IDENTIFYING POSSIBLE CONTINGENCIES DURING DESCRIPTIVE ANALYSES OF SEVERE BEHAVIOR DISORDERS

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Contingencies of reinforcement involve, in part, relations between behavior and subsequent environmental events. In this study we observed 11 individuals with developmental disabilities and severe behavior problems while they interacted with their primary care providers in simulated environments (hospital therapy rooms). We compared the probability of obtaining attention, escape from instructional demands, or access to materials following instances of problem behavior with the background probability of those events. However, the focus of our analysis was the evaluation of comparative probabilities ("contingency values") in the context of relevant establishing operations such as diverted attention, instructional demands, and restricted access to materials. Results showed that the method was useful in identifying relations between behavior and subsequent environmental events. Implications for linking descriptive and functional analyses are discussed, and difficulties in identifying naturally occurring contingencies are considered.

DESCRIPTORS: developmental disabilities, descriptive analysis, severe behavior disorders, contingency

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The discovery that severe behavior problems are sensitive to contingencies of reinforcement represented a watershed in the field of applied behavior analysis (e.g., Carr, 1977; Iwata, Dorsey, Slifer, Bauman, & Richman, 1982/1994). Previously, self-injury and aggression were often viewed as counterintuitive and inexplicable. Behavior modification approaches such as punishment and differential reinforcement were sometimes

successful in reducing problem behavior, but typical interventions provided no evidence of why the behavior occurred (Mace, 1994). Functional analysis changed this view, because cause–effect relations between behavior and consequent events could be established during an assessment.

Identifying reinforcement contingencies in an assessment provides useful information about the nature of a problem behavior and provides a direct link between assessment and treatment. For example, if a functional analysis shows that self-injurious behavior (SIB) is reinforced by social attention, then extinction of SIB and reinforcement of an alternative behavior are logical treatment components (Vollmer & Iwata, 1992). The information derived from the assessment can

be used to determine which reinforcer should be withheld following occurrences of problem behavior (Iwata, Pace, Cowdery, & Miltenberger, 1994) and which reinforcer should be delivered as a consequence for appropriate alternative behavior (Carr & Durand, 1985).

When a behavior problem is evaluated via functional analysis, a dependency between a response and a consequence is often arranged in the course of the assessment. For example, to test the reinforcement effects of attention and escape, Iwata et al. (1982/1994) arranged test conditions in which a particular event (attention or escape) was presented following every instance of SIB but at no other time (i.e., a continuous reinforcement schedule). Thus, during the attention condition, for instance, the probability of obtaining attention following SIB was 1 and the probability of obtaining attention given the nonoccurrence of SIB was 0. Similar relations are also now arranged to test reinforcement effects of tangible reinforcers such as food or toys (e.g., Vollmer, Borrero, Lalli, & Daniel, 1999).

Although current functional analysis methods involve arranging a complete dependency between a target response and a test consequence, it is now recognized that *dependent* relations are not synonymous with *contingent* relations (e.g., Galbicka & Platt, 1989; Lattal, 1995; Reynolds, 1975). The term *dependency* is used to describe if-and-only-if relations. On the other hand, the term *contingency,* or more specifically, *temporal contingency,* is used to describe relations that occur between two or more events with varying probabilities. That is, contingencies of reinforcement can arise accidentally or can arise when a behavior bears no causal relation to the subsequent event. For example, reinforcement effects sometimes occur when stimuli are presented response independently using time-based schedules (e.g., Skinner, 1948). Thus, rain dances do not

cause rain, but they persist because they are intermittently reinforced by rain (Reynolds, 1975). Behavior analysts describe these relations as contingencies of reinforcement, even though there is no true dependency between behavior and the subsequent environmental event. Also, as Lattal (1995) pointed out, organisms in natural environments encounter a mix of events that occur as a result of their behavior and other events that occur independently of behavior, yet that mix sometimes produces a reinforcement effect. In other words, the presentation of stimuli if and only if behavior occurs is not a prerequisite for reinforcement effects.

In the laboratory or in a functional analysis, contingencies of reinforcement often can be reduced to simple if–then statements, such as "if a lever press occurs five times, a food pellet is delivered" or "if SIB occurs, deliver attention." However, Lattal's (1995) and Reynolds' (1975) accounts of contingencies emphasize that relations between responding and reinforcement are complex in that sometimes events occur independently of behavior, sometimes they occur as a result of behavior, and sometimes they occur contiguous with behavior but bear no cause–effect (if–then) relation to behavior. Thus, the term *contingency* (as in contingency of reinforcement) is used very generally to describe relations between responses and other events but does not necessarily describe a dependency relation or a programmed relation.

The strength of a contingency can be eroded when some responses are not reinforced, when some reinforcers are presented independently of behavior, or both (Hammond, 1980). The strength of contingencies, then, exists on a continuum. A strong positive contingency is one in which every instance of behavior is reinforced and otherwise no reinforcer is delivered (1 vs. 0, in terms of probability of reinforcer delivery). These contingency values are commonly arranged in functional analyses (see discussion

above). Even intermittent schedules, such as variable-ratio (VR) or variable-interval schedules, represent strong positive contingencies, because no matter how low the probability of reinforcement following an instance of behavior, the probability of reinforcement following no behavior is 0. A neutral or zero contingency occurs when the probability of reinforcement for the occurrence and nonoccurrence of behavior is equal (Galbicka & Platt, 1989; Hammond, 1980). For example, attention may sometimes follow SIB, but it may be that attention would have been as likely to occur had SIB never happened. A negative contingency occurs when the probability of a reinforcer decreases as a function of behavior (Hammond). For example, in a differential-reinforcement-of-other-behavior (DRO) arrangement, the probability of a reinforcer given a behavior is 0 and the momentary probability of a reinforcer given the nonoccurrence of behavior is some value greater than 0. In natural environments, parents might at times actually be less inclined to provide attention or other potential reinforcers following an instance of problem behavior.

One area that is relevant to the issue of contingency evaluation is the research on descriptive analysis. Descriptive analysis involves, among other things, observing naturally occurring social interactions as they relate to a target problem behavior (Bijou, Peterson, & Ault, 1968). These methods have been applied directly to the assessment of severe behavior problems displayed by individuals with developmental disabilities (e.g., Lerman & Iwata, 1993; Mace & Lalli, 1991). Descriptive analyses can be useful in identifying the form of response-subsequent events (e.g., what type of attention is delivered) and the approximate schedule of subsequent events (Lalli & Goh, 1993). For example, if on average every fifth instance of SIB is followed by attention, a VR 5 sched-

ule could be arranged in a functional analysis.

