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EXPERIMENTAL ANALYSIS OF PRECURSORS TO SEVERE PROBLEM BEHAVIOR

JENNIFER N. FRITZ

UNIVERSITY OF HOUSTON–CLEAR LAKE

BRIAN A. IWATA

UNIVERSITY OF FLORIDA

JENNIFER L. HAMMOND

STANFORD UNIVERSITY

AND

SARAH E. BLOOM

UTAH STATE UNIVERSITY

Some individuals engage in both mild and severe forms of problem behavior. Research has shown that when mild behaviors precede severe behaviors (i.e., the mild behaviors serve as precursors), they can (a) be maintained by the same source of reinforcement as severe behavior and (b) reduce rates of severe behavior observed during assessment. In Study 1, we developed an objective checklist to identify precursors via videotaped trials for 16 subjects who engaged in problem behavior and identified at least 1 precursor for every subject. In Study 2, we conducted separate functional analyses of precursor and severe problem behaviors for 8 subjects, and obtained correspondence between outcomes in 7 cases. In Study 3, we evaluated noncontingent reinforcement schedule thinning plus differential reinforcement of alternative behavior to reduce precursors, increase appropriate behavior, and maintain low rates of severe behavior during 3 treatment analyses for 2 subjects. Results showed that this treatment strategy was effective for behaviors maintained by positive and negative reinforcement.

Key words: functional analysis, precursor behavior, response hierarchy, differential reinforcement, noncontingent reinforcement

Functional analysis (FA) methodology identifies environmental determinants of problem behavior, thereby facilitating the development of reinforcement-based intervention strategies. As a result, it is considered to be the standard approach for behavioral assessment (Hanley, Iwata, & McCord, 2003). Typical FAs involve repeated observation of problem behavior under controlled conditions in which antecedent and consequent events likely to maintain behavior are manipulated (Iwata, Dorsey, Slifer, Bauman, & Richman, 1982/1994); this approach has been replicated in hundreds of studies. Nevertheless, difficulties may arise when the problem behavior poses significant risk to the individual or caregivers and, as a result, cannot be permitted to occur frequently.

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Correspondence regarding this article should be addressed to Jennifer N. Fritz, University of Houston–Clear Lake, 2700 Bay Area Blvd. 112, Houston, Texas 77058 (e-mail: fritzj@uhcl.edu).

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One promising approach to minimizing risk is to assess behaviors (precursors) that may predict occurrences of the target problem behavior. In one of the first published studies on the assessment of precursors, Smith and Churchill (2002) reported that four individuals engaged in precursors to either self-injurious behavior (SIB) or aggression. They conducted independent FAs of precursor and severe problem behavior and found correspondence between outcomes for all subjects. More recent studies also have shown that precursors and severe problem behavior can be maintained by the same sources of reinforcement and that placing reinforcement contingencies on precursors reduces the occurrence of severe problem behavior (Borrero & Borrero, 2008; Dracobly & Smith, 2012; Herscovitch, Roscoe, Libby, Bourret, & Ahearn, 2009; Langdon, Carr, & Owen-DeSchryver, 2008).

Although results of Smith and Churchill (2002) were promising, their method for selecting precursors did not provide an empirical demonstration of the predictive relation between precursor and problem behavior. Subsequent studies addressed this limitation by using various types of descriptive analysis. For example, after observing informally that an individual tended to engage in stereotypy (finger waving) prior to eye poking, Hagopian, Paclawskyj, and Kuhn (2005) verified the correlation between stereotypy and eye poking through conditional probability analysis. They also examined cumulative records of responding and observed a temporal contiguity between stereotypy and eye poking. Borrero and Borrero (2008) used similar procedures (classroom observations, followed by conditional probability and lag-sequential analysis of data) and observed that two individuals' loud vocalizations were predictive of SIB, aggression, or property destruction. Results of these and other studies (Dracobly & Smith, 2012; Herscovitch et al., 2009; Langdon et al., 2008) showed that correlational analyses, and conditional probability analysis in particular, are useful in establishing the predictive characteristics of precursor behavior.

Nevertheless, a limitation common to all previous studies on precursor behavior was that the initial identification of potential precursors was based on caregiver verbal report or informal observations conducted prior to assessment. These methods provided useful information, but it is possible that precursors (a) might exist even when caregivers cannot identify them, (b) may be different than those reported, or (c) are not readily detected during informal observations. Thus, it is possible that an important step in the analysis of precursors could be based on inaccurate information or limited sampling of client behavior. In addition, numerous instances of the target problem behavior were observed in all of the studies before the relation between precursor and target responses was verified, thereby rendering the procedure difficult to use in situations for which it is ideally designed, that is, the assessment of severe problem behavior. One purpose of this study was to illustrate a method for identifying precursors that (a) was based solely on direct observation and (b) minimized the number of occurrences of the target problem behavior required to identify the precursors. We used this method (Study 1) to evaluate its utility and to determine the extent to which a number of individuals who engaged in problem behavior also engaged in precursor behavior. We then conducted independent FAs of precursor and target problem behavior (Study 2) to verify that the behaviors were maintained by the same source of reinforcement.

The practical benefit of a precursor analysis lies in its potential as a basis for treatment: Results of three studies (Dracobly & Smith, 2012; Langdon et al., 2008; Najdowski, Wallace, Ellsworth, MacAleese, & Cleveland, 2008) have shown that when the function of problem behavior can be inferred from an FA of its precursors, interventions for more severe forms of behavior might be based on assessment

Table 1
Subject Characteristics

Name	Age	Classification	Target problem behaviors
Liv	10	Down syndrome	Property destruction (throwing items, knocking over furniture)
Billy	15	Down and Kleinfelter syndromes	Clothing destruction (ripping, tearing, or unraveling)
Chuck	14	Arthrogryposis syndrome	SIB (head hitting)
Amanda	18	Autism, profound MR	SIB (face and head hitting)
Kelly	10	Seizure disorder and retinopathy	SIB (self biting)
George	9	Autism	Aggression (hitting, kicking, pinching, biting)
Amy	3	Down syndrome	Property destruction (throwing objects, tearing materials from walls, destroying materials)
Sammy	6	Deaf, learning disabilities	Aggression (hitting, kicking, biting, head butting; throwing objects at people)
Renee	15	Angelman's syndrome	Aggression (hair pulling, hitting, pushing)
Curtis	13	Autism	Aggression (hitting, kicking, biting, head butting)
Gerald	19	Cerebral palsy, MR (level unspecified)	SIB (hand biting)
Adam	11	Prader-Willi syndrome	Aggression (hitting, kicking, biting, throwing objects at people)
Donald	14	Autism, seizure disorder	Aggression (hitting, kicking, biting, head butting)
Leigh	13	Trainable mentally handicapped and language impaired	SIB (chin hitting and banging)
Guy	12	Autism	Aggression (hitting, kicking, biting, head butting)
Kevin	54	Severe MR, seizure disorder	Property destruction (throwing furniture, pounding on walls, destroying or throwing materials)

Note. MR = mental retardation.

of less severe behavior. The intervention in these studies consisted of differential reinforcement of alternative behavior (DRA), which resulted in an increase in alternative behavior and low rates of severe problem behavior. An alternative approach to treatment might consist of preceding the implementation of DRA with a schedule of noncontingent reinforcement (NCR), which might decrease the occurrence of both precursor and target behavior from the outset of intervention (Goh, Iwata, & DeLeon, 2000; Marcus & Vollmer, 1996). Thus, the third purpose of this study was to determine whether (a) an effective intervention could be designed based on the results of precursor analyses alone, and (b) the sequential introduction of continuous NCR followed by NCR schedule thinning plus DRA would be effective in reducing precursors while maintaining low rates of severe problem behavior.

STUDY 1: IDENTIFICATION AND PREVALENCE OF PRECURSORS

Method

Subjects and setting. The first 16 individuals with intellectual disabilities who had been referred from two programs at a day-treatment facility (Adam and Kevin) or from one of five classrooms at a special education school (the remaining 14 individuals) for the assessment of severe problem behavior participated. Subject characteristics (age, diagnostic classification, and definition of the target problem behavior) are listed in Table 1. All sessions were conducted in an observation room at the day program or in designated areas of a classroom at the special education school.

Procedure. Prior to assessment, we asked each subject's caregiver to identify the most severe class of problem behavior (SIB, aggression, or property

destruction), which was selected as the target problem behavior during subsequent assessments. We also asked caregivers if they had observed any behaviors that tended to precede the target behavior. We then conducted the precursor assessment to identify behaviors that predicted the occurrence of the target behavior.

The precursor assessment consisted of discrete trials in which antecedent conditions that might serve as establishing operations (EOs; Michael, 1982) for the target behavior were presented, and all trials were videotaped for subsequent data collection. Trial types resembled the attention and demand conditions of an FA (Iwata et al., 1982/1994) and lasted 5 min or less. Given that many problem behaviors are maintained by positive reinforcement in the form of access to attention or negative reinforcement in the form of escape from demands (Iwata et al., 1994), presentation of these conditions presumably increased the likelihood of observing the target in a relatively short period of time. A tangible condition was included if caregivers reported that the target was likely to occur when preferred items were removed or access to items was denied. Contingent on the target behavior, consequences relevant to the antecedent conditions (attention, escape, or access to leisure items) were delivered. Presumably, it was unlikely that the subject could engage in precursor behaviors while exhibiting a rapid sequence of target responses. To reduce the likelihood of multiple consecutive instances of the target and to increase the likelihood of observing a precursor prior to the occurrence of a given target, a trial was terminated immediately after a consequence was delivered, and the next trial began only when the subject had not engaged in the target for 30 s.

During attention trials, the therapist did not interact with the subject unless the target behavior occurred, at which time the therapist delivered a statement of concern (e.g., "Don't do that, you will hurt yourself.") and gentle physical contact. The therapist continued to interact with the subject (e.g., rubbing his or her back, talking about preferred topics, etc.) until the target was not observed for 30 s. Once the target was not observed for 30 s or if the target was not observed in 5 min (whichever came first), a demand trial was conducted.

During demand trials, the therapist presented instructions to complete tasks appropriate to the subject's functioning level. The therapist used a three-step prompting procedure (vocal instruction, model, physical guidance) but terminated the instructional sequence and moved away from the subject contingent on the first occurrence of the target. The next trial began once the target was not observed for 30 s or if the target was not observed in 5 min. If a tangible condition was included in the assessment, it was conducted after the demand trial. If a tangible condition was not included, another attention trial was conducted.

During tangible trials, the therapist allowed the subject brief (1 to 2 min) access to preferred items and then removed them. Contingent on the target, the items were returned to the subject. Once the target was not observed for 30 s or if the target was not observed in 5 min, another attention trial began.

Because a precursor assessment would be considered in an attempt to minimize the occurrence of severe problem behavior, we wanted to limit occurrences of the target yet observe a sufficient number as a basis for identifying precursors. Therefore, we considered the precursor assessment complete after 10 trials in which the target behavior occurred, assuming that the 10-trial limit also would yield a sufficient number of trials during which the target behavior did not occur. However, in the event that the target behavior occurred during the first 10 trials of the assessment, we conducted play trials in which the subject had noncontingent access to attention and preferred items in the absence of all demands. This procedure resulted in a sufficient number of nontarget trials during which precursors could occur, and the duration of the trials without the target behavior was approximately equal to or

greater than the duration of trials with the target behavior for all subjects.

Response measurement and reliability. Because potential precursors were unknown prior to assessment, we videotaped all trials to have a permanent record of all responses and later scored the videos using a checklist, which grouped responses topographically as (a) vocalizations, (b) facial expressions, (c) postures, (d) repetitive motor movements, (e) locomotion, (f) object manipulation, and (g) other problem behaviors. Examples of possible response topographies were listed in each category, and additional space was provided to allow observers to write in behaviors that were observed but not included on the checklist. All responses that were included in the topographical definition of the target behavior or could be considered mild forms of the target (e.g., pushing the therapist if the target behavior was hitting) were excluded as potential precursors.

