*PROGRESSING FROM IDENTIFICATION AND FUNCTIONAL
ANALYSIS OF PRECURSOR BEHAVIOR TO TREATMENT OF
SELF-INJURIOUS BEHAVIOR*

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This multiple-study experiment evaluated the utility of assessing and treating severe self-injurious behavior (SIB) based on the outcomes of a functional analysis of precursor behavior. In Study 1, a precursor to SIB was identified using descriptive assessment and conditional probability analyses. In Study 2, a functional analysis of precursor behavior was conducted. Finally, Study 3 evaluated the effects of a treatment in which precursor behavior produced the maintaining variable identified in the precursor functional analysis. Studies 1 and 3 were conducted in two settings in the participant's natural environment, where data collection was ongoing throughout the course of the study. Results showed that it was possible to identify a precursor to infrequent but severe SIB, that a functional analysis of precursor behavior suggested a clear operant function, and that treatment based on the results of the precursor functional analysis reduced SIB in the natural environment.

Key words: precursor behavior, functional analysis, lag-sequential analysis, problem behavior, naturalistic treatment

Functional analysis (Iwata, Dorsey, Slifer, Bauman, & Richman, 1982/1994) has been shown to be an effective method for identifying the variables that maintain problem behavior, including self-injurious behavior (SIB). Functional analysis involves the systematic presentation of antecedent and consequent events thought to evoke and maintain problem behavior, permitting direct demonstration of the variables that maintain problem behavior. These variables then may be manipulated as part of function-based treatment.

Some drawbacks to functional analysis of problem behavior have been identified. Because a functional analysis requires the presentation of events that may evoke and reinforce problem behavior, functional analysis may be contrain-

icated for severe topographies of problem behavior (e.g., Smith & Churchill, 2002). Another drawback is the difficulty in assessing problem behavior that occurs infrequently (e.g., Kahng, Abt, & Schonbachler, 2001; Tarbox, Wallace, Tarbox, Landaburu, & Williams, 2004). Typically, sessions in each condition of a functional analysis are 10 min, with a reported range of 1 min to 30 min (Hanley, Iwata, & McCord, 2003). For behavior that occurs relatively infrequently (e.g., less than once per day), the duration of a functional analysis session may be insufficient to allow observation of the problem behavior. Several procedural variations have been developed to address these limitations.

Kahng et al. (2001) developed a procedure known as the *all-day functional analysis*, in which participants were exposed to a single condition of the functional analysis for an extended time, such as during normal working hours (9:00 a.m. to 5:00 p.m.). An alternative method for assessing low-rate problem behavior involves implementation of standard functional analysis procedures (i.e., 10-min sessions) following occurrences of problem behavior

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(Tarbox et al., 2004). Sessions from two experimental conditions and one control condition are presented following the first occurrence of problem behavior, with the cycle continuing if problem behavior occurs after the third condition. Although the procedures described by Kahng et al. and Tarbox et al. have been shown to identify maintaining variables for infrequent problem behavior, both require problem behavior to be evoked and reinforced, which can pose risks for individuals and caregivers in cases of severe problem behavior.

To reduce risk during functional analysis, researchers have used brief or time-limited functional analysis, which may involve abbreviated sessions (e.g., Derby et al., 1992; Kahng & Iwata, 1999; Northup et al., 1991; Wallace & Knights, 2003), single-session presentation of conditions (e.g., Derby et al., 1992; Northup et al., 1991), progression through a series of analyses designed to reduce the overall time necessary to observe differentiation (e.g., Vollmer, Marcus, Ringdahl, & Roane, 1995), or within-session analyses of response patterns (Vollmer, Iwata, Zarcone, Smith, & Mazaleski, 1993; Vollmer et al., 1995). Although these procedures can decrease the time needed to identify variables related to some participants' problem behavior, each requires problem behavior to be evoked and reinforced, which may be contraindicated if the problem behavior is severe. Furthermore, these procedures have not been utilized with low-rate problem behavior, which may be insensitive to brief exposure to contingencies.

The results of several studies have suggested that examination of response class hierarchies can indirectly reveal the functional properties of problem behavior (e.g., Lalli, Mace, Wohn, & Livezey, 1995; Richman, Wacker, Asmus, Casey, & Andelman, 1999; Smith & Churchill, 2002). By placing contingencies on initial, less severe, members of sequentially ordered response hierarchies, subsequent and more severe responses may not occur. Thus, it may be

possible to infer the operant function of severe problem behavior by directly analyzing other, related behaviors. Smith and Churchill (2002) developed a precursor assessment, which involved identification of behaviors that reliably preceded severe topographies of problem behavior and conduct of a functional analysis of the precursor behavior. Results indicated that analyses of four participants' precursor behaviors matched functional analysis outcomes for their severe behavior. Furthermore, very little severe behavior was observed during the precursor functional analysis. Although follow-up studies have sought to identify precursors empirically (e.g., Borrero & Borrero, 2008; Langdon, Carr, & Owen-DeSchryver, 2008) and to treat precursor behavior (Najdowski, Wallace, Ellsworth, MacAleese, & Cleveland, 2008), the utility of precursor functional analysis to prescribe effective treatment has yet to be demonstrated.

