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# *AN EVALUATION OF CONTINGENCY STRENGTH AND RESPONSE SUPPRESSION*

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Typically, functional analyses of severe problem behavior have been conducted in two ways: (a) The target response is reinforced immediately after it occurs, or (b) the target response is reinforced on some schedule thought to mimic a naturally occurring schedule. We evaluated the effects of contingency strength in reducing levels of problem behavior with 2 participants who had been diagnosed with developmental disabilities. Results showed that under a neutral contingency, one in which the probability of reinforcement for aggression was equal to the probability of reinforcement for the nonoccurrence of aggression, rates of aggression were suppressed to low levels for both participants.

DESCRIPTORS: contingency, contingency strength, functional analysis, aggression

The term *contingency,* as in contingency of reinforcement, may be defined as a relation between responses and environmental events (Catania, 1998; Lattal, 1995). The term *contingency strength* refers to varying probabilities of responses and reinforcers in the context of environmental events (Vollmer, Borrero, Wright, Van Camp, & Lalli, 2001), and may be conceptualized along three very broad dimensions: positive, neutral (zero), and negative (Hammond, 1980).

A strong positive contingency is one in which each instance of the target response produces the reinforcer, and all other behaviors do not produce reinforcers (i.e., the probability of reinforcement following the target response is 1, and the probability of reinforcement for all other behavior is 0). Even intermittent schedules of reinforcement may be conceptualized as strong positive contingencies. For example, if reinforcement is produced on a variable-ratio (VR) 20 schedule, the probability of reinforcement following the nonoccurrence of behavior is still lower than the probability of reinforcement following the occurrence of behavior. Treatments to reduce severe problem behavior are often of this sort. For example, during functional communication training, appropriate communicative behavior may initially produce reinforcement on a continuous reinforcement schedule (CRF) and all other behavior produces no reinforcement (e.g., Carr & Durand, 1985).

A neutral, or zero, contingency is one in which the probability of reinforcement for the occurrence of the target response is equal, or at least is similar to the probability of reinforcement for the nonoccurrence of the target response. For example, if the probability of receiving a reinforcer for completing math problems is .5 and the probability of receiving a reinforcer for engaging in behaviors unrelated to completing math problems is .5, a neutral contingency has been arranged. Neutral contingencies have not typically been recommended as treatment for severe problem behavior; therefore, the effects of neutral contingencies in suppressing problem behavior are not known.

A negative contingency is one in which the probability of reinforcement for the occurrence of a behavior is actually lower than the probability of reinforcement following the nonoccurrence of behavior. For example,

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in a typical differential-reinforcement-of-other-behavior (DRO) arrangement, the probability of reinforcement decreases following instances of the target behavior.

Hammond (1980) evaluated the effects of varying contingency values on rates of responding in a basic operant preparation with rats as subjects. In Experiment 1, subjects were exposed to a series of very strong positive, strong positive, moderately positive, and neutral contingencies. For example, a very strong positive contingency was defined as a probability of reinforcement following a response of 1 and the probability of reinforcement following the nonoccurrence of the target behavior was 0. A strong positive contingency was defined as one in which the probability of reinforcement following an instance of behavior was .2 (as in a VR 5 schedule) and the probability of reinforcement for the nonoccurrence of behavior was 0. A moderately strong positive contingency was one in which the probability of reinforcement following an instance of the target response was .05 (as in a VR 20) and the probability of reinforcement following the nonoccurrence of the target response was 0. Finally, a neutral contingency was defined as one in which the probability of the target response producing reinforcement was .05 and the probability of reinforcement following the nonoccurrence of behavior was .05. In Experiment 2, subjects were exposed to a series of strong positive, moderately positive, neutral, and negative contingencies. Positive and neutral contingency arrangements in Experiment 2 were similar to those in Experiment 1. A negative contingency was one in which the probability of reinforcement following the nonoccurrence of behavior (.05) exceeded that of the probability following an occurrence of the target response (0). Collectively, the results showed that when neutral or negative contingencies were arranged, decreased response rates were obtained.