Observation was conducted in two phases: (a) Potential precursor topographies were identified and operationally defined and (b) potential precursors were scored as occurrence or nonoccurrence in all assessment trials. When the precursor assessment was complete, two observers watched the videos and marked potential precursor topographies during trials in which the target behavior occurred. The observers compared the topographies marked on their checklists and developed operational definitions of all potential precursors. The observers then watched and scored all of the trials independently using a binary code (i.e., 1 = occurrence and 0 = nonoccurrence of either precursors or the target within a trial). After each trial, they compared their data records and resolved any discrepancies by watching the trial again, clarifying the operational definition, and rescoring the trial until 100% agreement was attained for each precursor and the target. For example, if a subject engaged in several vocal responses (e.g., whining, screaming, and positive vocalizations) and observers disagreed on the classification of a particular response, they discussed the video segment together and included additional topographical description of the behavior or modified exclusionary criteria in the operational definition such that agreement could be obtained more readily for subsequent occurrences of the behavior. We used this process (rather than simply comparing observers' records) to ensure accurate identification of precursor responses.

Probability analyses. Several probabilities were calculated based on all trials of the precursor assessment to identify the precursors for each subject's target behavior (see Table 2 for formulas). First, the probability of the target given each potential precursor [$p(T|P)$] was calculated and compared to (a) the probability of the target given the absence of each precursor [$p(T|\sim P)$] and (b) the unconditional probability of the target [$p(T)$].

Table 2
Probability Analysis Formulas

Probability type	Formula
Conditional probability of the target (T) given the precursor (P)	$p(T\|P) = \frac{\text{trials with P that also contain T}}{\text{trials with P}}$
Conditional probability of the target given the absence of the precursor	$p(T\|\sim P) = \frac{\text{trials without P that contain T}}{\text{trials without P}}$
Unconditional probability of the target (numerator was always 10)	$p(T) = \frac{\text{trials containing T}}{\text{total trials}}$
Conditional probability of the precursor given the target (denominator was always 10)	$p(P\|T) = \frac{\text{trials with T that also contain P}}{\text{trials with T}}$
Conditional probability of the precursor given the absence of the target	$p(P\|\sim T) = \frac{\text{trials without T that contain P}}{\text{trials without T}}$
Unconditional probability of the precursor	$p(P) = \frac{\text{trials containing P}}{\text{total trials}}$

Next, the probability of each precursor given the target [p(P|T)] was calculated and compared to (a) the probability of each precursor given the absence of the target [p(P|∼T)] and (b) the unconditional probability of each precursor [p(P)]. Behaviors were selected as precursors if they satisfied both of the following criteria. First, the probability of the target given the precursor was higher than the probability of the target given the absence of the precursor and the unconditional probability of the target, or p(T|P) > p(T|∼P) and p(T|P) > p(T). Second, the probability of the precursor given the target was higher than the probability of the precursor given the absence of the target and the unconditional probability of the precursor, or p(P|T) > p(P|∼T) and p(P|T) > p(P). In general, we selected precursors that often were followed by the occurrence of the target behavior and that did not often occur when the target behavior was not observed. For example, Liv (Figure 1, top left) always engaged in the target behavior after exhibiting three responses (positive vocalizations, flapping her hands, and mouthing objects; top) and never engaged in those responses when the target behavior was not observed (bottom). Therefore, these three precursors appeared to be perfectly predictive of her problem behavior. By contrast, although Chuck (Figure 1, bottom left) engaged in problem behavior after smiling more often than not (i.e., the probability of the target given the precursor was higher than the probability of the target given the absence of the precursor; top), he also smiled frequently during trials in which the problem behavior was not observed (i.e., the probability of the precursor given the absence of the target also was high; bottom). By comparing these relative probabilities for each subject, we hoped to select precursors that were most predictive of the severe problem behavior.

If several potential precursors were observed, some response topographies were combined if all of the responses (a) met the criteria for classification as either precursors or nonprecursors and (b) could be described succinctly based on similar topographical features (e.g., "crawl," "run," and "climb" were combined into "move around room" for Amy).

Results and Discussion

Figures 1 through 4 show results of the precursor assessments. The top and bottom panels of each graph show the probability analyses for the target and for the potential precursors, respectively. Results showed that all 16 subjects engaged in precursor behavior. The number of identified precursors ranged from 1 (Renee) to 16 (Guy). (Operational definitions of identified precursors are available from the first author.) The precursor assessments required 11 (Liv) to 30 (Chuck) trials to observe 10 instances of the target behavior, which took approximately 10 min to less than 150 min of observation time to complete the assessment for each subject. Therefore, the assessments were completed in a relatively short amount of time.

Three precursors were identified for Liv (Figure 1) and all were perfectly correlated with the occurrence of target problem behavior [i.e., property destruction always occurred in trials in which the precursor was observed; p(T|P) = 1.0], although the probability of the target given the absence of each precursor [p(T|∼P)] also was high. In addition, precursors never occurred in trials in which the target was not observed [i.e., p(P|∼T) = 0]. Three of the five precursors selected for Billy (Figure 1) also were perfectly predictive of his target, and the two other precursors occurred infrequently but appeared to be somewhat predictive of the target. Chuck's three precursors (Figure 1) were somewhat less predictive, in that the target was not always observed following the selected precursors, and his precursors sometimes were observed when the target behavior did not occur. Four precursors were identified for Amanda (Figure 1), three of which were perfectly predictive of her target behavior.

Only one of Kelly's three precursors (Figure 2) was perfectly correlated with the occurrence of

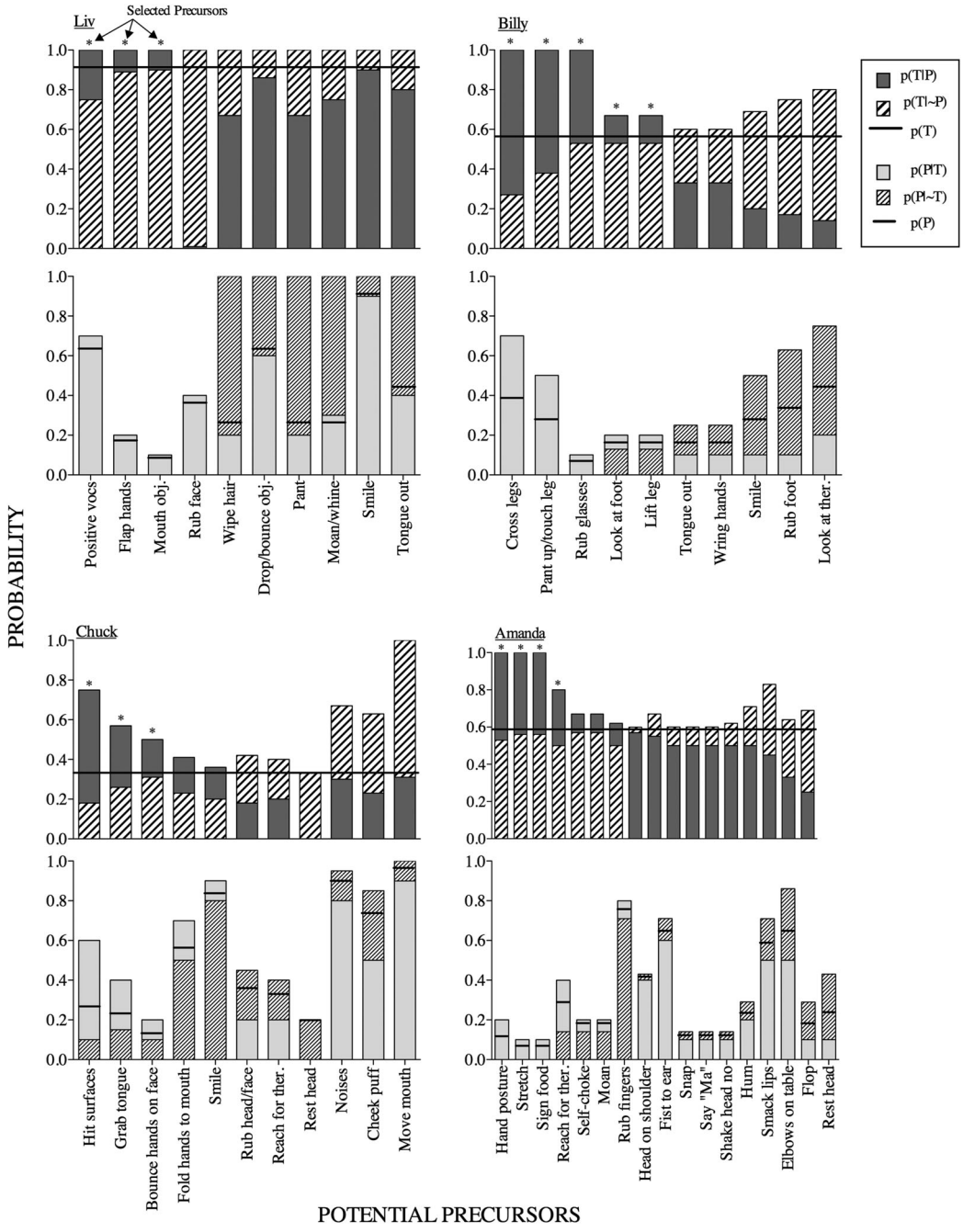

Figure 1. Results of the precursor assessment for Liv, Billy, Chuck, and Amanda. The top and bottom graphs for each subject show probabilities for target behavior and precursor behaviors, respectively. Asterisks indicate selected precursors. $p(T|P)$ = the probability of the target given each potential precursor; $p(T|{\sim}P)$ = the probability of the target given the absence of each precursor; $p(T)$ = the unconditional probability of the target; $p(P|T)$ = the probability of each precursor given the target; $p(P|{\sim}T)$ = the probability of each precursor given the absence of the target; $p(P)$ = the unconditional probability of each precursor.