Although intermittent schedules may approximate true response–reinforcer relations, they do not entirely address the issue of contingency strength. A VR 5 schedule has a contingency value of .2 versus 0 (probability of the reinforcer given the occurrence vs. nonoccurrence of behavior). If naturalistic observations show that attention occurs about 20% of the time independent of occurrences of SIB, the true contingency value is neutral (the probability of attention given SIB is .2 and the probability of attention given no SIB is .2). In fact, the observation that attention follows SIB 20% of the time could even represent a negative contingency. For example, it may be that a parent normally provides attention approximately 50% of the time but the probability of attention goes down to .2 if SIB occurs. Such a negative (DRO-like) contingency is unlikely to maintain behavior over sustained periods (Hammond, 1980). Thus, using descriptive analyses to identify possible reinforcement schedules represents an incomplete analysis of response-subsequent event relations if the background probability of the event is not incorporated.

One way to address this issue is to use descriptive analysis methods to identify the background probability of events and the response-contiguous probability of events. Galbicka and Platt (1989) have described contingencies as reflecting the change in the probability of a stimulus event relative to the probability of the stimulus events that constitute the background or context. These relations can be depicted mathematically by comparing the conditional probability of the event (given the occurrence of behavior) to the background probability of the event (also see Watson, 1997). A similar sort of evaluation would involve comparing the probability of the event given the nonoccurrence

Table 1
Participant Information

Participant	Age (years)	Problem behavior	Mental retardation	Observation time (hr)	Total instances of behavior
Linda	14	Disruption	Mild	2.1	118
Marshall	15	SIB	Profound	4.8	127
Mandy	24	SIB	Mild	2.5	73
Seth	8	Aggression	Moderate	1.5	61
Max	7	Aggression	Moderate	1.7	23
Todd	9	Aggression	Moderate	1.8	27
Joey	4	Aggression	Moderate	3.9	31
Jim	8	SIB	Profound	4.5	270
Missy	17	Aggression	Profound	5.0	51
Mitch	13	Disruption	Moderate	2.9	56
Jesper	3	Disruption	Mild	4.2	36

of behavior with that given the occurrence of behavior (Catania, 1992).

The purpose of this study was to use existing descriptive analysis methods (Lalli & Goh, 1993; Mace & Lalli, 1991) to compare the conditional probability of potentially reinforcing events to the background probability of those potentially reinforcing events (in the context of potential establishing operations [EOs]). This approach may provide applied researchers and clinicians with an additional data-analysis method that would allow more precise interpretations of response–stimulus relations.

METHOD

Participants and Setting

Participants were 11 individuals who had been admitted to an inpatient facility specializing in the assessment and treatment of severe behavior problems. Descriptive analyses were a routine part of the admission process at the facility. These individuals were the first 11 individuals referred following approval of the research protocol and for whom secondary observers were available to record data for interobserver agreement purposes. Table 1 provides information specific to each participant. Participants were 8 males and 3 females, ranging in age from 3

to 24 years. Problem behaviors included disruptive behavior, aggression, and SIB.

Beginning 1 or 2 days after admission to the inpatient unit, observations were conducted with parents, familiar teachers, or group-home staff. During each observation, data were collected with either one or both of the care providers present or with group-home staff (Mandy only). Observations were conducted in hospital rooms designed to resemble a typical room in a house or apartment. Care providers were aware of being observed through a one-way mirror; participants did not know they were being observed. Each room was equipped with a couch, table, chairs, and foldaway beds. Additional materials such as toys, books, magazines, televisions, and videocassettes were placed in the room. Observations were conducted over a period of 1 to 3 days, and the cumulative observation periods ranged from 1.5 to 5.0 hr (consisting of 4 to 10 individual sessions). Session durations were determined by naturally occurring transitions in activities (e.g., the morning routine was completed) or when 1 hr had elapsed. In some cases, sessions were extremely brief because of a medical emergency (e.g., a seizure occurred 1 min into the session) or because an activity did not last very long (e.g., a par-

ticipant made his or her bed and got dressed within 5 min).

Recording and Reliability

Observers were psychology interns and clinical specialists. All observers received at least 20 hr of training in behavioral observation, attended a 2-hr seminar on descriptive analysis data-recording methods, completed at least 5 hr of training, and had high interobserver agreement scores (>90%) with previously trained observers. Observers were seated behind a one-way mirror and recorded target behaviors on laptop computers that provided real-time data. The target behaviors observed for all participants are listed in Table 1. The data of principal interest were the conditional probability of attention, escape, or access to materials given the occurrence of a target behavior compared to the background probability of those events. These data were evaluated in the context of potential EOs (e.g., instructional activities, restricted access to materials, and low adult attention). Presumably the reinforcing efficacy of escape from instructional activities, access to previously restricted materials, and attention would increase under instructional situations, restricted access situations, or periods of low attention, respectively. If the conditional probability of an event was found to be higher than the background probability (within potential EOs) of the event, a possible positive contingency was identified. If the conditional probability was exactly the same, a possible neutral contingency was identified. If the conditional probability was lower, a possible negative contingency was identified. For example, if the background probability of attention was .05 during low-attention situations and the conditional probability of attention was .7, a potential positive contingency was determined to exist. Alternatively, if the background probability of attention was .05 during low-attention situations and the condi-

tional probability of attention was .01, a potential negative contingency was determined to exist. More specifically, a potential positive, negative, or neutral contingency was determined to exist if the conditional probability of one event exceeded the background probability of that event, did not exceed the background probability event, or was exactly the same as the background probability of that event to three decimal points (e.g., .005), respectively.

Care providers were given a thorough description of the assessment process upon admission of their child or ward. Prior to the descriptive observations, care providers were told the following (or a similarly phrased statement): "In this phase of the assessment, we will be watching interactions between you and [name]. We would like you to do the types of things you normally do. To the extent possible, pretend we are not watching." Academic, self-care, play, and leisure materials were placed in the room and snacks, drinks, or meals were available as needed. Descriptive data were either reviewed or formally summarized daily. For those participants whose care providers did not expose them to one or more of the EOs (and in the interest of time), a research assistant asked the care provider, in very general terms, to do so. For example, if a care provider had not yet exposed a participant to a low-attention situation, he or she was asked to read an admission form to simulate a low-attention situation. Similarly, care providers were asked to "show us the morning care routine" or "show us what it is like when you share (or put away) toys" to simulate instructional contexts and restricted access situations, respectively. The evaluation of behavior in the presence of each potential EO was an important dependent measure of this study; however, fewer than half of the primary care providers required prompts to arrange potential EOs.

