem behavior (e.g., Kern, Hilt, & Gresham, 2004). Although descriptive observation methods identify only correlations rather than causal relations among events, they have been shown to be useful for describing response sequences or the temporal organization of behavior (e.g., Bakeman & Gottman, 1997). For example, Samaha et al. (in press) gathered descriptive data on instances of problem behavior and events that occurred antecedent and subsequent to problem behavior for 4 individuals with developmental disabilities. After identifying the operant function of each participant's problem behavior by way of functional analysis, the descriptive data were exposed to lag-sequential analyses to assess moment-to-moment changes in the probability of known reinforcers, given problem behavior, for up to 2 min before (lag −2 min) and 2 min after (lag +2 min) instances of problem behavior. Results showed that, during naturally occurring interactions, the probability of events assessed in the functional analyses could be characterized broadly as either positive (relatively larger probability values given problem behavior as compared to the unconditional probability of problem behavior) or negative (relatively smaller probability values given problem behavior as compared to the unconditional probability of problem behavior) contingencies.

The purpose of the current study was to identify potential precursors to more severe problem behavior using several comparative probability calculations. This objective was designed to address the aforementioned limitation of the study by Smith and Churchill (2002). A secondary purpose of the current study was to assess the function of both precursors and problem behavior to determine whether they were members of the same or distinct response classes.

STUDY 1: DESCRIPTIVE ASSESSMENT

Method

Participants and Response Topographies

Two individuals participated in this study. Paolo was a 12-year-old boy who had been diagnosed with autism. His problem behavior consisted of *aggression*, defined as hitting another person with an open or closed hand, and *SIB*, defined as a closed hand hit to the bridge of the nose. The severity of Paolo's SIB had previously resulted in a broken nose. Bruno[1] was an 11-year-old boy who had also been diagnosed with autism. His problem behavior consisted of *aggression*, defined as hitting, slapping, or kicking another person; *SIB*, defined as hand biting; and *property destruction*, defined as hitting, kicking, or throwing objects. The potential precursor for both participants was *vocalizations*, defined as vocal utterances at a volume louder than normal conversation.

Descriptive Assessment and Settings

Descriptive data were gathered for each participant using methods described by Vollmer, Borrero, Wright, Van Camp, and Lalli (2001). Observers used a computerized data-collection system to record three potential reinforcers (instruction termination, access to tangible items, and attention), problem behavior (defined individually for each participant), potential precursors (vocalizations) and potential establishing operations (EOs; instructional demands, restricted access to tangible or edible items, and periods of low attention). Descriptive assessments were conducted prior to

[1]Descriptive data for Bruno were previously reported by Borrero, Francisco, Haberlin, Ross, and Sran (2007) and expressed as work and demand functions. These data were not subjected previously to conditional probability analyses or lag-sequential analyses.

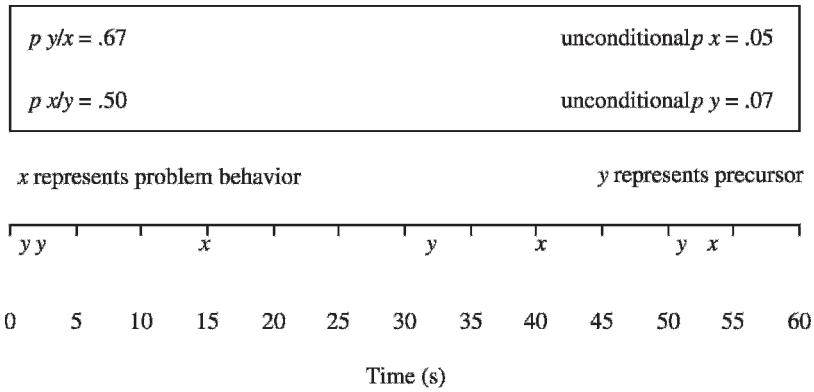

Figure 1. Example of data analysis depicting how the two conditional probability values and the two unconditional probability values were calculated, across 60 s of observation.

functional analyses to identify patterns of behavioral and environmental events in the natural environment prior to exposure to experimental contingencies in the functional analysis. *Attention* was defined as physical or verbal interaction between the participant and their teachers. *Instruction termination* was defined as removal of demands and instructional materials for a period of at least 3 s, or the absence of instructions if the participant disengaged from a previously specified task for at least 3 s. *Access to tangible items* was defined as availability of previously restricted (or unavailable) items for manipulation. Potential reinforcers and potential EOs were recorded as duration measures, and instances of problem behavior and the potential precursor were recorded as frequency measures.