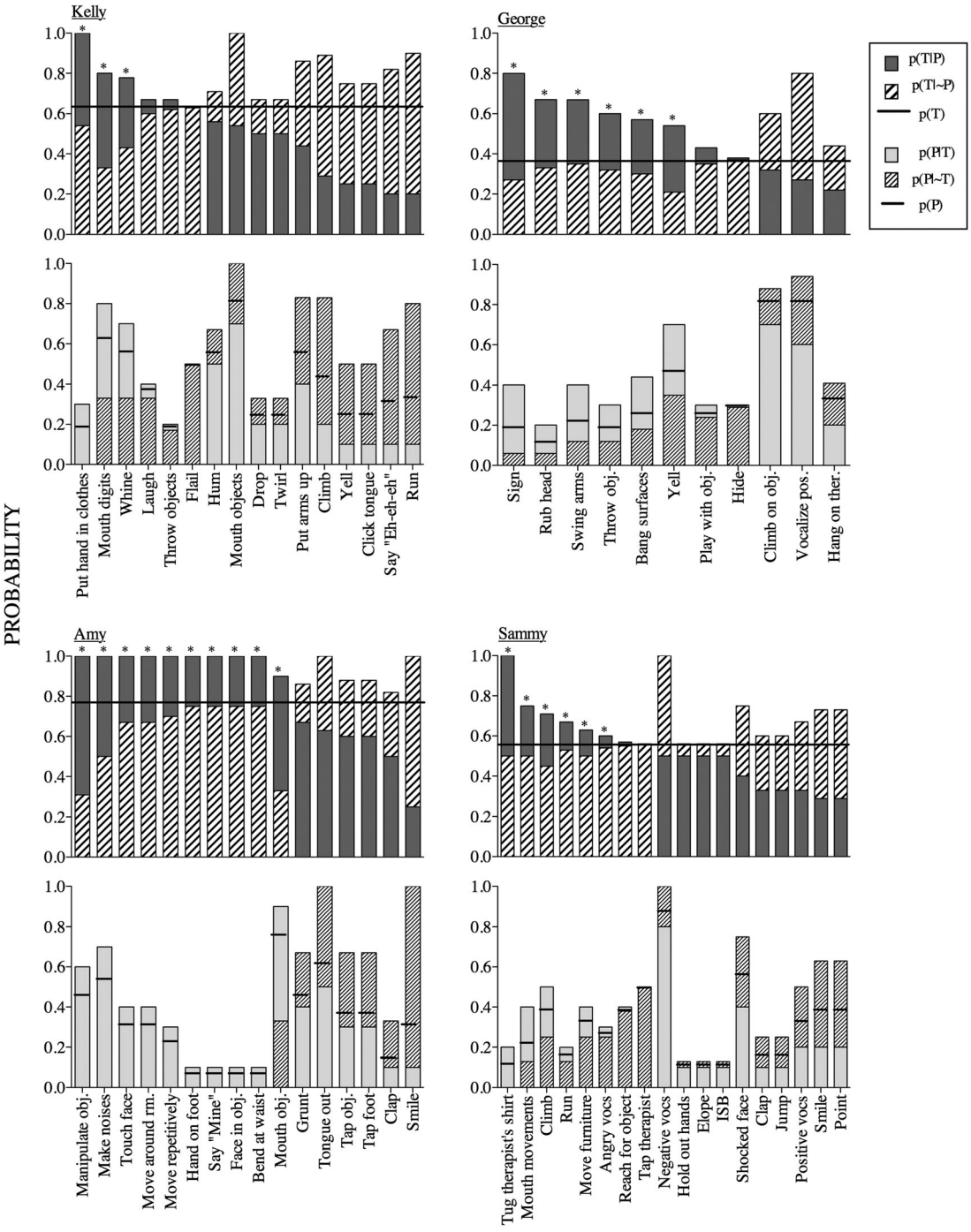

Figure 2. Results of the precursor assessment for Kelly, George, Amy, and Sammy.

target behavior; however, the other two precursors seemed to occur more often than not before the target behavior. Six precursors were identified for George (Figure 2), and, like Chuck, none of his precursors was perfectly correlated with the occurrence of the target behavior, but the relative conditional probabilities showed that these behaviors generally predicted the occurrence of the target. Ten precursors were identified for Amy (Figure 2), nine of which were perfectly correlated with the target behavior. Mouthing objects also was highly predictive of the target; however, this behavior occurred in trials in which the target was not observed [i.e., $p(P|\sim T) > 0$]. In addition, it should be noted that Amy engaged in the target behavior during the first 10 trials of the precursor assessment, thus precluding some of the probability calculations. Therefore, three play trials were conducted, and her precursor assessment was considered complete with 10 trials that contained the target and three play trials in which the target never occurred. Six precursors were identified for Sammy (Figure 2); however, only one precursor was perfectly correlated with his target behavior.

Few precursors were identified for Renee and Curtis (Figure 3). Only one behavior was selected as a precursor to Renee's aggression (covering her eyes with her hands), although results of the probability analysis did not suggest that this behavior strongly predicted the occurrence of the target [i.e., $p(T|P)$ and $p(P|T)$ were almost equal to $p(T|\sim P)$ and $p(P|\sim T)$, as well as the unconditional probabilities of the target and precursors, respectively]. Two precursors were identified for Curtis. Leg scratching only was observed during one trial of the precursor assessment, but it occurred during a trial in which aggression also occurred; thus, the behavior met the precursor selection criteria. Blocking the therapist from moving also was selected, and it occurred more often overall, even though aggression occurred during several trials in which blocking the therapist was not observed.

Moderate numbers of precursors were identified for Gerald, Adam, Donald, and Leigh. Four precursors were identified for Gerald (Figure 3), and three of the responses perfectly predicted the occurrence of the target (i.e., SIB always occurred in trials in which those behaviors were observed, and those behaviors were never observed without being followed by SIB). Six precursors were identified for Adam (Figure 3), and all perfectly predicted the occurrence of aggression. It should be noted that only seven trials with the target problem behavior were included in Adam's precursor assessment due to an oversight; however, the assessment clearly identified precursors to his target behavior. Six precursors were identified for both Donald and Leigh (Figure 4), although only two and four precursors were perfectly correlated with the occurrence of their target problem behavior, respectively.

Finally, 16 precursors were identified for Guy, and 13 were identified for Kevin (Figure 4). Several behaviors were perfectly correlated with the occurrence of the target behavior [i.e., $p(T|P) = 1.0$ and $p(P|\sim T) = 0$] for both subjects (8 and 12 precursors, respectively).

When precursors reported by caregivers were compared to those identified by the precursor assessment (Table 3), results showed that caregivers' verbal reports rarely matched the results of the precursor assessment. In cases in which the caregiver did identify similar behaviors, only one or two reported precursors matched the responses identified by the precursor assessment. The primary teachers of six subjects (Amanda, Billy, Chuck, Sammy, Renee, and Leigh) were unable to identify any precursors whatsoever; however, results of the precursor assessment showed that some behaviors did, in fact, predict the target behavior. Thus, relatively brief direct assessment can be used to identify behaviors that predict the target behavior even when caregivers cannot identify any precursors. Furthermore, caregivers of six subjects (George, Amy, Curtis, Gerald, Adam, and Donald) reported precursors other than those identified via the assessment. Even though it was possible for the subject to engage in the caregiver-reported precursors during the

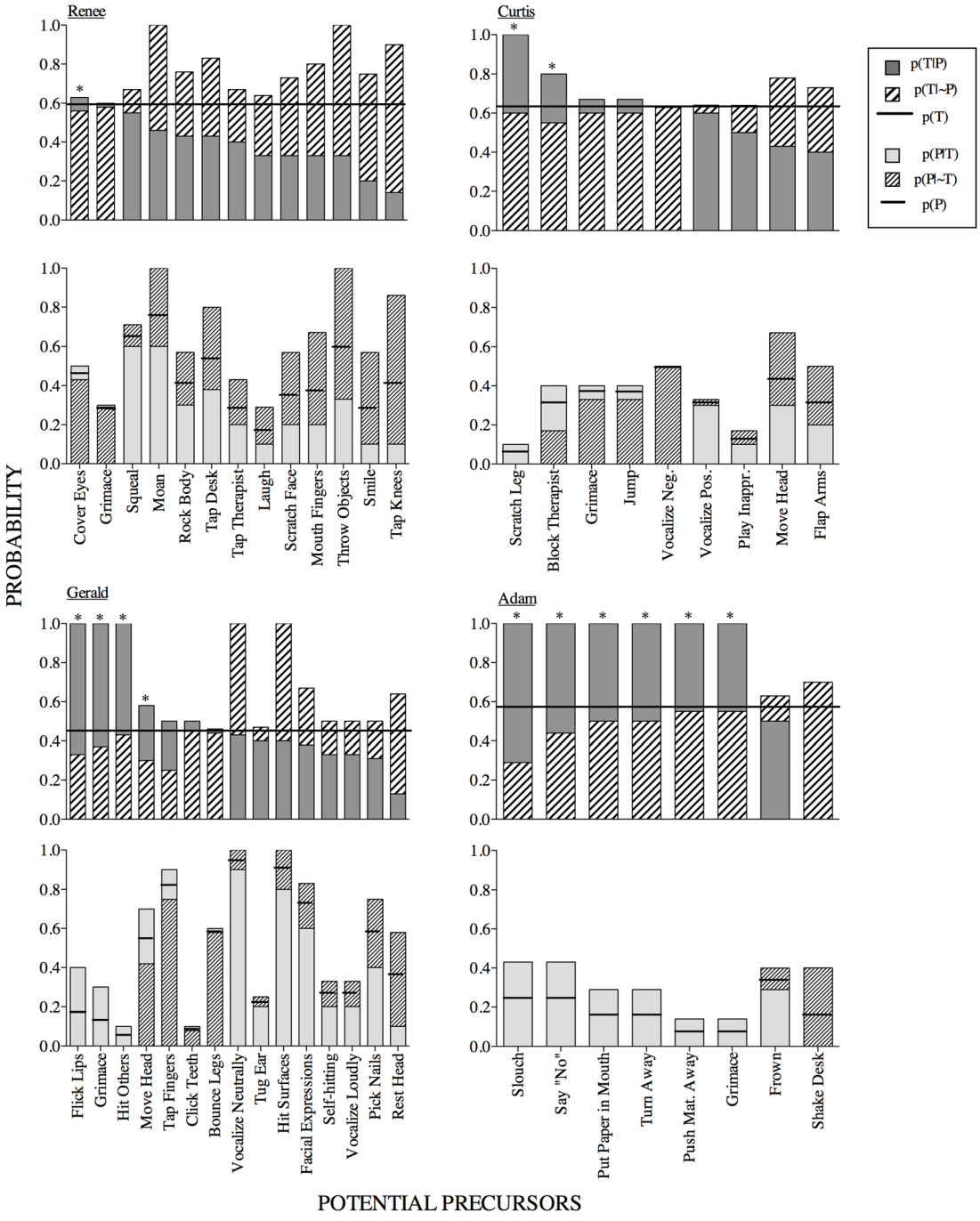

Figure 3. Results of the precursor assessment for Renee, Curtis, Gerald, and Adam.

Table 3
Precursors Reported by Caregivers and Assessment-Identified Precursors

Subject	Caregiver-reported precursors	Assessment-identified precursors
Liv	*Make a cry or screech noise*	*Vocalize positively*, flap hands, mouth objects
Billy	None	Cross legs, pull up pants or touch leg, rub glasses
Chuck	None	Hit surfaces, grab tongue, bounce hands on face
Amanda	None	Hand posture, reach for therapist, stretch
Kelly	Run away	Whine, mouth fingers, place hands in clothes
George	*Yell*, *throw items*, tip over chairs	*Yell*, *throw objects*, sign, rub head, swing arms, bang surfaces
Amy	Laugh	Manipulate objects, make noises, touch face, move around room, move repetitively, hand on foot, say "mine," put face in object, bend at waist, mouth object
Sammy	None	Angry vocalizations, run, climb, mouth movements, move furniture, tug on therapist's shirt
Renee	None	Cover eyes
Curtis	Whine, repeat phrases, grimace	Scratch leg, block therapist from objects
Gerald	Scream, hit head or ear	Flick lips, grimace, hit others, move head
Adam	*Vocalize negatively*, *put head down*, *change entire facial expression*, *make faces at others*, roll eyes, yell, tongue click	*Say "no,"* *slouch*, *grimace*, turn away, put paper in mouth, push materials away
Donald	Bruxism	Flap hands, put hand to mouth, snarl, clap hands, vocalize negatively, move to objects
Leigh	None	Cover eyes, chin down, say "yeah yeah," guide therapist, stomp or shuffle, circle hands
Guy	*Drop to ground*, *roll on floor*, *curse*, *scream*	*Flop* (includes rolling), *curse*, *vocalize negatively* (includes screaming), swing body, stomp, bite objects, throw objects, push materials away, crumple paper, bite hand, bang head, grimace, shake head "no," hit surfaces, slouch, make requests
Kevin	*Say "no"*	*Say "no,"* grunt, drop or scoot on floor, wave arms, pull therapist's arm, say "good boy," hold knees, smile, fidget, stack chairs, hit with head, knock on table, say "eat"

Note. Italicized precursors were behaviors identified by both caregivers and the precursor assessment.

assessment, either the behaviors never occurred (George, Amy, Curtis, Gerald, Adam, and Donald) or they did not predict the occurrence of the target behavior (Curtis and Gerald). Finally, the precursor assessment identified precursors that were not reported by caregivers (ranging from 1 precursor for Renee to 13 precursors for Guy) for all 16 subjects.

