

The Relative Efficacy of Three Procedures
for Reducing Canine Responding

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ABSTRACT

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Three response reduction procedures commonly employed in applied behavior analysis are extinction, differential-reinforcement-of-other-behavior (DRO) schedules, and time-based schedules of event delivery such as the fixed-time (FT) schedule. Each of these three procedures holds promise for the amelioration of canine behavior problems, yet none has been studied systematically, alone or in comparison with other procedures, with domestic dogs. In this research, the buoy-touching responses of eleven dogs were shaped and maintained using edible reinforcers. Responding then was exposed either to extinction, a fixed or an escalating DRO schedule, or an FT schedule. Extinction reduced responding more rapidly than the escalating DRO schedule and more rapidly and completely than the FT schedule. It also was easiest to implement and produced no differential emotional responding or response bursts. This research represents a rare application of single-subject research methods to the analysis of canine responding in the pet dog's natural (home) environment and may serve to bridge the gap between the fields of applied animal behavior and behavior analysis.

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Introduction

Over the last 30 years, the estimated number of pet dogs in the United States has increased from 40 to 55 million (Favre & Borchelt, 1999; Tuber, Hothersall, & Voith, 1974). The pet care market is booming, with an expanding variety of services and products for these dogs comprising an industry that generated \$38 billion in sales in 2002 (Kostelac, 2006). As the popularity of dogs increases, costs related to canine behavior problems increase as well. An average of 2 million dog bites per year cost \$30 million in health care, while insurance costs resulting from dog bites and other canine behavior problems exceed \$1 billion per year (Favre & Borchelt, 1999). Approximately 4 million dogs in the United States are relinquished to animal shelters each year, and more than half of these subsequently are euthanized or recycled through the shelter system, creating a financial burden for taxpayers while maintaining dogs in noisy, overcrowded, or isolated conditions (Coppinger & Zuccotti, 1999; Tuber et al., 1974). Many owners report relinquishing their pets because of behavior problems exhibited by the animals (Salman et al., 1998). For those dogs that are not relinquished by their owners, many still face quality-of-life reductions due to behavior problems. Such behavior problems often result in the dogs' isolation from family activities or living spaces and, in extreme cases, the dogs being abused or neglected. In less extreme cases, these dogs are exposed to a variety of inconsistent or naively applied, and often ineffectual, attempts at behavior change.

The most prevalent behavior problems exhibited by pet dogs are aggression, fearful behavior, destruction of property, jumping, barking, and other forms of excitability (Bennett & Rohlf, 2007; Kobelt, Hemsworth, Barnett, & Coleman, 2003; Wells & Hepper, 2000; Wright & Nesselrote, 1987). Such behavior often is considered most problematic when it occurs at high rates, yet little research has been conducted to compare procedures for reducing rates of problematic canine behavior. In the field of behavior analysis, several procedures have been demonstrated to reduce response rates. Three such procedures are extinction, differential-reinforcement-of-other-behavior (DRO) schedules, and time-based schedules of event delivery such as the fixed-time (FT) schedule. Extinction involves discontinuation of the reinforcer that previously maintained a response. In a DRO schedule, reinforcers are delivered following a period of time during which no response was emitted, and each response delays the upcoming reinforcer by some interval of time. In a time-based schedule, reinforcers are delivered independently of responding, following the passage of fixed or variable periods of time. Each of these three procedures holds promise for the amelioration of canine behavior problems, yet none has been studied systematically, alone or in comparison with other procedures, with canine subjects.

Across the three experiments comprising this dissertation, the responding of 11 dogs was exposed to these procedures to evaluate the efficacy of each in reducing canine response rates. Assessment, refinement, and generalization of these procedures as employed with dogs should provide the applied animal behaviorist, dog trainer, or dog owner with more precise and effective strategies for reducing canine problem behavior. More generally, the research presented here may serve as a methodological model for researchers interested in examining canine responding in the pet dog's natural environment. Most research in which canines have served as subjects either has not specifically addressed environmental determinants of canine responding or has suffered from empirical or conceptual weaknesses making interpretation of results difficult.

Behavior analysis and the research methods that exemplify it have much to offer the field of applied animal behavior, yet communication between the fields is minimal. The research presented here provides an example of scientific inquiry driven by applied problems that, via its use of an analogue approach, maintains the internal validity of single-subject, steady-state basic research methods. Such an approach has been proposed as an essential intermediate step, one not taken frequently enough, along the continuum of basic and applied research in behavior analysis (Bernstein & Paul, 1971; Johnston, 1996). Moreover, such an approach has been little utilized in applied animal behavior research and the field stands to gain methodological rigor by more closely approximating research methods commonly employed in behavior analysis.

Literature Review

Canine Behavior Research

Skinner (1951) provided an early exposition on the application of techniques from the behavioral psychology laboratory to the training of pet dogs. In his description of how to use shaping to teach a dog to touch its nose to a cupboard, Skinner emphasized the importance of the immediacy of reinforcement and described how a cricket toy (i.e., a clicker) could be used as a conditioned reinforcer by pairing it with the edible primary reinforcer. [Four decades later, a panel discussion was devoted to this topic at the Association for Behavior Analysis conference in San Diego, and clicker training, as it is popularly called, now has become a predominant technique used in canine obedience training and behavior problem resolution (Pryor, 2002).] In that same year, two of Skinner's graduate students, Keller and Marian Breland, introduced a field they called applied animal psychology, a field uniting professional animal training with behavioral science to the benefit of both (Breland & Breland, 1951). The Brelands proposed that basic research in the laboratory could provide answers to questions that arise from the application of behavioral techniques to the training of animals in field settings. In turn, the application in field settings of techniques proven effective in the laboratory could inform the basic science by, for example, demonstrating failures of those techniques to function similarly in non-laboratory settings (e.g., Breland & Breland, 1961). Others have called for a unification of behavioral psychology with animal training and pet behavior management, yet the field of applied animal behavior has been slow to develop (Donaldson, 1996; McIntire, 1968; Tuber et al., 1974).

There is a substantial body of research in which canines have served as subjects, yet the majority of this research falls short of accounting causally for environment-behavior relations. Canine behavior research falls into one of a few general categories: comparative social cognition research, in which canine cognitive processing or social understanding reportedly is determined via examination of canine choice responding (Miklosi & Topal, 2004); testing in which the fearful, exploratory, or aggressive responses of dogs to novel environmental stimuli are interpreted as indications of the dogs' temperaments (Diederich & Giffroy, 2006); or research in which canine behavior problems or responses to treatment are measured from questionnaires or surveys completed by owners (e.g., Guy et al., 2001). Each of these areas of research suffers from methodological problems that make interpretation of results difficult. For example, behavioral differences across subjects often are attributed to innate differences in cognitive ability without controlling for differences across subjects' learning histories (Cooper et al.,

2003), and behavioral measures often lack standardization across experiments (Diederich & Giffroy, 2006) or rely on potentially invalid owner reports instead of direct observation (Guy et al., 2001).

The field of applied animal behavior stands to benefit from research in which canine responses are defined precisely, comprised of observable dimensions of behavior, and measured directly by trained observers. When data are collected in the pet dog's natural environment, this can be achieved via direct observation, videotaping, or the use of recording equipment that reliably captures canine responding. Although such methods can enhance the internal validity of the research, they have been utilized only infrequently. McIntire and Colley (1967), for example, assessed whether praise functioned as a reinforcer for the responding of six dogs. Across conditions of a reversal design (cf., Barlow & Hersen, 1984), these authors used either praise alone (i.e., "Good dog") or praise plus 5 s of petting as reinforcement for compliance with several basic obedience commands. Using latency to respond calculated via a handheld timer, McIntire and Colley found that dogs took longer to respond when only praise was used as compared to when both praise and petting were provided. This effect was replicated across subjects who had and had not received prior obedience training. The authors concluded that praise alone is insufficient to maintain responding with short latencies and that tactile stimulation is an important component of reinforcement for the responding of pet dogs. This research represents a rare case in which experimental control was demonstrated via the reversibility of canine responding with individual subjects. Over the last 40 years, research in which canine responding is directly and objectively measured outside of the laboratory has been almost nonexistent. In the occasional cases in which it has been utilized, no experimental variables were manipulated (Dreschel & Granger, 2005; Lund & Jorgenson, 1999).

For research with canine subjects to best inform the field of applied animal behavior, it should involve the manipulation of an independent variable and direct and reliable measures of responding by trained observers (with a corresponding measure of interobserver agreement). Within-subject designs, standard in behavior analysis, are well-suited to the demonstration of experimental control via their replication of environmental effects across time within individual organisms and may prove useful to the field of applied animal behavior. In short, the field of applied animal behavior is in need of internally valid and reliable research that emphasizes objective measures of problematic or non-problematic canine responding. Behavior analysis offers research methods that meet these criteria. Such research methods have been employed, for example, to examine various response reduction procedures with human and nonhuman subjects. Some of this research now will be discussed.

Extinction

Extinction here refers to nondelivery of the reinforcer that previously maintained responding (but cf., Rescorla & Skucy, 1969). For example, if a dog's whining is maintained by attention from the owner, then extinction of this response would involve no longer providing attention to the dog during or immediately after whining occurs. The consequence of extinction is a reduction in the frequency of the response over time. In an early investigation of extinction, Skinner (1938) first reinforced approximately 100 lever presses emitted by each of four rats, after which he disconnected the food magazines from the levers. Cumulative records of lever

pressing across one hour of extinction revealed decreases in responding with progressively longer pauses between bursts of responses. Skinner noted that early in extinction, lever pressing occurred at rates higher than in the preceding baseline phase, a phenomenon known as an extinction burst. He also noted the presence of spontaneous recovery, in which previously-extinguished lever pressing increased following a period of time during which subjects were not exposed to the experimental situation. Both of these extinction phenomena continue to receive attention today (DuCharme & Van Houten, 1994) and will be discussed further below.

In a now-classic case study on the application of extinction, Williams (1959) decreased the duration of a 21-month-old infant's bedtime crying. Intake interviews revealed that the infant's crying when put to bed had resulted in the parents staying in the room with him for up to two hours until he fell asleep. When the parents discontinued this attention by simply putting the infant to bed and leaving the room, the duration of crying decreased from 45 to 0 min in seven days. Although it increased in duration when a family member ignorant to the treatment protocol reinforced it, crying again was reduced with another seven days of extinction. No further bedtime crying was recorded for two years following treatment. Ayllon and Haughton (1964) demonstrated the reversibility of reinforcement and extinction effects on rates of responding through their use of a reversal design. In reinforcement conditions, three patients who engaged in bizarre vocalizations were given candy, cigarettes, and attention by ward staff contingent on psychotic verbal behavior. In extinction, these reinforcers were withheld following this behavior. The psychotic verbalizations of each patient increased to twice the baseline levels when reinforcement was contingent upon them and decreased to near-zero levels when reinforcement was withheld.

Extinction can decrease problem behavior maintained by either positive or negative reinforcement. If the reinforcer to be withheld in extinction is not chosen based on the function of the response, then treatment may be ineffective or may even increase problem behavior. In the case of positively reinforced behavior, as described above, extinction involves no longer presenting the reinforcer contingent on the problem response. In the case of negatively reinforced behavior, such as behavior maintained by escape from demands, extinction involves continuing and not terminating the demands contingent upon the problem response. For example, a dog may learn to growl when growling results in discontinuation of nail-clipping. Extinction of growling would involve continuing with nail-clipping despite the dog's growling. Iwata, Pace, Cowdery, and Miltenberger (1994) conducted a functional analysis (cf., Iwata, Dorsey, Slifer, Bauman, & Richman, 1994) revealing that each of three children's self-injurious behavior (SIB) was maintained by attention, escape, and sensory stimulation, respectively. Extinction procedures that ensured removal of the functional reinforcer were implemented with each child and compared, where possible, with a variation of extinction that was not related to the functional reinforcer. When these irrelevant variations of extinction were implemented, responding was never reduced to lower than 75% of baseline rates. When extinction was based upon the functional reinforcer, however, it was quite effective in reducing responding: Implemented a total of eight times across three subjects, extinction reduced responding within several sessions to below 15% of baseline levels. Response rates remained at these low levels for up to 25 sessions. This rapid reduction to, and maintenance of, low levels of responding under extinction also has been reported by others (Repp, Felce, & Barton, 1988).

Extinction has not, however, consistently been implemented without criticism. Lovaas and Simmons (1969) exposed the SIB of each of two children to 60 sessions of extinction. Extinction consisted of leaving each child alone in a room for 90 min a day while the experimenters observed through one-way glass and recorded each instance of SIB. Although SIB was reduced across sessions for both children, Lovaas and Simmons cautioned against the use of extinction in cases where the response to be extinguished may cause harm to the individual or others. Specifically, they noted that reduction of SIB with these two participants was gradual, and was preceded by increased levels of intensity of SIB (i.e., an extinction burst) for the first several extinction sessions. These authors suggested that alternative procedures that reduce responding rapidly while avoiding initial response bursts may be preferable to extinction. In addition to the gradual reduction in responding and the extinction burst sometimes obtained in extinction, there are other characteristics or side effects of extinction that traditionally have inhibited its use in applied settings (DuCharme & Van Houten, 1994). These include extinction-induced aggression or agitated behavior and spontaneous recovery (see Lerman & Iwata, 1996, for a review). Each of these will be discussed briefly, and conclusions will be made regarding the role each should play in controlling practitioners' consideration of extinction as a response reduction procedure.

Speed of response reduction

As mentioned above, Skinner (1938) described responding under extinction as characterized by longer pauses between bursts of responding, the inter-response times of which were similar to those of baseline. Since then, the rate of change in responding exposed to extinction typically has been described as slow (DuCharme & Van Houten, 1994; Poling & Ryan, 1982), a characteristic that is problematic in applied settings, in which the rapid reduction of problem behavior typically is desirable. Lovaas and Simmons (1969) reported that one participant emitted almost 9000 self-injurious responses across ten 90-min sessions before SIB ceased. The second participant showed a gradual response reduction across the first 17 sessions, with the frequency of SIB dropping from approximately 900 to 500 responses per session before additional procedures were required to reduce SIB further.

Although others also have reported a gradual reduction in responding under extinction, (e.g., Wright, Brown, & Andrews, 1978), there are notable exceptions in which extinction reduced responding rapidly and efficiently (Ayllon & Haughton, 1964; Carr, 1988; Carr & Bicknell, 1985). Some reports of a gradual reduction in responding might be explained by the authors' failure to identify functional reinforcers prior to treatment. For example, in the study by Lovaas and Simmons (1969), it was hypothesized that attention was the maintaining reinforcer, and thus attention was withheld during experimental sessions. Yet no functional analysis was conducted prior to treatment and gradual reductions in responding might be expected if the responding was maintained by other reinforcers (e.g., sensory stimulation) in addition to or instead of attention, a possibility that cannot be ruled out in this case.

Lerman and Iwata (1996) suggested several strategies that applied behavior analysts might employ to accelerate the speed of response reduction under extinction (i.e., to decrease resistance to extinction). For example, decreasing delays to reinforcement (Mayhew & Anderson, 1980) or enriching the schedule of reinforcement (Kazdin & Polster, 1973) prior to

extinction can reduce subsequent resistance. In a rare application of such a manipulation with pet dogs, Carr and Bicknell (1988) implemented a continuous schedule of immediate reinforcement (CRF) prior to extinction in an attempt to reduce barking by a spaniel. An interview with the owner revealed that this dog's barking had been waking her approximately five times a night as she was sleeping in bed. The owner would intermittently and after varying delays respond to barking by getting out of bed and going to the kitchen, where she would deliver a biscuit to her dog. During the CRF condition, the owner immediately delivered a biscuit to the dog from the bedside table each time, and as soon as, the dog barked. After eight nights of this procedure, in which barking increased and was maintained between 15 and 35 barks per night, extinction was implemented. In extinction, the owner was instructed to discontinue completely all biscuit delivery. During the first night, an extinction burst occurred, in which the dog barked steadily for 3.5 hours. Across the subsequent nights of extinction, the dog whined only once in the fifth night and showed no further barking thereafter. Barking was maintained at zero levels during follow-up sessions conducted four months later. Procedures such as this should be considered and implemented where possible to decrease the resistance of problem behavior to extinction (see also Lerman, Iwata, Shore, & Kahng, 1996).

Extinction bursts

An extinction burst is an increase in the frequency, intensity, duration, or variability of responding when that response is first exposed to extinction. The possibility of an extinction burst is a common argument against its use in treating problem behavior (DuCharme & Van Houten, 1994). In the extinction burst noted by Lovaas and Simmons (1969), the SIB of each subject was reported to increase dramatically in intensity, causing "much apparent discomfort" (p. 147). This report was anecdotal, however, and no baseline data were presented with which to compare these increases. Iwata et al. (1994) obtained an extinction burst in only one of eight applications of extinction. In this extinction burst, a participant's SIB, which was present in 40% of recorded intervals during the last day of baseline, increased to 65% of intervals during the first session of extinction. It decreased dramatically by the second session, present in only 20% of intervals, and remained low thereafter. In their review of 113 sets of data in which extinction was employed to reduce problem behavior, Lerman and Iwata (1995) report that extinction bursts occurred in 36% of cases when implemented alone and in only 12% of cases when implemented in combination with other procedures such as differential reinforcement or time-based schedules of reinforcer delivery. Lerman, Iwata, and Wallace (1999) found that an extinction burst was reported in 62% of cases in which extinction was used alone and in 15% of cases in which extinction was combined with other treatments. From these reviews, it appears that the extinction burst may remain a viable threat to the application of extinction when used alone, especially in cases where the topography of the response is one that is injurious, dangerous, or severely maladaptive.

