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A Translational Investigation of Positive and Negative Behavioral Contrast

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A TRANSLATIONAL INVESTIGATION OF POSITIVE AND NEGATIVE BEHAVIORAL CONTRAST

by

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ABSTRACT

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Behavioral Contrast

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Behavioral contrast occurs when a change in reinforcement rate in one context causes behavior to change in the opposite direction in another context. Positive contrast occurs when a decrease in the rate of reinforcement in one context results in an increase in behavior in another context. Negative contrast occurs when an increase in the rate of reinforcement in one context results in a decrease in behavior in another context. Research with nonhumans has found that positive contrast is more reliably produced than negative contrast. Research with nonhumans has also found that positive contrast is influenced to a larger degree by changes in reinforcement rate in the following context (vs. in the preceding context); however, results regarding negative contrast and the influence of preceding versus following contexts have been mixed. Finally, within-session contrast effects have been demonstrated in nonhumans. Relative to the entire environmental context, the largest change in behavior occurs immediately prior to (anticipatory contrast) or immediately following (local contrast) the change in

reinforcement rate. Behavioral contrast has applied implications, in that practitioners may only be able to implement interventions in one context, which may result in concomitant worsening of behavior in other contexts. Few studies with humans have compared positive and negative contrast, and none have separated preceding- and following-schedule effects or have systematically investigated within-session contrast. The purpose of this study was to investigate these effects in humans in a translational arrangement. Positive contrast was found in five of six cases, while negative contrast was found in only three of six. The effect of the following schedule was larger with positive contrast, but the effect of the preceding schedule was larger with negative contrast. There were no systematic within-session effects characteristic of anticipatory or local effects.

(108 pages)

PUBLIC ABSTRACT

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Utah State University, 2015

Applied behavior analysts implement research-based techniques to improve behavior. However, research with nonhumans suggests that intervening to improve behavior in one context may result in a worsening of that same behavior in another context (*behavioral contrast*). Although there are clinical implications of behavioral contrast, the vast majority of research on contrast has been conducted with nonhuman animals. Results from basic research suggest that contrast is influenced differentially depending on whether a change in conditions follows versus precedes a given context. For example, a child might encounter three contexts each day: home, school, and daycare. An intervention to reduce the child's aggressive behavior might be implemented at school (the second context). Results from basic research suggest that the child's behavior at home and at daycare might worsen, showing behavioral contrast, but behavior at home (the first context) would be influenced to a larger degree than at daycare (the third context). Further, basic research suggests that there are changes in behavior on the order of smaller units of time. In the applied example, the child's behavior at home might become worse and worse as the time to go to school approaches. Similarly, the child's

behavior at daycare might be the worst immediately following arrival from school. The current study investigated whether the order of context influenced contrast as well as within-session effects with adults with intellectual and developmental disabilities. Applied implications and future directions are discussed.

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INTRODUCTION

When a behavioral intervention is implemented and improves behavior in one context, there are often corresponding changes in behavior in non-treatment contexts as well. For example, a clinician might implement functional communication training (FCT; Carr & Durand, 1985) plus extinction with an individual at school to increase appropriate requests for breaks and decrease escape-maintained problem behavior. Appropriate requests for breaks increase and problem behavior decreases at school with the introduction of the intervention. In addition, at home, appropriate requests for breaks increase and problem behavior decreases although the intervention was not implemented in that context. When the effects of an intervention occur in the presence of stimuli other than those present during the intervention, *generalization* has occurred (Stokes & Baer, 1977).

A second potential effect – *behavioral contrast* – occurs when a change in the rate of reinforcement in a treatment context causes a change in behavior in the opposite direction in a non-treatment context (Rachlin, 1973; Reynolds, 1961). An increased rate of reinforcement in a treatment context that results in a decrease in behavior in non-treatment contexts is called *negative contrast*. Conversely, a decreased rate of reinforcement in a treatment context that results in an increase in behavior in non-treatment contexts is called *positive contrast*. In the FCT plus extinction example, we would say contrast occurred if problem behavior increased at home (positive contrast) with the introduction of the intervention and reduction in the rate of reinforcement for problem behavior at school. In investigations of contrast, a change in responding in a non-treatment context in the same direction as a change in the rate of reinforcement in a

treatment context is called *induction* (McSweeney & Melville, 1991). Induction is to be distinguished from generalization, in that the former may occur without a change in responding in a treatment setting. The vast majority of research on contrast has been conducted with nonhuman subjects (Blough, 1983; Halliday & Boakes, 1974; Pliskoff, 1961; Wilkie, 1977), however contrast has also been demonstrated with humans in both applied (Koegel, Egel, & Williams, 1980) and basic arrangements (Waite & Osborne, 1972).

In the following sections, I will describe critical concepts related to behavioral contrast and illustrate them with examples from foundational nonhuman research. I will then review research that has been conducted with humans, within both human-operant and applied arrangements.

NONHUMAN INVESTIGATIONS

Behavioral contrast is a "ubiquitous concept in experimental psychology" (Williams, 2002, p. 1) and has been studied explicitly since at least the 1950s (Ferster, 1958). Contrast is generally studied in multiple (mult) schedules, which consist of at least two schedules of reinforcement arranged sequentially, each associated with its own discriminative stimulus (SD) (Ferster & Skinner, 1957). In a contrast preparation, components of the mult schedule are designated as either *varied* or *target.* Varied components are those in which reinforcement conditions are manipulated and here are analogous to the settings in which clinical interventions are implemented (e.g., a clinic or school). Target components are those in which reinforcement conditions are held constant and are analogous to non-intervention settings (e.g., home).

To illustrate a typical experiment, consider an early example of behavioral contrast demonstrated by Pliskoff (1961). Contrast was assessed in two groups of pigeons. In Group 1, subjects were trained on a mult variable-interval (VI) VI schedule in which the VI values were 1 min in both Component A and Component B. Next, the rate of reinforcement in Component B (the varied component) was reduced from VI 1 min to VI 10 min while the rate of reinforcement in Component A was held constant (the target component). As expected, responding decreased in Component B, showing a direct contingency effect. However, responding in Component A (the target component) *increased* relative to baseline, showing positive contrast.

In Group 2, baseline rates of reinforcement were VI 10 min in both Component A and Component B. In the next phase, the rate of reinforcement in Component A (varied) was increased from VI 10 min to VI 1 min, while reinforcement rate remained constant in

Component B (target). As expected, responding increased in Component A, showing a direct contingency effect. However, responding in Component B *decreased* relative to baseline, showing negative contrast. Table 1 provides a summary of these conditions and results.

Preceding- and Following-Schedule Effects

Early research on contrast, including the study by Pliskoff (1961), used a two-component mult schedule in which components alternated throughout each session: A followed by B followed by A followed by B, and so forth. Thus, the target component was both preceded *and* followed by the varied component. It is clear that the change in reinforcement rate in the varied component resulted in changes in responding in the target component (i.e., produced contrast); however, is impossible to determine the degree to which contrast was influenced by the varied component that *preceded* it, or by the varied component that *followed* it.

One way to assess the relative influence of varied components that precede and follow target components is to use a mult schedule with more than one target. Table 2 shows a hypothetical example of a three-component arrangement in which two

Table 1

Pliskoff (1961) Procedures and Results

	Group 1		Group 2	
	Component			
	A	B	A	B
Baseline	VI 1 min	VI 1 min	VI 10 min	VI 10 min
Contrast	**VI 1 min**	*VI 10 min*	*VI 1 min*	**VI 10 min**
Results	Positive contrast		Negative contrast	

Note. **Bold** = target components; *Italics* = varied components.

components are targets. Schedule values are equal across the three components during baseline (VI 1 min); in the contrast phase, the schedule value in the second component (varied) is reduced to VI 5 min. There are therefore two target components (A and C) in which reinforcement schedules remain constant from baseline to contrast conditions. Because the varied component (Component B) follows target Component A, contrast that occurs in Component A is described as a *following-schedule effect.* Similarly, because the varied component (Component B) precedes target Component C, contrast that occurs in Component C is described as a *preceding-schedule effect.*

Research has found that the following-schedule effect is larger and more consistent than the preceding-schedule effect (Williams, 1979, 1988; Williams & Wixted, 1986). For example, Williams (1981) used a three-component mult schedule in which Components A and C were targets and reinforcement was delivered according to the same schedule (VI 3 min). The schedule of reinforcement in Component B varied (VI 1 min or VI 6 min) (see Table 3). Results showed that variations in Component B resulted in larger contrast in Component A (following-schedule effect) than in Component C

Table 2

Example of Preceding- and Following-Schedule Effects

	Component		
	A	B	C
Baseline	VI 1 min	VI 1 min	VI 1 min
Contrast	**VI 1 min**	*VI 5 min*	**VI 1 min**
Effect	Following-Schedule	N/A (Direct-Contingency)	Preceding-Schedule

Note. **Bold** = target components; *Italics* = varied components. Changes in response rates in Component B are a result of a change in contingency and are not characterized in terms of contrast.

Table 3

Williams (1981) Experiment 2 Procedures and Results

	Component		
	A	B	C
Condition 1	VI 3 min	VI 1 min	VI 3 min
Condition 2	**VI 3 min**	*VI 6 min*	**VI 3 min**
Results	Large following-schedule effect		Small preceding-schedule effect

Note. **Bold** = target components; *Italics* = varied components.

(preceding-schedule effect).

In addition to magnitude, the preceding and following-schedule effects also differ in how they are influenced by SDs. Williams (1988) used a three-component mult schedule in which Components A and C were targets and reinforcement was delivered according to the same schedule (VI 90 s). The schedule of reinforcement in Component B varied (VI 30 s or VI 270) (see Table 4). Further, Williams manipulated the degree of similarity of SDs in the varied component (Component B) and the target components

Table 4

Williams (1988) Experiment 2 Procedures and Results

	Component		
	A	B	C
Condition 1	VI 90 s (similar SD)	VI 30 s	VI 90 s (dissimilar SD)
Condition 2	**VI 90 s (similar SD)**	*VI 270 s*	**VI 90 s (dissimilar SD)**
Condition 3	VI 90 s (dissimilar SD)	VI 270 s	VI 90 s (similar SD)
Condition 4	**VI 90 s (dissimilar SD)**	*VI 30 s*	**VI 90 s (similar SD)**
Results: SDs	Larger effect with dissimilar SD	N/A	Mixed
Results: Magnitude	Larger effect in general	N/A	Smaller effect in general

Note. **Bold** = target components; *Italics* = varied components. Reinforcement conditions in Conditions 1 and 4 were identical, as were those in Conditions 2 and 3. The degree of similarity of SDs in Components A and B and Components B and C was manipulated across conditions.

(Components A and C). In some conditions, the SDs in Components A and B were similar while the SD in Component C was dissimilar, and vice versa. This arrangement also allowed for the comparison of the magnitude of preceding- and following-schedule effects. Results showed that the degree of similarity between SDs in the target and varied components differentially influenced contrast depending on whether the varied component preceded or followed the target. The following-schedule effect was larger for all subjects when the SDs in Components A and B were *dissimilar*. Mixed results were found with the preceding-schedule effect, with half of subjects showing larger contrast with dissimilar stimuli and half showing larger contrast with similar stimuli. In addition, as with Williams (1981), the following-schedule effect (changes in Component A) was larger than the preceding-schedule effect (changes in Component C).

Within-Session Effects

Up to this point, contrast has been referred to as a molar phenomenon: A change in the reinforcement conditions of the varied component produces an overall change in responding in the target component. In this type of analysis, data are presented and evaluated in terms of an average measure for an entire session (e.g., responses/min). However, a more molecular analysis can be conducted by evaluating data in terms of the frequency of responses that occur per smaller unit of time (i.e., a *bin*) within a component (e.g., Nevin & Shettleworth, 1966). With a molecular analysis, when a larger change in responding occurs at the beginning of the target component, closely following the transition from the varied component in investigations of the preceding-schedule effect, the effect is described as *local*. When a larger change in responding occurs at the end of

the target component, immediately prior to the transition to the varied component in investigations of the following-schedule effect, the effect is described as *anticipatory* (Williams, 2002). It should be noted that the term "anticipatory" has sometimes been used to refer to following-schedule effects in general (molar as well as molecular) (e.g., Williams, 1992; Williams & McDevitt, 2001). However, for clarity, the use of "anticipatory" in this paper is reserved for the description of the within-session effect only.

Williams (1988) empirically demonstrated anticipatory and local effects. He used a three-component mult schedule in which Components A and C were targets and reinforcement was delivered according to the same schedule (VI 90 s). The schedule of reinforcement in Component B varied (VI 30 s or VI 270) (see Table 5). To examine within-session effects, he divided Components A and C into bins and calculated the extent to which responding changed across phases within each bin. Adapted results in Figure 1 show the change in responding that occurred in Components A and C as a result of a decrease in the rate of reinforcement in Component B (VI 30 s to VI 270 s). Contrast effects are displayed for the two target components (Component A on the left and Component C on the right) as a function of each bin. Contrast in Component A increased

Table 5

Williams (1988) Experiment 2 Procedures and Results

	Component		
	A	B	C
Condition 1	VI 90 s	VI 30 s	VI 90 s
Condition 2	**VI 90 s**	*VI 270 s*	**VI 90 s**
Molar Results	Following-schedule	N/A (Direct-Contingency)	Preceding-schedule
Molecular Results	Anticipatory		Local

Note. **Bold** = target components; *Italics* = varied components.

throughout the component (i.e., anticipatory) while contrast in Component C decreased throughout the component (i.e., local).

Research that has compared anticipatory and local effects has produced mixed results. For example, Williams (1988) found that anticipatory effects were larger than local in six of eight comparisons; however, Williams (1981) found only local contrast (not anticipatory). The local effect Williams found in 1981 decreased as more sessions were conducted. Several studies have demonstrated a within-session effect analogous to local or anticipatory contrast, but have used mult schedules with only two components (e.g., Buck, Rothstein, & Williams, 1975; Williams, 1988, Experiment 1). While the relative influence of preceding and following schedules has been consistently demonstrated, more research is needed regarding the conditions under which local and anticipatory effects (i.e., within-session effects) are observed. In order to develop a thorough understanding of behavioral contrast it is important to use procedures that allow for evaluating the effects separately (e.g., a three-component preparation; Williams 1981, 1988).

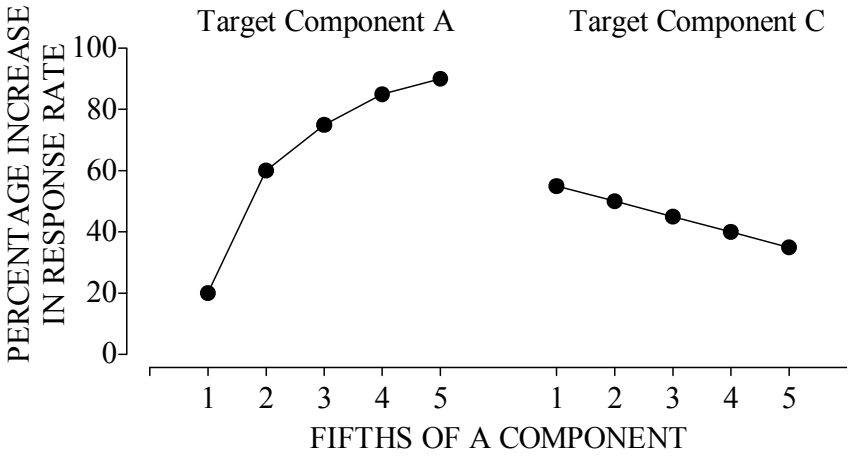

Figure 1. Results adapted from Williams (1988).

Positive Versus Negative Contrast

As mentioned earlier, contrast can occur in two directions: positive and negative. Both effects entail a change in behavior in a target in the opposite direction of a change in conditions of reinforcement in a varied component. However, research suggests that the two effects are not symmetrical.

Preceding- and Following-Schedule Effects

Research on positive contrast has confirmed that responding in target components is influenced to a greater degree by the following schedule than by the preceding schedule. Williams (1992), however, found that targets in which *negative* contrast occurred were *not* influenced to a greater extent by the following schedule. The primary purpose of the study was to evaluate preference between target components (results of which are not relevant to the current investigation and will not be considered here), but he also found differences in preceding- and following-schedule effects. Williams arranged a four-component mult schedule in which two pairs of components randomly alternated (A-B and C-D) (see Table 6). The order of components was such that one target (A) was always followed by the varied component (B) while the other target (C) was always followed by a component with the same rate of reinforcement (D). During baseline, the same rate of reinforcement was implemented in all components. In the first contrast condition, he evaluated positive contrast by decreasing the rate of reinforcement in the varied component. He found a larger contrast effect in the target component that was followed by extinction than the target that was preceded by extinction, replicating

findings from Williams (1979, 1981, 1988) and Williams and Wixted (1986) in showing a larger effect of the following schedule.