STUDY 2: FUNCTIONAL ANALYSIS OF PRECURSOR AND PROBLEM BEHAVIORS

Although the assessment conducted in Study 1 identified behaviors that were correlated with the target problem behavior, the functional relation between precursor and target behaviors was unknown. Therefore, we conducted independent FAs for a subset of subjects from Study 1 to identify the function of the identified precursors as well as the function of the target behavior. Unlike Smith and Churchill (2002) and Borrero and Borrero (2008), we conducted the precursor FAs first to determine whether precursor and target functions matched when subjects had not been exposed previously to FA conditions (Study 1 trials notwithstanding) and to perhaps limit the number of occurrences of the target. Although this may have introduced a sequence effect, we believed that this was the most conservative method of determining whether the function of precursors and target behavior matched. Presumably, if we had conducted the target FA first, the probability of precursors occurring in the same

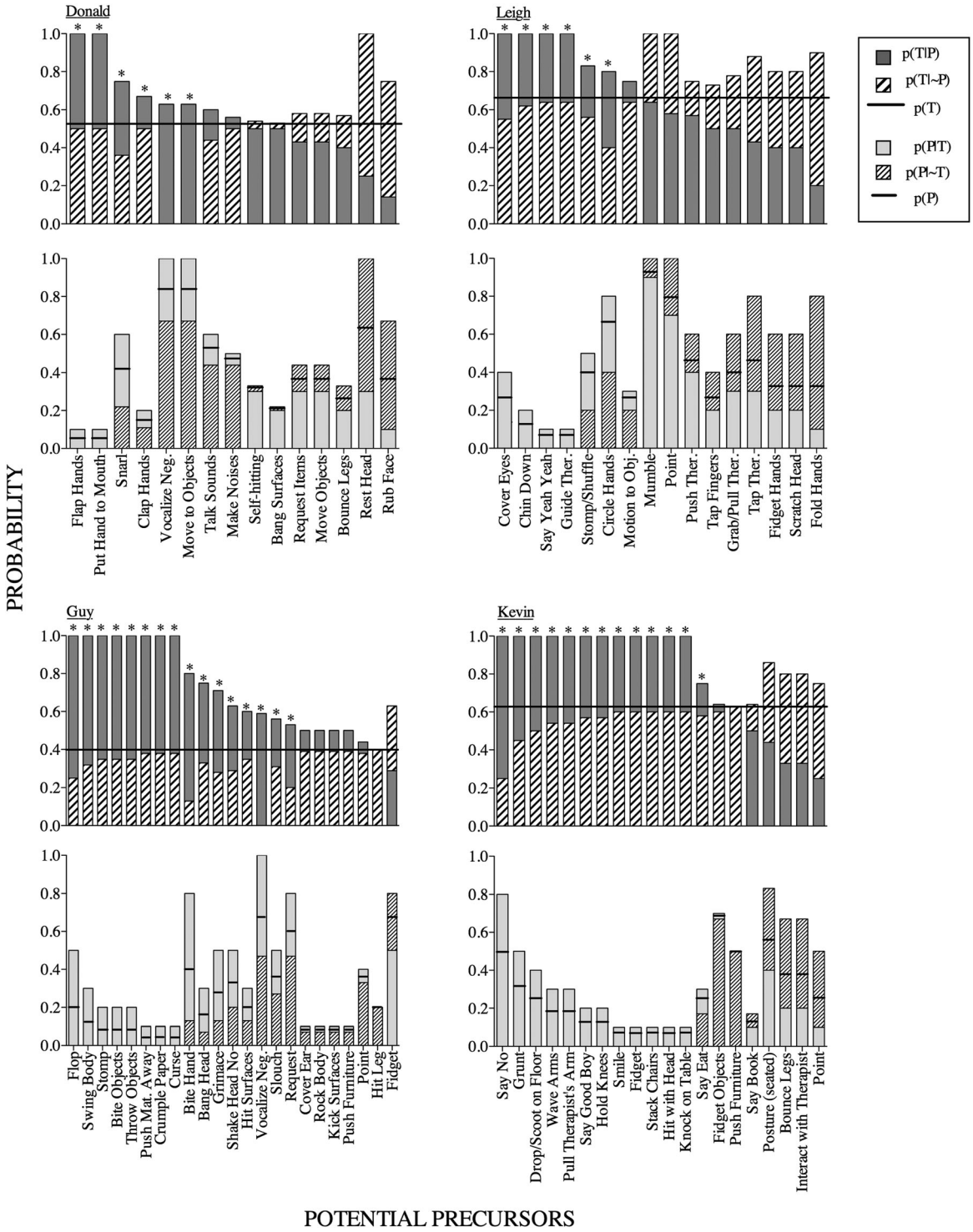

Figure 4. Results of the precursor assessment for Donald, Leigh, Guy, and Kevin.

conditions as the target behavior would increase due to experience with the session contingencies, potentially resulting in a higher probability of correspondence between the results of both assessments. In addition, under typical conditions in which a precursor FA would be considered, a target FA would not have been conducted.

Method

Subjects and setting. Eight individuals from Study 1 (Renee, Curtis, Gerald, Adam, Donald, Leigh, Guy, and Kevin) participated in Study 2. They were selected based on results of their precursor assessments, which identified varied numbers of precursors across subjects. No other inclusion criteria were considered. All sessions were conducted in an observation room at a day program for adults or in designated areas of a classroom at a special education school.

Response measurement and reliability. Observers used handheld computers to record the frequency of (a) targets, (b) precursors, and (c) therapist–client interactions during continuous 10-s intervals. One precursor, covering her eyes, was included in the precursor FA for Renee. Two precursors were included for Curtis (scratching his leg and blocking the therapist from moving). Four precursors were included for Gerald (flicking his lips, grimacing, hitting the therapist, and jerking his head). Although six precursors were identified for Adam, only five (slouching, saying "no," putting paper in his mouth, turning away from the therapist, and pushing materials away) were included in his precursor FA. Grimacing was excluded because he frequently turned his head away from observers. Six precursors were included for Donald (hand flapping, pressing his hand to his mouth, snarling, clapping his hands, vocalizing negatively, and moving toward objects), as well as for Leigh (covering her eyes, putting her chin down, saying "yeah yeah," guiding the therapist around the room, stomping or shuffling her feet, and moving her hands in circles by her side). Sixteen precursors were identified for Guy; however, only the eight that most strongly predicted the occurrence of the target behavior (flopping on the ground, swinging his body side to side, stomping his feet, biting objects, throwing objects, pushing materials away, crumpling paper, and cursing) were included in his precursor FA. Finally, 13 precursors were identified for Kevin, 12 of which were the most highly predictive of his target behavior and were included in his precursor FA (saying "no," grunting, dropping to or scooting on the floor, waving his arms in the air, pulling the therapist's arm, saying "good boy," holding his knees, smiling, fidgeting, stacking chairs, head butting the therapist, knocking on the table). The target problem behavior was the most severe form of behavior reported by caregivers during the initial interview or direct observation by the experimenters. Operational definitions of the target behaviors for each subject are listed in Table 1.

Interobserver agreement was assessed by having a second observer independently collect data during at least 25% of sessions. Proportional agreement percentages were calculated by comparing the two observers' recorded frequencies for all responses in each 10-s interval. The smaller number of responses was divided by the larger number of responses in each interval, and these fractions were averaged across all intervals. Mean reliability scores were as follows: Renee, 97% for targets (range, 94% to 100%), 98% for precursors (range, 91% to 100%), and 96% for therapist responses (range, 91% to 100%); Curtis, 99% for targets (range, 92% to 100%), 99% for precursors (range, 93% to 100%), and 99% for therapist responses (range, 92% to 100%); Gerald, 100% for targets, 99.8% for precursors (range, 99% to 100%), and 97% for therapist responses (range, 83% to 100%); Adam, 99.9% for targets (range, 99% to 100%), 99% for precursors (range, 89% to 100%), and 93% for therapist responses (range, 76% to 100%); Donald, 99.8% for targets (range, 98% to 100%), 99.6% for precursors

(range, 92% to 100%), and 98% for therapist responses (range, 90% to 100%); Leigh, 99% for targets (range, 90% to 100%), 98.7% for precursors (range, 89% to 100%), and 96% for therapist responses (range, 80% to 100%); Guy, 98% for targets (range, 86% to 100%), 99.9% for precursors (range, 98% to 100%), and 98% for therapist responses (range, 92% to 100%); and Kevin, 98% for targets (range, 90% to 100%), 99% for precursors (range, 88% to 100%), and 93% for therapist responses (range, 78% to 100%).

Procedure. FA procedures were similar to those described by Iwata et al. (1982/1994), and all sessions lasted 10 min. During the FA of precursors (FA 1), consequences were delivered for the occurrence of precursor behaviors but not for occurrences of the target behavior (which were ignored). During the FA of the target (FA 2), consequences were delivered for occurrences of the target behavior but not for occurrences of the precursor behaviors. Attention, play, and demand conditions were included in all FAs. An alone or ignore condition was included if the target behavior was not aggression, and a tangible condition was included if caregivers indicated that the subject tended to engage in problem behavior when preferred items were removed or access to preferred items was denied.

During attention sessions, the subject had access to two to three moderately preferred toys identified via a paired-stimulus (Fisher et al., 1992) or a multiple-stimulus (DeLeon & Iwata, 1996) preference assessment. At the start of session, the therapist told the subject, "I have some work to do, but you can play with these toys, if you'd like." The therapist then sat next to but did not interact with the subject. Contingent on each occurrence a precursor (FA 1) or target (FA 2) behavior, the therapist delivered a brief reprimand (e.g., "Stop doing that; that's not nice!") and gentle physical contact (e.g., placed a hand on the subject's arm).

During play sessions, the subject had access to two to three highly preferred toys (identified in the preference assessment), and the therapist interacted with him or her at least every 30 s or any time the subject initiated interaction. No consequences were delivered following occurrences of either precursor or target behaviors.

During demand sessions, the therapist continuously presented learning trials appropriate to the subject's functioning level using a three-step prompting sequence and delivered brief praise following compliance. Contingent on each instance of a precursor (FA 1) or target (FA 2) behavior, the therapist removed the work materials and provided a 30-s break from the task. If an alone or ignore condition was included in the FA, it was conducted before the attention condition. During alone sessions, the subject was seated alone in a room without any materials. If an ignore condition was conducted, the subject was seated in an area of the room away from all other individuals, and no consequences were delivered contingent on any behaviors emitted.

If a tangible condition was included in the FA, it was conducted following the play condition. At the start of the session, the therapist removed all toys and remained near the subject. If the subject initiated interaction during this condition, the therapist briefly responded (e.g., quickly answered a question) and then terminated interactions (e.g., "We can talk later."). Contingent on the occurrence of a precursor (FA 1) or target (FA 2) behavior, the therapist provided access to the toys for 30 s.