The current series of studies was designed to replicate and extend previous research related to the assessment and treatment of infrequent but severe problem behavior. Specifically, a precursor behavior was identified by measuring the problem and precursor behavior in the participant's natural environment (Study 1). That precursor behavior then was evaluated using the functional analysis methodology often used to identify functional relations related to problem behavior (Study 2). Finally, a treatment based on the outcome of the functional analysis was implemented, and its effects on SIB were evaluated (Study 3).

GENERAL METHOD

Participant and Setting

Peter was a 29-year-old man with mild intellectual disability who exhibited SIB in the forms of face slapping, face punching, and head banging. Although his SIB occurred relatively infrequently (e.g., records indicated a rate of 72 occurrences per month during the 12 months prior to this investigation, across an average of

15 days per month), it resulted in tissue damage (bruising, lacerations, and bone fractures) and destruction of property (e.g., holes in the wall, broken glass, etc.). Peter resided at a large residential and training facility for adults with developmental disabilities. His personal support team referred him to a specialized assessment and treatment clinic located at the institution for assessment and treatment of his SIB. All observation, functional analysis, and treatment sessions occurred at the facility.

Response Definitions, Measurement, and Interobserver Agreement

Self-injury was defined operationally as open-handed slaps to the head or face, punches to the head or face, and head banging against stationary objects. *Head-up* (precursor) was scored when no part of Peter's chin or neck touched his chest or shoulders. Although head-up may appear to be a standard position for most individuals, Peter had a muscular imbalance in his upper spine that, according to medical personnel, was unlikely to cause physical pain but made it difficult for him to remain in an upright position. Therefore, he often assumed a slouching position, with his head down (defined as any part of his chin or neck touching his chest or shoulders). Prior to the study, observers were trained to collect data with handheld computers by watching videos that contained vignettes typical of behavioral assessment, treatment, and skill-acquisition sessions. All observers achieved 90% or greater agreement with the primary observer for each training video. In addition, all observers received instruction on the specific behavioral definitions used in the current study. Observers with handheld computers were present throughout all contexts.

Interobserver agreement was calculated by dividing each session into 1-s intervals, summing the number of intervals in which the primary and secondary observers agreed on the occurrence or nonoccurrence of the target behavior within a moving 2-s window, dividing

the result by the total number of intervals in the session, and multiplying the outcome by 100%. For example, if the primary observer recorded the same type of event at time x , agreement was scored if the secondary observer recorded the same event at time $x - 1$ s, time x , or time $x + 1$ s. In addition, given the infrequent occurrence of SIB, agreement was calculated for the occurrence and nonoccurrence of SIB separately. Interobserver agreement was calculated for 42% of baseline sessions, 38% of precursor functional analysis sessions, and 40% of treatment sessions. The mean occurrence agreement for SIB was 92% (range, 83% to 100%), the mean nonoccurrence agreement for SIB was 99.9% (range, 99.9% to 100%), and the mean agreement for head-up was 98% (range, 84% to 100%).

Timeline

Observations in Peter's apartment and workplace took place over the course of 17 months. The precursor functional analysis began between Session 31 (his apartment) and Session 32 (his workplace). Baseline conditions remained in effect at the apartment and workplace during the precursor functional analysis. Following completion of the precursor functional analysis, 30 additional baseline observations were conducted before implementing treatment at the workplace. The additional baseline sessions were conducted to determine if any systematic changes in SIB or head-up occurred as a result of head-up coming into contact with reinforcement during the functional analysis. Baseline conditions remained in effect at the apartment for the duration of the study.

STUDY 1: DESCRIPTIVE ASSESSMENT

The purpose of Study 1 was to identify behavior that reliably preceded occurrences of SIB, using procedures similar to those described by Borrero and Borrero (2008). Lag-sequential and comparative probability analyses were conducted to evaluate the relation between

two responses, head-up and SIB, using data obtained via observations in the natural environment.

Settings

All observations took place in Peter's apartment and workplace. He lived with seven other individuals in an apartment located on the campus of the residential facility. His workplace, also located on the campus, was attended by all of Peter's housemates as well as other facility residents.