In the second contrast condition, he evaluated negative contrast by increasing the rate of reinforcement in the varied component. He found, contrary to what was predicted, that the target components showed comparable levels of negative contrast; preceding- and following-effects were similar in magnitude. It should be noted that these conclusions were based on aggregate data presented in a table. Session-by-session data displayed on a graph show considerable variability and trends that might influence one's interpretation of results. Specifically, a clear positive contrast effect was demonstrated in five of eight comparisons while negative contrast was demonstrated in only two of eight. At the very least, the study demonstrated that positive contrast was easier to obtain than negative, and data displayed in one format (the graph) also suggest that the following-schedule effect is more pronounced than the preceding-schedule effect for positive contrast only.

Table 6

Williams (1992) Procedures and Results

	Component Pairs			
	A	B	C	*D
Baseline	VI 2 min	VI 2 min	VI 2 min	VI 2 min
Positive Contrast	**VI 2 min**	*EXT*	**VI 2 min**	VI 2 min
Contrast Results	Larger effect on Component A (following-schedule)			
Baseline	VI 2 min	VI 2 min	VI 2 min	VI 2 min
Negative Contrast	**VI 2 min**	*VI 30 s*	**VI 2 min**	VI 2 min
Contrast Results	Comparable effects on A and C (following- and preceding-schedule)			

Note. **Bold** = target components; *Italics* = varied components. Pairs of Components (A-B, and C-D) alternated. * Component D is not designated as a target component as it never occurred adjacent to the varied component (B) and was not of direct interest in the study.

Weatherly, Melville, Swindell, and McMurry (1998) also investigated preceding- and following-schedule effects in positive and negative contrast arrangements. They used a three-component mult schedule in which the rate of reinforcement in Component B varied while Components A and C were targets (see Table 7). The authors analyzed the data for contrast by calculating differences in absolute rates of responding across conditions. However, analyzing data in terms of percentage change from baseline allows for comparing effects when baseline rates of responding differ. Thus, for the present analysis data were converted to percentage change from baseline. When the rate of reinforcement in Component B was reduced to extinction, positive contrast occurred in Components A and C, with an increase of 16.61% of baseline in Component A but only 13% of baseline in Component C (the effect of the following schedule was larger than the preceding schedule). When the rate of reinforcement in Component B was increased, negative contrast occurred in Components A and C, with an decrease of 4.53% of baseline in Component A and a decrease of 5.48% of baseline in Component C (the effect

Table 7

Weatherly et al. (1998) Procedures and Results

	Component		
	A	B	C
Baseline	VI 30 s	VI 30 s	VI 30 s
Positive contrast	**VI 30 s**	*EXT*	**VI 30 s**
Results	Larger following-schedule effect		Smaller preceding-schedule effect
Baseline	VI 30 s	VI 30 s	VI 30 s
Negative contrast	**VI 30 s**	*VI 15 s*	**VI 30 s**
Results	Smaller following-schedule effect		Larger preceding-schedule effect

Note. **Bold** = target components; *Italics* = varied components.

of the *preceding schedule* was larger than the following schedule). As with Williams (1992), the larger influence of the following schedule was demonstrated with positive contrast, however target components in which negative contrast occurred were *not* influenced by a larger degree by varied components that follow.

To summarize, the following schedule is more influential than the preceding schedule in targets in which positive contrast occurs. However, the following schedule may *not* be more influential in targets in which *negative* contrast occurs; effects of preceding and following schedules may be comparable (e.g., Williams, 1992), or the preceding schedule may be more influential (e.g., Weatherly et al., 1998).

Within-Session Effects

Only one study has investigated local and anticipatory contrast in both negative and positive contrast arrangements (Weatherly et al., 1998, described in the previous section). Local contrast occurred in two of three comparisons in both the positive and negative contrast conditions. However, anticipatory contrast was not observed in either the positive or negative contrast conditions. In fact, in four of six comparisons (three in the positive contrast condition and one in the negative contrast condition), the largest change occurred at the *beginning* of Component A. One possible explanation is that the components were not divided into small enough bins to detect subtler within-session changes. Components lasted either 30 or 60 s, and within-session data were analyzed in terms of "beginning," "middle," and "end" of each. In any case, results of Weatherly et al. (1998) did not show a difference in local and anticipatory effects between positive and negative contrast conditions. However, the conclusion that the effects are in fact

symmetrical is tenuous, given that anticipatory contrast did not occur at all (in positive or negative conditions).

Differences In Magnitude

Several studies suggest that the magnitude of positive contrast is larger than negative contrast. For example, Wilton and Gay (1969) used a four-component mult schedule (as in Williams, 1992) in which two pairs of components randomly alternated (A-B and C-D) (see Table 8). The order of components was such that one target (A) was always followed by one varied component (B) while the other target (C) was always followed by a second varied component (D). Positive contrast was seen in six of the eight comparisons in targets that were followed by extinction, however negative contrast was seen only in three targets followed by an increased rate of reinforcement. The authors suggest that despite their procedure arranging for variables that encouraged positive contrast and negative contrast, "the interaction of all the factors encouraging a rate increase outweighed the factors encouraging a rate decrease" (p. 245). In other words, the magnitude of positive contrast in the target that was followed by extinction was so large that it obscured the negative contrast that would have occurred in the target that was

Table 8

Wilton and Gay (1969) Procedures and Results

	Component Pairs			
	A	B	C	D
Baseline	VI 5 min	VI 5 min	VI 5 min	VI 5 min
Contrast	**VI 5 min**	*EXT*	**VI 5 min**	*VI 1 min*
Results	Positive contrast in six of eight comparisons		Negative contrast in three of eight comparisons	

Note. **Bold** = target components; *Italics* = varied components. Pairs of components (A-B and C-D) alternated.

followed by an increased reinforcement rate. Similar procedures were used by Pliskoff (1963), who found comparable results.

In a final example, McSweeney, Dougan, Higa, and Farmer (1986) evaluated positive and negative contrast over a range of reinforcement schedule values, and found that negative contrast was smaller across all values. The authors displayed contrast in terms of differences in absolute response rates across phases (as did Weatherly et al., 1998), and again absolute rates were converted to percentages for the present analysis: an average increase of 36% of baseline in the positive contrast condition, and an average decrease of only 12% of baseline in the negative contrast condition.

To summarize nonhuman findings on positive and negative contrast, with the exception of two studies (Weatherly et al., 1998; Williams, 1992), little research exists on negative contrast with respect to the influence of the following and preceding schedule. Williams (1992) found that negative contrast may not be more heavily influenced by the following schedule, a finding that contradicts results regarding positive contrast. Weatherly et al. (1998) also found inconsistencies in the influence of the following schedule with negative contrast arrangements, and further found the magnitude of negative contrast to be smaller than that of positive (as did McSweeney et al., 1986). Weatherly et al. also did not find anticipatory contrast in either positive or negative contrast conditions; in fact, the largest increase in responding in Component A occurred in the beginning of the component, which is an unusual finding. Because anticipatory contrast was not produced in the positive contrast condition, it may not be that anticipatory negative contrast does not exist, but rather the procedures used by Weatherly et al. somehow prevented anticipatory effects from occurring in general. Further research

is needed that examines preceding- and following-schedule effects, as well as local and anticipatory, in arrangements that produce positive and negative contrast.

HUMAN-OPERANT INVESTIGATIONS

Research on contrast has also been conducted with humans, the majority of which having used arbitrary responses in human-operant investigations. Such investigations have been conducted with typically developing children (Waite & Osborne, 1972), typically developing adults (Edwards, 1979; Hantula & Crowell, 1994; Tarbox & Hayes, 2005; Terrace, 1974; Weatherly, Melville, & McSweeney, 1996), adults with intellectual and developmental disabilities (O'Brien, 1968), and infants (Fagen, 1979; Rovee-Collier & Capatides, 1979). A variety of arrangements have been employed, ranging from the exclusion of a baseline condition (simply alternating between components of reinforcement and extinction; O'Brien, 1968), to a two-component mult schedule in both baseline and contrast conditions (Hantula & Crowell, 1994), to a single-component baseline but two-component mult contrast phase (Terrace, 1974), to the inclusion of rules (Tarbox & Hayes, 2005). Because there is no single study whose procedures and results are representative of the literature in its entirety (unlike nonhuman research), studies will be discussed with respect to specific molar and within-session effects below.

Preceding- and Following-Schedule Effects

Unlike the nonhuman literature, no human-operant studies have investigated contrast using mult schedules with more than two components. Recall that the use of two-component schedules does not allow for the separate examination of preceding- and following-schedule effects. Results from the nonhuman literature have shown that responding in target components is differentially influenced by changes in varied components that precede versus follow them (Williams, 1979, 1981, 1991; Williams &

Wixted, 1986), and further that the two effects may not be functionally equivalent (Williams, 1988). It is possible that such differences would also be obtained with humans; however, the generality of the nonhuman findings needs to be assessed empirically.

Within-Session Effects

The only study that reported within-session analyses in humans failed to find effects (Waite & Osborne, 1972). The authors used a two-component mult schedule with six typically developing children with lever pressing as the target response. For three of the subjects (Group 1), a mult VI 20-s VI 20-s schedule was used in baseline and was changed to a mult VI 20 s EXT (see Table 9). Positive contrast was demonstrated with all three subjects. For the other three (Group 2), a mult VI 20-s EXT schedule was used in baseline and was changed to a mult VI 20 s VI 20 s. Negative contrast was demonstrated in two of the three subjects. A cumulative record was presented for one of the subjects in Group 1, and neither local nor anticipatory effects occurred. The authors stated that these results were representative of all other subjects, including those in the negative contrast group. Because only two components were used, it is possible that the local and

Table 9

Waite and Osborne (1972) Procedures and Results

	Group 1		Group 2	
	Component			
	A	B	A	B
Baseline	VI 20 s	VI 20 s	VI 20 s	EXT
Contrast	**VI 20 s**	*EXT*	**VI 20 s**	*VI 20 s*
Results: Molar	Positive contrast in all three subjects		Negative contrast in two of three	
Within Session	No anticipatory or local		No anticipatory or local	

Note. **Bold** = target components; *Italics* = varied components.

anticipatory effects canceled each other out. As is the case with preceding- and following-schedule effects, we know virtually nothing about within-session (local and anticipatory) effects in humans.

Positive Versus Negative Contrast

Only two human-operant studies have investigated negative contrast with humans, the results of which indicate that further research is needed to determine the extent to which the effects are symmetrical. The first study was conducted by Waite and Osborne (1972) (described above). Positive contrast was found with all three subjects in Group 1 while negative contrast was found with only two of three in Group 2. The manipulation that was designed to produce positive contrast was a decrease in the rate of reinforcement in the varied component from VI 20 to extinction (reinforcement rates were equal in baseline). The manipulation that was designed to produce negative contrast was an increase in the rate of reinforcement in the varied component from extinction to VI 20 s, which resulted in equal reinforcement rates in the contrast condition. It is unclear whether this is a functionally symmetrical procedure, given that baseline with the positive contrast condition *began* with equal rates of reinforcement; labeling such results "negative contrast" should therefore be done cautiously.

The second human-operant study that has investigated negative contrast with humans was conducted by Weatherly et al. (1996), who arranged a two-component mult schedule with two groups of college students. With both groups, Component A was the target. In the contrast phase, the rate of reinforcement in Component B was decreased for Group 1 while the rate of reinforcement in Component B was increased for Group 2.

Results were consistent with those found in traditional contrast procedures: responding in Component A increased when the rate of reinforcement in Component B was decreased (positive contrast), and responding in Component A decreased when the rate of reinforcement in Component B was increased (negative contrast). It is important to note that several procedural features distinguish this study from those discussed thus far. First, the authors used a discriminated-operant procedure in which subjects were presented with trials to which to respond. Second, the likelihood of reinforcement was described to subjects prior to each trial. Third, when a response did not produce a reinforcer, tokens were removed from subjects (tokens were exchangeable for money at the end of sessions).

Given the differences between their procedures and those used in other studies, Weatherly et al. (1996) reported another experiment in the same paper in which they used a free-operant arrangement. Again, Component A was the target and Component B was varied (see Table 10). For Group 1, the rate of reinforcement in Component B was decreased in the contrast phase, and for Group 2 the rate of reinforcement in Component B was increased. It should be noted that the contingencies of reinforcement were again described to the subjects prior to each session. Positive contrast was seen in five of six subjects; negative contrast was seen in four of six, and the other three showed no effect. It

Table 10

Weatherly et al. (1996) Procedures and Results

	Group 1		Group 2	
	Component			
	A	B	A	B
Baseline	VI 30 s	VI 30 s	VI 45 s	VI 45 s
Contrast	**VI 30 s**	*EXT*	**VI 45 s**	*VI 15 s*
Results	Positive contrast in five of six		Negative contrast in four of six	

Note. **Bold** = target components; *Italics* = varied components.

is also worth pointing out that only one session was conducted in each phase. It is possible that had more sessions been conducted, results would have been more consistent (i.e., contrast would have occurred with all subjects).

To summarize human-operant literature, no studies have used mult schedules with more than one target to allow distinction between preceding and following effects, only one study has examined within-session effects, and only two studies have examined negative contrast. Given the implications of results of nonhuman investigations of contrast (e.g., behavior in certain settings may be more susceptible to contrast than others), it is important that studies examine contrast with human subjects. Specifically, research with humans on preceding- and following-schedule effects as well as local and anticipatory contrast, is necessary to assess the generality of findings obtained with nonhumans.

APPLIED RESEARCH

Only three published studies have systematically evaluated behavioral contrast in applied settings. The distinction between nonhuman, translational, and applied research is important in that it is unclear to what extent results from nonhuman and translational investigations generalize to issues of social significance. Although there may not be fundamental differences between behavior emitted by nonhumans and in translational arrangements, the strengths of those arrangements in terms of precise control of histories of reinforcement may limit generality of findings to applied situations in which histories of reinforcement are more complex.

Preceding- and Following-Schedule Effects

One study, conducted by Johnson and Kaye (1979), arranged a three-component mult schedule and manipulated rates of reinforcement in Component B, which theoretically allowed for an examination of preceding- and following-schedule effects. They varied reinforcement for "speech-reading," or receptively identifying an object by pointing to it when a therapist vocally instructed the subjects to do so, with two children with hearing impairments. Three sets of stimuli were used, which were conceptualized as three "components" (see Table 11). During each component, one of the three sets of stimuli was present and the therapist presented opportunities to respond by instructing the subjects to point to one of the objects in that set in a random order until all stimuli in the set were assessed. Baseline and contrast conditions were replicated. For both subjects, when reinforcement for responding in Component B was placed on extinction, the rate of responding in A increased, showing positive contrast. Responding in Component C was

Table 11

Johnson and Kaye (1979) Procedures and Results

	Component		
	A	B	C
Baseline	FR 1	FR 1	EXT
Contrast	**FR 1**	*EXT*	**EXT**
Baseline	FR 1	FR 1	EXT
Contrast	**FR 1**	EXT	**EXT**
Results	Positive contrast	N/A	No effect

Note. **Bold** = target components; *Italics* = varied components.

consistent in all conditions. The purpose of the study was not to specifically evaluate preceding- and following-schedule effects, and the fact that schedules in Components A and C were different (fixed-ratio (FR) 1 vs. EXT), makes comparison of the effects difficult. Further, as the schedule in C was extinction in all conditions, it was perhaps not surprising that positive contrast did not occur in that component.

Within-Session Effects

No applied studies have investigated within-session effects.

Positive Versus Negative Contrast

Unlike basic and human-operant research, no applied studies have compared positive and negative contrast. One study has investigated positive contrast (Johnson & Kaye, 1979, described above), and two studies have investigated negative contrast (Kistner, Hammer, Wolfe, Rothblum, & Drabman, 1982; Koegel et al., 1980).

Koegel et al. (1980) investigated the effects of reinforcement manipulations on compliance across two contexts with seven children with autism (see Table 12). Baseline consisted of extinction in both contexts. In the contrast phase, two manipulations were

Table 12

Koegel et al. (1980) Procedures and Results

	Component	
	A	B
Baseline	No consequence	No consequence
Contrast	*FR 1 (SR→ compliance) + FR 1 (PUN→ noncompliance)*	**No consequence**
Results	N/A	Negative contrast

Note. **Bold** = target component; *Italics* = varied component.

made to the varied component: compliance was reinforced on an FR 1 schedule and noncompliance was punished on an FR 1 schedule. They found that compliance increased in the varied component while compliance decreased in the target component.

It is worth noting that, in addition to the change in schedule of reinforcement in the varied component of the contrast phase, a potential punishment procedure in the form of reprimands was also implemented for noncompliance. It is possible that the relative decrease in compliance in the target component was partially contrast relating to punishment. Because both punishment and reinforcement contingencies were manipulated, it is impossible to isolate the effects of each procedure.