Results and Discussion

Figure 5 shows results of the precursor and target FAs, which yielded matched outcomes for seven of the eight subjects; for the remaining subject (Leigh), precursors were maintained by one of two sources of reinforcement that maintained the target behavior. It was expected that patterns of responding would generally conform to the reinforcement contingencies such that (a) elevated rates of precursors and low rates of the target behavior would occur in the

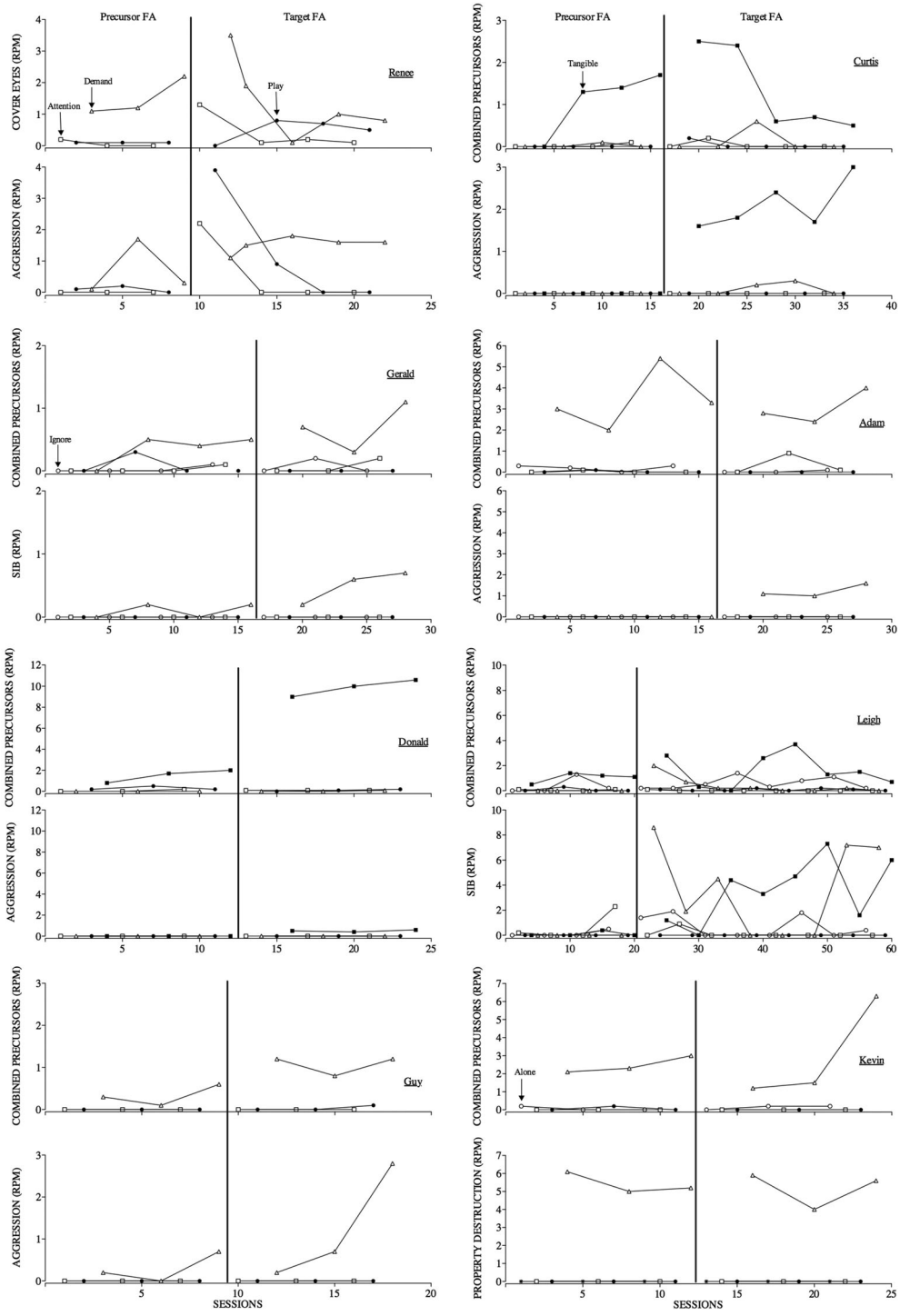

Figure 5. Results of the independent FAs conducted in Study 2. The top and bottom graphs for each subject show rates of the precursor and target behaviors, respectively. The left panel of each pair of graphs shows results of the FA of precursors; the right panel shows results of the FA of the target problem behavior.

precursor FA and (b) elevated rates of the target behavior would occur in the target FA. In general, observed patterns of responding during both FAs conformed to these predictions. More specifically, the precursor FA eliminated instances of the target behavior for three subjects (Curtis, Adam, and Donald), resulted in low rates of the target behavior for four subjects (Renee, Gerald, Leigh, and Guy), and had no effect on rates of the target behavior for one subject (Kevin).

Renee (Figure 5) engaged in higher rates of eye covering during the demand condition of her precursor FA (a higher rate of aggression also was observed in this condition, although the rate of aggression was lower than the rate of eye covering). During her target FA, aggression was maintained only in the demand condition, and Renee continued to engage in eye covering in the demand condition, as well as during the play condition. Thus, eye covering and aggression were maintained by negative reinforcement (escape from academic tasks).

Curtis (Figure 5) engaged in higher rates of precursors in the tangible condition of his precursor FA (zero instances of aggression were observed). During his target FA, he engaged in higher rates of aggression in the tangible condition (decreasing rates of precursors also were observed). Thus, precursors and aggression were maintained by positive reinforcement (access to preferred leisure items).

Gerald (Figure 5) engaged in higher rates of precursors in the demand condition of his precursor FA (SIB was observed during two demand sessions). During his target FA, he engaged in higher rates of SIB (as well as precursors) in the demand condition. These results indicate that precursors and SIB were maintained by negative reinforcement (escape from academic tasks).

Adam (Figure 5) engaged in higher rates of precursors during the demand condition of his precursor FA (aggression never was observed). During his target FA, he engaged in higher rates of aggression (and precursors) in the demand condition. These results indicate that precursors and aggression were maintained by negative reinforcement (escape from academic tasks).

Donald (Figure 5) engaged in higher rates of precursors in the tangible condition of his precursor FA (aggression never was observed). During the target FA, he engaged in higher rates of aggression (and precursors) in the tangible condition. These results indicate that precursors and aggression were maintained by positive reinforcement (access to preferred leisure items).

Leigh (Figure 5) engaged in higher rates of precursors in the tangible condition of her precursor FA (a higher rate of aggression was observed in one attention session). During the target FA, she engaged in high rates of SIB in the tangible and demand conditions (precursors also occurred initially during these conditions, but were not maintained in the demand condition). Thus, results indicated that precursors were maintained by positive reinforcement (access to preferred items), whereas SIB was maintained by both positive reinforcement (access to preferred items) and negative reinforcement (escape from academic tasks).

Guy (Figure 5) engaged in higher rates of precursors in the demand condition of his precursor FA (somewhat lower rates of aggression also were observed). During the target FA, he engaged in higher rates of aggression (and precursors) in the demand condition. These results indicate that precursors and aggression were maintained by negative reinforcement (escape from academic tasks).

Finally, Kevin (Figure 5) engaged in higher rates of precursors in the demand condition of his precursor FA (and even higher rates of property destruction). During the target FA, he engaged in higher rates of property destruction (and precursors) during the demand condition. These results indicate that precursors and property destruction were maintained by negative reinforcement (escape from academic tasks); however, the FA of precursors was not effective in reducing rates of his target behavior.

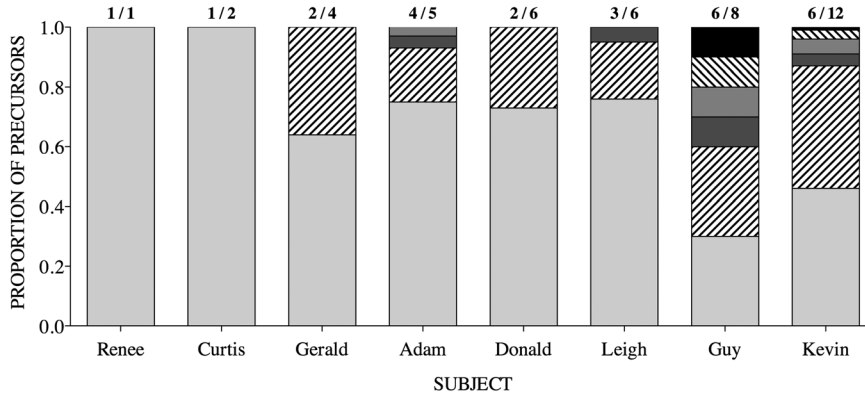

Figure 6. Proportional distribution of precursor responses observed during the FA of precursors (each section of a bar graph represents a different precursor). Numbers above each bar show the number of precursors observed out of the total number of selected precursors for each subject.

It is interesting to note that not all of the selected precursors actually occurred during the precursor FAs, except for Renee, who engaged in only one precursor. Figure 6 shows the proportions of identified precursors that were observed during the precursor FA for each subject. Curtis blocked the therapist only during his precursor FA; he never engaged in leg scratching. Gerald engaged in only two of four precursors (grimacing and head movements); lip flicking and hitting others were never observed during either FA. Adam engaged in four of five precursors (saying "no," turning away, slouching, pushing materials away); putting paper in his mouth was never observed. Donald engaged in two of six precursors (negative vocalizations and reaching for objects); a third, snarling, emerged only during the tangible condition of his target FA. Flapping and clapping his hands were observed once each in the first tangible session of his target FA, and all other instances of clapping were observed in the play condition of both FAs. Leigh engaged in three of six precursors (hand circles, chin down, and covering her eyes) during her precursor FA. Stomping or shuffling her feet occurred only during a few sessions of the target FA, and two other precursors (guiding the therapist and saying "yeah yeah") never occurred. Guy engaged in six of eight precursors (biting objects, pushing materials away, cursing, body swinging, throwing objects, and stomping); crumpling paper was never observed during either FA, and flopping emerged in the last demand session of his target FA. Kevin engaged in six of 12 precursors (saying "no," grunting, arm waving, table knocking, fidgeting with pants, and placing his hands on his knees). Five precursors (saying "good boy," smiling, stacking chairs, pulling the therapist's arm, and head butting) never were observed in the demand condition of either FA, and dropping or scooting on the floor emerged in the demand condition of his target FA.

The function of unobserved precursors remains unknown, and it is possible that either (a) the precursor assessment simply yields some false alarms or (b) these behaviors were maintained by the same source of reinforcement as the target behavior but were not observed because other precursors contacted the reinforcement contingency and were maintained. In addition, some precursors emerged in the same condition as the target during four subjects' target FAs, providing some evidence that those precursor topographies

might be maintained by the same source of reinforcement as the target and emerged as a function of extinction of other precursors. Additional analyses would be required, however, to verify this possibility, which was beyond the scope of the present study.

The comparison of precursors reported by caregivers and those identified by the precursor assessment conducted in Study 1 indicated that caregivers only reported 10 of 90 precursors identified by the precursor assessment (approximately 11%). Because a number of precursors identified by the precursor assessment were not observed during the FAs in Study 2, it was possible that precursors reported by caregivers might have been the ones actually observed in the FAs. Therefore, precursors reported by caregivers and those actually observed during the FAs were compared, and results showed that caregivers reported 7 of 31 precursors that were observed during the FAs (approximately 23%). Thus, more than 75% of the precursors observed during FAs were different than those identified by caregivers.

STUDY 3: PRECURSOR ASSESSMENT AS THE BASIS FOR INTERVENTION

Given that the precursor assessment was effective in identifying precursors for all subjects (Study 1) and that these behaviors typically were maintained by the same sources of reinforcement as the severe problem behavior (Study 2), a combined precursor assessment and precursor FA seemed to be a promising basis for making conclusions about the function of severe problem behavior while minimizing risk. The purpose of Study 3 was to determine whether an effective treatment could be designed based on results of precursor assessments alone while (a) obtaining indirect evidence regarding the function of severe problem behavior (i.e., the target behavior) and (b) maintaining low rates of the target behavior throughout assessment and treatment. In general, treatment consisted of a sequence beginning with continuous NCR, in which the reinforcer was identified from a precursor FA. Subsequently, the NCR schedule was thinned, and DRA was introduced for an alternative behavior that served the same function as the precursor behaviors.

Method

Subjects and setting. Because the intervention strategy consisted of sequential introduction of social reinforcers (noncontingent followed by contingent), only individuals whose precursor FA suggested that the behaviors were maintained by social reinforcement were included. Two individuals from Study 1 who engaged in severe problem behavior, who had not participated in Study 2, and who were not participating in other projects, participated in Study 3 (Amanda and Sammy). Three other individuals exhibited behavior that appeared to be maintained by automatic reinforcement and, thus, were not included. All sessions were conducted in a classroom at a special education school.

Response measurement and reliability. Table 1 shows operational definitions of target behaviors. Amanda's precursors included a hand posture (placing her elbow on the table with her wrist bent), stretching (leaning back in her chair with her arms stretched above her head), and reaching for the therapist. The response selected to be strengthened as an appropriate, alternative form of communication for reinforcement (mand) was signing "food," which was already in her repertoire and was shown to be predictive of SIB during the precursor assessment (Figure 1).