Extinction-induced aggression or agitated behavior

In the first demonstration of extinction-induced aggression, Azrin, Hutchinson, and Hake (1966) first shaped key pecking by pigeons and then exposed them to two conditions in alternation. In one condition, key pecks never produced grain within a session. In a second condition, responding intermittently produced grain within each session; a tone was presented

every 5 min, at which point the next 10 key pecks produced access to grain. Extinction then was in place for another 5 min before the tone again signaled the opportunity for responding to produce reinforcement. Across both of these conditions, a second, “target” pigeon was restrained within the experimental chamber in such a way that its head and neck were exposed to the subject. By measuring the closure of switch contacts located beneath the restraining box, these authors were able to assess attacks on the target pigeon by the subjects. They found that subjects attacked the target pigeon at near-zero rates in the extinction only condition. When extinction and reinforcement opportunities were alternated within sessions, however, subjects became highly aggressive as soon as extinction began, pecking at the target pigeon’s head and throat, pulling out feathers and bruising the skin of the target pigeon. These aggressive displays ranged in duration from 30 to 1200 s across subjects, occurred soon after the transition from reinforcement to extinction, and were longer for all pigeons in the condition wherein reinforcement and extinction alternated within sessions. Azrin et al. (1966) concluded that this transition to extinction constituted an aversive event, eliciting aggression in a manner similar to the presentation of other aversive events such as painful punishment (Azrin, Hake, & Hutchinson, 1965; Azrin, Hutchinson, & Sallery, 1964).

Along with the extinction burst, extinction-induced aggression remains one of the two negative side effects of extinction most commonly described in applied behavior analysis textbooks and review papers (Lerman & Iwata, 1996). In their review of the applied literature, Lerman et al., (1999) found that aggression was reported in 29% of the studies in which extinction was employed alone and in 15% of the studies in which extinction was employed in combination with other procedures. Other forms of agitated behavior also have been obtained when subjects are exposed to extinction. Rovee-Collier and Capatides (1979) examined the emotional responses of infants exposed to a multiple schedule in which one pattern on a mobile in the infant’s crib was correlated with reinforcement and a second pattern was correlated with extinction. In reinforcement conditions, infants could move the mobile by kicking one of their feet, which was attached by string to the mobile. In extinction, kicking had no effect on the mobile’s movement. Infants were observed to coo and smile upon presentation of the mobile correlated with reinforcement and to cry or fuss upon presentation of the mobile correlated with extinction. Other authors have observed agitated or emotional behavior in extinction with rats (Davis & Donenfeld, 1967), pigeons (Zeiler, 1971), and individuals with mental retardation (Baumeister & Forehand, 1971). Most of these reports are anecdotal, however, providing no quantification of emotional reactions to extinction (see Sullivan, Lewis, & Alessandri, 1992 for an exception). It also is possible that when such responses are observed, they are better explained by other processes, such as the resurgence of previously reinforced responses (Lieving & Lattal, 2003). Further examination of objectively defined and quantified emotional or agitated responses to extinction is warranted.

Spontaneous recovery

As mentioned above, Skinner (1938) observed increased rates of responding by rats whose response rates had previously been reduced to near-zero levels after the rats were away from, and then returned to, the experimental chamber. This spontaneous recovery decreased with each subsequent exposure to extinction until no further recovery of responding was observed. Spontaneous recovery is a common effect of extinction as described in textbooks and reviews

(e.g., DuCharme & Van Houten, 1994; Catania, 1998; Mazur, 2006), yet there are few applied studies that have examined its prevalence or characteristics (Lerman & Iwata, 1996; but see Lerman, Kelly, Van Camp, & Roane, 1999). Like extinction-induced emotional behavior, therefore, spontaneous recovery remains a potential side effect of extinction that may or may not diminish the value of extinction as a response reduction procedure. Future research must examine its prevalence and characteristics in applied settings.

Summary

The current and future status of extinction as an applied response reduction procedure is uncertain. Arguments in favor of its use remain tenable but face the challenge of reducing or eliminating its side effects described above. In particular, if there are other procedures that reduce responding more rapidly, completely, durably, and with fewer side effects than extinction, such procedures should be considered in place of extinction. Where other procedures may have these benefits, their ease of implementation also must be considered. This latter variable impacts treatment integrity and treatment adherence, topics that have received increased focus in applied behavior analysis in recent years (Noell & Witt, 1998). Treatment integrity and treatment adherence refer to the precise and consistent implementation of behavioral treatment and are reduced when treatments are complex, onerous, or time-consuming to implement (Allen & Warzak, 2000). Two alternatives to extinction are DRO and FT schedules. Although both DRO and FT schedules involve more response effort than extinction to implement, they provide access to reinforcement and thus may be more palatable in applied settings (Homer & Peterson, 1980).

Differential-Reinforcement-of-Other-Behavior Schedules

One procedure that sometimes reduces responding more rapidly, completely, and durably than extinction is the DRO schedule (e.g., Topping & Crowe, 1974; Topping & Larmi, 1973). Reynolds (1961) coined the term *differential reinforcement of other behavior* and defined the DRO schedule as one involving reinforcement for not responding in which an interval t specifies the length of time without responding that is required for reinforcement and also the length of time by which each response within the interval delays the upcoming reinforcer. Reynolds noted that DRO schedules reinforce pausing and other behavior incompatible with the previously reinforced response and thus reduce response rates. Studies examining DRO schedules proliferated in the late 1960s through the 1970s. For example, Davis and Bitterman (1971) trained rats on a variable-interval (VI) 30-s schedule before exposing half of the subjects to a DRO 10-s schedule. According to this schedule, each lever press delayed the next reinforcer by 10 s, and a reinforcer was delivered every 10 s as long as no response occurred. Across five sessions, responding was reduced rapidly. By the third session, the rats were making almost no responses, instead “waiting at the food cup, typically with head in the cup, and displaying considerable resistance to being removed from that location at the end of the session” (Davis & Bitterman, p. 238). The response reduction evidenced by the DRO group was greater than that within a control group, each member of which received response-independent reinforcers on a schedule yoked, or matched, to that of a member of the DRO group.

In addition to laboratory demonstrations of the efficacy of DRO schedules in reducing responding (e.g., Topping, Pickering, & Jackson, 1972; Zeiler, 1971), studies in which DRO

schedules were implemented to eliminate problem behavior began to appear in the literature and the utility of this procedure outside of the laboratory was demonstrated (e.g., Frankel, Moss, Schofield, & Simmons, 1976; Repp & Deitz, 1974; Sewell, McCoy, & Sewell, 1973). The DRO schedule effectively reduced problem behavior ranging from SIB and aggression to cigarette smoking, sibling conflict, and classroom disruption (Poling & Ryan, 1982) and was deemed the most common procedure for decreasing behavior in individuals with mental retardation (Bates & Wehman, 1977). Homer and Peterson (1980) suggested that the utility of DRO schedules in applied settings appeared limitless in that negative side effects were nonexistent and generalization of efficacy across topographies and subject populations was extensive.

Sewell et al. (1973) employed a DRO 15-min schedule with four individuals diagnosed with mental retardation who engaged in severe aggression and disruption. After collecting baseline data, aides were instructed to dispense tokens (exchangeable for other reinforcers) every 15 min while stating, "You have been good for 15 minutes." If a participant engaged in aggression or disruption during the 15-min interval, the token delivery was delayed by 15 min. Within one week, aggression and disruption had dropped from over 500 to 100 responses per week. These lower rates were maintained across several weeks, as long as the token reinforcers were available for the absence of these responses. Sewell et al. noted that the DRO procedure reduced the need for reprimands and other punishers while maintaining reduced levels of responding.

In most applications of DRO schedules, the DRO interval is increased across time based on a response reduction criterion. Intervals can be increased in fixed or proportional increments or they can be increased based on the subject's most recent performance. This procedure, known as an escalating DRO schedule, has reduced responding more rapidly than a fixed DRO schedule (Topping, Larmi, & Johnson, 1972). Topping et al. (1972) exposed pigeons first to a VI 30-s schedule, after which they were divided into two groups. One group was exposed to a DRO 30-s schedule for 10 sessions. The second group was exposed to an escalating DRO schedule, the intervals of which increased from 2 to 30 s in 2-s increments across 10 sessions. Intervals increased in length for each subject when that subject made three or fewer pecks within each of five consecutive inter-reinforcer intervals (IRIs). The escalating DRO schedule reduced responding more rapidly and completely than the fixed DRO schedule. Specifically, interval length reached 30 s on the escalating DRO schedule within four sessions. In this fourth session response rates were near zero for the escalating DRO group, while subjects in the fixed DRO group continued to make a considerable number of responses.

Cowdery, Iwata, and Pace (1990) employed an escalating DRO schedule to reduce the SIB exhibited by a 9-year-old boy. Baseline conditions involved leaving the participant in a room alone while he was observed through one-way glass. During the DRO condition, the participant received pennies if no SIB occurred for the duration of the DRO interval. Three DRO intervals per session initially were set at 2 min and were increased to 4 min by the end of the first treatment condition. The participant's SIB decreased immediately to near-zero levels. In the reversal, the participant was told that pennies no longer were available, but was encouraged to refrain from engaging in SIB nonetheless. In this reversal, rates of SIB returned to near-baseline levels. Thereafter, the DRO schedule was reinstated with intervals that continued to increase until a DRO 30-min schedule was in place. Self-injurious behavior remained at low levels

throughout the leaning of the DRO schedule. Others also have used the escalating DRO schedule successfully to reduce a variety of problematic responses (Kodak, Miltenberger, & Romaniuk, 2003; Repp & Slack, 1977; Topping, Graves, & Moss, 1975).

Like other differential reinforcement procedures, the DRO schedule is considered desirable in that it does not require the contingent delivery of aversive stimulation or the complete absence of reinforcement (as in extinction), a feature particularly relevant in applied settings, where an emphasis on positive reinforcement has become the norm (Vollmer & Iwata, 1992). Although some have argued that DRO schedules also are of practical advantage because they require “only accurate timing and the use of a positive reinforcer” (Homer & Peterson, 1980, p. 452), other authors consider the labor involved in monitoring responding and delivering reinforcers while timing DRO intervals to be prohibitively intensive in many settings (Corte, Wolf, & Locke, 1971; Barton, Brulle, & Repp, 1986; Lindberg, Iwata, Kahng, & DeLeon, 1999; Poling & Ryan, 1982). The response effort involved in implementing DRO schedules might be considered worthwhile only if DRO schedules clearly are more effective than procedures involving less effort to implement, such as extinction. Consideration now will be given to those studies in which DRO schedules have been compared with extinction.

Comparisons Between Extinction and DRO Schedules

Uhl and Garcia (1969) first exposed rats to baseline training on VI schedules and then compared response decrements across groups of rats exposed to either DRO 10-, 30-, or 90-s schedules or extinction. The extinction group consistently responded less than the DRO groups, a difference that was particularly large in the first session, with mean responding by the DRO groups more than double that of the extinction group. These relatively high rates during early exposure to DRO schedules have been reported elsewhere and may reflect either initial bursts of responding that occur before subjects contact the reinforcement contingency (Lowry & Lachter, 1977) or discriminative effects of reinforcement that may engender responding in DRO schedules (Franks & Lattal, 1976; Rescorla & Skucy, 1969; see Experiment 2 Discussion below). Uhl and Sherman (1971) also compared the responding of rats exposed either to extinction or a DRO schedule and found equivalent rates of decrement across groups in their first response elimination phase but more rapid and complete suppression in the extinction group in their second response elimination phase, replicating the effect obtained by Uhl and Garcia.

Zeiler (1971) compared the effects of a DRO schedule and extinction within subjects. After training pigeons to respond on a multiple fixed-ratio (FR) FR baseline schedule, the contingencies were changed to those of a multiple DRO 30-s extinction schedule. In this schedule, responding in the presence of one key color produced no programmed consequences (extinction) while each response in the presence of a second key color postponed reinforcement for 30 s and reinforcers were delivered every 30 s if no response occurred (DRO schedule). Contrary to the results obtained by Uhl and Garcia (1969) and Uhl and Sherman (1971), Zeiler found that response elimination occurred more rapidly and completely in the component correlated with the DRO schedule than in the component correlated with extinction. In a test for spontaneous recovery following 72 hours without exposure to the experimental chamber, responding also recurred only in the component previously correlated with extinction. This

finding replicated the finding of Uhl and Garcia and Uhl and Sherman that DRO schedules produce more durable response suppression than extinction.

In a systematic replication of Zeiler's (1971) study, Topping and Ford (1975) exposed three pigeons to a three-component multiple schedule. During baseline, each component was associated with a VI 30-s schedule. The schedule then was changed to multiple VI 30-s DRO 6-s extinction. The DRO schedule produced lower response rates than extinction in every session for each subject. Topping and Ford also replicated Zeiler's findings on three tests for spontaneous recovery. Specifically, when pigeons were exposed to the multiple schedule after 10, 25, and 55 days away from the experimental chamber, responding was at higher rates in the extinction component than in the DRO component. Although not without exception (e.g., Cross, Dickson, & Sisemore, 1978; Lowry & Lachter, 1977; McGlynn, Miller, & Fancher, 1975; Uhl, 1973), much of the research comparing DRO schedules and extinction with both human and nonhuman subjects supports the finding that DRO schedules produce more rapid response reduction, reduce responding to a lower asymptotic rate, and produce more durable response suppression than extinction (Johnson, McGlynn, & Topping, 1973; Mulick, Leitenberg, & Rawson, 1976; Topping & Crowe, 1974; Topping & Larmi, 1973; Topping, Pickering, & Jackson, 1971; Topping et al., 1972; Topping, Thompson, & Barrios, 1976).

As mentioned above, much of the applied research with DRO schedules has employed escalating schedules. The efficacy of escalating DRO schedules also has been examined in the basic research laboratory. Pickering and Topping (1974) compared the effects of extinction and fixed and escalating DRO schedules with human participants. Following training on a variable-ratio (VR) 12 baseline, college students were exposed to 15 min of either extinction, a DRO 10-s schedule, or an escalating DRO schedule. In the escalating schedule, intervals began at 4 s and increased in 2-s increments to 10 s, provided that the participant made three or fewer responses in each of five consecutive IRIs. Extinction was least effective of all three response elimination procedures. The escalating DRO schedule reduced responding more rapidly and completely than the fixed DRO schedule. This finding was replicated by Topping et al. (1975) with regular elementary and special education school children. Following training on a VR 10 baseline, participants' button pressing was eliminated under extinction, a DRO 10-s schedule, or an escalating DRO schedule the intervals of which were increased from 2 to 10 s across time. In all participants, responding was eliminated most rapidly by the escalating DRO schedule, while extinction produced the slowest response decrement. The authors suggested that the escalating DRO schedule was most effective because it gradually shaped longer pauses and exposed participants to both the extinction and differential reinforcement contingencies of the DRO schedule more immediately than the fixed DRO schedule.

In one early applied comparison of DRO schedules and extinction, Corte et al. (1971) attempted to decrease the SIB of four adolescents. Extinction involved placing the participants in an empty room for 60 min a day across 12 days. Experimenters observed the children through one-way glass. Because SIB did not decrease in frequency across sessions, the authors concluded that extinction (elimination of social consequences) was not effective. Across the first ten 15-min sessions in the DRO phase, participants were given a bite of food every 15 s if SIB had not been emitted in that 15-s interval. Each instance of SIB postponed the next reinforcer delivery by 45 s. After some modification of the type of edible reinforcer and level of food deprivation employed,

the DRO schedule decreased SIB for one participant but continued to have no effect for the second participant. The findings of Corte et al. (1971) draw attention to the necessity of identifying consequences that maintain problem behavior prior to using those consequences as reinforcers in DRO conditions. As with extinction, identification of the functional reinforcer is essential to the effectiveness of DRO schedules. By identifying that reinforcer, one ensures that the target response is under extinction and increases the probability that DRO contingencies will be effective (Mazaleski, Iwata, Vollmer, Zarcone, & Smith, 1993; Vollmer, Iwata, Zarcone, Smith, & Mazaleski, 1993). When arbitrary reinforcers are used in DRO schedules, a concurrent schedule of reinforcement may be in place, whereby problem behavior produces one reinforcer and the absence of problem behavior produces another reinforcer. If the arbitrary reinforcer is not sufficiently potent to compete with that maintaining problem behavior, DRO schedules typically will not be effective. Because a functional analysis of SIB was not conducted by Corte et al., their conclusion that extinction was ineffective and that the DRO schedule was only partially effective are misleading. Specifically, their DRO procedure involving food delivery contingent on the absence of SIB would not be expected to decrease SIB if it had been maintained by nonfood reinforcers. In the experiments presented in this dissertation, food was used as reinforcement in all DRO schedules only after having been demonstrated to function as such through its ability to shape and maintain responding in baseline.

In another comparison of response reduction produced by extinction and a DRO schedule, Thompson, Iwata, Hanley, Dozier, and Samaha (2003) first shaped and maintained arbitrary responses using reinforcers selected from preference assessments. The duration of DRO intervals was determined by each participant's mean interresponse time in baseline. Extinction and the DRO schedule were compared a total of 12 times across five participants. Contrary to the effect more commonly reported, extinction reduced responding more rapidly than DRO in nine of these comparisons. In fact, the DRO schedules often resulted in large increases in responding relative to baseline, producing high and variable rates across as many as 15 sessions. Like others before them (e.g., Rescorla and Skucy, 1969), these authors suggested that the DRO schedule maintained responding because reinforcers functioned as discriminative stimuli, a topic that will be visited in more detail below.

Taken together, previous research generally supports the superiority of DRO schedules over extinction in terms of the rapidity, extent, and durability of response reduction. Nonetheless, there are a sufficient number of exceptions to this general finding that it seems prudent to continue to examine these two procedures and the characteristics of their presentation that make each most effective across situations. Attention now will turn to a third response reduction procedure that has received considerable recent attention in applied behavior analysis: time-based schedules of response-independent event delivery.

Time-Based Schedules

After first exposing pigeons to fixed-interval (FI) and VI schedules, Zeiler (1968) examined response decrement across sessions of either FT or variable-time (VT) schedules. According to these schedules, reinforcement is delivered after fixed or variable periods of time, respectively, with no dependency on the organism's behavior. These schedules are extinction procedures to the extent that they remove the contingency between responding and

reinforcement. These procedures differ from conventional extinction in that reinforcers are still presented, albeit independently of responding. Zeiler found that the FT schedules gradually reduced rates in all three pigeons relative to the response-dependent baseline. In one of the pigeons, however, responding was maintained at substantial rates even after 10 sessions of exposure to the FT schedule. Lattal (1972) obtained similar response maintenance under an FT schedule following an FI baseline schedule with rats. In each of three subjects, responding under the FT schedule was maintained at approximately 50% of baseline response rates, even after as many as 50 sessions for one subject. This gradual or incomplete response reduction produced by time-based schedules has been replicated by others (Herrnstein, 1966; Neuringer, 1970).