In applied behavior analysis, the use of strong positive contingencies has been an integral component of functional analysis. Iwata, Dorsey, Slifer, Bauman, and Richman (1982/1994) exposed the self-injurious behavior (SIB) of 9 individuals to a variety of environmental conditions designed to identify reinforcers for SIB. More specifically, participants were exposed to conditions designed to test the reinforcing efficacy of (a) adult attention, (b) escape from instructional activities, and (c) nonsocially mediated reinforcement (i.e., automatic reinforcement). In each of these conditions, SIB was reinforced on a CRF, or fixed-ratio (FR) 1 schedule of reinforcement. For example, in the attention condition, the probability of attention given SIB was 1 and the probability of attention given no SIB was 0, thereby representing a strong positive contingency. The use of strong positive contingencies in an assessment is useful for several reasons: (a) Strong positive contingencies may reduce the frequency of behavior required to contact the reinforcement contingency, (b) the effectiveness of treatment following CRF schedules may be enhanced, and (c) potential reinforcing relations may be identified. The methods used by Iwata et al. have been replicated in hundreds of subsequent studies (e.g., Derby et al., 1992; Iwata et al., 1994).

As an alternative, researchers have also arranged functional analysis contingencies based on schedules thought to mimic those in the natural environment. Mace and Lalli (1991), for example, conducted both descriptive and experimental analyses of 1 man's bizarre speech. During the experimental analysis, instances of bizarre speech produced adult attention and escape from instructional demands on a VR 2 reinforcement schedule. The VR schedule was selected based on the finding in the descriptive analysis that bizarre speech produced attention or escape with a probability of .5. Although the schedule arrangement imple-

mented by Mace and Lalli differed from that of Iwata et al. (1982/1994) (i.e., it was intermittent), a strong positive contingency was in place for problem behavior. The probability of attention following bizarre speech was .5, whereas the probability of attention following no bizarre speech was 0. However, the experimenters did not test the effects of VR 2 attention when the probability of attention given the nonoccurrence of bizarre speech was greater than 0. Presumably, if the conditional probability of attention given no bizarre speech was greater than 0, the effects of response-contingent attention as reinforcement may have been weakened.

The literature on contingency strength during the assessment of severe problem behavior may be extended in at least two ways. First, it is not clear how results of a functional analysis with a strong positive contingency may differ from those in which the probability of reinforcement for problem behavior was equal to the probability of reinforcement for the nonoccurrence of problem behavior. Second, basic research on contingency strength has focused on behavior that was positively reinforced. It remains unclear if such relations would also be observed with negatively reinforced behavior.

The purposes of the current investigation were as follows. First we sought to identify a reinforcement effect during functional analyses of the aggressive behavior of 2 young boys using strong positive contingencies. Second, we evaluated the effects of varying contingency strengths along a continuum ranging from very strong to neutral. One boy's behavior was positively reinforced aggression, and another boy's behavior was negatively reinforced aggression.

## METHOD

### *Participants and Setting*

Two individuals participated; both had been admitted to an inpatient facility for the assessment and treatment of severe aggression. Dirk was a 15-year-old boy who had been diagnosed with moderate mental retardation, obsessive-compulsive disorder, and intermittent explosive disorder. Joey was a 4-year-old boy who had been diagnosed with moderate mental retardation. Experimental sessions were conducted in one of several therapy rooms at the inpatient facility. The rooms contained a couch, several chairs, a table, and other items or activities (e.g., television) when available. Functional analysis sessions lasted 10 min, and were conducted two to four times per day, 5 days per week.

### *Response Measurement and Interobserver Agreement*

Observers were bachelor's and master's level psychology interns and clinical specialists. All observers received at least 20 hr of training in behavioral observation, attended a 2-hr seminar on data-recording methods, completed at least 5 hr of in-session training, and had high interobserver agreement scores (>90%) with previously trained observers. Observers were seated behind a one-way window and recorded target behaviors on laptop computers that provided real-time data.

The primary data of interest for both participants were aggression and the nonoccurrence of aggression. For Dirk, *aggression* was defined as hitting or kicking the therapist. The *nonoccurrence* of aggression was defined as any 1-s period in which problem behavior did not occur. The nonoccurrence of aggression was set at 1 s because instances of aggression averaged 1 s. For Joey, *aggression* was defined as pulling hair, hitting, or kicking the therapist. The *nonoccurrence* of aggression was set at 5 s because instances of aggression averaged approximately 5 s.

