JOURNAL OF THE EXPERIMENTAL ANALYSIS OF BEHAVIOR 2005, **84,** 185–225 NUMBER 2 (SEPTEMBER)

EFFECTS OF ADDING A SECOND REINFORCEMENT ALTERNATIVE: IMPLICATIONS FOR HERRNSTEIN'S INTERPRETATION OF r_e

PAUL L. SOTO, JACK J. MCDOWELL, AND JESSE DALLERY

EMORY UNIVERSITY AND UNIVERSITY OF FLORIDA

Herrnstein's hyperbola describes the relation between response rate and reinforcer rate on variable-interval (VI) schedules. According to Herrnstein's (1970) interpretation, the parameter r_e represents the reinforcer rate extraneous to the alternative to which the equation is fitted (the target alternative). The hyperbola is based on an assumption that extraneous reinforcer rate remains constant with changes in reinforcer rate on the target alternative (the constant-r_e assumption) and that matching with no bias and perfect sensitivity occurs between response and reinforcer ratios. In the present experiment, 12 rats pressed levers for food on a series of 10 VI schedules arranged on the target alternative. Across conditions, six VI values and extinction were arranged on a second alternative. Reinforcer rate on the second alternative, r_2, negatively covaried with reinforcer rate on the target alternative for five of the six VI values on the second alternative, and significant degrees of bias and undermatching occurred in response ratios. Given covariation of reinforcer rate on the second and target alternatives, the constant-r_e assumption can be maintained only by assuming that reinforcer rate from unmeasured background sources, r_b, covaries with reinforcer rate on the second alternative such that their sum, r_e, remains constant. In a single-schedule arrangement, however, r_e equals r_b and thus r_b is assumed to remain constant, forcing a conceptual inconsistency between single- and concurrent-schedule arrangements. Furthermore, although an alternative formulation of the hyperbola can account for variations in bias and sensitivity, the modified equation also is based on the constant-r_e assumption and therefore suffers from the same logical problem as the hyperbola when reinforcer rate on the second alternative covaries with reinforcer rate on the target alternative.

Key words: Herrnstein's hyperbola, matching theory, extraneous reinforcer rate, concurrent VI schedules, lever pressing, rats

---

There is little doubt that Herrnstein's (1970) absolute response rate equation describes the relation between responding and reinforcer rate across a wide variety of contexts, species, responses, and reinforcers (de Villiers & Herrnstein, 1976; Williams, 1988). The equation, known as Herrnstein's hyperbola, can be written as:

$$R_T = k\left(\frac{r_T}{r_T + r_e}\right), \quad (1)$$

where R_T refers to the rate of responding on the target alternative, r_T refers to the reinforcer rate delivered on the target alternative, and k and r_e are parameters of the equation. The term target alternative is used to distinguish the alternative to which the equation is applied from other, extraneous alternatives. According to Herrnstein, k represents the maximum rate of responding and r_e represents the aggregate reinforcer rate obtained from extraneous sources. Although the descriptive accuracy of Equation 1 is not in question, the validity of the theoretical assumptions underlying the equation remains unresolved (Dallery, McDowell, & Soto, 2004; Dallery & Soto, 2004; Heyman & Monaghan, 1987; McDowell, 1986; Williams, 1988).

Herrnstein (1970) originally derived Equation 1 from the matching law, which, given two alternatives, 1 and 2, can be stated as:

$$\frac{R_1}{R_1 + R_2} = \frac{r_1}{r_1 + r_2}, \quad (2a)$$

where R_1 and r_1 refer to response rate and reinforcer rate, respectively, on Alternative 1 and R_2 and r_2 refer to response rate and reinforcer rate, respectively, on Alternative 2. Herrnstein reasoned that even in situations in which only a single alternative has been arranged by the experimenter, extraneous alternatives exist (e.g., rearing and scratching for a rat). In such a situation, Equation 2a can

The authors thank Jeanne Stahl, Fernando Gonzalez, and Ebony Roebuck for their help in conducting the experiment. Research was supported by National Institute on Drug Abuse Grant 5R24DA07256.

Correspondence should be sent to the Paul L. Soto, now at Department of Psychology, University of Florida, P.O. Box 112250, Gainesville, Florida 32611-2250 (e-mail: psoto@ufl.edu).

doi: 10.1901/jeab.2005.09-05

be rewritten as:

$$\frac{R_1}{R_1 + R_e} = \frac{r_1}{r_1 + r_e}, \tag{2b}$$

where R_e and r_e refer to the aggregate amount of responding and aggregate reinforcer rate delivered on extraneous alternatives and R_1 and r_1 refer to response rate and reinforcer rate on the arranged alternative. Herrnstein produced Equation 1 from Equation 2b by assuming that R_1 and R_e are exhaustive of the behaviors possible in the given environment and that total amount of behavior (k in Equation 1) is constant. Letting $R_1 + R_e = k$ and solving for R_1 produces Equation 1 (substituting the subscript T for the subscript 1).

One assumption of Equation 1 is that, within an experimental situation, extraneous reinforcer rate remains constant across target alternative reinforcer rates. That is, r_e is assumed to remain constant with respect to the individual r_T values to which the equation is fitted. Of course, it can only be so, because a single r_e is estimated for a range of r_T values. Belke and Heyman (1994) acknowledged the constant-r_e assumption stating, ''[r_e] is assumed to remain constant within a context and across components in the within-session procedure in both the single-operant and choice conditions'' (p. 71).

A second important assumption of Equation 1 is that strict matching between relative response and relative reinforcer rate occurs (i.e., that Equation 2b holds). Violations of strict matching known as bias and sensitivity (Baum, 1974, 1979) will affect estimates of k and r_e obtained from fits of Equation 1 (McDowell, 1986; Wearden, 1981). The generalized matching law (Baum, 1979) for a two-alternative arrangement can be written as

$$\frac{R_1}{R_2} = b\left(\frac{r_1}{r_2}\right)^a, \tag{3}$$

where R_1, R_2, r_1, and r_2 are as defined previously, b represents bias, and a represents sensitivity. Strict matching holds when both bias and sensitivity are equal to 1.0. Typically, however, sensitivity is less than 1.0 (undermatching) and some bias exists for one or the other alternatives. Occasionally sensitivity is greater than 1.0 (overmatching).

Beginning with Equation 3, McDowell (1986) derived an equation akin to Equation 1 that incorporates parameters for bias and sensitivity. McDowell's modified version of Herrnstein's hyperbola is called the exponentiated version of Herrnstein's hyperbola and can be used when bias and sensitivity are not equal to 1.0. The equation can be written as:

$$R_T = k\left(\frac{br_T^a}{br_T^a + r_e^a}\right), \tag{4}$$

where all parameters are as described previously. Equation 4 specifies, like the hyperbola, that response rate is an increasing asymptotic function of reinforcer rate. Equation 4 differs from Equation 1 because it dictates that reinforcer rate must be modified for the effects of bias and sensitivity. Note that when a and b are both equal to 1, Equation 4 reduces to Equation 1.

Although Equation 4 contains four parameters (a, b, k, and r_e), only three parameters can be obtained through fitting because the parameters r_e^a and b are confounded. For fitting purposes then, the top and bottom of the right side of the equation can be divided by b to produce:

$$R_T = \frac{kr_T^a}{r_T^a + c} \tag{5}$$

where

$$c = \frac{r_e^a}{b} \tag{6}$$

and all other parameters are as defined previously.

Herrnstein (1970) and de Villiers and Herrnstein (1976) have interpreted Equation 1 as a law of response strength in which response strength is proportional to relative reinforcement (the quotient on the right side of Equation 1). According to this interpretation, reinforcement manipulations such as changes in reinforcer magnitude or delay affect responding in the same fashion as do changes in reinforcer rate; namely, by changing relative reinforcement. Thus, just as k must remain constant with respect to reinforcer rate on the arranged alternative, k also must remain constant with changes in other reinforcer properties such as magnitude and delay.

A growing body of evidence indicates that contrary to theoretical requirements, k may vary with changes in reinforcer properties when certain conditions are met (Dallery, McDowell, & Lancaster, 2000; Dallery & Soto, 2004; McDowell & Dallery, 1999; McDowell & Wood, 1984, 1985). Although such evidence might be viewed as falsification of Herrnstein's theory, some researchers have proposed explanations that can account for variation in k (Dallery et al., 2000; Heyman & Monaghan, 1987, 1994) and Equation 1 therefore remains viable. Furthermore, McDowell (1986) has suggested that findings of a variable k may be due to the effects of bias and undermatching and that Equation 4 may reconcile such findings.

Other research has focused on Herrnstein's interpretation of r_e. Two empirical requirements follow from Herrnstein's interpretation of r_e. First, manipulations that affect the unit of the target reinforcer, such as changes in reinforcer magnitude, should change r_e. de Villiers and Herrnstein (1976) stated this requirement as follows: ''extraneous reinforcement, [r_e], is measured in the units of the programmed reinforcement. The smaller these units are, the larger the number of them it takes to measure a given amount of extraneous reinforcement'' (p. 1136). To test the requirement that the value of r_e should vary inversely with the units of the programmed reinforcer, researchers have manipulated either a property of the reinforcer itself (e.g., concentration or volume of a sucrose solution) or deprivation from the reinforcer. In both cases, the rationale was that increases in reinforcer magnitude or deprivation level should increase the unit of the target reinforcer and thereby decrease r_e (cf. McDowell, 2005).

Reinforcer property manipulations usually have produced results consistent with the prediction that r_e should decrease as a function of increases in reinforcer magnitude. Several studies found estimates of r_e to be inversely related to sucrose concentration (Bradshaw, Szabadi, & Bevan, 1978; Heyman & Monaghan, 1994), volume of a sucrose solution (Bradshaw, Ruddle, & Szabadi, 1981; see Williams, 1988 for other examples), and brain stimulation frequency (Hamilton, Stellar, & Hart, 1985), as predicted. Alternatively, one study found an increase in r_e when intensity of brain stimulation was increased (Keesey, 1964 as reanalyzed by de Villiers & Herrnstein, 1976), which is contrary to predictions.

Changes in deprivation level have produced mixed results in terms of changes in r_e. Williams (1988) reviewed two studies in which an increase in the number of hours of deprivation produced predicted decreases in r_e, which parallels the findings of Heyman and Monaghan (1987). Another study, however, did not find consistent decreases in r_e when number of hours of deprivation was increased (McDowell & Dallery, 1999). Also, decreases in body weight (measured relative to free-feeding body weight) produced appropriate changes in r_e in one study (Snyderman, 1983), and no change in r_e in another study (Bradshaw, Szabadi, Ruddle, & Pears, 1983).

One criticism of reinforcer magnitude manipulations is that the relation between the nominal and perceived magnitude of the reinforcer is not known. That is, it is not known if a nominal increase in sucrose concentration, for example, represents an increase in reinforcer magnitude for the organism. Seemingly contradictory findings, such as increases in r_e as a result of increases in reinforcer magnitude, might be explained by assuming the appropriate relation between nominal and perceived reinforcer values. For example, it is possible that the increase in brain stimulation intensity in Keesey's (1964, as reanalyzed by de Villiers & Herrnstein, 1976) study produced a decrease in the perceived magnitude of the reinforcer, which could account for the obtained increase in r_e.

The second requirement entailed by Herrnstein's definition of r_e is that manipulations that affect the amount of extraneous reinforcement should change estimates of r_e. If a second alternative is arranged,

$$r_e = r_2 + r_b, \tag{7}$$

where r_e represents total extraneous reinforcer rate, r_2 represents reinforcer rate on the second alternative, and r_b represents reinforcer rate from unmeasured, unarranged background sources. Assuming a constant r_b, Equation 7 dictates that estimates of r_e should be a direct function of r_2. If we assume that r_b can vary across conditions for which r_2 is varied, Equation 7 dictates the minimum value for r_e: r_e must equal or exceed r_2 under all circumstances because r_b cannot be less than zero. Varying r_2, therefore, may provide a more stringent test of the interpretation of r_e than magnitude or deprivation manipulations because, unlike magnitude or deprivation manipulations, there is no question about the unit of measure for r_2. That is, the same reinforcer, and therefore the same unit, can be arranged on the target and second alternatives.

Several studies have tested Herrnstein's interpretation of r_e by manipulating r_2 (Belke & Heyman, 1994; Bradshaw, 1977; Bradshaw, Szabadi, & Bevan, 1976). Each study used a similar experimental design. First, subjects were exposed to a series of VI schedules on one alternative, the target alternative (note that in a single-schedule arrangement $r_e = r_b$). Next, subjects were exposed to the same series of VI schedules on the target alternative and a constant VI schedule was arranged on a second alternative (note that in a concurrent-schedule arrangement $r_e = r_2 + r_b$). The prediction was that r_e should increase from the single to the concurrent arrangement by r_2. Bradshaw found increases in r_e greater than the arranged r_2 value, whereas Bradshaw et al. and Belke and Heyman reported increases in r_e that approximated arranged r_2 values.

A fourth study (White, McLean, & Aldiss, 1986) used a between-groups design to manipulate r_2. Rats were exposed to a series of VI schedules on one alternative and a constant VI on a second alternative. The value of the constant VI varied across three groups of rats (High, Medium, and Low extraneous reinforcer rate). The average r_e obtained for the Low group was higher than the average r_es obtained for the High and Medium groups, which is contrary to predictions. Interestingly, White et al. also found that individual subject r_es were less than obtained r_2 values for 15 of 16 rats in the High and Medium groups.

Differences in r_b between conditions or groups might account for some of the variability in r_e across experiments. For example, if r_b increased across conditions as r_2 increased, then r_e would increase by more than expected, as found by Bradshaw (1977). In contrast, if r_b decreased as r_2 increased, r_e could increase by less than expected or possibly decrease, as found by White et al. (1986). Finally, if r_b remained constant across changes in r_2, increases in r_e equivalent to the increases in r_2 would have occurred, as found by Bradshaw et al. (1976) and Belke and Heyman (1994). Although variation in r_b across conditions or groups might explain some of the findings, the finding that individual r_es were less than obtained r_2 values in White et al. can not be explained by variation in r_b. That is because, according to Equation 7, r_e must equal or exceed r_2 under all circumstances.

Alternatively, bias or undermatching or both might account for some of the variability in r_e across experiments. If strict matching is not assumed, as required by Equation 1, then the exponentiated hyperbola, Equation 4, can be fitted, using Equation 5, and changes in the parameter c can be compared to changes in reinforcer rate on the second alternative. In fact, White et al. (1986) concluded that accounting for bias and undermatching reconciled their data with Herrnstein's interpretation of r_e. In order to determine whether estimates of c conform to Herrnstein's interpretation of r_e, Equations 6 and 7 can be combined. Recall that Equation 7 states that r_e is the sum of r_2 and r_b. The parameter c must therefore obey the following relation with respect to r_2:

$$c = \frac{(r_2 + r_b)^a}{b}, \qquad (8)$$

where all terms are as defined previously. Equation 8 is similar to a power function with a positive intercept. In general, given positive values of a and b, c is an increasing function of r_2 with positive intercept. When a is greater than 1.0, the function is positively accelerated. When a is less than 1.0, the function is negatively accelerated, and when a is equal to 1.0, the function is linear.

The first objective of the present study was to investigate the effect of a range of second alternative reinforcer rates on estimates of r_e in Equation 1 or c in Equation 5. Three of the four studies (Belke & Heyman, 1994; Bradshaw, 1977; Bradshaw et al., 1976) discussed here manipulated reinforcer rate on the second alternative over only two conditions: one in which no reinforcement was available on the second alternative and a second in which some reinforcement was available (amount differed by study). The fourth study (White et al., 1986) varied reinforcer rate on the second alternative over three values; however, that variation occurred between subjects rather than within subjects. Parametric within-subject variation of reinforcer rates on a second alternative is therefore lacking.

The second objective of the present study was to address Belke and Heyman's (1994) finding of within-session covariation of reinforcer rates on the second (r_2) and target alternatives (r_T). Given covariation of r_2 and r_T, the constant-r_e assumption can only be maintained if r_b negatively covaries with r_2 such that their sum remains constant. Belke and Heyman suggested this to deal with the variation in r_2 found across target alternative VI schedules in their study. The suggestion that when r_2 varies with respect to r_T, r_e remains constant by virtue of variation in r_b is conceptually problematic because it requires a qualitative distinction between single- and concurrent-schedule arrangements. To understand this, consider that when only one alternative is arranged, r_e equals r_b. Thus assuming the constancy of r_e across target alternative VI schedules is equivalent to assuming the constancy of r_b across those schedules. When two alternatives are arranged, however, Belke and Heyman suggested that r_e remains constant through covariation of r_2 and r_b. Thus r_b is assumed to vary when two alternatives are arranged but to remain constant when a single alternative is arranged. Such a distinction between single and concurrent arrangements is at odds with Herrnstein's (1970) basic premise that the two arrangements are equivalent, in principle.

As discussed above, the assumption that r_b covaries with r_2 such that their sum, r_e, remains constant leads to a conceptual distinction between single- and concurrent-schedule arrangements that violates Herrnstein's (1970) assumption of equivalence between the two arrangements. Because the assumption that the two arrangements are equivalent is the foundation of Equations 1 and 4, it is logically inconsistent to conclude otherwise. Thus covariation of r_2 and r_T should be taken as a violation of the constant-r_e assumption. Such variation therefore precludes if not confounds the application of Equation 1 or 4. Because of the importance of the constant-r_e assumption for Equations 1 and 4, the present study sought to determine the extent to which covariation of r_2 and r_T occurs by arranging a wide range of VI values on both the target and second alternatives.

The present study used a within-subjects design in which each rat was exposed to a series of VI schedules on one alternative, the target alternative. A second alternative also was arranged, and the VI value on the second alternative remained constant within a condition but varied across conditions. This procedure allows assessment of the extent to which r_2 and r_T covary across a range of VI values on the second and target alternatives and if appropriate, allows comparison of r_e from Equation 1 and c from Equation 5 (the fitting version of Equation 4) across a range of r_2 values.

METHOD

Subjects

Twelve male Long-Evans hooded rats, approximately 70 days old at the start of the experiment, served as subjects. Each rat was housed individually in a colony room under a 12:12 hr light/dark cycle, with the light cycle starting at 7:00 a.m. Rats were maintained at 85% of their free-feeding body weights by postsession feeding of rat chow. Access to water was unrestricted in the home cages.

