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Molar and local effects of the fixed-ratio changeover requirement on choice, changeovers, and visits: A parametric examination of the fixed-ratio changeover requirement

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MOLAR AND LOCAL EFFECTS OF THE FIXED-RATIO CHANGEOVER REQUIREMENT ON CHOICE, CHANGEOVERS, AND VISITS: A PARAMETRIC EXAMINATION OF THE FIXED-RATIO CHANGEOVER REQUIREMENT

by
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BS, Brigham Young University, 1988
MS, Brigham Young University, 1990

DISSERTATION

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DEDICATION

Dedicated to my "mothers": Elodie, the woman who birthed me and seemingly could spell all the words I could not; Deena, the woman who loves me, birthed our children, and taught me that spelling skills are not the only intellectual skills; Blair, Brooke, and Whitney, my daughters who greet me with smiles, hugs, and kisses as they learn the relations between letters, sounds, and ideas, despite *Dad's* continual instruction; and Hal Miller, the man who mid-wifed my intellectual birth. May we all one day rejoice in that day of rejoicing.

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As with any human endeavor, this project would have never come to fruition were it not for the companionship, encouragement, and tutelage of others.

My academic interest in the experimental analysis of choice began when Harold Miller gave a seemingly simple answer, while walking a dark hall, to what I thought was a profound question. The question: "Why do individuals sin?" The answer: "Because the immediate rewards outweigh the delayed consequences." Hal's worldly answer to what I thought was a solely religious question occasioned my awakening to the compatibility, when defined in a particular fashion, of the two *Weltangschuungen*. Only recently have I begun to realize the full implications of his answer.

The specific questions addressed in this dissertation grew out of discussions with Billy Baum about how we might better understand choice. My questions were facilitated by Tony Nevin's Graduate Seminar in learning and behavior analysis, and his research grant from the Cambridge Center for Behavioral Studies. My life has been indelibly written upon by Billy and Tony and I am honored to call them my mentors. Along with being scholars and scientists in the strictest senses of the words, they are two of the finest human beings ever to set the occasion for my behavior.

I am fortunate to have had committee members committed to fostering (I promise, Will, only this one time) the development of young academics. Victor was most helpful throughout my years at UNH. Michelle taught a psychology student some things about animal behavior. And Will graciously traveled up from Cambridge twice for merely a dinner and a thank you. I am grateful to them all.

I was privileged to have what amounted to a sixth committee member in fellow graduate student Randy Grace. Our discussions and his willingness to give of his time to assist my work greatly improved this dissertation. Randy was particularly helpful with writing the extraction programs. Without his assistance, I may still be trying to mine the data. Exchanging pigeons will never be as efficient, nor as enjoyable, and few lab discussions will solve as many societal problems.

Other Conant Hall colleagues lent their assistance. Anthony "Ant" Mclean, a visiting scholar from New Zealand, encouraged and instructed at timely moments. Conversation with fellow BYU transplant, Steve Clark, kept religion and science conjoined and me sane. Alex Stevens, Yue Ping Zhang, and Daniel Henderson contributed to the dialogue, and the spice of life. Brad Stone kept the pigeons' home cages clean. Joy Bryan, a fellow Washingtonian, and I became fast friends soon after arrival. It was fortuitous for our desks to be close in the "bull pen." Their friendship and support is cherished.

My deepest appreciation and respect goes to Deena, my wife, and Blair, Brooke, and Whitney, our daughters. Few spouses and family members willingly live in the four room box called "married-student housing." They did so with smiles generally but some

frowns too; both smiles and frowns kept life interesting. My in-laws, Arla and Colonel Ed Beck (Ret.), were most encouraging, even though their grandkids could have been much closer to home had Deena and I settled on Pullman rather than Durham. In a true sense of community, members of our church and Forest Park neighborhood (too many to mention by name) extended their hands in friendship, their arms in support, and their hearts in love. Liz Falvey lent both moral and financial support throughout our stay. If all counseling psychologists were as talented as Liz, they would have much more free time. Thank you is inadequate.

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ABSTRACT

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by

Michael B. Ehlert
University of New Hampshire, December, 1995

The distribution of behavior by organisms in choice situations is of long-standing interest to psychologists. The generalized matching relation accurately predicts choice between concurrent variable-interval schedules of reinforcement. Researchers have assumed, on weak grounds, that the effect of the changeover requirement on sensitivity to reinforcement—the exponent in the generalized matching equation—was consistent. This experiment considered the effects of the changeover requirement by parametrically manipulating the fixed-ratio schedule required to switch alternatives. Pigeons pecked either of two side-response keys in a standard three-key operant chamber for food, delivered according to independent variable-interval schedules. No changeover delay was used, instead completion of five fixed-ratio schedules (FR 0, 2, 6, 12, or 20) on the center-response key alternated the active side key. Five reinforcer ratios (1:1, 1:2, 2:1, 1:4, and 4:1) were paired with most FR schedules. A matching relation analysis indicated that for two pigeons response-allocation sensitivity generally overmatched for all but the FR 0 condition, which undermatched. The other two pigeons' sensitivity increased to overmatching when FR 12 was in force. Excepting FR 0 conditions, time-allocation

sensitivity, on the other hand, decreased from extreme overmatching toward matching as the changeover requirement increased. Reliable changes in response rates to the two alternatives account for the results.

A positive relation between the conditional probability of switching and run length is reported. That is, the greater the number of consecutive pecks to an alternative, the greater the likelihood of switching. This result suggests that behavior is controlled in part by local reinforcement contingencies. I speculate that factors that increase visit duration may increase local control of switching.

The procedure encourages a foraging interpretation. The FR changeover requirement can be considered functionally equivalent to travel between patches. An analysis of visit measures supported earlier evidence that residence measures increase as travel between patches increases. These results together with the matching results suggest that behavior ecologists and operant psychologists are working on similar problems and the traditional tools of operant psychology can be used to simulate travel, an important component of foraging in the wild.

INTRODUCTION

Operant Behavior as Choice

Operant behavior is defined as acts made by organisms that are controlled by the consequences of those acts. The behavior of Thorndike's cats in a puzzle box illustrates operant behavior (Thorndike, 1898). When placed in a small cage outside the reach of appetizing food, cats eventually escaped confinement. The more times the cats were placed in the cage, on average, the shorter the latency to escape. This control by consequences, called the *law of effect*, typifies much of mammalian behavior. Rachlin (1991) argues that because there are almost always multiple behaviors possible, and since organisms generally engage in only one behavior at a time, essentially all operant behavior is choice behavior. Choice, here, means having more than one option available. Organisms must regularly distribute behavior among a variety of activities including sleeping, foraging, eating, and socializing. The questions of interest for operant psychology concern formulating rules that describe and explain choice; that is, why do organisms do the things they do?

Brief History of Psychology and Choice

The study of choice given multiple alternatives is a long-standing interest of psychologists. The so-called *Father* of American psychology, William James, wrote extensively on the topic. In an essay titled "The dilemma of determinism" he presented the classic problem for the study of choice (James, 1962/1896). James gave the example of leaving the building wherein he is lecturing and walking down Divinity Avenue. Suppose, he wrote, that "the powers governing the universe annihilate ten minutes of time with all that it contained, and set me back at the door of this hall just as I was before the choice was made" (p 155). In this second universe, rather than walking down Divinity Avenue, suppose James traverses Oxford Street, that is, he *chose* Oxford over Divinity. A "passive" spectator observing the two universes could not predict, *a priori*, which street James would walk. However, James asserts that any self-respecting determinist must argue that one of the universes, walking Divinity Avenue say, from eternity was not possible.

The problem, as set by James, is predicting behavior at every individual choice point. With Nineteenth-century mechanism as their scientific model, psychologists during the first half of the Twentieth century vigorously pursued the momentary causes of behavior. The predominant methodology involved rats running through mazes with several choice points. Which choice—left or right—the subject made at each choice-point, whether the choice moved it closer to the goal box, and the latency to run the maze were all recorded. When a few rats took a novel, more direct route to the goal box after being trained on a longer route, Tolman (1938), looking for an immediate cause to individual choices, postulated an internal cognitive map. Inferring a map present in a rat's mind is necessary only if an immediate cause is sought and the rat's history is ignored. The rats had a history of getting food from a particular location. Acknowledging that history frees one from the need to postulate an internal cause.