Kistner et al. (1982) also investigated negative contrast in an academic context. Six children with learning disabilities received instruction from three teachers each day. The authors implemented a token economy in the classroom of the first teacher only and assessed whether rates of completing academic tasks decreased with the second and third teachers (negative contrast). Procedures were similar to Koegel et al. (1980) in that no consequences were delivered during baseline and the contrast phase involved the introduction of reinforcement. Unlike Koegel et al., however, contrast occurred for only three of the six subjects, and the effect was small and decreased across sessions.

Contrast in Literature from Other Areas

The prevalence of contrast in clinical settings is unknown, although Koegel et al. (1980) pointed out that "it is quite common for parents to complain that a particular behavior has deteriorated at home, while a teacher or therapist reports substantial progress in school," and that "when two teachers or multiple therapists work on the same behavior at different times of the day, occasionally the child's behavior may improve with one and deteriorate with the other" (p. 423). In fact, applied researchers have encountered contrast-like effects while investigating other phenomena. For example, in a study on task interspersal, Charlop, Kurtz, and Milstein (1992) investigated the extent to which various conditions of reinforcement for compliance with mastered tasks influenced compliance with tasks that were in acquisition. They found that compliance with acquisition tasks was lowest when reinforcement for compliance with mastered tasks was high. On the other hand, compliance with acquisition tasks was highest when compliance with mastered tasks was placed on extinction. The authors discussed contrast as a possible explanation for this effect, although they point out that their arrangement was not the free-operant mult schedule typical of contrast research.

Another example of the mention of contrast in discussing treatment effects was in a study conducted by Wahler, Vigilante, and Strand (2004). The authors examined the extent to which effects of parent training at home to reduce a child's problem behavior (in the form of decreasing the rate of reinforcement for problem behavior) would generalize to the child's problem behavior at school. They found that not only did generalization of treatment effects not occur from home to school, but problem behavior got worse at school when it improved at home. The authors discussed behavioral contrast

as a possible mechanism for the fact that problem behavior increased at school with the reduction of reinforcement for problem behavior at home. However, they were cautious in this interpretation, as their measurement system did not separate reinforcement provided for problem behavior versus appropriate behavior at school.

To summarize applied literature on behavioral contrast, no studies have systematically assessed preceding- and following-schedule or within-session effects, or have compared positive and negative contrast. It is clear that more research with socially significant arrangements is necessary to determine how clinical situations might lend themselves to the occurrence of contrast, which may then lead to more effective treatment of undesired behavior across different contexts.

SUMMARY AND RATIONALE FOR CURRENT STUDY

Treatment of behavior in one context often affects that behavior in non-treatment contexts. One phenomenon, behavioral contrast, occurs when changes in the rate of reinforcement in the treatment context are accompanied by behavioral changes in the opposite direction in a non-treatment context. Positive contrast occurs when decreases in reinforcement in one context are accompanied by behavioral increases in another, and negative contrast occurs when increases in reinforcement in one context are accompanied by behavioral decreases in another (Rachlin, 1973). From an applied perspective, an understanding of these phenomena may allow those implementing treatment to avoid such effects in non-treatment contexts, or at the very least, to better inform caregivers regarding potential side effects of treatment. It is possible that when contrast occurs, caregivers associate this worsening with the treatment itself and may consider discontinuing behavioral services. In addition, if the conditions under which contrast occurs are predictable, clinicians may wish to address problem behavior in multiple contexts at the onset of treatment to avoid contrast effects altogether.

Given the potential importance of contrast effects and the lack of human research, the purpose of this study was to evaluate the separate and interacting effects of three variables related to contrast in a translational arrangement: (a) preceding versus following schedule effects, (b) positive and negative contrast, and (c) molar (session averages) versus molecular (within-session) effects. We chose adults with intellectual and developmental disabilities (IDDs) as subjects for two reasons. First, we wanted subjects that shared as many characteristics with the ultimate population of interest (individuals with behavior problems) as possible, and many individuals with behavior problems also

have an IDD. Second, we wanted to ensure that we would have access to subjects for a sufficient amount of time during which to complete the study without having to remove them from other therapeutic situations, which excluded children. Many adults with IDDs attend day programs during which activities are provided but are not necessarily therapeutic in nature. Specifically, we addressed the following questions:

1. To what extent are preceding and following schedule effects demonstrated with individuals with IDDs?
2. To what extent are positive and negative contrast demonstrated with individuals with IDDs?
3. To what extent do the preceding and following schedule effects interact with positive and negative contrast with individuals with IDDs?
4. To what extent are local and anticipatory contrast effects demonstrated with individuals with IDDs?
5. To what extent do the preceding and following schedule effects interact with positive and negative contrast in terms of local and anticipatory contrast with individuals with IDDs?

This study extended the current literature in at least three ways:

1. It was the first investigation with humans to separate preceding- and following-schedule effects by using a three-component mult schedule.
2. It was the first to systematically to investigate within-session contrast, and the first to investigate within-session negative contrast.

3. It was the first to investigate within-session contrast with a three-component mult schedule with humans, which allowed for the separation of local and anticipatory contrast.

METHOD

Subjects and Setting

Subjects were three adults with IDDs who attended a day program in northern Utah. All subjects were able to follow simple instructions and had expressive vocal-verbal repertoires, although the complexity of their verbal repertoires varied. Jimmy and Lucy spoke in complete sentences and Molly spoke in phrases. Lucy also engaged in repetitive, unusual speech (e.g., "You're a funny bunny, you're a funny bunny rabbit queen lover") throughout the majority of each session. Molly and Lucy wore corrective lenses. Jack was ambulatory with the aid of a walker and had fine motor difficulties. These individuals were selected because they attended the day program five days per week and did not have therapeutic obligations during the times when researchers were available to conduct sessions. Subjects did not have any health or medical conditions that precluded the use of edibles as reinforcers and did not engage in severe problem behavior (e.g., aggression, property destruction, self-injury). We obtained informed consent from the subjects' caregivers and assent from the subjects. Sessions took place at the day program and only the subject, therapist and data collectors were present. Subjects sat in a chair in front of a table on which experimental materials were presented.

Dependent Variables and Materials

The target response differed across subjects depending on their motor skills. We attempted to select responses that would not result in ceiling or floor effects in the contrast phases. The response needed to maintain a low enough level during baseline such that it would be possible for a further increase in extinction (positive contrast).

Similarly, the response needed to maintain a high enough level during baseline such that it would be possible for a further decrease in FR 1 (negative contrast).

Colors were used as SDs and included placemats underneath response-related materials and shirts worn by the therapist. Response-related materials also corresponded to the color of the respective component. A sheet of paper displaying the number 1, 2, or 3 (denoting Component A, B, and C, respectively), of the color corresponding to the component was also placed on the table directly behind the response-related materials.

Molly and Lucy

The response for Molly and Lucy consisted of picking up a crayon from one bowl and placing it at the bottom of a second bowl. If the crayon was picked up and placed into the same bowl from which it was picked up, the response was not scored. If the crayon was picked up, moved to the other bowl, but did *not* make contact with the bottom of it, the response was not scored. Materials required for this response included a crayon and two bowls.

Jack

The response for Jack consisted of inserting plastic pegs into a peg-board. A box of pegs of assorted colors was placed in front of Jack in addition to a peg-board of the color corresponding to the current component. A response was scored when Jack inserted a peg into a board of the same color. If Jack had inserted a peg of a different color (e.g., a blue peg into a red board), this would not have been scored (this never occurred). Materials necessary for this response included a peg-board and a box of pegs.

Response Measurement and Interobserver Agreement

Trained observers attended experimental sessions and collected frequency data on subjects' responses and reinforcers delivered by the therapist. A second observer independently collected data for 34.60%, 48.01%, and 32.77% of sessions for Molly, Lucy, and Jack, respectively. Percentage interval interobserver agreement (IOA) was calculated by dividing each session into 10-s bins and comparing the observers' data with respect to the number of occurrences of the event (subject responses and reinforcers delivered). A percentage-agreement score was calculated for each interval by dividing the smaller recorded number of responses by the larger and multiplying by 100%. The IOA score for each session was calculated by obtaining the mean of the interval IOA scores for that session. Scores on IOA for each subject are shown in Table 13.

Treatment Fidelity

In addition to collecting data on subject behavior, observers collected data on therapist behavior (changing SDs and delivery of reinforcers) to assess treatment fidelity. The fidelity with which the therapist changed SDs was assessed during 40.55%, 36.95%, and 32.21% of sessions for Molly, Jack, and Lucy, respectively. A computer facing the therapist but out of view of the subject prompted the therapist to change SDs at the time of component transition. During treatment integrity sessions, data collectors sat behind the therapist (or viewed video tapes of sessions) and recorded whether the therapist changed SDs within 5 s of the computer-generated prompt. If the therapist changed the SDs within 5 s of the prompt, the response was scored as correct. If the therapist changed the SDs after 5 s of the prompt, the response was scored as incorrect. A percentage-

Table 13

Interobserver Agreement

	Molly	Lucy	Jack
Target behavior	89.58 (72.70–94.50)	91.61 (85.30–98.30)	84.64 (80.20–94.60)
Reinforcer delivery	94.85 (80.00–100)	94.19 (82.20–100)	92.32 (77.80–98.90)

Note. Listed are the mean scores with lower and upper ranges in parentheses.

correct score was calculated by dividing the number of correct SD changes by the sum of corrects and incorrects, and multiplying the quotient by 100%. The mean percentage correct score was produced by calculating the mean of all integrity scores.

The fidelity with which the therapist delivered reinforcers was assessed during 33.47%, 33.41%, and 31% of sessions for Molly, Lucy, and Jack, respectively. Two criteria were used to assess reinforcer delivery fidelity. The first criterion specified which responses resulted in reinforcement. A response was considered to be eligible for reinforcement if it (a) occurred fewer than 3 s prior to the end the interval, (b) was one of several responses that occurred fewer than 3 s following the end of the interval, or (c) was the first response to occur following the end of the interval. The second criterion specified the timing of reinforcer delivery. A reinforcer was correctly delivered if it was delivered within 3 s of a response. A percentage-correct score was calculated by dividing the number of correct reinforcer deliveries by the sum of correct and incorrect reinforcer deliveries and multiplying the quotient by 100%. The mean percentage-correct score was produced by calculating the mean of all integrity scores. Treatment fidelity scores are shown in Table 14.

Table 14

Treatment Fidelity

	Molly	Lucy	Jack
Discriminative stimuli	95.98 (87.50–100)	95.78 (78.00–100)	91.67 (77.78–100)
Reinforcer delivery	94.20 (75.00–100)	96.87 (88.46–100)	95.18 (91.30–100)

Note. Listed are the mean scores with lower and upper ranges in parentheses.

Procedures

Stimulus Preference Assessments

To identify edibles to use during the study, interviews were conducted with caregivers and employees to produce a list of between 5 and 10 highly preferred edibles for each subject. These edibles were then assessed for preference with a paired preference assessment (Fisher et al., 1992) during which the edibles were presented in pairs and subjects were instructed to "pick one." Each edible was paired once with every other edible. A hierarchy was produced by dividing the number of selections of each edible by the number of opportunities to select that edible and multiplying by 100%. Prior to each experimental session, these top three edibles were presented to the subject, and he or she was instructed again to "pick one"; the edible chosen was delivered during that session. Recent studies (e.g., Carr, Miguel, & Sidener, 2012) have used this procedure (brief multiple-stimulus preference assessments before experimental sessions) to hopefully account for across-session changes in preference.

Response Training and Schedule Thinning

Prior to experimental conditions, subjects were taught to engage in the target response using materials of a different color than were used during the evaluation. The

purpose of this phase was to ensure that subjects emitted the response consistently throughout the session. Sessions lasted 5 min and consisted of a pre-exposure to the contingency prior to the session in the form of a physical prompt from the therapist to engage in the response followed by the delivery of the preferred edible. Edibles were delivered according to an FR 1 schedule, and physical prompts to engage in the response were delivered according to a delay, which increased by 5 s across sessions (the delay in the first session was 5 s). When three sessions occurred with at least 80% independent responding, with the first response in each session occurring independently, the schedule of reinforcement was thinned to variable-ratio (VR) 2, VR 4, VI 15-s, and finally VI 30-s schedules.

Experimental Arrangement

To determine the extent to which changes in the reinforcement conditions in one context affected responding in preceding and following contexts, we used a single-operant arrangement within a three-component (ABC) mult schedule. Components A and C were the designated target components and were analogous to non-treatment contexts (e.g., home and daycare). Component B was the varied component and was analogous to a treatment context (e.g., school). The target components were both associated with the same SDs (materials of a given color) and schedule of reinforcement regardless of the condition. In the varied component, the schedule of reinforcement and SD in the varied component differed depending on the condition. The therapist delivered a brief praise statement (e.g., “good job!”) along with each edible delivery.

All components lasted 2 min, and there was a brief (15-s) period between components during which response-related materials were removed and SDs were

changed. Each three-component presentation therefore lasted 6.5 min in addition to reinforcer access time, which differed across sessions and subjects depending on the number of reinforcers that were earned and amount of time necessary to consume the reinforcer.

Each three-component presentation was a *trial*, and a 45-s inter-trial interval (ITI) occurred between each trial during which all response-related materials were removed and a break card was presented on the table in front of the subject. Four trials constituted a *session.* Three trials were originally implemented per session, however with Molly we observed unexpected variability in the first trial compared to the others. We therefore implemented a "warm-up" trial and analyzed data for the last three trials only, as well as for all four. One session was conducted per day and lasted about 35 min, including time between components, ITIs, and reinforcer access time. At least eight sessions were conducted in each phase.

Stability and Termination Criteria

A minimum of eight sessions was conducted in all phases, including both baseline and contrast. Stability criteria for advancing to subsequent phases from baseline involved requirements for both responses and reinforcers earned. Criteria were as follows:

1. In each of the last three sessions of baseline, the rate of responding in each component must have been within 20% of the mean of responding across all components in that session.
2. The floating average (arithmetic mean of the most recent three sessions) of reinforcers earned in each component must have been within 20% of the mean of the floating average of reinforcers earned across all components.

3. If 20 sessions were conducted without meeting criteria (1) and (2) the next phase began, given that the data were not occurring on a trend that was expected to continue in the next phase (e.g., an upward trend in baseline would be undesirable if the next phase entailed data most likely continuing to increase). This occurred twice, once with Molly and once with Lucy.

Stability criteria for terminating contrast phases involved response rate requirements in Components A and C only and were assessed via visual inspection:

1. Response rates in Component A must have changed in the direction consistent with contrast, relative to the preceding baseline, for three consecutive sessions. We only required that rates occurred in the direction of contrast in Component A given that previous research suggests that the following-schedule effect (Component A) develops after the preceding-schedule effect (Component C). Thus, terminating contrast phases based on an effect consistent with contrast in Component A was more conservative than terminating phases based on such an effect in Component C. In addition, it might never have been the case that effects in both components occurred simultaneously (e.g., within the same three consecutive sessions). The criterion to terminate the phase when an effect was detected in Component A ensured terminating the phases in a reasonable number of sessions.
2. For those three sessions, response rates in Components A and C must either have not displayed a trend or have been on an increasing trend in extinction or on a decreasing trend in FR 1. This criterion was implemented to ensure that the effect consistent with contrast was not temporary. Even if response rates in

Component C did not meet criterion (1), we required that they did not display a trend in the opposite direction. For example, in the extinction phase, response rates must have been elevated in Component A relative to the respective response rates in baseline for three consecutive sessions, *and* response rates in both components must not have displayed a decreasing trend. In the FR 1 phase, response rates in Component A must have been below the respective response rates in baseline for three consecutive sessions, *and* response rates in both components must not have displayed an increasing trend. Lucy and Jack met criteria (1) and (2) in the extinction phase in 8 and 13 sessions, respectively; however, we conducted additional sessions given the large range of Lucy's data in Component C and the small magnitude of the effect for Jack.

3. If criteria (1) and (2) were not met within 20 sessions, the phase was terminated. This occurred twice, once with Molly and once with Jack and each in the FR 1 phase.

Baseline

For Molly, the schedule of reinforcement in the target components was VI 60 s. For Jack, the schedule of reinforcement in the target components was VI 45 s to enhance the discriminability of the change from baseline to extinction conditions. For Lucy, the schedule of reinforcement in the target components was VI 30 s, as her responding during training occurred at a low level such that further schedule thinning may have extinguished her responding.

Contrast Conditions

Two schedule manipulations were assessed: a lower rate of reinforcement (extinction) and a higher rate of reinforcement (FR 1). Each condition was identical to baseline with the exception of the schedule of reinforcement and SDs in the varied component (Component B). The schedules of reinforcement and SDs associated with the target components (Components A and C) remained the same as baseline (VI 60 s for Molly, VI 45 s for Jack, VI 30 s for Lucy).

Contrast: Extinction. The purpose of this condition was to determine whether a decrease in the rate of reinforcement in the varied component resulted in increases in responding in the target components (i.e., positive contrast). No reinforcers were delivered for responding in Component B. Edibles were removed from the subject's view to enhance the discriminability of the change in contingency from baseline to extinction.

