EFFECTS OF SIGNALS ON THE MAINTENANCE OF ALTERNATIVE BEHAVIOR UNDER INTERMITTENT REINFORCEMENT

By

CARRIE MELISSA DEMPSEY

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To my grandparents, Ernie and Betty Moretti

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Carrie Melissa Dempsey

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A common approach to the treatment of problem behavior is to strengthen an alternative, appropriate behavior. Although continuous reinforcement is required during acquisition, the practicalities of maintenance require intermittent reinforcement. Previous methods for thinning reinforcement for alternative behavior (i.e., delay fading), however, have resulted in response deterioration. Results of several basic studies have shown that exteroceptive stimuli (signals) may be used to control the rate and temporal distribution of responding when reinforcement is intermittent or delayed; however, only one applied study has examined the use of signals for maintaining alternative behavior during reinforcement-schedule thinning.

The purpose of this study was to evaluate patterns of responding when reinforcer availability was signaled by visual stimuli and delivered according to a variable-interval (VI) schedule. Study 1 involved a basic demonstration of the effects of signaled and unsignaled reinforcer availability under a VI schedule. Study 2 involved a clinical evaluation of signaled, VI reinforcement as a maintenance procedure for alternative behavior in the context of treatment for severe problem behavior. Results of Study 1 revealed that the signaled-VI schedule was associated with moderate rates of responding, whereas the unsignaled schedule tended to produce either high or zero rates of responding. Results of Study 2 replicated and extended the

results of Study 1,showing that the signaled-VI schedule produced low rates of problem behavior and moderate rates of alternative behavior as the reinforcement schedule was thinned.

CHAPTER 1
FUNCTIONAL COMMUNICATION TRAINING

Function-Based Treatment

The development of methods for identifying behavioral function, such as the functional analysis (Iwata, Dorsey, Slifer, Bauman, & Richman, 1982), spurred a new generation of treatment for problem behavior, commonly referred to as function-based treatment. In function-based treatment, the variables that maintain problem behavior are identified and then are used to inform the course of intervention. Function-based treatment may be applied in several ways. One application involves extinction (EXT), in which the functional reinforcer is eliminated following problem behavior. For example, Iwata, Kalsher, Cowdery, and Cataldo (1990) showed that the self-injurious behavior (SIB) of 7 participants with developmental disabilities was maintained by escape from task demands. Extinction was implemented by terminating escape following SIB, and resulted in decreases in SIB to near zero levels.

Another application of function-based treatment involves noncontingent reinforcement (NCR), in which the functional reinforcer is delivered on a time-based schedule that is independent of responding. For example, Vollmer, Iwata, Zarcone, Smith, and Mazaleski (1993) identified that the SIB of 3 participants with mental retardation was maintained by access to attention. During NCR, attention was delivered initially on a dense, fixed-time schedule, which was subsequently thinned. All participants showed immediate reductions in behavior, which were sustained over time.

A third application of function-based treatment involves differential reinforcement of an alternative behavior (DRA), in which the functional reinforcer is withheld following problem behavior, and used to establish an alternative, competing response. DRA has been used to increase compliance in participants with escape-maintained problem behavior (e.g., Lalli et al.,

1999) and leisure item engagement in participants who engage in automatically reinforced behavior (Vollmer, Marcus, & LeBlanc, 1994). In addition, and of particular relevance to the current study, DRA has been used to establish appropriate communication (e.g., Wacker et al., 1990). In the context of communication, a common term given to DRA is Functional Communication Training (FCT; Carr & Durand, 1985), although the basic structure of the intervention remains unchanged. The following sections review topics relevant to the use and effectiveness of FCT.

Applications of Functional Communication Training

Carr and Durand (1985) conducted the first application of FCT with 4 participants who engaged in disruption in a classroom setting. Antecedent variables were manipulated to generate information regarding the events that reinforced problem behavior. Once reinforcers were identified, participants were taught to emit two statements in response to an experimenter prompt: a relevant statement that produced access to the reinforcer, and an irrelevant statement that produced access to an arbitrary consequence. Throughout the evaluation, problem behavior resulted in EXT. When relevant statements were reinforced, decreases in problem behavior and increases in communication were observed for all participants. However, when irrelevant statements produced access to an arbitrary consequence, treatment effects were not observed.

Since its initial application, the effectiveness of FCT has been demonstrated across several behaviors including aggression (Thompson, Fisher, Piazza, & Kuhn, 1998), SIB (Wacker et al. 1990), elopement (Tarbox, Wallace, & Williams, 2003), inappropriate sexual behavior (Fyffe, Kahng, Fittro, & Russell, 2004), stereotypy (e.g., Durand & Carr, 1987), breath holding (Kern, Mauk, Marder, & Mace, 1995), and off-task behavior (Meyer, 1999). Given the positive treatment outcomes associated with FCT, studies have examined the components of FCT that contribute to its effectiveness.

Component Analyses of FCT

Carr and Durand (1985) and Wacker et al. (1990) suggested that FCT differs from other differential reinforcement procedures (e.g., DRO), in that it allows the participant to control the delivery of reinforcement. That is, the participant may engage in communication to produce the reinforcer at any time. Kahng, Iwata, Deleon, and Worsdell (1997) investigated the contributing role of control over reinforcement by comparing responding under two procedures, one in which participants' behavior influenced reinforcer delivery (FCT), and one in which participants' behavior did not influence reinforcer delivery (NCR). The amount of reinforcement was yoked across the two procedures. Both procedures produced comparable decreases in behavior, indicating that control over reinforcement by a participant did not influence treatment effects.

In addition, investigators have examined the role of EXT in FCT. For example, Hagopian, Fisher, Sullivan, Acquisto, and LeBlanc (1988) conducted a large-scale analysis of FCT and found that, in the absence of EXT, problem behavior was not reduced by 90% for any of 11 participants. Worsdell, Iwata, Hanley, Thompson, and Kahng (2000) evaluated the role of EXT during the acquisition of alternative behavior for 5 participants whose problem behavior was maintained by social positive reinforcement. When participants were exposed to an initial phase in which both problem behavior and alternative behavior were reinforced, only 1 participant acquired the alternative response. The schedule of reinforcement for problem behavior was made more intermittent for the remaining 4 participants to determine the point at which more responding would be allocated to alternative behavior than to problem behavior. Switching to alternative behavior did not occur until reinforcement for its occurrence was 2, 3, and even 20 times more likely than for problem behavior.

Shirley, Iwata, Kahng, Mazeleski, and Lerman (1997) examined the influence of EXT during both the acquisition and maintenance of manual signs during FCT for 3 participants.

When SIB continued to produce reinforcement, SIB remained at baseline rates, and communication was not acquired. The addition of EXT, however, was associated with decreases in SIB and increases in signing for all participants.

Collectively, these results suggest that EXT is a critical component of FCT; however, some research suggests that FCT may also be conducted with high integrity in the absence of EXT if the establishing operation for behavior (e.g., Smith, Iwata, Goh, & Shore, 1995), or parameters of reinforcement for appropriate and inappropriate responses are manipulated (Horner et al., 1980; Vollmer et al., 1999). Aside from examining the relative effects of FCT components, a small number of studies have investigated methods for maintaining treatment effects following FCT. These methods are reviewed briefly in Chapter 2.

CHAPTER 2
MAINTENANCE FOLLOWING FCT

The Natural Environment

During FCT sessions, communication is typically reinforced on a fixed-ratio 1 (FR-1) schedule to facilitate response acquisition, which tends to engender high and stable rates of communication (Carr & Durand, 1985). However, reinforcement for communication may be delayed or intermittent in the natural environment. Some examples: A busy parent may have to direct attention to other individuals or activities, some tangible items (e.g., edibles) are unhealthy if provided in large quantities, and some demands (e.g., hygiene tasks) require compliance.

If communication occurs frequently but fails to contact reinforcement, it may extinguish. Subsequently, other behavior that has produced reinforcement in the past (i.e., problem behavior) may re-emerge. In support of this, Durand and Carr (1991) observed a breakdown in communication and re-emergence in problem behavior when treatment was implemented in the natural environment for 1 of 3 participants. Direct observations, which were conducted during follow up, revealed that the teacher was not attending to the participant's requests for assistance.

Relatively few strategies have been designed to maintain communication under conditions of intermittent or delayed reinforcement. Two such strategies are delay fading (Fisher, Thompson, Hagopian, Bowman, & Krug, 2000) and fixed-interval (FI) schedule thinning (Hanley, Iwata, & Thompson, 2001).

Delay Fading

Delay fading involves gradually lengthening the delay between communication and reinforcement. Typically, interval increases are determined based on levels of responding during preceding sessions. Three applied studies have examined the effects of delay fading on responding following FCT and have obtained comparable results. Fisher et al. (2000) evaluated

progressively increasing delays to reinforcement for communication and found that additional treatments (e.g., providing tasks during delay) were required to maintain treatment effects once the delay interval was increased to 30 s. As part of a larger study, Hanley et al. (2001) examined delay fading by systematically increasing the delay to reinforcement for communication from 1 s to 25 s, and found that communication decreased to low rates under the 25-s delay, at which point problem behavior increased.