Time-based schedules typically reduce responding rapidly and to a low asymptotic rate in applied settings (e.g., Hagopian, Fisher, & Legacy, 1994; Kahng, Iwata, DeLeon, & Worsdell, 1997; Mace & Lalli, 1991; Van Camp et al., 2000; Vollmer et al., 1993). In fact, VT and FT schedules have become some of the most common and widely researched response reduction procedures in applied behavior analysis (Carr et al., 2000). [Such procedures sometimes are called noncontingent reinforcement, or NCR, but they will be referred to here as time-based or, more specifically, FT or VT schedules to be both more accurate and consistent with the terminology of basic literature. These schedules also are commonly described as delivering response-independent reinforcers and this description also will be used here (see Lattal & Poling, 1981, Poling & Normand, 1999, and Vollmer, 1999, for a discussion of this terminological debate).] Unlike their basic research counterparts, the majority of applied studies in which time-based schedules are employed involve schedule thinning. Under these conditions, the schedule typically begins with continuous access to the reinforcer which is then faded over time until a terminal FT or VT value is reached (a value that is practical to administer by caregivers, for example). In 23 of 33 applied studies published between 1977 and 1997, time-based schedules began with continuous or near-continuous access to reinforcement that was either faded gradually across time or maintained on a continuous access schedule (Carr et al., 2000). In cases such as this, it is not surprising that response reduction is immediate and complete because continuous access to the reinforcer removes the establishing operation (i.e., deprivation) for that reinforcer (see also Carr, Bailey, Ecott, Lucker, & Weil, 1998).

In those applied studies in which reinforcement is not provided continuously or near continuously from the outset of a time-based schedule, response reduction is more gradual. For example, Carr, Kellum, and Chong (2001) exposed two subjects to VR schedules of reinforcement before exposing them to FT schedules, the values of which were based on the IRIs in baseline. Although the responding of one participant was reduced gradually to zero levels, responding by the second participant was reduced to only 50% of the baseline response rate after 14 sessions. Mace, Shapiro, and Mace (1998) presented response-independent escape from task demands (in one condition) and response-independent access to preferred items (in another condition) on an FT 60-s schedule, following a functional analysis indicating that the participant's SIB was maintained by both positive and negative reinforcement. Response-independent access to escape produced no decrease in SIB, while response-independent access to preferred items produced only moderate decreases in responding relative to baseline. Thus, it appears that time-based schedules that are procedurally similar to those used in basic research produce only moderate decreases in behavior, sometimes maintaining low rates of responding over extended periods. When time-based schedules are leaned gradually over time, however,

response rates can be reduced rapidly and maintained at low rates over time (but see Vollmer, Ringdahl, Roane, & Marcus, 1997).

Comparisons Between Extinction and Time-Based Schedules

Rescorla and Skucy (1969) compared the response decrement of rats exposed to either extinction or a VT 2-min schedule following baseline responding on a VI 2-min schedule. Across three experiments, these authors found that extinction reduced responding more rapidly and completely than the VT schedule. These findings are in agreement with those of Lattal (1972). As mentioned above, Lattal was unable to eliminate the responding of rats under FT or VT schedules following FI or VI baselines, respectively. When these rats subsequently were exposed to extinction, rates dropped to zero or near-zero levels within 10 sessions. Boakes (1973) obtained similar results after exposing two groups of rats to either extinction or a VT 30-s schedule following VI 30-s baseline training. Across two exposures to extinction, rats reached the response reduction criterion in a mean of 42 and 21 min, respectively. Across two exposures to the VT schedule, rats took a mean of 371 and 226 min to reach the same response reduction criterion. The difference between groups was large, with all rats in the extinction group reaching criterion faster than any of the rats in the VT group.

Responding that is maintained under time-based schedules has been attributed to adventitious pairings between reinforcers and responding. Specifically, if a response occurs immediately prior to a time-based reinforcer delivery, such responding can be acquired or maintained “superstitiously”. Skinner (1948) first described the acquisition of superstitious responding by naïve pigeons that developed stereotypic, repetitive responses when presented with response-independent access to grain at regular intervals. In Skinner’s (1948) procedure, pigeons developed species-typical responses such as head bobbing. These are responses likely to occur in relation to food and thus have a higher probability of being adventitiously reinforced. Alternatively, one also may reinforce an explicit, arbitrary response and then remove the programmed contingency between that response and reinforcement. Herrnstein (1966) first reinforced pigeons’ key pecking on an FI 11-s schedule. He then presented food on an FT 11-s schedule and found that rates decreased but were maintained at non-zero levels even after more than 20 sessions. When the pigeons subsequently were exposed to extinction after a return to the FI schedule, responding was reduced to zero levels within 15 sessions. Herrnstein reiterated Skinner’s argument that an accidental temporal contiguity, even one that is intermittent or only approximate, is sufficient to maintain responding.

In the first direct comparison of extinction and time-based schedules in an applied setting, Vollmer et al. (1998) first assessed the function of three participants’ problem behavior. Once reinforcers were thus identified, these reinforcers were withheld in one condition (extinction) and were delivered on an FT schedule in a second condition. The reinforcer in the FT condition initially was available continuously, after which access was gradually faded until an FT 5-min schedule was reached. The FT schedule reduced responding immediately to zero levels. These reductions were maintained across more than 60 sessions. In extinction, an extinction burst in which rates of problem behavior were up to 10 times higher than baseline rates was apparent for one participant. For the two other participants, rates of problem behavior were variable across

sessions. In some sessions, rates were as high as or higher than those of baseline, while in other sessions rates were close to zero.

The opposite effect was obtained by Thompson et al. (2003), who exposed children to extinction or FT schedules following training on CRF schedules. The responses emitted by the children were arbitrary responses such as stair stepping or toe touching. These responses were maintained across several sessions before reinforcement was either withheld (in extinction conditions) or delivered at fixed intervals determined by each child's baseline IRI (in FT conditions). For three of five children, rates were reduced more rapidly and completely in extinction, dropping to near-zero levels within several sessions. For these children, the FT schedule reduced rates gradually but incompletely. In some cases, rates under the FT schedules were indiscriminable from baseline rates. For two other children, rates were reduced equally under extinction and the FT schedule. This study represents one of the few applied comparisons in which the FT schedules were initiated at their terminal interval value rather than being increased gradually via schedule thinning.

Even when FT schedules with gradually increasing intervals are employed, response maintenance has been obtained. Vollmer et al. (1997) found that accidental temporal contiguities between reinforcement delivered on a time-based schedule and occurrences of aggression resulted in increases in this response. As the schedule was leaned, cumulative records revealed that aggression began to appear and increase in frequency across intervals, resulting in high levels of aggression at the moment reinforcement was delivered. Reinforcer delivery was followed by low rates of aggression that again increased prior to delivery of the next reinforcer. The authors concluded that such a pattern was too dangerous to continue and a DRO schedule was added to the end of each interval to remove accidental temporal contiguity between aggression and reinforcement. This modification successfully reduced aggression.

Ringdahl, Vollmer, Borrero, and Connell (2001) compared the response reduction produced by extinction with that produced by FT schedules, the IRIs of which were either similar or dissimilar to baseline IRIs. They found that extinction reduced responding more rapidly and completely than FT schedules with IRIs similar to baseline, while FT schedules with IRIs dissimilar to baseline (either longer or shorter) were as effective as extinction. These authors argued that differences between basic and applied comparisons between extinction and time-based schedules may be based on the different IRIs used. Specifically, in basic research, IRIs during FT or VT schedules often are yoked to baseline IRIs (e.g., Lattal, 1972; Rescorla & Skucy, 1969). Under these conditions, extinction reduces responding more rapidly than the time-based schedules. When IRIs are different from those of baseline, as is often the case in applied research where reinforcement initially is available continuously or on a very rich schedule that is leaned across time, time-based reinforcer delivery reduces responding more rapidly and completely than extinction (e.g., Vollmer et al., 1998). Future research is needed to clarify and extend those procedural variables that may increase the efficacy of time-based schedules relative to conventional extinction.

Statement of the Problem

Behavior problems of pet dogs can result in financial and emotional burdens for owners and society generally. Such problems also can result in dogs being relinquished to animal shelters, euthanized, or exposed to a decreased quality of life. Canine behavior problem reduction might be facilitated by procedures that have proven efficacious in reducing rates of responding of other species in a variety of settings. Furthermore, the empirical assessment of the effects of such procedures with pet dogs in their natural environment exemplifies a research approach of much potential utility to, but not yet widely embraced by, applied animal behaviorists.

Three response reduction procedures commonly utilized in applied behavior analysis are extinction, DRO schedules, and time-based schedules of reinforcer delivery. Previous research has suggested that extinction can reduce behavior in and outside of the laboratory, although phenomena such as extinction bursts and extinction-induced emotional behavior have prompted some applied researchers to seek alternative response reduction procedures (Lerman & Iwata, 1996). Two such alternatives to extinction are DRO and time-based schedules. Unlike extinction, reinforcement is still available while responding is reduced in these schedules, a feature that has led some authors to recommend their use (Carr et al., 2000; Homer & Peterson, 1980). Although often effective, the DRO schedule is cumbersome to implement and sometimes produces a more gradual decline in response rates than extinction (Poling & Ryan, 1982; Uhl & Garcia, 1969). Thus, the relative advantages and disadvantages of extinction and DRO schedules are not unambiguous. Time-based schedules also have reduced responding effectively and are easier to implement than DRO schedules to the extent that IRIs need not be reset contingent on responding. Yet time-based schedules sometimes produce only gradual response rate reduction and may even maintain responding (Thompson et al., 2003; Vollmer et al., 1997). Findings on the relative speed and extent of response reduction produced by extinction in comparison with DRO or time-based schedules have not been consistent. Although some investigators have obtained greater response reduction with DRO schedules than with extinction (Johnson et al., 1973; Mulick et al., 1976; Zeiler, 1971), others have obtained the opposite finding (McGlynn et al., 1975; Uhl & Garcia, 1969; Uhl & Sherman, 1971). Similarly, some investigators have obtained more rapid response reduction with time-based schedules than with extinction (Vollmer et al., 1998), but others have not (Lattal, 1972; Rescorla & Skucy, 1969; Thompson et al., 2003). Given the mixed findings concerning the efficacy of these different procedures in eliminating responding, and particularly the inconsistencies across species with respect to these efficacies, it is difficult to discern which procedures would be most effective with dogs. The present experiments therefore were designed to further assess the relative efficacy of these procedures within new stimulus and setting conditions with dogs. In Experiments 1, 2, and 3 of the present report, extinction was compared with a fixed DRO schedule, an escalating DRO schedule, and an FT schedule, respectively, to determine the speed and extent of response reduction produced by each.

Experiment 1

Experiment 1 was a systematic replication of Zeiler's (1971) procedure. In the first within-subject comparison of extinction and a DRO schedule, Zeiler found that responding was

reduced more rapidly and completely in the DRO schedule than in extinction. In two tests for spontaneous recovery, Zeiler also found that response rates temporarily increased in extinction but not in the DRO schedule. Through the utilization of a multiple schedule, Zeiler thus was able to assess the capability of each procedure to reduce responding and maintain response suppression within the same organism. This within-subject approach, a rarity in research with canine subjects, is advantageous because it allows measurement of the effects of multiple variables within each session.

Method

Subjects

Three pet dogs (*Canis familiaris*), described in the upper portion of Table 1, served as subjects. Each was neutered, vaccinated, in good health, and lived with its owners. All were experimentally naïve and none had been exposed previously to experimental stimuli or materials. None had a history of aggression or fearfulness in the presence of food or strangers in their home. Each dog was allowed access to its normal daily food intake, but was deprived of food for between 17 and 22 hours prior to each session (see Table 1). Although food deprivation varied across dogs, it remained constant for each dog for the duration of the experiment.

Table 1
Subject Characteristics: Sex, Breed, Age, Weight, and Hours of Food Deprivation

<u>Experiment 1</u>					
<u>Name</u>	<u>Sex</u>	<u>Breed</u>	<u>Age</u>	<u>Weight</u>	<u>Food Deprivation</u>
Hank	M	Labrador Retriever mix	9 years	65 lbs	17 hrs
Iago	M	Pit bull terrier mix	7 years	50 lbs	18 hrs
Merlot	F	Beagle mix	3 years	30 lbs	22 hrs
<u>Experiment 2</u>					
<u>Name</u>	<u>Sex</u>	<u>Breed</u>	<u>Age</u>	<u>Weight</u>	<u>Food Deprivation</u>
Gadget	M	Dalmatian mix	8 years	75 lbs	5 hrs
Sam	M	Labrador Retriever mix	5 years	60 lbs	7 hrs
Sport	M	Terrier mix	1 year	50 lbs	5 hrs
Theo	M	Labrador Retriever mix	10 years	65 lbs	7 hrs
<u>Experiment 3</u>					
<u>Name</u>	<u>Sex</u>	<u>Breed</u>	<u>Age</u>	<u>Weight</u>	<u>Food Deprivation</u>
Buddy	M	Labrador Retriever mix	6 years	60 lbs	5 hrs
Jade	F	Terrier mix	8 years	40 lbs	6 hrs
Jake	M	Beagle mix	1 year	25 lbs	5 hrs
Max	M	Bichon Frise	9 years	30 lbs	6 hrs

Apparatus

A target-training buoy (Alley Oop®) served as the operandum. It stood 33 cm tall and had a weighted metal bottom that allowed it to sway without falling over when touched. A thin metal rod extended vertically from the bottom and was topped with a yellow foam ball, 3.8 cm in diameter. Reinforcers varied across dogs, depending on nutritional or dietary restrictions. Pieces of cooked chicken hot dog, approximately 0.5 cm in diameter, were used for two dogs, and semi-moist dog food pieces were used for one dog (Hank). For all dogs, these food types were effective in shaping and maintaining responding during initial training and subsequently were used as reinforcers throughout the experiment. All sessions were videotaped using a Sony Handicam and a tripod. Responses were tallied in each session using a hand-held counter. During the DRO component, for two dogs, a laptop displayed a timer that was used to time and reset DRO intervals. For the third dog (Iago), a hand-held stopwatch was used to time and reset intervals. One experimenter counted responses and counted and delivered reinforcers. A second experimenter operated the video camera and laptop computer or stopwatch timer and collected data with paper and pencil at the end of each session. Session numbers were printed on paper and positioned so as to remain visible to the video camera. Two knee-length T-shirts, one black and one white with a flashing red bicycle light attached to it, were used as schedule-correlated stimuli.

Procedure

Sessions lasted approximately 23-25 min each and were conducted five days per week in one room of the owner's home. Each session occurred during a time of day when the house typically was empty except for the dog and experimenters. Occasionally sessions were conducted when family members were present in the home but outside of the experimental room which, for Hank, was a spare bedroom and for Iago and Merlot was the living room. A response was defined as the dog's muzzle making contact with the foam ball or upper half of the rod of the buoy with sufficient force that the buoy moved or changed direction if already in motion. A second response was counted only if the dog moved its muzzle away from the buoy a sufficient distance that space between the dog's muzzle and buoy clearly could be seen from the angle of the video camera. Reinforcers were delivered by dropping the food item onto the floor in the direction of the dog and within approximately 60 cm of the experimenter and the buoy.

Initial training began with response shaping. Successive approximations to buoy-touching were reinforced with the sound of a dog training clicker followed immediately by delivery of the reinforcer. In some cases, the first response was prompted by moving the foam ball of the buoy to the dog's nose and providing a click and treat each time the buoy contacted the dog's nose. After several repetitions of this, the buoy gradually was moved further away from the dog's nose while the dog was required to move its nose to the buoy for reinforcement. Buoy-touching typically was shaped in either of these ways within the first 20-min session. Several subsequent sessions were devoted to increasing the force and discreteness of responses (i.e., requiring greater deflection of the buoy with each response and requiring larger movements of the dog's head away from the buoy between responses). During these sessions, the clicker was replaced with the hand-held counter (which also made a clicking sound and was able to record responses).

After responses were deemed forceful and discrete enough to be viewed by both the experimenter and the video camera lens, the reinforcement schedules were leaned across several sessions from an FR 1 to a VR 10 in the presence of each of two stimuli. This was conducted by exposing dogs to an increasing FR value across the first several days contingent upon successful maintenance of responding at each FR value. After responding was maintained on an FR 10, a VR 5 and then a VR 7.5 schedule were employed for two to four sessions before baseline sessions began. [In all three experiments presented here, the ratios of the VR schedules were based on a Fleshler-Hoffman (1962) distribution.] Throughout initial training and all subsequent experimental phases, the experimenter wore the black T-shirt in one component of the multiple schedule. In the second component, the experimenter wore the white T-shirt with the flashing red bicycle light attached to the T-shirt in such a position that it blinked in the direction of the dog's head. During initial training and baseline, each component was terminated after the first reinforcer delivered after 5 min had elapsed from component onset. Components were presented twice per session in strict alternation, with an intercomponent interval of approximately 30 s. For each of the three dogs, the first component of each daily session in initial training and baseline was determined by a coin toss, with the restriction that no more than three consecutive sessions begin with the same component.

Baseline consisted of a multiple VR 10 VR 10 schedule, wherein independent VR 10 schedules operated within each 5-min component. After a minimum of 20 baseline sessions under the multiple VR 10 VR 10 schedule, responding was judged to be stable when visual inspection revealed that responding was occurring at approximately equal rates in both components and showed minimal variability and no increasing or decreasing trend. The schedule then was changed to a multiple DRO 10-s extinction (mult DRO 10-s EXT) schedule. In this schedule, the black T-shirt stimulus was correlated with extinction and the white T-shirt stimulus with the DRO schedule for two dogs. These schedule-stimulus correlations were reversed for the third dog (Hank). In extinction, responses produced the click of the response counter but no other programmed consequence. In the DRO schedule, reinforcement was delivered following 10 s without a buoy touch, and each buoy touch reset the 10-s interval, at the end of which reinforcement was delivered if no subsequent buoy-touch had occurred. Each extinction and DRO component was terminated after 5 min. During this response elimination phase, the first component of each daily session was determined by a coin toss for one dog (Iago). For reasons described below, this order was counterbalanced for a second dog (Merlot) and was strictly alternated across sessions for the third dog (Hank). This phase continued for at least seven sessions and until response rates for three consecutive sessions were less than 20% of the mean response rate of the last three sessions of baseline.