Interobserver agreement was assessed by having a second observer simultaneously but independently record data. 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 Dirk, interobserver agreement was obtained for 20.4% of experimental sessions, and averaged 91.5% for aggression (range, 76.1% to 100%). For Joey, agreement was obtained for 19.0% of sessions, and averaged 98.4% (range, 95.1% to 100%) for aggression.

*Procedure*

*Functional analysis.* Four conditions were alternated in a multielement design using procedures similar to those described by Iwata et al. (1982/1994). Briefly, the conditions were attention, tangible (or edible), escape, and control. In the attention condition, the participant was seated in a chair and given access to leisure materials; aggression produced a brief reprimand from the therapist, followed by descriptive statements describing ongoing activities (totaling approximately 30 s). In the control condition, the participant was seated in a chair with leisure materials available. No demands were presented, and attention was delivered on a fixed-time (FT) 20-s schedule. Aggression resulted in no programmed consequences from the therapist. In the tangible condition, Joey received access to toys prior to the session. Following this initial access, the toys were withdrawn from his reach. A therapist then stood nearby. The programmed consequence for aggression was access to the toys for approximately 30 s. In the edible condition (Lalli et al., 1999), Dirk received several bites of a preferred edible item prior to the session. Following this initial access, the food was withdrawn from his reach. The programmed consequence for aggression in this condition was access to one small bite of food. This condition was included because Dirk's care provider reported that he sometimes became aggressive in the presence of food. In the escape condition, Dirk was asked to complete self-dressing. Dressing was targeted because staff reported that instructions to get dressed produced aggression. For Joey, tooth brushing was targeted in the escape condition because his mother reported that the task was problematic at times. Task demands for both Dirk and Joey were presented approximately every 30 s using a three-prompt hierarchy; aggression produced termination of the task until the next scheduled interval.

Throughout all functional analysis conditions, a strong positive contingency was arranged between aggression and the relevant consequence (Iwata et al., 1982/1994). Most important for Dirk, during the edible condition the probability of receiving a bite of food following an instance of aggression was 1, and the probability of receiving a bite of food following the nonoccurrence of aggression was 0. Similarly, for Joey, the probability of escape from instructional demands following an instance of aggression was 1, and the probability of escape following the nonoccurrence of aggression was 0.

*Experimental design.* For both Dirk and Joey, experimental control was demonstrated by way of a reversal design. The sequence of conditions for Dirk was A-B-C-B-C-B-D-C-D, in which, A is the functional analysis baseline ($p$ = 1.0 vs. $\bar{p}$ = 0, where $p$ represents the probability of reinforcement given aggression and $\bar{p}$ represents the probability of reinforcement given the nonoccurrence of aggression), B is the strong positive contingency ($p$ = .33 vs. $\bar{p}$ = 0), C is the neutral contingency ($p$ = .33 vs. $\bar{p}$ = .33), and D is the FT edible presentation. The sequence of conditions for Joey was A-B-C-B-C-D, in which A is the functional analysis baseline, B is the strong positive contingency ($p$ = .5 vs. $\bar{p}$ = 0), C is the neutral contingency ($p$ = .5 vs. $\bar{p}$ = .5), and D is FT escape.

*Strong positive contingency.* The edible and

escape conditions from the functional analysis were considered Condition A for Dirk and Joey, respectively. Condition A represented the strongest contingency ($p$ = 1.0 vs. $\bar{p}$ = 0). In Condition B, the schedule of reinforcement for aggression was thinned to a VR 3 for Dirk and a VR 2 for Joey. In other words, following an average of three instances of aggression, one bite of food was delivered, whereas the contingency for the nonoccurrence of aggression was still 0 ($p$ = .33 vs. $\bar{p}$ = 0). An analogous procedure was used for Joey; however, reinforcement was provided following an average of every two instances of aggression, whereas no reinforcement was provided given the nonoccurrence of aggression ($p$ = .5 vs. $\bar{p}$ = 0). Although the schedule requirement for contacting reinforcement increased from an FR 1 to a VR schedule, a strong positive contingency remained in place for aggression.

*Neutral contingency.* In Condition C, the probability of receiving reinforcement following aggression was equal to the probability of receiving reinforcement following the nonoccurrence of aggression. In keeping with the notation above, the neutral contingency condition for Dirk may be expressed as $p$ = .33 versus $\bar{p}$ = .33. Similarly, the neutral contingency for Joey may be expressed as $p$ = .5 versus $\bar{p}$ = .5.