Observations

The first author initially conducted two unstructured observations to develop an operational definition of SIB and record commonly occurring environmental events for inclusion in the computerized data-collection software. During these observations, the first author observed that Peter lifted his head and looked directly at him just prior to engaging in SIB. Because Peter spent a majority of his time with his head down (see discussion above), lifting his head was a salient change in his behavior. Because this response had preceded all occurrences of SIB, an operational definition of head-up was developed, and the response was included in subsequent data collection. In addition, a scatterplot assessment of data collected by caregivers prior to the study identified two times when SIB was most likely to be observed. Based on these outcomes, observations were scheduled in the apartment between 6:30 a.m. and 9:00 a.m. and in the workplace between 2:00 p.m. and 4:00 p.m. Data were collected on the environmental events (e.g., demands, staff attention, item delivery) and Peter's responses (e.g., SIB, head-up, etc.) identified in the narrative observations. Observations always were conducted in pairs (i.e., one observation at the apartment and workplace per day). These observations occurred two to five times per week throughout the duration of the study. Thus, SIB that occurred at the apartment and the workplace was recorded before, during, and

after the precursor functional analysis as well as before and during treatment. Observations were scheduled for 30 min at each site. Observations were shorter than 30 min only when Peter left his apartment prior to 30 min (e.g., for a medical appointment). If a morning observation lasted less than 30 min, the duration of the afternoon observation or treatment was yoked to the duration of the morning session. Of the 154 sessions, 58 (37.7%) were terminated before 30 min elapsed. Experimenters did not interact with Peter during baseline. His behavior was recorded continuously during baseline unless he entered the bathroom, at which time observation was suspended until he left the bathroom. Time spent in the bathroom was excluded from data analysis.

Precursor Identification

Comparative probability and lag-sequential analyses, using procedures and time parameters described by Borrero and Borrero (2008), were conducted using data from baseline observations. To determine potential relations between head-up and SIB, the conditional probabilities of head-up preceding SIB within 10 s, as well as SIB following head-up, were calculated. The unconditional probabilities of head-up and SIB were calculated to determine the ambient level of each. All probabilities were summarized both within and across sessions. In addition, second-by-second probabilities were calculated for head-up in the 60 s immediately preceding and following each occurrence SIB, and for SIB, in the 60 s immediately preceding and following each occurrence of head-up.

Results and Discussion

Results of the observations in the apartment and workplace are presented in Figure 1. Baseline observations were implemented between Sessions 1 and 81. At the workplace, SIB occurred, on average, every three observations, with a mean of 0.11 responses per minute. SIB occurred, on average, every five observations at his apartment, with a mean of 0.05 responses

Figure 1. Results of the baseline observations and treatment analysis at Peter's workplace and ongoing baseline at his apartment. Data are displayed as responses per minute for all sessions. Data for head-up are presented on the primary y axis, and data for SIB are presented on the secondary y axis.

per minute. Measures of head-up followed a similar pattern, with a mean rate at his workplace of 0.29 responses per minute and a mean rate at his apartment of 0.23 responses per minute. However, on the fourth observation at the apartment (Session 7), he was playing basketball for the majority of the session, which resulted in an unusually high rate of head-up (2.43 responses per minute). Participation in this activity artificially raised the mean rate of head-up at his apartment. Excluding this

session, the mean of head-up responding at his apartment was 0.17 responses per minute.

Across all sessions, the probability of head-up preceding SIB within 10 s was .74, and the probability of SIB following head-up within 10 s was .52. The conditional probability of SIB following head-up is somewhat lower than has been reported in previous studies on precursor identification (e.g., Borrero & Borrero, 2008). Peter's SIB frequently occurred in episodes, with individual responses occurring in relatively

Figure 2. Lag-sequential analysis. The horizontal line represents the unconditional probability of head-up. The vertical line represents all instances of SIB. The probability of head-up is depicted as a function of the time before (lag -50) and after (lag 50) an occurrence of SIB.

close temporal proximity within episodes and long periods of time separating episodes. Thus, when an episode of SIB followed an occurrence of head-up, some, but not all, SIB followed head-up within 10 s. When the lag interval for calculating the probability of SIB following head-up was increased to 20 s, the probability of head-up preceding SIB was .83, and the probability of SIB following head-up was .61. The overall unconditional probability of head-up was .0051, and the overall unconditional probability of SIB was .0008.