To obtain conditional probability and

background probability measures, data were collected on the behavior that resulted in hospitalization (listed in Table 1 for each participant). *Aggression* was defined as throwing objects within 1 m of another person, or hitting, kicking, pushing, pulling, or biting others. Movements to engage in any of the aforementioned target behaviors (e.g., a blocked kick) were also scored as aggression. *Disruption* was defined as throwing objects (but not within 1 m of another person), climbing on furniture (e.g., instances of climbing on counters); forceful contact of the hand or feet with tables, walls, or floors; and property destruction including tearing of books or magazines, breaking writing instruments, and drawing on walls. *Self-injury* included forceful contact with the head or hand and hard surfaces (e.g., floor, walls), self-pinching, and hair pulling. All target behaviors were scored as count measures.

In addition, duration data were collected on three potential EOs. To collect information on when a potential EO was in effect, a single key of the computer was pressed to indicate when the potential EO started and when it ended. *Low or diverted attention* was defined as the care provider physically turning away from the participant, or a period of at least 3 s in which the care provider did not interact (physically or verbally) with the participant. Relatively brief periods of diverted attention may be viewed as discriminative stimuli for longer periods of attention deprivation, but instances of diverted attention may still be viewed as an alteration of the reinforcing efficacy of attention as a reinforcer (i.e., an EO). *Instruction* was defined as any discrete request or demand delivered to the participant by the care provider and included periods when work activities were ongoing (e.g., making a bed), even if verbal instructions or prompts were not continuous. The instruction period was considered complete by observers if none of the aforementioned activities occurred for 3 s.

Restricted access to materials was defined as removal of any items in the room that the participant was previously allowed to manipulate or consume (e.g., rocking chair, food) or when the participant was denied access to requested items. Restricted access was scored 3 s after an item or activity was removed from the participant or 3 s after a request for an item or activity that was not met with access to the requested activity. Periods of restricted access were considered complete when 1 min had elapsed from the onset of activity restriction. For example, restricted access to materials was scored if the participant pointed to a juice can and a parent moved the juice can to an out-of-reach shelf. For all of these potential EOs, the EO was no longer "on" when the potential reinforcer was delivered, but the data analysis required only that the EO was "on" when the instance of behavior occurred.

Finally, data were also collected on three potential reinforcers (i.e., attention, instruction termination, and access to materials). Potential reinforcers were the inverse of potential EOs. *Attention* was defined as physical or verbal interaction between the participant and the care provider, including positioning the participant on the lap, hugging, manual restraining, comfort statements, reprimands, and so forth. *Instruction termination (escape)* was defined as removal of demands and instructional materials for longer than 3 s, or the absence of instructions if the participant stopped engaging in a previously specified task (e.g., putting on a shoe) for at least 3 s. That is, escape was scored if a participant had not been instructed to complete a specified task or had ceased completion of a specified task for at least 3 s. *Access to materials* was defined as the availability of tangible items for manipulation or consumption (e.g., toys, food). Each potential reinforcer and potential EO were scored continuously when present. For example, if a participant (a) requested, but did not re-

Table 2
Total Instances of Problem Behavior Across Potential Establishing Operations (EOs) and Total Time in EO
for Each Potential EO

Participant	Problem behavior in each potential EO			Time in each potential EO (min)		
	Low attention	Instruction	Restricted access	Low attention	Instruction	Restricted access
Linda	105	6	11	60	27	17
Marshall	44	34	0	120	70	7
Mandy	17	20	0	22	36	11
Seth	10	20	15	20	20	45
Max	16	12	0	27	14	30
Todd	14	8	9	25	7	22
Joey	19	20	0	26	110	21
Jim	92	42	36	26	42	36
Missy	3	19	17	106	60	22
Mitch	49	4	0	64	32	29
Jesper	0	6	14	20	60	120

ceive, access to a preferred edible item, (b) was making a bed after having received an instruction to do so, and (c) his or her mother was reading a book, then data collectors scored each potential EO with separate keys. Therefore, it was possible for three potential EOs to be in place at any given moment and for the same problem behavior to be counted as occurring during more than one EO. Table 2 summarizes the total number of problem behaviors observed across each potential EO and the total time in each potential EO.

Interobserver agreement was assessed by having a second observer simultaneously but independently score each potential reinforcer, each potential EO, and individual target behaviors during 29.6% of the total observation period (range for individual participants, 6.6% to 67.4%). Each observation was divided into consecutive 10-s bins, and the smaller number of observed responses was divided by the larger number of observed responses within each bin; these values were averaged for the entire observation session. For duration measures (i.e., duration of access to potential reinforcers, or duration of potential EOs), the smaller number was divided by the larger number of seconds within the 10-s bin; these values were aver-

aged for the entire observation session. Interobserver agreement averaged 87.4% for low attention (range, 73.4% to 100%), 92.9% for instruction (range, 77.7% to 100%), 95.9% for restricted access (range, 90.0% to 99.1%), 84.9% for attention (range, 61.4% to 100%), 91.7% for instruction termination (range, 83.5% to 100%), 95.7% for access to materials (range, 68.0% to 100%), 97.0% for aggression (range, 96.0% to 100%), 92.5% for disruption (range, 86.7% to 95.8%), and 94.3% for SIB (range, 84.0% to 99.6%). Table 3 summarizes agreement for each participant across potential EOs, potential reinforcers, and target responses.

Data Preparation

Our original plan was to compare conditional and background probability values within potential EOs and in the absence of potential EOs. Difficulties in interpreting background probabilities for the entire observational session will be highlighted in the discussion section; however, all individual participant data are available from the authors upon request.