*Fixed-time stimulus presentation.* In Condition D, food or escape was presented on an FT schedule for Dirk and Joey, respectively. Procedures for Dirk will be described first, followed by a description of the FT procedure for Joey. During the first FT edible-item condition, the schedule escalated from FT 10 s to FT 15 s. For example, in the FT 15-s condition, Dirk was presented with an edible item every 15 s independent of his behavior. During the second FT edible-item condition, the schedule escalated from FT 20 s to the terminal schedule of FT 300 s. This condition was included because Dirk's eventual treatment recommendations included an FT schedule. An FT 300-s schedule of food delivery was viewed as more practical than using a neutral contingency. For Joey, escape was presented on an FT schedule, escalating from FT 10 s to FT 120 s using procedures similar to those described by Vollmer, Marcus, and Ringdahl (1995). Specifically, Joey was allowed to take a break from the activity (i.e., tooth brushing) on an FT schedule, in which his behavior did not influence the probability of escape. For example, during the FT 30-s sessions, Joey received a break from tooth brushing every 30 s. During work periods, Joey was prompted to complete the instruction using the three-prompt instructional sequence. The use of the FT schedule was conceptually related to the contingency analysis in that it eliminated the contingency between problem behavior and reinforcer presentation.

## RESULTS

Figure 1 (top panel) depicts the results of Dirk's functional analysis of aggression. The highest levels of aggression were observed in the edible condition of the functional analysis ($M$ = 10.04 responses per minute) compared to the escape, attention, and control conditions ($M$ = 0.90, 0, and 0, respectively). Therefore, we concluded that Dirk's aggression was sensitive to edible items as reinforcement. The lower panel of Figure 1 depicts the results of the functional analysis for Joey. During the functional analysis, the highest levels of aggression were observed in the escape condition ($M$ = 0.43), whereas lower levels of aggression were observed in the tangible, attention, and control conditions ($M$ = 0.05, 0, and 0, respectively).

Figure 2 (top panel) depicts the results of the contingency analysis for Dirk. The first condition of the contingency analysis represents the last five sessions in the edible condition of the functional analysis ($p$ = 1.0

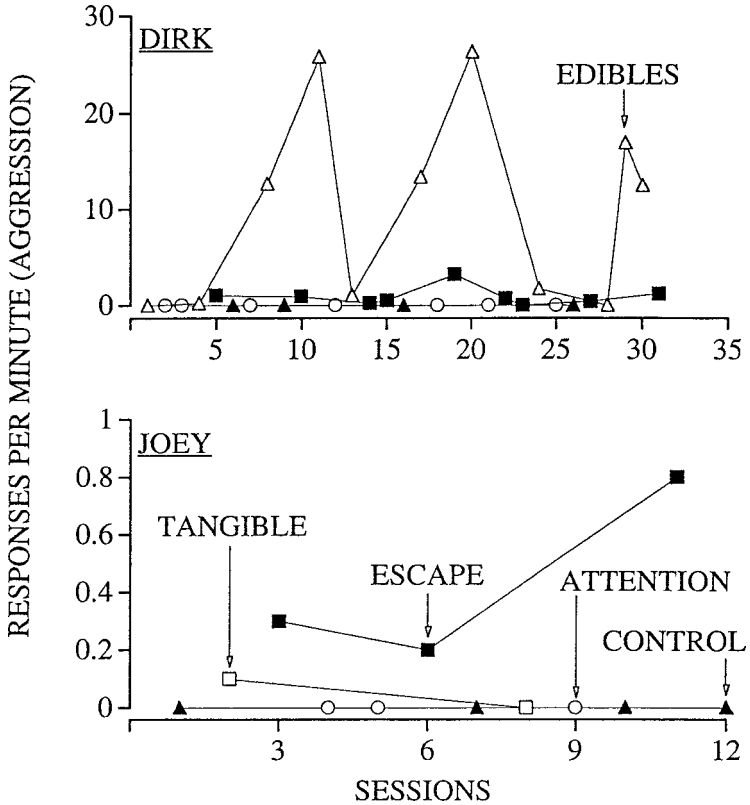


Figure 1. Results of the functional analysis for Dirk (top panel) and Joey (bottom panel).