A test for spontaneous recovery then was conducted. Sessions were suspended for nine days, after which the multiple DRO 10-s EXT schedule was again in effect for three sessions. Sessions then were suspended again for 25 days, after which a second test for spontaneous recovery occurred over three sessions with the mult DRO 10-s EXT schedule in effect. Although similar to those used by Topping and Ford (1975), the duration of these spontaneous recovery intervals was determined somewhat arbitrarily and in part dictated by owners' and experimenters' schedules. The sequence of conditions and number of sessions in each condition are shown in Table 2.

Table 2
Sequence of Conditions and Number of Sessions in Each

<u>Experiment 1</u>					
<u>Number of Sessions</u>					
<u>Condition</u>	<u>Hank</u>	<u>Iago</u>	<u>Merlot</u>		
Mult VR 10 VR 10	20	20	21		
Mult DRO 10 s EXT	13	13	13		
<u>Experiment 2</u>					
<u>Number of Sessions</u>					
<u>Condition</u>	<u>Gadget</u>	<u>Sport</u>	<u>Condition</u>	<u>Sam</u>	<u>Theo</u>
VR 10 Baseline	15	15	VR 10 Baseline	15	20
Escalating DRO 10 s	6	9	EXT	6	6
VR 10 Baseline	15	15	VR 10 Baseline	15	15
EXT	7	6	Escalating DRO 10 s	7	6
<u>Experiment 3</u>					
<u>Number of Sessions</u>					
<u>Condition</u>	<u>Buddy</u>	<u>Jade</u>	<u>Condition</u>	<u>Jake</u>	<u>Max</u>
VR 10 Baseline	15	15	VR 10 Baseline	15	15
FT 10 s	15	15	EXT	6	6
VR 10 Baseline	15	15	VR 10 Baseline	15	15
EXT	6	6	FT 10 s	15	15

To calculate interobserver agreement (IOA), a second experimenter recorded responses from 50% of all sessions through video tape observation, which was conducted for each dog several times throughout the experiment. These response tallies were compared with those collected within each session by the first experimenter and IOA was calculated by dividing the lower total number of responses by the higher total number of responses and multiplying the quotient by 100. Mean IOA for Iago, Merlot, and Hank, was 95.3%, 95.8%, and 97.3%, respectively, with a range of 80.0% to 100.0% across subjects.

To assess “emotional” or “agitated” behavior, which has been reported to occur under extinction (Rovee-Collier & Capatides, 1979; Zeiler, 1971), two observers separately reviewed from video tape the second and third components presented in the last session of baseline and in the first two and last sessions of the mult DRO EXT schedule. Because components were strictly alternating within each session, this resulted in observation of 5 min of the VR schedule correlated with each stimulus in the last session of baseline and 5 min of both DRO and extinction in each observed session of the mult DRO EXT schedule. “Emotional” behavior was defined as any vocalization (e.g., whining, barking, growling, or howling) emitted by the dog. This coding was accomplished using a partial-interval recording system (cf., Cooper, Heron, and Heward, 2007). Each 5-min component was broken into thirty 10-s intervals. A response was recorded during each 10-s interval if any vocalization occurred. The percentage of intervals in which vocalization occurred was calculated for each component in each observed session. An agreement was scored for each interval in which both of the observers recorded a response or in which both recorded no response. Interobserver agreement was calculated by dividing the total

number of agreements by the total number of intervals and multiplying by 100. Across Iago, Merlot, and Hank, mean IOA for vocalization was 93.3%, 94.2%, and 98.7%, respectively, with a range of 86.7% to 100.0%. Similar partial-interval recording was conducted to assess the percentage of intervals in which dogs moved away from the operandum by more than approximately 90 cm during the same 5-min segments in the same sessions as were used to measure vocalization. If the dog moved all parts of its body at least approximately 90 cm away from the buoy, a response was recorded. All subsequent calculations were identical to those described for measuring vocalization. Across Iago, Merlot, and Hank, mean IOA for this measure was 97.1%, 96.7%, and 100.0%, respectively, with a range of 90.0% to 100.0%.

Results

Response rates for each component across all sessions of the multiple VR 10 VR 10 schedule and the multiple DRO EXT schedule are shown for each dog in Figure 1. For all dogs, responding was maintained at equivalent rates across the two VR 10 components during baseline. Each dog was exposed to the minimum 20 baseline sessions. Merlot required one additional session in baseline because her response rates showed an increasing trend across the last six sessions. At the conclusion of baseline, stable response rates across dogs averaged between 40 and 60 responses per min. For all three dogs, responding was reduced to near-zero levels within the first three sessions of exposure to the mult DRO EXT schedule. For Iago, response rates were higher in extinction during 12 of the 13 sessions of exposure to the mult DRO EXT schedule, including all sessions conducted after both of the spontaneous recovery intervals. A floor effect notwithstanding, response rates in extinction were more than double those obtained under the DRO schedule in 10 of these sessions. This difference in rate was particularly marked in the first two sessions (see Figure 1). There was little evidence of spontaneous recovery for this dog.

During the first three sessions, Iago had been exposed to the extinction component first, as determined by coin toss. This component presentation order then was counterbalanced for Merlot, who thus was exposed to the DRO component first in each of the first three sessions of the mult DRO EXT schedule. As shown in Figure 1, response rates for Merlot were higher in the DRO component on each of these three sessions. For the subsequent 10 sessions, rates in extinction were equal to or higher than those under the DRO schedule irrespective of which component was presented first in each session. Merlot showed an increase in responding in extinction during the second session following the 9-day spontaneous recovery interval. She also showed higher rates, however, in the DRO component in the first session after the 25-day interval, precluding assertions of differential spontaneous recovery.

To assess further the role of component presentation order in controlling differential response rates, this order was strictly alternated across all sessions of the response elimination phase for Hank. Across the first five sessions, the component presented first in each session controlled the higher response rate for that session. After this, response rate in each session (including all sessions of the spontaneous recovery tests) was higher in the component correlated with extinction, irrespective of the order of component presentation. There was a slight increase in responding during the second session after the 25-day spontaneous recovery interval. Because

it did not appear in the first session of re-exposure to the experimental conditions, this rate increase is likely not an instance of spontaneous recovery.

Although response rates provide an absolute description of response reduction, consideration of the proportion of baseline response rates has the advantage of taking into account each dog's own baseline response rate (e.g., Nevin, 1974). To calculate the proportion of baseline response rate, the mean response rate in the extinction and DRO components of each session of the mult DRO EXT schedule was divided by the mean of the last three sessions of the corresponding component in the VR 10 baseline schedule. By this measure, a proportion of 1.0 indicates a response rate equal to that of baseline while a proportion of 0.0 indicates no responding. Figure 2 shows the proportion of baseline response rates for all three dogs across all 13 response elimination sessions. Although rates were higher during extinction for 32 of the total 39 sessions across dogs, the differences between extinction and the DRO schedule were smaller than those obtained by Zeiler (1971) and seemed confounded during initial sessions by the order of daily component presentation.

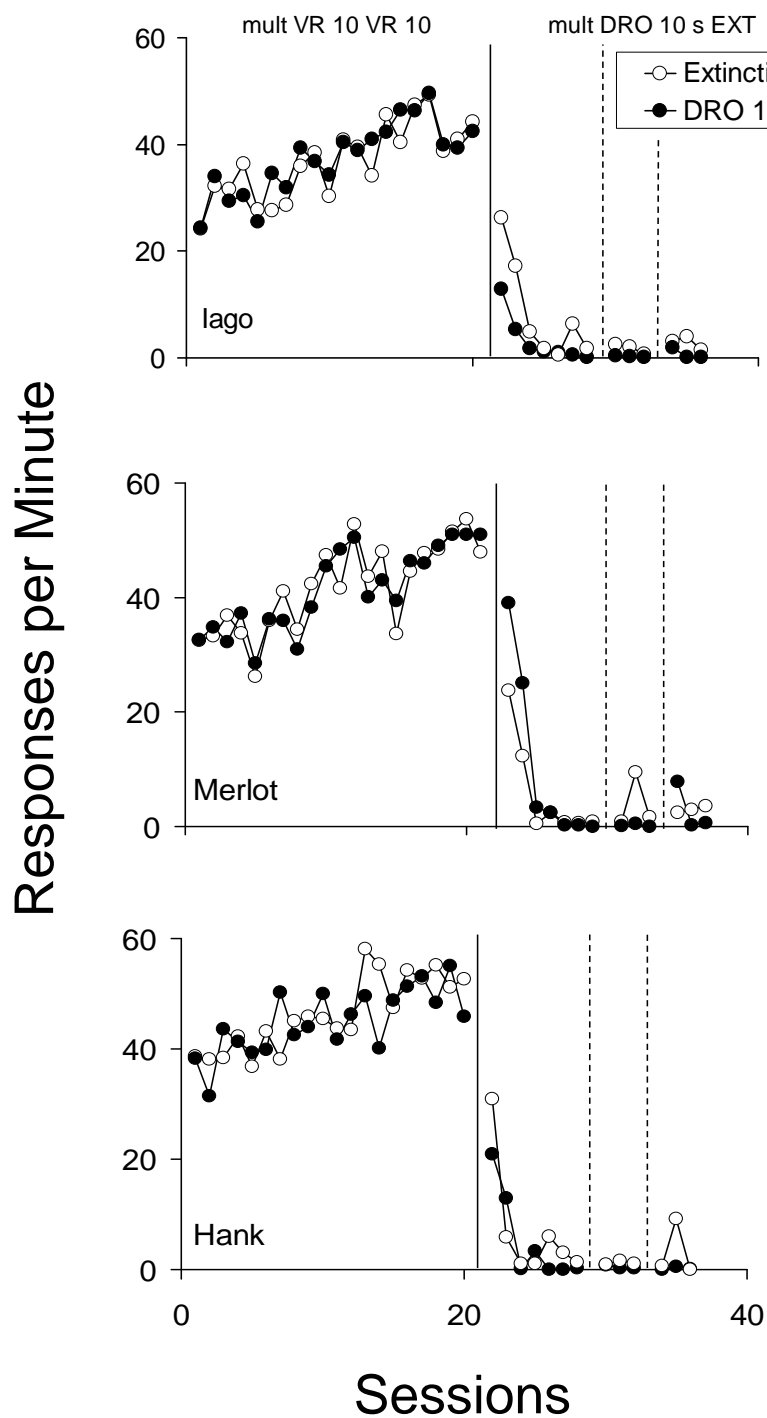


Figure 1. Responses per minute across sessions for each of three subjects in Experiment 1. Closed circles represent response rates in a VR 10 component in baseline and in the DRO component in the mult DRO EXT phase. Open circles represent response rates in the other VR 10 component in baseline and in the extinction component in the mult DRO EXT phase. Solid lines indicate the transition from baseline to the mult DRO EXT phase. Dotted lines indicate the 9- and 25-day recovery intervals prior to each three-day test for spontaneous recovery.

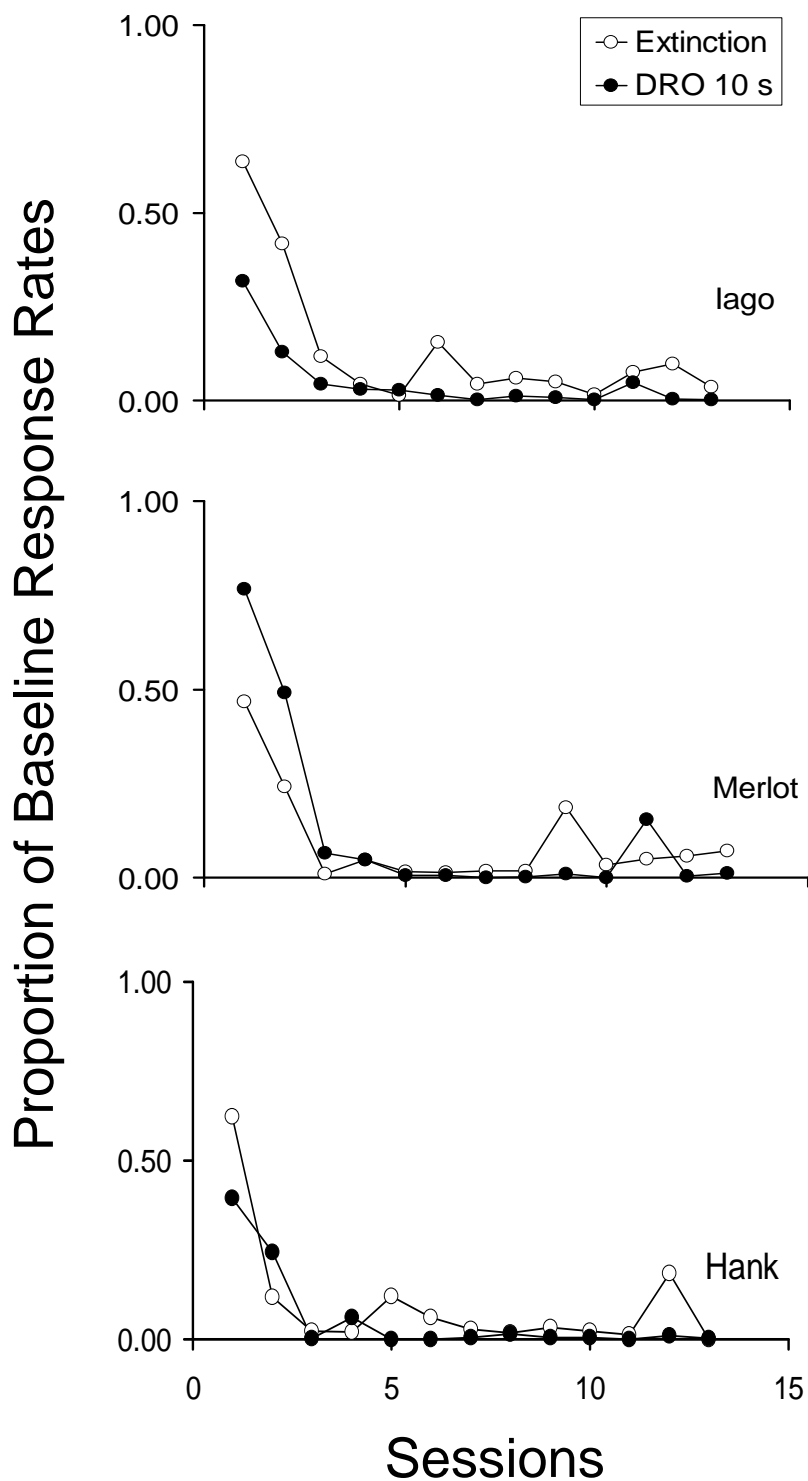


Figure 2. Proportion of baseline response rates within each component across all sessions of the mult DRO EXT schedule in Experiment 1. Closed circles represent the proportion of baseline response rates during the DRO component. Open circles represent the proportion of baseline response rates during the extinction component.

Reinforcement rates were calculated by dividing the total number of reinforcers by the total time spent in each component. The range and mean reinforcement rate for each dog in each condition are shown in Table 3. These means ranged from 3.6 to 4.6 reinforcers per min across dogs in baseline and from 3.9 to 4.9 reinforcers per min in the DRO component. It should be noted that prior to the first reinforcer delivery in the DRO schedule, this schedule is functionally equivalent to extinction. Therefore, any differences in responding prior to the first reinforcer delivery are due to variables unrelated to schedule contingencies. All three dogs did earn reinforcers, and thus did contact the DRO contingency, within the first two components of the DRO schedule (i.e., within the first session). Due to high response rates in the DRO schedule, Merlot earned only five reinforcers in the first session, while Iago and Hank earned 22 and 25 reinforcers, respectively.

The percentage of intervals in which dogs emitted vocalization is shown in Table 4. For each dog, the second and third components within each selected session were analyzed and percentages from each of these components are shown, except in the case of the VR schedule. Because both VR components were identical in the last session of baseline (i.e., both were VR 10 schedules), the mean proportion of vocalization across both of these components is shown. Vocalization increased for Iago from 0.0% of intervals in baseline to 60.0% of intervals during the sampled extinction component in the first session and 46.7% of intervals in the second session of the mult DRO EXT schedule. By the last session, vocalization had decreased to 23.3% in extinction. Vocalization also increased from baseline during the DRO component, although this increase was not as large as in extinction and had disappeared by the last session. Merlot vocalized in 26.7% of the baseline intervals. During the first two sessions of the mult DRO EXT schedule, vocalizing increased for Merlot in both extinction and DRO components. In extinction, vocalizing increased to 66.7% of intervals in the first and 30.0% of intervals in the second session. In the DRO schedule, vocalizing increased to 50.0% of intervals in the first and 40.0% of intervals in the second session. By the last session, vocalizing decreased to 0.0% of intervals in both extinction and DRO components. Hank exhibited almost no vocalization in any sessions of the experiment. Thus, under the definition of agitated or emotional behavior employed here, there were no consistent effects of either response reduction procedure across dogs.

The percentage of intervals in which dogs moved at least approximately 90 cm away from the buoy is shown in Table 5. Although Hank never left the area of the buoy under any conditions, both Merlot and Iago showed increases in this measure under both DRO and extinction conditions. Extinction, however, resulted in the largest percentage of intervals in which these two dogs were at least approximately 90 cm from the buoy. Iago was away from the buoy during 6.7%, 53.3%, and 26.7% of intervals during extinction in the first, second, and last session, respectively. During the DRO component of those sessions, he was away from the buoy during only 3.3%, 6.7%, and 6.7% of intervals. Similar results were obtained for Merlot, who spent 3.3%, 26.7%, and 30.0% of intervals away from the buoy in extinction, while she spent just 6.7% of intervals away from the buoy during the first session of the DRO schedule only.