The results of the lag-sequential analysis are presented in Figures 2 and 3. In both figures, the vertical line in the center depicts the anchor (either SIB or head-up), and the horizontal line depicts the unconditional probability of head-up (Figure 2) and SIB (Figure 3). Figure 2 depicts the probability of head-up before (lag -50 to lag -1) and after (lag 1 to lag 50) SIB. At lag -2, the probability of head-up was .09, and this probability increased to the highest value, .49, at lag -1. Further, following SIB, the probability of head-up decreased to .01 at

lag 1 and .03 at lag 2, with subsequent values (lag 3 to lag 50) remaining at levels similar to those found in the 40 s before SIB (lag -11 to lag -50). These results indicated that head-up was most likely to occur in the 10 s immediately preceding occurrences of SIB, with the probability of head-up increasing significantly as the time to SIB decreased.

Figure 3 depicts the probability of SIB before (lag -50 to lag -1) and after (lag 1 to lag 50) head-up. At lag 1, the probability of SIB was .11, and this value increased to the highest value, .19, at lag 2. Immediately before head-up, the probability of SIB decreased from .07 at lag -4 to .06 at lag -2 and 0 at lag -1, with subsequent values (lag -3 to lag -50) remaining at levels similar to those in the 40 s immediately following head-up. It should be noted that the probability values at lag -1 to lag -20 may be artificially high, because on multiple occasions, there were separate occurrences of head-up for occurrences of SIB that occurred in close temporal proximity. Therefore, it was possible for an occurrence of head-

Figure 3. Lag-sequential analysis. The horizontal line represents the unconditional probability of SIB. The vertical line represents all instances of head-up. The probability of SIB is depicted as a function of the time before (lag -50) and after (lag 50) an occurrence of head-up.

up to precede one occurrence of SIB within 10 s but follow multiple occurrences of SIB within 20 s.

Taken together, these results indicate that head-up and SIB were related, possibly as members of a response class hierarchy or a response chain. Although conditional probabilities using 10-s lag intervals were lower than those reported by Borrero and Borrero (2008), temporal relations were evident with 20-s lag intervals. In previous research (e.g., Sloman et al., 2005), shorter interval values (e.g., 10 s) were chosen when analyzing conditional relations if longer interval values (e.g., 20 s) produced similar results. Although larger lag intervals may be necessary to identify precursor relations, in some cases, particularly when problem behavior occurs infrequently, substantial increases in interval sizes may result in a Type 1 error, in which data suggest a relation between unrelated events (i.e., large interval windows may capture responses that occur at roughly the same rate as problem behavior but do not enter into a sequential relation with

problem behavior). Thus, a reasonable strategy for identifying precursor behavior is to use the shortest interval that results in identification of an apparent precursor-problem behavior relation. In the current study, expanding the lag interval to 20 s resulted in an increase of less than .1 in the probability of SIB following head-up, which allowed the use of the smaller interval value.

Furthermore, although smaller lag intervals may increase the validity of precursor analyses, identification of temporal relations with somewhat longer latencies might have practical implications. For example, if two responses occur in very close temporal proximity (e.g., less than 2 s apart), it may be difficult to deliver consequences for the first (precursor) response before the second (problem) response has occurred, thereby negating an advantage of precursor functional analysis. Thus, if more than one precursor topography occurs prior to problem behavior, it may be advantageous to identify and arrange experimental contingencies for that topography that is most temporally

distant from the problem behavior. Subsequent investigations might examine the relative utility of various lag intervals to identify sequential relations between responses.

STUDY 2: FUNCTIONAL ANALYSIS OF THE PRECURSOR

The purpose of Study 2 was to conduct a functional analysis of the precursor behavior identified in Study 1 (head-up), using procedures described by Smith and Churchill (2002).

Setting

Preference assessments and the precursor functional analysis were conducted in an observation room at a clinic located on the campus of the residential facility. The room (3.7 m by 3.7 m) contained furnishings and equipment as appropriate for each condition. A one-way mirror was installed on the entry wall to the room, through which trained observers recorded data for all sessions.

Preference Assessments

Three preference assessments were conducted to identify stimuli for use in the tangible condition of the functional analysis. The items included in the assessment were selected because Peter had been observed to request the items or caregivers had been observed to present the items to him following episodes of SIB. A multiple-stimulus without replacement preference assessment (DeLeon & Iwata, 1996) using food items indicated that Peter's most preferred food was a pizza-flavored chip. Chewy chocolate chip cookies and pudding tied for the second most preferred items. A multiple-stimulus engagement preference assessment (Hagopian, Rush, Lewin, & Long, 2001) was conducted using leisure items; however, Peter shook his head "no" when each item was placed in front of him, and made the manual sign and gesture for cookie. Although results of this assessment did not identify preferred leisure items, caregivers reported that Peter enjoyed reading magazines; therefore, magazines were

used in the subsequent functional analysis when appropriate. Finally, a paired-choice preference assessment (Fisher et al., 1992) was conducted with the same food items used in the multiple-stimulus without replacement preference assessment. The results of the paired-choice preference assessment indicated that chewy chocolate chip cookies were his most preferred item and that, when given the choice between chewy chocolate chip cookies and pizza-flavored chip or pudding (two previously identified highly preferred items), he always chose chewy chocolate chip cookies. Therefore, the chewy chocolate chip cookie was used, when appropriate, during the functional analysis.