vs. $\bar{p}$ = 0). During Condition B ($p$ = .33 vs. $\bar{p}$ = 0), the rate of aggression occurred at levels slightly higher than those observed during the functional analysis ($M$ = 21.05). In Condition C ($p$ = .33 vs. $\bar{p}$ = .33), aggression rates decreased ($M$ = 0.87). In a reversal to Condition B ($p$ = .33 vs. $\bar{p}$ = 0), high levels of aggression recurred ($M$ = 7.27). We returned to Condition C ($p$ = .33 vs. $\bar{p}$ = .33), and rates of aggression were variable for the first 13 sessions but decreased to zero during the last four sessions of the condition ($M$ = 3.42). In a subsequent reversal to Condition B ($p$ = .33 vs. $\bar{p}$ = 0), high levels of aggression recurred ($M$ = 21.90). Next, in Condition D (FT), variable levels of aggression were observed during the first four sessions, but aggression decreased for the remaining six sessions ($M$ = 3.14). Condition C ($p$ = .33 vs. $\bar{p}$ = .33) was briefly reintroduced, and low levels of aggression were observed ($M$ = 0.07). Finally, Condition D (FT edible presentation) was reintroduced. The schedule of FT reinforcement was thinned to 300 s, and rates of responding remained low ($M$ = 0.19).

The lower panel of Figure 2 depicts the results of the contingency analysis for Joey. Condition A was the escape sessions from the functional analysis ($p$ = 1.0 vs. $\bar{p}$ = 0). High rates of aggression occurred ($M$ = 0.43). During Condition B ($p$ = .5 vs. $\bar{p}$ = 0), the rate of was aggression maintained at levels higher than those observed during the functional analysis ($M$ = 0.59). In Condition C ($p$ = .5 vs. $\bar{p}$ = .5), aggression rates decreased ($M$ = 0.08). Next, we reversed to Condition B ($p$ = .5 vs. $\bar{p}$ = 0) and observed an increase in aggression rates ($M$ = 0.80). We returned to Condition C ($p$ = .5 vs. $\bar{p}$