Table 3
Range and Mean Reinforcers per Minute For Each Component of Experiment 1

Condition	Hank		Subject		Merlot	
	Mean	Range	Iago Mean	Iago Range	Mean	Range
Mult VR 10 VR 10 (future EXT component) ^a	4.6	3.6 - 6.2	3.6	1.8 - 4.8	4.1	2.5 - 5.6
Mult VR 10 VR 10 (future DRO component) ^b	4.6	3.7 - 5.8	3.7	2.2 - 4.8	4.1	3.1 - 4.9
Mult DRO 10 s EXT (EXT component)	0.0	0.0 - 0.0	0.0	0.0 - 0.0	0.0	0.0 - 0.0
Mult DRO 10 s EXT (DRO component)	4.9	2.8 - 5.5	3.9	2.2 - 4.5	4.1	0.5 - 5.2

^a Stimulus subsequently correlated with extinction

^b Stimulus subsequently correlated with DRO schedule

Table 4
Percent of Intervals in which Vocalization was Emitted Within 5-min Components, Presented by Schedule and Session of Exposure for Experiment 1

Subject	Schedule	Session of Exposure		
		First	Second	Last
Hank	VR	--	--	3.3 ^a
	EXT	0.0	3.3	0.0
	DRO	0.0	0.0	0.0
Iago	VR	--	--	0.0 ^a
	EXT	60.0	46.7	23.3
	DRO	16.7	36.7	0.0
Merlot	VR	--	--	26.7 ^a
	EXT	66.7	30.0	0.0
	DRO	50.0	40.0	0.0

^a Percentage based on mean of two VR 10 components in last session of baseline.

Table 5
Percent of Intervals in which Subject's Body was at Least Approximately 90 cm From Operandum Within 5-min Components, Presented by Schedule and Session of Exposure for Experiment 1

Subject	Schedule	Session of Exposure		
		First	Second	Last
Hank	VR	--	--	0.0 ^a
	EXT	0.0	0.0	0.0
	DRO	0.0	0.0	0.0
Iago	VR	--	--	0.0 ^a
	EXT	6.7	53.3	26.7
	DRO	3.3	6.7	6.7
Merlot	VR	--	--	0.0 ^a
	EXT	3.3	26.7	30.0
	DRO	6.7	0.0	0.0

^a Percentage based on mean of two VR 10 components in last session of baseline.

Discussion

Both the DRO schedule and extinction reduced responding to near zero within three sessions. Zeiler (1971) obtained a robust difference between response rates in the extinction and DRO components of his multiple schedule, with the DRO schedule controlling lower rates across all sessions for each of three pigeons. Although the results of Experiment 1 were in the same general direction as those obtained by Zeiler, with the DRO schedule controlling lower rates across most sessions, the differences were small and the data in general were less conclusive than Zeiler's. Zeiler also obtained spontaneous recovery in each test during extinction and not during the DRO component, but there was no differential spontaneous recovery across dogs in this experiment. When rate differences were largest in this experiment, during the first three sessions of exposure to the mult DRO EXT schedule, the order of daily component presentation was confounded with schedule effects. That is, response rates were higher in the component that was presented first within the session and decreased across the session. Thus, order effects may have interfered with or overshadowed schedule effects. Unfortunately, Zeiler did not report the order of presentation of components during his multiple DRO EXT schedule. Thus, direct comparisons in terms of order effects were not possible. Interactions between schedule components also may have blurred or precluded differences between DRO and extinction via repeated presentation of both procedures within each session (Mulick et al., 1976; Topping et al., 1976).

It also is possible that stimulus control did not develop, reducing or preventing discrimination between components. The selection of black and white visual discriminative stimuli in Experiment 1 was based on reports suggesting that the lightness or darkness of stimuli is a more discriminable stimulus dimension to dogs than are color or detail (Lindsay, 2000). Dogs also are particularly adept at discriminating movement in the periphery (Lindsay, 2000) and thus the flashing light was correlated with one component to simulate movement and potentially enhance discriminability. Given that dogs' audition and olfaction are particularly

keen, use of auditory or olfactory stimuli may have enhanced the dogs' ability to discriminate between components.

Although a number of comparisons of extinction and DRO schedules conclude that DRO schedules reduce responding more rapidly than extinction, there also are comparisons in which extinction and DRO schedules have reduced responding similarly. This has been observed using both within- (Lowry & Lachter, 1977; Topping & Ford, 1975; Topping et al., 1976) and between- (Moss, Ruthven, Hawkins, & Topping, 1983; Pacitti & Smith, 1977) subject designs and with rats (Pacitti & Smith, 1977), pigeons (Lowry & Lachter, 1977), and humans (Moss et al., 1983). Still other comparisons have demonstrated that extinction reduces responding more rapidly than DRO schedules (McGlynn et al., 1975; Thompson et al., 2003; Uhl, 1973; Uhl & Garcia, 1969). These inconsistencies across experiments have been attributed to differences in experimental designs, subjects, baseline parameters, and DRO schedule parameters. Conflicting results have been obtained with similar experimental designs and subject populations, however, suggesting that these are not essential variables. A variety of baseline schedules also have been employed and some studies suggest that baseline parameters do not determine the relative efficacy of DRO and extinction (Topping & Crowe, 1974; Topping & Larmi, 1973). It has been suggested that longer DRO intervals (e.g., 60 s) reduce the efficacy of DRO schedules relative to extinction (Topping & Ford, 1975), yet extinction has reduced responding more rapidly than DRO schedules with intervals as short as 5 or 10 s (McGlynn et al., 1975; Uhl & Garcia, 1969). Thus, it remains unclear why these inconsistencies are obtained.

Experiment 2

Experiment 1 led to a reconsideration of how best to compare DRO and extinction as response-reduction procedures. Two potential problems with the first experiment were the use of a multiple schedule to make the comparisons and the use of a fixed DRO procedure. With the multiple schedule design of Experiment 1, it was not possible to assess whether the results obtained were partially or entirely a function of order effects, interactions between responding in the two components, or questionable stimulus control. Because of these potential confounds, a reversal design was employed in Experiment 2. In a reversal design, order effects may be exposed more clearly through the counterbalancing of the order of exposure to extinction and the DRO schedule across subjects. Although a reversal design cannot eliminate order effects, it reduces their likelihood relative to a multiple schedule design by reinstating baseline conditions until stability in responding has been achieved (Sidman, 1960). The single exposure to, and reinstatement of baseline conditions between, experimental conditions also minimizes interaction effects between the two (cf. Catania, 1963). Finally, the lack of schedule-correlated stimulus control does not confound results in a reversal design.

The fixed DRO used by Zeiler (1971) and others, and also used in Experiment 1 above, may not be the most efficacious means of DRO response reduction. In contrast to a fixed DRO schedule, where each response simply restarts a constant time period, an escalating DRO schedule is one in which the DRO intervals increase across time rather than remaining at a fixed duration throughout the time they are in effect. This procedure reduces responding more rapidly than either extinction or fixed DRO schedules (Moss et al., 1983; Topping et al., 1975). Cross et al. (1978) exposed 30 adults to a VR 6 baseline schedule and then to either extinction, a DRO 8-s

schedule, or an escalating DRO schedule the intervals of which increased from 2 to 8 s in 2-s increments contingent upon participants emitting less than four responses within each of five consecutive IRIs. Across the 15-min response elimination period, the fixed DRO schedule maintained responding near baseline rates, extinction decreased responding to approximately half of the baseline rate, and the escalating DRO schedule reduced responding to near-zero rates. Moss et al. (1983) replicated this effect using a VR 10 baseline schedule and comparing extinction with a fixed DRO 10-s schedule and an escalating DRO schedule the intervals of which increased from 2 to 10 s. These latter parameters were selected for the escalating DRO schedule employed in Experiment 2, while the procedure used by Cross et al. was selected for increasing the DRO interval durations.

Method

Subjects

Four pet dogs, described in the middle portion of Table 1, served as subjects. Two dogs were deprived of food for five hours prior to each session and two were deprived for seven hours prior to each session. All other subject characteristics were identical to those of Experiment 1.

Apparatus

The operandum was identical to that used in Experiment 1. Reinforcers consisted of small pieces of cooked chicken hot dog, approximately 0.5 cm in diameter. For one dog (Theo), a small rubber tire dog toy was placed around the base of the buoy to prevent Theo's paws from moving the buoy after observing that often he touched the buoy with his nose and paws simultaneously. A laptop computer was used during the escalating DRO condition. In this condition, using Visual Basic™ software, the second experimenter operated and reset DRO intervals while recording responses and reinforcers. As in Experiment 1, a hand-held counter was used to tally responses, a video camera was used to record each session, and session numbers were displayed on paper. A radio or television in the experimental room was turned to a channel without reception and remained on throughout each session to provide masking noise.

Procedure

For Gadget and Sport, sessions were conducted in the living room and for Sam and Theo, sessions were conducted in the den of the respective homes of their owners. Response definition, response shaping, and procedures for leaning the schedule were identical to those of Experiment 1. Sessions during initial training and baseline were terminated after the first reinforcer that was delivered after 20 min had elapsed. Baseline consisted of a minimum of 15 sessions of the VR 10 schedule. After 15 sessions, and when response rates across the last six sessions showed minimal variability and no decreasing trend, each dog was exposed to either extinction or an escalating DRO schedule. Order of exposure to these conditions was counterbalanced across dogs such that Sam and Theo were exposed to extinction first while Gadget and Sport were exposed to the escalating DRO schedule first. Each of these conditions, described in detail below, was in effect for a minimum of six sessions and until response rates for three consecutive sessions were less than 10% of the mean response rate of the last three sessions of baseline.

In extinction, each response produced the click of the hand-held counter but no other programmed consequence. In the escalating DRO schedule, responding produced the click of the hand-held counter but no reinforcer was delivered. Instead, a reinforcer was delivered after an interval of time during which no responses were emitted. At the onset of each session, the second experimenter began the first interval, at the end of which he or she said “Go” and the first experimenter delivered a reinforcer. To exclude reinforcer delivery time from the DRO intervals, each subsequent interval began only when the reinforcer reached the dog’s mouth (this typically occurred about 1 s after the “Go” prompt). Each response during a DRO interval reset the interval, delaying the upcoming reinforcer. Within each session, the duration of this interval increased in 2-s increments if the subject made three or fewer responses within each of five consecutive IRIs. For example, if no responses were emitted, a reinforcer was delivered every 2 s until five reinforcers had been delivered, after which a reinforcer was delivered every 4 s until five reinforcers had been delivered, and so on until reinforcers were being delivered 10 s apart. If a response was made during the initial 2-s interval, that interval reset and no reinforcer was delivered until 2 s had passed without a response. When this criterion was met five consecutive times, the interval was increased to 4 s, and so on. Once the interval duration had reached 10 s, all subsequent reinforcers in that session were delivered at 10-s intervals. The DRO schedule also was leaned across sessions, in that the first two sessions began with a 2-s interval, the third session began with a 4-s interval, the fourth session began with a 6-s interval, the fifth session began with an 8-s interval, and the sixth and any subsequent sessions contained only 10-s intervals. In each case, responding at the end of the previous session had surpassed the criterion for increasing the interval by 2 s at the start of the next session (i.e., intervals were larger at the end of each session than they were at the beginning of the next session). Each extinction and DRO session was terminated after 20 min.

After the minimum six sessions in either extinction or the escalating DRO schedule, and when response rates met the reduction criterion, baseline was reinstated for 15 sessions. After 15 sessions of this VR 10 schedule, and when the last six sessions showed minimal variability and no decreasing trend, dogs that had been exposed to extinction first were exposed to the escalating DRO schedule and dogs that had been exposed to the escalating DRO schedule were exposed to extinction. The sequence of conditions and number of sessions in each are shown in Table 2. Interobserver agreement was calculated as described in Experiment 1. Mean IOA for Gadget, Sam, Sport, and Theo, respectively, was 97.4%, 95.4%, 95.2%, and 93.3%, with a range of 67.0% to 100.0%.

To calculate the mean percentage of intervals in which vocalization occurred and intervals in which dogs left the buoy by at least approximately 90 cm in each schedule, 5-min segments were coded separately from video tape by two observers. For each dog, this segment began at the 10th minute and ended at the 15th minute of each selected session. Segments were selected from the last session of each baseline VR condition, and from the first two and last sessions of the extinction and DRO conditions. Partial-interval recording was conducted and IOA was calculated as described in Experiment 1. For vocalization, mean IOA across Gadget, Sam, Sport, and Theo was 99.2%, 97.5%, 98.3%, and 97.5%, respectively, with a range of 93.3% to 100.0%. For the measure of leaving the buoy, mean IOA across these dogs was 99.6%, 97.5%, 99.2%, and 99.6%, respectively, with a range of 93.3% to 100.0%.

Results

Response rates were calculated by dividing the total number of responses by the total session time. These rates are shown in Figure 3. Response rates during the VR 10 schedule were similar across dogs, averaging between 35 and 55 responses per min at stability. For Gadget and Sport, the reversal to the baseline VR 10 schedule resulted in a slightly higher asymptotic rate than the initial VR 10 baseline, while for Sam and Theo, response rates in the first and second exposure to the VR 10 schedule were similar. For Sam, Sport, and Theo, response rates during the first two sessions of the DRO schedule were higher than those during the first two sessions of extinction. Thereafter, response rates for Sam and Theo were similar in extinction and DRO conditions while for Sport, rates remained higher during the DRO condition across the first seven sessions. Sport required nine sessions of DRO to meet the response reduction criterion. Gadget's response rates during the first two sessions of extinction were higher than those in the first two sessions of the DRO condition. Thereafter, response rates in extinction and DRO were equivalent. Although Gadget's response rates during extinction met the reduction criterion after six sessions, one additional session of extinction was conducted because rates showed an increasing trend across the fourth through sixth sessions and because a burst in potentially-aggressive vocalization (i.e., barking) resulted in the sixth session being terminated after 17.3 min.

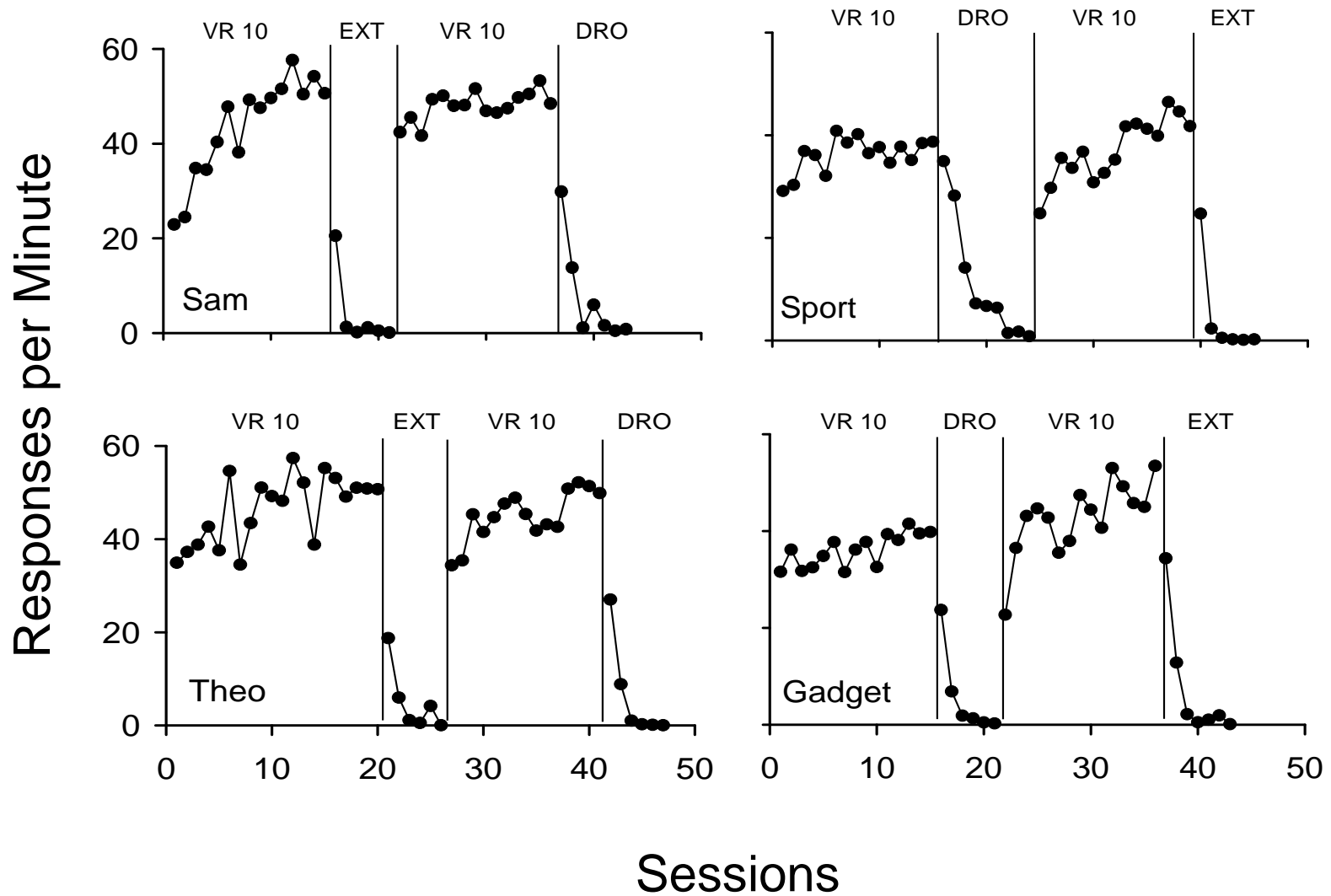


Figure 3. Responses per minute across sessions for each of four subjects in Experiment 2.

The proportion of baseline response rate was calculated by dividing the response rate of each session of extinction and DRO by the mean of the last three sessions of the immediately preceding exposure to the VR 10 schedule. Figure 4 shows the proportion of baseline response rates for each dog. All dogs in both conditions showed rapid response reduction and reached the reduction criterion within seven sessions with the exception of Sport, who required nine sessions in the DRO condition. The relative expediency of extinction relative to the DRO schedule is particularly apparent for this dog, whose relative rates were higher during the DRO schedule in all nine sessions. This pattern occurred for Sam and Theo across the first two sessions, but thereafter relative response rates for Sam and Theo were not consistently different in extinction and DRO conditions. Gadget's relative rates were similar in extinction and DRO, with slightly higher relative rates in extinction for the first two sessions.