Hagopian et al. (1998) conducted a large-scale study to assess the outcome of FCT alone or in combination with other procedures (e.g., EXT) with 21 clients who engaged in problem behavior such as SIB, aggression, and property destruction. Functional analyses revealed that problem behavior was maintained by access to attention for 9 participants, by escape from demands for 7 participants, by access to tangible items for 1 participant, and by multiple sources of control for 4 participants. Demand fading or delay-to-reinforcement fading was conducted in 12 of 25 applications of FCT with EXT, but reductions in problem behavior were maintained after fading in only 5 applications. Further, attempts to regain control over the behavior in the remaining 7 cases (e.g., reducing delay interval or number of demands) were unsuccessful.

The results of these studies suggest that a newly acquired response may deteriorate under delayed reinforcement, a conclusion that is also supported by basic research (Azzi, Fix, Keller, & Rocha E Silva, 1964; Schaal & Branch, 1988; Sizemore & Lattal, 1978). Decrements in responding under delay may reflect a decrease in contingency strength, which is determined by the temporal contiguity between response and reinforcement (Baum, 1973) and the probability of reinforcement for a response relative to the response-independent probability of reinforcement (Hammond, 1980; Lattal, 1995). Under conditions of delay, the temporal contiguity between a response and reinforcer is eroded. For example, Sizemore and Lattal (1978) showed that

response rates decrease systematically with obtained (actual) delays to reinforcement, in addition to nominal (programmed) delays.

Fixed-Interval Schedule Thinning

Under an FI reinforcement schedule, a reinforcer is delivered for the first response that occurs after an interval of time has elapsed since the last reinforced response (Ferster & Skinner, 1957). FI schedule thinning occurs by gradually lengthening the time interval across sessions, based on levels of responding during preceding sessions (Hanley et al., 2001). In this arrangement, the contingency between a response and reinforcer may be preserved given the high probability of immediate reinforcement for communication.

Hanley et al. (2001) implemented FI thinning by gradually increasing the interval length from 1 s to 58 s. Results showed that problem behavior remained low throughout thinning. However, communication gradually increased to rates that were higher than those observed during initial training, and only a small proportion of communication responses resulted in reinforcement.

Elevated rates of communication during FI schedule thinning suggest that the contingency was preserved. On the other hand, a large proportion of communication responses occurred when reinforcement was not available. Persistence of high rates of unreinforced responding over time may degrade the contingency between the response and reinforcement, causing a break down in responding (Hammond, 1980).

The results of studies on delay fading and FI schedule thinning illustrate that communication may not occur at appropriate levels under intermittent reinforcement if reinforcement is delayed or difficult to discriminate. As such, the identification of strategies that enhance reinforcer immediacy and discrimination is warranted. Research relevant to the development of one strategy is addressed in the next chapter

CHAPTER 3
SIGNALS

In basic and applied research, exteroceptive stimuli, or signals, have been used to control the occurrence of responding under conditions in which reinforcement is delayed (Kelley, 2003; Lattal, 1984; Morgan, 1972; Pierce, Hanford, & Zimmerman, 1972; Richards, 1981; Schaal & Branch, 1988, 1990; Williams, 1976) or intermittent (Fisher, Kuhn, & Thompson, 1998; Hanley et al., 2001).

Several basic studies have shown that response rates may be maintained under delayed reinforcement when the response that begins the delay also produces a change in visual stimulation, such as a blackout or flashing light. For example, Azzi et al. (1964) trained three rats on a schedule of continuous reinforcement before exposing them to unsignaled reinforcement delays of 1, 3, 5, 7.5, 10, 15, and 20 s. Results showed that response rates decreased systematically for all 3 subjects. Subjects were then exposed to a reinforcement delay of 20 s and then 30 s for several days. Under each reinforcement delay, half of the sessions involved an unsignaled reinforcement delay, and half of the sessions involved signaled reinforcement delay, in which responses produced a blackout period (chamber light off) that endured until reinforcement was delivered. The signaled delay was associated with high response rates at both interval values, whereas the unsignaled delay was associated with low response rates.

Richards (1981) examined the influence of signals using two reinforcement schedules that were expected to produce similar response rates but disparate reinforcer rates under reinforcement delay: a VI 60-s schedule and a differential-reinforcement-of-low-rate (DRL) 20-s schedule. Four pigeons were trained on the VI-60 s schedule, and 5 pigeons were trained on the DRL schedule, following which all subjects were exposed to 48, 1-hour sessions with the following reinforcement delays: 10 s, 5 s, 2.5 s, 1 s, .5 s. Half of the subjects were exposed to

signaled delays (blackout) in the first half of sessions and unsignaled delays in the second half of sessions. The other subjects were exposed to the reverse order. Although higher rates of responding were observed under unsignaled rather than signaled delays at short delay values (e.g., 1 s), large decreases in response rates under unsignaled delays and little reduction relative to baseline under signaled delays was observed at longer delay values.

Schaal and Branch (1988) compared the effects of briefly signaled versus continuously signaled delay intervals with three pigeons trained on a VI-60 s schedule. Under briefly signaled delays, a .5 s change in key light color from red to green occurred immediately following a key peck that initiated the delay. Under continuously signaled delays, the key light color changed to green, but remained green throughout the delay and during delivery of the reinforcer. Brief signals maintained response rates under delays up to 9 s; however, continuous signals were required to maintain responding at delays of 27 s. In a follow-up study, Schaal and Branch (1990) showed that key-pecking rate was an increasing function of the duration of the key light that signaled a 27-s delay.

Kelley (2003) extended findings on signaled reinforcement delay from basic research to application with 3 participants diagnosed with developmental disabilities who were taught communicative responses. During signaled delays, a visual (timer that tracked the delay) or auditory (shaking a can of money) stimulus was presented continuously during the delay interval. During unsignaled delays, no stimuli were presented. Communication maintained under progressively longer delays when the delay period was signaled but not when it was unsignaled.

Vollmer, Borrero, Lalli, and Daniel (1999) investigated the effects of signals within a choice paradigm in which, following FCT, problem behavior produced access to a smaller, immediate reinforcer (e.g., one chip immediately after aggression), whereas communication

produced access to a larger, delayed reinforcer (e.g. three chips after 10 s). When the delay to the large reinforcer was unsignaled, participants made impulsive choices (chose the smaller, immediate reinforcer); when the delay to the large reinforcer was signaled (e.g., placement of timer in front of the participant), participants engaged in self-control (chose the larger, delayed reinforcer).

The mechanism(s) by which signals maintain responding during reinforcement delay has not been identified definitively. However, it is often speculated that response maintenance may be a function of either conditioned reinforcement or discrimination (Richards, 1981; Schaal & Branch, 1990). From a conditioning standpoint, a signal may acquire reinforcing value due to its close temporal relationship with the delivery of food reinforcement. From the standpoint of discrimination, nonresponding comes under discriminative control of the delay signal, and is therefore less likely to influence responding at other points in time.

In applied research, signals have been programmed during periods of reinforcement and EXT to facilitate discrimination of changing conditions. Specifically, signals function as discriminative stimuli due to a differential correlation of reinforcement in their presence relative to their absence (Michael, 1982). Fisher et al. (1998), for example, trained participants to use communication responses to access two different sources of positive reinforcement (e.g., toys) in the context of FCT. During training, each response was paired with a distinct stimulus (e.g., picture of a person playing with toys). Following training, reinforcement contingencies and associated stimuli were alternated every 30 min, and participants displayed only the response that would be reinforced during that period, suggesting that the signals had become discriminative for each response.

Hanley et al. (2001) compared the effects of a multiple schedule, in which different stimuli signaled periods of reinforcement and EXT, to those of a mixed schedule, which contained similar, but unsignaled periods, to evaluate the effects of thinning reinforcement for communication following FCT. Under the multiple schedule, a white card was present when the reinforcement component was in effect and communication produced 10-s access to a preferred item on a FR-1 schedule, whereas a red card was present when the EXT component was in effect and communication produced no programmed reinforcement. Initially, the component durations were 45 s and 15 s for FR 1 and EXT, respectively. The reinforcement schedule was then thinned to 1 min, whereas the EXT schedule was eventually increased to 4 min. Schedule thinning progressed when problem behavior remained at or below 85% of the baseline mean for two consecutive sessions. Throughout the assessment, problem behavior produced no programmed consequences.

Under the mixed schedule, indiscriminate responding (i.e., high across both schedule components) occurred across components for both participants, and problem behavior occurred at high rates for 1 participant. Under the multiple schedule, differential responding occurred across schedule components (i.e., low rates during EXT and moderately high rates under FR-1), and problem behavior was maintained at low rates for both participants. The authors concluded that discriminative stimuli, which were not present in the mixed schedule, contributed to differential responding observed under the multiple schedule.