Apparatus

Experimental sessions were conducted in eight modular operant test chambers (MED Associates, Inc. ENV-007) 24.0 cm wide, 30.5 cm deep, and 29.0 cm high. The front of each chamber was clear Plexiglas, and all other sides were stainless steel. Each chamber was housed in a sound-attenuated cubicle. Two response levers, extending 4.5 cm into the chamber, were located on the front panel 7 cm above the chamber floor, equidistant from the sides of the chamber, and separated by 11.5 cm. A minimum force of approximately 0.20 N was required to register a response. In the middle of the front panel, 2 cm above the floor, was a recessed opening where 45-mg food pellets were delivered into a food cup. Three small stimulus lights were centered 7 cm above each lever. The stimulus lights from left to right were red, yellow, and green. A 28-V white light was centered on the front panel of the chamber 2 cm from the ceiling. Two speakers introduced white noise into the experimental room in order to mask extraneous sounds. A computer operating MED-PC software controlled programming of experimental events and recording of data.

Procedure

During each condition, the rats were exposed to 10 VI schedules (6, 10, 14, 20, 45, 55, 100, 200, 350, and 450 s) presented on the left lever (the target alternative), and a second VI schedule arranged on the right lever (the second alternative). The value of the second alternative VI schedule varied over conditions: Extinction (ALT-EXT), 10 s (ALT-10), 17 s (ALT-17), 50 s (ALT-50), 75 s (ALT-75), 150 s (ALT-150), and 350 s (ALT-350). Three conditions (ALT 17, 50, and 150) were randomly selected for replication. Exposure to 5 of the 10 target alternative VI values occurred in the morning and exposure to the remaining five VI values occurred in the afternoon; a minimum of 5 hr separated each session. One group of schedules was designated as Group A: 6, 14, 55, 100, and 450 s. The other group, Group B, included the 10, 20, 45, 200, and 350 s VI schedules. The order of exposure to Group A and B schedules alternated from day to day.

Each VI value was presented once per session in random order for 8 min. Schedule presentations were separated by 3-min blackouts. During blackouts, the chamber remained darkened, and lever pressing produced no programmed consequences. Most conditions consisted of 40 sessions of exposure (20 sessions of the Group A VI values and 20 sessions of the Group B VI values at each value of the second alternative VI). Two conditions, the ALT-10 condition and the replication of the ALT-17 condition, consisted of 24 sessions (12 sessions of Group A and 12 sessions of Group B). Two other conditions, the ALT-150 Replication and ALT-50 Replication conditions, consisted of 20 sessions (10 of Group A and 10 of Group B). Each VI value was arranged using 20 intervals calculated according to the method of Fleshler and Hoffman (1962). Following reinforcement (one 45-mg Noyes AI rodent pellet), there was a period of 2.5 s reinforcer blackout time for pellet consumption, during which the VI timer stopped, lever pressing produced no programmed consequences, and only the houselight remained illuminated.

During both Group A and B sessions, each target alternative VI value was signaled by a unique combination of stimulus lights and flash frequency. The mean VI value and discriminative stimuli used for each VI are shown in Table 1. During both Group A and B sessions, a switch from target alternative responding to responding on the second alternative turned off whichever of the three left stimulus lights was currently illuminated and initiated flashing of the green light over the second alternative. The light continued to flash on for 0.2 s and off for 0.2 s until a switch back to the target alternative occurred. Thus the different VI values arranged on the second alternative were not signaled separately. A 3-s changeover delay was employed. Rats were fed immediately following the second session of the day.

Table 1

The VI schedules presented on the target alternative and their associated discriminative stimuli.

Presentation group	VI (s)	Discriminative stimuli
A	6	Red light flashed on for 0.5 s and off for 0.2 s
	14	Yellow light flashed on for 1.0 s and off for 0.5 s
	55	Green light flashed on for 1.5 s and off for 1.0 s
	100	Red and yellow lights flashed on for 2 s and off for 0.5 s
	450	Red and green lights flashed on for 2 s and off for 1 s
B	10	All lights flashed on and off at 0.2-s intervals
	20	All lights flashed on and off at 0.5-s intervals
	45	All lights flashed on and off at 0.75-s intervals
	200	All lights flashed on and off at 1.5-s intervals
	350	All lights flashed on and off at 2.5-s intervals

RESULTS

Data were averaged over the last six sessions of each condition for each rat. As noted previously, both Equations 1 and 5 (the fitting version of Equation 4) assume that extraneous reinforcer rate remains constant with changes in reinforcer rate on the target alternative within a session. It is therefore important to assess whether extraneous reinforcer rate did, in fact, remain constant where required.

Figure 1 depicts reinforcer rate on the second alternative as a function of reinforcer rate on the target alternative. Each panel represents data from a single condition. Each

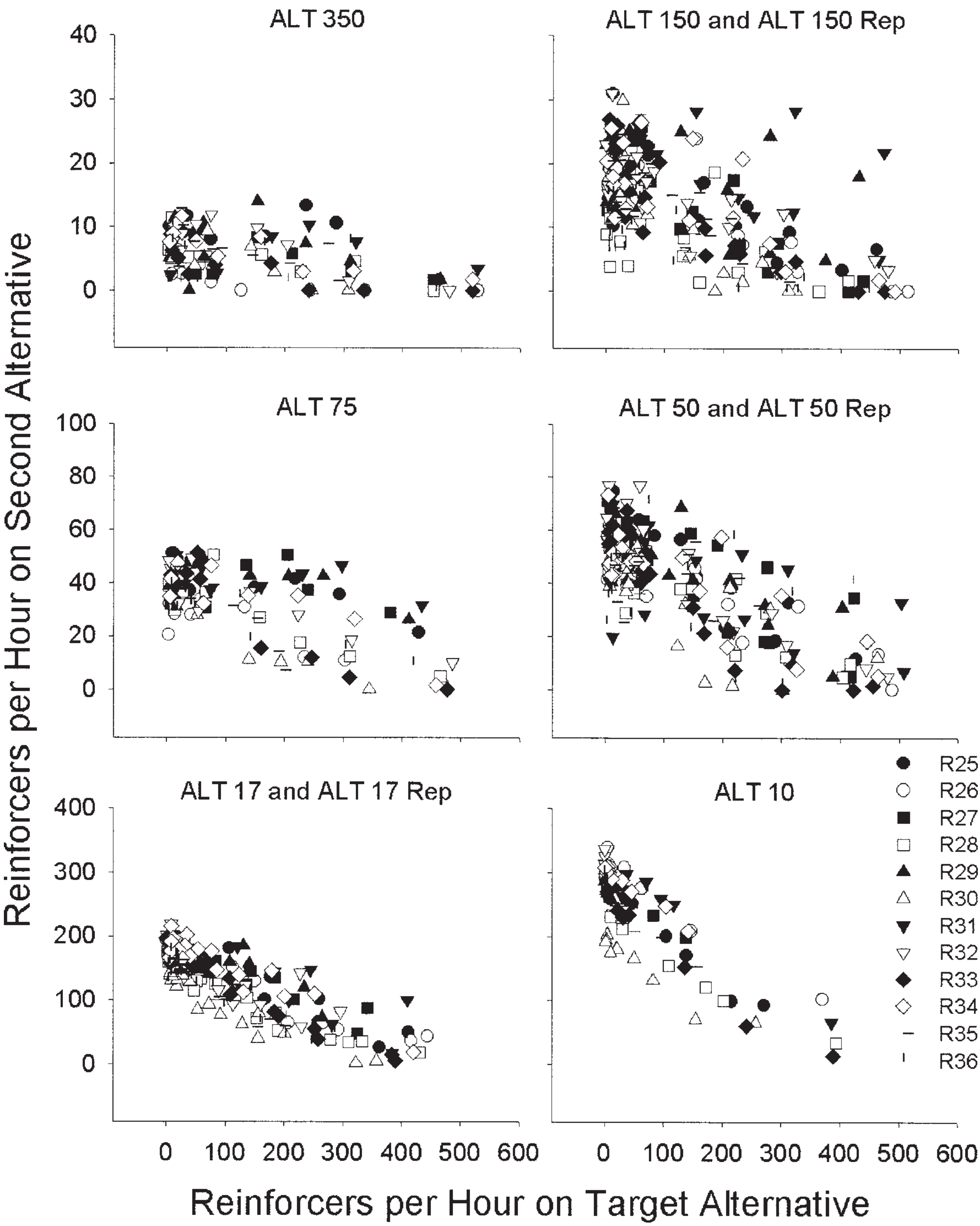

Fig. 1. Reinforcer rate on the second alternative as a function of reinforcer rate on the target alternative. Each panel depicts data for all rats for a single condition or for a condition and its replication.

data point represents the average reinforcer rate on the second alternative versus the average reinforcer rate on the target alternative for an individual target alternative VI schedule. Reinforcer rate on the second alternative negatively covaried with reinforcer rate on the target alternative, replicating the finding of Belke and Heyman (1994). The degree of variation in r_2 was directly related to the VI value on the second alternative as illustrated by the slope of the relation becoming more negative as the VI value on the second alternative decreased from 350 s to 10 s. Note the change of scale for each row of Figure 1.

One concern of the present procedure is the use of two daily sessions. It is important to determine that the covariation of r_2 and r_T depicted in Figure 1 was not an artifact of the current procedure. Figure 2 depicts reinforcer rate on the second alternative as a function of reinforcer rate on the target alternative separately for morning and afternoon sessions. Each panel depicts data from a single condition and each data point represents the average across rats at a given target alternative VI. Note the *y*-axis differences for each row of panels. There is little difference between the data from morning and afternoon sessions except possibly during the ALT-150 replication condition (open vs. solid triangles) where r_2 values from the afternoon sessions appear slightly higher. Thus, although there may be a difference in terms of the absolute r_2 values and possibly in the slope of the relation, it is not the case that the obtained correlation is an artifact of the use of two daily sessions.

Setting aside for a moment the implications of variation in r_2 with r_T, the second assumption underlying the application of Equation 1 is that matching occurs between response and reinforcer rate proportions. Although matching between the target alternative and extraneous alternatives cannot be determined, matching between the target and second alternatives can be assessed. The generalized matching equation, Equation 3, was fitted to the response and reinforcer rate ratios from the target and second alternatives. Table 2 presents obtained values of *a*, *b*, and the percentage of variance accounted for (VAC) by the best fit of Equation 3. Equation 3 described the variation in response ratios well, accounting for an average of 92.14% of the variance. The average value of *a* and *b* across rats and conditions was 0.56 and 2.05, respectively, indicating a significant degree of undermatching in response ratios and a bias for the target alternative. Figure 3 depicts the average value of *a* and *b* across rats for each condition. Estimates of *a* remain relatively constant across conditions whereas estimates of *b* decrease as the VI value on the second alternative decreases.

Equations 1 and 5 were fitted to the response rate versus reinforcer rate data to determine if the equations provide accurate descriptions of responding despite violations of their underlying assumptions. Prior to fitting, response rates were corrected for postreinforcement pausing because initial calculations revealed a decrease in responding at the two richest VI values (6 and 10 s), which is inconsistent with both Equations 1 and 5. Previous research has indicated that a downturn in responding at rich VI values may be due to time spent pausing after reinforcement (Baum, 1993). One possible cause of the postreinforcement pause (PRP) is the time required for reinforcer consumption. A constant consumption time will produce larger suppressive effects on response rate during rich VI schedules than during leaner VI schedules.

In order to eliminate the suppressive effects of postreinforcement pausing on response rate, response rates were corrected as follows. First, the average PRP was calculated for each VI schedule for each condition for each rat. The smallest average PRP obtained for each rat was taken as the obligatory time required to consume a single food pellet for that rat. If the obtained minimum average PRP for a given rat was less than or equal to the programmed 2.5-s reinforcer blackout, then only the 2.5-s blackout time was excluded from the time base for each reinforcer delivery. If the obtained minimum average PRP was greater than the programmed 2.5-s blackout, the PRP value was multiplied by the number of reinforcers delivered, and the result was subtracted from the time base.

The obtained minimum PRP values for each rat are listed in Table 3. The average minimum PRP across rats was 3.7 s. Five of the 12 rats produced minimum PRP values less than the postreinforcement blackout of 2.5 s whereas the other 7 produced PRP values greater than 2.5 s.

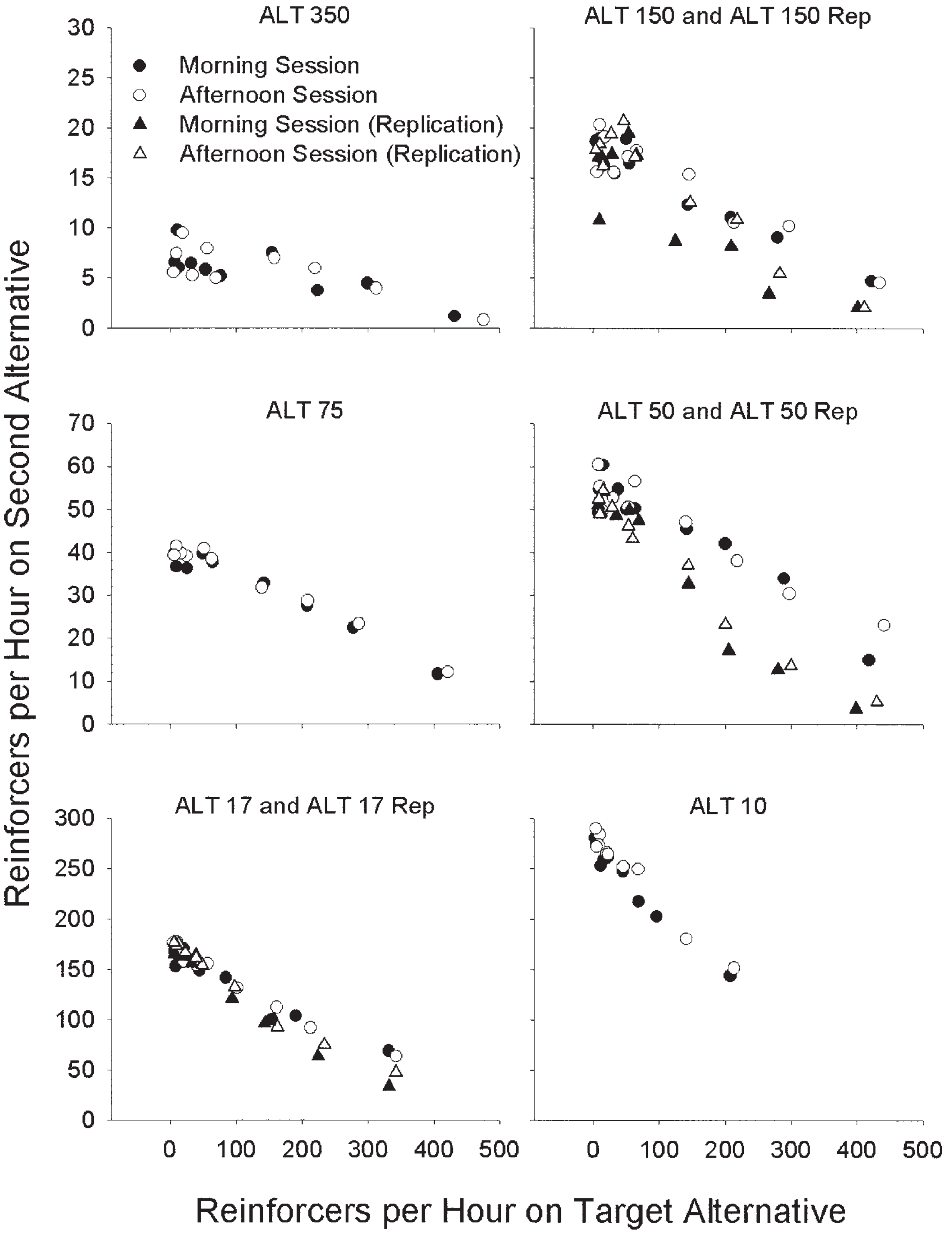

Fig. 2. Reinforcer rate on the second alternative as a function of reinforcer rate on the target alternative for morning and afternoon sessions. Each panel depicts data from a single condition or a condition and its replication. Each data point represents the average reinforcer rate on the second alternative, across rats, versus the average reinforcer rate on the target alternative, across rats, at each target alternative VI value. Filled symbols represent averages from morning sessions and open symbols represent averages from afternoon sessions.

Table 2

Estimates of *a*, *b*, and obtained percentage of variance accounted for (VAC) from fits of Equation 3.