For Molly, an additional manipulation was made during Component B. At the onset of the Component, the therapist switched the colors of the materials and removed the edibles (as with the other subjects), but the therapist and data collectors then left the room and remained out of Molly's sight for the duration of the component. Molly was thus in the experimental room alone, and a video camera was used from which data on her responding were scored following the session. Molly never attempted to leave her chair or engage with materials in the room.

We made this manipulation with Molly because we had conducted several sessions of extinction with her *without* making this manipulation but her responding persisted at levels comparable to the preceding baseline (see Figures 10 and 11 in Appendix A). Responding may have persisted in the researchers' presence because of the

history of reinforcement for responding (delivery of edibles and brief social interactions) in their presence in the past. By removing the researchers during Component B, responding might have extinguished due to the removal of SDs potentially associated with such a history of reinforcement.

Contrast: FR 1. The purpose of this condition was to determine whether an increase in the rate of reinforcement in the varied component resulted in decreases in responding in the target components (i.e., negative contrast). Jack was the first subject to experience this condition. The high rate of reinforcement schedule in the varied component was initially VI 10 s (compared to VI 45 s in his baseline), but after 15 sessions negative contrast had not occurred. We therefore further increased the rate of reinforcement to FR 1. To increase the likelihood of detecting an effect with Molly and Lucy in this phase, we used an FR 1 schedule with them as well.

Experimental Design

A reversal design (ABAC) was used with conditions occurring in the following order: baseline, extinction, baseline, FR 1 (see Table 15).

Table 15

Experimental Design

Condition	Component		
	A	B	C
Baseline (A)	VI	VI	VI
Extinction (B)	**VI**	*Extinction*	**VI**
Baseline (A)	VI	VI	VI
Higher SR rate (C)	**VI**	*FR 1*	**VI**

Note. **Bold** = target component; *Italics* = varied component.

RESULTS

Response Training

Figures 2 and 3 show results of response training for all subjects. All subjects acquired the response quickly. The response for Jack initially consisted of placing a block into a bucket (Figure 3, training sessions 1-20). However, his baseline response rates were such that it might not have been possible for a further increase in rates in Components A and C in the extinction condition (i.e., a ceiling effect), and thus we selected a new response (inserting pegs into a board). We conducted an FR 1 probe session with the new response in which, prior to the session, a prompt to engage in the response and an edible were delivered but *no* prompts were delivered during the session. We then progressed to VI 15 and VI 30 s without training VR 2 and VR 4, as responding during the initial schedule thinning was relatively consistent.

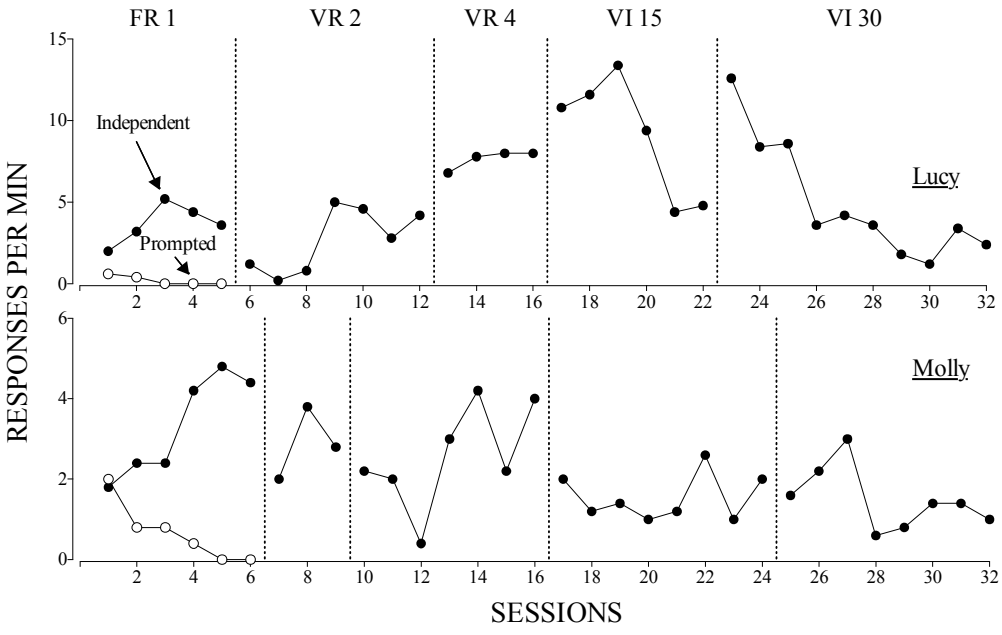

Figure 2. Training results for Lucy and Molly. Note different y-axis ranges.

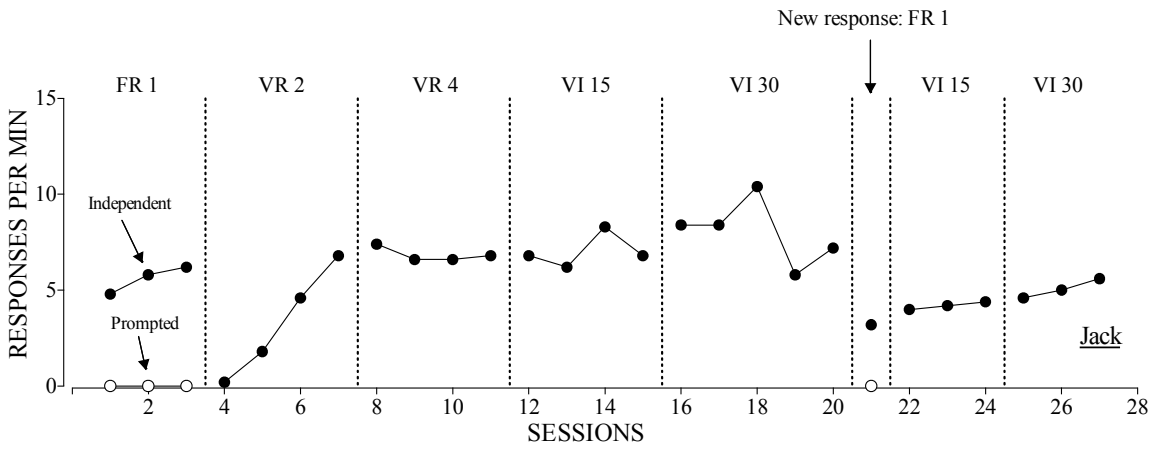

Figure 3. Training results for Jack.

Contrast Evaluation: Response Rates in All Phases

Figure 4 shows response rates for all subjects during all phases of the evaluation. Molly's responding (top panel) met stability criteria in 11 sessions in the initial baseline. During extinction, responding in Component B immediately decreased to near-zero levels (recall that the therapist and data collectors left the room during this component for Molly). Response rates in Components A and C were variable, with rates in A generally above baseline but rates in C varying between above and below baseline levels. Responding in all components in the replication of baseline was variable and began to decrease about midway through the phase (session 36) to below rates in the initial baseline. Twenty sessions were conducted without meeting stability criteria (our designated maximum number of sessions per phase), however we conducted four additional sessions as we did not want to implement the FR 1 condition while response rates were already quite low (as in session 42). In the FR 1 condition, response rates in Component B immediately decreased by about 50% and were stable throughout the phase. Response rates in Components A and C were variable, with rates in A generally above

baseline and rates in Component C varying between above and below baseline. Twenty sessions were conducted in the FR 1 condition, which was terminated after responding did not meet the stability criteria for contrast phases.

For Lucy (middle panel), 20 sessions were conducted in the initial baseline with responding failing to meet stability criteria with respect to response rates and reinforcers earned. However, responding in Components A and C was on a decreasing trend and thus extinction was implemented in Component B (an increased rate of responding was expected in Components A and C with the implementation of extinction in Component B). During extinction, responding in Component B decreased but did not extinguish, while responding in Components A and C increased. In the replication of baseline, responding in all three components increased and maintained higher rates than in the initial baseline condition. During FR 1, responding in Component B continued to increase while rates in Components A and C reversed their trend and decreased.

Jack's responding (bottom panel) across all components was consistent in the initial baseline (with the exception of session 3). During extinction, responding in Component B initially maintained at its baseline level, but extinguished completely by session 13. Responding in Components A and C also initially maintained at baseline levels but began increasing at session 18. In the replication of baseline, responding in Component B recovered and responding in all three components occurred at higher levels than in the initial baseline (as occurred with Lucy). Next, we implemented VI 10 s for Jack, but response rates in Components A and C were consistent with rates in the preceding baseline. We then implemented FR 1, during which response rates in Components A and C were variable, with some sessions showing a decrease relative to

baseline (e.g., sessions 55-57, 59, 62, and 65) and others showing no change. Rates in Component B were variable as well, with just over half of sessions showing an increase relative to baseline and the other half showing no change. As with Molly, we conducted 20 sessions before terminating the phase as per the criteria described above.

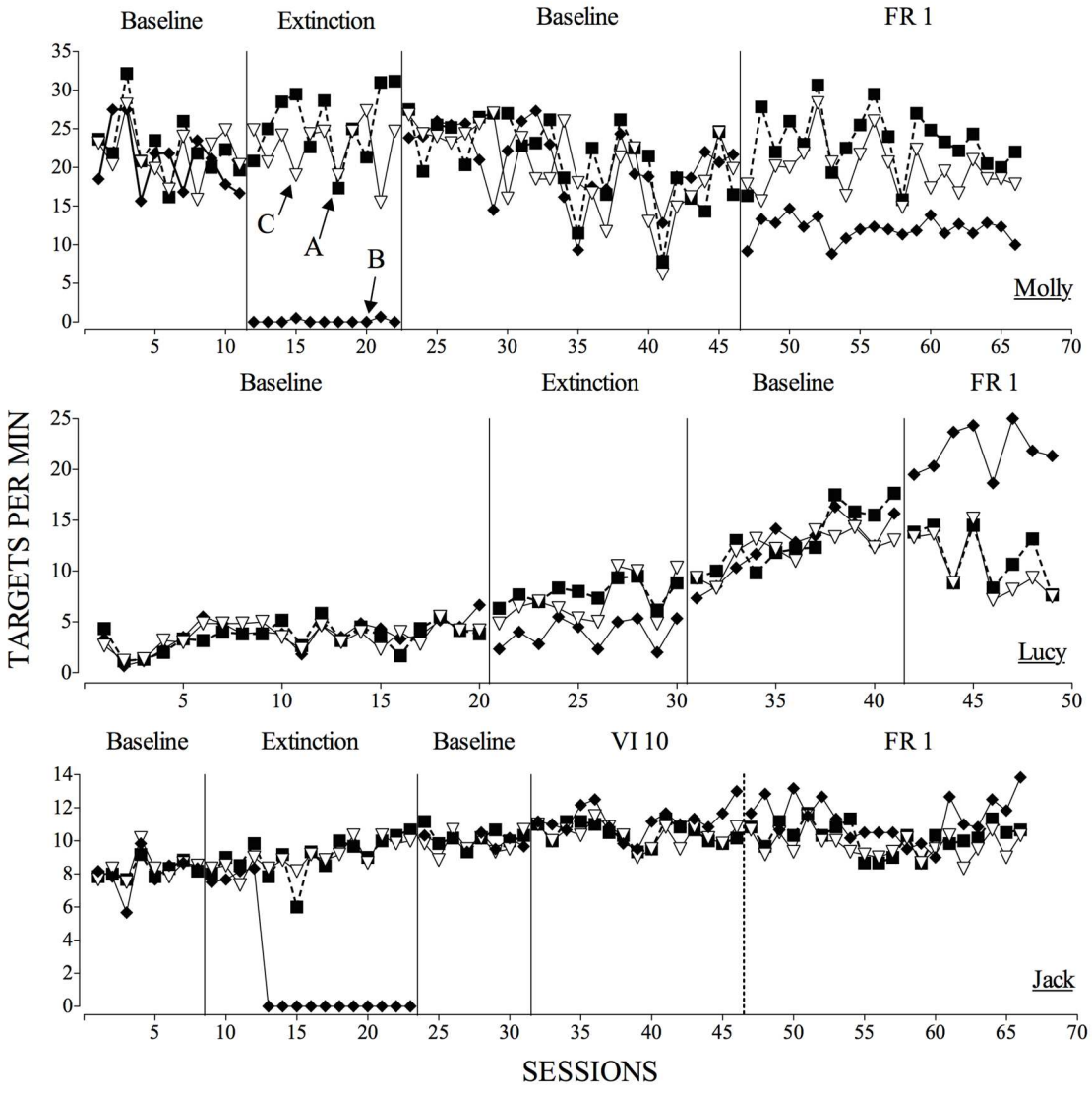

Figure 4. Response rates for all subjects in all phases of the contrast evaluation. Note different y-axis ranges across subjects.

Contrast Evaluation: Molar

Figure 5 shows results from extinction (left-hand panels) and FR 1 (right-hand panels) phases for all subjects. Recall that each session consisted of three trials (discussion of four-trial results are described in the following section). Proportion of baseline rates were obtained by calculating the mean of the last three sessions of baseline for each component. Each data point reflects the quotient of the response rate in a given component and the mean of the last three sessions of baseline for that component. The dotted horizontal line represents the baseline level of responding (i.e., proportion of 1.0).

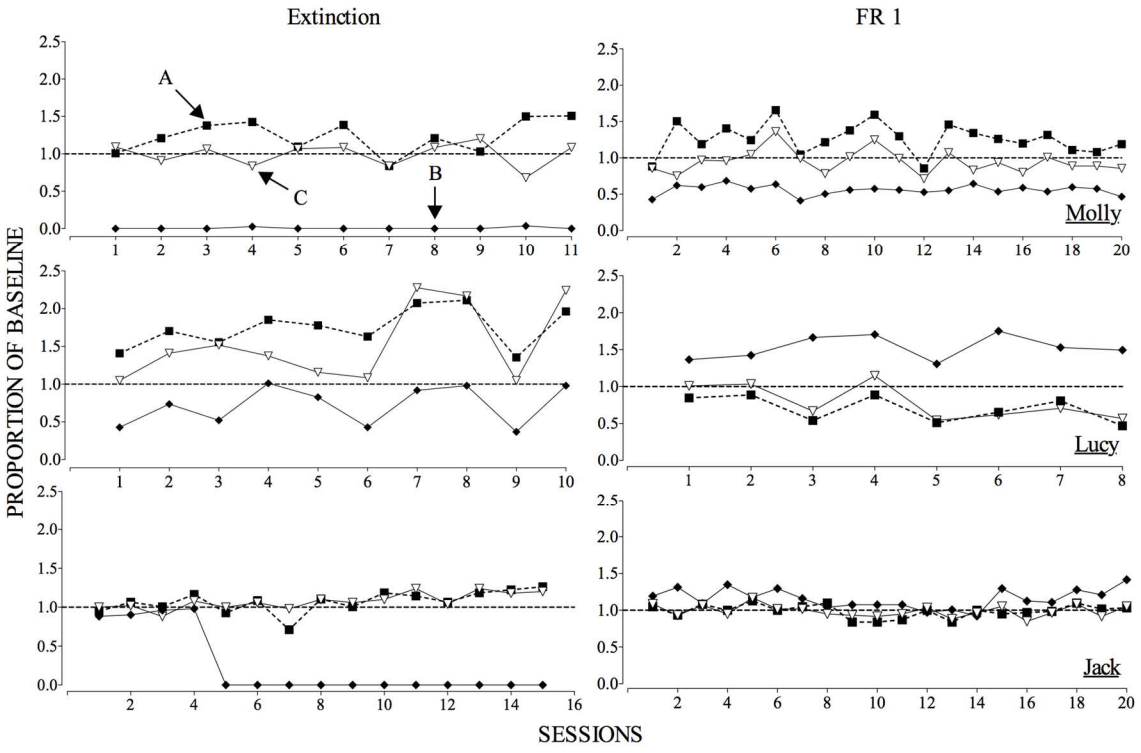

Figure 5. Molar contrast results for all subjects. Results from extinction are on the left-hand side, and results from FR 1 are on the right-hand side. The horizontal dotted line denotes the baseline level of responding. Top panels show results for Molly, middle panels show results for Lucy, and bottom panels show results for Jack.

Extinction (positive contrast)

Results for Molly during extinction are shown in the upper-left panel of Figure 5. Rates in Component B, in which responding was on extinction, were at or near zero during the entire phase. Responding in Component A occurred at or above the baseline level (with the exception of session 7), while responding in Component C varied above and below baseline.

Lucy's responding during extinction (middle-left panel of Figure 5) generally covaried across all components, with responding in Component A elevated relative to Component C (with the exception of sessions 3, 7, 8, and 10), which were both elevated relative to Component B. Responding in Component B, in which responding was on extinction, was consistently at or below baseline. Rates in Components A and C were elevated relative to baseline in all sessions. Rates in Component C were more variable than in A and were often just above baseline (sessions 1, 6, and 9).