Collectively, this research suggests that signaled procedures may facilitate control over the rate and temporal distribution of responding under conditions of delayed or intermittent reinforcement. Only one study (Hanley et al., 2001) has examined the influence of signals on responding during intermittent reinforcement following FCT. However, signals may be

particularly important in maintaining communication under such conditions. Specifically, signals may increase the discrimination of reinforcer availability so that communication is more likely to occur when reinforcement is available, and therefore, more likely to contact reinforcement. If the majority of communication responses result in reinforcement, the contingency between communication and reinforcement is likely to remain strong, resulting in the maintenance of communication over time.

Moreover, signals are common components of the natural environment. For example, the green light at the intersection indicates that accelerating through the intersection is likely to result in obtaining safe passage to the other side. Walking through a door labeled "exit" is correlated with successfully vacating a building. Further, the presence of a child's mother is likely to engender a number of attention-seeking behaviors, due to the probability by which her mother has delivered attention in the past. As such, the programming of signals to control appropriate communication following FCT appears to be a pragmatic approach to maintaining communication under intermittent reinforcement.

Interval reinforcement schedules, whether fixed or variable, often characterize the way in which adaptive behavior is reinforced in the natural environment. As such, the use of interval schedules in maintaining communication following FCT seems logical. Hanley et al. (2001) showed that a FI schedule of reinforcement was associated with excessively high rates of communication; however, more moderate rates of communication might have occurred if reinforcer availability was signaled.

No previous studies have investigated the use of a VI schedule during maintenance following FCT. Nevertheless, VI schedules reflect the manner in which several important

reinforcers are provided to individuals. For example, caregivers often provide attention following varying durations of time given the influence of other schedule requirements.

In the current study, the effectiveness of a signaled VI schedule in maintaining appropriate responding under intermittent reinforcement was examined. Study 1 involved a basic operant comparison of performance under two VI-30 s schedules: one in which the availability of reinforcement was signaled, and one in which the availability of reinforcement was unsignaled. Demonstrating the effects of the VI schedule using arbitrary responses within a basic arrangement prior to using the schedule clinically carries two potential advantages. First, the responses selected for study could be made comparable so that differences obtained across the schedules would be more likely to reflect the role of the signal, as opposed to other sources of uncontrolled variability. Second, a basic demonstration would allow for the assessment of the VI schedule with the signal present and absent, so that a clinical evaluation of responding under both types of schedule would be unnecessary. As such, the risk of exposing participants to an ineffective or even counter-therapeutic procedure might be minimized. Once a basis for using the signaled VI schedule was established in Study 1, Study 2 was conducted, which involved a clinical evaluation of signaled reinforcer availability under a VI schedule following response acquisition with FCT.

CHAPTER 4
STUDY 1: COMPARISON OF UNSIGNALED VERSUS SIGNALED VI SCHEDULES

Method

Participants and Setting

Four individuals who attended a local special education school participated. Katy was a 21-year-old female who had been diagnosed with mental retardation and who had a limited vocabulary. Charlotte was a 19-year-old nonverbal female who had been diagnosed with mental retardation and who communicated through gestures. Lesley was a 40-year-old male, who was diagnosed with mental retardation and communicated through vocalizations and gestures. All participants could follow one-step instructions and were capable of performing simple tasks. George was a 15-year-old male diagnosed with Down's syndrome, who engaged in speech at home but not at school (i.e., was selectively mute).

Sessions were conducted in isolated areas of a treatment room located at the school. Session areas were equipped with a table, two chairs, and target task materials (see below). Sessions lasted for five min and were conducted 2 to 5 times per day, 3 to 5 days per week.

Response Measurement and Reliability

Target behaviors consisted of arbitrary responses that were selected based on each participant's level of adaptive functioning. The task for Katy and Lesley consisted of pressing a switch, which was defined by the onset of a light. Charlotte’s task involved placing an index card into a slotted bin, which was defined as the moment at which the card left Charlotte's hand. George's task was touching his nose, and was scored when his index finger contacted any part of his nose. Data were collected by trained observers on laptop computers during continuous 10-s intervals, and were converted to responses per minute. A second observer simultaneously and independently collected data during at least 27% of sessions for each participant. Interobserver

agreement was calculated based on interval-by-interval comparisons of observers' records. The smaller number of responses scored in each interval was divided by the larger number of responses; these fractions were then average and multiplied by 100%. Mean agreement for the arbitrary task was 89.6% (range, 85%-100%), 93.5% (range, 83.3%-100%), 90.7% (range, 71.7%-100%), 91.6% (range, 70%-100%) for Katy, Charlotte, George, and Lesley, respectively.

Stimulus Preference Assessment

Paired-stimulus preference assessments (Fisher et al., 1992) were conducted to identify a highly preferred edible item to use as a reinforcer for task completion. Preference for 9 edible items was assessed. Prior to the assessment, participants were allowed to sample a small portion of each item. During the assessment, items were presented in pairs, and the participant was prompted to select one item. Each item was paired once with every other item, in a quasi-random fashion, for a total of 36 trials. The item selected most often, and on at least 80% of trials, was selected to serve as the reinforcer.

Procedure

The effects of unsignaled and signaled VI schedules on response rates were evaluated using a combined multiple baseline and reversal design.

No-reinforcement baseline. An initial baseline was conducted to ensure that participants did not engage in the target task in the absence of reinforcement. Participants were seated at a table facing the therapist with the task positioned directly in front of them. Immediately prior to session, the participant was prompted to engage in the response using a three-step prompting procedures consisting of verbal, model, and physical prompts, and no programmed consequence occurred. During the session, target responses resulted in no programmed consequences.

Fixed-ratio 1(FR-1) baseline. The FR-1 baseline served as an "acquisition" condition to ensure that the item identified in the preference assessment functioned as a reinforcer for target

responses and to establish a baseline of responding for comparing the effects of unsignaled and signaled VI schedules. This condition was identical to baseline except that the pre-session prompt resulted in the delivery of the reinforcer, and target responses during the session resulted in the delivery of the reinforcer on an FR-1 schedule.

Unsignaled VI schedule. During this condition, the seating arrangement and task position were identical to the FR-1 baseline; however, target responses resulted in the delivery of the reinforcer according to a VI-30 s schedule. The first response in a session was reinforced. Thereafter, a reinforcer was delivered for the first response that occurred after a pre-determined interval of time had elapsed since the last response was reinforced. The programmed time intervals varied around an average value of 30 s and ranged from 15 s to 45 s. The VI 30-s schedule was generated using Microsoft Excel RAND function, and a different schedule was used for each session.

Signaled VI schedule. This condition was identical to the unsignaled VI schedule condition, except that a signal (e.g., colored card or light) was presented in front of the participant as soon as a time interval had elapsed, and remained present until the participant engaged in a target response.

Results

Figure 4-1 shows the rate of responding on the arbitrary task during the comparison of the unsignaled and signaled VI schedules. Katy (top panel) emitted no responses during the no-reinforcement baseline but high rates of responding during the first FR-1 condition. Higher and more variable rates of responding were observed under the unsignaled VI schedule, sometimes as high as 140 rpm. Response rates stabilized during the second FR-1 phase. When the availability of reinforcement was signaled during the second VI 30-s phase, response rates gradually decreased until they became low and stable. An additional measure, the percentage of target

responses that resulted in reinforcement during the last ten sessions of the unsignaled and signaled VI schedules, was calculated to determine the extent to which the signal exerted control over responding. This measure was calculated by dividing the number of reinforcers earned in each session by the number of responses that occurred in each session and multiplying by 100%. The mean percentage of responses resulting in reinforcement for Katy was 5.9% in the unsignaled VI condition and 56.7% in the signaled VI condition.

Charlotte (second panel) emitted no responses during the no-reinforcement baseline and moderate rates of responding during the initial FR-1 phase. Her responding increased initially under the unsignaled VI schedule but then fell to near zero rates and ceased completely during the final nine sessions of the condition. The second FR-1 phase was associated with moderate, variable rates of responding. During the Signaled VI Schedule condition, her responding increased initially but then decreased. In contrast to the unsignaled VI condition, however, Charlotte's responding decreased, but maintained at a low rate as the condition progressed. The mean percentage of responses resulting in reinforcement was 10% in the unsignaled condition and 98.6% in the signaled condition.

Lesley (third panel) emitted very few responses during the no-reinforcement baseline. His responding increased during the first FR-1 phase and then decreased immediately with the introduction of the unsignaled VI schedule, but gradually increased across the condition and continued to increase during the second FR-1 phase. Lesley's responding dropped to moderate, stable, rates during the signaled VI condition. The mean percentage of responses resulting in reinforcement was 53.7% in the unsignaled condition and 100% in the signaled condition.

George (bottom panel) emitted very few responses during the no-reinforcement baseline. His responding increased steeply and remained at high rates during both FR-1 phases.

Decreased rates of responding were observed under both the unsignaled and signaled VI schedules; however, response rates were somewhat lower under the signaled VI schedule relative to the unsignaled VI schedule. George's mean percentage of responses resulting in reinforcement was 40.1% in the unsignaled condition and 67.4% in the signaled condition.

In summary, idiosyncratic patterns of responding were observed across participants during the unsignaled VI schedule condition, and none of the participants engaged in stable, moderate rates of responding. Further, a relatively small percentage of responses resulted in reinforcement under the unsignaled VI schedule. By contrast, response patterns became moderate and stable for all participants, and a large percentage of responses resulted in reinforcement, under the signaled VI schedule condition.