Sammy's precursors included tugging on the experimenter's shirt, mouth movements (opening and closing his mouth without making noise), climbing on furniture, running across the room, throwing or pushing furniture, and angry vocalizations (growling or guttural sounds) (Figure 2). The responses selected to be strengthened as appropriate, alternative forms of communication for reinforcement were signing "break" (during treatment for behavior maintained by negative

reinforcement) or signing "play" (during treatment for behavior maintained by positive reinforcement).

Methods used for collecting data and assessing interobserver agreement were the same as those used in Study 1 for the precursor assessment and Study 2 for the precursor FA and treatment. Interobserver agreement was assessed during at least 25% of sessions in each condition of the precursor FA and in each condition of treatment for both subjects.

During the precursor FA, mean interobserver agreement scores for Amanda were 99% for precursors (range, 92% to 100%) and 99% for SIB (range, 94% to 100%). Mean agreement scores for Sammy were 99% for precursors (range, 88% to 100%) and 98% for aggression (range, 90% to 100%). During treatment, mean interobserver agreement scores for Amanda were 98% for precursors (range, 80% to 100%), 98% for SIB (range, 92% to 100%), and 99% for mands (range, 80% to 100%). During treatment for Sammy's behaviors maintained by negative reinforcement, mean interobserver agreement scores were 98% for precursors (range, 75% to 100%), 97% for aggression (range, 81% to 100%), and 97% for mands (range, 85% to 100%). During treatment for Sammy's behaviors maintained by positive reinforcement, mean interobserver agreement scores were 99% for precursors (range, 95% to 100%), 100% for aggression, and 98% for mands (range, 93% to 100%).

Procedure. Precursors identified in Study 1 for each subject were included in a precursor FA in which consequences were delivered following precursors only (no consequences were provided after the target behavior). Conditions of the FA were the same as described in Study 2 and consisted of attention, demand, play, and tangible sessions. An ignore condition also was included for Amanda to rule out the possibility that SIB was maintained by automatic reinforcement.

Given the results of Study 2 that showed the function of precursor and target behaviors typically match, treatment was based on the results of the precursor FA only (the function of the target behavior was inferred from response patterns during this assessment) to determine the extent to which precursors were reduced and the target behavior was suppressed as reinforcement contingencies changed. An FA of the target behavior was not conducted to more closely approximate clinical conditions in which it is undesirable to place reinforcement contingencies on the target behavior. Treatment consisted of baseline, continuous NCR, and NCR schedule thinning plus DRA. All sessions lasted 10 min.

Baseline. Sessions were identical to the condition of the precursor FA in which the highest rates of precursors were observed. These were the tangible (Amanda and Sammy) and demand (Sammy) conditions. Consequences were delivered following precursors only (a small piece of food for Amanda, 30-s escape from academic tasks for Sammy in the first treatment, or 30-s access to toys for Sammy in the second treatment). No consequences were delivered following either target or appropriate behavior.

Continuous NCR. The reinforcer shown to maintain precursors during the precursor FA was delivered freely and noncontingently throughout each session. No consequences were delivered following precursors, the target behavior, or appropriate behavior in this condition. During treatment for behaviors maintained by positive reinforcement, subjects had continuous access to highly preferred food (Amanda) or leisure items (Sammy). During treatment for behavior maintained by negative reinforcement, no demands were placed on Sammy throughout session.

NCR schedule thinning plus DRA. After low and stable rates of precursor and target behavior had been observed under continuous NCR, the NCR schedule was thinned by removing one 10-s interval of NCR per minute using procedures similar to those described by Goh et al. (2000). When precursors were observed at rates less than 80% of baseline rates and rates of the target

behavior were low, schedule thinning progressed by removing another 10-s interval of NCR per minute. At the start of this condition, DRA was implemented during intervals in which NCR was not provided by physically prompting the subject to emit the sign for the relevant reinforcer. Initially, the subject was prompted immediately to sign for the reinforcer. A progressive prompt delay then was used (i.e., the prompt was delayed approximately two additional seconds each time the reinforcer was not available) to systematically delay the physical prompt and allow the subject to sign for the reinforcer independently. Prompts were discontinued when he or she began to exhibit the sign consistently. Contingent on signing (independent or prompted), the reinforcer was delivered. No consequences were delivered following precursor or target behaviors. Eventually, the NCR component was removed for both subjects as signing persisted at consistent rates. Additional treatment components were implemented as needed and are described in the results section for each subject to clarify the rationale for their inclusion.

Results and Discussion

Figure 7 shows results of Amanda's and Sammy's precursor FAs. Amanda's precursors were maintained by positive reinforcement in the form of access to tangible items (preferred foods). Amanda also engaged in SIB at increasing rates in the tangible condition, even though no consequences were delivered for this behavior, suggesting that her target behavior was likely maintained by the same source of reinforcement as precursors. Results of Sammy's FA showed that his precursors were maintained by both positive reinforcement (access to preferred leisure items) and negative reinforcement (escape from demands). In addition, he engaged in increasing rates of aggression in the demand condition, suggesting that this behavior also was maintained by negative reinforcement. He engaged in high rates of aggression during the first session of the

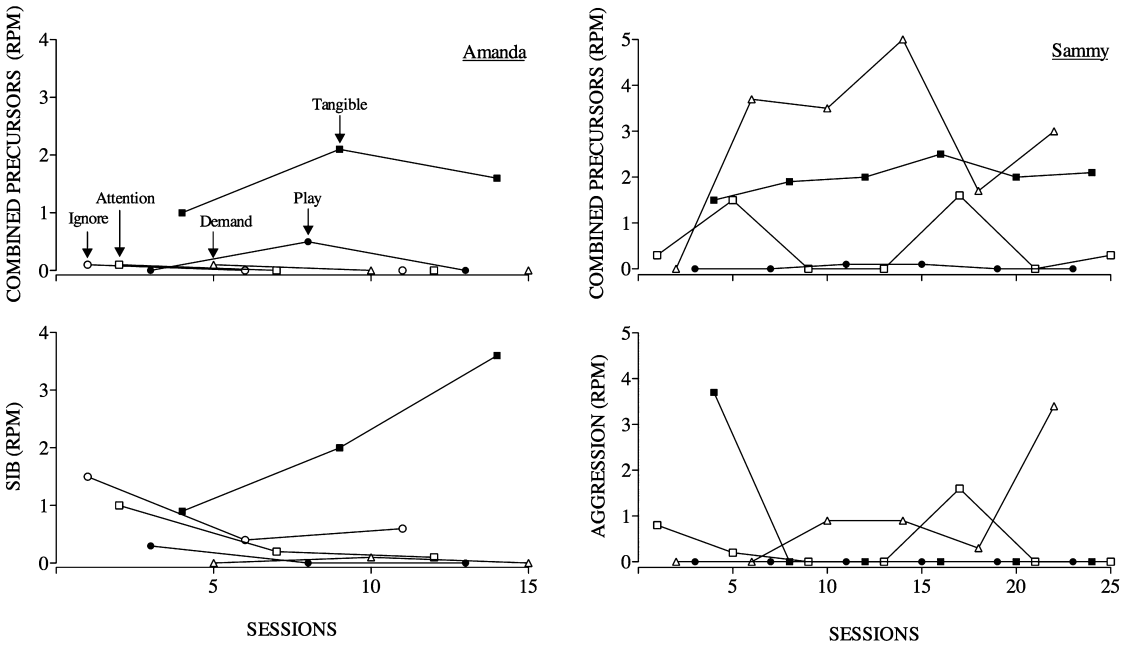

Figure 7. Results of the precursor FA for Amanda and Sammy.

tangible condition only, which appeared to be an extinction burst (perhaps as a result of his recent reinforcement history, albeit brief, for the target behavior in the precursor assessment). After he engaged in precursor behaviors that contacted the reinforcement contingency, these behaviors persisted and aggression no longer occurred. These results provide indirect evidence that the identified function of precursors likely matched the function of his target behavior.

As in Study 2, not all precursors identified via the trial-based assessment were observed during the precursor FA in Study 3. The function of Amanda's precursors was determined primarily by the occurrence of reaching (hand postures and stretching rarely occurred). The negative reinforcement function of Sammy's precursors was determined by the occurrence of climbing, angry vocalizations, mouth movements, and moving furniture; the positive reinforcement function was determined solely by the occurrence of angry vocalizations. Two of Sammy's precursors (running across the room and tugging on the therapist's shirt) were never observed, even though results of the precursor assessment indicated that tugging on the therapist's shirt was the most highly predictive of aggression.

During treatment (Figure 8), Amanda engaged in high rates of precursors ($M = 3.1$ responses per minute) during baseline. She also engaged in moderate rates of SIB ($M = 1.1$) and low rates of mands ($M = 0.2$), even though no consequences were provided for these behaviors. When continuous NCR was implemented, she did not exhibit any precursors, and rates of SIB and mands were low (Ms $= 0.1$ and 0.3, respectively). During NCR schedule thinning plus DRA, she engaged in variable and increasing rates of precursors ($M = 1.1$), SIB ($M = 0.2$), and independent mands ($M = 1.6$). It appeared that a response hierarchy was developing in which Amanda engaged in precursors (and sometimes SIB) followed shortly by independent mands. Therefore, it seemed possible that precursors and SIB might have been adventitiously reinforced as a result of their close temporal contiguity with the delivery of reinforcement for mands. Other factors might have accounted for the development of this particular sequence, including the presumably low effort necessary to engage in precursors (primarily reaching toward the therapist), a recent history of reinforcement for precursors during baseline, and possibly a recent history of reinforcement for SIB outside the experimental setting. Therefore, response blocking for precursors was added to disrupt the response sequence (blocked responses were scored and included in the session rate). This intervention resulted in decreasing rates of precursors ($M = 0.7$ responses per minute), near-zero rates of SIB ($M = 0.03$), and increased rates of independent mands ($M = 3$). Next, a reversal to baseline was conducted and resulted in increased rates of precursors ($M = 3$), low rates of SIB ($M = 0.3$), and variable rates of mands ($M = 2$). A return to NCR thinning plus DRA and response blocking resulted in decreasing rates of precursors ($M = 0.4$), zero rates of SIB, and high rates of independent mands ($M = 4$). By the end of this phase, Amanda was engaging primarily in independent mands, which seemed to preclude the need for NCR and response blocking. Therefore, DRA alone was evaluated and resulted in low rates of precursors ($M = 0.1$) and a rate of independent mands similar to that observed in the preceding phase ($M = 4.1$). Although SIB increased slightly compared to the previous condition ($M = 0.2$), SIB was reduced by more than 80% compared to baseline and occurred at near-zero rates during most sessions.