Precursor Functional Analysis

Cycles of 10-min no-interaction, attention, tangible, play, and demand sessions were conducted in a multielement format. Attention was provided every 30 s for the first three sessions in the play condition. However, during intervals between scheduled interactions, Peter frequently lifted his head and attempted to communicate with the therapist about material in the magazine. Therefore, for subsequent play sessions, the therapist delivered attention and participated in joint engagement with the magazine throughout the sessions.

Results and Discussion

The results of the precursor functional analysis are presented in Figure 4. SIB occurred in the first attention session only, at a rate of 0.60 responses per minute. Head-up occurred in all conditions. For the first three cycles of the assessment, head-up occurred most often in the play condition, with a mean of 2.45 responses per minute (range, 1.4 to 3.15). However, after the change to continuous attention during the play condition, the mean rate of head-up was 0.59 (range, 0.1 to 1.0). Following an initial period during which data were relatively undifferentiated, head-up occurred most frequently in the attention condition throughout the last six cycles of assessment, at a mean of

Figure 4. Results of the precursor functional analysis. Data are displayed as responses per minute for all sessions. The top panel contains data for head-up. The bottom panel contains data for SIB, which was measured for tracking purposes only.

1.70 responses per minute. Decreasing trends were observed in all other conditions. These results indicated that head-up was maintained by social positive reinforcement in the form of attention.

The temporal patterning of head-up and SIB observed during Study 1, combined with the results of the functional analysis showing that head-up persisted when it produced experimental

consequences while SIB almost never occurred, suggested that placing the putative contingencies of reinforcement on the precursor behavior reduced occurrences of SIB. That is, whereas the probability of SIB occurring within 10 s and 20 s of head-up was .52 and .61, respectively, during observations in the natural environment, the probability of SIB occurring within either 10 s or 20 s of head-up was .01 for functional analysis

sessions. The probability value is identical for the 10-s and 20-s values because all occurrences of SIB occurred in one session and within less than 10 s of head-up. Although previous research (e.g., Lalli et al., 1999) has demonstrated that reinforcement of a functionally unrelated response can reduce problem behavior, the temporal relation between head-up and SIB shown in Study 1, combined with the near nonoccurrence of SIB throughout Study 2, suggest that attention may have functioned as a maintaining reinforcer for both behaviors. However, a clear demonstration of response class membership would require a separate functional analysis, as conducted by Smith and Churchill (2002).

STUDY 3: EVALUATION OF TREATMENT FOR SIB

Based on the results of Studies 1 and 2, the effects of providing attention following head-up and withholding attention following SIB were evaluated in the natural environment.

Procedure

Treatment was initiated in Peter's workplace because the results of baseline observations yielded higher rates of SIB there than at his apartment. Sessions were conducted during the same time period as baseline observations (between 2:00 p.m. and 4:00 p.m.), and baseline observations continued in the apartment for the duration of the treatment evaluation. A therapist sat next to Peter and implemented procedures during all treatment sessions. No other systematic changes to the workplace context were made relative to baseline. Treatment effects were evaluated in the workplace using a reversal design.

Before each session, the therapist instructed Peter's staff not to interact with Peter during the session. The therapist sat next to him at his work table and instructed him to lift his head if he wanted to talk to the therapist. Each time he lifted his head, the therapist delivered 5 to 10 s of attention. If his head remained up, the therapist continued to deliver attention (identical to the attention condition of the precursor

functional analysis). The therapist provided no programmed consequences for SIB (i.e., if SIB occurred immediately after head-up, attention continued to be provided until the scheduled 5- to 10-s period had elapsed). Sessions were suspended when Peter entered the restroom.