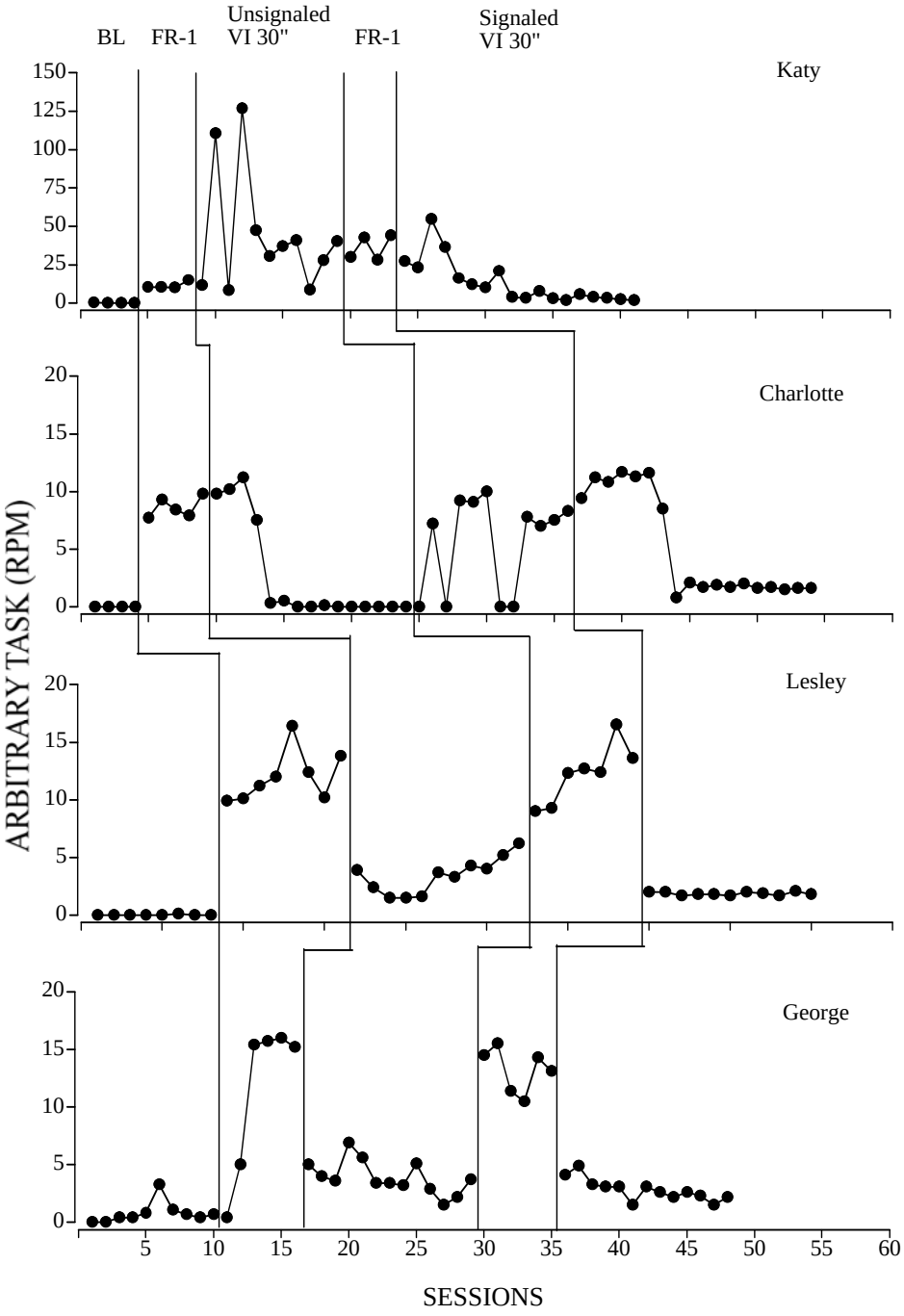

Figure 4-1. Responses per minute on the arbitrary task under the unsignaled and signaled VI-30" schedules

CHAPTER 5
STUDY 2: CLINICAL EVALUATION OF SIGNALED VI SCHEDULE THINNING

Method

The results of Study 1 indicated that the signaled VI schedule may be an effective way to maintain desirable response patterns (low rates) under conditions of intermittent reinforcement. Given these positive results in the context of establishing and maintaining an arbitrary response, a clinical extension seemed warranted. Thus, Study 2 involved an evaluation of signaled VI-schedule thinning as a maintenance procedure for adaptive behavior following its initial acquisition as a replacement for problem behavior.

Participants and Setting

Six individuals who attended either a special education school or outpatient clinic and who were referred for the assessment and treatment of problem behavior participated. Amanda was a verbal 18-year-old female who was diagnosed with Prader-Willi syndrome. Her problem behavior consisted of aggression, which staff reported to occur more frequently when preferred items were removed or denied. Jennifer was a verbal 15-year-old female, also diagnosed with Prader-Willi Syndrome, who engaged in severe SIB, aggression, and disruption. In several cases, Jennifer's SIB produced open wounds and bleeding that resulted in her being temporarily removed from the school. Robert was a verbal 15-year-old male who was diagnosed with autism and who engaged in severe aggression directed toward teachers and other students. Shelly was a verbal 13-year-old female who engaged in several topographies of severe SIB, aggression, and disruption, which had caused her to be permanently removed from five previous educational settings. Mandy was a verbal 10-year-old female who was diagnosed with Pervasive Developmental Disorder. Her problem behaviors consisted of aggression and disruption, which were reported to occur more often when asked to do something she did not like to do (e.g.,

schoolwork). Elaine was a nonverbal 10-year-old female with Down's syndrome who had a history of aggression toward adults during work situations. Sessions were conducted in an isolated room at the special education school or in a room equipped with a one-way mirror at the outpatient clinic. Sessions were 10 min in length and were conducted 3 to 6 times a day, 1 to 5 times per week.

Response Measurement and Reliability

Data were collected on participants' problem behaviors, alternative communication responses, and the presentation of a signal. Amanda's aggression was defined as hitting. Jennifer's SIB consisted of skin picking, scratching, self-biting, and tampering with bandages that covered existing wounds. Jennifer's aggression was defined as hitting, kicking, biting, and throwing objects at others. Robert's aggression was defined as hitting, kicking, choking, and head butting**.** Like Jennifer, Shelly's topographies of SIB included skin picking, scratching, self-biting, and bandage tampering; however, Shelly also engaged in head banging, head hitting, teeth banging, and nose picking**.** Shelly's aggression consisted of hitting, kicking, biting the body or clothing of others, and throwing objects at others. Her disruption included throwing, breaking, hitting, and kicking objects, and overturning furniture. Mandy's aggression was defined as hitting, kicking, and biting, and her disruption was defined as throwing or breaking objects, hitting or kicking surfaces, and drawing on walls. Elaine's aggression was defined as hair pulling, scratching, and pinching. See Table 5-1 for a detailed listing of operational definitions for problem behaviors.

Alternative responses were selected for participants based on their level of adaptive functioning. The verbal response, "Can I have my toys back, please?" was selected for Amanda, Robert, and Shelly. The verbal response "Can we talk?" was selected for Jennifer, and the verbal response "Break please?" was selected for Mandy. A voice-output microswitch, which produced

“Break please,” was selected as the alternative response for Elaine. All verbal responses were scored immediately following emission.

Signals were identified individually for participants based on a signal discrimination assessment (see details in procedure section). Signal presentation was defined as the introduction of the signal into the participant's immediate environment. Signals consisting of colored cards were presented either directly in front of a participant (Mandy) or on a wall (using Velcro) to the participant's immediate left (Amanda, Robert). Colored badges were presented by attaching the badge to the therapist's shirt (Jennifer, Shelly). The light panel, which was affixed to a wall to the participant's immediate left, was presented by activating a switch that turned on the light.

Data were collected by trained observers on laptop computers during continuous 10-s intervals. Data on problem behavior and communication responses were converted to a rate measure; communication responses also were summarized as the percentage of responses that occured in the presence of the signal. Reliability was assessed by having a second observer simultaneously and independently collect data during at least 27% of sessions for each participant. Agreement percentages were calculated based on interval-by-interval comparisons of observers’ records. The smaller number of responses was divided by the larger number of responses in each interval; these fractions were then averaged and multiplied by 100%. Mean agreement for problem behavior was 99.6% (range, 95%-100%), 99% (range, 90%-100%), 99.3% (range, 88.1%-100%), 99.5% (range, 97.2%-100%), 98.8% (range, 93.3%-100%), and 98.6% (range, 92.5%-100%) for Amanda, Jennifer, Robert, Shelly, Mandy, and Elaine, respectively. Mean reliability for alternative communication responses was 98.8% (range, 96.7%-100%), 97.1% (range, 91.6%-100%), 99% (range, 96.7%-100%), 97.8% (range, 86.7%-

100%), 98.1% (range, 93.3%-100%), and 98.9% (96.7%-100%) for Amanda, Jennifer, Robert, Shelly, Mandy, and Elaine, respectively.