Jack's results during extinction are shown in the bottom-left panel of Figure 5. Following session 4, no responding occurred during Component B, in which responding was on extinction. Responding in Components A and C began to increase about midway through the phase (session 10 and 8, respectively), and by the end of the phase, proportion of baseline response rates in Components A and C were comparable.

FR 1 (negative contrast)

The upper-right panel of Figure 5 shows results during FR 1 for Molly. The proportion of baseline rates in Component B was stable throughout the phase, occurring at about .5. Response rates in Component A were variable but were generally higher than baseline (with the exception of sessions 1 and 12). Rates in Component C varied above

and below baseline throughout the phase, although the proportion of baseline rates in each of the last three sessions was less than 1.0.

The middle-right panel of Figure 5 shows results during FR 1 for Lucy. Responding in Component B, in which responding was reinforced on an FR 1 schedule, was consistently above baseline. Proportion of baseline rates in Components A and C covaried, with rates in Component A below baseline in all sessions and those in Component C at or near baseline for the first four sessions but then decreasing to a level comparable to Component A.

The lower-right panel of Figure 5 shows results during FR 1 for Jack. Rates in Component B were variable, but most often occurred above baseline. Responding in Components A and C was inconsistent across the phase as well, varying between below (e.g., sessions 9-11) and above baseline (sessions 5, 18), but most often occurred at the baseline level (sessions 2-4, 6, 7, 12, 14, 17, 20).

Statistical Analyses: Molar Contrast

To determine the magnitude of change from baseline to contrast phases, we calculated Cohen's *d* as a measure of effect size for each subject. We also conducted paired-sample t-tests for each subject by comparing baseline to extinction, and the replication of baseline to FR 1, to determine whether the changes in responding in Components A and C from baseline to contrast conditions were statistically significant. Significance was assessed at $p < .05$. Because we analyzed the last three data points of each phase only, we may not have had adequate statistical power to detect effects, and insignificant results from a t-test may reflect a Type II error (incorrectly failing to reject

the null hypothesis that contrast did not occur when in fact it did). Therefore, we primarily relied upon Cohen's *d* in determining whether effects were obtained in contrast phases. We included the last three sessions of each phase only in both analyses because we terminated phases based on three sessions of responding meeting stability criteria.

Extinction (positive contrast)

Figure 6 shows effect sizes during extinction. Recall that four trials were conducted in each session due to potential warm-up effects. To determine whether different conclusions would be reached depending on whether analyses were conducted with all four trials versus with the last three trials of each session only, effect sizes are displayed separately for those calculated with three versus four trials. White bars represent effect sizes calculated with data from all four trials and shaded bars represent effect sizes with data from three trials only. Effect sizes were not systematically different (e.g., not consistently higher or lower) when analyzing contrast using three versus four trials (also see Figure 7), and we therefore based our conclusions and within-session analysis on data from three trials only (shaded bars). Positive effect sizes reflect an increase in responding relative to baseline (i.e., positive contrast), and negative effect sizes reflect a decrease in responding (i.e., negative induction). For the purpose of this paper, effect sizes greater than 1.0 (or less than -1.0 in the FR 1 condition) reflect an effect consistent with contrast. The designation of an effect size of a given magnitude as reflecting a meaningful increase is somewhat arbitrary, but others have described effect sizes of 1.0 as "large" (Cohen, 1988). A behavioral change consistent with positive contrast occurred for all subjects in all components, again with the exception of Molly in Component C, with effect sizes exceeding 1.0.

Table 16 shows t-test results during extinction. Of the five cases in which responding changed in the direction consistent with contrast, three were statistically significant: Jack in Components A and C and Lucy in Component A.

FR 1 (negative contrast). Figure 7 shows effect sizes during FR 1. Negative effect sizes reflect a decrease in responding relative to baseline (i.e., negative contrast), and positive effect sizes reflect an increase in responding. Responding changed in the direction consistent with negative contrast in three of six cases, and effect sizes were less than -1.0: Molly in Component C and Lucy in both components. For the remaining three

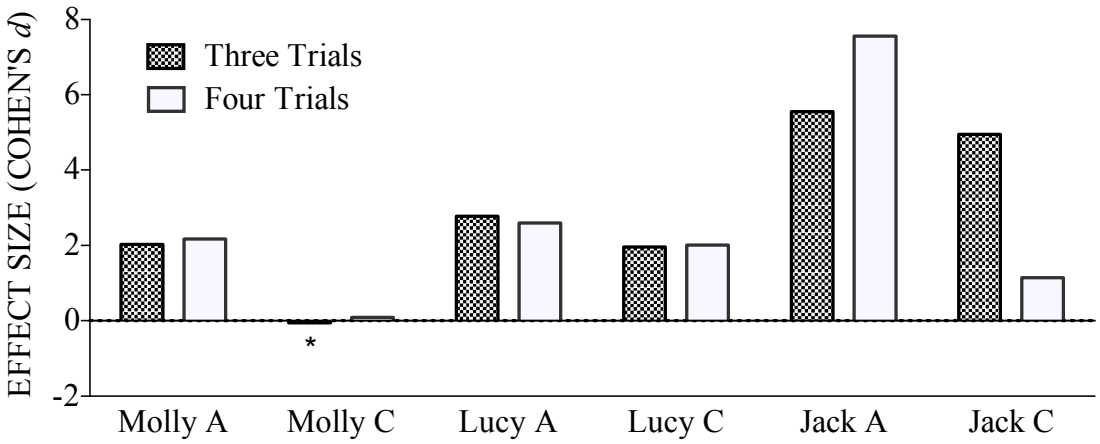

Figure 6. Cohen's *d* for all subjects during extinction. Asterisks denote cases in which behavior changed in the opposite direction of contrast.

Table 16

Results of t-Test Analyses in Extinction

	Extinction: Component A		Extinction: Component C	
	t	p	*t*	p
Molly	-2.366	.14	.05	.97*
Lucy	-4.16	**.05**	-2.32	.15
Jack	-6.11	**.03**	-4.30	**.05**

Note. Bolded p-values indicate statistical significance at $p < .05$. Asterisks indicate that responding decreased from baseline to extinction phases.

cases (responding changed in the direction consistent with induction), effect sizes were inconsistent, ranging from small (.21 for Jack in Component C), to large (1.29 for Jack in Component A).

Table 17 shows t-test results during FR 1. Of the three cases in which responding changed in the direction consistent with contrast, only one was statistically significant: Lucy in Component C. Of the three cases in which responding changed in the direction consistent with induction, one was statistically significant: Jack in Component A.

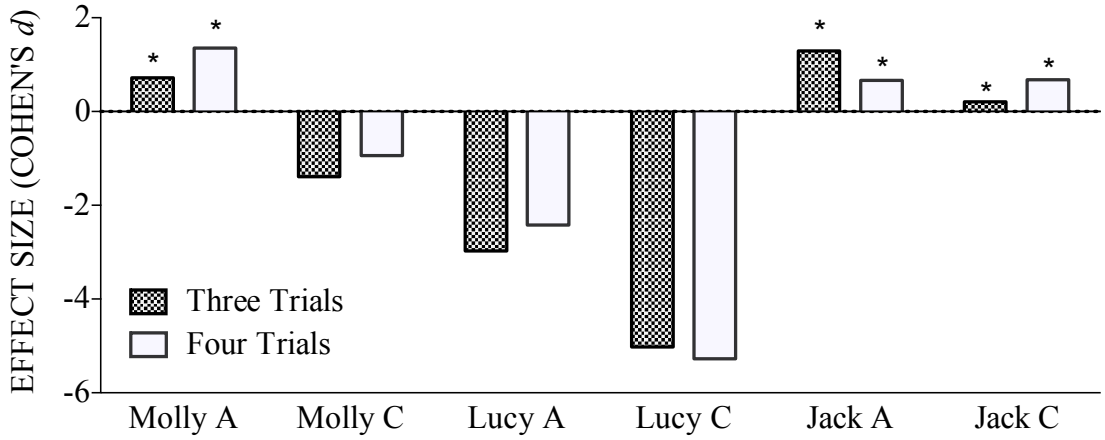

Figure 7. Cohen's *d* for all subjects during FR 1. Asterisks denote cases in which behavior changed in the opposite direction of contrast.

Table 17

Results of t-Test Analyses in FR 1

	FR 1: Component A		FR 1: Component C	
	t	p	*t*	p
Molly	-.67	.57*	1.38	.30
Lucy	2.61	.12	5.07	**.04**
Jack	-5.20	**.04***	-.29	.80*

Note. Bolded p-values indicate statistical significance at $p < .05$. Asterisks indicate that responding increased from baseline to FR1 phases.

Contrast Evaluation: Within-Session

Figures 8 and 9 show within-session analyses from extinction and FR 1 phases. Because previous research suggests anticipatory and local effects may differ in their development over time (e.g., Williams, 1981), data from the first three sessions were analyzed separately from data from the last three sessions.

The frequency of responding per 12-s bin was calculated for each of the first three and last three sessions of extinction and FR 1 phases. The mean frequency of responding in each bin was then calculated for the first three sessions and separately for last three sessions. The same calculations were made for the last three sessions of baseline phases against which to compare results from contrast phases. The mean baseline frequency of responding in each bin was calculated as opposed to obtaining an average across bins due to variability in responding across bins (see Figure 12 in Appendix B), due to (for example) variables related to habituation and sensitization (e.g., McSweeney, Hinson, & Cannon, 1996) or fatigue. Horizontal dotted lines denote the baseline level of responding per bin. For each bin, baseline is plotted at 1.0 and responding during contrast is plotted as a proportion of baseline, per bin. Data points falling on the horizontal dotted lines represent responding equivalent to that observed during baseline.

To determine whether anticipatory or local contrast occurred, data were first fitted to regression lines. If the slope of the line was consistent with that of anticipatory effects (positive in extinction and negative in FR 1) or local effects (negative in extinction and positive in FR 1), statistical significance was assessed at $p < .05$ to determine whether the slope was significantly different from zero. In extinction, the slopes of only 4 of 12 regression lines were consistent with anticipatory and local contrast, however the slopes

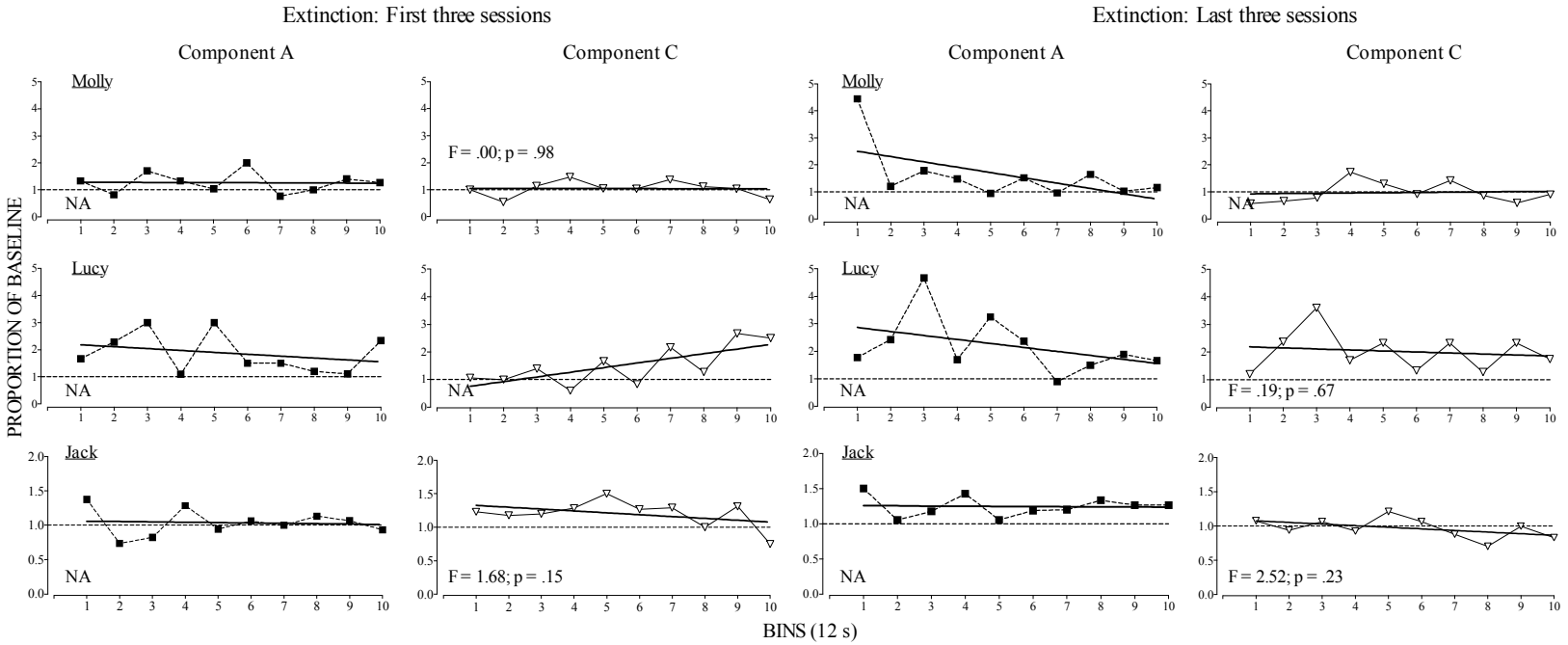

Figure 8. Within-session analyses for the first three (left two columns) and last three (right two columns) sessions of extinction. Top panels show results for Molly, middle panels show results for Lucy, and bottom panels show results for Jack.

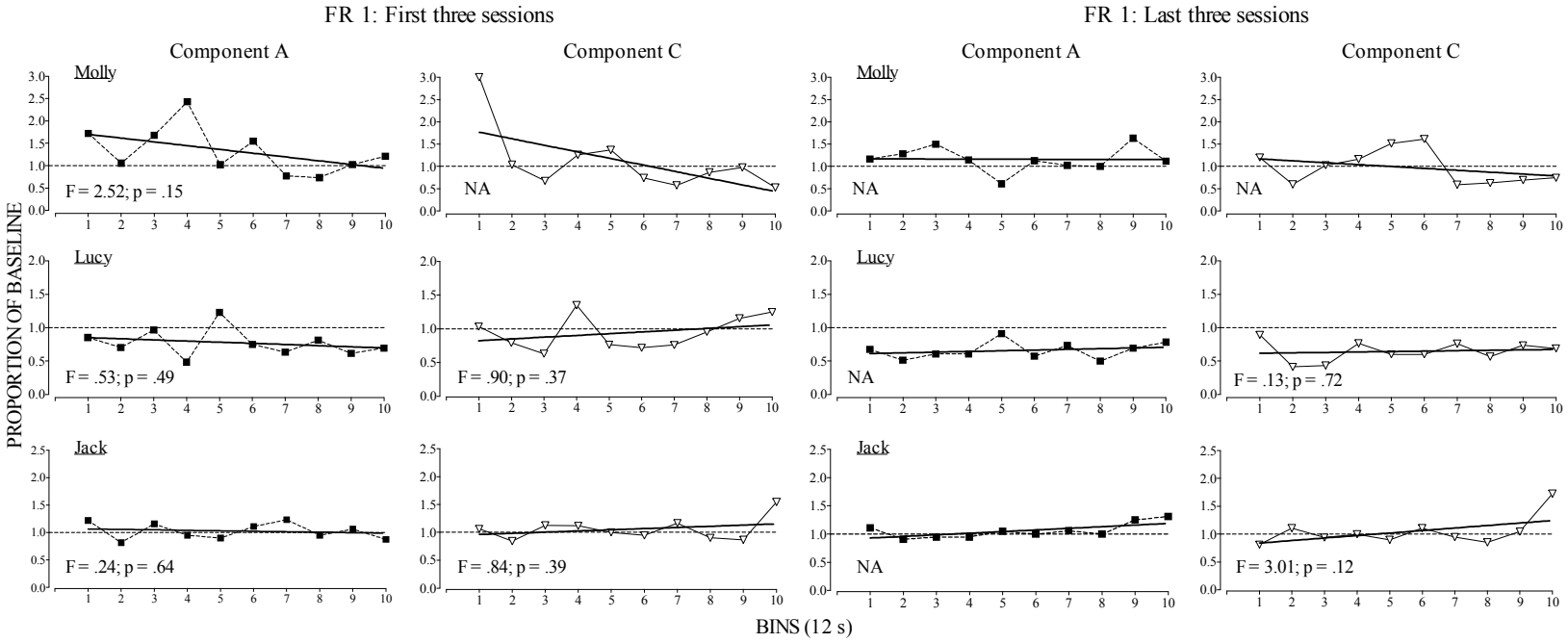

Figure 9. Within-session analyses for the first three (left two columns) and last three (right two columns) sessions of FR 1. Top panels show results for Molly, middle panels show results for Lucy, and bottom panels show results for Jack.

were not significantly different from zero in any case. In FR 1, the slopes of only seven of 12 regression lines were consistent with anticipatory and local contrast, but again, the slopes were not significantly different from zero.