Prior to conducting the formal data analysis, each instance of the problem behavior was counted and summarized. In addition,

Table 3
Interobserver Agreement Scores (Percentages) Across Potential Establishing Operations, Potential Reinforcers, and Target Responses

Participant	Potential establishing operations			Potential reinforcers			Target response
	Low attention	Instruction	Restricted access to materials	Attention	Escape	Access to materials	
Linda	79.3	91.7	96.4	79.5	93.6	92.8	86.7
Joey	73.4	89.4	97.2	67.6	85.7	100	96.9
Mandy	87.2	91.1	95.0	94.3	88.9	68.0	84.0
Jim	92.5	95.4	95.5	100	91.5	100	99.3
Seth	92.3	95.7	99.1	90.2	96.8	99.8	96.0
Missy	88.1	98.6	98.9	91.4	98.9	98.9	100
Jesper	100	100	91.5	99.8	100	100	95.8
Todd	91.1	93.9	98.0	88.8	87.3	98.9	96.1
Max	74.2	77.7	90.0	69.5	83.5	95.4	96.0
Marshall	90.8	99.3	99.0	61.4	97.6	100	99.6
Mitch	92.3	89.4	94.5	93.2	85.4	98.7	95.0

all of the instances from each potential EO were counted and summarized. Next, we usually selected 50 random points in time (seconds) from the observation to evaluate the background probability of potential reinforcers. That is, 50 random points in time were selected from each potential EO. The only exception to this was if the participant displayed more than 50 responses during a particular (potential) EO (e.g., Linda during periods of low attention), in which case we selected an equal number of random points in time. Given that these seconds were selected randomly, it was possible for random instances to co-occur with instances of problem behavior. Thus, the resulting probability was the background probability (or response-independent probability) of the event and served as a point of comparison to the conditional probability. By calculating the background probability (within potential EOs) versus the conditional probability, the probability of an event following a behavior could be evaluated against the background probability of the event.

Data Analysis

Event probabilities were calculated in two ways. First, a binary calculation method was used; that is, the potentially reinforcing event was scored as either occurring (yes) or not (no). Each probability was calculated for the 5, 10, 15, and 20 s following problem behaviors (conditional probabilities) or following the random points in time (background probabilities). For example, suppose 40 instances of aggression occurred during a low-attention situation and attention followed the aggression 10 times within 5 s, 20 times within 10 s, 30 times within 15 s, and 40 times within 20 s. The probability of aggression for the 5-, 10-, 15-, and 20-s windows would be .25, .50, .75, and 1, respectively. Note that with the binary method the probability of an event must either stay the same or increase as the time window moves away from the behavioral instance (e.g., if attention happened within 5 s it necessarily happened within 10 s). Further suppose that for randomly selected moments in time the probability of attention occurring within 5, 10, 15, and 20 s was .2, .3, .4, and .5, respectively. This example shows a case in which a care provider was more likely to provide attention given the occurrence of aggression (a possible positive contingency).

It is possible that the occurrence of a target behavior does not change the probability

of an event but does change the proportion of time with that event. For example, a parent might provide some attention at least once every 20 s whether or not behavior occurs, but they may provide attention of greater duration following instances of problem behavior. Thus, a "proportion of seconds" calculation method was used to supplement the binary data analysis. In this method, if 4 of the 5 s following a response contained attention, then a proportion of .8 was recorded. If 4 of the 10 s following the behavior contained attention, then a proportion of .4 was recorded, and so on. Note that with the proportion method, the probability value does not necessarily increase as the time window moves away from the instance of behavior. For example, if a parent provided 2 s of attention immediately after a behavior but then nothing else, the proportion within 5 s would be .4; the proportion within 10 s would be .2, and so on.

It would also have been possible to calculate the probability of possibly reinforcing events given the occurrence versus nonoccurrence of behavior. However, such a method would have required arbitrarily deciding what constitutes a nonoccurrence of behavior (i.e., how long after a behavior occurs?). From a mathematical standpoint, comparing the conditional versus background probability (within potential EOs) shows whether the probability of the possibly reinforcing event increases when behavior occurs. From a behavioral and conceptual standpoint, this can be interpreted as either an index of increased or decreased probability of possible reinforcers given a response or stimulus control of an individual's behavior over care-provider behavior (or both).

RESULTS

Results are presented for the probabilities calculated within potential EOs only. We have presented samples of the data obtained to demonstrate potential relations that may be identified between behavior and environmental events.

Figure 1 shows representative comparisons of conditional and background probabilities (within potential EOs) of events that may indicate possible positive contingencies. The upper panel depicts the results for Jim during the instruction EO. During 4.5 hr of observation, he was involved in instructional activities (mainly self-care and daily living routines) for a total of 42 min. He engaged in 42 instances of SIB during instructional activities. As the data suggest, the probability of escape following instances of SIB was much higher than the probability following randomly selected seconds at all of the time values calculated for both the binary (left panel) and proportional (right panel) calculation methods.

The center panel of Figure 1 shows similar results for Joey during the low-attention EO. During 3.9 hr of observation, he spent 26 min in low-attention circumstances and he displayed 19 instances of aggression during that EO. The probability of attention from his mother was considerably higher following instances of disruption.

The lower panel shows results for Todd during the low-attention EO. During 1.8 hr of observation, 25 min were spent in low-attention circumstances, and he displayed 14 instances of aggression toward his grandmother (primary care provider). Although 14 instances of aggression may be viewed as a relatively small number from which to evaluate contingency relations, it is important to note that every instance of aggression produced attention within 10 s. When viewed as a whole, the probability of attention following aggression was much higher than following randomly selected seconds.

Figure 2 shows representative comparisons of conditional and background probabilities (within potential EOs) of events that may indicate possible negative contingencies. The