The free-operant chamber developed by Skinner (see Skinner 1938, 1956) is an apparatus that allows an analysis of choices made through time while in a relatively stable environment. In the chamber an organism moves about freely, perhaps manipulates an object (a key or lever), and occasionally gets food. The apparatus fosters recording *rates* of events rather than discrete responses only. Because a rate is the number of target responses that occur during a given unit of time, operant psychologists are not limited to single instances of choice as their fundamental measure; we are freed from the dilemma of determinism, of predicting molecular behavior as cast by James, because now the measured variable occurs through time (Hineline, 1990). It is as if one observed James leave the lecture hall multiple times and then predicted his future course of action based on his past performance. Choice is no longer a single event with one immediate cause. The free-operant chamber allows an analysis of choice extended through time.

The analysis of choice is made explicit when a second manipulandum is added to the apparatus and response rates on both are recorded (Ferster and Skinner, 1957; Findley, 1958). Herrnstein (1961) spawned the experimental analysis of choice when he used two manipulanda and reported a reliable relationship between relative reinforcement rates and relative response rates. Over the past three decades, this line of research has become highly quantitative (Miller, 1984), which encourages connections with other quantitative sciences. Recent years have demonstrated that the mathematical models of choice and their theoretical underpinnings are intimately related with models derived from research on foraging by behavioral ecologists. Chapter I is a review of the matching law with a particular emphasis on changeover requirements. Chapter II addresses some similarities between foraging and choice. Chapter III presents the methods and procedures. Chapter IV presents the results and Chapter V discusses the results and draws some conclusions.

CHAPTER I

THE MATCHING LAW

Strict and Generalized Matching

The experimental analysis of choice began in earnest when Herrnstein (1961) described a consistent relation between the allocation of pigeons' pecks on two response keys and the relative rate of reinforcement received from the two alternatives. The consistency is expressed mathematically by the *strict* matching equation:

$$\frac{B_L}{B_L + B_R} = \frac{R_L}{R_L + R_R} \qquad (1)$$

B represents behavior (usually measured in number of pecks or time in seconds), *R* reinforcers (number of hopper presentations, for example), and the subscripts indicate the alternatives, left and right. Baum and Rachlin (1969) demonstrated that the relation holds whether behavior is measured in units of responses or time. Subsequent research has demonstrated that the matching relation, in either its strict or generalized forms (see below), describes the behavior of many species including rats, cows, wagtails, human, and others. Herrnstein's results occasioned vigorous research with a variety of hypotheses proposed to explain matching. Some have called the matching relation a fundamental law of choice (for reviews, see Davison & McCarthy, 1988; Williams, 1988).

As investigation continued, consistent deviations from strict matching emerged. Baum (1974b) developed the *generalized* matching equation to account for these deviations:

$$\log\left(\frac{B_L}{B_R}\right) = s\ \log\left(\frac{R_L}{R_R}\right) + \log b \qquad (2)$$

Equation 2 has the form of a linear equation with a slope of s and a y-intercept of log b. Exponentiating both sides of the equation, to express it in power function form, yields the ratio version of Equation 1 with two added terms, a multiplicative constant, b (*bias*), and an exponent, s (sensitivity to relative reinforcement or, simply, *sensitivity*):

$$\left(\frac{B_L}{B_R}\right) = b\left(\frac{R_L}{R_R}\right)^s \qquad (3)$$

Strict matching results when b and s both equal 1.0. The bias term captures consistent preferences for a particular alternative regardless of the relative reinforcement rates. The sensitivity term, on the other hand, measures reliable deviations across conditions of behavior ratios from reinforcer ratios. The observation that these two terms are necessary to account for the data—that is that the strict matching equation fails—suggests that either or both of the following are true: a) Strict matching is the norm but current procedures sometimes prevent its observation; b) Reinforcement rates are not the sole determiners of behavior allocation.

In normal procedures, bias seems to remain relatively constant across conditions and generally hovers near zero, although marked deviations do occur particularly when different reinforcement-schedule types are available (Nevin, 1971). Miller (1976) demonstrated that the bias parameter can be used to measure preferences for different food types. Pigeons pecked a green or red colored key. Each color was associated with one of two magazines containing a particular type of grain. Three types of grain (buckwheat, wheat, and hemp) were successively paired with each other and bias for each pair was used to empirically derive the pigeons' hedonic scale of the grains. This result suggests and other studies confirm that bias, though malleable, is controlled by straightforward variables. Consequently, bias has produced limited debate.

The sensitivity term has proved to be more theoretically fruitful. The values the term can take on have been categorized into three ranges: matching ($s \approx 1.0$), undermatching ($s < 1.0$), and overmatching ($s > 1.0$). Undermatching occurs when the behavior ratio is consistently closer to indifference ($b = 1.0$) than the reinforcer ratio; that is, when relatively more behavior is allocated to the leaner alternative than strict matching predicts, regardless of which alternative is leaner. Overmatching is just the converse of undermatching: when relatively more behavior is allocated to the richer alternative than strict matching predicts, regardless of which is richer.

Different researchers have debated which category, if any, is normative. Originally matching was thought to be normative and recently Williams (1988) supported that view when he concluded that if the "proper" procedures are employed strict matching will be observed. Baum (1979) on the other hand, after reviewing 103 data sets, reported that s was usually less than 1.0. Later, the results obtained when incorporating a procedure that required pigeons to travel around a partition to switch alternatives led him to conclude that overmatching may be the norm (Baum, 1982; see Chapter II). Furthermore, he suggested that overmatching may be a sign of an underlying optimizing strategy.

Theories about Matching

Several theories have been proposed to explain matching. They can be categorized along two major axes: level of aggregation and type of explanatory theory (see Table 1 below). The first category has two rough sub-categories: molecular and molar. Molecular theories are concerned more with instantaneous events (e.g., an individual lever press and its consequence) and their proximal mechanisms. Molar theories, on the other hand, are based on events that happen over time, at some level of aggregation (e.g., number of presses on a bar per minute). There are two broad levels of the second category also: matching and maximizing. Matching theories are based on some version of Equation 1 and accept the matching relation as fundamental to behavior. Maximizing theories are based on utility maximization, often operationalized as maximizing energy

Table 1

Theories of the Matching Law

	Type of Theory	
Level of Aggregation	Matching	Maximizing
Molecular	Momentary Matching	Momentary Maximizing
Molar	Strict & Generalized Matching	Optimization
	Melioration	

gained per unit time or minimizing time spent in gaining a fixed unit of energy (Stephens & Krebs, 1986).

Matching Theory. The matching equations describe molar behavior and leave unspecified molecular processes. Herrnstein (1970, 1974), however, proposed that molar matching occurs because organisms match at the local level also. Given the momentary possibilities of reinforcement, behavior is distributed according to the organism's estimates of those momentary rates. Later (see Herrnstein & Vaughan, 1980), Herrnstein reported that the theory failed because it was silent concerning which of two unequal VR reinforcement schedules organisms would prefer. Matching predicts only that one alternative would be preferred exclusively.

Momentary Maximizing. Shimp (1966, 1969) and Silberberg, Hamilton, Ziriax, and Casey (1978) suggested that local behavior controlled by momentary reinforcement probability produces molar matching. The specifics of concurrent variable-interval variable-interval schedules of reinforcement (*conc* VI VI) produce an oscillation back and forth between schedules as to which has the higher momentary probability of reinforcement (for elaboration see *Common Procedures* section below). Momentary maximizing theorists reason that, if behavior is sensitive to these oscillations, then an analysis of response sequences should reveal patterns of responding that track these oscillations, called *momentary maximizing.* If, the reasoning continues, matching is observed at the molar level and momentary maximizing at the molecular level, then momentary maximizing is the fundamental process, and matching is an artifact that results from aggregating.

Using both pigeons and computer simulation, Shimp (1966, 1969) and Silberberg et al. (1978) reported sequential dependencies in response sequences that tracked the momentary probability of reinforcement. However, in an empirical study (Nevin, 1969) and a subsequent re-analysis (Nevin, 1979), Nevin reported that the probability of switching remained approximately constant as a function of consecutive pecks to an alternative. Williams (1988) argued that Nevin's failure to find a correspondence between the probability of changing over and the probability of reinforcement for switching is "prima facie evidence against momentary maximizing as a general explanation" (p. 191). Even so, the role of momentary maximizing in choice continues to be a point of controversy (see Nevin, 1982; Silberberg and Ziriax, 1982).

Optimization. Another approach to maximization as the controlling process of matching is called *optimization*. Optimization is based on the assumption that organisms distribute behavior in such a way as to get the best return for their effort. In the *conc* VI VI arrangement, an optimizing strategy is to get the most reinforcers possible within some specified period. Rachlin, Green, Kagel, and Battalio (1976) demonstrated that matching is a special case of maximization because, given the two alternatives, matching maximizes the overall reinforcement rate from both alternatives (in economic language, the rates of return). Complicating the debate, Vaughan (1981) reported that pigeons failed to maintain behavior within an optimizing range (global maximizing) when local reinforcement contingencies lead them away from that range (see *Melioration* below; see also Mazur, 1981; Vaughan and Miller, 1984).