Reinforcement rates were calculated by dividing the total number of reinforcers in each session by total session time. Mean reinforcement rates and ranges for each dog in each condition are shown in Table 6. During the VR 10 schedule these rates ranged from 3.6 to 4.7 reinforcers per minute across dogs. During the escalating DRO schedule, mean reinforcement rates ranged from 4.2 to 5.2 reinforcers per minute across dogs. Like the fixed DRO schedule, the escalating DRO schedule is functionally equivalent to extinction prior to the first reinforcer delivery and thus differences in responding until that point must be attributed to variables other than the contingencies arranged in the schedules. All dogs in Experiment 2 contacted the DRO contingency within the first 20-min session, earning between 33 and 79 reinforcers.

Table 7 shows the proportion of intervals containing vocalization within each 5-min segment selected from the last session of each VR baseline and the first, second, and last sessions of extinction and the DRO schedule. Segments from the last session of the first VR baseline and the last session of the reversal to baseline were combined and the mean of these two segments is shown for each dog. For Gadget, there were increases in vocalization during the first and last session of exposure to extinction, from 0.0% of intervals in baseline to 10.0% and 50.0% of intervals, respectively. There was no vocalization for this dog during the DRO schedule. For Sam, there were small increases in vocalization from 0.0% of intervals in baseline to 10.0% in the first session of extinction and 10.0% during the second session of the DRO schedule. In all other sessions of both conditions, vocalization was at or near zero levels. For Sport, the only session in which vocalization occurred was the first session of extinction (3.3% of intervals). Finally, for Theo, rates of vocalization increased from 0.0% in baseline to 10.0% during the first session of extinction and to 53.3% during the first session of the DRO schedule. Thus, although vocalization increased from baseline for all dogs, there was no consistent difference in vocalization between extinction and DRO conditions across dogs. Table 8 shows the percentage of intervals in which dogs moved at least approximately 90 cm away from the buoy in each condition. Dogs frequently were away from the buoy during extinction, often for 100.0% of the intervals, while they remained close to the buoy during almost all intervals of the VR and DRO conditions. These dogs often moved to a dog bed or couch to sleep during extinction, especially after the first or second session.

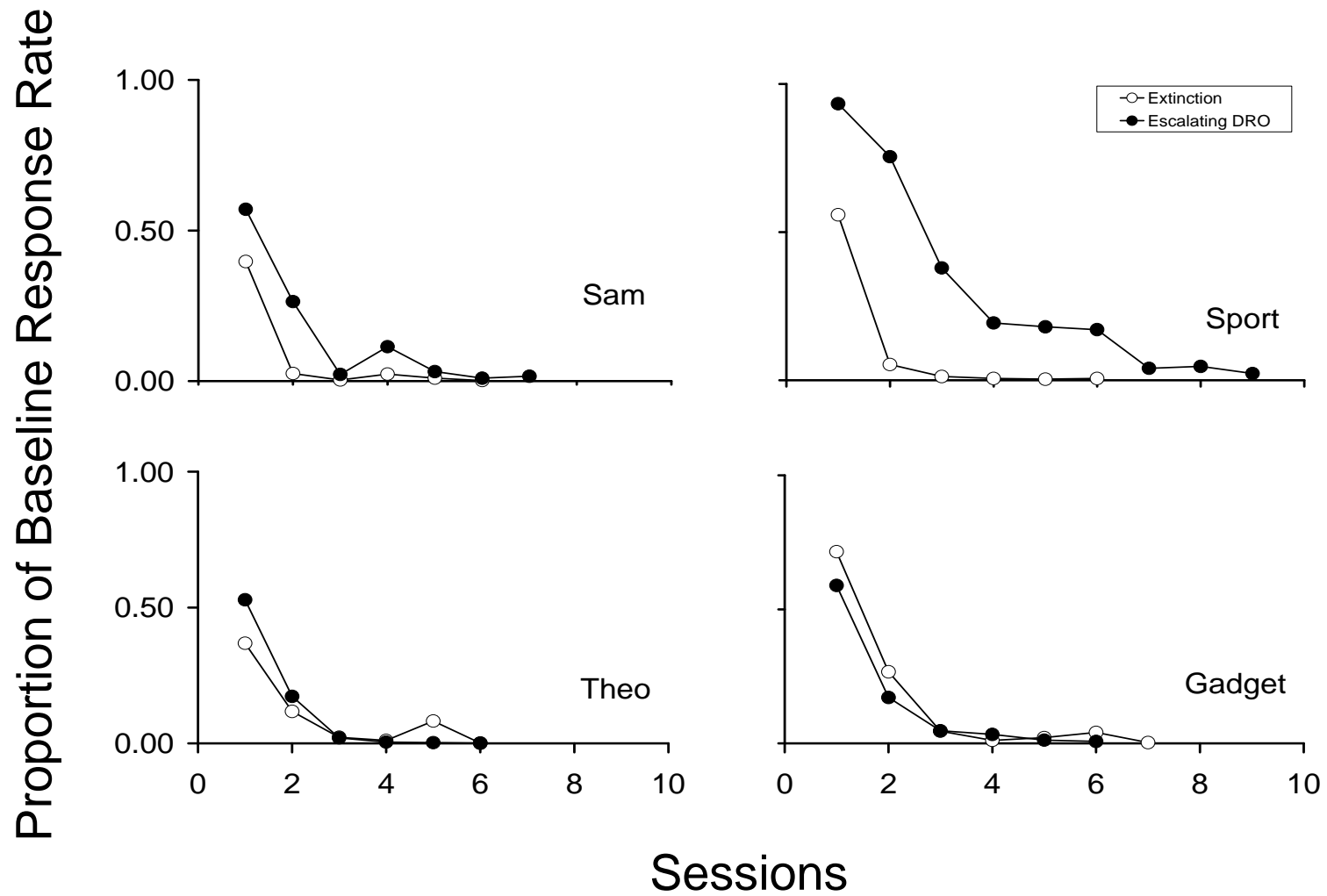


Figure 4. Proportion of baseline response rates across all sessions of the extinction and DRO conditions for each of four subjects in Experiment 2. Closed circles represent the proportion of baseline response rates during the escalating DRO schedule. Open circles represent the proportion of baseline response rates during extinction.

Table 6
Range and Mean Reinforcers per Minute For Each Condition of Experiments 2 and 3

<u>Experiment 2</u>				
Subject				
Condition	Gadget		Sport	
	Mean	Range	Mean	Range
VR 10 Baseline	3.6	3.1 - 4.1	3.6	2.9 - 4.1
Escalating DRO 10 s	4.8	3.5 - 5.7	4.2	1.6 - 5.5
VR 10 Baseline	4.3	2.0 - 5.3	3.7	2.1 - 4.6
EXT	0.0	0.0 - 0.0	0.0	0.0 - 0.0
Condition	Sam		Theo	
	Mean	Range	Mean	Range
VR 10 Baseline	4.3	2.2 - 5.7	4.6	3.3 - 5.8
EXT	0.0	0.0 - 0.0	0.0	0.0 - 0.0
VR 10 Baseline	4.7	4.0 - 5.2	4.5	3.1 - 5.4
Escalating DRO 10 s	4.5	3.4 - 5.2	5.2	4.0 - 5.7
<u>Experiment 3</u>				
Subject				
Condition	Buddy		Jade	
	Mean	Range	Mean	Range
VR 10 Baseline	3.3	2.5 - 3.8	4.3	3.5 - 4.7
FT 10 s	4.9	4.6 - 5.1	4.7	4.4 - 4.9
VR 10 Baseline	3.4	1.7 - 4.5	4.5	3.1 - 5.0
EXT	0.0	0.0 - 0.0	0.0	0.0 - 0.0
Condition	Jake		Max	
	Mean	Range	Mean	Range
VR 10 Baseline	3.8	2.7 - 4.9	2.7	2.1 - 3.1
EXT	0.0	0.0 - 0.0	0.0	0.0 - 0.0
VR 10 Baseline	4.7	3.3 - 5.5	3.6	2.5 - 4.3
FT 10 s	5.2	5.1 - 5.3	5.0	4.9 - 5.2

Table 7
Percent of Intervals in which Vocalization was Emitted, Presented by Schedule and Session of Exposure for Experiment 2

Subject	Schedule	Session of Exposure		
		First	Second	Last
Gadget	VR	--	--	0.0
	EXT	10.0	0.0	50.0
	DRO	0.0	0.0	0.0
Sam	VR	--	--	0.0
	EXT	10.0	0.0	3.3
	DRO	0.0	10.0	3.3
Sport	VR	--	--	0.0
	EXT	3.3	0.0	0.0
	DRO	0.0	0.0	0.0
Theo	VR	--	--	0.0
	EXT	10.0	0.0	0.0
	DRO	53.3	6.7	0.0

Table 8
Percent of Intervals in which Subject's Body was at Least Approximately 90 cm From Operandum, Presented by Schedule and Session of Exposure for Experiment 2

Subject	Schedule	Session of Exposure		
		First	Second	Last
Gadget	VR	--	--	0.0
	EXT	0.0	3.3	13.3
	DRO	0.0	0.0	0.0
Sam	VR	--	--	1.7
	EXT	66.7	100.0	100.0
	DRO	0.0	6.7	0.0
Sport	VR	--	--	1.7
	EXT	53.3	100.0	100.0
	DRO	0.0	0.0	0.0
Theo	VR	--	--	3.3
	EXT	100.0	100.0	100.0
	DRO	0.0	0.0	0.0

Discussion

In this experiment, extinction generally was more efficient than the escalating DRO schedule in reducing response rates. Extinction controlled lower response rates across the first two sessions for Sam, Theo, and Sport. For these three dogs, responding was reduced by extinction to near zero within three sessions and remained at or near zero thereafter. For Sam and Theo, the DRO schedule also reduced responding within three sessions and rates in DRO and extinction thereafter were overlapping. Sport's rates were reduced only gradually by the DRO schedule and did not meet the response reduction criterion until the ninth session. Gadget's results differed from those of the other three dogs, with the DRO schedule reducing responding slightly more rapidly than extinction during the first two sessions.

A gradual decline in response rates produced by fixed DRO schedules has been obtained by others (e.g., Cross et al., 1978; Thompson et al., 2003; Uhl & Garcia, 1969; Uhl & Sherman, 1973), but such results under an escalating DRO schedule are inconsistent with previous research. Moss et al. (1983) and Topping et al. (1975) utilized baseline schedules identical to that used here (i.e., VR 10) and then exposed groups of participants to extinction or to an escalating DRO schedule the parameters of which increased from 2 to 10 s after a minimum of two (Moss et al., 1983) or three (Topping et al., 1975) reinforcers at each interval duration. In both studies, responding was reduced more rapidly and to a lower asymptotic rate by the escalating DRO schedule than by extinction. Unfortunately, in both cases authors reported that once the minimum criterion for increasing interval durations was met, the parameter values were changed at the discretion of the experimenter and no further detail was given on what might have controlled these increases in DRO interval duration. It is possible that these participants were given differing amounts of exposure to each DRO interval, making direct comparisons with the results of the present experiment difficult. Others, however, have specified the response reduction criterion and, using a criterion similar to that of the present experiment, also have found greater response reduction under an escalating DRO schedule than under extinction (Cross et al., 1978; Pickering & Topping, 1974). It is possible that different experimental designs produced these results that conflict with those of the present experiment. In each of the comparisons between escalating DRO schedules and extinction just described, human participants were exposed to one session in which responding was shaped, maintained, and then eliminated. The response elimination phase consisted of one 15-min exposure either to extinction or to the escalating DRO schedule that immediately followed response maintenance. Such procedural differences might account for the differences between the present results and those of previous research with escalating DRO schedules.

Two variables that may have contributed to the higher response rates in DRO than in extinction are the dogs' proximity to the operandum and the discriminative effects of reinforcer delivery during the DRO schedule. Increased proximity to the operandum in DRO schedules relative to extinction has been reported by others (Davis & Bitterman, 1971; Pacitti & Smith, 1977; Zeiler, 1971) and may be explained either by extinction producing variability in responding that sometimes results in subjects moving away from the operandum (Zeiler, 1971) or by the DRO schedule reinforcing proximity to the reinforcement delivery area (Davis & Bitterman, 1971; Pacitti & Smith, 1977). Food was delivered within approximately 60 cm of the buoy and thus dogs received food most rapidly and efficiently by remaining in that area. Because

reinforcers were not presented in extinction, this contingency was absent. As seen in Table 8, Sam, Sport, and Theo spent nearly 100% of recorded intervals away from the buoy during most extinction sessions and almost no time away from the buoy during the DRO schedule. These three dogs also showed more rapid response reduction under extinction than under the DRO schedule. In contrast, Gadget, whose rates were higher in extinction than in DRO, remained in close proximity to the buoy during most of each recorded session of extinction.

Reinforcers can have a discriminative effect whereby they engender responding subsequent to their presentation. The amount of responding generated is a function of baseline response rates (Franks & Lattal, 1976; Rescorla & Skucy, 1969; Uhl & Garcia, 1969). In a DRO schedule, when the absence of responding meets the criterion for reinforcement, subjects are exposed to a reinforcer identical to that in baseline. It has been suggested that consumption of this reinforcer becomes part of a chain of behavior in baseline, the subsequent links of which involve returning to the operandum to make further responses (Uhl & Garcia, 1969). Specifically, during a baseline schedule such as a ratio schedule, returning to the operandum and responding following consumption of reinforcement produces additional reinforcement. Consumption of each reinforcer thus comes to serve as a discriminative stimulus in the presence of which further responding produces reinforcement. When the reinforcer is first introduced in the DRO schedule, its presentation and consumption serve as discriminative stimuli for further responding. Such an effect is precluded in extinction because no reinforcers are delivered. Uhl and Garcia, who observed greater response reduction under extinction than under fixed DRO schedules of various parameters, concluded that this discriminative effect of reinforcement is in opposition to the response reduction contingencies operating in DRO schedules, and thus slows response decrement relative to extinction. Others have made this argument in explaining slow response reduction during early exposure to DRO schedules (Lowry & Lachter, 1977; McGlynn et al., 1975).

Experiment 3

In Experiment 2, extinction reduced responding more rapidly than DRO and was easier to implement, giving it an advantage over the DRO schedule as an applied response reduction procedure. The DRO schedule, however, allowed for the continued availability of reinforcement, a feature that may increase its appeal in applied settings. The development and refinement of response elimination procedures that involve the delivery of positive reinforcers is an important theme in applied behavior analysis (Homer & Peterson, 1980; Tucker, Sigafos, & Bushell, 1998). In addition to the DRO schedule, one procedure that has this benefit is the time-based schedule. Time-based schedules have been used to treat a variety of problematic responses in humans and have become particularly popular over the last decade (Vollmer et al., 1993; Vollmer et al., 1997). In most previous comparisons between time-based schedules and extinction, however, extinction has reduced responding more rapidly and completely (Rescorla & Skucy, 1969; Ringdahl et al., 2001; Thompson et al., 2003). Some authors have suggested that time-based schedules are nonetheless preferable to extinction because, in addition to providing access to reinforcement, they preclude extinction bursts and emotional behavior (Vollmer et al., 1993; Vollmer et al., 1998). To further examine the relative efficacy of response reduction procedures commonly used in behavior analysis, a time-based schedule was selected for comparison with extinction in a reversal design in Experiment 3.

Method

Subjects

Four pet dogs, described in the lower portion of Table 1, served as subjects. Two were food-deprived for five hours and two were food-deprived for six hours prior to each session. All other subject characteristics were identical to those of Experiment 1.

Apparatus

The operandum was identical to that used in Experiment 1. Reinforcers consisted of pieces of chicken hot dog identical to those used in Experiments 1 and 2. A stopwatch was used to time FT intervals. As in Experiments 1 and 2, a hand-held counter was used to tally responses, a video camera was used to record each session, and session numbers were displayed on paper. For Jade and Max, a padded blanket was placed under the buoy to prevent excessive swaying which occurred when the buoy was placed directly on the tile floor. A radio or television turned to a channel without reception remained on throughout each session to provide masking noise.

Procedure

For Jake, sessions were conducted in the living room, for Buddy they were conducted in the home office, and for Jade and Max they were conducted in the kitchen of the owners' homes. Response definition, response shaping, and initial training were identical to those of Experiment 1. Baseline conditions were identical to those of Experiment 2. After the minimum 15 sessions of VR 10 and when response rates showed minimal variability and no decreasing trend, each dog was exposed either to extinction, which was identical to that described in Experiment 2, or to an FT 10-s schedule. Order of exposure to these conditions was counterbalanced such that Buddy and Jade were exposed to the FT 10-s schedule first and Jake and Max were exposed to extinction first. According to the FT 10-s schedule, a reinforcer was delivered every 10 s, irrespective of the dog's responding. The first experimenter tallied responses and delivered reinforcers while the second experimenter operated a stopwatch. Beginning at session onset, the second experimenter said, "Go" every 10 s, at which point the first experimenter delivered a reinforcer. To exclude reinforcer delivery time from the FT intervals, each subsequent interval began only when the reinforcer reached the dog's mouth (this typically occurred about 1 s after the "Go" prompt). Sessions were terminated after 20 min had elapsed.

Dogs were exposed to a minimum of six sessions of extinction and six sessions of the FT schedule. Each of these conditions remained in effect until response rates across three consecutive sessions were less than 10.0% of the mean response rate of the last three sessions of the preceding VR 10 condition or until a maximum of 15 sessions. Dogs then were exposed to 15 more sessions of a reversal to the baseline VR 10 schedule. When response rates showed minimal variability and no decreasing trend across the last six sessions, those dogs previously exposed to extinction were exposed to the FT 10-s schedule and those dogs previously exposed to the FT 10-s schedule were exposed to extinction. The sequence of conditions and number of sessions in each are shown in Table 2. Interobserver agreement was calculated as described in

Experiment 1. For Buddy, Jade, Jake, and Max, mean IOA was 96.4%, 94.3%, 95.2%, and 93.4%, respectively, with a range of 60.0% to 100.0%.