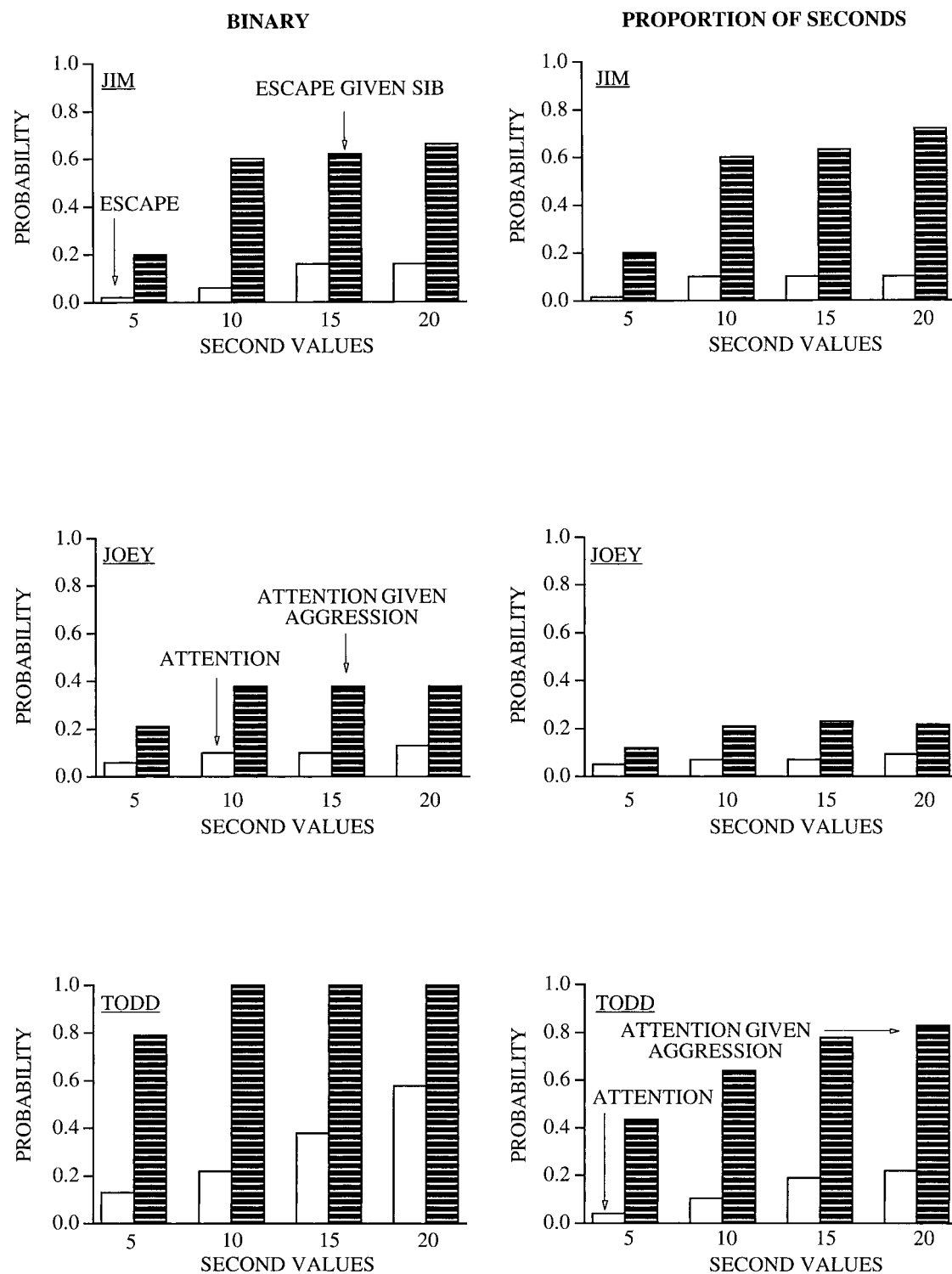**BINARY**   **PROPORTION OF SECONDS**

Figure 1.   Representative examples of potentially positive contingency values for Jim (upper panel), Joey (center panel), and Todd (lower panel) during the instruction, low-attention, and low-attention EOs, respectively.
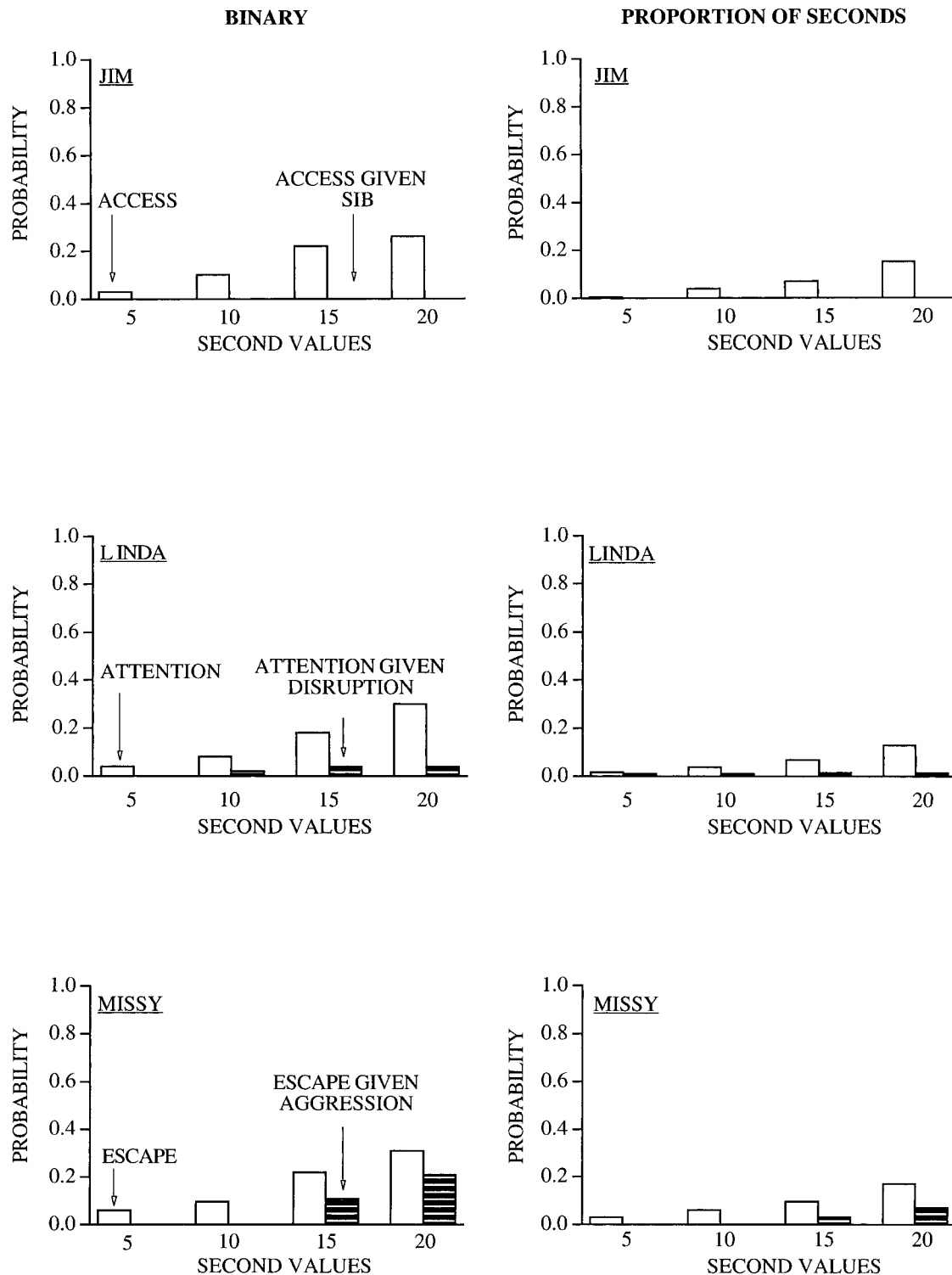
Figure 2. Representative examples of potentially negative contingency values for Jim (upper panel), Linda (center panel), and Missy (lower panel) during the restricted-access, low-attention, and instruction EOs, respectively.

upper panel shows results for Jim. Jim was observed for 4.5 hr and spent over 36 min in the restricted-access context. During the restricted-access EO, he displayed a total of 36 instances of SIB. He never received access to the restricted items following instances of SIB, but there was some probability of gaining access to restricted materials following randomly selected moments. Thus, the probability of gaining access to restricted materials was actually lower following instances of problem behavior.