Rat	Condition	*a*	*b*	VAC
R25	ALT-350	0.42	2.49	91.34
	ALT-150	0.49	1.85	93.71
	ALT-75	0.47	1.25	91.51
	ALT-50	0.51	2.60	98.10
	ALT-17	0.56	0.70	96.41
	ALT-10	0.53	1.01	95.06
	ALT-150 Rep	0.59	1.63	96.29
	ALT-50 Rep	0.53	1.75	95.60
	ALT-17 Rep	0.56	1.06	95.19
R26	ALT-350	0.41	4.67	91.93
	ALT-150	0.60	2.65	94.53
	ALT-75	0.70	2.07	98.24
	ALT-50	0.52	2.78	96.14
	ALT-17	0.63	1.46	99.27
	ALT-10	0.69	1.00	97.32
	ALT-150 Rep	0.66	2.17	93.58
	ALT-50 Rep	0.70	2.52	95.52
	ALT-17 Rep	0.78	0.99	93.08
R27	ALT-350	0.59	1.52	80.38
	ALT-150	0.57	1.40	88.79
	ALT-75	0.54	0.86	92.88
	ALT-50	0.46	1.37	92.41
	ALT-17	0.61	0.75	92.98
	ALT-10	0.43	0.31	87.28
	ALT-150 Rep	0.65	0.99	94.54
	ALT-50 Rep	0.69	1.07	94.36
	ALT-17 Rep	0.62	0.34	96.29
R28	ALT-350	0.59	4.34	91.00
	ALT-150	0.48	3.80	90.14
	ALT-75	0.61	3.63	96.15
	ALT-50	0.46	3.37	93.22
	ALT-17	0.46	2.99	97.95
	ALT-10	0.61	2.59	97.70
	ALT-150 Rep	0.75	1.97	95.24
	ALT-50 Rep	0.65	3.51	96.13
	ALT-17 Rep	0.59	2.60	94.15
R29	ALT-350	0.48	3.84	95.46
	ALT-150	0.37	4.39	90.25
	ALT-75	0.42	2.32	95.24
	ALT-50	0.52	2.24	94.41
	ALT-17	0.43	0.43	91.29
	ALT-10	0.10	0.17	16.96
	ALT-150 Rep	0.57	2.12	95.71
	ALT-50 Rep	0.49	2.79	95.00
	ALT-17 Rep	0.39	0.69	96.16
R30	ALT-350	0.43	5.20	79.46
	ALT-150	0.56	4.44	88.88
	ALT-75	0.50	3.10	94.68
	ALT-50	0.47	4.04	97.52
	ALT-17	0.64	3.79	97.21
	ALT-10	0.40	1.77	92.37
	ALT-150 Rep	0.78	1.82	86.99
	ALT-50 Rep	0.45	2.34	86.46
	ALT-17 Rep	0.64	2.98	94.17
R31	ALT-350	0.62	2.64	90.81
	ALT-150	0.53	1.66	93.31
	ALT-75	0.45	1.34	97.94
	ALT-50	0.60	2.36	96.20
	ALT-17	0.52	0.93	97.01
	ALT-10	0.51	0.94	93.31

Table 2

(*Continued*)

Rat	Condition	*a*	*b*	VAC
R31	ALT-150 Rep	0.68	2.11	92.60
	ALT-50 Rep	0.64	2.71	98.34
	ALT-17 Rep	0.54	1.29	98.58
R32	ALT-350	0.78	1.71	94.86
	ALT-150	0.69	1.66	95.80
	ALT-75	0.72	1.99	96.69
	ALT-50	0.51	1.04	94.89
	ALT-17	0.67	0.60	93.86
	ALT-10	0.22	0.03	97.07
	ALT-150 Rep	0.96	1.51	97.98
	ALT-50 Rep	0.72	1.53	92.81
	ALT-17 Rep	0.71	0.66	94.40
R33	ALT-350	0.53	2.18	77.48
	ALT-150	0.47	1.94	94.96
	ALT-75	0.54	1.67	98.51
	ALT-50	0.42	1.91	95.43
	ALT-17	0.55	1.03	97.70
	ALT-10	0.57	1.70	98.17
	ALT-150 Rep	0.82	1.47	97.47
	ALT-50 Rep	0.81	3.09	96.48
	ALT-17 Rep	0.55	1.30	96.12
R34	ALT-350	0.71	2.17	93.96
	ALT-150	0.55	3.28	83.99
	ALT-75	0.58	2.82	94.99
	ALT-50	0.53	3.20	97.34
	ALT-17	0.56	1.07	91.91
	ALT-10	0.61	1.25	93.28
	ALT-150 Rep	0.74	2.05	94.89
	ALT-50 Rep	0.75	3.10	98.49
	ALT-17 Rep	0.73	1.73	93.68
R35	ALT-350	0.57	1.26	69.93
	ALT-150	0.28	1.05	71.44
	ALT-75	0.37	0.72	90.08
	ALT-50	0.36	1.34	86.73
	ALT-17	0.26	0.32	82.19
	ALT-10	0.28	0.28	85.77
	ALT-150 Rep	0.43	1.65	86.11
	ALT-50 Rep	0.51	0.95	96.34
	ALT-17 Rep	0.36	0.58	84.38
R36	ALT-350	0.52	5.74	87.39
	ALT-150	0.46	7.35	64.60
	ALT-75	0.62	4.04	95.91
	ALT-50	0.44	2.22	94.85
	ALT-17	0.69	2.28	98.77
	ALT-10	0.91	1.09	87.97
	ALT-150 Rep	0.81	2.80	95.58
	ALT-50 Rep	0.85	2.62	94.76
	ALT-17 Rep	0.68	1.08	94.00

The obtained corrected response rates and reinforcer rates are listed in the Appendix. In the majority of cases, correcting response rates for pausing eliminated the downturn in responding for the VI 10-s schedule, but did not do so for the VI 6-s schedule. One possibility for the downturn in responding at the VI 6-s schedule is that at high reinforcer rates, the actual feeding time following reinforcement exceeded the minimum pause

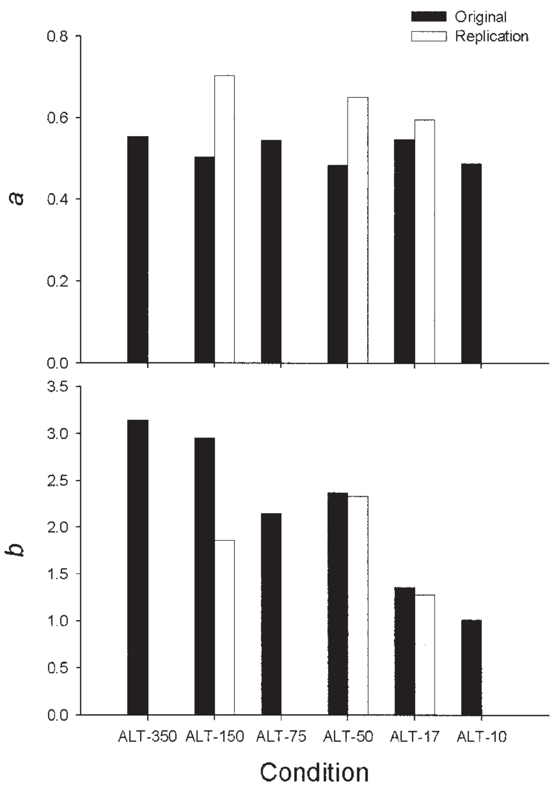

Fig. 3. Estimates of *a* and *b* obtained from fits of Equation 3 to response versus reinforcer ratios. The top panel depicts estimates of *a* from each condition and the bottom panel depicts estimates of *b* from each condition. Each bar represents the average estimate across rats.

calculated for each rat. In fact, the average PRP obtained for each exposure to the VI 6-s schedule for each rat (10 exposures per rat) was greater than the minimum PRP calculated for each rat in every case except one. In that single case, the minimum PRP for the rat and the average PRP on the VI 6-s schedule were equal (i.e., the minimum PRP was the average PRP). Additionally, the modal number of responses per reinforcer on the VI 6 s schedule was one. These data suggest that the VI 6 may have operated more as a ratio than interval schedule. The VI 6-s schedule data, therefore, were not used when fitting Equation 1 or 5.

Equation 1 was fitted, using Microsoft® Excel's Solver routine, to the obtained corrected response and reinforcer rates on the target alternative (excluding the VI 6-s schedule data) for each rat for each condition. This yielded 120 fits of Equation 1 (12 rats by 10

Table 3

Minimum average postreinforcement pause (PRP) calculated for each rat.

Rat	Minimum PRP (s)
R25	4.8
R26	1.7
R27	3.6
R28	4.8
R29	3.8
R30	6.2
R31	2.4
R32	2.2
R33	1.7
R34	2.2
R35	7.5
R36	3.5

conditions). Table 4 lists the obtained parameter estimates and the resulting VAC. On average, Equation 1 accounted for 83% of the variance, with a minimum VAC of 3% and a maximum of 99%. In 65 of the 120 fits, Equation 1 accounted for 90% or more of the variance in response rates.

Fits of Equation 1 were poor in many cases for Rats R30 and R35. If the fits from Rats R30 and R35 are discarded, the average percentage VAC by Equation 1 rises to 90% with 63 of the 100 fits accounting for greater than 90% of the variance. Figure 4 depicts fits of Equation 1 from selected conditions. Each panel depicts data for an individual rat.

According to Equation 7, r_e should vary as a linear function of the average r_2 with slope 1 and positive intercept. Figure 5 depicts estimates of r_e obtained from each condition plotted as a function of the average r_2 obtained during each condition. The solid line in each panel is the best fit of Equation 7. Table 5 lists the intercept of the best fit of Equation 7 for each rat. Equation 7 did a poor job of describing the variance in estimates of r_e across conditions: For all 12 fits, the mean of the data accounted for more of the variance than did the fitted function.

In order to determine if the poor fits of Equation 7 were due to estimates of r_e obtained under relatively rich conditions, Equation 7 was fitted to the r_e versus r_2 data with r_e from the ALT-10 condition excluded and, alternatively, with r_e from the ALT-10, 17, 50, 75, 17 Rep, and 50 Rep conditions excluded. Table 5 lists the obtained estimates of r_b for those fits. In both cases, Equation 7 poorly described the variance in estimates of r_e.

Table 4

Estimates of k, r_e, and percentage of variance accounted for (VAC) obtained from fits of Equation 1.

Rat	Condition	k	r_e	VAC
R25	ALT-EXT	90.24	21.04	98.03
	ALT-350	97.15	8.21	76.55
	ALT-150	115.43	22.07	84.03
	ALT-75	94.72	24.24	85.93
	ALT-50	105.69	22.54	85.69
	ALT-17	87.26	112.79	87.83
	ALT-10	48.45	38.83	78.32
	ALT-150 Rep	81.52	19.96	92.58
	ALT-50 Rep	71.21	14.12	74.41
	ALT-17 Rep	58.79	29.06	72.59
R26	ALT-EXT	165.61	51.74	96.67
	ALT-350	131.84	40.16	93.77
	ALT-150	128.10	55.70	93.96
	ALT-75	122.09	69.73	96.76
	ALT-50	114.54	52.89	94.07
	ALT-17	84.35	48.80	96.76
	ALT-10	95.83	144.80	94.04
	ALT-150 Rep	146.46	61.66	94.25
	ALT-50 Rep	137.50	53.25	93.80
	ALT-17 Rep	170.90	241.77	94.83
R27	ALT-EXT	56.46	45.39	96.45
	ALT-350	56.49	27.21	91.08
	ALT-150	54.45	33.79	86.10
	ALT-75	49.79	16.83	90.50
	ALT-50	48.42	11.34	80.34
	ALT-17	31.40	27.78	90.87
	ALT-10	11.67	12.66	63.01
	ALT-150 Rep	49.35	28.21	94.75
	ALT-50 Rep	45.93	19.92	89.67
	ALT-17 Rep	37.51	78.35	87.59
R28	ALT-EXT	142.32	87.60	97.27
	ALT-350	147.18	100.97	95.32
	ALT-150	90.72	86.21	94.41
	ALT-75	138.31	74.66	93.71
	ALT-50	83.73	42.61	81.45
	ALT-17	79.41	17.08	83.12
	ALT-10	65.35	48.47	92.64
	ALT-150 Rep	198.70	329.28	94.57
	ALT-50 Rep	122.64	73.09	91.16
	ALT-17 Rep	119.15	69.32	82.31
R29	ALT-EXT	103.59	28.94	93.61
	ALT-350	97.39	25.11	88.61
	ALT-150	95.63	77.55	96.87
	ALT-75	63.74	27.68	95.03
	ALT-50	54.87	30.22	91.38
	ALT-17	39.19	73.21	90.11
	ALT-10	4.93	0.11	21.59
	ALT-150 Rep	99.75	45.62	82.75
	ALT-50 Rep	76.41	25.98	88.79
	ALT-17 Rep	27.67	12.30	70.20
R30	ALT-EXT	12.86	0.24	2.60
	ALT-350	27.57	0.75	2.99
	ALT-150	31.04	6.21	52.71
	ALT-75	25.72	5.68	81.20
	ALT-50	62.09	31.61	89.72
	ALT-17	26.01	17.07	92.07
	ALT-10	15.15	25.85	71.29
	ALT-150 Rep	20.16	1.94	25.69
	ALT-50 Rep	11.96	0.94	23.44
	ALT-17 Rep	21.96	11.69	66.76
R31	ALT-EXT	156.50	115.42	96.42
	ALT-350	156.49	53.33	92.83
	ALT-150	138.69	91.41	93.91
	ALT-75	100.78	50.76	96.13
	ALT-50	116.85	40.71	91.03
	ALT-17	63.68	31.61	88.94
	ALT-10	60.76	66.73	72.16
	ALT-150 Rep	130.47	63.07	96.25
	ALT-50 Rep	124.24	39.76	96.07
	ALT-17 Rep	85.79	26.34	87.06
R32	ALT-EXT	97.59	29.43	94.36
	ALT-350	111.96	28.49	96.88
	ALT-150	107.51	36.85	95.06
	ALT-75	118.20	38.49	97.38
	ALT-50	89.61	46.17	79.65
	ALT-17	92.30	102.53	95.16
	ALT-10	1.83	1.10	88.60
	ALT-150 Rep	115.07	57.07	97.13
	ALT-50 Rep	102.74	50.49	98.36
	ALT-17 Rep	132.03	143.28	98.48
R33	ALT-EXT	81.53	9.38	75.63
	ALT-350	109.64	10.65	83.13
	ALT-150	109.73	15.52	87.48
	ALT-75	97.63	15.53	87.39
	ALT-50	67.19	12.94	85.52
	ALT-17	58.74	26.99	90.79
	ALT-10	51.87	41.02	89.81
	ALT-150 Rep	82.56	21.25	87.13
	ALT-50 Rep	68.92	12.19	82.21
	ALT-17 Rep	69.62	58.66	86.20
R34	ALT-EXT	154.31	62.68	97.14
	ALT-350	146.96	53.90	95.72
	ALT-150	148.90	70.15	97.20
	ALT-75	133.69	58.92	97.72
	ALT-50	92.97	53.27	92.94
	ALT-17	78.00	142.63	84.76
	ALT-10	72.05	100.68	96.75
	ALT-150 Rep	103.89	48.34	88.18
	ALT-50 Rep	120.66	53.54	95.50
	ALT-17 Rep	63.30	53.22	92.85
R35	ALT-EXT	31.58	43.20	92.97
	ALT-350	38.37	9.84	60.69
	ALT-150	19.45	1.06	26.27
	ALT-75	14.45	0.78	4.35
	ALT-50	21.18	7.04	29.30
	ALT-17	5.93	1.43	19.69
	ALT-10	13.31	6.22	48.07
	ALT-150 Rep	33.56	14.57	60.24
	ALT-50 Rep	42.14	20.81	75.91
	ALT-17 Rep	21.03	4.57	64.84
R36	ALT-EXT	143.10	103.73	96.46
	ALT-350	105.06	49.64	96.42
	ALT-150	156.24	133.98	97.50
	ALT-75	88.33	80.11	95.73
	ALT-50	120.01	157.35	96.03
	ALT-17	99.92	106.84	96.49
	ALT-10	32.88	75.74	99.06
	ALT-150 Rep	125.00	97.61	98.94
	ALT-50 Rep	132.57	99.49	95.52
	ALT-17 Rep	151.54	220.13	99.17

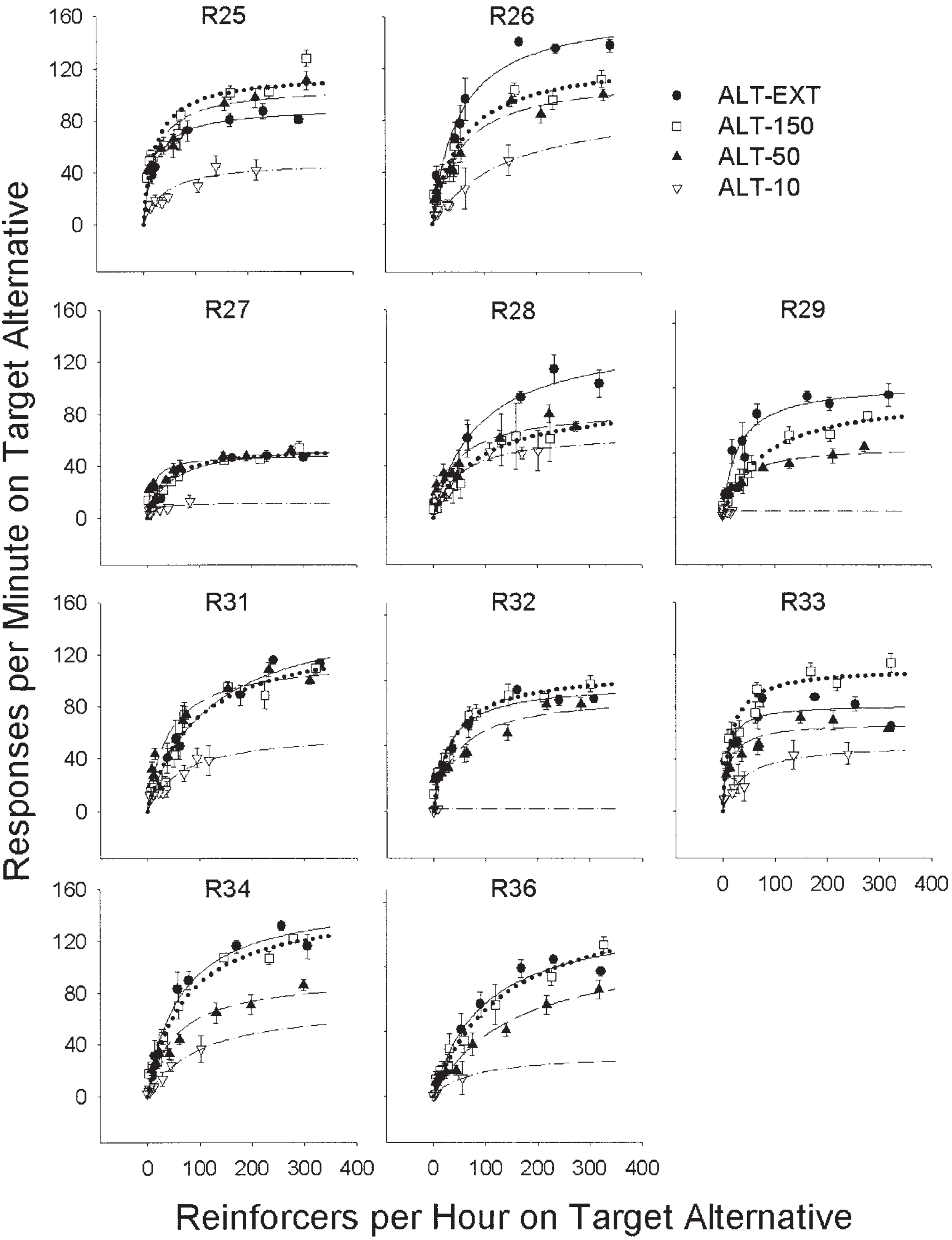

Fig. 4. Target alternative response rate as a function of target alternative reinforcer rate. Each panel depicts data for an individual rat from the ALT-EXT, ALT-150, ALT-50, and ALT-10 conditions. Error bars represent plus or minus one standard error of the mean. Curved lines in each panel represent fits of Equation 1 to the data from a condition.

Table 5

Estimates of r_b from fits of Equation 7 to r_e versus r_2 data.