Safety Precautions

Certain measures were taken to prevent participants who engaged in SIB from harm throughout the course of the study. First, attempts at severe SIB were physically blocked by the therapist in the session. Second, criteria for (a) terminating sessions, and (b) seeking additional medical assistance were set for each participant prior to admission into the study. If the participant met the session termination criterion (e.g., presence of blood, bruising, or swelling) during the study, he or she was immediately removed from the session area and first aid was administered (e.g., compress or cold pack applied). If first aid did not result in a decrease in injury, as assessed by the experimenter, the participant was brought to the school or clinic nurse for additional medical assistance.

Procedure

A functional analysis, FCT intervention, and evaluation of maintenance under a signaled VI schedule were conducted for each participant. Responding during the functional analysis was evaluated within a multielement design; the effects of FCT and VI reinforcement were evaluated in a multiple baseline design across participants.

Functional analysis (baseline)

The functional analysis was conducted using a pairwise format (Iwata, Duncan, Lerman, Iwata, & Shore, 1994) during which responding in one test condition and one control condition was compared and contrasted. In the test condition, the reinforcer presumed to maintain behavior was provided contingent on the occurrence of problem behavior (contingent reinforcement; CR). Specifically, test conditions consisted of contingent access to preferred items (tangible condition) for Andrea, Robert, and Shelly, attention (attention condition) for Jennifer, and escape from task

demands (demand condition) for Mandy and Elaine. During the attention condition, the therapist provided moderately preferred toys to the participant, and instructed the participant to play with the toys while the therapist completed work. The therapist then sat down and ignored the participant unless the participant engaged in problem behavior. Contingent on problem behavior, the therapist provided approximately 10-15 s of attention in the form of response interruption, reprimands (e.g., “don’t do that”) and statements of concern. During the demand condition, the therapist instructed the participant to perform a variety of educational and vocational tasks using a three-step graduated prompting procedure (i.e., verbal, model, physical). Contingent on problem behavior, the therapist terminated task instructions, moved away from the participant, and did not interact with the participant for 30 s. During the tangible condition, the participant was given 2 min of continuous access to preferred tangible items (e.g., toys) prior to the session, after which, the therapist removed the preferred items, and the session began. The therapist returned the items to the participant for 30 s following each occurrence of problem behavior, and ignored all other behavior.

In the control condition, the same reinforcer was available continuously and irrespective of the occurrence of problem behavior (noncontingent reinforcement; NCR). Each condition was conducted in a separate area of a classroom (school) or a different treatment room (clinic), and was associated with the therapist wearing a distinctly colored t-shirt. The functional analysis continued until a pattern of responding emerged in which high rates of problem behavior during the CR condition relative to the NCR condition verified that the presumed reinforcer was responsible for behavioral maintenance. The CR condition of the pairwise FA served as a baseline for evaluating treatment effects during the FCT and signaled VI schedule conditions.

Functional communication training (FCT)

During the FCT condition, the contingency was reversed from baseline so that appropriate communication, as opposed to problem behavior, produced access to the reinforcer identified for each participant. At the outset of session, the therapist associated with the CR condition implemented antecedent events in a manner identical to the CR condition. That is, preferred items were removed from Andrea, Robert, and Shelly, Mandy and Elaine were instructed to engage in tasks, and Jennifer was "ignored". During session, each communication response resulted in 30-s access to the reinforcer identified during baseline, whereas, problem behavior resulted in extinction (no reinforcement). To facilitate the emission of communication, a second therapist verbally prompted the participant to appropriately communicate for the reinforcer at the beginning of each session. If the participant appropriately requested the reinforcer, no additional prompting occurred. If the participant did not request the reinforcer independently following the initial verbal prompt, additional prompts were given (initially at an interval 25% less than the interresponse time for problem behavior during baseline) and then were eliminated using a prompt-fading procedure, in which the prompt interval was increased by 50%. Additional prompting was required for the first session with Amanda and Robert, and for the first 6 sessions with Elaine. Fading was accomplished by gradually increasing the latency to the verbal prompt over time. The initial delay to prompt the communication response was set at 25% below the average inter-response time between occurrences of problem behavior during the last three CR sessions for Amanda and Robert, and 25% below the average latency to engage in problem behavior following an instruction during the last 3 baseline CR sessions for Elaine. The prompt delay was increased by 50% following two sessions at which problem behavior was at or below a 90% reduction from baseline. The FCT condition was terminated when a participant

engaged in (a) five consecutive sessions with problem behavior at or below a 90% reduction from baseline, and (b) independent communication.

Signal discrimination assessment

An assessment was conducted to identify a signal that was likely to be discriminated by each participant. During the assessment, visual stimuli were presented in random locations near the participant, with each presentation constituting a trial, and attending behavior (i.e., eyes directed toward stimulus) within 10 s of stimulus presentation was measured. Each stimulus was presented on 10 separate trials. A colored card or badge represented the first stimulus assessed for all participants, with the assumption that the presentation of a colored card would be easy to use in the natural environment. If the participant attended to the card on 80% of the trials, the colored card was selected as the signal. If the participant did not attend to the card on at least 80% of trials, additional stimuli were assessed. Five of the 6 participants attended to the colored card (Amanda, Robert, Maggie) or badge (Jennifer, Shelly) during the assessment; Elaine required assessment with 5 additional stimuli before a tungsten light panel was identified.

Signaled VI schedule thinning

During this condition, communication continued to produce access to the functional reinforcer, and problem behavior produced no programmed consequences; however, communication was reinforced according to a VI schedule that was thinned gradually over time. According to the VI schedule in effect, reinforcement was delivered for the first communication response that occurred after an interval of time had elapsed since the last communication response had been reinforced. Within the VI schedule, the availability of reinforcement for communication was signaled by the presentation of the stimulus identified during the signal assessment. The signal was presented to the participant at the precise second that the VI interval elapsed and remained present until the participant engaged in communication and received the

reinforcer. Once the signal was removed, the next interval began. Throughout this condition, each session began with the immediate presentation of the signal.

VI schedules were generated and randomized for each session using the Microsoft Excel RAND function, and schedule values ranged from 50% below to 50% above the VI schedule value used within that session. For example, if communication was reinforced according to a VI 70-s schedule, 50% of the VI values included interval lengths between 35-70 s, and 50% of the VI values would include interval lengths between 70 and 105 s. The initial VI value was set at 25% below (a) the average interresponse time between communication responses during the last three FCT sessions (Amanda, Jennifer, Robert, and Shelly) or (b) the average latency to engage in communication following an instruction during the last three FCT sessions (Mandy and Elaine).

The VI schedule was thinned by increasing the interval value by 50% following two consecutive sessions in which (a) the rate of problem behavior did not increase and (b) communication maintained. Thinning was terminated following five consecutive sessions in which the rate of problem behavior was at or below a 90% reduction from baseline, communication continued to occur, and a large proportion of communication responses occurred in the presence of the signal under a terminal schedule of VI 240 s.

Results

Figures 5-1 and 5-2 depict the results of the clinical evaluation of the signaled VI schedule for the participants whose problem behavior was maintained by social positive reinforcement. During baseline, Amanda (Figure 5-1, top panel) engaged in aggression during the CR condition but not during the NCR condition, indicating that her aggression was maintained by positive (tangible) reinforcement. During FCT, when requests ("Can I have my toys back please") produced access to toys, and aggression was placed on EXT, Amanda immediately began

making requests, while her aggression decreased to zero. During thinning, when the schedule of reinforcement for requests was increased from VI-30 s to VI-240 s, her requests gradually decreased and maintained at low rates, with no observed increase in problem behavior. The percentage of requests that resulted in reinforcement during thinning was 80%.

Jennifer (Figure 5-1, bottom panel) engaged in problem behavior (SIB, aggression, and disruption) during the CR condition in baseline but not during the NCR condition, indicating that these problem behaviors were maintained by positive reinforcement (access to attention). The implementation of FCT resulted in an immediate increase in requests for attention ("Can we talk?"), and an immediate decrease in problem behavior. Thinning reinforcement from a VI-30 s to a VI-240 s was associated with an immediate decrease in requests, which decreased further as the condition progressed. With the exception of a few sessions, thinning was associated with low rates of problem behavior relative to the baseline CR condition. In addition, 98% of Jennifer's communication responses resulted in access to reinforcement.

Robert (Figure 5-2, top panel) engaged in aggression during the CR condition in baseline but not during the NCR condition, indicating that his aggression was maintained by positive (tangible) reinforcement. During FCT, when reinforcement was delivered following appropriate requests ("Can I have my toys back, please?") but not following aggression, requests increased immediately, and aggression decreased to zero. Thinning the reinforcement schedule to the terminal value of VI-240 s was accomplished with gradual reductions in requests while maintained zero rates of aggression. In addition, 90% of Robert’s requests resulted in reinforcement during thinning.