Results and Discussion

The results of the treatment analysis are presented in Figure 1. After implementation of treatment at the workplace (Session 82), Peter's rate of head-up increased and SIB decreased both at the workplace (top panel) and in the apartment (bottom panel). It should be noted that decreases in SIB in the workplace were not observed immediately. Although instances of head-up increased from a baseline mean of 0.29 to 0.97 responses per minute on the first day of treatment, SIB also occurred during that session. Workplace staff responded to SIB with attention (instructions to stop the response) and continued to do so whenever SIB was observed for the first nine sessions of treatment. To address this treatment integrity issue, each treatment session thereafter began with the investigator reminding all staff present not to interact with Peter during the session. Within two sessions of this change in procedure, the rate of head-up increased to just below the level at which the rate of head-up stabilized during Treatment Phase 1 ($M = 4.68$ responses per minute during the last five sessions of Treatment Phase 1) and SIB ceased. Further, changes in SIB and head-up were observed in his apartment (where baseline procedures remained in effect) during this phase. During the initial baseline observations in the apartment, the mean rate of head-up was 0.23 and the mean rate of SIB was 0.05. After implementation of treatment at the workplace, the mean rate of head-up at his apartment increased to 0.36 and the mean rate of SIB at his apartment decreased to 0.02. This covariance in SIB and head-up across contexts precluded a replication of treatment across environments; a reversal design was therefore used to evaluate the effects of

treatment. After 10 consecutive sessions without SIB (twice the number of consecutive sessions without SIB as in the immediately preceding work baseline), a return to baseline was implemented.

At the start of the reversal phase, staff were instructed to interact with Peter as usual (i.e., as if the investigator was not present). SIB began to reoccur on the fourth session and was observed during 41.7% of sessions (compared to 27.5% of sessions during the initial baseline). The mean rate of SIB during this condition was 0.09. Head-up decreased to a mean of 0.69, with the last five sessions all below 1 per minute. The return to treatment yielded an immediate cessation of SIB as well as a return of head-up to levels observed during the first treatment phase. The second treatment phase continued until SIB did not occur for six consecutive sessions (twice the number of consecutive sessions without SIB observed in the immediately preceding baseline). Head-up increased to a mean of 4.77 responses per minute during this final treatment. Finally, the rates of SIB and head-up continued to covary across contexts when treatment was in effect at his workplace. Following the second implementation of treatment at the workplace, the mean rate of head-up at the apartment increased to 0.42 and there were no additional occurrences of SIB.

Results of the treatment analysis showed that an intervention based on the results of precursor functional analysis successfully reduced SIB in the natural environment. Although Najdowski et al. (2008) also assessed precursor behavior to develop a course of treatment for severe problem behavior, these investigators did not conduct ongoing measurement of problem behavior during the precursor functional analysis and treatment; therefore, it is unclear what accounted for the nonoccurrence of SIB. By including observations before, during, and after the precursor functional analysis, the current study provides several converging lines of

evidence that head-up and SIB were related. Further, this study provides a clear demonstration that the assessment and treatment of Peter's precursor behavior were responsible for the reduction and eventual elimination of SIB.

An interesting finding was the covariation of SIB in Peter's apartment and workplace during the treatment evaluation, even though the intervention was applied only at the workplace. Although SIB occurred at a low rate at his apartment, treatment implementation at his workplace was associated with a cessation in SIB at his home. This pattern continued during a subsequent reversal and replication. This finding, taken together with the results of the head-up functional analysis and the efficacy of the head-up treatment, provides an additional line of evidence that head-up and SIB were related responses.

GENERAL DISCUSSION

The current study utilized a multiple-component approach to assess and treat the infrequent but severe SIB exhibited by a man with a mild developmental disability. The results of ongoing observation in the natural environment indicated that Peter was frequently observed to lift his head just prior to episodes of SIB but not at other times. A functional analysis of head-up indicated that it was maintained by positive reinforcement in the form of attention. While the precursor functional analysis was being conducted, SIB continued to occur and follow head-up responses in the natural environment at levels seen prior to the precursor functional analysis. Finally, SIB was reduced successfully through differential reinforcement of alternative behavior (head-up), whereby head-up produced attention from a therapist and no attention was provided after instances of SIB.

This research produced converging lines of evidence that a functional relation existed between head-up and SIB. First, head-up almost always was observed to occur just prior

to episodes of SIB throughout the study. Second, when functional analysis contingencies were placed on head-up, it was observed to occur more frequently in the attention condition than in other conditions and at levels much higher than those observed in the natural environment, strongly suggesting that attention effectively reinforced head-up. Third, whereas head-up was followed frequently by SIB during baseline observations in the natural environment, head-up almost never was followed by SIB during the functional analysis (when attention was available only for head-up). Fourth, when head-up reliably produced attention from a therapist in the natural environment (during treatment), head-up significantly increased in frequency and SIB was nearly eliminated.