Rat	All conditions	Excluding ALT-10	Excluding ALT-10, 17, 50, 75, 17 Rep, and 50 Rep
R25	0.00	0.00	1.96
R26	14.33	29.58	44.44
R27	0.00	0.00	16.22
R28	40.29	59.58	77.09
R29	0.00	0.00	23.76
R30	0.00	0.00	0.00
R31	0.00	4.82	60.70
R32	0.00	7.38	18.87
R33	0.00	0.00	1.59
R34	0.00	14.06	46.56
R35	0.00	0.00	0.16
R36	48.85	77.17	81.93

When estimates of r_e from the ALT-10 condition were not included in the fits, 9 of 12 fits of Equation 7 produced a negative VAC (indicating that the mean of the data accounted for more of the variance than did the fitted function). When estimates of r_e from the ALT-10, 17, 50, 75, 17 Rep, and 50 Rep conditions were not included in the fits, 11 of 12 fits of Equation 7 produced a negative VAC.

Equation 1 also was fitted to the group average response and reinforcer rate data (R30 and R35 excluded) for each condition. The left column of Figure 6 depicts estimates of r_e and k from fits of Equation 1 to group average response versus reinforcer rates plotted against the average r_2 obtained for a condition. Estimates of r_e remain roughly constant and estimates of k decrease with increases in r_2.

Equation 5 also was fitted to the corrected response rate versus reinforcer rate data for each rat; however, in many cases, reliable estimates could not be obtained. Table 6 lists the estimates of k, a, and c and resulting VAC from fits of Equation 5 where reliable fits were obtained. On average, the equation accounted for 88% of the variance in responding with a minimum percentage VAC of 7% and a maximum of 100%. In 62 of the obtained 76 fits, Equation 5 accounted for 90% or more of the variance in responding. If the fits for R30 and R35 are discarded, the average percentage VAC rises to 93% with 59 of 66 fits accounting for 90% or more of the variance in response rates.

Equation 5 also was fitted to the average corrected response rate versus reinforcer rate data for the group (R30 and R35 excluded). The right column of Figure 6 depicts estimates of c and k from fits of Equation 5 for each condition versus the average r_2 obtained in each condition. Both c and k decrease with increases in the average r_2.

DISCUSSION

The main finding in the present experiment was the negative correlation between reinforcer rate on the second and target alternatives (see Figures 1 and 2). Given covariation of reinforcer rate on the second alternative (r_2) and reinforcer rate on the target alternative (r_T), extraneous reinforcer rate can remain constant only if the decreases in r_2, are accompanied by increases in background reinforcer rate, r_b, of equivalent magnitude. However, when the experimenter arranges only one alternative, r_b represents all extraneous reinforcement. To assume that extraneous reinforcer rate remains constant in both single- and concurrent-schedule arrangements therefore requires a qualitative distinction between the two arrangements when r_2 is known to covary with r_T because r_b must vary in the concurrent-schedule arrangement but remain constant in the single-schedule arrangement. Such a conclusion is at odds with Herrnstein's (1970) original premise that the two arrangements are equivalent, in principle.

In addition to the conceptual difficulties associated with assuming that r_b covaries with r_2, there is no empirical or theoretical basis to assume that r_b varies in precisely the manner necessary to maintain the assumption that extraneous reinforcer rate remains constant. From an empirical point of view, the variation in r_b required to offset the variation in r_2 obtained in the present experiment seems unreasonable. Consider that when the VI value on the second alternative was 10 s, reinforcer rate on the second alternative decreased by 137.3 reinforcers per hour, on average, from the leanest to the richest target alternative VI schedule. Background reinforcer rate, r_b, would have to increase by an equivalent amount to offset such a decrease in r_2. Some specific examples illustrate this point further. Consider that reinforcer rate obtained on the second alternative during the ALT-10 condition for Rats R26, R31, and R33 decreased by 237.1, 236.5, and 276.3 reinforcers per hour, respectively, from the leanest to richest target

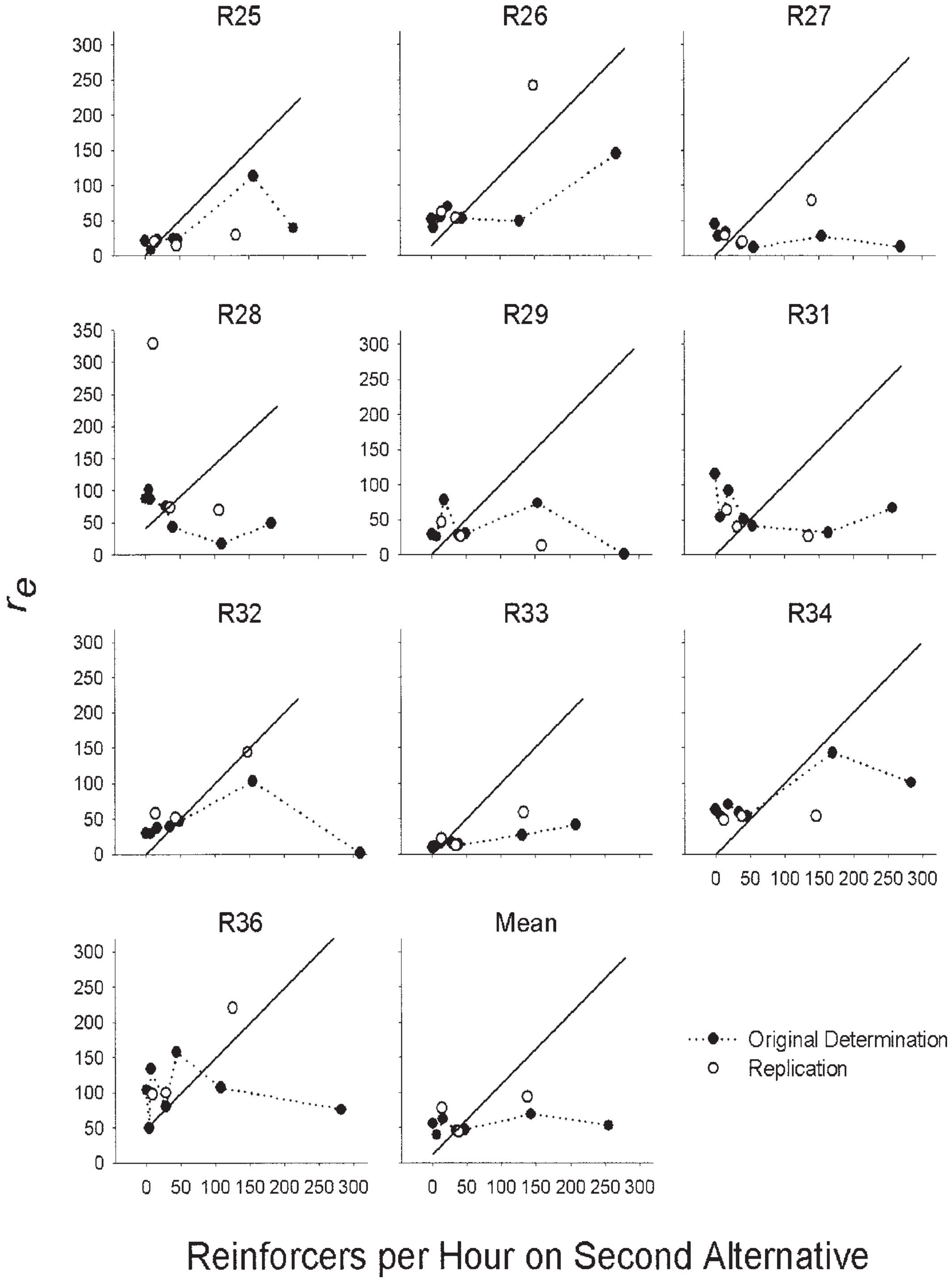

Fig. 5. Estimates of r_e from fits of Equation 1 as a function of average reinforcer rate on the second alternative. Each panel depicts data for an individual rat. Solid circles represent estimates obtained from original determinations. Open circles represent estimates obtained from replication conditions. The solid line in each panel represents the best fit of Equation 7.

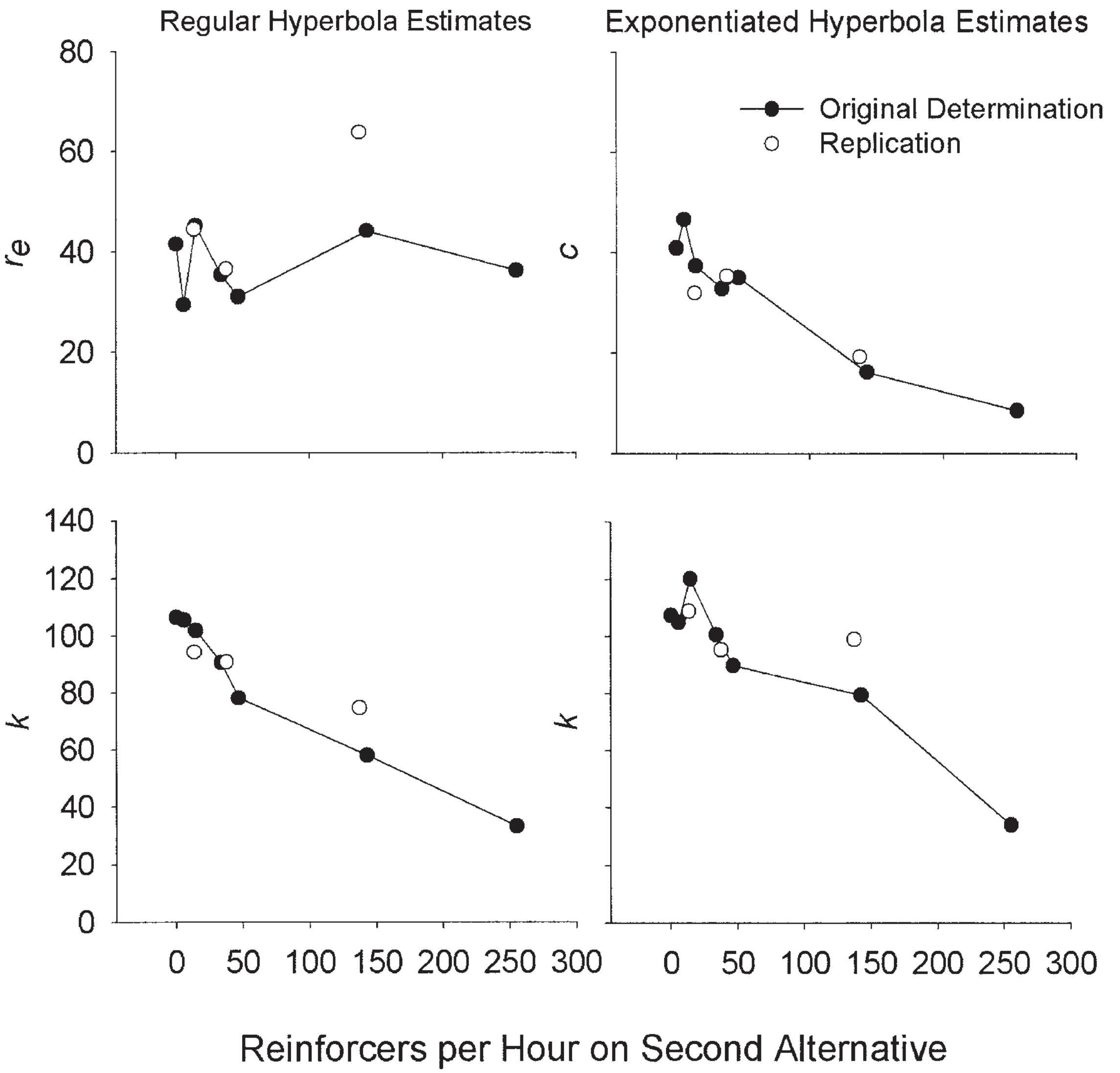

Fig. 6. Estimates of r_e and k from fits of Equation 1 (left column) and c and k from fits of Equation 5 (right column) to group average response versus reinforcer rates across all rats.

alternative VI schedule. In order for overall extraneous reinforcer rate to remain constant given such variation in r_2, r_b would have had to increase by 237.1, 236.5, and 276.3 reinforcers per hour, respectively, to offset the decreases in r_2. Such increases in r_b seem unreasonable given the relatively impoverished environment of the experimental apparatus. Given that there is no theoretical rationale for assuming that r_b covaries with r_2 such that their sum remains constant and that the empirical requirements of such an assumption appear unreasonable, variation in r_2 with reinforcer rate on the target alternative, r_T, likely should be taken as a violation of the constant-r_e assumption.

One question concerning the covariation of r_2 and r_T is the extent to which such variation is likely to occur. Belke and Heyman (1994) reported covariation of r_2 and r_T when the VI value on the second alternative was 27 s. The present study replicates that finding for a range of VI values. Unfortunately, the three remaining studies (Bradshaw, 1977; Bradshaw et al., 1976; White et al., 1986) that varied r_2 did not report the obtained rate of reinforcement on

Table 6

Estimates of *k*, *a*, *c*, and obtained percentage of variance accounted for (VAC) from fits of Equation 5.

Rat	Condition	*k*	*a*	*c*	VAC
R25	ALT-EXT	92.84	0.91	17.16	98.10
	ALT-350	310.89	0.28	9.43	93.44
	ALT-150	–	–	–	–
	ALT-75	–	–	–	–
	ALT-50	–	–	–	–
	ALT-17	–	–	–	–
	ALT-10	–	–	–	–
	ALT-150 Rep	91.15	0.76	12.26	93.43
	ALT-50 Rep	96.72	0.51	6.14	79.66
	ALT-17 Rep	–	–	–	–
R26	ALT-EXT	173.89	0.91	41.15	96.77
	ALT-350	145.84	0.83	27.40	94.07
	ALT-150	187.59	0.65	29.16	95.04
	ALT-75	196.91	0.65	39.10	98.05
	ALT-50	176.00	0.62	26.07	96.04
	ALT-17	113.59	0.71	28.31	97.80
	ALT-10	–	–	–	–
	ALT-150 Rep	375.05	0.52	39.11	96.89
	ALT-50 Rep	265.02	0.55	27.61	96.83
	ALT-17 Rep	–	–	–	–
R27	ALT-EXT	52.45	1.19	75.81	96.80
	ALT-350	151.49	0.39	16.51	97.58
	ALT-150	–	–	–	–
	ALT-75	225.79	0.32	20.61	98.41
	ALT-50	–	–	–	–
	ALT-17	83.99	0.50	24.93	94.80
	ALT-10	–	–	–	–
	ALT-150 Rep	63.16	0.67	15.35	96.27
	ALT-50 Rep	98.76	0.40	10.71	96.08
	ALT-17 Rep	–	–	–	–
R28	ALT-EXT	139.09	1.03	95.99	97.27
	ALT-350	–	–	–	–
	ALT-150	143.30	0.72	57.51	94.96
	ALT-75	–	–	–	–
	ALT-50	–	–	–	–
	ALT-17	121.89	0.49	8.20	88.40
	ALT-10	82.00	0.77	31.74	93.08
	ALT-150 Rep	–	–	–	–
	ALT-50 Rep	203.23	0.64	39.26	92.86
	ALT-17 Rep	–	–	–	–
R29	ALT-EXT	106.61	0.93	24.66	93.68
	ALT-350	223.83	0.41	13.64	95.98
	ALT-150	154.07	0.68	46.42	97.52
	ALT-75	75.66	0.72	15.85	96.02
	ALT-50	–	–	–	–
	ALT-17	–	–	–	–
	ALT-10	4.94	8.98	12.18	27.70
	ALT-150 Rep	128.52	0.69	22.61	83.51
	ALT-50 Rep	141.97	0.50	14.62	92.31
	ALT-17 Rep	–	–	–	–
R30	ALT-EXT	12.85	4.24	200.07	12.42
	ALT-350	27.57	2.87	89.34	6.60
	ALT-150	–	–	–	–
	ALT-75	37.21	0.36	2.87	91.98
	ALT-50	–	–	–	–
	ALT-17	39.20	0.57	10.72	94.68
	ALT-10	–	–	–	–
	ALT-150 Rep	22.60	0.42	0.96	28.18
	ALT-50 Rep	–	–	–	–
	ALT-17 Rep	–	–	–	–
R31	ALT-EXT	207.76	0.80	78.18	96.72
	ALT-350	203.16	0.70	27.68	94.05
	ALT-150	130.95	1.08	114.58	93.96
	ALT-75	135.78	0.70	27.93	97.37
	ALT-50	173.62	0.61	19.91	93.68
	ALT-17	121.97	0.52	18.47	92.32
	ALT-10	–	–	–	–
	ALT-150 Rep	142.29	0.87	44.91	96.37
	ALT-50 Rep	125.70	0.97	37.15	96.08
	ALT-17 Rep	133.73	0.52	11.68	91.31
R32	ALT-EXT	108.84	0.78	17.79	95.11
	ALT-350	127.54	0.77	17.21	97.68
	ALT-150	115.58	0.86	25.80	95.22
	ALT-75	148.63	0.70	20.96	98.59
	ALT-50	–	–	–	–
	ALT-17	–	–	–	–
	ALT-10	–	–	–	–
	ALT-150 Rep	106.59	1.18	95.63	97.31
	ALT-50 Rep	111.51	0.87	36.47	98.55
	ALT-17 Rep	146.36	0.94	130.11	98.50
R33	ALT-EXT	84.80	0.82	6.50	76.39
	ALT-350	151.12	0.46	4.78	91.56
	ALT-150	172.55	0.45	7.17	93.25
	ALT-75	125.18	0.57	7.50	91.34
	ALT-50	99.19	0.48	6.66	91.99
	ALT-17	63.71	0.84	19.46	91.09
	ALT-10	166.29	0.47	34.39	94.52
	ALT-150 Rep	79.29	1.18	34.06	87.48
	ALT-50 Rep	71.96	0.84	8.81	82.54
	ALT-17 Rep	–	–	–	–
R34	ALT-EXT	135.01	1.33	162.33	97.96
	ALT-350	145.72	1.02	56.31	95.72
	ALT-150	177.65	0.82	47.30	97.37
	ALT-75	236.67	0.62	34.25	99.79
	ALT-50	–	–	–	–
	ALT-17	–	–	–	–
	ALT-10	–	–	–	–
	ALT-150 Rep	–	–	–	–
	ALT-50 Rep	118.78	1.03	58.16	95.51
	ALT-17 Rep	78.86	0.80	37.33	93.32
R35	ALT-EXT	38.37	0.77	26.94	93.56
	ALT-350	–	–	–	–
	ALT-150	19.22	1.41	1.88	27.40
	ALT-75	–	–	–	–
	ALT-50	–	–	–	–
	ALT-17	5.68	3.97	120.83	23.89
	ALT-10	–	–	–	–
	ALT-150 Rep	76.72	0.33	7.76	67.47
	ALT-50 Rep	44.30	0.87	15.57	76.09
	ALT-17 Rep	–	–	–	–
R36	ALT-EXT	115.64	1.42	379.47	97.49
	ALT-350	119.95	0.82	33.86	96.68
	ALT-150	–	–	–	–
	ALT-75	173.19	0.64	53.19	97.31
	ALT-50	–	–	–	–
	ALT-17	–	–	–	–
	ALT-10	–	–	–	–
	ALT-150 Rep	112.71	1.16	155.31	99.06
	ALT-50 Rep	108.45	1.42	383.35	96.23
	ALT-17 Rep	–	–	–	–

Note. Dashes indicate a failure to obtain unique estimates.

the second alternative for each target alternative VI schedule. Still, based on the VI values used in those studies, it appears likely that covariation of r_2 and r_T occurred in some cases. In the present study, covariation of r_2 and r_T occurred for all rats when the VI value on the second alternative was between 10 and 50 s, for most rats when the VI value was between 75 and 150 s, and for some rats when the VI value was 350 s. For comparison, the second alternative VI values used in previous studies were 174 s (Bradshaw), 51 s (Bradshaw et al.), and 40, 120, and 300 s (White et al.). Excluding the Bradshaw study and the VI 300-s schedule in the White et al. study, the VI values arranged on the second alternative in previous studies are within the range of those in the present study for which covariation of r_2 and r_T occurred.