Optimization is an organizing principle in several research areas including economic theory and behavioral ecology. An area of common interest between behavioral ecology and behavior analysis is foraging. Animals responding on manipulanda in operant chambers and obtaining food can be viewed as being analogous to animals foraging for food in the wild. Optimal foraging theory makes specific predictions that can be tested and have been supported, generally (see Hanson and Green, 1989; Stephens and Krebs, 1986). The research reported in this dissertation lends itself to a foraging analysis and, thus, has something to say about foraging in particular and optimization in general. This comparison will be made explicit in Chapter II.

Melioration. A theory that crosses the categorical boundaries of both axes is called *melioration* (Herrnstein and Vaughan, 1980; Vaughan, 1981; Vaughan & Herrnstein, 1987). It is at once a molar theory and molecular theory: molecular because it relies on "local" reinforcement contingencies, though not at the micro-level of momentary maximizing; molar because it uses aggregated behavior, though not at the global level of matching. It is also both a matching theory and a maximizing theory: matching because it builds on the assumptions of Equation 1 (see below); maximizing-like theory because the richer local reinforcement rate garners more behavior than the leaner when unequal reinforcement rates are in force. Melioration is represented mathematically by the following equation:

$$R_D = \frac{R_L}{T_L} - \frac{R_R}{T_R} \qquad (4)$$

T represents time; the two terms to the right of the equals sign represent the local reinforcement rates for each alternative, indicated by the subscripts; and R_D represents the difference between the two local reinforcement rates. When R_D equals 0, behavior stabilizes. Simple manipulation results in the time-allocation ratio version of Equation 1:

$$\frac{T_L}{T_R} = \frac{R_L}{R_R}$$

Williams and Royalty (1989) performed three experiments testing melioration theory and argue that their results fail to support the theory. Each condition employed different baseline contingencies but all used probe trials to compare whether local or absolute reinforcement rates controlled behavior. The baseline contingencies were such that, when probes were introduced, if local reinforcement contingencies controlled choice then a specific alternative would be preferred whereas if absolutes reinforcement rates controlled choice then the other alternative would be preferred. Regardless of some inconsistency, Williams and Royalty argue that taken as a whole the three conditions support absolute rather than local control; a result contrary to melioration (For evidence against control by absolute reinforcer rates see Vyse & Belke, 1992).

Evidence both for and against all the above theories proposed to account for matching has been reported. Some theories have been more successful than others, while others have been discarded (e.g., molecular matching). Several researchers have wondered if there are definitive tests between the theories and if, perhaps, all are involved depending on how the question is framed (Miller, Heiner, & Manning, 1990; Nevin 1982). Perhaps one reason for being unable to arrive at an acceptable theory of matching is that we don't understand the particulars of matching well enough. Baum developed the generalized matching relation to account quantitatively for systematic deviations from strict equality. I will now return to the questions surrounding deviations from strict matching.

Why Deviations?

Attempting to determine why sensitivity to reinforcement deviates from 1.0 has motivated much discussion and research. Baum (1974b) presents two possible approaches. Investigators, such as Williams (1988), could assume that a particular value of s is normative; that there is a "true" measure of sensitivity and deviations from that value result from measurement error. The second approach asserts that Equation 1 is simply a special case of Equation 3 and that the absolute value of s is of no special importance. What is important is the matching relation as a theoretical framework (see Killeen, 1972; Rachlin, 1971). Regardless of which rationale one takes, both lead to the same practice: determining the specific factors that affect sensitivity.

Sensitivity. It is possible that sensitivity varies due to random error (Baum, 1979). If so, across experiments the values of s would fall both above and below the central tendency and in effect cancel out the variation when data from different experiments are pooled. However, separate reviews by Baum (1979), Taylor and Davison (1983), and Wearden and Burgess (1982) conclude that deviations from strict matching are systematic. One striking result is the consistently different sensitivities obtained from time- and response-allocation measures. Baum (1979) reported that the mode of time-allocation sensitivities was 1.0 and the distribution was skewed to values less than 1.0.

The mode of response-allocation measures was .79 and the distribution was slightly skewed toward 1.0. Further, he noted a consistent difference between sensitivity estimates obtained in his own and Davison's laboratory. Baum's exponents tended around 1.0 while Davison's tended to be less than 1.0. Undermatching is the predominant result with time-allocation sensitivities larger than response-allocation sensitivities. However, Wearden and Burgess (1982) point out that, on those infrequent occasions that overmatching occurs, time-allocation sensitivities tend to be less extreme than response-allocation sensitivities. This suggests that deviations are from some anchor and not that response-allocation sensitivities are consistently less than time-allocation sensitivities (see Davison, 1991).

Baum (1974b, 1979) suggested five possible factors that contribute to the exponent deviating from 1.0, in particular toward undermatching. Two factors concern experimental procedures, while the other three are organismic.

One of the suggested procedural factors was that the changeover delay (COD) may not sufficiently separate the alternatives. A COD is a fixed delay to reinforcement following a changeover, commonly employed in concurrent schedules research (COD is discussed in later sections). The second proposed procedural factor was level of deprivation, although McSweeney (1975) reported that it does not affect s.

A suggested organismic factor was poor discrimination between alternatives. Animals that discriminate poorly will tend toward indifference which yields undermatching. Davison and McCarthy (1988) considered three possible sources of poor discrimination: stimulus discriminability (cf., Davison & McCarthy, 1994; Miller, Saunders, & Bourland, 1980), reinforcement rate discrimination, and misallocation of reinforcer origin. Other proposed organismic factors included inconsistency of preference and different response patterns on each alternative. Regarding inconsistency of preference, Nevin (1971) reported that, on concurrent fixed-interval (FI) and variable-interval (VI) schedules, preference for the FI schedule oscillated according to the location in the interval. Preference for the FI increased as the end of the interval approached. Perhaps something similar is occurring in *conc* VI VI procedures. Regarding different patterns of responding to the two alternatives, the final suggested organismic factor, pigeons may emit different response-to-pause ratios to the rich and lean alternatives. Such a result, in conjunction with low interchangeover times, would have a disproportionate effect on the leaner alternative. Undermatching would be the result. These proposed factors may contribute individually or sympathetically to produce undermatching.

In a more recent review, Taylor and Davison (1983) considered 155 data sets from 18 studies and reported consistent undermatching. Their analysis focused on the progression used to calculate the VI schedules. Traditionally, variable-interval schedules of reinforcement are derived using one of two methods to produce the interreinforcement intervals (IRIs): arithmetic and exponential progressions. The IRIs of arithmetic VI schedules are symmetrically distributed around the mean with the longest interval no more than twice the mean interval (Williams, 1988). Exponentially derived IRIs, on the other hand, are skewed toward the longer intervals and have means and standard deviations that are approximately equal. Whereas Baum (1979) reported differences in *s* between time- and response-allocation measures, Taylor and Davison reported that the means and standard deviations of the two measures of behavior were about the same for exponential VI schedules; however, the means of the two measures differed by .10 for arithmetic VI schedules. Taylor and Davison assert that the differences in the slope obtained in the two labs occurred because Baum usually used exponential VI schedules while Davison and his associates usually used arithmetic VI schedules. The accuracy of Taylor and Davison's conclusions need to be reassessed after more appropriate methods of analysis are performed. They plotted the sensitivity measures on arithmetic scales, but since sensitivity is always a ratio logarithmic axes should be used (see Robinson, 1992). Contrary to Taylor and Davison's finding, recent research in our lab indicates that the methods of constructing the intervals does not produce consistently different values of *s* when a within-subject design is used (Ehlert & Grace, 1994).

The general consensus is that the exponent in equation 3 is not invariant. However, the variation is regular. Reviews indicate that controlling factors responsible for the variation may be found but more research is needed to determine exactly what they are. Six sources (Baum, 1974b, 1979; Davison & McCarthy, 1988; Taylor & Davison, 1983; Wearden & Burgess, 1982; Williams, 1988) suggest that the variation may be due to procedural[1] differences, with Baum, Wearden and Burgess, and Williams all implicating the COD as a prime factor. Since procedural details seem crucial to sensitivity, the next section will describe the two main experimental arrangements used in the experimental

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[1] Wearden & Burgess write that "the degree of undermatching exhibited appears little affected by *procedural variations* between experiments and occurs in studies using different...values of changeover

analysis of choice. Particular attention will be paid to how the two procedures treat the changeover requirement.