Two treatments were evaluated for Sammy. During his baseline for behavior maintained by negative reinforcement (Figure 9), he engaged in moderate rates of precursors ($M = 3.1$ responses per minute), low rates of aggression ($M = 0.4$), and low rates of independent mands ($M = 0.1$). When continuous NCR was implemented, he engaged in low rates of precursors ($M = 0.3$), near-zero rates of aggression ($M = 0.03$), and

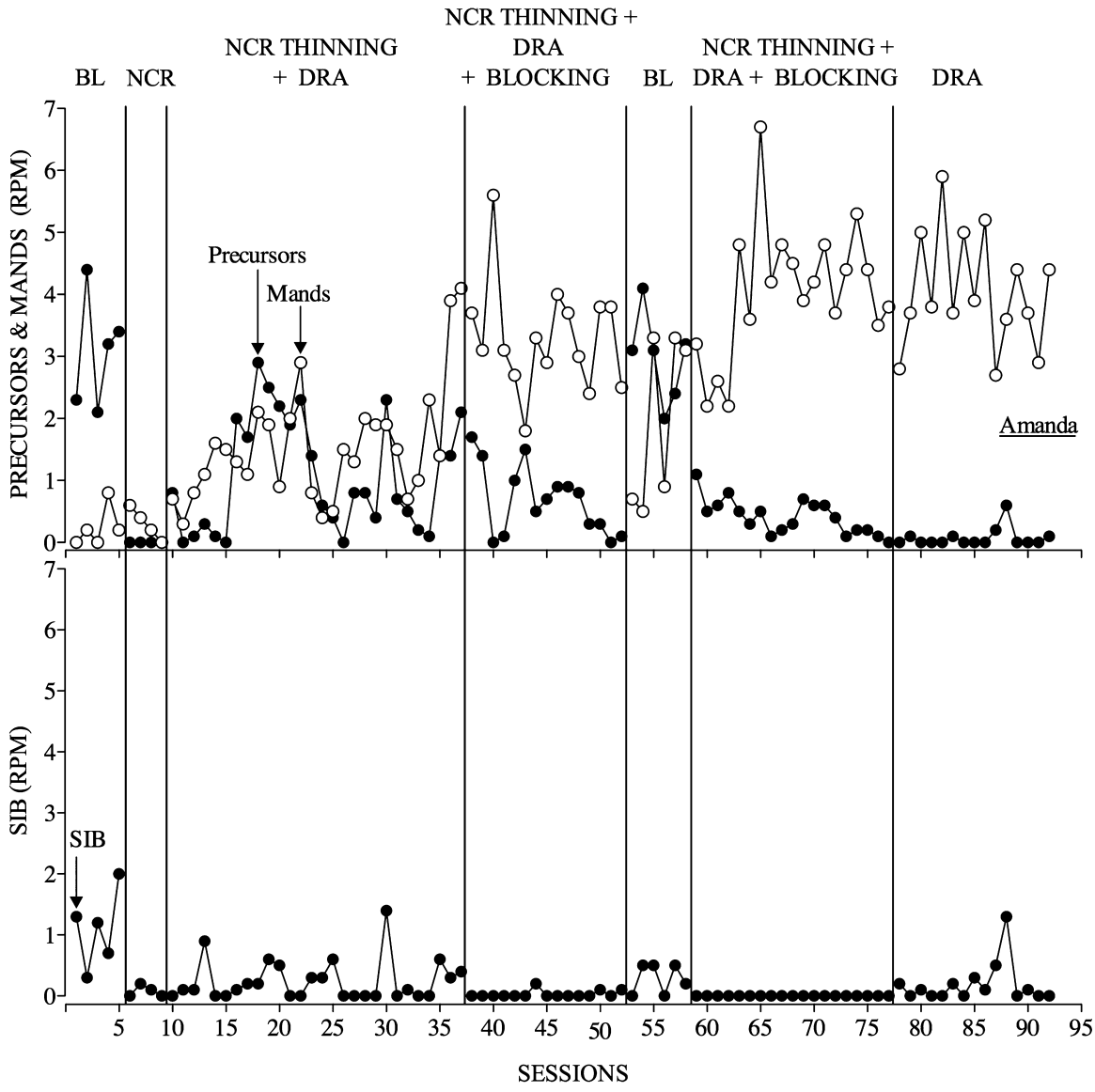

Figure 8. Treatment results for Amanda.

zero independent mands. During NCR schedule thinning plus DRA, he engaged in variable rates of precursors ($M = 1.6$), variable and increasing rates of aggression ($M = 0.8$), and increasing rates of independent mands ($M = 1.2$). Like Amanda, it seemed that Sammy engaged in precursors as the experimenter approached to deliver a demand and, when escape was not provided for the precursors, he engaged in an independent mand (or sometimes aggression). Therefore, a changeover delay (COD) was added in which independent mands were prevented immediately following a precursor, and he was physically guided to complete the task. When he had not engaged in a precursor behavior for 5 s, he was permitted to mand for escape, and a 30-s

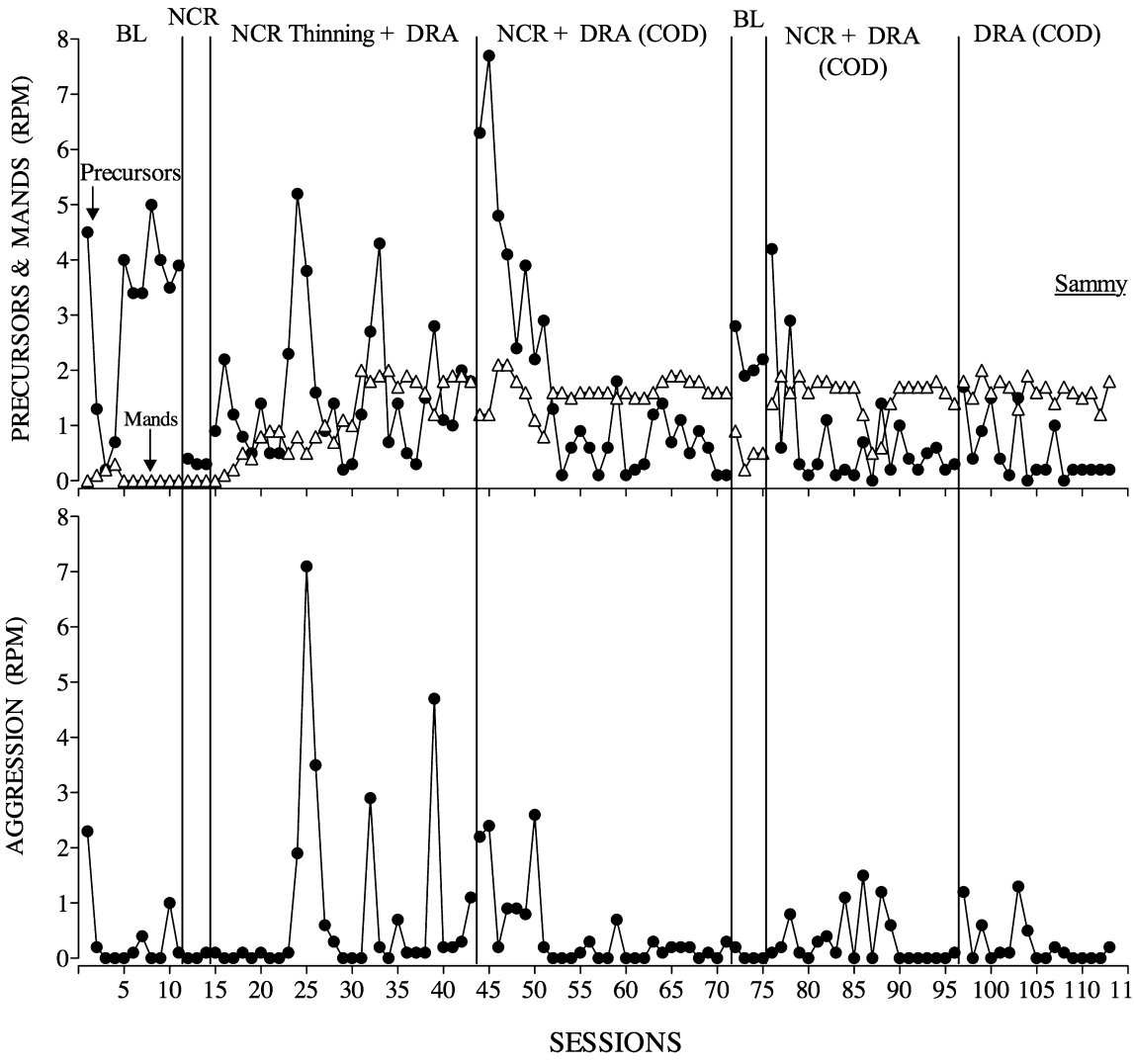

Figure 9. Treatment of behavior maintained by negative reinforcement for Sammy.

break was provided. This resulted in an initial burst in precursors, which decreased over subsequent sessions ($M = 1.7$ responses per minute), decreasing rates of aggression ($M = 0.5$), and steady rates of independent mands ($M = 1.6$). A reversal to baseline then was conducted, in which rates of precursors increased ($M = 2.2$), and rates of aggression ($M = 0.1$) and mands ($M = 0.5$) were low. NCR thinning plus DRA with the COD again was implemented and resulted in decreasing rates of precursors ($M = 0.7$), low rates of aggression ($M = 0.3$), and increased rates of mands ($M = 1.5$). By the end of the condition, NCR seemed unnecessary and, thus, was removed in the final phase. DRA plus the COD alone resulted in decreasing rates of precursors to near zero ($M = 0.5$), near-zero rates of aggression ($M = 0.3$), and steady rates of independent mands ($M = 1.6$).

During Sammy's treatment for behavior maintained by positive reinforcement (access to preferred leisure items), he engaged in moderate

rates of precursors during baseline ($M = 2.1$ responses per minute), near-zero rates of aggression ($M = 0.03$), and zero independent mands (Figure 10). During continuous NCR, he engaged in near-zero rates of precursors ($M = 0.2$) and zero instances of aggression and mands. When NCR schedule thinning plus DRA was implemented, he engaged in decreasing rates of precursors ($M = 0.3$), near-zero rates of aggression ($M = 0.01$), and increasing rates of independent mands ($M = 1.3$). A return to baseline resulted in increasing rates of precursors ($M = 1.6$), near-zero rates of aggression ($M = 0.03$), and decreasing rates of mands ($M = 0.6$). When NCR schedule thinning plus DRA was again implemented, precursors decreased ($M = 0.8$), aggression occurred at higher rates during the first session but remained at zero for all subsequent sessions

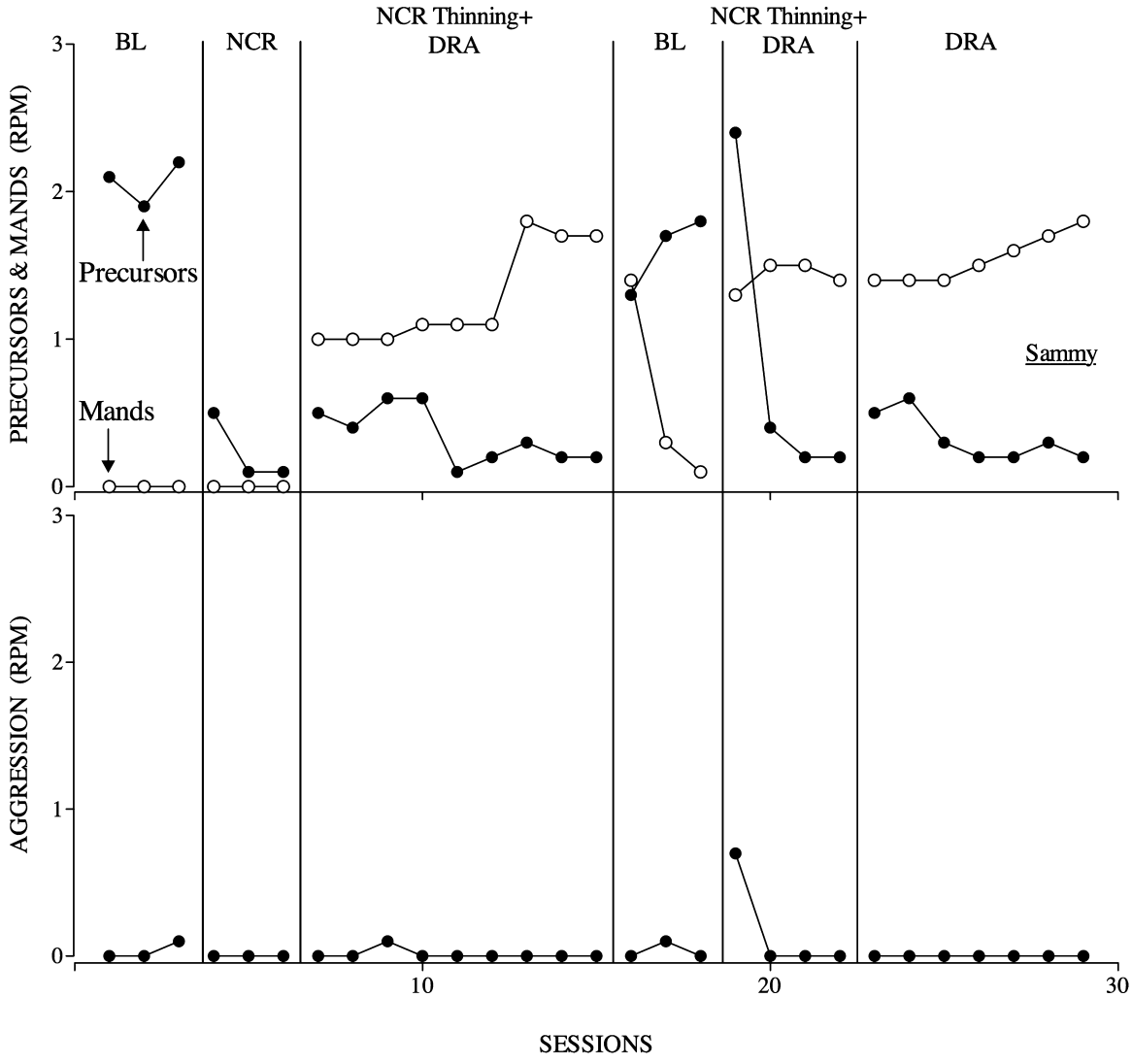

Figure 10. Treatment of behavior maintained by positive reinforcement for Sammy.