The center panel shows similar results for Linda during the low-attention EO. During 2.1 hr of observation, she was in the low-attention EO for a total of 60 min, and she displayed 105 instances of disruption. Although a few instances of disruption were followed by attention within 10, 15, or 20 s, the background probability of attention from her parents was lower when she engaged in disruption.

The lower panel shows results for Missy during the instruction EO. During 5.0 hr of observation, she spent 60 min in the instruction EO, and she displayed 19 instances of aggression toward her mother. Although 19 instances of aggression may be viewed as a relatively low number from which to evaluate possible contingency relations, it is important to note that Missy never received escape within 10 s following instances of aggression. The background probability of escape was lower when aggression occurred.

Figure 3 shows comparisons of conditional and background probabilities (within potential EOs) of events that produced idiosyncratic or ambiguous outcomes. The upper panel shows the results for Mandy during the low-attention EO. During 2.5 hr of observation, she was in the low-attention EO for 22 min, and she displayed 17 instances of SIB. The idiosyncratic finding for Mandy was that there was an apparent positive contingency value immediately following SIB (5-s and 10-s windows), but the

contingency eventually became apparently negative (15-s and 20-s windows). In fact, her mother typically provided a brief reprimand and physically attempted to block the SIB as it occurred or shortly thereafter, then typically proceeded to ignore Mandy.

The center panel shows the results for Seth during the instruction EO. During 1.5 hr of observation, Seth was engaged in instruction for 20 min. During that time he displayed 20 instances of aggression toward his mother. As the figure indicates, his mother never terminated the instruction immediately following aggression, but terminated instruction within 15 s following all 20 instances of aggression. These results are idiosyncratic insofar as the contingency was a strong potential negative contingency immediately following the behavior, but became a strong potential positive contingency following a short delay.

The lower panel depicts the results for Mitch during the low-attention EO. During 2.9 hr of observation, Mitch spent 64 min in low attention, and he displayed 49 instances of disruption. Mitch's results are idiosyncratic in that the contingency values are neither clearly positive nor clearly negative. In fact, the probability of attention from his parents following disruption was exactly equal to the probability following randomly selected seconds at the 10-s window. Overall the contingency value is slightly negative; that is, Mitch was slightly less likely to obtain attention following disruption.

Table 4 provides an overall summary of the positive, negative, or neutral contingency relations for each participant in each EO at the 10-s value and using the binary method. The values at 10 s using the binary method were found to be generally representative of other time windows and of the proportional calculation method.

Of the potential EOs evaluated, the largest proportion of potential positive contingencies was observed during periods of low
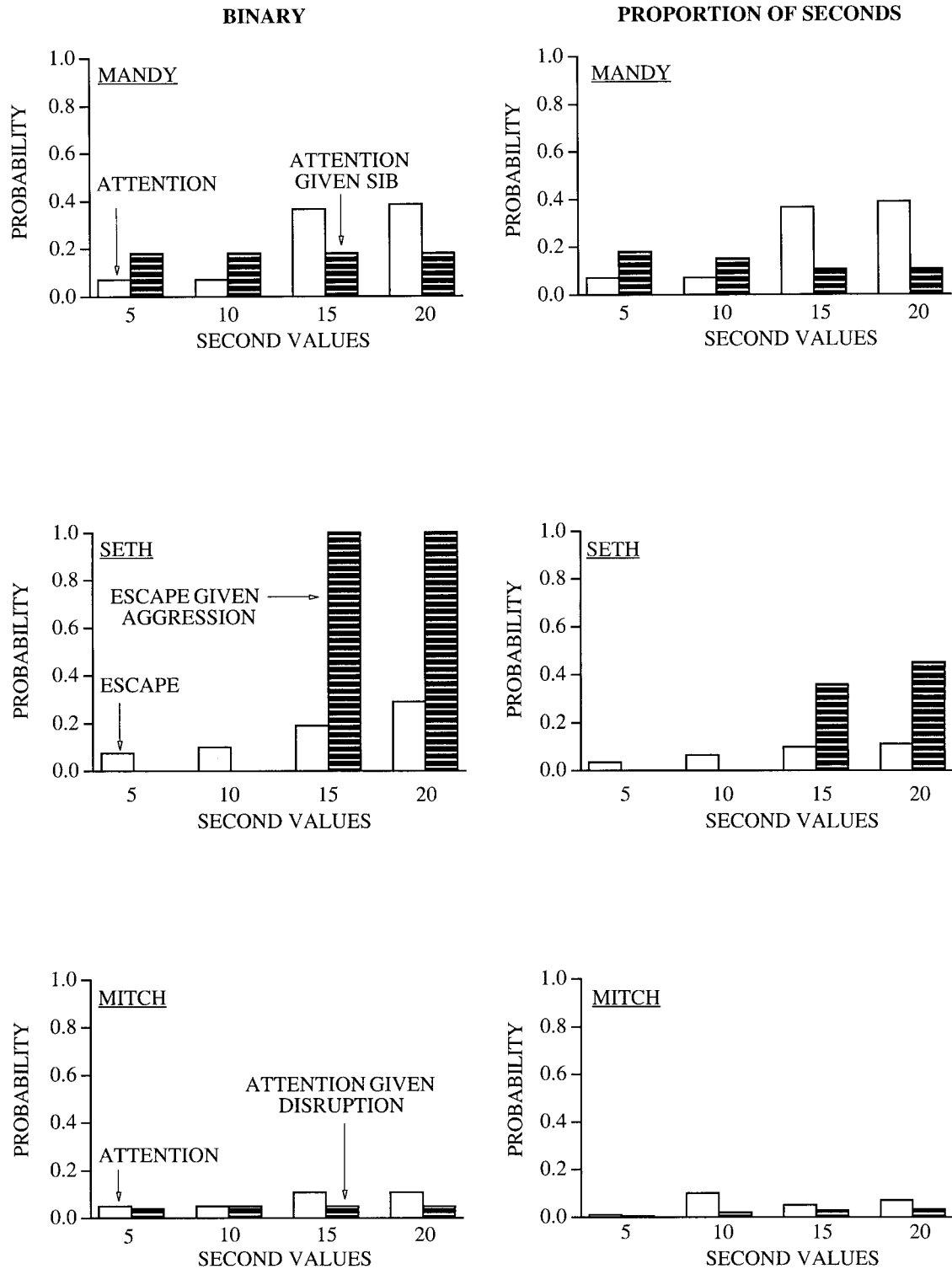
BINARY

PROPORTION OF SECONDS

Figure 3. Representative examples of potentially ambiguous contingency values for Mandy (upper panel), Seth (center panel), and Mitch (lower panel) during the low-attention, instruction, and low-attention EOs, respectively.