Shelly (Figure 5-2, bottom panel) engaged in SIB and aggression during the CR condition in baseline but not during the NCR condition of baseline, indicating that these behaviors were

maintained by positive (tangible) reinforcement. FCT was associated with an increase in requests ("Can I have my toys back please?") and a decrease in problem behavior to zero. Signaled VI thinning was associated with an immediate decrease in requests and further decreases throughout the condition. Problem behavior increased temporarily when the schedule was first increased to a VI 30-s but subsequently decreased to zero for the remainder of the condition except for one session. Further, 100% of her requests resulted in reinforcement during thinning.

Figure 5-3 shows data for the 2 participants whose problem behavior was maintained by social negative reinforcement (escape from task demands). Mandy (top panel) and Elaine (bottom panel) both engaged in problem behavior under the CR condition but not in the NCR condition of baseline, verifying that problem behavior was maintained by escape. When FCT was implemented for Mandy, appropriate requests ("Break please") increased to variable rates, whereas aggression and property destruction showed noticeable variability initially, before decreasing to zero. Schedule thinning produced an immediate and then more gradual decrease in requests and low to zero rates of problem behavior. For Mandy, 97% of communication responses resulted in reinforcement during thinning. During Elaine's FCT condition, voice-output microswitch presses emerged somewhat slowly but then increased steadily. Her problem behavior showed some variability throughout the first part of the FCT condition but eventually decreased to zero. During schedule thinning, Elaine's microswitch press decreased gradually throughout the condition, and problem behavior remained at or near zero except for three sessions. In addition, 97% of Elaine's microswitch press resulted in reinforcement during the thinning phase.

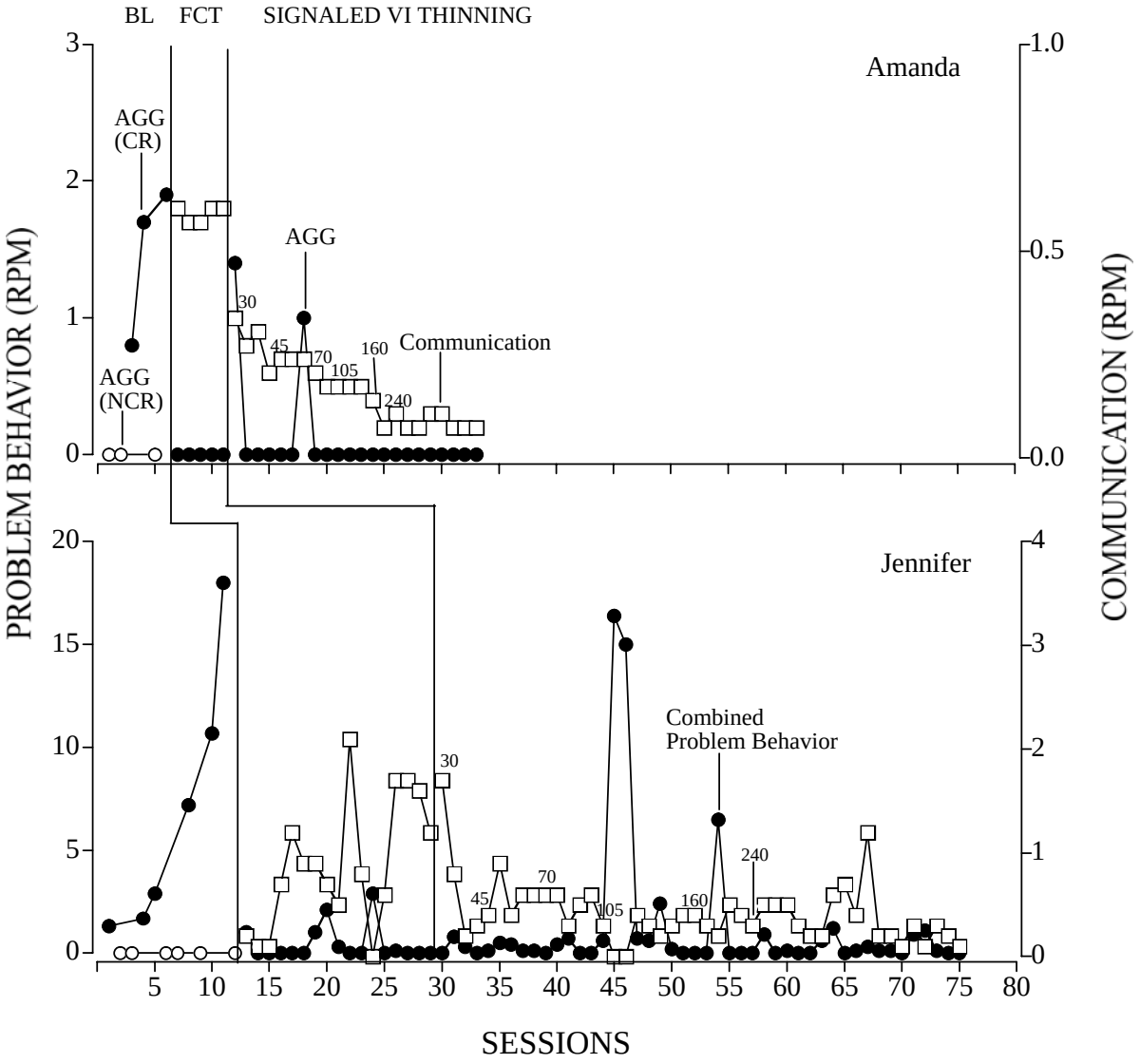

Figure 5-1. Rate of problem behavior and communication during baseline (CR v. NCR), FCT, and during signaled VI thinning for Amanda and Jennifer

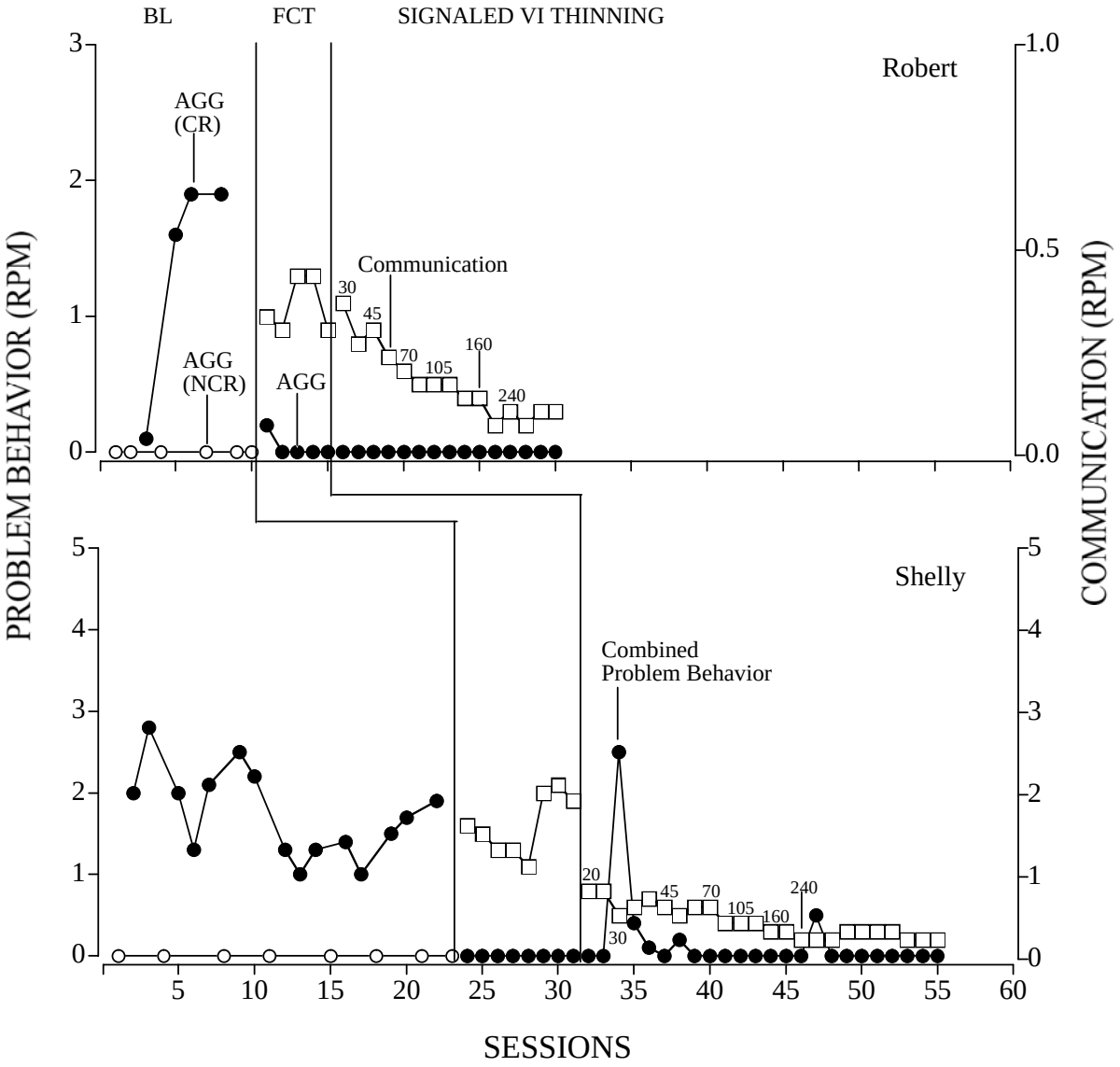

Figure 5-2. Rate of problem behavior and communication during baseline (CR v. NCR), FCT, and during signaled VI thinning for Robert and Shelly