Covariation of r_2 and r_T has implications for the application of Equations 1 and 4 to single-schedule arrangements. It seems possible, perhaps even likely, that the rate of reinforcement from unmeasured background sources covaries with reinforcer rate from the experimenter-arranged alternative unless the background environment is comprised of very lean VI schedules. Such variation is even more likely if background sources of reinforcement are comprised of ratio schedules rather than interval schedules because changes in response allocations to a background ratio schedule will produce greater changes in obtained reinforcer rate than a background interval schedule. In either case, it seems possible that extraneous reinforcer rate covaries with reinforcer rate on the arranged alternative. That possibility questions the logic of both Equations 1 and 4 in single-schedule arrangements.

It is worthwhile to note that, despite violations of underlying assumptions, Equations 1 and 5 (the fitting version of Equation 4) provide, for the most part, a good description of the relation between responding and reinforcer rate. Despite the fact that the description provided by the equations was very good in many cases, estimates of r_e from Equation 1 and c from Equation 5 did not increase systematically with increases in r_2, as required. Additionally, estimates of k from Equations 1 and 5 decreased with increases in r_2, contrary to theoretical requirements. The failure of estimates from Equations 1 and 5 to vary as theoretically required is perhaps not surprising given violations of some of the assumptions of the equations.

Table 7

Estimates of r_e from fits of Equation 1 to the data reported in Appendix C of Belke and Heyman (1994) for the first Single condition and the Choice condition, difference between estimates of r_e, and average reinforcer rate obtained on the added alternative (Avg r_2).

Rat	Single r_e	Choice r_e	Change in r_e	Avg r_2
991	37.09	148.21	111.12	67.86
992	129.07	149.43	20.36	81.89
994	65.91	116.19	50.28	96.00
995	52.31	137.47	85.16	66.60
996	54.02	240.78	186.76	74.33
997	88.04	224.57	136.54	73.50

Given that Belke and Heyman (1994) also found covariation of r_2 and r_T, it is interesting that estimates of r_e increased as predicted from the single-schedule condition (Single condition) to the concurrent-schedule arrangement (Choice condition) in their experiment. However, Belke and Heyman's conclusion that the increase in estimates of r_e approximated the rate of reinforcement on the added second alternative was based on group averages. A reanalysis in terms of individual rats does not support their conclusion. Table 7 presents estimates of r_e for each rat obtained from fits of Equation 1 to the data reported in Appendix C of Belke and Heyman's study for the first Single and Choice conditions. Table 7 also includes the difference between r_e from the Single condition and r_e from the Choice condition along with the average r_2 obtained in the Choice condition. Average r_2 varied across rats from 67 reinforcers per hour to about 96 reinforcers per hour. The increase in r_e from the Single to the Choice condition was more variable. The smallest increase in r_e was just over 20 reinforcers per hour and the largest increase was nearly 187 reinforcers per hour. The increase in r_e was not systematically related to the average r_2 as required by Herrnstein's interpretation. Thus, viewed in terms of the estimates from individual rats, the data are not in agreement with theoretical predictions.

One concern in the present experiment is the response rate correction procedure that was used to correct for the downturn in response rate at the VI-6 and 10-s schedules.

Another possibility for correcting response rates would have been to subtract all postreinforcement pause time from the time base. Alternatively, one could leave response rates uncorrected and discard both the VI 6- and 10-s schedule data prior to fitting. Both of these procedures were used in the present study. In no case was the pattern of estimates consistent with the prediction that r_e in Equation 1 or c in Equation 5 should increase systematically with r_2 and that k in either equation should remain constant with increases in r_2. Although the method of response rate calculation may affect the exact values of the equation parameters, the main finding of covariation of r_2 and r_T was not affected by how response rates were calculated.

The present results demonstrate that changes in the distribution of responding among alternatives can affect obtained reinforcer rates even on relatively lean VI schedules. Of course, Herrnstein's account predicts covariation of responding between alternatives because an increase in responding on one alternative must be compensated for by a decrease in one or more of the remaining alternatives in order for total behavior, k, to remain constant. Neither Equation 1 nor Equation 4, however, allows for the variation in extraneous reinforcer rate that can occur with changes in response allocations. Perhaps Equations 1 and 4 apply only to environments in which extraneous alternatives are represented by very lean VI schedules where changes in response allocations do not produce significant changes in obtained reinforcer rate. Unfortunately, it is not known what type of schedules comprise the extraneous environment in single- or concurrent-schedule arrangements, nor whether these schedules are lean or rich or even if these schedules are best conceptualized as VI schedules. This lack of knowledge compromises the application of Equations 1 and 4. Perhaps the present data only reveal boundary conditions beyond which the equations may not be legitimately applied. If so, the domain of the equations may be more circumscribed than previously acknowledged.

REFERENCES

Baum, W. M. (1974). On two types of deviation from the matching law: Undermatching and bias. *Journal of the Experimental Analysis of Behavior, 22*, 231–242.

Baum, W. M. (1979). Matching, undermatching, and overmatching in studies of choice. *Journal of the Experimental Analysis of Behavior, 32*, 269–281.

Baum, W. M. (1993). Performance on ratio and interval schedules of reinforcement: Data and theory. *Journal of the Experimental Analysis of Behavior, 59*, 245–264.

Belke, T. W., & Heyman, G. M. (1994). Increasing and signaling background reinforcement: Effect on the foreground response-reinforcer relation. *Journal of the Experimental Analysis of Behavior, 61*, 65–81.

Bradshaw, C. M. (1977). Suppression of response rates in variable-interval schedules by a concurrent schedule of reinforcement. *British Journal of Psychology, 68*, 473–480.

Bradshaw, C. M., Ruddle, H. V., & Szabadi, E. (1981). Relationship between response rate and reinforcement frequency in variable-interval schedules: II. Effect of the volume of sucrose reinforcement. *Journal of the Experimental Analysis of Behavior, 35*, 263–269.

Bradshaw, C. M., Szabadi, E., & Bevan, P. (1976). Behavior of humans in variable-interval schedules of reinforcement. *Journal of the Experimental Analysis of Behavior, 26*, 135–141.

Bradshaw, C. M., Szabadi, E., & Bevan, P. (1978). Relationship between response rate and reinforcement frequency in variable-interval schedules: The effect of the concentration of sucrose reinforcement. *Journal of the Experimental Analysis of Behavior, 29*, 447–452.

Bradshaw, C. M., Szabadi, E., Ruddle, H. V., & Pears, E. (1983). Effect of deprivation level on performance in variable-interval schedules. *Behaviour Analysis Letters, 3*, 267–273.

Dallery, J., McDowell, J. J, & Lancaster, J. S. (2000). Falsification of matching theory's account of single-alternative responding: Herrnstein's k varies with sucrose concentration. *Journal of the Experimental Analysis of Behavior, 73*, 23–43.

Dallery, J., McDowell, J. J, & Soto, P. L. (2004). The measurement and functional properties of reinforcer value in single-alternative responding: A test of linear system theory. *The Psychological Record, 54*, 45–65.

Dallery, J., & Soto, P. L. (2004). Herrnstein's hyperbola and behavioral pharmacology: Review and critique. *Behavioural Pharmacology, 15*, 443–459.

de Villiers, P. A., & Herrnstein, R. J. (1976). Toward a law of response strength. *Psychological Bulletin, 83*, 1131–1153.

Fleshler, M., & Hoffman, H. S. (1962). A progression for generating variable-interval schedules. *Journal of the Experimental Analysis of Behavior, 5*, 529–530.

Hamilton, A. L., Stellar, J. R., & Hart, E. B. (1985). Reward, performance, and the response strength method in self-stimulating rats: Validation and neuroleptics. *Physiology and Behavior, 35*, 897–904.

Herrnstein, R. J. (1970). On the law of effect. *Journal of the Experimental Analysis of Behavior, 13*, 243–266.

Heyman, G. M., & Monaghan, M. M. (1987). Effect of changes in response requirement and deprivation on the parameters of the matching law equation: New data and review. *Journal of Experimental Psychology, 13*, 384–394.

Heyman, G. M., & Monaghan, M. M. (1994). Reinforcer magnitude (sucrose concentration) and the matching law theory of response strength. *Journal of the Experimental Analysis of Behavior, 61*, 505–516.

Keesey, R. E. (1964). Duration of stimulation and the reward properties of hypothalamic stimulation. *Journal of Comparative and Physiological Psychology, 58*, 201–207.

McDowell, J. J (1986). On the falsifiability of matching theory. *Journal of the Experimental Analysis of Behavior, 45*, 63–74.

McDowell, J. J (2005). On the classic and modern theories of matching. *Journal of the Experimental Analysis of Behavior, 84*, 111–127.

McDowell, J. J, & Dallery, J. (1999). Falsification of matching theory: Changes in the asymptote of Herrnstein's hyperbola as a function of water deprivation. *Journal of the Experimental Analysis of Behavior, 72*, 251–268.

McDowell, J. J, & Wood, H. M. (1984). Confirmation of linear system theory predictions: Rate of change of Herrnstein's *k* as a function of changes in reinforcer magnitude. *Journal of the Experimental Analysis of Behavior, 41*, 183–192.

McDowell, J. J, & Wood, H. M. (1985). Confirmation of linear system theory predictions: Rate of change of Herrnstein's *k* as a function of response-force requirement. *Journal of the Experimental Analysis of Behavior, 43*, 61–73.

Snyderman, M. (1983). Body weight and response strength. *Behaviour Analysis Letters, 3*, 255–265.

Wearden, J. H. (1981). Bias and undermatching: Implications for Herrnstein's equation. *Behaviour Analysis Letters, 1*, 177–185.

White, K. G., McLean, A. P., & Aldiss, M. F. (1986). The context for reinforcement: Modulation of the response-reinforcer relation by concurrently available extraneous reinforcement. *Animal Learning & Behavior, 14*, 398–404.

Williams, B. A. (1988). Reinforcement, choice, and response strength. In R. C. Atkinson, R. J. Herrnstein, G. Lindzey, & R. D. Luce (Eds.), *Stevens' handbook of experimental psychology: Vol. 2* (2nd ed., pp. 167–244). New York: Wiley.

Received January 29, 2005
Final acceptance June 8, 2005

APPENDIX

Average response and reinforcer rates on the target and second alternatives. Response rates were corrected for postreinforcement pausing using the procedure described in the Results section.

			Target alternative		Second alternative	
Subject	Condition	VI value (s)	Reinforcers per hour	Responses per minute	Reinforcers per hour	Responses per minute
R25	ALT-EXT	6	405.9	47.3	0.0	0.1
		10	297.2	80.6	0.0	0.8
		14	229.3	87.1	0.0	0.7
		20	165.9	80.6	0.0	2.5
		45	85.2	72.2	0.0	3.7
		55	69.6	68.7	0.0	5.8
		100	23.0	44.3	0.0	6.2
		200	19.1	43.0	0.0	4.9
		350	16.5	38.2	0.0	4.8
		450	13.9	40.2	0.0	3.7
	ALT-350	6	460.9	76.8	1.6	2.8
		10	286.7	97.1	10.5	7.4
		14	236.2	103.5	13.3	9.9
		20	166.9	108.2	8.4	11.2
		45	60.2	72.8	5.3	16.6
		55	74.3	83.6	8.0	14.8
		100	33.7	67.3	11.7	22.0
		200	27.0	60.5	9.0	19.9
		350	5.1	45.5	10.2	19.7
		450	3.8	43.9	10.1	22.2
	ALT-150	6	460.5	83.5	6.6	3.7
		10	312.1	127.8	9.2	14.9
		14	239.8	102.2	13.2	11.3
		20	166.3	101.3	17.0	21.9
		45	72.1	84.6	22.7	31.1
		55	66.3	69.8	17.1	25.6
		100	39.1	60.8	19.5	28.8
		200	14.2	53.8	24.5	35.4
		350	11.7	49.0	31.0	36.2
		450	6.4	36.3	19.2	26.8
	ALT-75	6	428.3	74.6	21.4	11.5
		10	293.7	87.9	35.5	21.9
		14	218.7	93.8	41.5	34.6
		20	149.9	84.1	38.2	35.4
		45	65.8	62.2	36.2	50.7
		55	41.6	51.3	48.1	56.5
		100	39.5	48.0	37.0	50.3
		200	17.1	40.3	48.7	51.8
		350	9.2	38.4	51.1	49.0
		450	11.8	40.4	51.1	55.2
	ALT-50	6	425.6	78.4	11.5	4.4
		10	311.4	110.6	32.6	11.4
		14	214.7	97.4	38.2	15.8
		20	154.9	93.0	42.7	21.7
		45	58.0	66.3	54.0	29.1
		55	57.2	60.5	63.9	27.0
		100	34.6	58.6	49.2	29.7
		200	14.6	45.6	74.5	37.2
		350	10.4	42.4	41.6	32.1
		450	9.3	42.8	64.9	36.9
	ALT-17	6	411.3	64.9	49.4	23.9
		10	259.8	67.6	101.7	50.4
		14	177.3	47.4	135.7	66.2
		20	106.8	40.1	181.5	77.4
		45	52.1	22.9	176.9	84.9
		55	44.9	19.5	176.6	73.9

APPENDIX

(*Continued*)

			Target alternative		Second alternative	
Subject	Condition	VI value (s)	Reinforcers per hour	Responses per minute	Reinforcers per hour	Responses per minute
		100	18.7	16.8	198.6	74.1
		200	20.0	20.2	174.7	92.6
		350	18.6	16.6	184.2	94.3
		450	10.0	16.8	186.3	97.8
	ALT-10	6	270.3	31.3	92.3	16.6
		10	215.3	42.0	99.0	23.2
		14	138.6	45.1	170.8	40.8
		20	104.3	30.1	200.5	52.8
		45	36.0	17.1	259.9	64.2
		55	46.9	21.4	252.4	67.0
		100	22.5	18.8	259.0	70.6
		200	13.4	13.3	264.3	69.1
		350	8.9	16.3	259.8	73.8
		450	9.0	15.7	286.4	82.6
	ALT-150 Rep	6	401.3	57.7	3.4	2.8
		10	291.0	71.4	4.5	3.0
		14	220.7	78.7	10.3	6.7
		20	157.9	78.8	11.2	7.9
		45	72.1	62.3	21.3	19.4
		55	59.7	56.8	25.3	23.1
		100	24.5	40.0	15.4	24.2
		200	12.7	30.1	10.3	21.6
		350	10.2	25.6	19.1	19.4
		450	10.2	38.6	17.9	26.9
	ALT-50 Rep	6	404.6	54.9	4.8	3.3
		10	289.9	62.7	18.2	8.7
		14	204.2	74.0	23.2	8.0
		20	128.4	69.8	56.4	25.0
		45	83.9	66.6	57.9	32.4
		55	56.6	47.9	39.0	26.4
		100	30.6	34.5	57.2	37.1
		200	22.4	43.1	50.5	47.4
		350	9.2	35.1	73.2	50.5
		450	10.6	37.1	74.4	48.7
	ALT-17 Rep	6	362.0	41.3	25.9	6.9
		10	259.1	60.7	66.1	25.5
		14	167.7	53.7	100.9	37.6
		20	122.4	43.6	118.8	51.2
		45	63.5	32.5	160.8	66.0
		55	47.3	26.8	163.6	65.8
		100	34.2	29.9	165.4	77.8
		200	18.4	24.2	166.6	84.1
		350	11.3	27.7	173.6	82.2
		450	9.9	21.6	172.0	82.6
R26	ALT-EXT	6	525.9	118.0	0.0	0.0
		10	342.0	137.3	0.0	0.0
		14	237.6	135.1	0.0	0.2
		20	167.5	139.9	0.0	0.1
		45	64.3	96.4	0.0	3.1
		55	53.6	77.4	0.0	5.6
		100	43.9	65.4	0.0	4.5
		200	13.9	34.1	0.0	3.9
		350	7.6	22.6	0.0	1.9
		450	8.9	37.5	0.0	3.7
	ALT-350	6	528.5	106.0	0.0	0.2
		10	336.3	117.8	0.0	0.1
		14	242.8	122.6	0.0	0.9
		20	125.9	81.4	0.0	2.2

APPENDIX

(*Continued*)