Descriptive observations were conducted during regularly scheduled activities at a private school that specialized in the education of individuals with developmental and emotional disabilities. All descriptive observations lasted at least 1 hr (71 min for Paolo, 134 min for Bruno) or until at least 45 instances of problem behavior and 45 instances of the potential precursor had occurred. For Paolo, 106 instances of problem behavior and 212 instances of the potential precursor were observed. For Bruno, 76 instances of problem behavior and 46 instances of the potential precursor were observed.

Data Analysis

Descriptive data were analyzed to assess two conditional probability values (*p* of a precursor given problem behavior and the probability of problem behavior given a precursor) and two unconditional probability values (the unconditional probability of problem behavior and the unconditional probability of a precursor).

Conditional probability analyses. Instances of problem behavior and potential precursors served as anchor points from which to identify conditional probability values. Figure 1 is an adaptation of the figure presented by Sloman et al. (2005) to illustrate the conditional probability and unconditional probability analyses conducted in the present investigation. To calculate the probability of a precursor (*y* in Figure 1) given problem behavior (*x* in Figure 1), *x* served as the anchor point from which the occurrence of *y* (precursor) within 10 s *before* each anchor point (*x*) was assessed. In Figure 1, three instances of *x* occurred. The first instance of *x* at 15 s was not preceded by an instance of *y* within 10 s. The second and third instances of *x* were, however, preceded by *y* within 10 s, yielding a conditional probability of .67.

The conditional probability of problem behavior given an instance of the potential precursor was calculated using the method described previously; however, the anchor point in this analysis was each instance of the

potential precursor. To calculate the probability of problem behavior (x in Figure 1) given an instance of the precursor (y in Figure 1), y served as the anchor point from which the occurrence of x (problem behavior) within 10 s *after* each anchor point (y) was assessed. In Figure 1, four instances of y occurred. The first two instances of y at 1 s and 2 s were not followed by an instance of x within 10 s. The third and fourth instances of y were, however, followed by x within 10 s, resulting in a conditional probability of .5.

Unconditional probability analyses. The unconditional probability of problem behavior was calculated by dividing the total number of instances of problem behavior by the total number of opportunities to engage in problem behavior. Each instance of problem behavior lasted 1 s. In Figure 1, three instances of problem behavior (x) occurred during 60 s of observation (i.e., 60 opportunities to engage in problem behavior), producing an unconditional probability of $x = .05$. Four instances of the precursor (y) are depicted in Figure 1; thus, the unconditional probability of y is .07 in this example.

Lag-sequential analysis. Lag-sequential analyses were conducted to assess the probability of a potential precursor during each of the 50 s before (lag −50) an instance of problem behavior and for each of the 50 s after (lag +50) an instance of problem behavior. For each 1-s value, the number of instances in which a precursor was scored was divided by the total instances of problem behavior. For example, if 50 instances of problem behavior occurred and precursors were scored in 49 of the 50 1-s intervals occurring 1 s prior to problem behavior, the probability for that 1-s value (−1) would be .98. The unconditional probability of a potential precursor (calculation described above) also was included in these analyses as a point of comparison. A relative increase in the probability of a potential precursor in the intervals immediately preceding instances of problem behavior and a subsequent decrease in the intervals immediately following instances of problem behavior were considered indicative of a response that reliably preceded an instance of problem behavior.

Similar analyses were conducted to assess the probability of problem behavior during each of the 50 s before (lag −50) and after (lag +50) instances of the precursor. For these analyses the unconditional probability of problem behavior was included as a point of comparison. An increase in the probability of problem behavior in the 1-s intervals immediately following an instance of the precursor and a decrease in the 1-s intervals immediately following an instance of the precursor were considered indicative of a response that reliably followed instances of the precursor.

Interobserver Agreement

Interobserver agreement was assessed by having a second observer simultaneously but independently record data on problem behavior, potential EOs, and potential reinforcers. Data were calculated using the method of partial agreement within intervals (e.g., Iwata, Pace, Cowdery, & Miltenberger, 1994). Each observation was divided into 10-s intervals, and agreement between both observers was assessed across each interval. The smaller number (in each 10-s interval) was divided by the larger number, and values were averaged for the entire observation. Interobserver agreement during the descriptive analysis was assessed for 20% of observations for Paolo and 26% of observations for Bruno. Mean agreement for Paolo was 89% for attention (range, 79% to 89%), 94% for escape from instructional demands (range, 92% to 95%), 87% for access to tangible items (range, 83% to 91%), 100% for problem behavior, and 100% for the potential precursor. Mean agreement for Bruno was 89% for attention (range, 69% to 100%), 87% for escape from instructional demands (range, 80% to 99%), 98% for access to tangible items (range, 97% to 98%), 100% for problem

behavior, and 99% for the potential precursor (range, 97% to 100%).