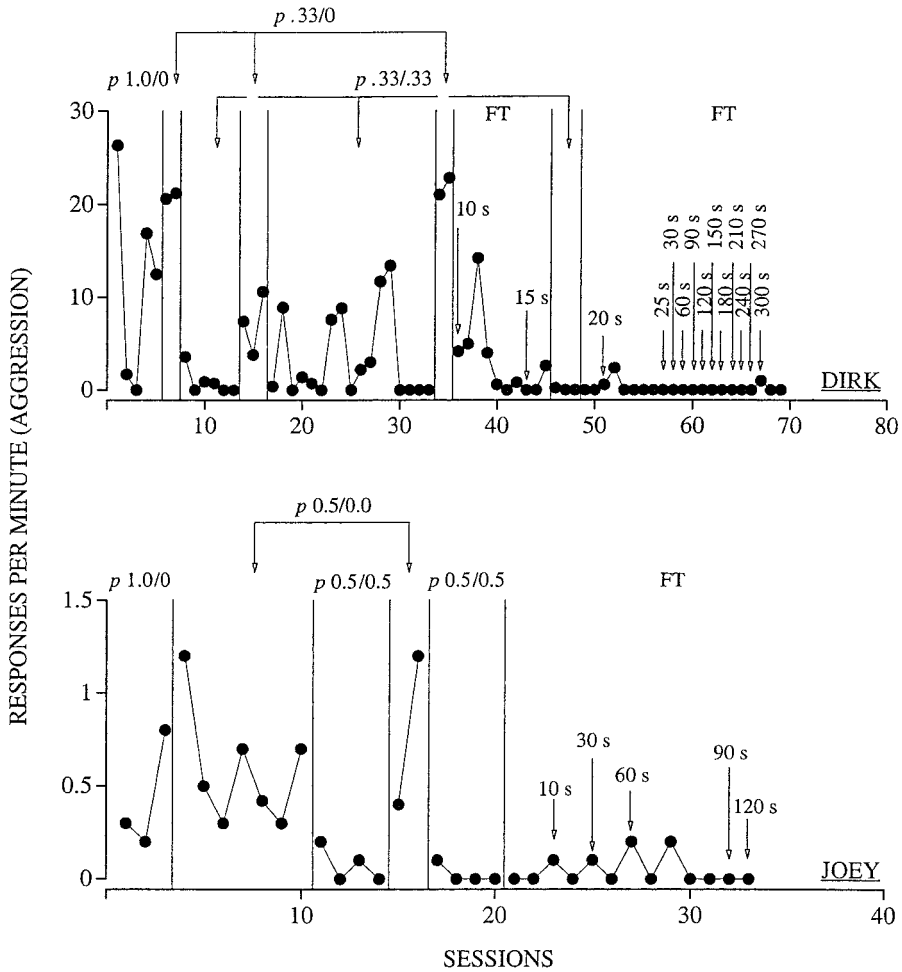


Figure 2. Results of the contingency analysis for Dirk (top panel) and Joey (bottom panel). The probability of reinforcement for aggression is denoted by the first number, and the probability of reinforcement for the nonoccurrence of aggression is denoted by the second number.

= .5), and low levels of aggression were again observed ($M$ = 0.03). Finally, escape was introduced on an FT schedule ranging from 10 s to 120 s, and low levels of responding were observed across the condition ($M$ = 0.05).

## DISCUSSION

We evaluated various parameters of contingency strength in the assessment of severe problem behavior. For these 2 participants, the rate of problem behavior was influenced by the strength of the contingency. More specifically, when the probability of reinforcement following aggression and the nonoccurrence of aggression were equal, aggression was suppressed relative to conditions in which the probability of reinforcement was higher following aggression. In addition, when the strength of the contingency between problem behavior and the nonoccurrence of problem behavior was weakened slightly (i.e., more responses were required on average to contact reinforcement), behavior was maintained at levels similar to, if not higher than, those observed under the very strong positive contingency. These findings

support previous results from the basic operant laboratory (e.g., Hammond, 1980).

This experiment illustrates that the probability of reinforcement given aggression interacts with the probability of reinforcement given the nonoccurrence of aggression, such that the reinforcement effect is either enhanced or weakened. This finding has implications for functional analysis because it may be important to evaluate whether strong positive contingencies actually exist in the natural environment prior to arranging them in a functional analysis. Vollmer et al. (2001) conducted contingency analyses in the context of descriptive observations among patients admitted to an inpatient facility and their primary care providers. Vollmer et al. collected data on potential reinforcers (e.g., adult attention) and problem behavior (e.g., aggression). They then compared the background probability of a potential reinforcer (e.g., attention) with the response-contiguous probability of the potential reinforcer. Results suggested that the method was useful in identifying potential contingencies between problem behavior and environmental events. For example, in some instances the probability of a particular environmental event (a) increased following problem behavior (characteristic of a positive contingency), (b) was similar to the background probability of the event (characteristic of a neutral contingency), or (c) decreased following problem behavior (characteristic of a negative contingency).

It is possible that at times a strong positive contingency does not exist in the natural environment. If so, arranging a strong positive contingency in a functional analysis might lead to erroneous conclusions about maintaining variables. For example, results of a study conducted by Shirley, Iwata, and Kahng (1999) suggested that the inclusion of highly preferred tangible stimuli during a functional analysis incorrectly indicated a socially mediated positive reinforcement function for 1 woman's SIB. Although SIB occurred at high levels during the tangible condition of the functional analysis, observations conducted in the home suggested that SIB rarely produced any differential consequences. The implication was that by arranging a strong positive contingency, a reinforcement contingency was created even though it did not exist in the natural environment.

Future research may incorporate conditional and background probabilities obtained from descriptive observations into functional analysis. For example, if the background probability of escape (e.g., .4) was greater than the response-contiguous probability of escape (e.g., .2), the escape condition of the functional analysis could be arranged to mimic the respective probabilities observed during natural interactions. Similar comparisons could be conducted with other commonly assessed environmental manipulations. Further, it may be the case that, at times, functional analyses identify a sensitivity to reinforcement, whereas a descriptive analysis might identify current contingency strengths in natural interactions.