Subject	Condition	VI value (s)	Target alternative: Reinforcers per hour	Target alternative: Responses per minute	Second alternative: Reinforcers per hour	Second alternative: Responses per minute
		45	74.6	88.7	1.3	3.2
		55	53.8	85.0	3.9	5.4
		100	25.6	51.5	2.6	5.6
		200	17.9	31.1	6.4	4.5
		350	7.6	22.2	2.5	3.4
		450	5.1	25.6	6.3	5.0
	ALT-150	6	514.3	89.1	0.0	1.1
		10	325.6	111.7	3.1	2.0
		14	232.3	95.9	7.3	3.9
		20	157.9	103.4	9.8	8.3
		45	41.9	60.1	15.5	16.0
		55	43.2	42.1	22.2	15.4
		100	24.6	36.1	18.2	15.0
		200	20.7	38.8	19.4	13.8
		350	3.8	23.2	23.0	14.3
		450	7.7	18.7	19.1	13.3
	ALT-75	6	469.8	72.6	1.7	0.5
		10	303.2	97.2	10.6	4.1
		14	234.5	97.2	11.8	6.7
		20	132.5	83.5	30.7	13.9
		45	57.6	45.6	33.5	20.0
		55	41.3	43.4	27.8	23.7
		100	17.0	24.8	38.0	22.1
		200	14.2	26.1	28.3	20.3
		350	3.8	16.5	20.4	20.8
		450	5.1	14.8	32.1	19.5
	ALT-50	6	464.8	76.4	13.3	3.6
		10	328.1	99.7	31.2	8.6
		14	208.9	85.0	32.1	13.6
		20	152.2	95.5	45.5	16.7
		45	54.9	54.8	44.3	24.0
		55	40.2	41.5	50.6	19.7
		100	34.7	42.4	49.1	24.9
		200	9.2	20.8	57.7	15.2
		350	3.9	18.5	57.6	23.5
		450	7.9	26.0	61.6	25.3
	ALT-17	6	415.9	54.8	35.9	7.2
		10	266.3	70.0	63.4	20.0
		14	206.9	70.1	64.0	23.4
		20	125.0	62.7	126.4	40.7
		45	41.4	38.2	159.7	69.4
		55	52.7	39.3	151.6	53.4
		100	14.1	14.1	150.8	54.2
		200	8.4	17.5	171.9	78.6
		350	4.2	12.3	180.6	77.2
		450	4.2	13.6	169.7	83.8
	ALT-10	6	369.7	70.4	102.3	26.7
		10	147.0	49.3	208.5	52.1
		14	63.0	27.5	275.5	71.2
		20	33.0	14.4	307.8	85.4
		45	29.1	15.7	274.6	92.1
		55	28.8	15.3	268.8	87.6
		100	10.4	12.1	279.6	104.1
		200	6.1	7.9	313.4	94.2
		350	10.6	8.1	307.3	95.5
		450	4.6	7.4	339.3	114.9
	ALT-150 Rep	6	487.1	93.6	0.0	0.1
		10	315.4	124.0	7.7	6.1

APPENDIX

(*Continued*)

Subject	Condition	VI value (s)	Target alternative: Reinforcers per hour	Target alternative: Responses per minute	Second alternative: Reinforcers per hour	Second alternative: Responses per minute
		14	224.8	114.9	8.7	3.6
		20	153.1	107.3	23.9	12.4
		45	53.1	52.0	14.6	14.4
		55	54.3	70.4	19.7	20.8
		100	23.4	43.4	24.8	19.9
		200	19.3	35.4	11.5	15.8
		350	8.9	27.0	23.1	18.9
		450	3.8	27.3	16.5	27.9
	ALT-50 Rep	6	487.6	87.0	0.0	0.1
		10	312.7	114.5	10.7	3.7
		14	233.7	117.7	17.6	4.9
		20	154.9	107.2	41.4	18.0
		45	70.1	75.5	34.9	28.3
		55	51.1	50.8	50.9	33.2
		100	23.9	43.4	48.8	30.2
		200	10.4	32.5	48.4	37.9
		350	5.2	24.9	57.6	44.3
		450	3.9	21.8	41.5	33.4
	ALT-17 Rep	6	443.5	83.4	42.9	17.6
		10	291.1	97.1	53.0	11.1
		14	150.3	55.6	129.3	69.5
		20	112.6	58.2	151.1	70.6
		45	53.5	28.9	169.1	113.1
		55	30.5	17.8	195.6	113.9
		100	15.5	13.7	174.1	121.5
		200	8.5	14.2	189.5	119.4
		350	7.2	14.2	185.8	124.9
		450	9.9	14.2	189.3	118.0
R27	ALT-EXT	6	405.5	32.3	0.0	0.9
		10	299.0	46.2	0.0	0.1
		14	229.0	47.2	0.0	0.4
		20	162.8	45.9	0.0	0.9
		45	62.7	33.8	0.0	2.3
		55	62.9	37.2	0.0	1.1
		100	26.7	15.1	0.0	1.0
		200	16.5	13.5	0.0	4.0
		350	8.8	9.1	0.0	0.7
		450	10.1	12.8	0.0	2.6
	ALT-350	6	452.8	48.2	1.7	0.9
		10	312.7	54.3	3.1	1.1
		14	212.1	52.6	5.8	3.6
		20	153.0	45.9	8.4	5.2
		45	76.8	41.2	2.6	7.8
		55	49.4	31.9	2.6	8.0
		100	29.5	25.6	5.1	6.8
		200	19.1	22.7	5.1	8.3
		350	16.6	25.0	5.1	8.6
		450	6.3	18.7	8.9	7.4
	ALT-150	6	437.5	45.2	1.6	0.6
		10	291.8	53.8	7.6	6.4
		14	216.6	45.0	17.4	8.3
		20	147.4	44.6	12.6	12.2
		45	59.3	32.0	17.1	15.4
		55	46.0	27.9	23.7	18.0
		100	31.1	21.5	15.6	14.5
		200	15.5	19.5	23.2	18.6
		350	11.7	20.3	24.7	17.7
		450	2.6	13.7	12.7	11.7

APPENDIX

(*Continued*)

Subject	Condition	VI value (s)	Target alternative		Second alternative	
			Reinforcers per hour	Responses per minute	Reinforcers per hour	Responses per minute
	ALT-75	6	379.3	44.3	28.8	13.4
		10	240.3	47.9	37.3	15.8
		14	204.9	50.3	50.3	22.5
		20	135.2	44.7	46.5	24.4
		45	66.9	36.1	30.8	42.1
		55	56.1	34.2	30.7	39.3
		100	22.2	24.5	37.9	40.2
		200	13.1	22.0	44.3	46.0
		350	10.4	21.3	40.2	48.7
		450	6.4	20.1	32.2	51.1
	ALT-50	6	422.2	47.3	34.7	9.7
		10	275.2	51.4	46.0	14.5
		14	190.2	46.9	54.4	15.9
		20	145.7	47.4	58.8	21.7
		45	64.5	38.4	63.3	34.1
		55	51.1	36.7	55.3	35.6
		100	36.1	29.1	63.0	36.7
		200	11.8	26.3	58.0	41.8
		350	11.9	23.1	56.3	37.8
		450	4.0	21.8	71.3	39.8
	ALT-17	6	341.3	38.4	87.7	15.8
		10	184.2	26.8	134.3	32.2
		14	142.7	30.3	144.6	34.3
		20	84.3	22.1	160.7	50.5
		45	48.9	17.9	154.2	60.1
		55	50.5	18.1	157.4	62.5
		100	11.3	9.6	172.3	68.4
		200	8.5	7.8	171.9	72.7
		350	9.8	7.6	167.1	65.9
		450	5.7	10.2	192.1	65.8
	ALT-10	6	137.6	14.9	199.2	47.2
		10	82.5	12.7	233.4	55.3
		14	41.1	8.2	270.8	64.7
		20	39.6	7.0	270.5	67.3
		45	24.3	6.2	284.4	63.6
		55	7.5	4.3	289.6	70.5
		100	4.5	6.4	280.1	78.1
		200	10.4	5.8	267.0	71.2
		350	7.5	3.1	291.7	65.2
		450	4.6	3.1	298.3	65.8
	ALT-150 Rep	6	412.3	33.7	0.0	0.0
		10	274.8	44.0	3.0	1.6
		14	227.0	47.8	7.2	5.0
		20	126.8	37.6	9.8	9.4
		45	74.6	36.5	17.3	14.8
		55	47.1	28.6	9.6	23.6
		100	24.7	21.1	23.4	22.2
		200	12.8	15.4	19.3	22.1
		350	11.5	13.6	17.9	19.9
		450	9.0	18.0	25.8	19.9
	ALT-50 Rep	6	416.0	34.6	4.8	0.9
		10	270.5	45.0	18.0	7.2
		14	208.9	43.3	21.8	10.6
		20	149.6	40.4	35.4	15.1
		45	70.5	33.5	48.8	34.9
		55	55.1	32.7	47.0	33.7
		100	37.0	27.1	49.3	42.8
		200	13.1	16.5	55.1	37.3

APPENDIX

(*Continued*)

			Target alternative		Second alternative	
Subject	Condition	VI value (s)	Reinforcers per hour	Responses per minute	Reinforcers per hour	Responses per minute
		350	19.8	22.1	52.6	39.3
		450	7.9	21.0	69.0	45.9
	ALT-17 Rep	6	324.3	25.4	47.6	24.9
		10	216.7	29.5	100.9	45.4
		14	135.9	23.9	123.5	55.9
		20	74.0	13.3	158.4	80.7
		45	37.4	9.4	170.2	102.1
		55	36.8	12.3	154.5	86.3
		100	26.6	12.4	150.6	100.5
		200	9.9	6.7	167.3	117.2
		350	12.6	7.4	160.4	110.7
		450	9.8	7.1	172.0	97.4
R28	ALT-EXT	6	422.8	75.4	0.0	0.0
		10	319.5	103.3	0.0	0.0
		14	232.4	114.3	0.0	0.4
		20	169.0	92.8	0.0	0.3
		45	67.0	61.9	0.0	0.7
		55	65.7	61.0	0.0	0.3
		100	24.2	27.9	0.0	0.9
		200	15.2	14.8	0.0	0.1
		350	6.3	17.0	0.0	0.9
		450	2.5	11.7	0.0	0.3
	ALT-350	6	452.0	96.3	0.0	0.0
		10	318.6	113.3	4.6	1.3
		14	226.3	104.9	2.9	1.4
		20	160.3	87.1	5.6	3.0
		45	66.0	48.5	5.3	3.9
		55	54.8	53.1	5.2	4.9
		100	36.2	39.5	5.2	4.3
		200	2.5	16.9	6.3	5.1
		350	8.9	22.8	11.4	5.1
		450	6.3	18.8	5.1	3.5
	ALT-150	6	361.9	43.9	0.0	0.1
		10	224.8	61.1	3.0	1.2
		14	159.3	62.9	1.4	2.2
		20	130.9	59.8	5.6	2.4
		45	38.0	24.3	4.0	3.1
		55	52.9	26.2	15.9	4.4
		100	24.6	24.8	7.8	4.8
		200	7.6	7.5	3.8	1.9
		350	1.3	6.3	8.9	2.7
		450	7.7	14.5	12.8	5.2
	ALT-75	6	464.8	94.3	5.0	1.6
		10	311.0	118.8	12.2	3.6
		14	226.7	106.7	17.6	5.0
		20	158.0	84.8	26.9	9.1
		45	79.6	69.7	50.6	13.1
		55	67.0	55.7	36.2	12.5
		100	26.1	36.3	36.7	16.2
		200	19.6	34.5	41.9	18.9
		350	12.9	32.3	29.8	18.1
		450	3.9	21.1	39.0	14.3
	ALT-50	6	416.1	63.0	9.6	2.1
		10	274.1	70.2	28.7	8.9
		14	222.5	80.2	41.7	11.5
		20	128.6	60.7	37.7	13.2
		45	46.1	32.0	46.0	8.7
		55	49.6	41.4	36.3	13.2

APPENDIX

(*Continued*)

Subject	Condition	VI value (s)	Target alternative: Reinforcers per hour	Target alternative: Responses per minute	Second alternative: Reinforcers per hour	Second alternative: Responses per minute
		100	36.9	33.7	39.5	13.0
		200	19.9	34.4	54.3	15.5
		350	6.6	25.6	53.6	17.5
		450	5.2	19.6	44.3	12.3
	ALT-17	6	430.2	70.8	18.3	5.7
		10	279.5	80.0	38.3	8.9
		14	185.3	62.9	79.3	13.3
		20	137.1	80.9	104.0	25.7
		45	84.5	67.6	124.8	28.9
		55	58.2	59.0	133.5	29.9
		100	27.9	37.0	132.2	31.9
		200	18.2	39.0	145.1	35.9
		350	9.8	34.0	165.9	43.0
		450	4.2	27.6	160.2	37.9
	ALT-10	6	392.7	83.5	34.0	6.4
		10	201.7	51.4	99.4	11.3
		14	171.4	49.7	120.8	18.0
		20	109.3	50.6	154.3	27.4
		45	31.3	20.1	239.2	34.5
		55	35.7	29.1	233.1	28.9
		100	30.7	19.9	212.0	27.0
		200	19.2	22.1	260.5	34.2
		350	13.3	13.8	233.0	35.4
		450	10.1	17.4	231.2	38.0
	ALT-150 Rep	6	411.6	65.9	1.7	0.3
		10	270.8	91.0	6.2	2.6
		14	184.7	64.2	18.7	5.2
		20	132.8	67.1	8.4	6.1
		45	58.0	23.9	10.5	4.2
		55	41.7	19.1	17.0	7.1
		100	40.5	21.1	15.8	7.3
		200	12.8	8.7	12.7	5.0
		350	7.6	14.3	11.4	6.0
		450	5.1	12.7	14.0	9.5
	ALT-50 Rep	6	403.7	54.7	4.8	0.8
		10	307.5	95.2	12.3	2.5
		14	221.0	96.1	13.1	5.2
		20	146.7	89.7	38.1	9.2
		45	69.9	50.1	52.0	12.4
		55	56.8	53.7	54.0	13.1
		100	35.4	26.1	28.9	12.6
		200	10.3	26.3	41.8	15.6
		350	15.7	34.1	55.5	17.4
		450	10.5	20.9	54.9	18.1
	ALT-17 Rep	6	333.1	43.5	34.9	7.1
		10	309.8	107.5	34.2	7.4
		14	190.3	63.8	51.9	9.8
		20	153.2	97.9	71.0	17.5
		45	52.0	53.3	129.6	35.4
		55	47.4	31.6	114.1	30.0
		100	35.3	41.9	149.6	42.8
		200	19.7	32.4	152.9	44.9
		350	8.5	21.2	169.2	49.3
		450	7.0	22.2	162.7	42.1
R29	ALT-EXT	6	467.3	74.1	0.0	0.0
		10	319.3	94.6	0.0	0.3
		14	205.9	87.6	0.0	0.9
		20	162.9	93.2	0.0	0.4

APPENDIX

(*Continued*)

Subject	Condition	VI value (s)	Target alternative: Reinforcers per hour	Target alternative: Responses per minute	Second alternative: Reinforcers per hour	Second alternative: Responses per minute
		45	66.9	79.7	0.0	1.0
		55	44.0	46.0	0.0	1.1
		100	38.7	58.7	0.0	1.4
		200	19.1	51.3	0.0	1.6
		350	6.3	18.4	0.0	0.4
		450	6.3	17.3	0.0	0.8
	ALT-350	6	463.3	71.2	1.7	1.2
		10	311.0	94.7	4.6	2.6
		14	235.3	88.2	7.4	4.3
		20	153.6	87.5	14.0	6.9
		45	61.1	59.7	10.6	7.0
		55	62.9	71.0	5.2	7.4
		100	37.3	46.4	0.0	6.9
		200	14.1	36.8	9.0	10.4
		350	12.7	39.1	11.4	9.3
		450	3.8	29.0	5.1	6.2
	ALT-150	6	429.6	64.6	18.0	3.4
		10	278.7	78.2	24.3	6.1
		14	206.6	63.8	15.9	6.0
		20	127.7	63.2	25.0	7.6
		45	55.6	39.4	13.2	7.1
		55	39.9	27.8	25.1	5.8
		100	33.8	29.9	15.5	5.0
		200	10.3	15.1	16.8	4.1
		350	10.2	12.5	11.4	4.0
		450	1.3	9.4	14.0	3.9
	ALT-75	6	410.9	48.5	26.1	8.6
		10	265.8	57.2	42.6	10.1
		14	207.0	53.9	42.5	9.9
		20	141.3	59.6	42.6	14.0
		45	62.3	41.1	48.8	14.8
		55	52.5	40.6	47.0	15.1
		100	15.6	20.7	33.8	13.5
		200	16.9	23.4	31.1	15.4
		350	13.3	21.7	40.8	16.1
		450	3.9	15.3	38.7	16.5
	ALT-50	6	402.5	46.4	30.9	5.4
		10	271.6	54.7	31.6	6.4
		14	211.9	47.6	41.2	8.8
		20	128.8	41.3	68.6	12.8
		45	78.0	37.8	50.7	14.9
		55	37.1	27.2	40.9	18.4
		100	29.4	23.3	60.0	15.7
		200	17.3	22.9	66.4	19.2
		350	13.0	18.2	44.3	18.9
		450	6.5	16.9	54.9	16.2
	ALT-17	6	233.9	24.7	119.8	47.9
		10	131.3	23.5	184.8	59.6
		14	140.8	28.8	156.9	56.1
		20	72.2	17.8	140.8	50.2
		45	37.5	12.3	164.1	58.1
		55	44.4	14.0	160.4	54.3
		100	19.8	7.0	148.8	47.4
		200	19.5	8.1	141.8	53.6
		350	8.4	7.8	164.4	55.4
		450	11.3	9.1	157.9	55.7
	ALT-10	6	36.9	7.8	264.4	43.7
		10	18.1	5.5	277.4	37.1

APPENDIX

(*Continued*)