Results and Discussion

Figure 2 depicts the comparative probability analyses based on the entire descriptive analysis for Paolo and Bruno. The probability of a precursor given an instance of problem behavior for Paolo was high (.98), suggesting that vocalizations occurred consistently prior to instances of problem behavior. The probability of problem behavior given a precursor was lower (.59) but exceeded both the unconditional probability of problem behavior and a precursor (.03 and .05, respectively). For Bruno, both conditional probability values (i.e., the probability of a precursor given an instance of problem behavior and the probability of problem behavior given a precursor) exceeded the unconditional probability values (i.e., the probability of problem behavior and the probability of a precursor).

Figure 3 depicts the results of the lag-sequential analyses for Paolo and Bruno, using problem behavior as the anchor point. The vertical lines in the center of each panel represent the point in time at which instances of problem behavior were recorded and the horizontal line represents the unconditional probability of a precursor. In the 2 s immediately preceding problem behavior, the probability of a precursor increased from .38 (lag −2) to .98 (lag −1). Immediately following problem behavior (i.e., 1 s after problem behavior), the probability of a precursor decreased to .76 until it stabilized at levels similar to those obtained in the 40 s preceding problem behavior. Results for Bruno show that in the 2 s immediately preceding an instance of problem behavior, the probability of a precursor increased from .08 (lag −2) to .38 (lag −1). Immediately following an instance of problem behavior (i.e., 1 s after an instance of problem behavior), the probability of a precursor decreased to .07 until it stabilized at levels similar to those obtained in the 40 s preceding problem behavior.

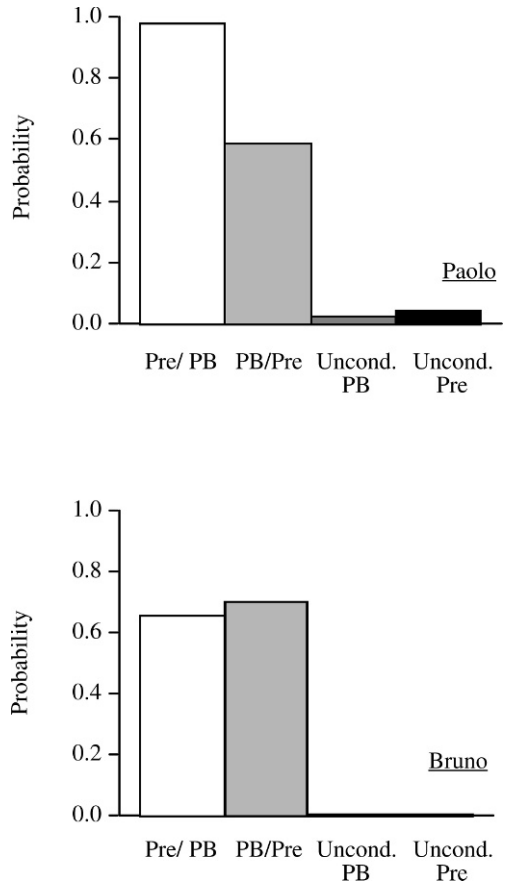

Figure 2. Comparative probability analyses for Paolo and Bruno. Comparisons include the probability of a potential precursor given an instance of problem behavior (open bars), the probability of an instance of problem behavior given a potential precursor (light gray bars), the unconditional probability of problem behavior (dark gray bars), and the unconditional probability of a potential precursor (black bars).