Common Procedures

Researchers in the experimental analysis of choice commonly employ one of two experimental procedures. In the *two-key* procedure each manipulandum is directly associated with a reinforcement schedule; responses to either manipulandum (the "side" keys) can be reinforced. In the *changeover-key* procedure one manipulandum (the main key) is associated with two or more schedules, signaled by different discriminative stimuli, while a response to a second manipulandum (the changeover key) changes the stimulus and associated reinforcement schedule on the main key. Herrnstein (1961) used the two-key procedure. Later, Catania (1963) used the changeover-key procedure and obtained close approximations to matching also. The two procedures are considered to be functionally equivalent (Pliskoff, Cicerone, and Nelson, 1978).

Both procedures can handle any combination of schedules. Although other schedule types (e.g., FI, variable ratio (VR)) and other combinations (e.g., VI VR, VI FI, VR VR) have been used since, Herrnstein and Catania used two VI schedules that were simultaneously available. Behavior controlled by other than *conc* VI VI schedules of reinforcement has produced less controversy.

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delay" (p.346, italics mine). For this dissertation, the changeover requirement is considered a procedural variation.

VI schedules have a number of characteristics that, when combined with a second VI schedule, foster matching. One characteristic is that scheduled reinforcement probability is independent of time since last reinforcement and is unaffected by behavior (Baum, 1992). In effect, this property allows organisms to switch between alternatives without greatly altering the reinforcement rates. A second property of VI schedules is that reinforcement becomes more likely the longer the time since the last response. A slow response rate, then, yields a high probability that an individual response will be reinforced, and in the lower limit every response will obtain reinforcement (Baum, 1992).

These two characteristics set up a dynamic when two VI schedules of reinforcement are made available concurrently. While working on one alternative, because the reinforcement availability is unpredictable, it is always possible that the next response will yield reinforcement. Yet, because reinforcement probability increases the greater the interresponse time, the longer an organism stays away from the other alternative the higher the probability that switching to it will yield reinforcement. The question an organism working in a *conc* VI VI preparation must answer is: Should I stay or should I switch? Left unchecked, behavior switches rapidly between the two alternatives, resulting in measured behavior centering around indifference, indicating insensitivity to relative reinforcement rates, and thereby obviating the matching law.

To counter rapid switching, Herrnstein (1961) included a COD. The specifics of the COD depend on whether the two-key or changeover-key procedure is used. The two-key procedure usually initiates the COD upon a response to the other side key (a changeover response). After the delay, another response to the new alternative is required before a reinforcer may be obtained. This arrangement means that the changeover response, even though it is delivered to a key that usually produces food, can never be reinforced immediately. As commonly arranged, then, the COD begins *after* the organism responds on the new alternative, and in effect punishes changing over *after* already having switched alternatives (see de Villiers, 1977; Pliskoff, 1971). The time since the last response on the old alternative, during which the organism travels the distance between the response keys and actually switches, is not a measured component of the COD.

The COD in a changeover-key procedure is treated differently mainly due to the location of the changeover response. This procedure has a manipulandum dedicated solely to the changeover response. Responses to the changeover-key change the color of the main key (Findley, 1958) and no response to the changeover-key ever yields food. Generally, the COD begins after a single response to the changeover key. Until the COD times out, responses to the main key cannot produce food. Because the COD for the changeover-key procedure begins with a response to the changeover key, unlike the two-key procedure, a fraction of the time the organism spends switching alternatives contributes to satisfying the COD. But the time traveling to the changeover key is usually not factored into the COD.

The location of the changeover response for the two procedures leads to different treatment of the response. The two-key procedure usually includes the changeover response with total behavior, while the changeover-key procedure excludes the response. Exactly what should be done with the changeover response is not clear. With the changeover-key procedure it makes sense to exclude it, because it is on a never-reinforced key. With the two-key procedure, it is less clear; the changeover response is on a reinforced key but the response itself is never reinforced. Researchers have discussed what should be done with behavior during the COD. Baum (1974a) analyzed relative responding during and after changeover delay. He reported that COD responding produced extreme undermatching, with some slopes almost horizontal. Should all COD behavior be excluded? Baum (1982) suggested that it should. Davison and McCarthy (1988, pp. 147-48) argue for including changeover behavior because sensitivity measures are more constant when changeover behavior is included than when it is excluded. To settle this question, we must determine how COD procedures affect sensitivity.

The Changeover Delay. Using a changeover-key procedure, Catania (1963) reported that the two sides of Equation 1 better approximated equality when a 2-second COD was included in the procedure than when it was excluded. Also using a changeover-key procedure, Shull and Pliskoff (1967) reinforced rats' lever pressing with electrical brain stimulation, using one pair of VI schedules, and varied the COD across six values from 0-seconds (a single press to the changeover key was required) to 20-seconds. As the COD duration increased relative behavior more closely matched relative reinforcement, but matching performance did not decrease as the COD duration was subsequently reduced. Davison and McCarthy (1988) assert that the Shull and Pliskoff result refutes Baum's claim that the COD affects the exponent. Their conclusion, however, should be accepted with caution. Because Shull and Pliskoff kept each condition in effect for five days only and did not signal the COD, it is unlikely that the rats had sufficient exposure to each

COD duration to alter behavior, particularly in the descending series. Longer exposure may alter the conclusion.

A number of other studies have manipulated the COD (for review, see Stubbs, Pliskoff, & Reid, 1977). Dreyfus, Dorman, Fetterman, and Stubbs (1982) re-analyzed data from Silberberg and Fantino (1970). Silberberg and Fantino incorporated three COD durations (0.88, 1.75, & 3.5 seconds) and varied the relative reinforcement rates. Dreyfus et al. report three main findings. First, as originally reported by Silberberg and Fantino, the pigeons emitted higher rates of responding during the COD than after. If such response rate differences hold for both major procedures, then including or excluding COD responses will have a marked effect on sensitivity. Second, the alternative with the leaner reinforcement rate produced more rapid response rates during COD. This response pattern, by adding relatively more COD responses to the leaner alternative, decreases the values of *s* for response allocation but not for time, consistent with Baum (1979) and Taylor and Davison (1983). And third, response rate during COD decreased as COD duration increased. Together, these findings indicate that the COD and how the data are treated can have a powerful impact on sensitivity.

The Fixed-ratio Changeover. Another method used to impose a changeover requirement is the fixed-ratio changeover (FRCO; see Pliskoff & Fetterman, 1981). Usually the changeover-key procedure requires a single response (FR 1) to switch alternatives; however, increasing the FR required to complete a changeover can be seen as similar to lengthening the COD. An advantage of the FRCO method of programming the changeover requirement is that it requires that the work associated with changing over be performed *while* changing over rather than, as is the case with a COD, *after* the organism has arrived at the new alternative. Whether the COD merely separates the two schedules (Herrnstein, 1961, 1970) or punishes the changeover response (Pliskoff, 1971) may depend on when during the act of switching the two methods impose the work. As will be discussed below, both methods can produce similar sensitivity measures; nevertheless, the above distinction may have important subtle effects on behavior allocation. In particular, the FRCO method readily produces overmatching.

Stubbs et al. (1977) reviewed and analyzed several studies to consider the effects of the changeover requirement on time at an alternative. Included in the review was an unpublished study by Pliskoff on the effects of increasing the fixed-ratio changeover. Pliskoff used one pair of *conc* VI 3-minute VI 3-minute schedules throughout the experiment. The FRCOs were 1, 2, 5, 10, or 20. A power function describes the relation between changeover rates and changeover requirement for both the FRCO and COD preparations. Pliskoff's study is the first I know of that used a FRCO without a COD to impose the changeover requirement. However, the reinforcement rates were not varied for Pliskoff's unpublished study, precluding determining a slope.

Later studies reported that varying the ratio changeover requirement also affects the exponent of Equation 3. Experiment 1 in a study by Pliskoff, Cicerone, and Nelson (1978) used a changeover-key procedure with FRCO 1, 5, and 10. Two replications were performed using three different pigeons for each replication. The first replication contained seven conditions with all conditions using a FRCO 10 except the last one, which used a FRCO 1. The second replication included five conditions, all with FRCO 5.

Pliskoff et al. reported overmatching as the normative result for both replications. The last condition of Replication 1 was an attempt to demonstrate matching using traditional arrangements (i.e., FR 1 on the changeover key); all three birds approximated matching.