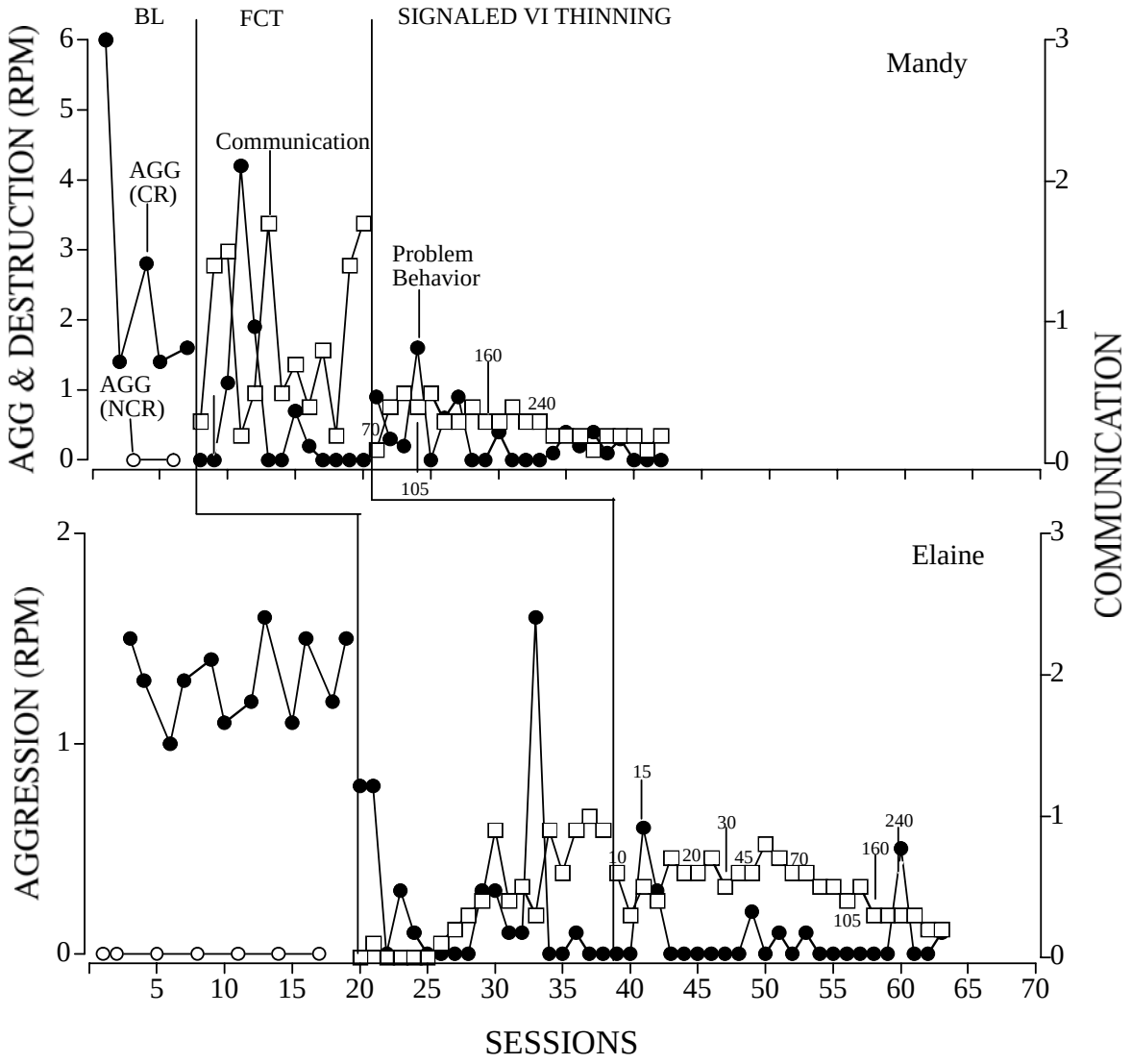

Figure 5-3. Rate of problem behavior and communication during baseline (CR v. NCR), FCT, and during signaled VI thinning for Mandy and Elaine

Table 5-1. Operational definitions

Participant	Target	Operational Definitions
Amanda	Aggression	Hitting: Forceful contact between hand and the body of another individual. Scoring required hand to travel at least 6" and to produce an audible sound upon contact
Jennifer	SIB	Skin picking: fingernail to skin contact with movement associated with skin depression or lifting Scratching: movement of a fingernail across the skin Self-biting: closure of teeth on any part of participant's body Bandage tampering: finger to bandage contact with movement of bandage
	Aggression	Hitting: forceful contact between hand and body of another individual. Scoring required hand to travel at least 6" and to produce an audible sound upon contact Kicking: forceful contact between foot and body of another individual. Same scoring criteria as with aggression Biting: closure of teach on any part of another individual's body Throwing objects at others: object must pass within 2' of individual
	Disruption	Ripping/tearing objects: ripping at least 1 " or breaking objects such that tear or break in material is visible Throwing objects: object must travel at least 2'
Robert	Aggression	Hitting: Forceful contact between hand and the body of another individual. Scoring required hand to travel at least 6" and to produce an audible sound upon contact Kicking: forceful contact between foot and body of another individual. Same scoring criteria as with aggression Head butting: Forceful contact between head and the body of another individual Choking: placement around neck of another individual with pressure directed inward
Shelly	SIB	Skin picking: fingernail to skin contact with movement associated with skin depression or lifting Scratching: movement of a fingernail across the skin Self-biting: closure of teeth on any part of participant's body Bandage tampering: finger to bandage contact with movement of bandage Head banging: forceful contact between the head and any surface from a distance of 6" or greater with audible sound. Head hitting: forceful contact between the hand and any part of the head from a distance of 6" or greater with audible sound Teeth banging: forceful contact between teeth and any surface Nose picking: insertion of a finger into the nose
	Aggression	Hitting: forceful contact between hand and body of another individual. Scoring required hand to travel at least 6" and to produce an audible sound upon contact Kicking: forceful contact between foot and body of another individual. Same scoring criteria as with aggression Biting: closure of teach on any part of another individual's body or clothes Throwing objects at others: object must pass within 2' of individual
	Disruption	Throwing objects: object must travel at least 2' Breaking objects: tear or break in material must be visible Hitting/Kicking objects: forceful contact between hand/foot and any surface. Body part must travel at least 6" and produce audible sound Overturning furniture: furniture must be displaced 45 degrees from upright
Mandy	Aggression	Hitting: forceful contact between hand and body of another individual. Scoring required hand to travel at least 6" and to produce an audible sound upon contact Kicking: forceful contact between foot and body of another individual. Same scoring criteria as with aggression Biting: closure of teach on any part of another individual's body or clothes
	Property Destruction	Breaking objects: tear or break in material must be visible Hitting/Kicking objects: forceful contact between hand/foot and any surface. Body part must travel at least 6" and produce audible sound Writing on walls
Elaine	Aggression	Hair pulling: grasping hair with any part of hand and pulling in direction away from head Scratching: movement of fingernail across skin Pinching: closure of at least two fingers around the skin with pressure directed toward the skin

CHAPTER 6
DISCUSSION

The present studies provide both a basic demonstration and a clinical extension of the effects of signaled VI reinforcement on responding. Data from both studies indicated that this type of schedule may facilitate maintenance when relatively low rates of responding are desirable following initial response acquisition.

In Study 1, response rates were compared under two VI-30 s schedules that were identical except that the end of the VI interval (i.e., the availability of reinforcement) was unsignaled in one schedule but signaled by the presentation of a visual stimulus in the other. Under the unsignaled VI-30 s schedule, only 1 of the 4 participants engaged in moderate response rates (George), and a small percentage of responses resulted in reinforcement across participants. By contrast, responding became moderate and efficient for all participants under the Signaled VI 30-s schedule, occurring at approximately 2.0 rpm at the end of the condition. Further, a large proportion of responses resulted in reinforcement across participants.

As the unsignaled and signaled conditions differed only with respect to the presence and absence of the signal, differences in responding observed between the two conditions can be attributed to the effects of the signal. In the absence of the signal, it is likely that participants could not discriminate the availability of reinforcement (the end of the interval), particularly given the variable nature of the schedule. Hence, other factors, such as those discussed below, may have contributed to the variability in responding observed.

The presence of the signal may have increased the likelihood that participants could discriminate the availability of reinforcement, such that responding occurred primarily in the presence of the signal, when it was likely to contact reinforcement. Given the high probability of

reinforcement for responding, the response-reinforcer contingency was likely to remain strong, resulting in low but persistent rates of behavior.