Figure 4 depicts the results of the lag-sequential analyses for Paolo and Bruno, using precursor behavior as the anchor point. The vertical lines in the center of each panel represent the point in time at which instances of the precursor were recorded, and the horizontal line represents the unconditional probability of problem behavior. In the 2 s immediately preceding problem behavior, the probability of problem behavior increased from .09 (lag −2) to .27 (lag −1). Immediately

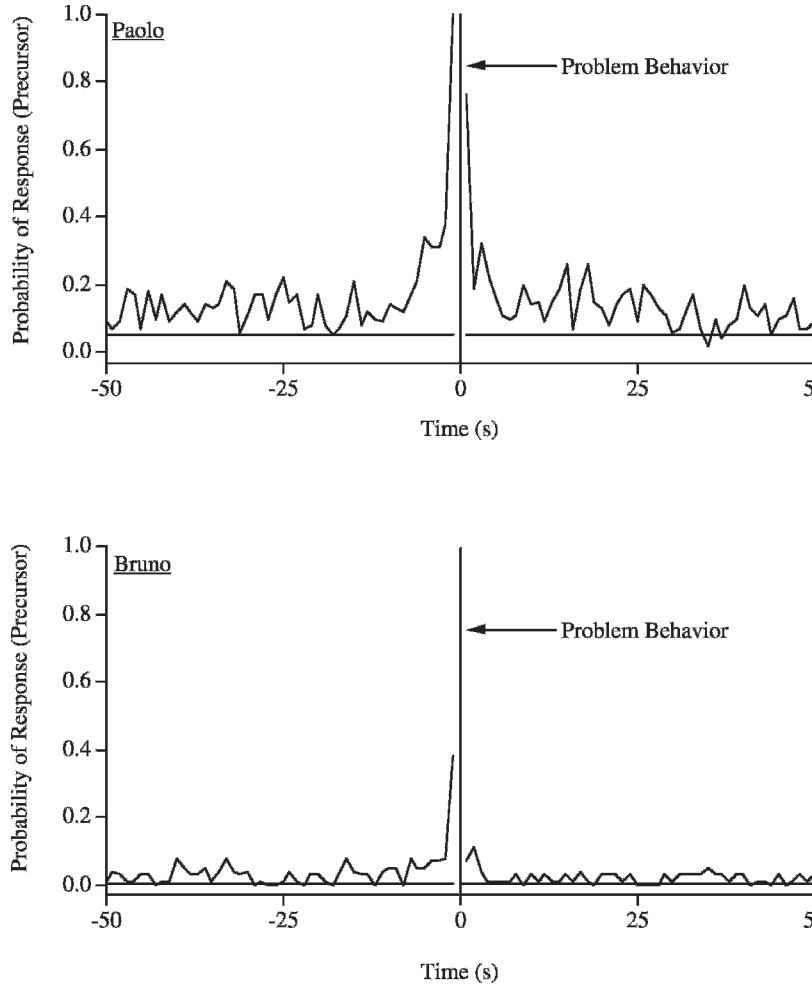

Figure 3. Lag-sequential analyses for Paulo and Bruno. The horizontal line represents the unconditional probability of the potential precursor. The vertical line represents all instances of problem behavior. The probability of a potential precursor is depicted as a function of time, beginning 50 s prior to an instance of problem behavior (lag −50 s) and ending 50 s after an instance of problem behavior (lag +50).

following the precursor however (i.e., 1 s after problem behavior), the probability of problem behavior increased to .80 until it stabilized at levels similar to those obtained in the 40 s preceding problem behavior. Results for Bruno show that in the 2 s immediately preceding an instance of the precursor, the probability of problem behavior went from .17 (lag −2) to .11 (lag −1). Immediately following an instance of the precursor (i.e., 1 s after an instance of the precursor), the probability of problem behavior increased to .53 until it stabilized at levels similar to those obtained in the 40 s preceding problem behavior.

Results of Study 1 showed that conditional probability values exceeded unconditional probability values, and that the probability of a precursor increased markedly immediately preceding an instance of problem behavior. As further evidence that vocalizations were more likely to precede an instance of problem behavior, we found that the probability of