Although the outcomes of this study indicate that a relation existed between head-up and SIB, the precise nature of the relation remains unclear. An interpretation that head-up and SIB were members of a response class maintained by attention is consistent with the current data. An alternative explanation is that head-up was an initial link in a response chain that culminated in SIB and was maintained by attention. However, this account seems to be inconsistent with data gathered from observations in Peter's apartment and workplace because some instances of head-up were followed by attention, some instances of head-up were not followed by SIB, and (perhaps most important), some instances of SIB were not preceded by head-up. Future researchers could examine ways to assess whether responses are related through class membership or as members of a response chain. For example, preventing (e.g., blocking) the occurrence of a response that tends to precede a second response, and measuring the effects of this prevention on the occurrence or nonoccurrence of the second response, could provide details about the response-response relation. If the first response is prevented, elimination of the second response would suggest a response

chain, whereas increases in the second response would suggest a hierarchically ordered response class. Clarifying the nature of the response could have important treatment implications. For example, reinforcing a precursor could reduce a later member of the response class, but reinforcing an earlier member of a response chain could increase later members of the chain.

The method used to identify sequentially ordered responses also may have implications for identifying functional relations among those responses. Previous research (e.g., Lalli et al., 1995; Najdowski et al., 2008; Smith & Churchill, 2002) has identified precursor behaviors through staff interviews and informal observations. Although staff interviews and informal observations are not time intensive and do not require extended amounts of observation or training, these methods have two drawbacks. First, if a given response occurs at a very high rate (a high unconditional probability), it may precede many behaviors the individual emits, including the problem behavior. Thus, informal observations may be especially sensitive to potential false positive outcomes, because there is no systematic measurement of both the immediate and ambient levels of behaviors and environmental events of interest. Second, caregiver reports may be vulnerable to confounding influences (e.g., recent or dramatic events, limited observation of low-rate problem behavior). These drawbacks are not associated with comparative probability and lag-sequential analysis procedures (e.g., Borrero & Borrero, 2008) and, although they require repeated observation of the individual's problem behavior, they provide a quantitative basis for identifying precise temporal relations among problem behavior, other responses, and potentially relevant environmental events. For example, if potential precursor responses are observed occasionally to produce the same environmental consequence as problem behavior and, on those occasions, escalation to problem behavior does not occur, the precursor

and problem behavior may be members of the same response class.

In the current experiment, observations revealed that Peter's head-up occurred at somewhat higher rates compared to SIB. This outcome is consistent with several previous findings that earlier, less severe members of response class hierarchies sometimes occur at relatively greater frequencies (e.g., Harding et al., 2001; Lalli et al., 1995; Richman et al., 1999). In the current study, this appeared to facilitate both the functional analysis and treatment processes, because more opportunities were available to observe and provide consequences for precursor behavior. Future researchers should evaluate whether identifying higher rate precursors to low-rate problem permits more rapid assessment and treatment of low-rate problem behavior.

Some limitations of this study should be noted. The assessment and treatment evaluation required a significant amount of time (17 months) and resources to complete. Although the low rate of Peter's SIB was a factor in the extended time frame, other approaches (e.g., anecdotal assessment) may have led to more rapid treatment. In addition, appropriate temporal parameters for using comparative probability and lag-sequential analyses to identify precursor behavior are not well understood. Borrero and Borrero (2008) noted that unconditional probability values in their study may have been artificially low when compared to conditional probability values, because unconditional probability was calculated using a 1-s interval and conditional probability was calculated using a 10-s interval. However, calculating unconditional probabilities using longer intervals (e.g., 10 s) could call into question the actual relation between two events. Future researchers may focus on determining what temporal parameters are appropriate and whether certain idiosyncratic variables, such as ambient levels of the reinforcing consequence, are correlated with specific temporal relations among members of a response class hierarchy.

Recent findings suggest that precursor functional analysis may represent a promising approach to the assessment and treatment of severe problem behavior. This approach reduces the risk of harmful problem behavior occurring during assessment while still using an empirical experimental analysis. The current investigation provides a method for conducting a sequence of analyses designed to identify, assess, and treat a response that reliably precedes a severe problem behavior. This progression allowed effective treatment of severe SIB without requiring the interventionist to directly evoke and reinforce SIB.