The results of the current investigation also have some implications for evaluations of treatment integrity. Several studies have evaluated the effectiveness of treatment implementation when the integrity of the procedure was less than optimal (e.g., Vollmer, Roane, Ringdahl, & Marcus, 1999; Worsdell, Iwata, Hanley, Thompson, & Kahng, 2000). For example, Vollmer et al. evaluated the effectiveness of differential reinforcement of alternative behavior in reducing problem behavior when the procedure was implemented at optimal (100%) and less than optimal (e.g., 20%, 40%, 75%) levels. Results showed that treatment effects were observed when the schedule of reinforcement for appropriate behavior was implemented with less than 100% integrity. In the current study, neutral contingencies involved a great

deal of response–reinforcer contiguity, yet there was no reinforcement effect. Presumably then, for Dirk and Joey, some degree of integrity failure could be absorbed, in that some problem behavior could be reinforced as long as enough reinforcers were available for the nonoccurrence of behavior.

The behavioral process or processes responsible for the observed rate-decreasing effects remain unknown. It is possible that the partial disruption of the response–reinforcer contingency was responsible for the observed rate decreases. Alternatively, the frequent presentation of food (Dirk) or escape (Joey) may have altered the establishing operation for the response-contingent presentation of those events as reinforcement. Future research may be designed specifically to identify the controlling processes.

One limitation of the current investigation involves the distinction between programmed and obtained schedules of reinforcement. For example, Condition C for Dirk ($p$ = .33 vs. $\bar{p}$ = .33) may not have functioned as a neutral contingency, in part because of the manner in which nonoccurrences of aggression were defined. Nonoccurrences were defined as periods of time during which aggression did not occur that were equal in duration to the average duration of aggression (1 s). As a result, the rates of nonoccurrences always exceeded the rates of aggression, even when aggression produced reinforcement and nonoccurrences of aggression did not (i.e., during the functional analysis, $p$ = 1.0 vs. $\bar{p}$ = 0, and the strong-contingency conditions, $p$ = .33 vs. $\bar{p}$ = 0). For example, in an average tangible session during the strong-contingency sessions ($p$ = .33 vs. $\bar{p}$ = 0), there were approximately 21 occurrences of aggression per minute, each lasting about 1 s. Thus, on average, there were 21 occurrences and 39 nonoccurrences of aggression during each minute. Even if the rate of aggression remained unchanged when the neutral contingency was introduced, the obtained rate of reinforcement would have been almost twice as high for nonoccurrence than for occurrence of aggression.

For the obtained rate of reinforcement to be equal for nonoccurrences and occurrences of aggression during the neutral contingency condition ($p$ = .33 vs. $\bar{p}$ = .33), aggression would have had to increase to 30 responses per minute, a highly unlikely event following the introduction of reinforcement for the absence of aggression. The change from $p$ = .33 versus $\bar{p}$ = 0 to $p$ = .33 versus $\bar{p}$ = .33 was essentially a DRO 3-s schedule superimposed over a VR 3 schedule of contingent reinforcement. This is not a neutral arrangement with regard to the relative rate of reinforcement for occurrences and nonoccurrences of aggression; it clearly favors the absence of aggression. Thus, future research could be designed to evaluate the effects of programmed schedules of reinforcement compared to obtained schedules of reinforcement. Procedurally, the $p$ = .33 versus $\bar{p}$ = .33 and $p$ = .5 versus $\bar{p}$ = .5 arrangements described in the current investigation were neutral by design. However, obtained rates of reinforcement under the programmed schedules resulted in schedules that favored the nonoccurrence of aggression.

The parameters and ranges of contingency strength evaluated in this study were very limited. Specifically, two positive contingency values were compared to a neutral contingency value for both participants. Future research could evaluate more subtle parameters to identify the point at which problem behavior is no longer suppressed. Further, parameters of negative contingency values should be evaluated (i.e., $p < \bar{p}$). The clinical implications for DRO-based treatments could make evaluations of negative contingencies an especially important line of research.

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## *STUDY QUESTIONS*

1. Define *contingency strength* and describe three dimensions along which it may be conceptualized.

2. What are the benefits of using strong positive contingencies when conducting functional analyses of problem behavior?

3. Describe the procedures by which the strong positive contingencies were implemented.

4. How were the neutral contingencies programmed?

5. Summarize the results of the contingency analysis for both participants. According to the authors, what is the implication of these results for programming contingencies during functional analyses?

6. What features of the data suggest that the use of intermittent schedules of reinforcement for problem behavior during functional analyses may be problematic?

7. What do results obtained during the neutral-contingency condition predict about the likely effects of reinforcement-based interventions that are implemented inconsistently?

8. Discuss how the neutral contingency programmed in the present experiment did not actually result in a neutral contingency.

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