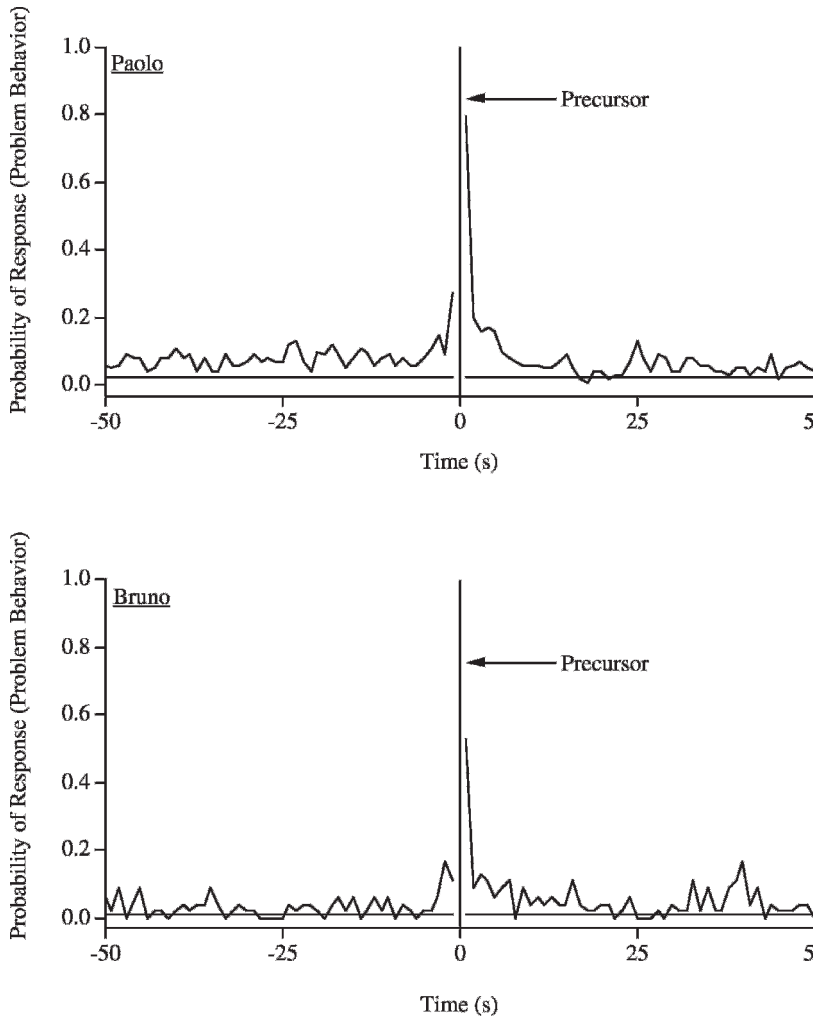

Figure 4. Lag-sequential analyses for Paulo and Bruno. The horizontal line represents the unconditional probability of problem behavior. The vertical line represents all instances of the precursor. The probability of a problem behavior is depicted as a function of time, beginning 50 s prior to an instance of the precursor (lag −50) and ending 50 s after an instance of the precursor (lag +50).

problem behavior reached its highest value in the 1-s interval immediately following an instance of the precursor. Results of Study 1 also showed that vocalizations were more probable in the 1-s intervals immediately preceding instances of problem behavior. However, due to the correlational nature of descriptive research, conclusions regarding operant function could not be drawn definitively. Thus, the purpose of Study 2 was to conduct independent functional analyses of precursors (as identified in Study 1) and problem behavior, to identify the function of both.

STUDY 2: FUNCTIONAL ANALYSES OF PROBLEM BEHAVIOR AND PRECURSORS

METHOD

Participants and Settings

Participants in Study 2 were the same as those in Study 1. Functional analysis sessions

were conducted in a secluded area of the classroom at the participants' school.

Functional Analysis of Problem Behavior

Prior to conducting the functional analyses of problem behavior, participants were exposed to a stimulus preference assessment using procedures described by Roane, Vollmer, Ringdahl, and Marcus (1998). The problem behavior of each participant (aggression and SIB for Paolo; aggression, SIB, and property destruction for Bruno) was exposed to functional analysis using procedures similar to those described by Iwata et al. (1982/1994). The first author or trained therapists conducted all functional analysis sessions. Three (Paolo) or four (Bruno) test conditions and a control condition were alternated in a multielement design. Functional analysis sessions were 5 min in duration and conducted twice per week. Attention, tangible, escape, and no-consequence (Bruno) test conditions were conducted, as well as a control condition in which no programmed consequences were arranged for problem behavior. Details of the functional analysis are available from the corresponding author.

Functional Analysis of Precursors

The functional analysis of precursors was identical to the functional analysis of problem behavior with one exception: Condition-specific consequences were provided following instances of the precursor (vocalizations) but not following instances of problem behavior. For both participants, the functional analysis of problem behavior preceded the functional analysis of precursors.

Interobserver Agreement

Interobserver agreement was assessed during 50% of functional analysis sessions for Paolo and 23% of functional analysis sessions for Bruno, and was calculated as in Study 1. Interobserver agreement for Paolo was 98% for problem behavior (range, 87% to 100%) and 88% for the precursor (range, 60% to 100%). Agreement for Bruno was 99% for problem behavior (range, 92% to 100%) and 93% for the precursor (range, 80% to 100%).