($M = 0.2$), and moderate rates of mands were observed ($M = 1.4$). The NCR component was removed in the final phase, and Sammy engaged in decreasing rates of precursors ($M = 0.3$), zero rates of aggression, and increasing rates of mands ($M = 1.5$).

GENERAL DISCUSSION

We examined the relation between precursor and problem behavior in three stages: empirical identification and selection of precursor responses (Study 1), FAs of precursor and problem behavior (Study 2), and evaluation of treatment based on the FA of precursor behavior (Study 3). Taken together, results indicated that precursor behaviors are both common and readily identifiable, they often are maintained by the same source of reinforcement as problem behavior, and they may be used as the basis for developing effective interventions.

Study 1 evaluated an objective yet brief method for identifying precursors to problem behavior, and results of the assessment indicated that all 16 subjects engaged in at least one precursor. In addition, the assessment required very few instances (10 or fewer) of the severe problem behavior to identify precursors; thus, it seems to be a viable method of assessing severe problem behavior while risk is minimized. The fact that problem behavior often is preceded by precursors suggests that problem behavior may simply be the terminal response in a hierarchy that begins with mildly disruptive behaviors (e.g., negative vocalizations, pushing materials away, etc.) or appropriate behaviors that are not reinforced (e.g., saying "no" or signing "food"). If so, it is somewhat surprising that caregivers rarely were able to identify precursors. In fact, caregivers for only six subjects were able to report potential precursors, and the reported precursors matched the behaviors identified by the precursor assessment in only 11% of cases. When the precursors reported by caregivers were compared to those actually observed during the FAs in Study 2, correspondence only increased to 23%. It is possible that caregivers are not as attentive when problem behaviors do not occur and miss the occurrence of precursors. These behaviors still might acquire the same function as problem behavior if precursors typically are followed by problem behavior that contacts reinforcement (Catania, 1971). However, caregivers might not be able to identify these behaviors readily as precursors because they may be subtle and do not necessarily resemble the target behavior topographically. Alternatively, caregivers might reinforce precursors intermittently, causing them to persist, or precursors and problem behavior might consist of a response chain that is reinforced as a larger unit.

Our trial-based method for identifying precursor behavior also poses some limitations. First, the procedure may not be practical for very low-rate problem behavior because the duration of trials (5 min) may be too brief to evoke the target behavior. Wallace and Iwata (1999) compared results from FA sessions based on 5-, 10-, and 15-min durations and found that some individuals did not engage in the target behavior until conditions had been in effect longer than 5 min. In fact, precursor assessments could not be completed for three potential subjects in the present study because their problem behavior occurred rarely; their behavior subsequently was assessed during FAs with extended session durations. The assessment also might not be useful for very high-rate problem behavior because short interresponse times of the target behavior would reduce the likelihood of observing other behaviors that could be identified as precursors. This problem was encountered with Amy, but the inclusion of play trials was sufficient to produce periods of time in which the target behavior was not observed in order to calculate the probability of the precursor given the absence of the target behavior.

Results of Study 2 verified that responses selected from the precursor assessment were maintained by the same source of reinforcement

as the target behavior for seven of eight subjects (precursor and target behaviors matched for one of two functions for Leigh). In addition, the precursor FAs eliminated the occurrence of the severe problem behavior for three subjects and reduced rates of the severe problem behavior for four other subjects. These findings provide some evidence of generality for the data reported by Smith and Churchill (2002) and validate a combined precursor assessment and precursor FA as a viable method for identifying contingencies that maintain severe problem behavior.

It is unclear why the precursor FA did not result in reduced rates of the target behavior for three subjects (Kevin in Study 2 and Amanda and Sammy in Study 3). It is possible that the precursors identified for these subjects were part of a response chain; however, evaluation of this possibility was beyond the scope of the current study. Future research might identify strategies to determine why problem behavior persists during the precursor FA for some individuals.

Because not all precursors were actually observed for each subject during the precursor FA, it is unclear whether the unobserved precursors were maintained by the same source of reinforcement as the target behavior. One possibility is that subjects simply allocated responding toward topographies that initially contacted the reinforcement contingency, whereas other precursors were extinguished but remained functional nevertheless. Evidence of this can be seen in cases in which previously unobserved precursors emerged in the same condition as the target behavior during the target FA. Previous research has shown that extinction of frequently observed response topographies of problem behavior resulted in increased rates of other topographies (Magee & Ellis, 2000; Richman, Wacker, Asmus, Casey, & Andelman, 1999), and similar effects have been shown with adaptive behavior (Grow, Kelley, Roane, & Shillingsburg, 2008). Thus, it is possible that selective extinction of observed precursors might have clarified the results of the current study; however, because the function of observed precursors matched the function of the target behavior in almost all cases, additional analyses seemed unnecessary.

Another potential determinant of subjects' allocation toward particular precursor behaviors is the relative response effort required to emit them. In fact, many of the identified precursors (e.g., negative vocalizations) did not appear to require much effort. In a review of research on precursor behavior, Fahmie and Iwata (2011) found that the most commonly reported precursors were unintelligible vocalizations, which are relatively easy to emit.

An alternative explanation for unobserved response topographies during the precursor FA is that the current methodology simply yields some number of false alarms. The criterion for including a potential precursor in the probability analyses was simply its occurrence within a trial, and interpretations were based on conditional and unconditional probabilities for each potential precursor. This method was used because it seemed to be a simple and conservative method for identifying responses that preceded and were correlated with the target behavior, but it might have resulted in the selection of precursors that did not occur frequently before the target behavior or occurred only at the beginning of trials (i.e., temporally distant from problem behavior and possibly influenced by different EOs). In addition, the precursor assessment was terminated after 10 trials in which the target behavior was observed; therefore, a high rate of false alarms might have resulted as a function of the brevity of the assessment. No attempt was made to standardize the number of 5-min trials in which the target behavior was not observed for most subjects, except for Amy, who engaged in property destruction during the first 10 trials of the assessment. Coincidentally, however, the total duration of trials without the target behavior was nearly equal to or greater than the total duration of trials with the target behavior for all subjects. It is possible that modifications to the methods of

data analysis or precursor selection criteria might have led to better predictions with respect to which responses are likely maintained by the same source of reinforcement as the target behavior; however, those analyses were beyond the scope of the present study. Future research might evaluate different precursor selection or assessment-termination criteria in an attempt to clarify these results.

It also is important to note that only half the relation between precursors and the target behavior was examined in the current study by determining the function of responses that were predictive of the target behavior. That is, the function of responses that were not predictive of the target behavior remains unknown. It is possible that any behavior that occurs frequently enough to contact the reinforcement contingencies might be maintained and acquire the same function as the target behavior even though it typically might not be predictive of the target behavior. Renee's data most closely approximate this possibility in that only one precursor to aggression was identified, and it did not appear to predict the occurrence of the target behavior. Results of independent FAs, however, showed that both behaviors were maintained by the same source of reinforcement. Future research might provide a more comprehensive account of the relation of precursors to severe problem behavior by comparing the results of FAs of behaviors that do not predict the target behavior to the results of an FA of the target behavior to determine the extent to which these nonpredictive behaviors are maintained by the same or different sources of reinforcement.

Finally, it is highly unlikely that a precursor FA would be effective in reducing instances of a target behavior that is maintained by automatic reinforcement because arranging social consequences for precursors would not be expected to affect the rate of the target behavior. This would not, however, necessarily preclude the development of an effective treatment for behavior maintained by automatic reinforcement based on the results of precursor assessments. For example, Hagopian et al. (2005) designed treatment following an assessment of precursors by blocking stereotypy (hand flapping) that predicted the occurrence of SIB (eye poking) for one individual. SIB was maintained by automatic reinforcement, and blocking the precursor (stereotypy) was shown to be more effective in reducing both stereotypy and SIB than blocking SIB alone. Their results suggest that precursor analyses per se may have some clinical utility regardless of the function of problem behavior, even if rates of the target behavior do not decrease during assessment. Future research might examine the extent to which (a) precursors can be identified for problem behavior maintained by automatic reinforcement and (b) identification of precursors in this situation leads to more effective treatment.

Results of Study 3 showed that effective interventions can be designed based on the results of precursor analyses. Although severe problem behavior was not eliminated during baseline for these subjects, lower rates of the target behavior were observed relative to rates of precursors. Therefore, had target behaviors been reinforced during baseline, it is probable that higher rates would have been exhibited by both subjects.

The effects of continuous NCR replicated the results of previous studies (Goh et al., 2000; Marcus & Vollmer, 1996) in that nearly all responding (precursor and target behavior) was suppressed under these conditions, and subjects did not emit the appropriate alternative response (mand). As the DRA component was introduced while the NCR schedule was thinned, both subjects increased their manding; however, these procedures were not effective in reducing precursors while maintaining low rates of the target behavior in two of three cases. The addition of response blocking (Amanda) or a COD (Sammy, treatment for behavior maintained by negative reinforcement) was effective in reducing rates of precursors and target behaviors, while mands were maintained under the DRA contingency. When low rates of precursors and target

behaviors were attained, the additional treatment components (NCR and blocking for Amanda and NCR for Sammy) were removed, and similar effects on all behaviors were observed. (The COD component remained in Sammy's final treatment package due to the severity of his aggression, although it was rarely implemented during the final sessions of treatment.) Therefore, both subjects allocated responding toward mands under conditions that would typically be encountered in their classrooms (i.e., Amanda could sign to receive food, and Sammy could sign to receive a break from work). It is also interesting to note that no additional treatment components were necessary to reduce Sammy's precursors and maintain low rates of the target behavior during his second intervention for behavior maintained by positive reinforcement. In fact, his second evaluation was completed in approximately a a quarter of the number of sessions required to complete his first evaluation, raising the possibility that simultaneous intervention for both functions of his problem behavior might have produced reductions in his behavior more quickly. For example, arranging DRA in which completion of tasks resulted in a break from work and access to preferred items might have been a more efficient treatment strategy.

In summary, the current studies illustrate a method for identifying precursor behavior and for progressing from assessment to treatment of severe problem behavior while minimizing risks posed by those behaviors. In particular, Study 1 provided an objective, empirical method for identifying precursor behavior, which yielded more accurate information than that provided by caregivers, and showed that precursor behavior might be a common phenomenon. Results of Study 2 verified that the function of identified precursors very often was the same as the function of severe problem behavior. Finally, the sequential introduction of NCR and NCR schedule thinning plus DRA appears to be a viable treatment option for shifting response allocation from problem behavior to appropriate behavior.

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