Table 4
Contingency Relations for the 10-s Value Using the Binary Calculation Method

Participant	Low attention				Instruction				Restricted access			
	+	−	N	NB	+	−	N	NB	+	−	N	NB
Linda		X				X					X	
Marshall		X			X							X
Mandy	X				X							X
Seth	X					X						X
Max		X				X						X
Todd	X					X						X
Joey	X					X						X
Jim	X					X				X		
Missy	X					X				X		
Mitch			X			X				X		
Jesper				X		X				X		
Percentage of participants	54.5	27.3	9.1	9.1	18.2	81.8	0.0	0.0	0.0	36.4	9.1	54.5

Note. Potential positive (+), negative (−), and neutral (N) contingencies are denoted by an X. Potential establishing operations during which no problem behavior (NB) occurred are also denoted by an X.

attention (54.5%, 6 of 11 participants), and instructional activities produced the greatest number of potential negative contingencies (81.8%, 9 of 11 participants). The terms *positive* and *negative* contingency are used here to describe the apparent relation between behavior and a consequent event compared to the probability of the consequent event without reference to the target response. Therefore, a positive contingency during periods of low attention would suggest that problem behavior was more likely to result in attention as a consequence (i.e., a potential positive reinforcement contingency). Alternatively, a positive contingency during periods of instructional activities would suggest that task termination was more likely to result following instances of problem behavior (i.e., a potential negative reinforcement contingency). During restricted-access situations, 54.5% (6 of 11 participants) engaged in no problem behavior.

DISCUSSION

A method was evaluated for comparing the probability of potentially reinforcing events contiguous with problem behavior to the probability of those events following randomly selected points in time. In the past, descriptive data have been used to identify potential reinforcement schedules, but have not taken into account the background probability of the putative reinforcer. For some participants there was a distinct probability of obtaining access to some event following an instance of behavior. For example, the probability of obtaining attention within 10 s of a response may have been .2, which might be interpreted as roughly a VR 5 schedule. However, the probability of attention following problem behavior is a more meaningful piece of information if the probability is compared to the background probability of attention.

Another way to view these data is from the perspective of the care providers' behavior. That is, if an individual's behavior increased the likelihood of a care-provider response, it is reasonable to conclude that the individual's response exerted stimulus control, or functioned as EOs, over the care provider's behavior. Thus, the values described herein as "contingency values" may equally refer to the stimulus–response contingency

between an individual and care-provider behavior. Equipped with information obtained from probability analyses of descriptive data, care providers may be informed of potential reinforcement contingencies, and the environment could be arranged in a way that reduces the probability of potentially reinforcing consequent events becoming reinforcers.

The contingency calculations used in the current study represent only one way to summarize probabilistic relations between behavior and subsequent stimulation. For example, Catania (1992) describes contingencies according to the relation to two conditional probabilities: the probability of an event given behavior and the probability of an event given the nonoccurrence of behavior. However, in naturally occurring behavior streams, it is impossible to define the nonoccurrence of behavior once a response has occurred, because it is not known how far removed from behavior a stimulus can be and still influence future response rates. From a mathematical standpoint, the comparison of the background probability and the conditional probability is appropriate because the probability of the event following behavior can be compared to the background probability of that event (Galbicka & Platt, 1989).

When positive contingency values are identified, researchers and clinicians might use this information in at least two possible ways. First, as a preventive measure they may make recommendations about neutralizing or even making the contingency values negative (e.g., "Do not provide attention until he has not engaged in problem behavior for at least one minute"). Second, they may wish to mimic those contingency values in a functional analysis to add a greater degree of external validity to the assessment. Most functional analyses use very strong positive contingency values; it may be the case that certain events are reinforcers only if access to

those events *depends* on the occurrence of behavior. The results of the current methodological study suggest that contingency values of various sorts may exist during typical human interactions, but it is not known how various contingency values might influence the occurrence of problem behavior.

When negative contingencies are identified, researchers and practitioners may need to be cautious about arranging strong positive contingencies during functional analysis test conditions. It is possible that problem behavior initially occurs for other reasons, but when the only way to obtain escape or access to materials is via engaging in problem behavior, the behavior may become more likely to occur. Thus, false positive outcomes may be identified in a functional analysis (e.g., Shirley, Iwata, & Kahng, 1999). An alternative functional analysis format might be to mimic the contingency values derived from a descriptive analysis conducted prior to a functional analysis. However, the use of strong positive contingencies during a functional analysis is pragmatic for several reasons. First, the rich schedules of reinforcement arranged in a functional analysis may reduce the risk of injury incurred during an assessment. For example, if a VR 5 schedule of reinforcement is arranged for SIB during a functional analysis, participants will be required to emit a greater absolute number of responses before contacting reinforcement. Second, the extensive literature on reinforcement schedules (e.g., Ferster & Skinner, 1957) suggests that reductions in problem behavior following the introduction of treatment will occur more rapidly following a continuous reinforcement schedule relative to intermittent schedules of reinforcement. Third, potential reinforcing relations can be identified and, hence, avoided. For example, a parent might learn that escape would be a reinforcer if it were made contingent on problem behavior. However, the analysis of conditional probability values col-

lected from descriptive observations appears to be necessary if we are to distinguish between consequent events that maintain problem behavior in the natural environment and those that behavior is sensitive to during functional analyses. Future research should evaluate the outcomes of functional analyses using strong positive contingencies compared to functional analyses using contingency values derived from descriptive observations. Although analyses of this sort may be difficult to conduct in typical clinical settings, experimental manipulations under highly controlled conditions, in the context of research, may provide more useful insight into the nature of reinforcement contingencies that support problem behavior.