Subject	Condition	VI value (s)	Target alternative		Second alternative	
			Reinforcers per hour	Responses per minute	Reinforcers per hour	Responses per minute
		14	15.3	3.7	284.1	45.7
		20	12.2	4.2	288.8	37.7
		45	8.9	4.3	259.9	31.1
		55	3.0	5.4	294.4	51.5
		100	0.0	2.0	287.2	35.5
		200	1.5	3.9	297.9	37.7
		350	3.0	4.5	272.9	41.0
		450	4.5	7.0	267.8	44.0
	ALT-150 Rep	6	372.8	54.7	4.8	2.1
		10	278.8	90.7	5.9	3.4
		14	210.0	69.2	5.7	4.0
		20	130.4	85.7	9.6	12.7
		45	42.3	35.6	15.7	13.2
		55	59.7	61.6	26.6	17.5
		100	33.9	36.9	18.2	12.9
		200	20.6	37.8	19.3	17.2
		350	0.0	18.9	23.0	17.6
		450	5.1	18.7	15.3	12.4
	ALT-50 Rep	6	386.7	58.2	4.8	3.1
		10	276.8	77.6	24.3	5.6
		14	149.1	56.5	41.2	12.0
		20	107.9	62.8	43.0	12.0
		45	61.4	57.1	56.4	19.4
		55	48.5	44.0	57.8	22.9
		100	19.9	25.0	56.8	13.9
		200	17.0	32.5	46.0	22.9
		350	10.5	27.4	40.3	16.1
		450	9.3	26.4	52.5	23.2
	ALT-17 Rep	6	264.5	32.1	73.1	25.7
		10	107.5	32.7	159.6	47.5
		14	67.4	17.4	149.2	39.1
		20	47.2	21.9	168.5	48.2
		45	31.4	18.6	160.3	55.5
		55	27.1	15.5	169.1	49.8
		100	5.5	10.4	175.0	53.5
		200	5.7	12.3	174.6	59.7
		350	8.5	9.3	178.6	55.2
		450	4.3	9.3	188.8	54.5
R30	ALT-EXT	6	338.1	15.6	0.0	0.0
		10	239.2	12.2	0.0	0.0
		14	186.5	12.5	0.0	0.0
		20	123.6	12.2	0.0	0.0
		45	54.6	12.9	0.0	0.6
		55	58.7	12.4	0.0	0.5
		100	30.7	15.0	0.0	1.1
		200	16.5	12.2	0.0	1.7
		350	6.3	11.8	0.0	1.1
		450	12.7	13.4	0.0	1.3
	ALT-350	6	307.1	14.8	0.0	0.0
		10	244.8	18.1	0.0	0.0
		14	182.0	25.5	2.8	0.7
		20	142.1	28.6	6.9	1.0
		45	76.9	32.4	4.0	2.3
		55	68.8	32.0	9.3	2.3
		100	46.8	29.3	3.9	3.1
		200	14.2	25.2	10.4	3.9
		350	11.5	26.5	10.2	3.6
		450	10.1	24.3	5.1	4.6

APPENDIX

(*Continued*)

Subject	Condition	VI value (s)	Target alternative: Reinforcers per hour	Target alternative: Responses per minute	Second alternative: Reinforcers per hour	Second alternative: Responses per minute
	ALT-150	6	323.1	19.6	0.0	0.0
		10	266.1	37.0	4.5	0.5
		14	199.7	28.7	2.9	0.9
		20	148.5	33.7	9.7	1.1
		45	67.7	27.5	17.2	3.4
		55	52.9	21.1	18.4	3.9
		100	35.1	22.8	16.9	4.8
		200	21.9	23.2	18.0	5.6
		350	12.8	20.0	17.9	5.5
		450	5.1	19.2	20.5	5.6
	ALT-75	6	344.3	21.9	0.0	0.0
		10	239.9	25.8	10.5	1.3
		14	194.2	25.0	10.1	1.5
		20	139.5	27.4	11.1	3.1
		45	58.7	23.2	31.9	6.0
		55	51.6	22.0	27.8	7.2
		100	39.8	20.9	42.5	7.8
		200	14.3	17.6	38.9	10.1
		350	13.0	15.7	41.7	8.5
		450	5.2	15.6	42.7	10.7
	ALT-50	6	462.3	67.7	11.9	2.6
		10	279.9	60.4	30.4	5.8
		14	211.9	54.4	38.3	5.1
		20	135.9	51.0	32.1	7.7
		45	63.7	36.5	48.7	8.7
		55	53.7	32.4	54.0	8.7
		100	33.2	28.8	46.3	8.9
		200	14.4	23.5	51.1	10.1
		350	11.8	23.8	56.6	10.2
		450	15.9	23.6	62.1	11.1
	ALT-17	6	356.7	29.5	4.7	0.3
		10	157.7	23.4	79.1	5.2
		14	129.1	23.4	62.3	4.7
		20	72.9	21.6	93.4	8.1
		45	53.4	20.1	85.2	8.0
		55	17.9	9.8	131.2	10.4
		100	17.9	11.6	120.9	10.8
		200	6.8	9.4	137.8	12.5
		350	8.2	9.5	130.8	13.7
		450	6.9	9.9	142.4	13.6
	ALT-10	6	256.2	18.1	65.2	4.4
		10	154.3	15.1	70.4	4.8
		14	81.6	10.9	131.6	8.8
		20	50.4	7.7	165.4	8.3
		45	19.9	4.7	181.1	10.6
		55	21.2	6.7	180.1	9.3
		100	4.3	4.0	203.1	11.3
		200	9.9	5.5	175.0	10.1
		350	2.8	3.7	195.0	11.1
		450	1.4	3.9	191.6	10.9
	ALT-150 Rep	6	310.8	17.8	0.0	0.0
		10	232.8	22.8	1.4	0.1
		14	185.3	14.5	0.0	0.2
		20	142.0	23.3	5.5	0.8
		45	70.1	22.9	12.0	5.4
		55	45.8	16.7	10.4	8.9
		100	28.6	17.2	29.9	10.4
		200	20.5	18.0	15.4	10.4

APPENDIX

(*Continued*)

			Target alternative		Second alternative	
Subject	Condition	VI value (s)	Reinforcers per hour	Responses per minute	Reinforcers per hour	Responses per minute
		350	10.2	17.2	17.9	8.9
		450	5.1	15.2	17.9	11.0
	ALT-50 Rep	6	301.2	12.3	0.0	0.8
		10	216.0	13.3	1.4	1.1
		14	169.4	12.5	2.8	0.3
		20	122.4	15.0	16.5	2.0
		45	39.7	9.0	45.2	4.6
		55	35.6	10.7	36.8	6.7
		100	39.6	10.2	39.7	5.1
		200	15.7	10.2	48.3	8.1
		350	7.8	11.6	39.0	14.0
		450	2.6	9.1	59.1	9.2
	ALT-17 Rep	6	321.9	24.4	1.6	0.2
		10	200.9	21.3	46.9	5.0
		14	156.3	23.5	39.7	3.3
		20	92.3	20.5	76.8	8.4
		45	40.5	11.0	127.2	12.7
		55	27.9	12.5	138.1	15.7
		100	17.9	13.7	131.2	15.3
		200	11.0	13.4	136.5	15.5
		350	12.6	11.9	155.1	15.5
		450	7.0	10.0	142.2	14.4
R31	ALT-EXT	6	509.5	100.8	0.0	0.0
		10	330.5	112.6	0.0	0.1
		14	241.0	115.6	0.0	0.0
		20	178.5	88.7	0.0	0.2
		45	62.9	49.3	0.0	0.2
		55	54.8	55.1	0.0	0.5
		100	38.8	40.7	0.0	0.2
		200	24.3	18.2	0.0	0.1
		350	10.1	18.8	0.0	0.4
		450	12.7	25.5	0.0	0.3
	ALT-350	6	527.1	97.9	3.4	1.2
		10	321.1	128.4	7.7	4.5
		14	240.9	127.7	10.3	5.0
		20	178.0	132.7	8.5	6.7
		45	85.1	102.1	2.7	9.1
		55	52.5	67.6	9.2	8.0
		100	38.9	47.4	9.0	9.0
		200	14.0	38.8	6.4	8.3
		350	10.2	41.8	7.6	10.3
		450	6.3	26.5	2.5	6.7
	ALT-150	6	472.5	80.4	21.8	10.0
		10	321.8	109.6	28.3	15.1
		14	224.9	88.8	14.7	13.6
		20	153.5	95.5	28.2	19.6
		45	71.0	73.7	22.6	23.6
		55	51.2	43.1	18.4	15.7
		100	34.2	22.3	18.4	14.1
		200	19.3	27.3	12.9	15.0
		350	11.5	19.8	15.3	14.2
		450	7.7	14.4	16.6	10.2
	ALT-75	6	433.4	55.1	31.5	14.0
		10	297.3	83.0	46.5	23.9
		14	230.6	86.6	43.3	28.2
		20	160.8	81.7	38.5	31.4
		45	74.8	55.4	37.0	34.3
		55	59.5	47.5	45.8	29.9

APPENDIX

(*Continued*)

Subject	Condition	VI value (s)	Target alternative: Reinforcers per hour	Target alternative: Responses per minute	Second alternative: Reinforcers per hour	Second alternative: Responses per minute
		100	31.6	35.7	39.4	32.0
		200	15.8	30.5	50.1	35.2
		350	14.2	24.1	37.7	26.5
		450	13.1	25.8	47.0	36.5
	ALT-50	6	503.1	99.3	32.8	8.8
		10	310.2	99.7	45.2	14.2
		14	232.0	108.5	50.9	14.2
		20	154.1	94.3	48.5	21.9
		45	68.2	69.5	60.2	27.6
		55	74.1	73.7	61.8	23.5
		100	40.3	41.6	59.2	30.1
		200	9.2	32.0	59.1	34.0
		350	12.2	27.7	69.3	41.7
		450	14.4	43.9	52.4	35.0
	ALT-17	6	409.9	53.3	99.9	26.3
		10	245.4	55.0	146.6	47.2
		14	183.2	62.6	144.2	49.4
		20	121.7	46.6	183.4	69.8
		45	67.4	42.1	172.0	80.5
		55	48.9	34.2	157.0	73.9
		100	26.1	23.3	198.3	84.4
		200	12.8	26.3	177.0	91.0
		350	9.9	20.8	181.5	88.9
		450	11.2	15.7	175.6	81.8
	ALT-10	6	385.2	53.7	65.9	17.7
		10	117.8	38.6	250.1	61.7
		14	94.8	40.6	259.1	64.7
		20	70.4	28.8	285.4	73.1
		45	37.4	16.5	297.6	66.5
		55	30.0	14.2	262.2	61.8
		100	21.3	14.1	278.3	69.7
		200	12.1	12.6	283.7	72.1
		350	6.0	15.9	284.0	83.5
		450	4.5	12.6	302.4	92.8
	ALT-150 Rep	6	464.3	68.0	5.0	0.8
		10	318.2	105.1	12.3	7.5
		14	251.4	103.4	11.8	7.4
		20	160.0	99.7	16.8	11.5
		45	86.1	80.1	21.5	16.4
		55	58.5	60.8	23.9	13.4
		100	31.0	37.6	18.2	18.4
		200	24.5	28.0	19.3	15.9
		350	3.8	17.3	14.0	11.7
		450	9.0	26.8	20.5	19.8
	ALT-50 Rep	6	507.6	79.3	6.8	1.9
		10	320.5	105.0	13.9	5.1
		14	236.7	105.9	26.6	11.1
		20	167.4	110.4	27.1	9.6
		45	66.8	74.4	28.3	15.0
		55	67.0	77.0	55.6	26.4
		100	43.9	66.5	46.6	30.6
		200	19.8	40.0	54.5	26.2
		350	13.0	22.4	19.7	13.4
		450	7.8	32.0	40.5	28.2
	ALT-17 Rep	6	383.9	45.6	16.1	5.8
		10	282.0	74.0	61.9	28.2
		14	207.8	86.6	98.8	37.9
		20	127.6	72.2	118.5	58.2

APPENDIX

(*Continued*)

Subject	Condition	VI value (s)	Target alternative: Reinforcers per hour	Target alternative: Responses per minute	Second alternative: Reinforcers per hour	Second alternative: Responses per minute
		45	56.7	58.4	174.1	89.6
		55	62.1	52.1	155.6	67.4
		100	28.7	37.5	183.6	91.4
		200	27.2	40.8	177.0	96.2
		350	10.0	33.7	179.9	101.6
		450	12.9	34.3	185.4	102.8
R32	ALT-EXT	6	495.9	70.4	0.0	0.2
		10	308.5	85.7	0.0	0.1
		14	241.5	84.7	0.0	0.9
		20	161.3	92.9	0.0	0.9
		45	69.8	69.4	0.0	3.0
		55	67.1	65.7	0.0	3.5
		100	37.4	47.6	0.0	3.2
		200	10.1	25.6	0.0	6.1
		350	17.8	35.1	0.0	4.8
		450	5.1	25.9	0.0	4.7
	ALT-350	6	479.1	80.0	0.0	0.2
		10	308.8	100.3	1.5	1.3
		14	203.7	102.8	7.2	2.5
		20	153.1	97.4	9.8	4.9
		45	74.8	73.6	11.9	12.3
		55	49.8	73.5	10.4	12.0
		100	24.4	47.0	8.9	14.4
		200	23.0	46.8	6.4	14.5
		350	8.9	30.4	6.3	13.4
		450	10.1	37.1	7.6	15.2
	ALT-150	6	479.7	75.9	3.3	1.3
		10	301.8	97.6	12.2	4.3
		14	213.1	86.6	14.5	7.5
		20	143.8	88.7	5.6	9.7
		45	69.3	73.4	17.2	17.5
		55	81.9	75.2	18.9	13.9
		100	29.8	39.7	20.7	23.9
		200	23.3	40.9	22.0	24.7
		350	9.1	29.3	25.7	30.8
		450	0.0	13.1	22.9	22.2
	ALT-75	6	485.8	100.5	10.1	2.8
		10	314.0	104.1	18.5	7.1
		14	223.4	102.6	27.9	8.9
		20	142.0	96.5	36.6	15.3
		45	54.5	64.5	29.3	28.7
		55	42.7	59.2	49.2	33.5
		100	20.8	37.6	32.5	39.3
		200	13.1	31.8	47.1	52.9
		350	6.5	22.6	45.5	43.0
		450	3.9	22.8	48.3	43.4
	ALT-50	6	480.0	75.7	5.0	6.2
		10	283.5	81.8	28.9	18.0
		14	217.4	81.7	22.0	20.8
		20	142.1	59.8	51.3	42.8
		45	64.2	44.4	60.4	58.4
		55	59.0	43.1	76.9	58.6
		100	28.0	32.5	59.9	59.9
		200	15.8	28.7	59.4	57.9
		350	7.9	25.9	60.4	65.4
		450	2.6	24.3	64.6	73.2
	ALT-17	6	227.9	47.4	142.0	72.4
		10	113.6	41.8	92.9	65.4

APPENDIX

(*Continued*)

Subject	Condition	VI value (s)	Target alternative: Reinforcers per hour	Target alternative: Responses per minute	Second alternative: Reinforcers per hour	Second alternative: Responses per minute
		14	134.9	57.7	121.8	66.2
		20	33.4	27.3	154.8	80.0
		45	23.1	13.4	164.9	99.7
		55	18.2	14.8	165.2	112.5
		100	20.1	13.7	197.2	108.3
		200	8.4	7.4	164.5	99.9
		350	11.4	8.9	155.2	105.3
		450	5.7	8.0	188.9	115.9
	ALT-10	6	0.0	0.1	287.0	119.1
		10	0.0	0.0	313.8	124.4
		14	4.7	1.5	336.2	118.7
		20	9.2	1.6	295.7	116.1
		45	0.0	0.0	301.7	116.0
		55	0.0	0.6	312.7	120.0
		100	1.5	1.1	299.3	113.6
		200	0.0	0.3	325.9	124.6
		350	0.0	0.1	292.0	119.6
		450	0.0	0.0	336.2	115.9
	ALT-150 Rep	6	456.3	71.8	5.0	0.6
		10	290.5	91.4	3.0	1.0
		14	209.2	87.7	10.1	2.7
		20	138.3	91.7	13.9	3.8
		45	62.2	66.3	13.2	10.2
		55	53.1	51.1	21.1	16.0
		100	25.9	27.6	14.1	19.0
		200	10.3	17.3	31.0	30.7
		350	3.8	9.4	15.3	19.7
		450	3.8	11.1	16.5	29.1
	ALT-50 Rep	6	443.8	61.5	8.1	5.4
		10	308.3	86.0	16.9	4.9
		14	200.0	81.5	26.2	6.5
		20	140.0	82.0	32.2	12.9
		45	54.0	49.6	49.8	35.0
		55	59.7	54.8	51.6	24.9
		100	36.3	40.7	70.2	55.0
		200	18.4	27.0	55.5	50.2
		350	6.6	16.0	76.9	61.9
		450	5.1	14.1	45.6	46.8
	ALT-17 Rep	6	295.6	47.3	82.0	51.5
		10	229.8	84.3	58.2	30.6
		14	160.5	63.9	93.4	58.3
		20	88.8	55.0	115.5	77.2
		45	45.9	28.2	165.5	103.9
		55	27.0	25.3	172.7	112.6
		100	12.8	9.5	177.0	134.2
		200	8.7	5.9	219.2	127.6
		350	0.0	1.5	188.2	138.8
		450	1.4	3.8	201.5	140.5
R33	ALT-EXT	6	426.6	41.8	0.0	0.0
		10	323.2	64.4	0.0	0.0
		14	254.7	81.7	0.0	0.1
		20	176.9	86.9	0.0	0.9
		45	68.3	71.5	0.0	2.9
		55	76.8	86.1	0.0	0.7
		100	29.5	52.9	0.0	5.5
		200	23.0	51.0	0.0	3.8
		350	5.1	37.6	0.0	4.0
		450	10.1	40.4	0.0	3.9

APPENDIX

(*Continued*)

Subject	Condition	VI value (s)	Target alternative: Reinforcers per hour	Target alternative: Responses per minute	Second alternative: Reinforcers per hour	Second alternative: Responses per minute
	ALT-350	6	519.1	82.7	0.0	0.7
		10	334.4	103.9	0.0	1.8
		14	241.1	112.3	0.0	2.7
		20	175.8	110.0	4.2	3.8
		45	82.3	99.8	4.0	9.0
		55	48.4	86.3	7.9	14.4
		100	36.0	72.2	2.6	16.7
		200	19.2	57.9	5.1	17.8
		350	8.9	51.7	6.3	21.3
		450	5.1	54.8	8.9	23.1
	ALT-150	6	473.9	67.7	0.0	1.7
		10	322.2	113.4	4.6	7.2
		14	218.7	97.6	7.2	8.5
		20	168.6	107.3	9.9	13.1
		45	66.2	93.2	14.7	24.5
		55	63.4	75.1	9.3	22.1
		100	32.5	60.1	11.7	26.4
		200	16.9	59.5	21.9	30.0
		350	12.8	55.2	16.6	31.8
		450	6.4	41.4	27.0	35.3
	ALT-75	6	476.5	64.0	0.0	2.3
		10	311.0	90.7	4.6	5.0
		14	246.2	91.7	11.8	11.7
		20	159.9	105.6	15.5	15.7
		45	56.2	68.7	41.3	41.3
		55	52.4	67.8	51.1	41.3
		100	32.9	57.1	43.4	48.7
		200	11.6	44.6	40.3	46.3
		350	7.7	42.0	43.0	52.6
		450	9.0	38.7	34.8	50.3
	ALT-50	6	454.6	52.5	1.6	3.6
		10	317.6	63.0	9.3	6.6
		14	212.3	69.5	21.8	9.8
		20	149.1	71.2	31.0	13.6
		45	69.5	51.3	51.5	25.8
		55	67.2	48.3	41.9	25.5
		100	36.3	43.6	67.3	28.3
		200	14.3	33.0	45.6	36.5
		350	6.6	28.1	59.2	35.3
		450	6.6	28.5	54.9	37.9
	ALT-17	6	383.5	37.6	14.5	7.2
		10	258.3	49.9	39.2	18.6
		14	183.7	54.1	81.9	23.8
		20	109.4	50.7	107.9	42.6
		45	38.5	37.0	159.5	68.0
		55	43.9	29.5	153.9	69.6
		100	12.8	15.5	186.7	81.9
		200	7.2	16.4	203.9	89.0
		350	0.0	10.2	196.2	90.5
		450	7.0	15.1	157.7	84.1
	ALT-10	6	388.3	38.4	12.4	2.7
		10	240.2	43.8	60.7	9.7
		14	136.1	43.0	152.7	34.9
		20	41.4	18.8	234.5	35.4
		45	30.5	24.5	230.0	46.3
		55	22.0	18.1	241.5	42.1
		100	18.2	14.2	281.3	48.5
		200	4.5	9.4	271.1	69.9