Results and Discussion

Results of the functional analyses of problem behavior and precursors are presented in Figure 5. We should note that separate analyses of each topography of problem behavior were also conducted for each participant. Results of those analyses did not suggest that responses that made up the problem behavior category were members of different response classes. The left column depicts response rates of problem behavior and precursors when contingencies were applied to problem behavior. The right column depicts response rates of problem behavior and precursors when contingencies were applied to the precursor.

Rates of problem behavior for Paolo were most elevated in the tangible condition (M = 0.9 responses per minute) when consequences were presented following problem behavior. Although the precursor did not produce programmed consequences, vocalizations were also highest during the tangible condition (M = 4.4 responses per minute). When consequences were presented following precursors (and not problem behavior), lower levels of problem behavior were observed during the tangible condition (M = 0.1 responses per minute, compared to the functional analysis during which contingencies were arranged for problem behavior), and elevated and differentiated levels of vocalizations were observed in the tangible condition (M = 2.7 responses per minute).

Rates of problem behavior for Bruno were most elevated in the tangible and escape conditions when consequences were presented following problem behavior (M = 2 responses per minute in the tangible condition; M = 1.1 responses per minute in the escape condition). Although the precursor did not produce programmed consequences, vocalizations were also highest during the tangible condition (M =

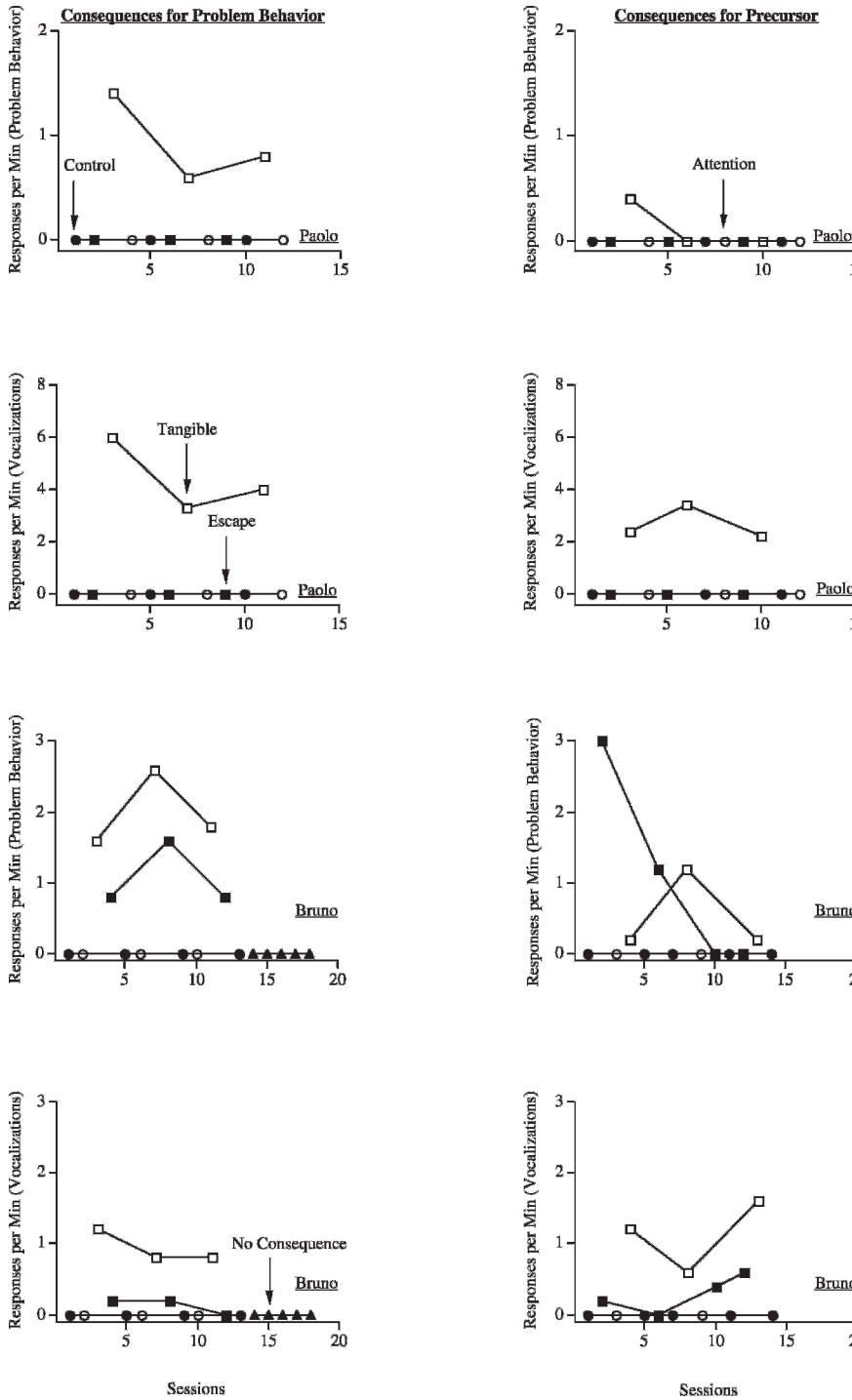

Figure 5. Results of the functional analyses of problem behavior and precursors. Data are depicted in columns, with rates of problem behavior and precursors in the left column for Paolo (first and second panels) and Bruno (third and fourth panels) when consequences were provided for problem behavior. Data in the right column depict response rates for problem behavior and precursors for Paolo (first and second panels) and Bruno (third and fourth panels) when consequences were provided for the precursor.

0.9 responses per minute) and were initially elevated in the escape condition during the first two escape sessions. When consequences were presented following precursors (and not problem behavior), problem behavior was also most elevated during the tangible and escape conditions (M = 0.8 responses per minute in the tangible condition; M = 1.1 responses per minute in the escape condition), and elevated and differentiated levels of vocalizations were observed in the tangible and escape conditions (M = 1.1 responses per minute in the tangible condition; M = 0.3 responses per minute in the escape condition).