Contrast Evaluation: Reinforcers Obtained

Tables 18 – 20 show the mean frequency of obtained reinforcers for all components for Molly, Lucy, and Jack, respectively. For Molly (Table 18), obtained reinforcers were relatively consistent across all components in baseline. In extinction, Molly earned slightly more reinforcers in Component C than in Component A. In the replication of baseline and in the FR 1 condition, she earned more reinforcers in Component C than in Component A.

Table 19 shows the mean frequency of obtained reinforcers for all three components across all sessions for Lucy. Obtained reinforcers were relatively consistent across all components during baseline. In extinction, Lucy earned more reinforcers in Components A and C than during baseline, and she continued to earn more reinforcers in both components in the replication of baseline. This might explain why Lucy's responding did not return to the initial baseline rates, as the increased response rates in

Table 18

Obtained Reinforcers for Molly

Condition	Mean Frequency of Obtained Reinforcers from All Sessions in Each Condition		
	A	B	C
Baseline	5.73 (2.00)	5.36 (1.82)	5.55 (2.10)
Extinction	5.42 (2.02)	0	5.83 (1.52)
Baseline	5.38 (2.04)	5.04 (2.19)	5.92 (2.20)
FR 1	5.10 (1.70)	71.95 (8.65)	5.50 (2.48)

Note. Standard deviations are in parentheses.

Table 19

Obtained Reinforcers for Lucy

Condition	Mean Frequency of Obtained Reinforcers from All Sessions in Each Condition		
	A	B	C
Baseline	6.65 (2.31)	7.40 (2.76)	6.95 (1.88)
Extinction	9.50 (2.11)	0	9.30 (3.52)
Baseline	13.36 (2.71)	11.36 (3.98)	10.36 (2.96)
FR 1	9.63 (2.74)	131.13 (13.20)	10.38 (2.29)

Note. Standard deviations are in parentheses.

extinction in the form of contrast contacted a higher rate of reinforcement (Figure 4). In the FR 1 condition, the number of reinforcers earned in Component A decreased relative to the previous baseline, while the number of reinforcers earned in Component C remained the same.

Table 20 shows the mean frequency of obtained reinforcers for all sessions in each component across all conditions for Jack. Jack earned fewer reinforcers in Component C than in Components A and B in the initial baseline, but stability criteria (within 20% of the mean of all three components within the last three sessions) were met. In extinction, Jack earned more reinforcers in Component C than during baseline, which might explain the failure of responding in Component C to return to baseline levels in the

Table 20

Obtained Reinforcers for Jack

Condition	Mean Frequency of Obtained Reinforcers from All Sessions in Each Condition		
	A	B	C
Baseline	8.38 (1.58)	7.75 (1.64)	6.63 (2.00)
Extinction	7.13 (1.82)	0	7.80 (2.62)
Baseline	7.63 (2.12)	8.13 (1.36)	8.00 (1.66)
FR 1	7.55 (1.43)	67.80 (7.82)	6.50 (2.73)

Note. Standard deviations are in parentheses.

replication of baseline (Figure 4). However, Jack earned a comparable number of reinforcers in Component A in baseline and extinction conditions; the failure of responding to return to initial baseline levels in this component cannot be explained by contacting an increased rate of reinforcement. In the FR 1 condition, the number of reinforcers earned in Component C decreased, however the number of reinforcers earned in Component A was relatively unchanged.

DISCUSSION

The current study is the first to systematically investigate preceding- and following-schedule behavioral contrast with humans and is the second to investigate within-session contrast with humans. It is also one of few that have compared positive and negative contrast with humans. Discussion of the results in each of the contrast conditions with respect to unexpected findings is presented, as well as theoretical implications and future directions.

Extinction – Positive Contrast

Preceding- and Following-Schedule Effects

Responding changed in the direction consistent with contrast during extinction in both components for all subjects with the exception of Molly in Component C. For Lucy and Jack, effect sizes in Component A were larger than in C. Together, these results suggest a stronger influence of the following schedule with respect to positive contrast.

The larger and more consistent results with respect to the following-schedule effect (Molly and Lucy) replicate findings from the nonhuman literature (e.g., Williams, 1979, 1988; Williams & Wixted, 1986). It is interesting, however, that the one subject for whom preceding- and following-schedule effects were similar (Jack, with effect sizes of 4.95 and 5.56, respectively) was the same for whom contrast developed only after several sessions. It is possible that the manner in which the effects develop over time influences the degree of similarity between them. Further research employing larger numbers of subjects is needed in order to examine covariation in the development in the effects and similarities between them.

Within-Session Effects

Despite finding large effect sizes in both following- and preceding-schedule effects (with the exception of Molly in Component C), none showed statistically significant within-session patterns consistent with anticipatory contrast (Figure 8). Further, in only four of 12 cases were the slopes of regression lines consistent with either effect. The most obvious explanation for the lack of finding within-session effects is that the subjects were unable to discriminate the passage of time. Responding may not have differed systematically across bins (i.e., larger contrast in earlier vs. later bins or vice versa) because subjects may have lacked the ability to discriminate an early bin from a later one, representing either a general skill deficit or an artifact of a procedural feature. The use of an additional stimulus that systematically signals time into a component (e.g., a warning stimulus; Pliskoff, 1963) may result in a greater likelihood of producing local and anticipatory effects.

Of course, it is possible that responding in subsequent bins did not demonstrate local or anticipatory effects due to something other than a skill deficit. One explanation is that the component duration or reinforcement rates we arranged (2 min duration for all; VI 60 s, 30 s and 45 s schedules of reinforcement for Molly, Lucy, and Jack, respectively) were not ideal for producing within-session changes. For example, Weatherly et al. (1998) found local effects for some combinations of reinforcement rates and component durations but not for others: baseline reinforcement rates of VI 30 s produced contrast when components lasted 60 s, but *not* when they lasted 30 s. It is possible that we did not employ the ideal combination of reinforcement rates and component durations to produce anticipatory contrast.

Finally, it is possible that the SDs were not ideal for producing within-session changes. Colors of materials were used to differentiate the components, and the same color was used for Components A and C throughout the experiment. Although a sheet of paper denoting the number of each component (1, 2, or 3) was present throughout each one, it is possible that had we varied the SDs along a different dimension (e.g., employed a pattern), anticipatory effects would have been demonstrated. Some investigations (e.g., Williams, 1988) have found that increasing the discriminability between components by varying SDs along different dimensions (colors vs. patterns) is more likely to produce anticipatory contrast than varying along a single dimension (different colors only).

FR 1 – Negative Contrast

Preceding and Following Effects

Responding changed in the direction consistent with negative contrast in three of six cases. The magnitude of change for Lucy was greater in Component C (ES = -5.02) than in Component A (ES = -2.98), and Molly's responding in Component C only changed in the direction consistent with negative contrast (not in Component A). Together, these results suggest a stronger influence of the preceding schedule with respect to negative contrast.

It is possible that negative contrast (a reduction in overall response rates in Components A and C) did not occur with Jack in either component for at least three reasons. First, It could be that their responding was a function of a history of punishment for noncompliance (i.e., engaging in behavior other than compliance). For example, staff might have reprimanded clients in the past for engaging in behavior other than work tasks.

Clients would then be more likely to work when staff are present, in order to avoid reprimands (i.e., the staff function as *conditioned reflexive motivating operations* [Michael, 1993]). The researchers might have functioned similarly to staff and evoked responding as a result of a history of punishment for noncompliance. In fact, this explanation is consistent with Molly's responding in that her responding only extinguished when the researchers left the room. In addition, we conducted sessions at the day program (where punishment may have been delivered) and during normal business hours (when staff were present). It is thus possible that Jack's and Molly's (in Component A) responding maintained at previous levels due to an adventitious contingency of avoidance of punishment. This seems unlikely, however, given that Jack's and Molly's responding completely extinguished in Component B during extinction.

The second possible explanation for the lack of negative contrast with Jack and Molly (in Component A) (and a more general limitation of working with adults in vocational facilities) is that responding was a result of an adventitious contingency of postponing the return to the activities of the day program. Jack, for example, often requested we work with him first or volunteered to work with us instead of attending a planned activity through the day program. It is possible that his continued high rates of responding during sessions were partially under the control of a motivating operation to avoid returning to the day-program activities. As with the previous possibility, though, this seems unlikely given the extinction of responding in Component B.

As may have been the case with within-session effects during extinction, a third possibility is that procedural variables related to component duration, reinforcement rate, or discriminative stimuli were not ideal to produce contrast. For example, Weatherly et al.

(1998) found negative contrast with 30-s components and baseline reinforcement schedules of VI 60 s but not with baseline reinforcement schedules of VI 30 s.

Within-Session Effects

Although only Lucy and Molly (in Component C) demonstrated changes in molar levels of responding consistent with negative contrast, it was still possible for Molly's responding in Component A and Jack's responding in either target component to demonstrate within-session patterns consistent with anticipatory or local contrast. In seven of 12 cases the slopes of regression lines were consistent with these within-session effects, and as with extinction, none were statistically significant. Issues related to the passage of time, reinforcement rate, component duration, and the nature of SDs, discussed related to positive contrast (i.e., extinction condition), may also be responsible for the lack of correspondence between these results and those reported by Williams (1981, 1988).

Positive Versus Negative Contrast

In five of six cases, positive contrast (effect sizes greater than 1.0) was demonstrated in extinction; the exception was Molly, who did not demonstrated contrast in Component C (the preceding-schedule effect). However, less consistent results were obtained with negative contrast during FR 1: effect sizes greater than -1.0 in only three of six cases. Further, for the subject who demonstrated negative contrast in both Component A (following-schedule effect) and in Component C (preceding-schedule effect) (Lucy), the magnitude of the preceding-schedule effect was larger than the following-schedule effect. This is in opposition to what was found with positive contrast – the following-

schedule effect was larger than the preceding for all subjects. This is consistent with what some others have found regarding the differential influence of preceding and following schedules depending on the direction of contrast (Weatherly et al., 1998; Williams, 1992). Potential reasons for the discrepancy between the two effects are discussed below.

Aversive Versus Appetitive Stimulus Changes

Rasmussen and Newland (2008) recently reported asymmetry in the magnitude of behavior change produced with reinforcement versus punishment, in that the magnitude of behavior change is larger when one unit of a stimulus is removed (punishment in the form of response cost), than when one unit of the same stimulus is presented (reinforcement). A decrease in the rate of reinforcement may be conceptualized as an aversive stimulus change in the same way that an increase in the rate of reinforcement functions may be conceptualized as an appetitive stimulus change. Assuming that the former influences behavior to a larger degree than the latter, it could be that even indirect effects of that change (i.e., behavioral contrast) are larger as well. Following this logic, positive contrast resulting from an aversive stimulus change (in terms of the reduction in reinforcement rate from baseline to extinction conditions) may be expected to be larger than negative contrast resulting from an appetitive stimulus change (the increase in rate of reinforcement).

Discriminability of Contingency Change

It could be that the discrepancy between positive and negative contrast was related to how many times the subjects contacted the change in contingency from baseline to extinction and from the replication of baseline to FR 1. Responding for Molly

and Jack might have contacted the change from baseline to extinction more often than the change from the second baseline to FR 1, which might have contributed to their showing changes in responding in the direction consistent with contrast in extinction but not in FR 1. To evaluate this possibility, the mean IRT was calculated for each subject across all sessions of baseline. The mean inter-reinforcement interval was also calculated, and was then divided by the mean IRT. This yielded the mean number of responses per reinforcer. The frequency of responses in the contrast (extinction) phase was then divided by the mean number of responses per reinforcer in the preceding baseline. This value is how many reinforcers *would* have been earned in the contrast (extinction) phase had the contingency remained the same as in baseline. The frequency of responding contacting the change in contingency from the second baseline to FR 1 was calculated by subtracting the number of reinforcers that would have been earned had the contingency remained unchanged from the number of obtained reinforcers. This value is the number of *additional* reinforcers that were earned in FR 1 due to the change in contingency. Table 21 shows results of this analysis for all subjects. The frequency with which Molly contacted extinction was extremely low (.39), and is the lowest of the three subjects as her responding was almost completely suppressed in extinction. Recall that the therapists left the room. Interestingly, she is the only one to have not shown a change in responding consistent with positive contrast during extinction in Component C. It is possible that had her responding contacted the change in contingency more often, her responding would have changed in the direction consistent with positive contrast.

Lucy contacted the change from the second baseline to FR 1 phases the fewest times of all subjects but was the only subject to demonstrate changes in responding

Table 21

Frequency of Contact with Contingency Change in Extinction and FR 1 Phases

	Molly	Lucy	Jack
Contact with EXT	.39	76.78	30.36
Behavior Change Consistent w/Contrast	A only	A and C	A and C
Contact with FR 1	1380.51	159.13	1173.81
Behavior Change Consistent w/Contrast	C only	A and C	Neither

Note. EXT = extinction. FR = fixed ratio.

consistent with negative contrast in both components. Further, Molly and Jack each contacted the change in contingency to FR 1 over 1,000 times, compared to only .39 for Molly and 30.36 for Jack in extinction. If the lack of negative contrast were due to a failure to discriminate the change in contingency, we would expect subjects to have contacted the change in contingency from baseline to FR 1 fewer times than the change from baseline to extinction, however this was not the case. This analysis suggests that the discrepancy in positive and negative contrast results was not due to a difference in discriminability between baseline and contrast phases.

Direct Effects of Contingency Change

Although researchers have demonstrated that a change in behavior in the varied component is neither a sufficient nor necessary condition for behavioral contrast to occur (e.g., Halliday & Boakes, 1974; McSweeney et al., 1986; O'Brien, 1968), it is possible that the magnitude of behavior change in Component B is associated with magnitude of contrast in Components A and C. To evaluate this, the percentage change in behavior in Component B from baseline to contrast phases was calculated in the last three sessions of each phase. The last three sessions were used (instead of all sessions) as contrast evaluations were based on responding in the last three sessions in each phase. Results of

this analysis are shown in Table 22. The magnitude of change in behavior during extinction did not seem to contribute to the presence of positive contrast – Molly's responding decreased by nearly 100%, however she showed only a following-schedule effect (not a preceding). However, it is possible that magnitude (and possibly direction) of change in responding contributed to negative contrast. Lucy demonstrated negative contrast in both components, and the magnitude of change in her responding in Component B was also the largest of the three subjects. Jack's responding increased in Component B during FR 1 as well, although only by half the magnitude as Lucy's, and Molly's responding did not increase at all, but in fact decreased. Molly however *did* show negative contrast in Component C, while Jack showed neither preceding- nor following-schedule effects. It is also important to note that for Lucy only was the magnitude of behavior change from baseline to FR 1 larger (59.77%) than the magnitude of change from baseline to extinction (22.45%). For Molly and Jack, the magnitude of behavior change in FR 1 was much lower than in extinction. Table 21 demonstrates that the change in contingency to FR 1 may have been more discriminable than the change to extinction, but Table 22 demonstrates that for the two subjects who did not show negative contrast (Jack in both components and Molly in Component A), the magnitude of change in their responding in Component B during FR 1 was much smaller than in extinction. For Molly, the change in responding was also in the opposite direction: a decrease rather than an increase. For Jack, the smaller magnitude of behavior change in FR 1 compared to extinction (30.11% compared to 100%) was likely due to a ceiling effect. If his responding doubled (an increase of equal magnitude), he would have been engaging in

Table 22

Percentage Change in Responding from Baseline to Contrast Phases in Component B

	Molly	Lucy	Jack
BL to EXT	- 98.80%	- 22.45%	- 100%
Behavior Change Consistent w/Contrast	A only	A and C	A and C
BL 2 to FR 1	- 45.34%	+ 59.77%	+ 30.11%
Behavior Change Consistent w/Contrast	C only	A and C	Neither

Note. BL = baseline. EXT = extinction. FR = fixed ratio.

about 20 responses per min. Jack had relatively poor motor skills and his response consisted of inserting a peg into a pegboard. It is possible that he was simply unable to respond any faster than 12.72 responses per min (his mean rate of responding during FR 1). Molly's responding, unlike Lucy's and Jack's, decreased in Component B with the increased rate of reinforcement, so it does not seem appropriate to conclude that the failure of negative contrast to occur with her in Component A was solely a result of a smaller magnitude of behavior change in FR 1 than in extinction.

Limitations

There are a few limitations of this study, the first of which relates to the variability in the data. We applied the 20 session maximum criterion during the initial baseline for Lucy and the replication of baseline for Molly, as their responding had not met the stability criteria. This was a problem mainly for Molly in Component A in FR 1, in that the amount of variability in the second baseline may have obscured a change in responding consistent with negative contrast. The level of responding in FR 1 in Components A would have had to be extremely low to produce a convincing effect, given the large range of responding in the preceding baseline. Variable responding may have

been due to unprogrammed consequences influencing behavior, such as generalized compliance or avoidance of day-program activities, described earlier. It could also have been a result of fluctuations in motivating operations. For example, we sometimes conducted sessions with some subjects at slightly different times during the day due to logistical reasons, and it is possible that doing so changed the value of the programmed reinforcers such that responding was influenced accordingly. Similarly, a different room was sometimes used in which to conduct sessions, also due to logistical reasons. It is possible that subjects had different histories of reinforcement in each room, or that some other feature of the rooms exerted control over behavior (e.g., one room was slightly darker than the other, one room was upstairs, etc.). It would have been ideal to conduct sessions at exactly the same time and in the same room throughout the study, but it was not feasible given the nature of the setting.