Even in cases when contingency values are positive (i.e., the probability of a reinforcer is greater following behavior than following random points in time), it is possible that weak positive contingencies would affect behavior differently than those contingencies typically arranged in a functional analysis. If problem behavior only slightly increases the probability of attention, the contingency may not be strong enough to engender a reinforcement effect. The sufficient conditions for a reinforcement effect remain entirely unknown. Seemingly, even negative contingency values might support problem behavior if the problem behavior increases the overall time with access to the reinforcer. One implication of this study, then, is that contingency relations should not necessarily be expressed in terms of simple if–then statements. The relations between behavior and environmental events can be evaluated and, presumably, subsequently analyzed along a range of dimensions.

Although the data were not presented here, we would be remiss not to comment on our finding that the probabilities for the entire observation period, rather than solely in the context of the EOs, were relatively uninformative for one main reason. Specifi-

cally, the probability of access to a potential reinforcer for the entire observation period was very high in many cases and the behavior was likely to occur only when access to that potential reinforcer was eliminated. As such, the probability of access to the reinforcer frequently exceeded the response-contiguous probability of access to that reinforcer, but only because there was apparently no motivation to engage in the problem behavior until the EO was "turned on." For example, some parents attended to their child almost continuously (e.g., >.8 probability). However, during the brief intervals in which they diverted their attention, high rates of problem behavior occurred that were subsequently followed by a relatively rich presentation of attention (e.g., .5 probability). Thus, the probability of attention assessed across the entire observation period may have been greater than the response-contiguous probability only because the behavior did not occur until the EO was in effect. For this reason, many researchers have recommended the technique of plotting the conditional rate of problem behavior when an EO is in effect (e.g., Lalli & Goh, 1993; Mace & Lalli, 1991). We obtained conditional rate data and used them for clinical purposes, but the data were not included in this study because the central focus was to evaluate a previously unused data analysis method in the context of descriptive analyses.

The study was designed mainly to evaluate a method for identifying possible contingencies during descriptive analyses. However, several aspects may warrant additional investigation. First, all of the observations were conducted in an artificial (hospital) environment rather than at home, school, or the workplace, where entirely different contingency arrangements may have been observed. We are currently replicating this study in home and school environments.

Second, all of the individuals who were

admitted to the inpatient unit had previously been exposed to less restrictive behavioral interventions in an effort to keep them in the community and out of the hospital setting. Thus, many care providers may have already been taught to avoid providing access to materials, attention, or escape and, therefore, they may represent a more behaviorally educated group than what might be typically observed with severe behavior disorders in the community.

Third, difficulties associated with reactivity are implicit during descriptive observations in either natural or experimental settings (e.g., Johnson & Bolstad, 1975). For example, the novel environment, or informing care providers that their behavior was being observed, probably influenced the behavior of both the care providers and participants. However, alternative data-collection methods (e.g., videotaping observations) were determined to be ineffective because of difficulties associated with sound and participants moving beyond the view of the camera.

Fourth, not all care providers arranged all of the potential EOs independently; some required minimal prompting to do so. One possible explanation with respect to why some care providers did not arrange particular EOs is that previous experience under a given potential EO may have evoked higher levels of problem behavior than other potential EOs. For example, after prompting one parent to arrange an instructional situation by simulating a self-care routine, she responded by saying "he doesn't like brushing his teeth" and "now you're going to see problem behavior." In other words, some parents may have avoided contexts during which problem behavior was more likely to occur.

Fifth, some concerns may arise with regard to the low levels of problem behavior observed under varying potential EOs. For example, for Joey and Todd, only 14 and 19 instances of problem behavior were observed

during the low-attention context, respectively. Future research may evaluate procedures similar to those described in this study and include as a criterion a minimum number of problem behaviors per context before concluding descriptive observations. Given the clinical environment of the current study, descriptive observations were limited by the care provider's availability and by a 3-day maximum, so that patients could progress through the assessment and treatment phases of their admission in a timely manner.

Sixth, potentially positive, negative, or neutral contingency values were determined in the absence of statistical analyses. Future research may consider the use of statistical analyses (e.g., Bakeman & Gottman, 1997) to augment decisions based on probability values alone. We chose not to use statistical analyses because it is unknown whether statistically significant differences represent meaningful differences related to reinforcement contingencies. For example, Skinner (1956) showed that a single pairing of a rat's lever press and consequent food resulted in a sustained reinforcement effect. Clearly, an observation of one pairing is not a statistically significant sample of behavior or stimulus events, but a reinforcement effect emerged nonetheless. Thus, it would be beyond the scope of the current study to assume relations between statistical accounts and reinforcement effects. Rather, we chose to merely present a method for describing response–stimulus relations.

Seventh, the probability of observing exactly equal conditional and background probability values in the context of research is extremely low. For example, in the current study, a background probability of .58 compared with a conditional probability value of .62 was concluded to be a potential positive contingency rather than a neutral contingency. As an alternative, future research in the area of descriptive analysis may evaluate

"comparable" probability values rather than exact probability values.

Although the hallmark of behavior analysis is experimental manipulation, a thorough understanding of human behavior will require complex analyses under relatively uncontrolled conditions. The information derived from such descriptive observations could help to define the independent variables (e.g., contingencies) of interest for subsequent experimentation. The goal of our study was to develop a method by which this could be accomplished in the assessment of severe behavior disorders, but analogous methods could be used to assess the development of verbal behavior (see Moerk, 1990), social skills, and work productivity, among other phenomena. For this assessment methodology to be practical, it will need to brief and efficient. Future research may attempt to evaluate the effectiveness of abbreviated observation periods and computerized calculation procedures to make the descriptive analysis methods described here as feasible as possible for clinicians and practitioners.

Reinforcement is a fundamental principle of behavior analysis, and the concept of contingency is fundamental to our understanding of reinforcement. In applied behavior analysis we now understand the effects of strong positive contingency values, but little is known about how other values along the contingency continuum affect behavior.

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STUDY QUESTIONS

1. According to the authors, why are "dependent" and "contingent" relations not necessarily synonymous?

2. To what does the "strength" of a contingency refer?

3. What is the relevance of "background" probabilities of events (i.e., potential reinforcers) when using data from descriptive analyses to infer schedules of reinforcement?

4. Briefly describe the dependent variables for which data were collected during the descriptive analyses.

5. How were the conditional and unconditional (background) probabilities calculated?

6. Briefly summarize the data depicted in Table 4.

7. According to the authors, what are the advantages of programming strong positive contingencies when conducting functional analyses of problem behavior?

8. What are some limitations of the present study?

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