Reinforcement rates were calculated as in Experiment 2. To calculate the mean percentage of intervals in which vocalization occurred and in which dogs left the buoy by more than approximately 90 cm in each schedule, 5-min segments were coded separately from video tape by two observers. For each dog, this segment began at the 10th minute and ended at the 15th minute of each selected session. Segments were selected from the last session of each baseline VR condition, and from the first two and last sessions of the extinction and FT conditions. Partial-interval recording was conducted and IOA was calculated as described in Experiment 1. For vocalization, mean IOA across Buddy, Jade, Jake, and Max was 97.9%, 95.8%, 95.0%, and 95.0%, respectively, with a range of 86.7% to 100.0%. For the measure of leaving the area of the operandum, mean IOA across these dogs was 97.5%, 96.2%, 100.0%, and 99.6%, respectively, with a range of 83.3% to 100.0%.

Results

Response rates were calculated by dividing the total number of responses by the total session time. As seen in Figure 5, response rates during the VR 10 schedule were similar across dogs, averaging between 25 and 50 responses per min at stability. For all four dogs, the reversal to the baseline VR 10 schedule resulted in a slightly higher asymptotic rate than that in the initial VR 10 baseline. For all dogs, response rates in extinction were reduced to near zero within three sessions, where they remained for the duration of extinction. In contrast, the FT 10-s schedule produced only small decreases in responding and all dogs were exposed to the maximum 15 sessions with responding never reaching the response reduction criterion. The proportion of baseline response rates for each dog in Experiment 3 is shown in Figure 6. Across all extinction sessions, the highest proportion of baseline response rates emitted by any dog was 0.6, which was obtained for Buddy's first session of extinction. By the third session of extinction, all dogs' responding had been reduced to between 0.02 and 0.04 of baseline response rates. In contrast, rates were higher than baseline for two dogs (Buddy and Jade) during the first session of exposure to the FT schedule and never were reduced to less than 0.08 of baseline rates in any session across dogs.

Mean reinforcement rates and ranges for each dog in each condition are shown in Table 6. Mean reinforcement rates during the VR 10 and FT schedules, respectively, ranged between 2.7 and 4.7 and between 4.7 and 5.2 reinforcers per minute across dogs. The percentage of intervals containing vocalization across conditions is shown in Table 9. Buddy exhibited no vocalization in baseline or FT conditions but did vocalize during 66.7% and 13.3% of intervals during the first and second session of extinction, respectively. Jade, Jake, and Max all vocalized in baseline. Jake subsequently engaged in more vocalization during FT than extinction, while Max showed the opposite pattern. Jade emitted high levels of vocalization in all conditions. Thus, there was no consistent difference across dogs in levels of vocalization emitted across conditions. Table 10 shows the percentage of intervals in which dogs moved at least approximately 90 cm away from the buoy in each condition. As in Experiment 2, dogs were more likely to move away from the operandum in extinction. Only one dog (Jake) left the operandum during the FT schedule, and this was during only 6.7% of intervals. In extinction, the

four dogs were away from the operandum for a mean of 71.39% (with a range of 16.7% to 100.0%) of intervals across all coded sessions.

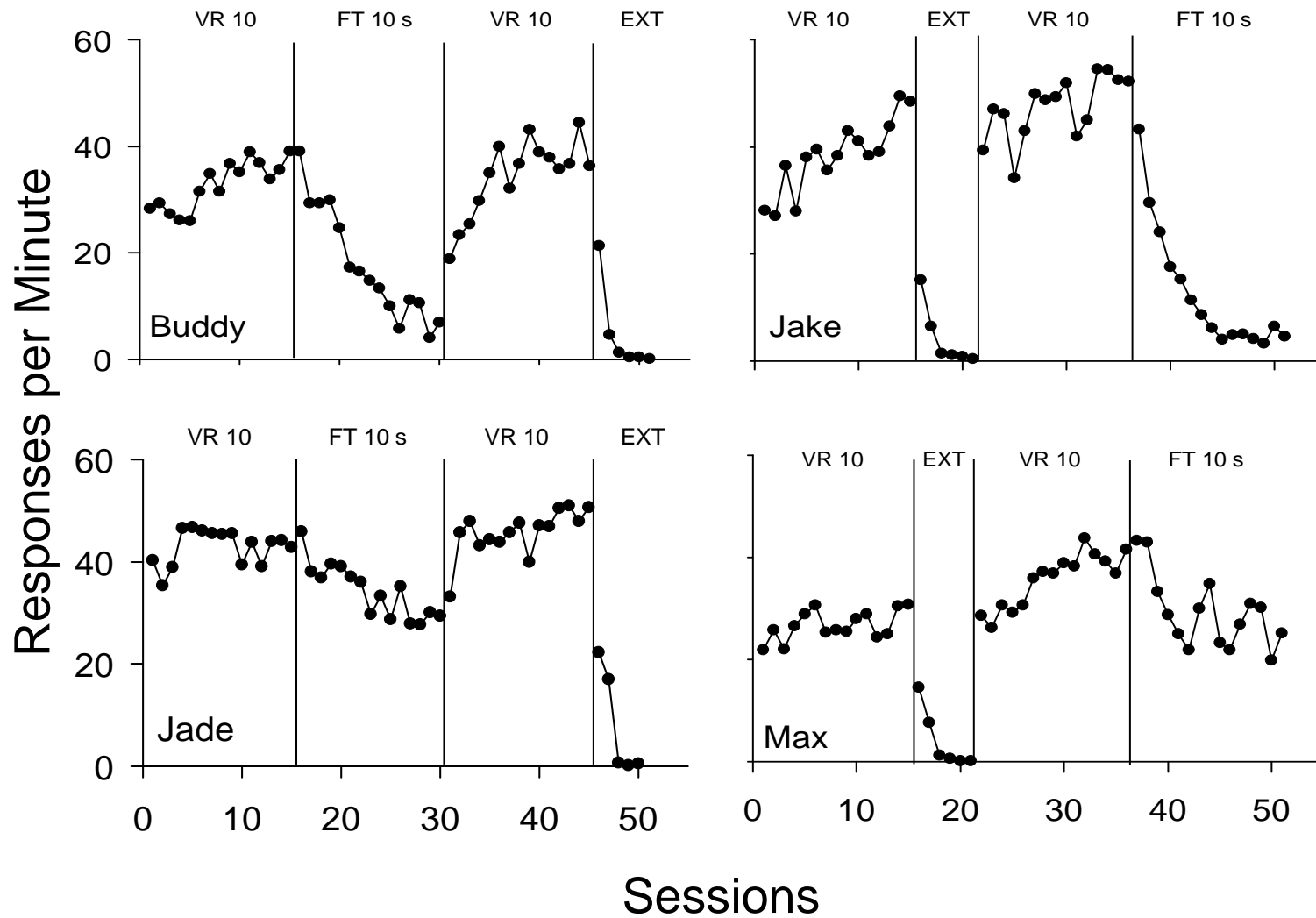


Figure 5. Responses per minute across sessions for each of four subjects in Experiment 3.

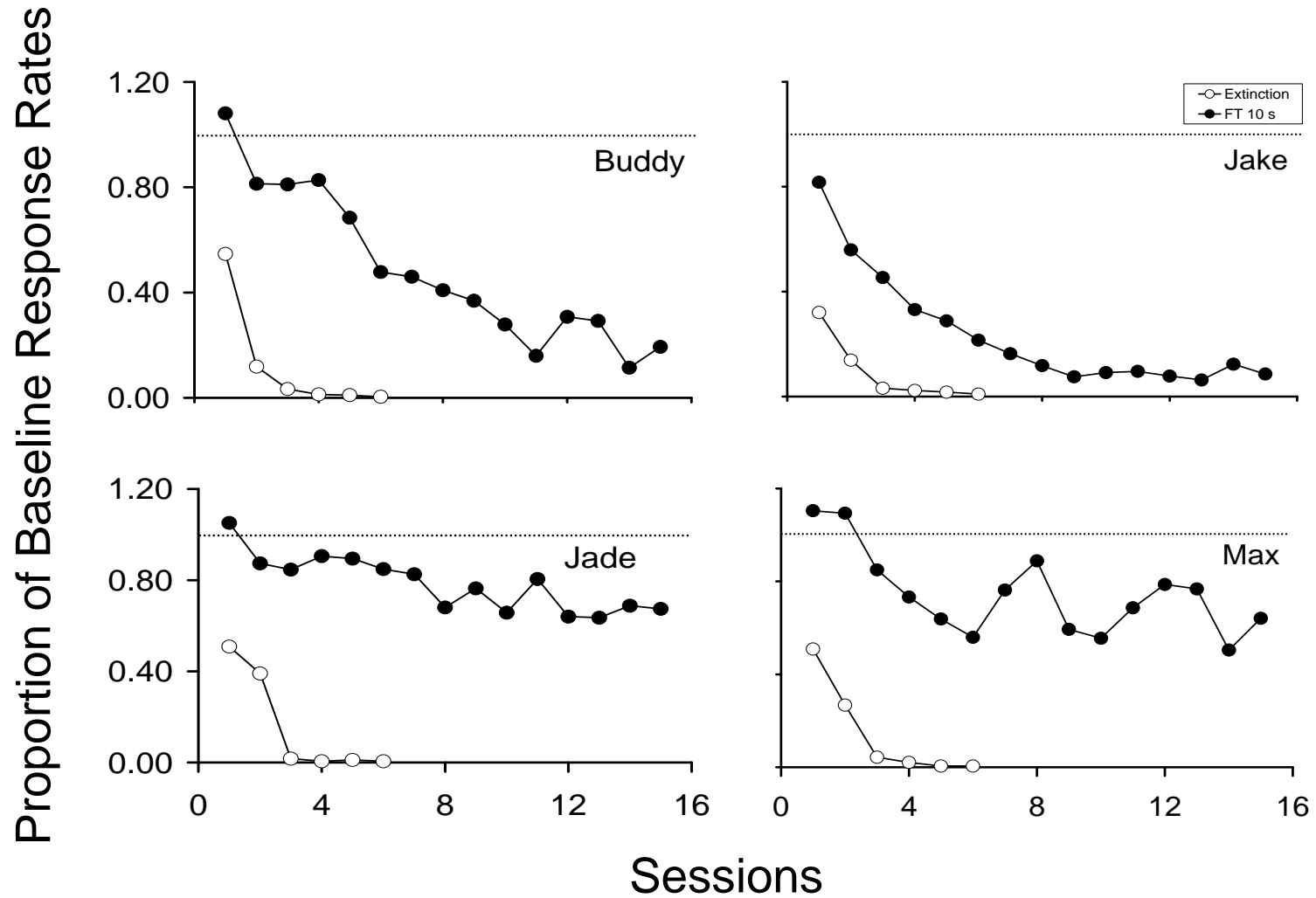


Figure 6. Proportion of baseline response rates across all sessions of the extinction and FT conditions for each of four subjects in Experiment 3. Closed circles represent the proportion of baseline response rates during the FT schedule. Open circles represent the proportion of baseline response rates during extinction.

Table 9
Percent of Intervals in which Vocalization was Emitted, Presented by Schedule and Session of Exposure for Experiment 3

Subject	Schedule	Session of Exposure		
		First	Second	Last
Buddy	VR	--	--	0.0
	EXT	66.7	13.3	0.0
	FT	0.0	0.0	0.0
Jade	VR	--	--	91.7
	EXT	46.7	96.7	0.0
	FT	86.7	60.0	93.3
Jake	VR	--	--	35.0
	EXT	20.0	0.0	0.0
	FT	86.7	70.0	26.7
Max	VR	--	--	38.3
	EXT	3.3	13.3	0.0
	FT	0.0	6.7	0.0

Table 10
Percent of Intervals in which Subject's Body was at Least Approximately 90 cm From Operandum, Presented by Schedule and Session of Exposure for Experiment 3

Subject	Schedule	Session of Exposure		
		First	Second	Last
Buddy	VR	--	--	3.3
	EXT	43.3	90.0	100.0
	FT	0.0	0.0	0.0
Jade	VR	--	--	1.7
	EXT	33.3	46.7	100.0
	FT	0.0	0.0	0.0
Jake	VR	--	--	1.7
	EXT	100.0	100.0	100.0
	FT	0.0	0.0	6.7
Max	VR	--	--	0.0
	EXT	16.7	26.7	100.0
	FT	0.0	0.0	0.0

Discussion

Extinction reduced responding more rapidly and completely than the FT schedule in Experiment 3. Responding was maintained at non-zero rates in the FT schedule across the maximum 15 sessions for all dogs. Across dogs, response rates stabilized in the FT schedule at a proportion of 0.10 to 0.70 of baseline rates as compared with extinction, which reduced response rates to near zero within three sessions. Such high rates of response maintenance under FT schedules have been obtained by others as well (e.g., Dozier et al., 2001; Lattal, 1972; Thompson et al., 2003). Lattal (1972) found that responding by three rats exposed to an FT 1-min schedule was maintained at approximately half of baseline rates, even after as many as 50 sessions for one subject. When these subjects later were exposed to extinction, response rates were reduced to near zero within 10 sessions. In a between-groups comparison, Rescorla and Skucy (1969) found that rats exposed to a VT 2-min schedule emitted more responses than rats exposed to extinction in every session of exposure and responding under the VT schedule was maintained at non-zero rates even after 20 sessions. In both studies, response maintenance under the time-based schedule was attributed to the adventitious temporal pairing of reinforcers with responding. As described in the Literature Review above, adventitious pairings between response-independent reinforcers and responding can result in the acquisition (Skinner, 1948) and maintenance (Herrnstein, 1966) of responding. In Experiment 3, all four dogs were responding throughout the 10-s FT intervals and many of their responses were immediately followed by reinforcement. It is possible that such adventitious pairings were responsible for response maintenance in the FT schedule.

One influential variable in the superstitious maintenance of responding is the rate of reinforcer delivery. Skinner (1948) acknowledged this, stating that shorter IRIs would be expected to produce more superstitious responding for two reasons. First, as intervals increase, the animal is more likely to be engaging in diverse responses, precluding the repeated accidental reinforcement of topographically similar responses. Second, longer intervals allow for more unreinforced responses to be emitted, increasing the likelihood that these responses will extinguish. Lachter, Cole, and Schoenfeld (1971) found that shorter VT intervals maintained higher rates of responding following exposure to a response-dependent baseline schedule. In fact, at the shortest IRIs of 5 and 15 s, rates were higher than baseline rates in the first several sessions of the VT schedule. It appears that a combination of high baseline response rates and short IRIs in subsequent time-based schedules is an ideal environment for creating superstitious response maintenance. By moving from a VR 10 to an FT 10-s schedule, this set of conditions was met in Experiment 3 of the current report and an effect like that obtained by Lachter et al. (1971) was replicated (i.e., high response rates occurred in the FT schedule and response rates of three of four dogs were higher in the first session of the FT schedule than in baseline).

As in DRO schedules, it is possible that reinforcer delivery serves a discriminative function in FT schedules. In most demonstrations of response maintenance under time-based schedules, it is difficult to separate the role of reinforcers as discriminative stimuli from the role of adventitious temporal pairings between responding and reinforcement. Rescorla and Skucy (1969) conducted a series of tests to separate the effects of these two variables. They concluded that the discriminative effect of reinforcers (in addition to their potential role in increasing activity and keeping organisms closer to the operandum), and not their adventitious pairings with responding, was responsible for response maintenance under time-based schedules. In

Experiment 3 of the current report, either or both of these processes may have produced response maintenance on the FT schedule. As in Experiment 2, dogs also spent more time away from the buoy during extinction. Thus, it is possible that responses again were more likely to occur simply because proximity to the reinforcer delivery area, and thus the operandum, was reinforced during the FT schedule and not during extinction. The FT schedule, however, maintained rates of responding higher than those produced by the DRO schedule of Experiment 2, suggesting that some process in addition to, or instead of, mere proximity to the operandum was controlling dogs' responding under the FT schedule.

The results of Experiment 3 are in contrast to many applied studies that have found that time-based schedules decrease rates of responding rapidly and completely (Carr et al., 2000; Hagopian et al., 1994). It is important to note again, however, that reinforcement on FT schedules in applied studies often is provided continuously at first and then thinned across time. It is not surprising that problem behavior decreases dramatically when continuous access to the reinforcer is provided because such access removes the establishing operation for that reinforcer. This procedural difference between applied and basic research examinations of time-based schedules is common and may explain the disparate results obtained across previous comparisons of these procedures (Ringdahl et al., 2001) as well as the differences between those applied studies and the results of Experiment 3 of the current report.

General Discussion

In the three experiments comprising this dissertation, an attempt was made to establish experimental control over the responding of pet dogs in their natural environment. Specifically, the relative efficacy of three response reduction procedures was assessed using either a multiple schedule (Experiment 1) or a reversal design (Experiments 2 and 3). In the multiple schedule, several potential confounds made interpretation of the results difficult. The reversal design surmounted some of these methodological confounds and responding was reduced more rapidly under extinction than under the comparison schedules in Experiments 2 and 3. Furthermore, no differential negative side effects were produced by extinction and it was the easiest of the three procedures to implement. In the first section of this General Discussion, the methodological advantages and disadvantages of the analogue approach taken in this research will be examined. It will be argued that utilization of an arbitrary response, although it reduces the generalizability of findings to canine behavior problem reduction, was necessary to establish internal validity. Because extinction was more effective than comparison procedures as arranged in Experiments 2 and 3, its application to the reduction of canine behavior problems will be recommended in the second section of the General Discussion. Given the conflicting results of previous research and the specific arrangements of the present experiments, it seems prudent also to examine conditions under which DRO or FT schedules still might be preferable. Therefore, the General Discussion will conclude with a brief examination of the mechanisms involved in response reduction under DRO and FT schedules and the variables that enhance their efficacy or palatability to consumers.

Methodological Considerations and Conclusions

One goal of this research was to delineate valid and reliable procedures that will allow researchers to examine further the functional relations controlling canine behavior in the pet dog's natural environment. To fulfill this goal, it was deemed necessary to conduct this research outside of the laboratory while maintaining an emphasis on methods based on a laboratory research model. Specifically, the response selected as the dependent variable was one chosen for its ease of development, measurement, and maintenance (i.e., its repeatability) rather than for its topographical similarity to any of the problematic canine responses to which the experimental results purport to generalize. A within-subject design that allowed responding to be measured at steady-state and returned to baseline conditions following implementation of experimental conditions was utilized. Owners were not involved in implementing experimental procedures as they typically would be in application of behavioral interventions and edible reinforcers were utilized although such reinforcers may not be those that maintain many problematic canine responses. Thus, there are procedural features of this research that resemble those of basic laboratory research although its goals are better categorized as applied.