Fitting the data from FRCO 5 and 10 separately to Equation 2 confirmed the visual analysis of Pliskoff et al., but not universally. Two conditions from Replication 1 and one from Replication 2 were excluded because extinction was one of the reinforcement schedules. Also excluded was the FRCO 1 condition. For both FRCOs for each bird, response-allocation slopes were always greater than time allocation. The means of the slopes for FRCO 5 ($\overline{X}_{resp} = 1.25$, $\overline{X}_{time} = 1.06$) were consistently less than FRCO 10 ($\overline{X}_{resp} = 1.78$, $\overline{X}_{time} = 1.54$). For FRCO 5, two of the three birds' time slopes approximated matching. Bias was negligible and the lowest variance accounted for was .91. The re-analysis suggests that a) response-allocation slopes were greater than time-allocation and thus deviated more from matching, b) the larger FRCO produced steeper slopes, and c) contrary to Pliskoff et al.'s claim, overmatching was not the norm for FRCO 5. Perhaps a within-subject design is needed to compare different FRCOs.

A few other studies report similar results when using the FRCO method. Pliskoff and Fetterman (1981) used a FRCO 1, 2, or 4 and reported overmatching with the FRCO 4 and matching with FRCO 2. More recently Dreyfus, DePorto-Callan, and Pesillo (1993) implemented a 2-second COD and a FRCO 5. One or the other changeover method was in effect throughout the first half of a 90-minute daily session. The other method was in effect for the second half. Traditional analyses of the FRCO data obtained results similar to Pliskoff et al. (1978) reviewed above and others (Dunn, 1982): response allocation overmatched while time allocation matched. However, when time and responses accrued during changeover were included, Dreyfus et al. reported undermatching for both COD and FRCO changeover requirements.

The reviewed results derived from the FRCO procedure indicate that overmatching is the more common result when a fixed number of responses is required to switch alternatives. Taylor and Davison (1983) claim that FRCO-derived overmatching is artifactual because the responses on the changeover key are not included with the total responses. They re-analyzed the Pliskoff et al. (1978) data by adding the changeover-key responses to the alternative to which the pigeons were going, similar to Dreyfus et al. (1993), and found close approximations to matching. However, as pointed out by Dreyfus et al., asserting what should be done with behavior during switching depends on whether one assumes matching is normative.

The indication that the changeover requirement affects sensitivity demands that the procedure be studied in more detail. Developing a procedure that disentangles the various components of changing over would assist in furthering the debate over what should be done with the changeover response(s) and other behavior occurring while switching. This dissertation contributes to our understanding of the intricacies of changing over by: first, testing a procedure that completely separates switching behavior from active-key responding; second, exploring parametrically the effects the FRCO procedure has on Equation 3's exponent in a within-subjects design with extensive training in each condition; and third, looking for local regularities in changeover behavior in relation to reinforcement rates and changeover requirement.

CHAPTER II

FORAGING AS OPERANT BEHAVIOR

The similarity between the experimental analysis of choice by psychologists and research on foraging by behavioral ecologists has been made explicit over the last few decades (see, Green & Kagel, 1987, 1990; Krebs & Kacelnik, 1991; Lea, 1981; Staddon, 1980; Shettleworth, 1988; Stephens & Krebs, 1986). In the 1980s at least three conferences brought together investigators from both disciplines for reports on topics of mutual interest. Each conference published a book containing those reports (Commons, Kacelnik, & Shettleworth, 1987; Kamil, Krebs, & Pulliam, 1987; Kamil & Sargent, 1981). The similarity between the two research veins is evident in this dissertation. Chapter II will briefly review relevant issues from the foraging literature and operant research that has simulated travel between patches.

Foraging

Foraging is the procurement of resources by organisms in the wild. Modern exploration of foraging incorporates an economic analysis of costs and benefits. The behavior of starling parents during breeding season illustrates such cost/benefit analysis (from Krebs & Davies, 1993, Chapter 3, and Krebs & Kacelnik, 1991; see also Stephens & Krebs, 1986). During the height of breeding season, starling parents make up to 400 round trips per day to provide food for their hatchlings. Each of these trips involves a number of important measurable factors: load size, distance of prey from nest, patch density, ease of prey capture, among others. Should the forager bring back the maximum load it can carry on each trip? How far should it travel from the nest? What affect does travel have on load size? Are travel and load size affected by the frequency of encountering prey or the handling time required to access prey once encountered? Using economic models to describe how organisms solve these problems has fostered both research on and theory about animal behavior (Shettleworth, 1988).

Load size is particularly illustrative. With multiple nestlings to feed, parent starlings must balance the cost of each trip with providing sufficient food for the nestlings, called the *loading curve*. The advantage of foraging until the beak is filled with prey before returning to the nest is apparent, improved ability to meet nestlings' nutrient requirements. However, any benefits gained from increasing the number of prey returned per trip is counter-balanced by the reduction in foraging efficiency including such costs as greater prey capture time, increased risk of losing already captured prey, and increased load weight. When considered in economic terms, balancing the costs and benefits of an activity is a form of the *principle of lost opportunity*, the benefits of one option are evaluated in relation to the next-best option (Stephens & Krebs, 1986).

Load size is just one of the possible measurable components of starling's foraging. One can imagine that all of the factors listed above could influence the offsprings' survival. Obviously, the parents' expertise in procuring food will impact that survival. Over evolutionary history, nature will have selected traits that enhance prey procurement and thereby increased those traits' *relative fitness*. Thus, modern starlings should perform optimally, or close to it, when foraging for their offsprings' food. Such reasoning fosters optimal models of foraging.

The starling example also introduces three concepts of foraging that are important for this dissertation: patchy environments, patch profitability, and travel. Prey can be localized in clumps, called *patches*, or be separate from other like items. MacArthur & Pianka (1966) used this feature to form two categories of resource exploitation: prey and patch. Although the distinction between a discrete prey and a patch is somewhat ambiguous (see Stephens & Krebs, 1986), because the alternatives in an operant chamber are locations to which organisms go to obtain food, most operant researchers consider the available alternatives to be patches.

Once a forager is in a patch, one problem of interest to behavioral ecologists concerns when the patch will be vacated. Both patch profitability and travel influence the problem's solution. *Patch profitability* denotes the frequency of prey captures within a patch, analogous to the operant concept of *schedule of reinforcement*. A major influence on when the patch is vacated is the profitability of the present patch relative to the other available patches, or simply *relative profitability*. The picture becomes more complicated when distance between patches, called *travel*, is considered. Ceteris paribus, as distance between patches increases stay time in a patch increases also. Similar results occur as relative profitability increases; stay time in richer patches increases (for review see Shettleworth, 1988). Counter-intuitively, however, as the environment's overall profitability increases, stay time decreases. Such reduction makes sense in light of the principle of lost opportunity. Persistence in a depleting patch when other patches have high yields decreases prey-capture rate. Therefore, in a rich environment, an organism that stays in a patch loses the opportunity to forage in relatively richer patches.

Mathematical models of behavior, and optimal models of foraging in particular, allow a quantitative analysis of the principle of lost opportunity, an intuitive model. Furthermore, mathematical models benefit scientific investigation in at least two ways: a) the model's assumptions are unambiguous and b) precise predictions are afforded (Krebs & Kacelnik, 1991). These two benefits move behavioral ecology closer to satisfying Williams's (1966) injunction to rigorous rather than intuitive theories.

Organisms working in an operant chamber can be seen as a constrained version of organisms foraging in the wild. Since operant behavior is behavior that is controlled by its consequences, in its most general sense, foraging obviously fits this definition because one consequence of not foraging is starvation, an aversive consequence to organisms formed from selfish genes. Those organisms whose behavior changes relative to the environmental contingencies, prey density say, have a greater likelihood of food procurement and, thus, of survival. Therefore, because foraging is sensitive to consequences, it is operant behavior (see Baum, 1982, 1983, 1987).

The VI reinforcement schedules commonly used in matching law research, though not originally intended to do such, model some types of naturally occurring patch profitability. Variable-interval schedules of reinforcement can be seen as analogous to rapidly depleting food sources that replenish while the predator is away (Stephens & Krebs, 1986). Real-world examples include insects washing on the shore of a lake or stream and the accumulation of floral nectar. In both instances, resources amass regardless of predator behavior; analogous to the "something-outside-control-of-responding" component of variable interval schedules (Baum, 1992).

Foraging and operant behavior are similar in another sense. Even in a single-manipulandum chamber, a variety of behavior is possible. A rat can press the response bar or not, fall asleep in the corner, explore the chamber, eliminate waste, or scratch an itch. The rat "chooses" among these various options; that is, behavior is distributed between them. A two-manipulanda chamber affords explicit measurement of competing opportunities. A foraging bird is not constrained to merely forage; like a rat in a single-manipulandum chamber it too can engage in other activities. Also, like a rat in a two-manipulanda chamber, foraging organisms choose between multiple patches.