A second limitation related to the data is that responding did not return to initial baseline levels for Jack and Lucy following extinction. As a result of the increase in responding in Components A and C during extinction, Lucy's responding contacted more reinforcers than in the initial baseline (see Table 19). It is possible that the maintenance and increased rate of responding in the replication of baseline was due to having contacted an increased rate of reinforcement in the previous phase. Notwithstanding this possibility, it is not clear that the implementation of extinction in Component B caused the increased response rates in Components A and C, as responding in Components A and C did not return to their initial levels when the reinforcement contingency for Component B was reinstated. Jack's responding also did not return to baseline levels, but only responding in Component C (not Component A) contacted an increased rate of

reinforcement when responding in Component B was placed on extinction, thus the appeal to the direct reinforcement of higher rates of responding is not applicable to Component A with Jack. In addition, the increased response rates developed slowly with Jack. It is possible that the increase in responding in Components A and C was due to a practice effect and not to extinction in Component B; responding may have increased in those components without that manipulation. This seems unlikely, though, as the increasing trends in Components A and C stopped with the reintroduction of baseline.

Future Directions

Some research suggests that contrast is the result of a reallocation of responses between components across baseline and contrast conditions (Hinson & Staddon, 1978; Killeen, 2014). "Competition theory" asserts that individuals allocate responding between two general response classes: one that produces programmed reinforcers (target responses) and one that produces unprogrammed reinforcers and whose members are incompatible with the response class of interest (competing responses). During baseline, members of both response classes occur at a given level across all components. When target responses are placed on extinction in a varied component (e.g., in the current study, Component B in the extinction condition), target responses in the varied component decrease, and competing responses from constant components (here, A and C) are reallocated to the varied component. This reallocation of competing responses to the varied component results in the reallocation of *target* responses to the varied components, or positive behavioral contrast. Conversely, an increased rate of reinforcement in a varied component (Component B in the FR 1 condition) results in an increase in target responses

in that component, and competing responses in the varied component are reallocated to the target components (A and C). The reallocation of competing responses to the target components results in a decrease in target responses in those components, or negative behavioral contrast. We did not explicitly arrange for competing sources of reinforcement (e.g., concurrently available materials) and did not systematically measure competing behavior. Results from the negative contrast phase are consistent with this theory, though, in that the largest change in responding in Component B from baseline to FR 1 occurred with Lucy (allowing for the largest reallocation of competing and target responses), and she was the only subject who displayed negative contrast in both components. A future direction may be to explicitly arrange for, or at least measure, competing responses. It is possible that if competing responses occurred at a given level during baseline (e.g., Hinson & Staddon, 1978), and were then reallocated to Components A and C during an FR 1 condition, negative contrast would be more likely to occur. A programmed arrangement of a competing response class would also increase the social validity of a human-operant arrangement, as the day-to-day environment includes members of multiple response classes in which to engage (Herrnstein, 1970).

A second future direction includes the use of different response topographies. Some research (e.g., Davison & Ferguson, 1978) suggests that less effortful responses may be more sensitive to changes in reinforcement than more effortful responses, and may thus be more likely to show contrast with changes in reinforcement rate. This would be an interesting future direction in the development of interventions to decrease problem behavior. It could be that increasing the effort required to engage in problem behavior reduces the likelihood of contrast in non-treatment settings. For example, Zhou, Goff, and

Iwata (2000) increased the effort required for individuals to engage in self-injury by having subjects wear protective equipment that increased the force required to emit the response of hand mouthing. Future human-operant and applied researchers may manipulate response effort to determine the extent to which contrast is influenced by easier and more difficult responses.

Finally, many parameters of the current investigation may be inconsistent with those found in applied settings: schedules of reinforcement, component duration, nature of discriminative stimuli, inter-component intervals, ITIs, etc. Although the ultimate goal of the current research is to improve upon clinical practice (e.g., prevent positive contrast in the form of problem behavior in non-treatment settings), we used procedures and parameters from basic research with nonhumans as a first step to assess the generality of findings from such arrangements. We were indeed able to replicate several findings (e.g., more consistency with respect to positive contrast vs. negative, greater influence of the following schedule with positive contrast only); however, we were unable to replicate others (e.g., local and anticipatory effects). It is important that procedural variations with respect to more socially valid arrangements be made systematically, as doing so will assist researchers in identifying specific variations that may be responsible for obtaining results inconsistent with previous research. Future investigations may systematically manipulate variables that are known to influence contrast in nonhumans, such as component duration, schedules of reinforcement, nature of SDs, etc. The generality of the findings of the current investigation to applied settings is unknown, and further research is necessary to determine the extent to which results from basic arrangements are consistent with findings from more applied situations. In any case, the findings from this

study may be useful to future researchers who wish to continue to investigate behavioral contrast in humans, in that the procedures partially replicated those found with nonhumans.

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APPENDICES

Appendix A

Initial Evaluation for Molly

Initial Evaluation for Molly

We initially defined the target response for Molly as moving a crayon back and forth between two bowls with the requirement that she needed to release the crayon (i.e., drop it into the bowl) each time. We conducted 38 sessions with this response definition, results of which are shown in Figures 10 and 11.

At the end of baseline, response rates in all three components were relatively low: about 1.0 per min in Components B and C and about 3.0 per min in Component A. When responding in Component B was put on extinction (session 10), responding in all three components increased. We hypothesized that responding in Component B was not extinguishing because edibles were still present (on the table) during that component. Even though edibles were never delivered in Component B in extinction, the presence of the edibles might have functioned as an SD, as their presence in the past preceded the response-contingent delivery of edibles. Beginning at session 18, we therefore removed the edibles during Component B, after which we saw a decrease in responding in that component. However, rates were consistent with those seen in the initial baseline. There was a large positive contrast effect in Component C and a smaller effect in Component A, with mean proportions of baseline of 2.79 and 1.41, respectively (see Figure 2).

During the replication of baseline, response rates in Components A and C initially decreased to their original baseline levels, however rates in all components began to increase in session 36 to levels higher than in the initial baseline. This indicated that Molly's responding might not have been under the control of the programmed contingencies of reinforcement. In addition to target responses, Molly also engaged in "close-in nonresponses" in which she moved the crayon back and forth between the

bowls but did not release it from her fingers. We hypothesized that these nonresponses were members of the same functional class as the target responses, and that the failure of the target responses to return to initial baseline levels was due to variability in the rates of the nonresponses. We therefore revised the target response definition for Molly to include moving the crayon between the bowls without the requirement of releasing it from her fingers, and restarted the experiment. Results based on this new definition are reported in the main part of the dissertation.

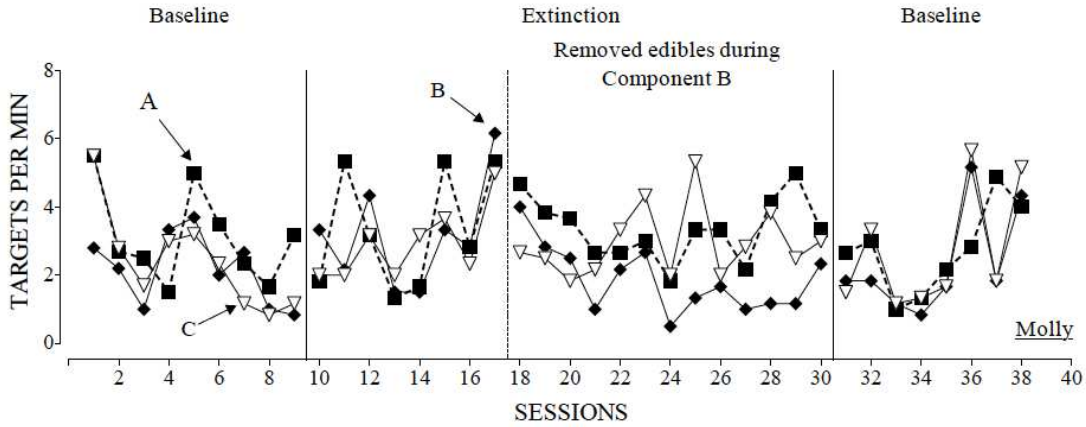

Figure 10. Response rates across all sessions and in all components with the original response definition for Molly.

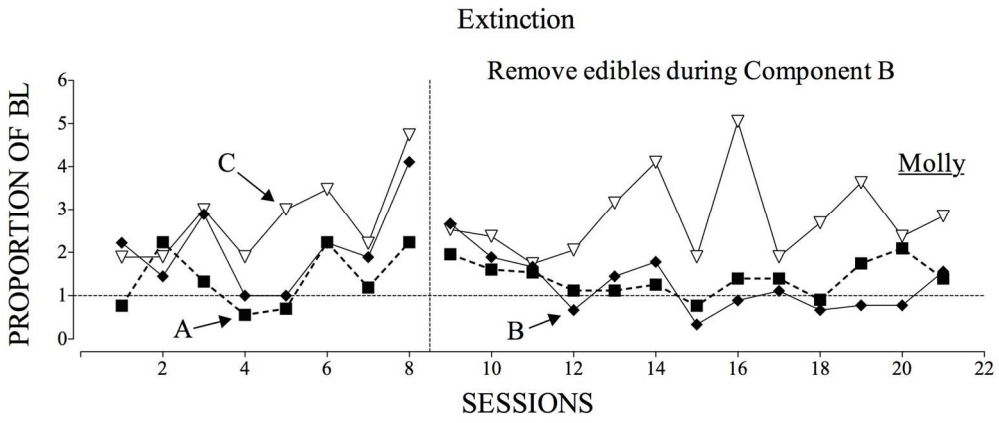

Figure 11. Proportion of baseline response rates during extinction in all components with the original target definition for Molly.

Appendix B

Response Rates during Baseline

Response Rates during Baseline

Figure 12 shows the mean frequency of responding across bins in the last three sessions of both baseline phases for all subjects. The top six panels show results from the initial baseline phase, and the bottom six panels show results from the second baseline phase. Left-hand panels show data from Component A and right-hand panels show data from Component C. Vertical lines represent standard deviations.

Responding across bins was relatively stable for Jack, with the exception of the first bin in Component A in the initial baseline and the last bin in Component C in the second baseline. For Molly and Lucy, however, responding was more variable, with Molly's responding increasing across bins in Component C in both baselines, and Lucy's responding decreasing across bins in Component C in both baselines. Responding across *sessions* was also variable for all subjects, reflected by large standard deviations.

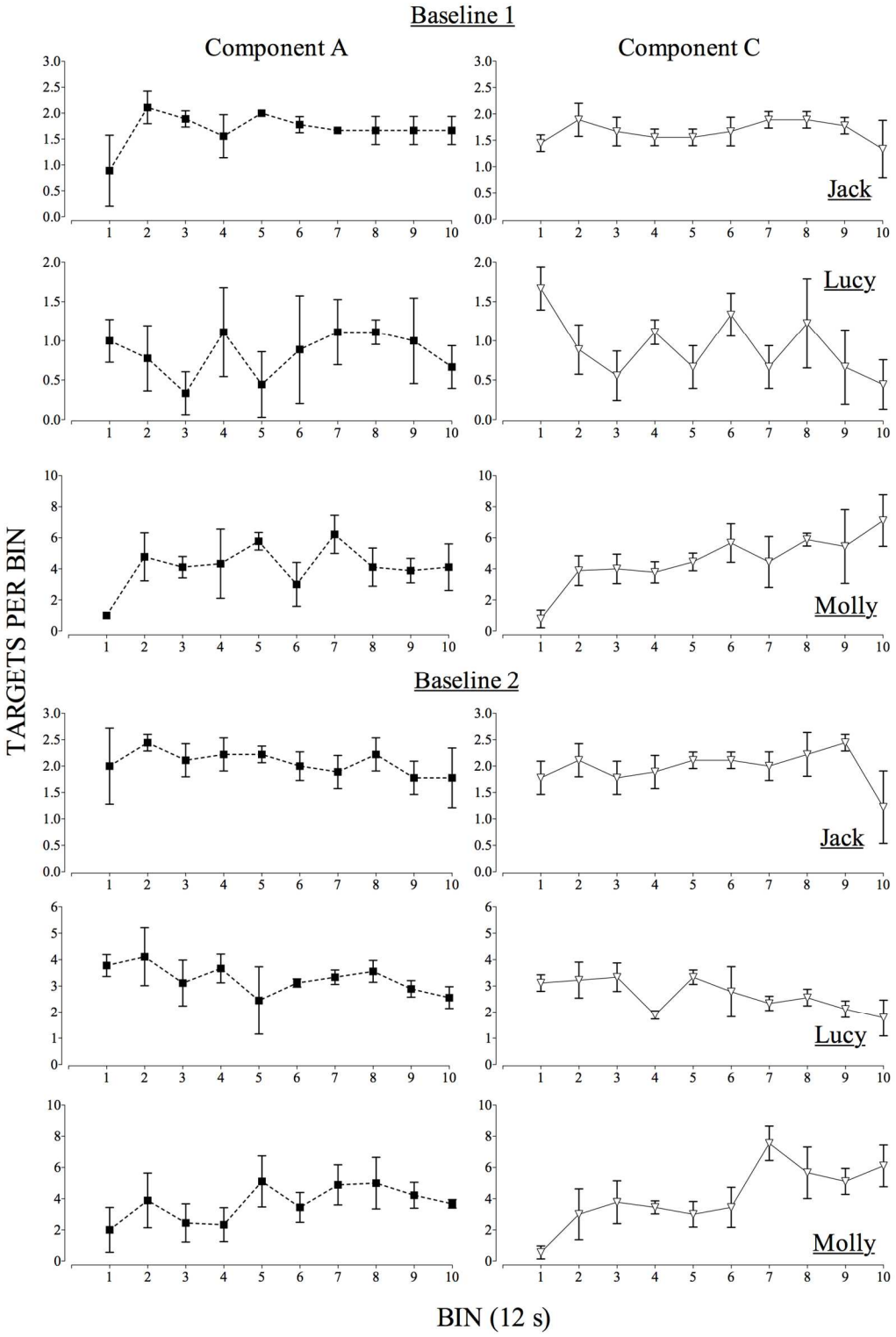

Figure 12. Mean frequency of responding per bin for the last three sessions of the first (top six panels) and second (bottom six panels) baseline phases. Vertical lines represent standard deviations.

CURRICULUM VITA

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Education

Institution	Degree	Date	Major
Utah State University Logan, UT	Ph.D.	Spring 2015	Disability Disciplines
Florida Institute of Technology Melbourne, FL	M.S.	2010	Applied Behavior Analysis & Organizational Behavior Management
Western Michigan University Kalamazoo, MI	B.S.	2007	Psychology & Spanish

Certification

Board Certified Behavior Analyst (Certified September 30, 2010)
Certificate number: 1-10-7324

Peer-Reviewed Publications

Clay, C. J., Samaha, A. L., Bloom, S. E., Bogoev, B. K., & Boyle, M. A. (2013). Assessing preference for social interactions. *Research in Developmental Disablities, 34,* 362-371.

Boyle, M. A., Samaha, A. L., Rodewald, A. M., & Hoffman, A. N. (2012). Evaluation of the reliability and validity of GraphClick as a data extraction program. *Computers in Human Behavior, 29,* 1023-1027.

Samaha, A. L., Keyl-Austin, A., Bloom, S. E., & Boyle, M. A. (2012). Effects of preference and reinforcer variation on within-session patterns of responding. *Journal of Applied Behavior Analysis*, *45,* 637-641.

Sparling, J. H., Wilder, D. A., Kondash, J., Boyle, M. A., & Compton, M. (2011). Effects of interviewer behavior on the accuracy of children's testimony during simulated forensic interviews. *Journal of Applied Behavior Analysis, 44,* 587-592.

Manuscripts under Review

Boyle, M. A., Samaha, A.L., Bloom, S.E., & Kunnavatana, S.S. Use of social interactions as reinforcers with individuals with autism: A data-based review. *Behavior Analysis: Research and Practice.*

Hoffman, A. N., Samaha, A. L., Bloom, S.E. & Boyle, M. A. Preference and reinforcer efficacy of high-tech items: A comparison of item type and duration of access. *Journal of Applied Behavior Analysis.*

Manuscripts in Preparation

Bloom, S. E., Clark, D., Boyle, M. A., & Clay, C. Effects of delaying demands on escape-maintained problem behavior.

Boyle, M. A., Samaha, A. L., & Bloom, S. E. Unit price: A comparison of two ways of fading token schedules.