Results of Study 2 indicated that problem behavior and precursors were members of the same operant classes (positive reinforcement in the form of access to tangible items for Paolo, and positive reinforcement in the form of access to tangible items as well as negative reinforcement in the form of escape from instructional demands for Bruno). These results replicate those reported by Smith and Churchill (2002) in at least two ways. First, operant functions for problem behavior and precursors were identical for all participants in both studies. Second, mean levels of problem behavior were suppressed when consequences were presented following precursors. As suggested previously, this finding is encouraging in that it suggests that the risk of injury to the participant or the therapist (e.g., when aggression is the response targeted for assessment) may be reduced by conducting analyses of precursors. However, the inclusion of probability analyses (as reported in Study 1) provides an empirical method for identifying precursors to severe problem behavior.

GENERAL DISCUSSION

Descriptive analyses were conducted for problem behavior and potential precursors to problem behavior for 2 participants. Data from the descriptive observations were transformed into static (based on the entire descriptive observation) and dynamic (based on moment-to-moment changes) probability values. Results showed that conditional probability values of a precursor given problem behavior and of problem behavior given a precursor exceeded the unconditional probability values of a precursor or problem behavior for both participants. Results of the lag-sequential analyses, using the same descriptive data, showed that the probability of a precursor increased substantially in the 1-s intervals immediately preceding an instance of problem behavior. Following instances of problem behavior, the probability of a precursor decreased until it became relatively stable. In addition, the probability of problem behavior reached its highest absolute value in the 1-s interval following the precursor for both participants. Based on the results of the lag-sequential analyses, we concluded that the vocalizations of both participants were reliable precursors to problem behavior. Separate functional analyses of precursors and problem behavior showed that precursors and problem behavior were most elevated in the same functional analysis conditions, suggesting that both problem behavior and vocalizations were members of the same response class.

The present study involved the use of descriptive analysis methods to assess the extent to which changes in the probability of one response (vocalizations) were associated with changes in the probability of a second response (problem behavior). This type of analysis was recently employed by Hagopian, Paclawskyj, and Contrucci-Kuhn (2005) to assess the relation between two responses (eye poking and stereotypy) exhibited by a young man with Down syndrome. Hagopian et al. compared the probability of eye poking given instances of stereotypy to the probability of eye poking given no stereotypy during observations in which treatment (protective goggles, continuous access to toys, and response blocking) was in place. Results showed that eye poking and stereotypy were most suppressed when blocking was implemented for

both responses. Results of the study by Hagopian et al. demonstrated the effectiveness of an intervention that was informed by the analysis of response–response relations.