Despite the noted similarities, Baum (1983) suggests "three artificialities" of free-operant chamber research: (a) the small size of the chamber, which precludes broad-range foraging typical of non-central-place foragers; (b) the experimental-session time comprises only a small portion of an organism's day, which forces unusual feeding patterns; and (c) the schedules of reinforcement's dissimilarity to patterns of prey-capture in free-ranging foraging. Various attempts to ameliorate the differences have met with some success (Baum, 1983; Shettleworth, 1988). In a similar vein, Lea (1981) acknowledges that foraging and operant behavior are not necessarily the same simply because of apparent similarities. However, after an extensive review, he draws three conclusions: (a) the experimental analysis of behavior has advanced our understanding of naturally occurring behavior; (b) research on foraging has increased the range of behavior analysis to new species, responses, and situations; and (c) the natural selection framework of foraging provides a potential explanation for the regularities formulated in the laboratory. In a more recent review, Shettleworth (1988) concludes that developments in both fields "have considerably enriched this enterprise since it was reviewed by Lea" (p. 41).

Travel in an Operant Chamber

Baum (1982) reported an innovative modification to a standard operant chamber that more closely modeled travel between patches, addressing the first "artificiality" (Baum, 1983). Contrary to foraging in the wild, "patches" (response keys) in operant chambers are separated by small distances (e.g., the two-key procedure). Often only a color distinguishes between two patches; the location is identical (e.g., the changeover-key procedure). Baum's general arrangement was similar to the two-key procedure described above. However, rather than using a delay as the changeover requirement, Baum required the pigeons to travel around barriers of various lengths and, for some pigeons, a hurdle at barrier's end. The barrier projected perpendicular from the center of the instrument panel with a cut-away that allowed access to the hopper from either side, maintaining the economy of a single feeder. The partition creates a more naturalistic relationship between "patches" in a chamber. The added distance between the patches required the subjects to engage in locomotor activity to switch patches, as if they were in the wild. Baum (1982) reports different average sensitivity values for two groups of pigeons. The group with the larger distance between patches overmatched while the group with the smaller distance undermatched, consistent with typical results. Related research using rats has been performed by another of Baum's graduate students, but with even greater distances and vertical climbing (Aparicio, 1992; 1994).

Considering this arrangement from a foraging perspective, the different travel requirements affect sensitivity by altering the duration of patch visits (called *visit duration*, or *dwell*, *residence*, or *stay times*). As noted above, increasing distance between patches in naturalistic settings alters load size and other behavior (e.g., Kacelnik, 1984). Baum (1982) reported increasing stay times as distance between patches increased, measured in either pecks or time. Lea (1985) considered stay times using a 21-cm partition and reported relatively constant stay time for each visit except in visits that contained reinforcement. Also, stay times on the richer patch were generally longer than those on the leaner.

As reported in the next chapter, this dissertation manipulated travel between patches in a way more common to operant techniques. Rather than adding a partition to the standard chamber, a response key was used to simulate travel between patches (see also Davison & McCarthy, 1994; McCarthy, Voss, & Davison, 1994). Organisms that move from one patch to another engage in work to switch patches. A schedule of reinforcement commonly used to simulate a work requirement is a FR schedule. If a large FR produces results similar to inserting a partition, we could conclude that operant methods can be made to be functionally equivalent to more naturalistic settings and thereby provide even more support for the common interests of behavioral ecologists and operant psychologists. Baum's (1983) argument that the two fields not only should but must integrate in order to fully understand behavior will be made an easier task to complete.

CHAPTER III

THE EXPERIMENT

Subjects

Four White Carneaux pigeons, numbered W34, W35, W36, and W37, served as subjects. All had experience with operant chambers and reinforcement schedules prior to beginning this research program. With few exceptions, sessions were conducted daily, approximately 22.5 hours apart. As necessary to maintain each pigeon at approximately 80% of free-feeding body weight, supplemental feedings were given in the home cage after all pigeons finished a session. Water and grit were freely available in the home cage.

Apparatus

Experimental sessions were conducted in four standard three-key operant chambers. The chambers measured 35 cm wide by 35 cm high by 32 cm deep. The distance from the chamber walls to the outside edge of the openings for both side keys measured 80 mm. The outside edges of the center key were 56 mm from the inside edges of both side keys. Each key opening had a 26 mm diameter. The hopper measured 50 mm high by 57 mm wide and the top edge was 90 mm directly below the center key with the bottom edge 95 mm off the floor. Ambient illumination was provided by a white houselight centered above the center response key.

Reinforcement consisted of three seconds' access to wheat, provided according to variable-interval schedules of reinforcement. Each schedule had 16 intervals obtained from a Fleshler-Hoffman progression (Fleshler & Hoffman, 1962). The mean of the base intervals was 15.02 seconds with a standard deviation of 15.01. All schedules arranged a constant minimum interval of .5 seconds. During reinforcement, a white light illuminated the hopper, house and stimulus lights darkened, and timing ceased. An IBM-compatible personal computer using MEDPC software controlled all data recording and scheduling of experimental events. The computer was located in an adjacent room and connected with the chambers through a MED Associates interface. Turbo Pascal routines extracted the raw data from MEDPC generated files and data analyses were performed using Microsoft Excel.

Procedure

The procedure combined elements of the two-key procedure with the changeover-key procedure. Responding on either side key was reinforced according to independent *conc* VI VI schedules. The center key functioned as the *changeover* key. Pecks to this key switched the active alternative. To distinguish this preparation from the more standard ones, I call this the *three-key FRCO* procedure. The three-key FRCO procedure completely disentangles active-key responding from imposed changeover requirements. This allows changeover behavior to be reasonably excluded from a matching relation analysis, a common concern of researchers (see Common Procedures above and Dreyfus, et al., 1993).

Sessions began with the two side keys illuminated. A peck to either side key darkened the other key, turned on the houselight, illuminated the changeover key, and began both schedule timers. A peck to the changeover key darkened the active side key and, when the FRCO was satisfied, the changeover key darkened and the other side key illuminated. The first peck to the new side key re-illuminated the changeover key and could be reinforced. Schedule timing continued during switching. Data collection terminated on the first changeover after 50 hopper presentations. Terminating data collection after a changeover assured that the visit that contained the last reinforcer ended in the same fashion as all other visits and, therefore, was complete. Thus a recorded session consisted only of complete visits.

Depending on the condition and date, sessions terminated in either of two ways: after the next hopper presentation following data-collection termination, or when the variables reached the computer system's memory limit. Generally, termination due to memory limits only occurred in FRCO 0 conditions, the first FRCO 2 condition, and a few other sessions with many changeovers. During Phase IV or V, depending on the pigeon, a program change ended any need to terminate sessions due to the system's memory limitation (see below for sequence of conditions). Terminating the session after the first hopper presentation after a changeover prevented a session ending on a changeover.

Data were recorded in detail. The changeover was divided into three times: changeover initiation latency (time from last peck on "old" alternative to first peck on changeover key), FR response duration (time to emit the FRCO), and changeover termination latency (time from last peck on changeover key to first peck on "new" alternative). These three measures allowed a complete record of changeover times. At every event, with event meaning changeover or reinforcer, the active alternative when the event occurred and the number of pecks and time since last event were recorded. Also recorded were the latency to and side of the first peck, and number of pecks and changeovers and duration after formal data collection terminated.

Table 2

Sequence of Conditions: FRCO by Reinforcer ratio

	Fixed-Ratio Changeover Requirement				
RFT Ratio	0	2	6	12	20
2':.5' (1:4)	4	18	17	16	13, 15
2':1' (1:2)	3 (W37: 6)	19	x	x	12
2':2' (1:1)	1, 6	7	8	9	10
2':4' (2:1)	2	20	x	x	11
2':8' (4:1)	5	21	22	23	14

Exceptions
1. Condition 6 for W37 was the 1:2 reinforcer ratio
2. Between conditions 6 & 7, all pigeons were exposed to a FRCO 1
3. Between conditions 7 & 8, W34 was exposed to a FRCO 4

To investigate the effects on the matching relation of the changeover requirement, two variables were manipulated: reinforcer ratio and changeover requirement. See Table 2 for sequence of conditions. Numbers in cells indicate condition number. Cells containing two numbers indicate repeated conditions. Exceptions are noted at bottom and exceptions 2 and 3 were not included in analyses. The reinforcer ratio was manipulated by varying the reinforcement schedule associated with one of the response alternatives (the "variable" alternative, right key), while pecks on the other alternative were reinforced according to a VI 2-minute schedule throughout the experiment (the "constant" alternative, left key). The reinforcer rates for the variable alternative included the following schedules: VI 30-second (a 1:4 reinforcer ratio), VI 1-minute (a 1:2 ratio), VI 2-minute (a 1:1 ratio), VI 4-minute (a 2:1 ratio), and VI 8-minute (a 4:1 ratio). Initial order of presentation was determined by random draw.