Lambert, J. M., Bloom, S. E., Kunnavatana, S. S., Boyle, M. A., & Samaha, A. L. Evaluating correspondence between functional analyses of mands and problem behavior. *Journal of Applied Behavior Analysis.*

Non-Refereed Publications

Boyle, M. A. (2010). Thoughts on the use of OBM techniques and systems analyses in restaurants. *OBM Network Newsletter, 24,* 1.

Assistantships & Fellowships

Fall 2012	Utah State University, Department of Psychology Graduate Student Teaching Assistantship
Fall 2011 – Spring 2012	Utah State University, Department of Psychology Graduate Student Research and Teaching Assistantship
Fall 2010 – Spring 2011	Utah State University, Department of Psychology Presidential Fellowship
Fall 2009 – Spring 2010	Florida Institute of Technology, Department of Applied Behavior Analysis

Graduate Student Research Assistantship

Research Experience

Spr 2012 – Spring 2014	Utah State University, Department of Special Education and Rehabilitation Role: Student Researcher Project title: Effects of delaying demands on escape-maintained problem behavior Principal student investigator: Daniel Clark, B.A. Faculty investigator: Sarah Bloom, PhD, BCBA-D
Summer 2013 – Fall 2014	Utah State University, Department of Special Education and Rehabilitation Role: Principal Student Investigator Project title: A translational investigation of behavioral contrast Faculty investigators: Andrew Samaha, PhD, BCBA-D, and Timothy Slocum, PhD
Spr 2012 – Summer 2013	Utah State University, Department of Psychology Role: Principal Student Investigator Project title: Increasing unit price: A comparison of fixed and variable schedules of reinforcement Faculty investigators: Andrew Samaha, PhD, BCBA-D, and Sarah Bloom, PhD, BCBA-D
Spr 2011–Summer 2013	Utah State University, Department of Psychology Role: Principal Student Investigator Project title: Unit price: A comparison of two methods of fading token schedules Faculty investigator: Andrew Samaha, PhD, BCBA-D
Spring 2013	Utah State University, Department of Special Education and Rehabilitation Role: Student Researcher Project title: Evaluation of a mand assessment as a technology for identifying socially-mediated functions of problem behavior Principal student investigator: Joseph Lambert, M.S., BCBA Faculty investigators: Andrew Samaha, PhD, BCBA-D, and Sarah Bloom, PhD, BCBA-D
Spring 2011	Utah State University, Department of Special Education and Rehabilitation

Role: Student Researcher
Project title: Evaluating the effects of reinforcer choice and reinforcer variation on response rates of children with autism
Principal student investigator: Alice Keyl-Austin, M.A., BCBA
Faculty investigator: Thomas Higbee, PhD, BCBA-D

Fall 2010 — Utah State University, Department of Psychology
Role: Student Researcher
Project title: Effects of preference and stimulus variation on response persistence
Principal student investigator: Alice Keyl-Austin, M.A., BCBA
Faculty investigators: Andrew Samaha, PhD, BCBA-D, and Sarah Bloom, PhD, BCBA-D

Fall 2009 – Summer 2010 — Florida Institute of Technology, Department of Applied Behavior Analysis
Role: Student Researcher
Project title: Assessing preference for positive and negative reinforcement
Faculty investigator: Guy Bruce, PhD, BCBA-D

Fall 2008 – Summer 2010 — Florida Institute of Technology, Biology Department, Behavioral Neuroscience Laboratory
Role: Student Researcher
Project title: Determining the sensitivity and mechanisms of snake infrared imaging through the application of operant conditioning techniques
Principal student investigator: Sherri Emer, M.S.
Faculty investigator: Michael Grace, PhD

Spring 2009 – Fall 2009 — Florida Institute of Technology, Department of Applied Behavior Analysis
Role: Student Researcher
Project title: REACH project – Assisting caregivers of individuals with Alzheimer's
Faculty investigators: Frank Webbe, PhD, Celeste Harvey, PhD, BCBA-D, and Guy Bruce, PhD, BCBA-D

Spring 2007 – Fall 2007 — Western Michigan University, Psychology Department, Human-Operant Laboratory
Role: Research Assistant
Project titles:

Probabilistic discounting in cigarette smokers and non-smokers
Adaptive choices in situations of risk
Behavioral sensitivity to losses
Behavioral sensitivity to negative outcomes under a rapid assessment procedure
Probabilistic outcomes and human choice
An assessment of romantic couples in relation to their Internet activity
Principal student investigators: Adam Bennett, M.S., Gabriel Searcy, M.S.
Faculty investigator: Cynthia Pietras, PhD

Teaching Experience

Spring 2015 — Missouri State University, Department of Counseling, Leadership, & Special Education
Role: Instructor
Course title: Clinical Practicum for Special Needs Populations
Course topics: Conducting functional behavior assessments, making data-based decisions, implementing function-based treatments.

Spring 2015 — Missouri State University, Department of Counseling, Leadership, & Special Education
Role: Instructor
Course title: Seminar in Developmental and Sensory Disabilities
Course topics: Early intervention, discrete-trial teaching, prompting, research-based interventions for children with autism.

Spring 2015 — Missouri State University, Department of Counseling, Leadership, & Special Education
Role: Instructor
Course title: Seminar in Verbal Behavior
Course topics: Skinner's verbal operants, research on and clinical applications of Skinner's analysis of verbal behavior

Fall 2014 — Missouri State University, Department of Counseling, Leadership, & Special Education
Role: Instructor
Course title: Advanced Assessment of Individuals with Developmental and Sensory Disabilities

	Course topics: Preference assessments, functional behavior assessments, communication assessments.
Fall 2012	Utah State University, Department of Psychology Role: Instructor Course title: Behavior Modification Course topics: Functional behavior assessments, function based interventions (extinction, differential-reinforcement, noncontingent reinforcement), punishment procedures, stimulus preference assessments, token economies.
Spring 2011	Utah State University, Department of Psychology Role: Teaching Assistant Course title: Behavior Modification Instructor: Andrew Samaha, PhD, BCBA-D
Fall 2011	Utah State University, Department of Psychology Role: Teaching Assistant Course title: Practicum in Behavior Modification Instructor: Andrew Samaha, PhD, BCBA-D
Fall 2007	Western Michigan University Department of Psychology Role: Teaching Assistant Course title: Topics in Behavior Analysis Course topics: Clinical psychology, child psychology, behavioral medicine, environmental quality, developmental disability, education and geriatrics. Instructor: Alyce Dickinson, PhD
Fall 2006	Western Michigan University Department of Psychology Role: Teaching Assistant Course title: Statistics in Behavioral Psychology Course topics: Measures of central tendency and variability, frequency distributions and graphic presentations, the normal curve, probability theory and the binomial, hypothesis testing, the t-test, chi square and correlation. Instructor: Eric Marmolejo, M.S.

Clinical Experience

Fall 2010 – present	Utah State University, Severe Behavior Clinic, Logan, UT

	Role: Behavior Specialist Description of position: Conduct functional analyses and other functional behavior assessments with individuals with problem behavior, implement function-based interventions, and train caregivers to implement interventions. Consult with clients' schools, attend IEP meetings, give recommendations for treatment and train teachers and paraprofessionals to implement interventions. Supervisors: Sarah Bloom, PhD, BCBA-D, and Andrew Samaha, PhD, BCBA-D
Summer 2012 – present	Utah Behavior Services, Inc., Salt Lake City, UT Role: Behavior Specialist Description of position: Deliver in-home behavior analytic services to individuals with intellectual and developmental disabilities and their families, including functional behavior assessments, academic assessments, function-based treatments for problem behavior, pre-academic, academic, and social skills instruction, and parent and teacher trainings. Supervisors: Sarah Sanders, M.Ed, BCBA and Natalie Whatcott, M.S., BCBA, SSW
Summer 2013 – present	Solace Residential, Logan, UT Role: Behavior Specialist Description of position: Conduct functional analysis and other functional behavior assessments, develop and evaluate function-based behavior plan for an adult woman with severe intellectual and developmental disabilities in a group-home setting, and train staff on intervention procedures. Supervisor: Polly Peart
Summer 2011	Autism Support Services: Education, Research, and Training (ASSERT), Utah State University, Logan, UT Role: Preschool Instructor Description of position: Provided early intensive behavior intervention services to children with autism, ages 3-5, including academic, social-skills, and communication training. Supervisor: Thomas Higbee, PhD, BCBA-D
Fall 2009 – Summer 2010	Private client, Melbourne, FL Role: Behavior Specialist

Description of position: Provided early intensive behavior intervention services, including academic and communication training, to a 2 year-old child with autism.
Supervisor: Melissa Knoll, M.S., BCBA

May 2009 – October 2009 Scott Center for Autism Treatment, Melbourne, FL
Role: Behavior Specialist
Description of position: Provided early intensive behavior intervention services to children with autism, ages 3-5, including conducting assessments (VB-MAPP, ABLLS, functional analyses) and academic, social-skills, and communication training.
Supervisor: Ivy Chong, PhD, BCBA-D

Summer 2007 Bronson Methodist Hospital, Kalamazoo, MI
Role: Practicum Student
Description of position: Observed, collected data on, and developed behavioral intervention for improving safety-related behavior of hospital staff.
Supervisor: Alyce Dickinson, PhD

Summer 2006 Gryphon Place, Kalamazoo, MI
Role: Practicum Student
Description of position: Received intensive training in answering crisis intervention hotline phone calls and implementing crisis-reduction techniques. Continued on as a volunteer crisis worker.
Supervisor: Lester Wright, Jr., PhD

Conference Presentations, Posters, & Workshops

Boyle, M. A., Samaha, A. L., Slocum, T. A., Hoffman, A. N., & Bloom, S. E. (accepted for 2015 May). *A human-operant investigation of behavioral contrast.* In M. A. Boyle, Chair. Translational investigations along the basic-to-applied continuum. Symposium to be presented at 41th annual meeting of the Association for Behavior Analysis International, San Antonio, TX.

Hoffman, A. N., Samaha, A. L., Bloom, S. E., & Boyle, M. A. (accepted for 2015 May). *Preference and reinforcer efficacy of high-tech items: A comparison of item type and duration of access.* In M. A. Boyle, Chair. Translational investigations along the basic-to-applied continuum. Symposium to be presented at 41th annual meeting of the Association for Behavior Analysis International, San Antonio, TX.

(Presenting author) Boyle, M. A., Samaha, A. L., Bloom, S. E., & Bogoev B. (2014 May). *Increasing unit price: A comparison of fixed- and variable-ratio token*

schedules. In J. C. Borrero, Chair. Application and investigations of token reinforcement systems. Symposium presented at 40th annual meeting of the Association for Behavior Analysis International, Chicago, IL.

Clay, C., Samaha, A. L., Bloom, S. E., Bogoev, B., & Boyle, M. A. (2013 May). *Assessing preference for social interactions.* In. A. L. Samaha, Chair, Evaluating the use of attention in preference and reinforcer assessments. Symposium presented at 39th annual meeting of the Association for Behavior Analysis International, Minneapolis, MN.

(Presenting author) Corry, S. N., Samaha, A. L., Bloom, S. E., & Boyle, M. A. (2013 May). *An analysis of auditory stimulus generalization in children with autism following two training procedures.* In W. K. Berg, Chair, Treatment outcomes across types of reinforcement and treatment settings for persons with ASD and ID. Symposium presented at 39th annual meeting of the Association for Behavior Analysis International, Minneapolis, MN.

Keyl-Austin, A. A., Higbee, T. S., Boyle, M. A., & Brodhead, M. T. (2013 May). *Evaluation of the effects of reinforcer choice and reinforcer variation on response rates of children with autism.* In C. L. Dozier, Chair, An evaluation of variables that influence preference and reinforcer efficacy. Symposium presented at 39th annual meeting of the Association for Behavior Analysis International, Minneapolis, MN.

Boyle, M. A., Samaha, A. L., Dayton, E., & Bloom, S. E. (2012 May). *Comparison of two methods of fading token schedules*. In. S. E. Bloom, Chair, Evaluations of interventions for problem behavior using contingent and noncontingent reinforcement. Symposium presented at 38th annual meeting of the Association for Behavior Analysis International, Seattle, WA.

(Presenting author) Sparling, J. H., Wilder, D. A., Kondash, J., Boyle, M. A., & Compton, M. (2012 May). *The effects of interviewer behavior on the accuracy of children's responses*. In. S. F. Walker, Chair, Sex offending: Prevention and intervention. Symposium presented at 38th annual meeting of the Association for Behavior Analysis International, Seattle, WA.

(Presenting author) Boyle, M. A., Samaha, A. L., Bloom, S. E., Rodewald, A., Kunnavatana, S. S. & Dayton, E. (2011 May). *Recent publication trends in the assessment and treatment of individuals with autism and other intellectual and developmental disabilities.* In. A. L. Samaha, Chair, Factors Influencing Selection of Assessment and Treatment Development and Refinement of Assessment and Treatment Approaches for Individuals with Intellectual and Developmental Disabilities. Symposium presented at 37th annual meeting of the Association for Behavior Analysis International, Denver, CO.

Keyl-Austin, A. A., Bloom, S. E., Samaha, A. L., Lambert, J. M., & Boyle, M. A. (2011 May). *Effects of preference and stimulus variation on response persistence.* In. A. L. Samaha, Chair, Factors Influencing Selection of Assessment and Treatment Development and Refinement of Assessment and Treatment Approaches for Individuals with Intellectual and Developmental Disabilities. Symposium presented at 37th annual meeting of the Association for Behavior Analysis International, Denver, CO.

Keyl-Austin, A. A., Samaha, A. L., Bloom, S. E., & Boyle, M. A. (2011 February). *Effects of preference and stimulus variation on response persistence.* In S. E. Bloom, Chair, Reinforcer effectiveness: Choice, predictability, and price. Paper presented at the 29th annual meeting of the California Association for Behavior Analysis, Burlingame, CA.

Boudreau, J. P., Becker, N., DeRosa, D. C., Knopf, L., Yoffe, S. L., Boyle, M. A., & Bruce, G. S. (2010 May). *Engineering a data-based program change process to improve client learning efficiency at a school for children with autism.* In G. S. Bruce, Chair, Learning efficiency research and practice: Better client outcomes with reduced time and costs. Paper presented at the 36th annual meeting of the Association of Behavior Analysis International, San Antonio, TX.

(Presenting author) Boyle, M. A., Nicholson, C. A., Allison, J., Purnell, G. M., Loughrey, T., Boudreau, J. P., & Bruce, G. S. (2010 May). *Preference and productivity for completing a task under positive or negative reinforcement conditions.* In G. S. Bruce, Chair, Preference and productivity when performers are allowed to choose between positive and negative reinforcement. Paper presented at the 36th annual meeting of the Association of Behavior Analysis International, San Antonio, TX.

Bruce, G. S., & Boyle, M. A. (2010 May). *Positive and negative reinforcement: Performer preference, productivity and implications for business results.* In G. S. Bruce, Chair, Preference and productivity when performers are allowed to choose between positive and negative reinforcement. Paper presented at the 36th annual meeting of the Association of Behavior Analysis International, San Antonio, TX.

Nicholson, C. A., Boyle, M. A., Allison, J., Purnell, G. M., Loughrey, T., Boudreau, J. P., & Bruce, G. S. (2010 May). *Effect of response rate requirements on preference and productivity between positive and negative reinforcement conditions*. In G. S. Bruce, Chair, Preference and productivity when performers are allowed to choose between positive and negative reinforcement. Paper presented at the 36th annual meeting of the Association of Behavior Analysis International, San Antonio, TX.

Boyle, M. A., Samaha, A. L., Rodewald, A. M., Bloom. S. E., Kunnavatana, S. S., & Dayton, E. (2011 June). *Use and effectiveness of reinforcers with individuals*

with autism. Poster presented at the annual Utah Association of Behavior Analysis, Logan, UT.

Nicholson, K. A., Rey, C. N., Boyle, M. A., Olson, M. C., Wilder, D. A. (2010 October). *First and last impressions: Improving customer service behaviors at a local seafood restaurant.* Poster presented at the annual Florida Association of Behavior Analysis, Orlando, FL.

Searcy, G. D., Bennett, J. A., Boyle, M. A., & Pietras, C. J. (2007 October). *Dynamic optimization model predictions: Effects of energy budget manipulations on choice between high and low risk options.* Poster presented at the annual Mid-American Association of Behavior Analysis, Milwaukee, WI.

Bruce, G. S., Boudreau, J. P., Boyle, M. A., Becker, N. (2010 May). *Data-based process to improve outcomes for children with autism*. Workshop given at the 36th annual meeting of the Association of Behavior Analysis International, San Antonio, TX.

Grants in Preparation

Bloom, S. E., Boyle, M. A., & Lambert, J. M. Assessing sensitivity to parameters of negative reinforcement and evaluating reinforcement-based interventions without the use of extinction. U.S. Department of Health and Human Services