In addition to the results presented, we also evaluated the probability of a known reinforcer (tangible items for Paolo and tangible items or escape from instructions for Bruno) following instances of problem behavior and following instances of the precursor during naturally occurring interactions. Results of those analyses showed that, in their classroom environments, teachers did not provide access to tangible items (for Paolo and Bruno) or escape from instructional activities (for Bruno) following instances of the precursor or problem behavior at levels that exceeded the unconditional probability of those events. There are at least two possible explanations for this finding. First, the primary data collector also served in the capacity of supervisor for the implementation of classroom management strategies. It is possible that the teachers' behavior was influenced by the presence of the data collector; however, such reactivity effects might be expected to wane over repeated observations. Second, all classroom teachers were exposed to extensive behavior management training that emphasized minimizing attention, continuing presentation of instructions, and maintaining restricted access to tangible items following problem behavior. Had either the precursor or problem behavior reliably produced reinforcers in the current investigation, results may have been altered substantially. For example, had the precursor produced reinforcers during the descriptive observations, the conditional probability of problem behavior given a precursor would likely have been much lower. Future research along these lines might involve explicit comparisons between cases in which precursors are and are not reinforced during descriptive observations. Such comparative analyses may highlight the conditions under which probability analyses of the sort applied in the current investigation are most suggestive of response-response relations.

Results of the current study both extend and replicate findings reported by Smith and Churchill (2002). First, we conducted static and dynamic probability analyses based on extensive (formal) descriptive observations to assess the relation between potential precursors and problem behavior. As noted previously, Smith and Churchill concluded that responses were precursors based on informal observations. Second, the present results substantiate those reported by Smith and Churchill in that problem behavior and precursors were shown to be reinforced by the same events (i.e., access to tangible items for Paolo and access to tangible items and escape from instructional demands for Bruno). This suggests that under some circumstances, when supported by lag-sequential analyses of descriptive data, functional analyses of less severe response topographies may be used as a basis for designing function-based treatments to address more severe topographies of problem behavior (e.g., intense SIB). Third, as reported by Smith and Churchill, we also found that levels of problem behavior were suppressed when contingencies during the functional analysis were withheld for problem behavior and arranged for the precursor. Clinically, this is an encouraging finding because the potential for harm incurred during functional analyses of severe problem behavior might be reduced if the functional properties of problem behavior can be inferred from outcomes of a functional analysis of precursors.

Limitations of the current study also should be considered when interpreting the results. Unconditional probability values were calculated based on intervals of 1 s, but conditional probability values were based on intervals of 10 s, which in most cases would not produce similar outcomes. For example, if we assume a 60-s observation period in which 12 instances of behavior are equally distributed in each of six 10-s intervals (i.e., two instances per 10-s bin), the obtained probability values differ substantially. By assessing the unconditional probabil-

ity of behavior in 10-s intervals, the obtained probability would be 1 (i.e., at least one instance of behavior occurred in each 10-s interval). On the other hand, by assessing the unconditional probability of behavior in 1-s intervals, the obtained probability would be .2 (i.e., 12/60). Because the two probability values were calculated using different methods, the unconditional probability of behavior may have been suppressed artificially (as evidenced by the aforementioned example). On the other hand, the analysis in terms of 1-s intervals may be a more representative account of behavior in that each instance of behavior and each opportunity to emit behavior are taken into consideration. Future research in this area may involve comprehensive comparative analyses of various methods of calculating descriptive data (e.g., methods of calculating unconditional probability values as described) to elucidate the merits and limitations of each.

An additional limitation of the current investigation involves the omission of a treatment component based on the results of the functional analyses. Thus, it is currently unknown whether a treatment based on the results of the functional analyses of precursors would have produced clinically significant reductions in either or both response categories. However, the extensive literature on function-based treatments suggests that such treatments would have produced improvements in behavior. Future research may be designed to evaluate treatments based on functional analyses of precursors identified via probability analyses of the sort evaluated in the current investigation.

In addition, the absence of inferential statistical analyses of the relations between precursors and problem behavior may be viewed as a limitation of the current investigation. Instead, we relied on visual analysis of comparative probability values. The rather pronounced differences were considered sufficient to draw conclusions from these data; however, researchers interested in the sequential association of response–response relations may evaluate odds ratios or Yule's *Q*, as suggested by Yoder and Feurer (2000), in future investigations.

Although the functional analysis of severe problem behavior has proven extremely useful as a basis for treatment development, there remain circumstances in which such assessments are not possible due to the risk of harm to the participant or therapists. We do not suggest that precursor analyses supplant functional analyses of problem behavior, but that they may represent useful alternative procedures for minimizing risk during the assessment of particularly harmful response topographies.

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