The style of these experiments might be characterized as analogue research. Analogue research is that which seeks to study a particular process or answer an experimental question with procedures that only resemble or approximate the clinical treatment or application to which the research is intended to generalize (Kazdin, 1978). Analogue studies in behavior therapy have been acknowledged as essential links between laboratory research and application (Bernstein & Paul, 1971; Kazdin, 1978). Because it is not subject to the ethical, practical, or procedural constraints of an applied setting, analogue research can enhance experimental control over important variables and the internal validity of its findings. Yet the external validity of the findings thus obtained also is a function of the degree to which the analogue situation resembles the contingencies and variables present in the applied situation. Analogue research thus faces a challenge common to all behavioral research: striking a sound balance between the processes of internal and external validity. It will be argued below that the internal validity gained by the analogue approach taken in these experiments outweighs any external validity lost.

There are several ways in which experimental control, precision, and elegance were enhanced by the analogue approach taken here. The buoy touch was selected as the operant for several reasons. First, many of the problematic responses commonly exhibited by dogs occur under the control of stimuli not likely to be present during experimental sessions as arranged herein. Many behavior problems may occur at high rates in the presence of the owner, for example, and at much lower rates in the presence of visitors (i.e., experimenters). Second, problematic canine responses may occur sporadically, making them difficult to study in a free-operant procedure. Specifically, replicating such responses in discrete experimental sessions at rates that allow one to maintain sufficient levels of responding in baseline until stability is achieved and then measure decreases in rate across multiple sessions is difficult. The approach taken in these experiments relied on the measurement of response rate in a free-operant situation and this necessitated that responding occur repeatedly within and across multiple sessions. Third, the buoy touch was ideal in that it was durable, repeatable, and easily measured and maintained across sessions (cf., Skinner, 1938). It also was shaped easily (i.e., it took advantage of a nosing response, which dogs emit easily), had a near-zero operant level, and was not a part of any

sequence of other responses that dogs were likely to emit during experimental sessions (e.g., grooming, begging, orienting toward the food bowl). Finally, if a response that the dog might have emitted outside of experimental sessions had been chosen as the dependent variable, its frequency within sessions might have been influenced by extra-experimental variables. For these reasons, the buoy touch was selected as the dependent measure in all three experiments.

An analogue preparation allowed the utilization of a single-subject design in which multiple sessions could be conducted until stability in responding was achieved. The achievement of steady-state responding is an indication that researchers successfully have controlled extraneous variables and allows interpretations of changes in responding that are based on manipulations of the independent variable (Baron, Perone, & Galizio, 1991). This steady-state strategy is a hallmark of within-subject research and its neglect under the constraints imposed in most applied research settings has been lamented (Johnston, 1996). The dogs' owners were not involved in data collection or implementation of procedures because it was deemed likely that the practical difficulties of maintaining such involvement with consistency and accuracy could threaten the internal validity of the research. Nonetheless, such involvement, along with utilization of canine problem behavior as the dependent variable, inevitably is necessary in the final evaluation of any procedure designed to reduce problem behavior in pets. Future research must address variables such as treatment integrity and treatment adherence by pet owners administering behavior change procedures to reduce problematic canine responding.

By virtue of its utilization of canine subjects studied in their natural environment, this research might provide enhanced face validity for research consumers in the dog-training and veterinary community. This community is beginning to embrace behavior-analytic approaches to dog training and behavior management and some popular dog training books incorporate behavior-analytic terminology and treatment (e.g., Donaldson, 1996; Lindsay, 2005; Pryor, 2002; Tortora, 1977). That being said, it is important to note the corresponding weaknesses of this approach. Because an arbitrary response was selected, consumers of this research may question its face validity relative to research in which problem behavior is the dependent variable. External validity was enhanced by conducting this research with the target population in the subjects' natural environment, while internal validity also was maintained by the selection of an arbitrary response and the laboratory research model employed. It is hoped that this research might be viewed as a "bridge", tying steady-state, basic research methods with applied goals. Innovative approaches to testing environment-behavior relations have garnered support in the behavior-analytic community and there has been increasing interest particularly in utilizing arbitrary responses to examine such relations in applied settings (Carr et al., 2000; Ringdahl et al., 2001). In one seminal paper on the basic-applied continuum in behavior analysis, Hake (1982) recommended that the scientific community reinforce innovative content and methods, arguing that such a community would recognize that the laboratory is "not the only controlled setting suitable for discovery" (p.24). The present research hopefully represents a step toward such an innovation.

This research also provides a demonstration of the generality of the procedures employed. Generality refers to the universality or replicability of variables, methods, or processes across species, subjects, responses, or settings (Johnston, 1993). In the present research, three response reduction procedures were implemented in a novel setting with a species

and response with which such procedures had not yet been compared. By demonstrating the relative response reduction capabilities of extinction and either a DRO schedule or an FT schedule under these conditions, this research provides an assessment of the generality of these procedures. Like any applied science, behavior analysis has the responsibility of demonstrating its external validity via research in field settings with the population to which findings are to be applied. Baer (1978) argued that the testing of experimental variables in less well-controlled settings is crucial to an understanding of the generality and robustness of variables. Yet, Baer maintained, such research must be conducted in “a way designed to prove to the inventor and the audience that the resulting apparent solution is also the functional solution” (p. 15). Thus, while a less well-controlled setting was selected for the research presented here, attempts were made to maintain the experimental control necessary to ensure that the results were confounded minimally by extraneous variables.

The experimental analysis of behavior and applied behavior analysis offer unique advantages in the study of pet behavior. A behavior-analytic approach to the treatment of canine behavior problems offers a pragmatic, straightforward, and sound technology that emphasizes the measurement and change of overt behavior based on its function rather than its form. Baer (1978) suggested that applied research might be labeled as such to the extent that it either will solve a social problem or “is part of the tooling-up necessary to mount a program that will solve a problem” (p. 16). The present research may be characterized thusly. In future research in the area of pet behavior, problematic responses might be selected and examined. For example, a response with greater face validity such as jumping or barking might be shaped and maintained by food reinforcement and then eliminated using any of the response reduction procedures employed herein. Such research may necessitate loss of the experimental control maintained here, yet may prove more convincing to the audience of those consuming research on canine behavior. Although both behavior-analytic research and application have much to offer the field of applied animal behavior, communication between the fields has not yet been fully forged. Research like that presented here hopefully represents a bridge across which increasing dialogue between the fields of behavior analysis and applied animal behavior may travel.

Extinction in Application

A more specific purpose of this dissertation was to assess the relative efficacy of extinction and each of two alternative response reduction procedures in reducing canine responding. Across the three comparisons made, extinction was either as effective as (Experiment 1) or more effective than (Experiments 2 and 3) the comparison procedure selected. It will be argued here that extinction is preferable to DRO or FT schedules not only because of its efficiency in reducing responding but also because it was easier to implement and produced no differential negative side effects relative to the DRO or FT schedules.

Speed of response reduction

Extinction has been criticized as a “notoriously inefficient behavior-therapy procedure” for reducing canine problem behavior (Lindsay, 2005, p. 397). Within the field of behavior analysis as well, response rate reduction under extinction has been described as slow (DuCharme & Van Houten, 1994; Poling & Ryan, 1982). In the applied literature, this perception may stem

from reports that are based on early applications of extinction which often neglected to identify the functional reinforcer maintaining problem behavior and thus may not have removed this reinforcer during extinction (Iwata et al., 1994; Lerman & Iwata, 1996). It is clear from the three experiments reported here that, at least under the conditions arranged, extinction was far from inefficient, reducing responding to near zero within three sessions in all 11 applications. There are two variables, known to reduce the resistance of responding to extinction (Lerman & Iwata, 1996), that may have played a determining role in the rapid response reduction observed in these experiments.

First, responses reinforced on an intermittent schedule will be more resistant to extinction than responses reinforced on a CRF schedule (Kazdin & Polster, 1973; Lerman et al., 1996) and resistance generally is positively related to the intermittency of the baseline schedule (Hearst, 1961). The VR 10 baseline schedule used in all experiments reported here provided a mean reinforcement rate at stability of 2.7 to 4.7 reinforcers per minute across dogs (see Tables 3 and 6). This schedule is likely to be richer than the naturalistic baseline schedule maintaining the problematic responses selected for extinction in those applied studies that have reported a slow decrement in responding (e.g., Lovaas & Simmons, 1969; Wright et al., 1978). Similarly, many problematic responses emitted by dogs are reinforced on leaner interval or ratio schedules in the natural environment. It is possible that, if responding had been maintained on a leaner baseline schedule, extinction would have produced slower response decrement than the DRO or FT schedules. Future research should examine the effects of extinction following baseline schedules that more closely resemble naturalistic schedules or rates of reinforcement of common canine behavior problems. Second, the variability in reinforcement conditions in baseline (e.g., reinforcement delay, deprivation level, or type of reinforcer) is positively correlated with resistance to extinction (Lerman & Iwata, 1996). In the present experiments, variability along these dimensions in baseline was minimal. Presumably, the variability in environmental conditions typically maintaining canine problem behavior is greater and extinction following such conditions might reduce responding more gradually than DRO or FT schedules.

Ease of implementation

In addition to its efficacy in reducing responding rapidly and completely, extinction also was easier to implement than the DRO and FT schedules, requiring only that the reinforcer previously maintaining responding be withheld. During DRO conditions, monitoring responding while timing and resetting intervals was cumbersome, suggesting that its use in applied settings might be impaired by other activities in which most dog owners or trainers must concurrently engage. Both DRO and time-based schedules have been lauded for their ease of implementation (Homer & Peterson, 1980; Vollmer et al., 1993). It is difficult, however, to maintain that either of these is easier to implement than extinction. Treatment adherence is a function of several variables, including the complexity of the intervention (Allen & Warzak, 2000). More complex treatments, especially those that do not result in immediate or rapid response reduction, are less likely to be administered consistently, thus reducing treatment integrity and the likelihood of treatment success. Noell and Witt (1998) stated that one of the crucial challenges in behavior-analytic consultation and treatment is developing “an intervention that is compatible with the demands made by the consultee’s other responsibilities” (p. 43). Extinction meets this criterion while schedules requiring the monitoring of time, responses, and reinforcer deliveries are less likely to do so. Most behavior change procedures require consistent implementation by all relevant individuals and extinction is no different in this regard. Within this

basic requirement, however, it is of benefit to select the procedure that requires the least response effort for those responsible for its implementation.

Side effects

Vollmer et al. (1993) claimed that one advantage of time-based schedules relative to extinction is that they preclude negative side effects such as response bursts and emotional behavior. Such a claim is brought into question by the experiments reported here, in which the FT schedule was the only schedule to produce bursts of responding the rates of which were higher than those in baseline. In fact, the highest proportion of baseline rates evidenced in extinction across all three experiments was 0.7 while the highest proportion of baseline rates during either DRO schedule was 0.9 and during the FT schedule was 1.1. If one defines a response burst as an increase in response rate above mean baseline levels, then the FT schedule was the only one to produce such bursting.

According to the definition employed herein, extinction produced no differential increase in emotional behavior relative to the DRO, FT, or baseline VR schedules. In fact, in many cases, dogs simply removed themselves from the area of the operandum and reposed or slept during extinction sessions. Although some dogs emitted higher rates of vocalization during extinction than during DRO or FT, other dogs showed the opposite pattern and no consistencies across dogs were observed. In previous reports of emotional behavior during extinction, the conditions of reinforcement and extinction were alternated within sessions (Azrin et al., 1966; Rovee-Collier & Capatides, 1979; Zeiler, 1971). Azrin et al. reported that aggression occurred immediately after each transition from reinforcement to extinction. In Experiments 2 and 3 of the present report, the transition to extinction was across rather than within sessions, perhaps reducing the likelihood that emotional responding would occur. Dogs were exposed to alternating periods of extinction and a DRO schedule in Experiment 1, however, and greater levels of emotional responding in extinction than in DRO were observed only for Iago.

Finally, spontaneous recovery has been characterized as a negative side effect of extinction to the extent that it results in less durable response suppression. This phenomenon has not been examined in the applied literature (Lerman & Iwata, 1996) and it remains unclear whether it is detrimental to extinction as a treatment for problem behavior. Spontaneous recovery was measured only in Experiment 1 of the present report and, contrary to previous findings (Topping & Ford, 1975; Zeiler, 1971), no differential spontaneous recovery was observed in extinction. It is possible that spontaneous recovery was not observed here because dogs were exposed to the experimental space during recovery intervals (i.e., throughout both spontaneous recovery intervals, dogs had access to the room in which experimental sessions were conducted). Although the operandum, experimenters, and reinforcers were not present during these periods, it is possible that exposure to the experimental room precluded spontaneous recovery.

Considering DRO and FT Schedules

Carr et al. (2000) discuss three mechanisms of response reduction under FT schedules, mechanisms that also can be used to interpret such reduction under DRO schedules. First, as mentioned above, DRO or FT schedules that deliver reinforcers on rich schedules attenuate the

establishing operation for the target response via satiation. (Extinction would be expected to have the opposite effect because reinforcers are withheld.) Second, in both DRO and FT schedules, the response-reinforcer relation is disrupted. In DRO schedules, both the temporal and contingent relations between responding and reinforcement are disrupted by, respectively, the imposed delay between responding and reinforcement and the delivery of reinforcement contingent on the absence of responding. In FT schedules, the contingent relation between responding and reinforcement is disrupted, although the temporal relation may or may not be. Because responding can occur immediately before reinforcer delivery in FT schedules, temporal contiguities are not prevented. Third, both DRO and FT schedules involve the reinforcement of other responses that can compete with the target response. In both schedules, these responses are left unspecified and are likely to be those responses that happen to precede reinforcer delivery, such as orienting toward the food magazine (Davis & Bitterman, 1971). Although no data were collected on competing responses during the present experiments, it was observed anecdotally that some dogs developed stereotyped responses that were maintained in DRO and FT schedules across sessions in each of the three experiments. In most cases, this response consisted of dogs swaying their heads between the experimenter and the operandum. These responses were deteriorated derivations of the original operant, of course, but because these responses were sometimes followed by reinforcer delivery in both DRO and FT schedules, they were maintained.

These three possible mechanisms of response reduction in DRO and FT schedules may serve as the context for interpreting the mixed results of previous research in which either procedure has been compared with extinction. For example, in much of the research in which escalating DRO schedules have reduced responding more rapidly than extinction, the initial IRI often is short (e.g., 2 s) and this may, via satiation, rapidly attenuate the efficacy of the reinforcer that had been maintaining the target response, resulting in a rapid reduction in its frequency. The same interpretation of the efficacy of time-based schedules in applied research, which characteristically involve thinning schedules of reinforcement that begin with continuous access to reinforcement, has been described above. The second possible mechanism, disruption of the response-reinforcer relation, is guaranteed in both DRO schedules and in extinction, and thus cannot be utilized to explain disparities in previous research between these two procedures. In FT schedules, only the contingent relation is disrupted and accidental temporal contiguities indeed may explain responding in FT schedules while the absence of such contiguities may result in more rapid response reduction under FT schedules than in extinction. Finally, the reinforcement of alternative responses may occur under either DRO or FT schedules. When an alternative, albeit unspecified, response is “captured” and maintained by adventitious temporal pairings with reinforcement in either DRO or FT schedules, this response may come to compete with the target response, resulting in more rapid response reduction than obtained under extinction.

Even while the differential effectiveness of DRO or FT schedules relative to extinction remains an empirical question, there are circumstances under which either schedule might be considered preferable to extinction. Both DRO and FT schedules allow delivery of the reinforcer that previously maintained problem behavior. It has been demonstrated that procedures employing positive reinforcement are preferred to other response reduction procedures (Kazdin, 1980) and such preferences can dictate treatment selection, implementation, and adherence.

According to some authors (e.g., Poling & Ryan, 1982), these schedules may raise less ethical or legal concerns than extinction, especially in situations where resistance to extinction is likely (e.g., when problem behavior was reinforced on lean baseline schedules). Indeed, the issue of ethicality may control practitioners' selection of treatment to a greater extent than the empirical demonstration of procedures' relative efficacies (Poling & Ryan, 1982). In this regard, it should be noted that, although both DRO and FT schedules may be preferred to extinction because they continue to provide reinforcement, one drawback of both procedures (as well as extinction) is that none involve the reinforcement of a specific, adaptive, alternative response. Differential reinforcement procedures in which an explicit, adaptive response is reinforced while problematic responding is under extinction may be particularly useful for application with canines and such procedures deserve further study (Carr & Durand, 1985; Vollmer, Roane, Ringdahl, & Marcus, 1999).

As described above, both DRO and FT schedules typically are most effective when their IRIs are increased across time (Topping et al., 1972; Ringdahl et al., 2001). Although this variable, as manipulated in Experiment 2 of the present report, did not enhance the efficacy of the DRO schedule relative to extinction, previous research supports the practice of beginning the application of DRO (Pickering & Topping, 1974; Topping et al., 1975) or FT (Carr et al., 2000; Hagopian et al., 1994) schedules with short IRIs that can be increased across time. In the DRO schedule, this practice has the advantage of allowing other responses to contact the reinforcement contingency early and regularly, and may, through the gradual nature of the learning process, allow practitioners to maintain response suppression at IRIs that are less onerous to monitor. In the FT schedule, frequent or continuous access to reinforcement can eliminate the establishing operation for the response via satiation. Once responding is thus reduced by either schedule, the schedule of reinforcer presentation can be thinned across time while low rates of responding are maintained (Carr et al., 2000). Procedures that involve thinning the schedule of reinforcer delivery in either DRO or FT schedules may be useful in the treatment of canine problem behavior and deserve further study.

Conclusions

The present results lead to three broad conclusions. First, it was demonstrated that steady-state, single-subject designs have utility in the investigation of canine responding and its reduction. This outcome is consistent with observations in the Introduction that called for such research methods in the field of applied animal behavior. Second, comparisons were made between three response elimination procedures that have demonstrated effectiveness in applied behavior analysis. Where experimental control was achieved, results suggested that extinction is a procedure of potential utility to pet owners interested in reducing canine responding easily, efficiently, and completely. Third, this research emphasized the value of controlled experimentation in providing information that might be used in the development of empirically-based treatment recommendations for those interested in reducing canine responding.

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