REFERENCES

- Borrero, C. S., & Borrero, J. C. (2008). Descriptive and experimental analyses of potential precursors to problem behavior. *Journal of Applied Behavior Analysis, 41*, 83–96.
- DeLeon, I. G., & Iwata, B. A. (1996). Evaluation of a multiple-stimulus presentation format for assessing reinforcer preferences. *Journal of Applied Behavior Analysis, 29*, 519–533.
- Derby, K. M., Wacker, D. P., Sasso, G., Steege, M., Northup, J., Cigrand, K., et al. (1992). Brief functional assessment techniques to evaluate aberrant behavior in an outpatient setting: A summary of 79 cases. *Journal of Applied Behavior Analysis, 25*, 713–721.
- Fisher, W., Piazza, C. C., Bowman, L. G., Hagopian, L. P., Owens, J. C., & Slevin, I. (1992). A comparison of two approaches for identifying reinforcers for persons with severe and profound disabilities. *Journal of Applied Behavior Analysis, 25*, 491–498.
- Hagopian, L. P., Rush, K. S., Lewin, A. B., & Long, E. S. (2001). Evaluating the predictive validity of a single stimulus engagement preference assessment. *Journal of Applied Behavior Analysis, 34*, 475–485.
- Hanley, G. P., Iwata, B. A., & McCord, B. E. (2003). Functional analysis of problem behavior: A review. *Journal of Applied Behavior Analysis, 36*, 147–185.
- Harding, J. W., Wacker, D. P., Berg, W. K., Barretto, A., Winborn, L., & Gardner, A. (2001). Analysis of response class hierarchies with attention-maintained problem behaviors. *Journal of Applied Behavior Analysis, 34*, 61–64.
- Iwata, B. A., Dorsey, M. F., Slifer, K. J., Bauman, K. E., & Richman, G. S. (1994). Toward a functional analysis of self-injury. *Journal of Applied Behavior Analysis, 27*, 197–209. (Reprinted from *Analysis and Intervention in Developmental Disabilities, 2*, 3–20, 1982)
- Kahng, S., Abt, K. A., & Schonbachler, H. E. (2001). Assessment and treatment of low-rate high-intensity problem behavior. *Journal of Applied Behavior Analysis, 34*, 225–228.

- Kahng, S., & Iwata, B. A. (1999). Correspondence between outcomes of brief and extended functional analyses. *Journal of Applied Behavior Analysis*, 32, 149–160.
- Lalli, J. S., Mace, F. C., Wohn, T., & Livezey, K. (1995). Identification and modification of a response-class hierarchy. *Journal of Applied Behavior Analysis*, 28, 551–559.
- Lalli, J. S., Vollmer, T. R., Progar, P. R., Wright, C., Borrero, J., Daniel, D., et al. (1999). Competition between positive and negative reinforcement in the treatment of escape behavior. *Journal of Applied Behavior Analysis*, 32, 285–296.
- Langdon, N. A., Carr, E. G., & Owen-DeSchryver, J. S. (2008). Functional analysis of precursors for serious problem behavior and related intervention. *Behavior Modification*, 32, 804–827.
- Najdowski, A. C., Wallace, M. D., Ellsworth, C. L., MacAleese, A. N., & Cleveland, J. M. (2008). Functional analyses and treatment of precursor behavior. *Journal of Applied Behavior Analysis*, 41, 97–105.
- Northup, J., Wacker, D., Sasso, G., Steege, M., Cigrand, K., Cook, J., et al. (1991). A brief functional analysis of aggressive and alternative behavior in an outclinic setting. *Journal of Applied Behavior Analysis*, 24, 509–522.
- Richman, D. M., Wacker, D. P., Asmus, J. M., Casey, S. D., & Andelman, M. (1999). Further analysis of problem behavior in response class hierarchies. *Journal of Applied Behavior Analysis*, 32, 269–283.
- Sloman, K. N., Vollmer, T. R., Cotnoir, N. M., Borrero, C. S. W., Borrero, J. C., Samaha, A. L., et al. (2005). Descriptive analyses of caregiver reprimands. *Journal of Applied Behavior Analysis*, 38, 373–383.
- Smith, R. G., & Churchill, R. M. (2002). Identification of environmental determinants of behavior disorders through functional analysis of precursor behaviors. *Journal of Applied Behavior Analysis*, 35, 125–136.
- Tarbox, J., Wallace, M. D., Tarbox, R. S., Landaburu, H. J., & Williams, W. L. (2004). Functional analysis and treatment of low rate problem behavior in individuals with developmental disabilities. *Behavioral Interventions*, 19, 187–204.
- Vollmer, T. R., Iwata, B. A., Zarcone, J. R., Smith, R. G., & Mazaleski, J. L. (1993). Within session patterns of SIB as indicators of behavioral function. *Research in Developmental Disabilities*, 14, 479–492.
- Vollmer, T. R., Marcus, B. A., Ringdahl, J. E., & Roane, H. S. (1995). Progressing from brief assessments to extended analyses in the evaluation of aberrant behavior. *Journal of Applied Behavior Analysis*, 28, 561–576.
- Wallace, M. D., & Knights, D. J. (2003). An evaluation of a brief functional analysis format within a vocational setting. *Journal of Applied Behavior Analysis*, 36, 125–128.

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