The results of the signaled VI condition are consistent with those reported by Azrin (1958), who examined the effects of an auditory stimulus, noise, on the FI observing responses of 80 soldiers. A meter needle was deflected every 3 min, and soldiers were trained to release a switch to bring the needle back to its normal position. The room was kept dark, and presses on a button illuminated the needle for 0.1 s; the sight of the needle deflecting was considered the reinforcer. During baseline, responses occurred rarely during the first 2 min of the FI schedule; however, high response rates occurred throughout the 3rd min of the FI until the needle was detected and restored. When a 110-decibel white noise was continuously present throughout the first 165 s of the interval but was discontinued for the 15 s preceding a needle deflection, observing responses occurred only during the 15-s period of quiet and never during the initial 165 s of noise.

The temporal relation of noise to the target was then reversed so that 165 s of quiet preceded a 15-s period of noise. Soldiers responded by making observing responses during the 165 s of quiet and no observing responses during the 15 s of noise. Recovery occurred around interval 14, and soldiers began to respond only during the 15 s of noise. At that point, the temporal relation of noise to the target was again reversed to the initial conditions, and soldiers again responded exclusively during periods of quiet. Azrin (1958) concluded that the noise (or quiet) had acquired discriminative control over observing responses to the exclusion of control by the temporal properties of the FI schedule.

Previous research with nonhuman subjects has shown that unsignaled VI schedules tend to produce low to moderate, stable response rates (Ferster & Skinner, 1957). In the current study, however, only 1 participant engaged in moderate response rates throughout the unsignaled

condition (George), and the responding of the other participants was characterized by a high degree of variability. High response rates, which stabilized toward the end of the condition, were observed for 1 participant (Katy) whereas moderate, but increasing response rates were observed for Lesley. Initially high response rates, that decreased to low to zero rates after four sessions, were observed for Charlotte.

Responding that is inconsistent with a current reinforcement schedule, such as that observed with Katy, Charlotte, and Lesley, may reflect the influence of historical variables such as prior experience with a different reinforcement schedule (Weiner, 1969). Freeman and Lattal (1992), for example, trained three pigeons on an FR-1 schedule before exposing them to a VI schedule, while discriminative stimuli were held constant across the schedules. Following training, all pigeons engaged in high response rates during the initial 8 sessions of the VI condition, and one pigeon engaged in high response rates across all sessions of the VI condition.

Historical control, such as that identified in the study by Freeman and Lattal (1992) may have accounted for the persistent high rate responding observed under the VI schedule for Katy and Lesley. In Charlotte's case, however, high response rates may have interacted with the temporal delivery of reinforcement under the VI schedule to produce the steep decline in responding after four sessions. More specifically, if high response rates were emitted under the VI schedule, and reinforcement was not delivered for an average of 30 s, several responses would have been unreinforced, resulting in EXT of the response. In support of this, Charlotte's data under the VI schedule are characteristic of responding during EXT. That is, a slight increase in responding resembling an extinction-induced burst was observed immediately after Charlotte switched schedules, followed by systematic decreases in response rate to zero.

The generally decreasing trend observed across the unsignaled and signaled VI conditions for George may suggest the occurrence of an order effect. That is, responding under the unsignaled VI schedule may have influenced responding under the signaled VI schedule. However, the greater percentage of responses that produced reinforcement under the signaled VI schedule (67.4%) relative to the unsignaled VI schedule (40.1%) suggested that the signal, as opposed to a previous history with the VI schedule, accounted for the moderate and efficient responding observed under the signaled VI schedule for George.

To summarize, the signaled VI schedule was effective in maintaining moderate and efficient response rates, which provided a basis for evaluating the schedule in an applied context in Study 2.

Study 2 involved a clinical evaluation of the signaled VI schedule as a maintenance procedure following acquisition of an alternative response to problem behavior. A pairwise functional analysis similar to that used by Hanley et al. (2001) identified a maintaining contingency for each participant's problem behavior. Although the pairwise assessment included only one test condition and did not rule out other environmental influences on problem behavior, it was sufficient to develop an intervention strategy based on the identified function. The differential reinforcement procedures implemented as FCT were effective in decreasing problem behavior and increasing communication for all participants. These results were consistent with those from a large body of research supporting the use of FCT as treatment for problem behavior maintained by social consequences (e.g., Hagopian et al., 1998; Wacker et al. 1990).

The vast majority of studies on FCT involve continuous schedules of reinforcement for alternative behavior (e.g., Carr & Durand, 1985). Although continuous reinforcement may be advantageous during response acquisition, a comparable reinforcement schedule is not likely to

exist in the natural environment, where several factors preclude the immediate delivery of reinforcement (e.g., parent attending to another child). To preserve the integrity of FCT outcomes under naturalistic conditions, strategies for maintaining communication under conditions of intermittent or delayed reinforcement are necessary.

A survey of the basic and applied literature revealed that response maintenance is related to preservation of the response-reinforcer contingency (Hanley et al., 2001; Sizemore & Lattal, 1978), and that contingency preservation may be facilitated through the use of signals that are correlated with the availability of reinforcement (Hanley et al., 2001). In the current study, signaled VI thinning, in which alternative behavior was reinforced less frequently over time according to an increasing VI schedule that included a signal when the interval terminated, was used as the maintenance strategy. The schedule was effective in maintaining treatment effects under increasingly intermittent reinforcement. That is, as the reinforcement schedule was thinned to the terminal value of 240 s, problem behavior remained low, and alternative behavior decreased to rates that reflected the availability of reinforcement.

Data indicating that a high percentage of alternative responses resulted in reinforcement during thinning provides evidence that the signal had acquired stimulus control over appropriate behavior. At any given interval value during thinning, there are limited opportunities for reinforcement. Under a VI-70 s schedule, for example, there are approximately 8 potential reinforcer deliveries within a 10-min session. For a high percentage of responses to contact reinforcement, a participant would have to respond when, and only when reinforcement was available. Across participants, 93.7% of communication responses resulted in reinforcement, indicating that participants discriminated the availability of reinforcement and responded accordingly.

Results of the current study are consistent with those of Hanley et al. (2001), showing that signaled reinforcer availability produces moderate rates of communication that occur at appropriate points in time (i.e., when reinforcement was available) and low rates of problem behavior. The differences between the multiple-schedule used by Hanley et al. (2001) and the VI schedule in the current study suggest different types of application. When only one response is sufficient for reinforcement, but reinforcement will be delayed or available only once in awhile, the signaled VI schedule may be preferred. Most relevant to the use of the signaled VI schedule are instructional or other demand-related situations in which only one request for a break or task termination is required and appropriate; however, completion of the task is mandatory (e.g., brushing teeth). By contrast, when higher rates of behavior are either acceptable or desirable, but reinforcement will be unavailable for periods of time, the multiple-schedule may be advantageous. For example, repeated requests for attention are considered appropriate during periods of conversation or play, and may be accommodated nicely within a multiple schedule.

During reinforcement thinning, several sessions were conducted before alternative behavior became moderate and efficient, which suggests that discriminative control over responding may require time to develop. Future investigations may examine procedures for facilitating the establishment of stimulus control prior to exposing newly acquired behavior to conditions of intermittent or delayed reinforcement. For example, presenting a stimulus during the initial reinforcement phase (FR-1) would establish a longer history of reinforcement in the presence of the signal and may be an efficient way to generate stimulus control over responding prior to using the signal clinically.

The structure of the signaled VI procedure is potentially susceptible to producing inadvertent reinforcement of problem behavior. More specifically, the onset of the signal is time-

based, and if problem behavior occurs temporally close to the onset of the signal, it may become associated with the signal, and the subsequent production of reinforcement. The terminal result of this process is that the signal may become discriminative for the occurrence of problem behavior (as opposed to alternative behavior), engendering high rates of problem behavior in its presence. Although not a problem in the current investigation, therapeutic use of the signaled VI procedure may incorporate a changeover delay contingent on the occurrence of problem behavior. A changeover delay involves a brief delay to reinforcement (or onset of the signal) following problem behavior, such that inadvertent reinforcement of problem behavior can be reduced.

Future research may also examine additional therapeutic uses of signals. In some situations, it is not possible or acceptable to use extinction during the treatment of problem behavior, and discriminative control over appropriate responding may decrease the likelihood that problem behavior will occur and inadvertently contact reinforcement. For example, severe SIB may be maintained by attention; however, the delivery of attention following self-inflicted injury may be unavoidable. If, however, appropriate requests for attention are brought under the control of signals, appropriate requests may occur to the exclusion of problem behavior.

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BIOGRAPHICAL SKETCH

Carrie Dempsey was born in Santa Rosa, California (CA), in 1975. She graduated with a Bachelor of Arts degree in psychology and Latin American & Iberian studies from the University of California-Santa Barbara in 1995. Following graduation, Carrie pursued higher education at the University of the Pacific in Stockton, CA, where she was first exposed to behavioral psychology and became inspired to develop as a behavior analyst. Carrie entered graduate school at the University of Florida in 2002 under the supervision of Brian A. Iwata. Upon graduation, she intends to return to CA to establish a research-oriented treatment center for severe problem behavior. In her spare time, Carrie enjoys being in the outdoors, kayaking, traveling, and learning about various aspects of computer technology.