The second variable, the changeover requirement, was manipulated by varying the number of changeover-key pecks required to switch alternatives. The changeover requirement was one of the following fixed-ratio schedules: 0, 1, 2, 4, 6, 12, or 20. Note that FRCO 0 is identical to the two-key procedure without a COD; the changeover key remained dark and only the side keys were operative. The equal and two extreme reinforcer ratios were combined with all changeover requirements. The 1:2 and 2:1 reinforcer ratios were combined with FRCO 0, 2, & 20.

Preliminary training. Because these were experienced pigeons, preliminary training was minimal. The pigeons were exposed to the three-key FRCO procedure with a FRCO 2 and *conc* VI 18" VI 18" schedules controlling reinforcement for the initial experimental session. Nineteen additional pre-training sessions were given, in which the changeover key was inactive. *Conc* VI VI schedules reinforced pecking on the side keys. The VI schedules remained equal and were increased to 27 seconds, then to 63 seconds, and, lastly, to 116 seconds.

Experimental conditions. Conditions in *Phase I* manipulated the reinforcer ratios while fixing the FRCO at 0 (see Table 2). The first condition had a FRCO 0 with the 1:1 reinforcer ratio. All pigeons then progressed through the four other reinforcer ratios. In

Phase II the reinforcer ratio remained 1:1 while the FRCO was successively increased to the maximum schedule (FR 20). During *Phase III* the FRCO 20 remained while the reinforcer ratios were manipulated. Throughout *Phase IV* the reinforcer ratio remained 1:4 while the FRCO progressed down to 2. In *Phase V* the reinforcer ratios were manipulated while a FRCO 2 was in effect and in *Phase VI* FRCOs 6 & 12 were in effect while the reinforcer ratio remained constant at 4:1.

Stability criteria. Each condition remained in effect at least until, and for some conditions well after, the following criteria were satisfied:

1. Sessions were in effect for a minimum number of days. Usually the minimum was 15, but Phase I conditions were in effect for only 10 days because day-to-day behavior ratios were highly consistent.
2. At least 100 reinforcers needed to have been obtained from the leaner alternative. In a few of the earlier conditions, some pigeons received only about 80 reinforcers from the lean alternative. Pigeon W36 received only 28 reinforcers from the lean alternative in Condition 5.
3. Behavior ratios were without obvious trends over the sessions used to satisfy the second criterion. A loosely held rule was used to define “obvious”: no new high nor low behavior ratios in the sessions wherein the 80 to 100 reinforcements are obtained. The weakness of this rule was evident whenever large variations in choice occurred, usually this accompanied a marked change in the programmed reinforcer ratio. As behavior stabilized after large fluctuations in choice, the “no new high nor low” criterion became ineffective as a stability measure. When such

occurred, the condition was continued until no trends were obvious and day-to-day behavior ratios were relatively consistent.

CHAPTER IV

THE RESULTS

Tables (Appendix I) and figures (Appendices II, III, & IV) of data for each pigeon are shown in the appendices, segregated by analysis and sorted by figure. The results are presented in three major sections. The first section, *Molar Results*, contains molar analyses. A traditional generalized matching relation analysis is presented. Included are a) fitting the data from individual pigeons to Equation 2 to derive response- and time-allocation sensitivities and log biases for each changeover requirement, b) point estimates of sensitivity measures across conditions, c) response rates across conditions, and d) changeover rates by FRCO and reinforcer ratio.

The second section, *Local Results*, focuses on local analyses. An analysis of changeover latencies and response rates on the changeover key by FRCO and reinforcer ratio is presented first. Next, what may be the most surprising results from this study are presented: the conditional probability of changing over as a function of pecks since either visit entry (for definition of visit, see below) or last reinforcer. Results show that the probability of switching increases the longer the visit, and the effect becomes more pronounced the greater the changeover requirement.

Finally, the third section, *Foraging Analyses*, presents results from an extensive analysis of visits, both number of pecks and duration. Visits are categorized into non-reinforced and reinforced, and reinforced visits are subdivided into single and multiple reinforcers.

Molar Analyses

The data used in the molar analyses were obtained by summing across the stable sessions of each condition. Ratios (constant alternative divided by variable alternative) were then calculated for responses, time spent, and reinforcers obtained. All ratios were re-expressed as logarithms (base 10). Response rates on each side key were obtained by dividing number of pecks in a visit by visit duration. Changeover rates were calculated by dividing total number of changeovers in a condition by total time spent pecking on the side response keys. Time and responses that accrued during switching were kept separate from time spent on and responses made to side keys. All molar-analyses figures are in Appendix II.

Matching Relation Analysis. Figure 1 displays choice (log response and time ratios) as a function of log reinforcer ratio (obtained) for W37 for each FRCO. Linear equations are listed in the same order as their legend labels. Standard errors of the slope estimate are included beside the equations (see Appendix 1 for other measures).

Figure 2 displays the fitted parameters of the generalized matching relation for all pigeons at all FRCOs. Parameters were fitted using least-squares linear regression. Slopes obtained for FRCO 0, 2, and 20 were taken from five reinforcer ratios while slopes for FRCO 6 and 12 were taken from three (the two extreme ratios and one equality). Because behavior from two pigeons in the repeated conditions was

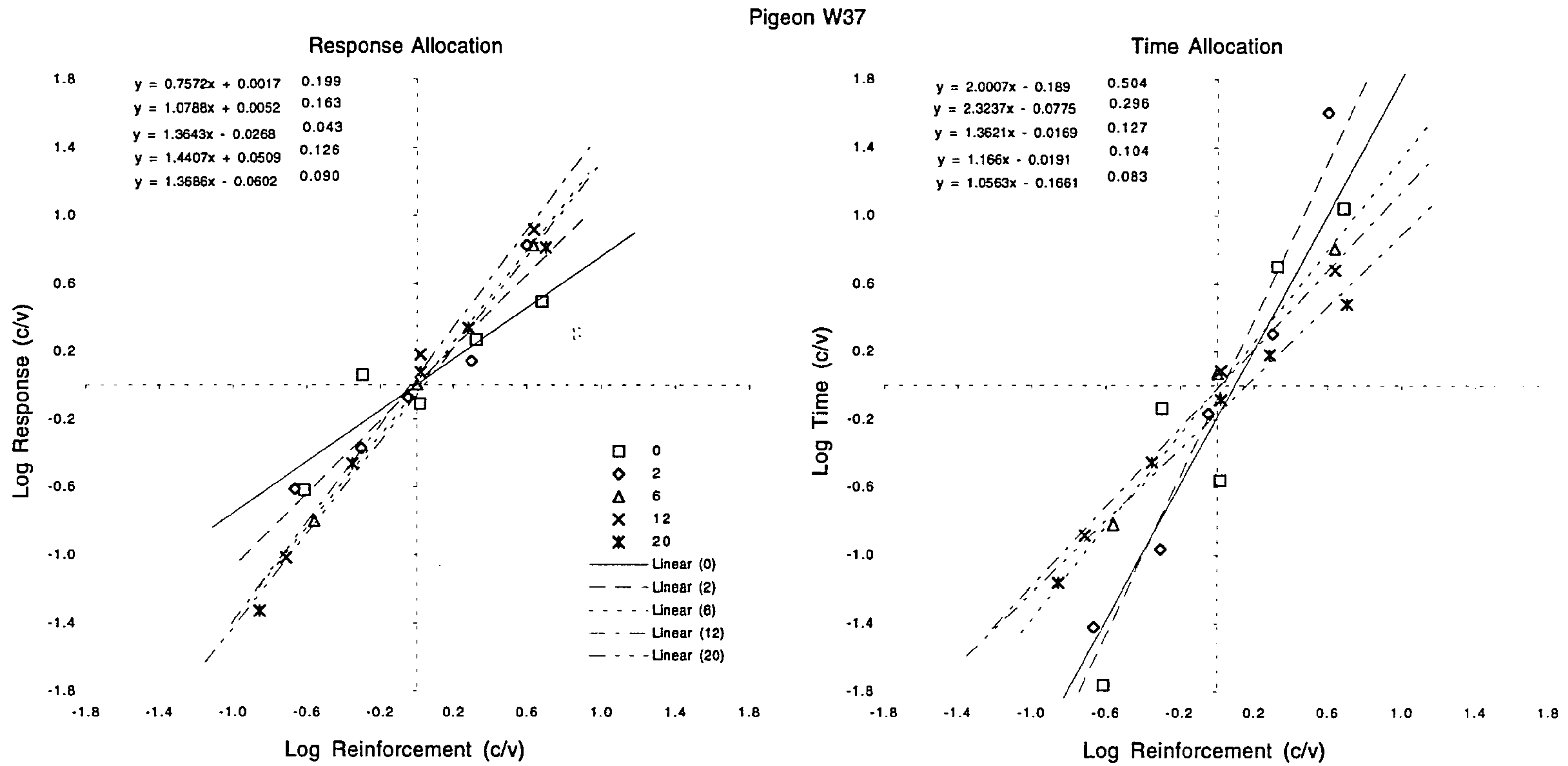

Figure 1. Log response (left; c/v) and log time (right; c/v) plotted as a function of log reinforcement (c/v; obtained) for Pigeon W37. Least-squares linear regression equations with their standard errors of the estimate for each changeover requirement are listed in the same order as the lines' identifiers are listed in the legend.