APPENDIX

(*Continued*)

			Target alternative		Second alternative	
Subject	Condition	VI value (s)	Reinforcers per hour	Responses per minute	Reinforcers per hour	Responses per minute
		350	3.1	9.0	311.1	51.9
		450	3.0	9.3	288.7	62.7
	ALT-150 Rep	6	429.5	39.1	0.0	0.1
		10	298.2	65.7	3.0	0.7
		14	228.3	75.8	5.8	2.5
		20	169.7	81.2	5.6	5.5
		45	90.3	75.5	20.2	12.6
		55	55.6	58.9	26.4	19.1
		100	18.0	37.2	12.8	26.2
		200	19.3	31.4	25.9	27.5
		350	16.8	31.7	23.2	27.7
		450	11.5	38.0	17.9	31.5
	ALT-50 Rep	6	422.3	36.0	0.0	0.1
		10	300.9	57.0	0.0	0.1
		14	220.1	68.7	7.3	0.9
		20	168.4	75.7	21.3	5.3
		45	76.1	56.4	43.4	17.6
		55	62.0	59.8	44.4	16.0
		100	40.2	44.7	60.3	27.6
		200	11.8	34.5	61.9	33.2
		350	11.8	39.9	56.3	37.5
		450	10.5	29.1	48.3	29.0
	ALT-17 Rep	6	388.6	36.9	4.8	2.5
		10	251.8	62.5	54.5	13.6
		14	191.3	48.9	74.2	22.1
		20	107.3	43.5	134.2	46.9
		45	36.1	25.9	173.3	51.1
		55	30.2	20.7	172.9	58.1
		100	31.5	19.1	179.7	56.5
		200	5.7	15.3	188.8	64.5
		350	11.3	17.1	172.1	56.9
		450	4.2	15.6	176.1	63.4
R34	ALT-EXT	6	496.3	78.7	0.0	0.0
		10	306.5	115.8	0.0	0.0
		14	256.8	131.8	0.0	0.1
		20	170.6	115.9	0.0	0.2
		45	79.4	89.5	0.0	0.6
		55	58.7	83.0	0.0	0.6
		100	26.8	39.3	0.0	0.6
		200	21.6	31.3	0.0	0.6
		350	8.8	15.5	0.0	0.3
		450	14.0	31.1	0.0	0.5
	ALT-350	6	519.4	109.9	1.7	0.6
		10	316.4	118.0	3.1	1.6
		14	229.6	119.3	2.9	4.0
		20	159.2	118.6	8.4	5.6
		45	85.5	96.7	5.4	10.0
		55	50.0	64.3	7.8	10.1
		100	24.5	41.7	11.6	11.4
		200	14.0	27.3	10.3	12.2
		350	10.2	19.6	8.9	10.5
		450	3.8	28.9	7.6	10.8
	ALT-150	6	491.7	88.0	0.0	0.2
		10	279.1	121.8	7.5	5.4
		14	232.9	107.0	20.7	4.0
		20	147.1	107.2	23.9	12.2
		45	59.9	69.7	26.5	15.0
		55	29.8	38.7	23.3	14.6

APPENDIX

(*Continued*)

Subject	Condition	VI value (s)	Target alternative: Reinforcers per hour	Target alternative: Responses per minute	Second alternative: Reinforcers per hour	Second alternative: Responses per minute
		100	31.0	46.1	16.8	14.0
		200	19.2	27.1	19.3	13.1
		350	9.0	23.9	25.6	13.1
		450	2.5	17.8	20.4	9.4
	ALT-75	6	457.6	82.6	1.7	1.4
		10	319.5	119.7	26.4	5.1
		14	223.3	105.6	35.2	10.5
		20	138.9	88.1	35.1	15.3
		45	76.0	72.2	46.2	24.2
		55	62.7	64.0	32.1	23.9
		100	18.3	34.8	47.3	23.6
		200	9.1	22.3	41.6	22.2
		350	7.8	20.6	41.7	16.9
		450	5.2	20.8	34.8	18.1
	ALT-50	6	444.6	65.6	18.4	3.1
		10	299.0	85.8	35.5	8.9
		14	197.9	70.5	57.4	10.8
		20	131.8	64.6	49.7	13.0
		45	61.9	43.8	48.5	14.0
		55	42.6	32.7	48.0	14.3
		100	22.7	32.8	58.4	15.8
		200	15.9	26.1	47.3	14.3
		350	7.7	20.5	47.3	14.7
		450	14.4	24.0	43.1	12.0
	ALT-17	6	251.6	42.6	109.7	22.2
		10	178.8	45.6	145.5	27.9
		14	124.2	37.1	139.0	33.7
		20	76.5	19.1	176.5	41.6
		45	53.9	22.4	178.6	44.1
		55	35.1	15.4	202.4	42.7
		100	31.8	13.5	184.2	48.5
		200	11.3	12.7	178.4	47.0
		350	8.7	9.4	215.8	54.4
		450	5.6	10.0	165.3	46.4
	ALT-10	6	141.5	23.6	209.0	31.2
		10	103.3	36.6	247.2	42.0
		14	45.8	23.8	270.0	42.7
		20	29.3	13.2	288.2	46.1
		45	12.1	7.5	290.7	43.3
		55	4.5	5.6	308.0	52.5
		100	4.6	2.7	309.2	48.4
		200	4.5	6.0	304.3	48.6
		350	3.0	3.9	301.4	50.9
		450	0.0	2.5	308.5	44.8
	ALT-150 Rep	6	463.6	67.2	1.7	0.4
		10	305.2	98.1	3.1	1.5
		14	216.1	89.6	11.6	4.1
		20	141.4	61.8	11.1	6.8
		45	70.4	55.9	13.2	9.1
		55	52.5	60.8	18.4	16.4
		100	33.6	33.4	13.0	14.9
		200	15.3	37.0	11.6	8.5
		350	14.1	29.0	16.7	11.6
		450	12.9	22.2	18.0	13.6
	ALT-50 Rep	6	464.4	76.0	5.0	0.6
		10	325.2	97.7	7.8	1.9
		14	206.8	90.1	16.0	5.2
		20	160.6	107.3	37.2	10.1

APPENDIX

(*Continued*)

Subject	Condition	VI value (s)	Target alternative: Reinforcers per hour	Target alternative: Responses per minute	Second alternative: Reinforcers per hour	Second alternative: Responses per minute
		45	65.2	64.6	47.4	20.5
		55	52.5	58.5	48.4	17.8
		100	27.7	34.3	53.0	18.6
		200	5.2	17.1	73.2	27.4
		350	10.4	21.2	43.1	28.0
		450	13.0	23.8	51.2	20.1
	ALT-17 Rep	6	419.3	59.1	18.2	2.0
		10	200.7	47.7	105.0	27.4
		14	131.9	47.8	112.6	29.1
		20	85.6	41.4	146.7	38.8
		45	41.5	26.3	168.5	48.0
		55	21.4	10.4	178.2	49.6
		100	28.2	20.6	164.1	48.1
		200	11.4	13.9	196.4	51.8
		350	8.4	14.9	176.5	49.0
		450	8.6	11.9	191.3	48.8
R35	ALT-EXT	6	266.9	14.2	0.0	0.1
		10	249.5	28.0	0.0	1.5
		14	186.5	25.7	0.0	4.7
		20	104.8	20.7	0.0	4.8
		45	64.8	17.0	0.0	5.2
		55	45.2	20.4	0.0	5.0
		100	34.7	13.1	0.0	3.8
		200	21.7	8.3	0.0	1.6
		350	10.1	6.8	0.0	1.3
		450	7.6	6.6	0.0	1.1
	ALT-350	6	282.6	18.7	1.5	0.2
		10	264.6	42.3	7.4	6.0
		14	199.9	42.0	4.3	7.2
		20	137.5	32.5	5.5	6.3
		45	85.2	29.8	6.7	9.5
		55	68.7	32.0	6.5	8.8
		100	37.6	24.5	7.7	9.3
		200	19.3	23.7	10.2	9.2
		350	16.8	26.3	12.9	11.5
		450	11.4	25.5	3.8	8.1
	ALT-150	6	223.2	10.1	4.4	1.7
		10	204.1	14.7	11.5	5.9
		14	150.7	19.0	15.4	9.9
		20	125.6	20.2	6.8	13.8
		45	68.0	21.2	20.1	17.2
		55	55.6	22.5	18.5	18.3
		100	40.4	18.3	18.3	17.1
		200	15.5	18.4	24.6	16.6
		350	16.7	17.5	20.5	18.7
		450	3.8	15.1	20.4	17.6
	ALT-75	6	193.9	6.8	7.1	2.1
		10	182.2	11.8	14.4	6.1
		14	145.6	13.4	26.7	11.9
		20	105.5	12.8	31.5	14.7
		45	71.4	17.4	39.1	22.3
		55	45.5	15.4	41.2	23.1
		100	32.7	15.6	34.1	24.5
		200	15.7	14.9	37.8	22.1
		350	10.4	12.9	37.5	24.8
		450	11.8	12.2	45.8	26.8
	ALT-50	6	261.6	19.9	18.6	4.2
		10	252.1	33.2	31.6	9.6

APPENDIX

(*Continued*)

			Target alternative		Second alternative	
Subject	Condition	VI value (s)	Reinforcers per hour	Responses per minute	Reinforcers per hour	Responses per minute
		14	175.6	17.1	25.8	5.9
		20	130.6	17.0	43.7	9.7
		45	60.5	18.0	43.0	14.5
		55	41.2	13.3	46.5	15.7
		100	48.0	14.3	48.3	14.5
		200	13.1	14.8	51.2	16.1
		350	9.1	12.8	46.8	16.1
		450	6.6	12.9	68.4	16.5
	ALT-17	6	167.8	7.2	70.0	13.9
		10	93.9	5.4	100.9	17.9
		14	81.3	7.2	104.6	24.7
		20	46.5	4.4	141.8	23.4
		45	28.0	6.1	147.7	29.5
		55	21.2	5.2	162.1	32.4
		100	22.3	4.3	142.2	27.5
		200	15.3	7.1	146.1	31.3
		350	4.2	4.0	165.0	30.9
		450	5.6	5.0	153.0	35.0
	ALT-10	6	148.4	15.8	153.4	52.0
		10	87.7	16.4	198.2	58.0
		14	33.2	8.9	248.2	73.0
		20	42.4	11.0	208.9	68.0
		45	27.0	10.0	257.6	76.8
		55	20.7	8.0	237.9	55.2
		100	8.9	6.5	247.9	59.8
		200	10.5	10.3	275.9	92.1
		350	5.8	6.0	254.0	54.9
		450	3.0	7.3	272.8	80.8
	ALT-150 Rep	6	303.1	29.6	1.5	1.0
		10	168.9	24.2	8.7	4.1
		14	161.7	35.8	11.3	8.0
		20	104.6	29.6	15.1	9.9
		45	50.4	28.4	27.7	17.7
		55	37.9	28.2	11.7	11.0
		100	24.5	19.2	12.9	9.9
		200	8.9	9.8	14.0	8.5
		350	19.2	15.9	11.6	9.9
		450	1.3	13.7	12.7	10.7
	ALT-50 Rep	6	269.8	22.9	15.7	5.2
		10	219.8	34.1	42.0	17.1
		14	144.4	40.8	55.6	22.2
		20	133.3	40.0	50.8	28.2
		45	50.0	28.3	36.1	23.6
		55	48.3	25.5	50.2	25.9
		100	23.3	14.9	25.3	21.2
		200	27.9	29.6	61.8	44.3
		350	15.7	23.3	51.1	42.3
		450	11.6	14.4	32.9	24.7
	ALT-17 Rep	6	194.0	13.2	59.0	14.6
		10	146.8	26.1	57.9	20.4
		14	74.5	19.2	100.3	45.0
		20	59.7	16.4	138.6	36.6
		45	49.6	18.5	145.0	62.2
		55	33.8	15.5	121.7	62.5
		100	26.6	18.3	144.2	45.4
		200	18.2	17.3	155.7	67.8
		350	4.0	7.9	142.1	50.7
		450	4.2	13.4	163.7	64.8

APPENDIX

(*Continued*)

Subject	Condition	VI value (s)	Target alternative		Second alternative	
			Reinforcers per hour	Responses per minute	Reinforcers per hour	Responses per minute
R36	ALT-EXT	6	445.4	74.1	0.0	0.0
		10	319.3	96.3	0.0	0.0
		14	231.0	105.8	0.0	0.3
		20	170.6	97.9	0.0	0.4
		45	82.6	64.3	0.0	1.6
		55	53.5	51.3	0.0	1.2
		100	28.1	19.7	0.0	1.0
		200	17.9	15.7	0.0	1.7
		350	15.2	18.9	0.0	0.9
		450	7.6	12.8	0.0	1.0
	ALT-350	6	456.6	66.6	0.0	0.3
		10	311.6	92.4	7.6	1.4
		14	205.4	74.3	1.5	0.9
		20	165.3	91.7	7.1	2.6
		45	52.1	50.1	1.3	2.0
		55	30.1	39.2	6.6	2.7
		100	23.3	32.4	1.3	2.2
		200	8.9	18.6	7.6	2.5
		350	8.9	17.3	10.3	2.8
		450	2.5	11.0	1.3	1.8
	ALT-150	6	446.7	84.5	0.0	0.1
		10	326.9	117.0	0.0	0.7
		14	226.1	92.2	0.0	1.2
		20	118.7	70.6	12.2	2.6
		45	58.2	42.6	14.5	2.6
		55	27.4	23.7	9.1	2.1
		100	31.1	36.9	6.5	2.5
		200	16.6	20.5	6.3	2.9
		350	12.8	19.4	15.3	3.6
		450	5.1	13.3	6.3	1.2
	ALT-75	6	419.0	58.2	9.4	0.9
		10	304.0	72.5	15.3	3.5
		14	142.1	49.4	18.5	3.3
		20	124.8	58.0	34.6	7.1
		45	41.6	29.5	31.7	7.1
		55	31.7	20.1	46.4	8.0
		100	9.1	13.3	29.7	5.7
		200	18.3	19.3	29.8	7.8
		350	7.9	11.0	39.0	8.4
		450	3.9	10.5	28.3	5.9
	ALT-50	6	421.6	74.6	40.1	10.8
		10	317.6	82.4	35.8	12.2
		14	217.8	70.4	56.9	16.9
		20	139.7	51.1	45.2	15.9
		45	74.6	39.8	70.4	17.0
		55	43.6	19.9	27.7	9.6
		100	23.6	19.2	44.9	13.8
		200	11.6	15.1	36.2	10.3
		350	5.2	10.6	34.9	8.8
		450	10.4	14.4	48.2	13.2
	ALT-17	6	409.3	68.2	40.9	7.2
		10	203.9	61.2	70.4	11.0
		14	203.7	72.0	42.6	8.4
		20	98.0	44.6	89.3	20.4
		45	52.2	32.7	125.0	24.8
		55	42.3	24.5	133.5	27.4
		100	25.1	20.4	139.4	31.9
		200	19.8	19.5	163.7	41.4

APPENDIX

(*Continued*)

			Target alternative		Second alternative	
Subject	Condition	VI value (s)	Reinforcers per hour	Responses per minute	Reinforcers per hour	Responses per minute
		350	8.3	11.1	139.7	33.4
		450	4.0	8.2	129.7	33.0
	ALT-10	6	0.0	0.1	290.3	52.7
		10	55.3	13.9	245.5	53.7
		14	0.0	0.1	286.9	58.0
		20	0.0	0.0	299.6	62.8
		45	3.0	0.6	287.7	65.5
		55	4.5	1.7	259.3	52.2
		100	4.3	2.4	285.1	60.9
		200	0.0	0.7	286.4	59.1
		350	0.0	0.4	277.9	60.0
		450	0.0	0.1	299.0	57.8
	ALT-150 Rep	6	336.8	48.6	1.7	0.2
		10	306.8	89.7	0.0	0.2
		14	226.9	92.2	7.3	1.1
		20	114.1	70.8	4.2	2.9
		45	43.7	38.2	10.6	4.1
		55	49.9	41.1	18.4	10.5
		100	28.5	24.6	18.2	7.8
		200	5.1	5.5	7.6	2.5
		350	7.6	8.4	8.9	3.5
		450	3.8	9.6	15.2	7.1
	ALT-50 Rep	6	414.9	54.6	1.6	0.1
		10	301.3	90.1	1.5	0.6
		14	221.1	95.0	2.9	2.0
		20	145.6	91.4	22.3	5.4
		45	63.2	55.9	41.7	11.8
		55	53.4	35.9	40.2	16.2
		100	18.5	15.3	50.2	17.8
		200	13.3	13.3	56.7	22.9
		350	2.5	11.6	24.6	13.4
		450	7.8	10.4	44.6	22.2
	ALT-17 Rep	6	285.9	33.9	50.7	19.8
		10	247.5	78.9	31.6	11.7
		14	160.0	66.8	65.8	20.8
		20	79.6	38.3	123.5	42.6
		45	16.8	10.4	168.1	52.3
		55	21.0	9.8	157.8	52.3
		100	8.4	8.3	176.4	49.6
		200	18.4	12.3	168.3	54.7
		350	4.2	5.9	153.7	53.0
		450	6.9	7.5	157.7	59.0