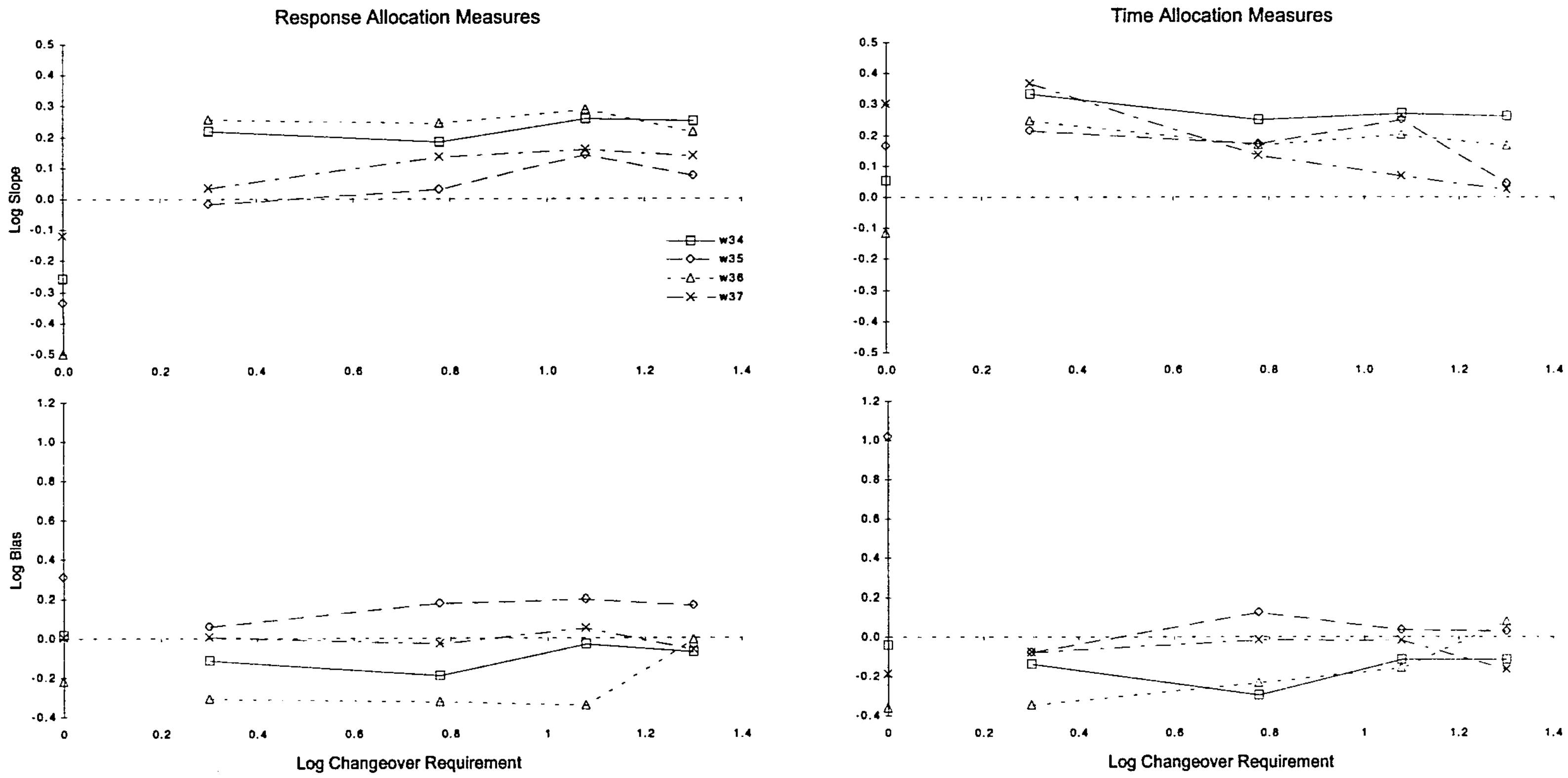

Figure 2. Fitted parameters of Equation 2 for response (left) and time (right) allocation are plotted as a function of log changeover requirement for each pigeon (see legend for symbol). Logarithm (base 10) of the slopes are presented in the top panels and log bias in the bottom panels.

inconsistent with the first condition, only the first condition of repeated conditions was included in the matching relation analyses. The two left panels present response-allocation measures while the two right panels present time-allocation measures. The two top panels depict the logarithms (base 10) of the slopes and the bottom two depict log biases (see Equation 2). The logarithms of the slopes were taken because slopes should be expressed in equal intervals away from matching. Log slopes equate matching with zero, while positive numbers show overmatching and negative numbers show undermatching. The x-axis in each panel is the logarithm of the changeover requirement, with FRCO 0 plotted at 0, equivalent to log 1.

Since FRCO 0 was essentially a different procedure, in that it was a two-key procedure, whereas the non-zero FRCOs used the three-key FRCO procedure, I treat the data obtained from them separately. First, the response-allocation slopes for FRCO 0 indicate that response ratios undermatch reinforcer ratios (see Table 3 below). All values are well below 1.0 (range = .31 to .76) and are markedly lower than the central tendency ($\overline{X}$ =.965) for response-allocation sensitivity obtained using exponential VI schedules reported by Taylor and Davison (1983); however, they are not outside the ranges reported in the three reviews of generalized matching, particularly considering that no changeover-key pecks were required to switch. Except for W36, time-allocation sensitivities, on the other hand, show strong overmatching (range = 1.13 to 2.0); three of the four are higher than the central tendency reported by Taylor and Davison ($\overline{X}$ =.962) and sensitivities for Pigeons W35 & W37 are beyond the upper class interval (1.3-1.4; for other ranges of response- and time-sensitivities, see also Baum, 1979; Wearden & Burgess, 1982). Using a different procedure than FRCO, but one that excluded changeover behavior from active-key responding also, Baum (1982) reported strong time-allocation overmatching, within a similar range (.95 to 2.70; see also Chapter II).

The sensitivities obtained from changeover requirements greater than FRCO 0 in Figure 2 manifest different trends for response- and time-allocation choice. A nonparametric test for monotonic trends, *S* (Davison & McCarthy, 1988; Ferguson, 1965), for the two choice measures produced opposite results for three of the four pigeons. All *S*s from the time-allocation sensitivities are negative, indicating a downward trend, while three of four are positive for the response-allocation sensitivities. Although none of the statistics for individual pigeons reach two-tailed significance ($N = 1$, $k = 4$, $p > .05$), *S* for data pooled across pigeons does exceed significance ($N = 4$; $k = 4$, $z = 2.21$, $p < .05$). Since no prior research suggests a negative trend, according to the rules of significance testing , z-critical must be for a two-tailed test. The medians of the standard errors of the slope estimate for response and time allocation are .14 and .13, respectively; however, the maximum for time allocation is much larger (response = .29, time = .50).

The above analysis highlights one other puzzling result: Sensitivity for both response- and time-allocation shows no consistent increase after FRCO 2. Pigeons W34 and W36 have their largest increases between FRCO 0 and FRCO 2, and remain at about the same value for all other changeover requirements. Response-allocation sensitivity for Pigeons W35 and W37 shifted from undermatching to matching as changeover requirement went from FRCO 0 to FRCO 2, but their sensitivity for FRCO 20 is lower than smaller changeover requirements. They, also, never reached the same level of overmatching as the other two pigeons. This effect is even more prominent in time-allocation sensitivity. For all pigeons, sensitivity is lower for FRCO 20 than for FRCO 2. For W35 and W37, it is close to matching. As indicated above, Pliskoff et al.'s data showed response-choice overmatching and time-choice matching, but that was with a FRCO 5. Their results from FRCO 10 showed overmatching for both. However, each replication used different pigeons and sensitivity may be subject specific. Although the ranges for sensitivities are in accord with prior research (see The Fixed-ratio Changeover section above and Table 3), the lower sensitivities from higher FRCOs are surprising.

Table 3

Individual and Median Slopes and Standard Errors for Response (Top Section) and Time Allocation (Bottom Section) by Changeover Requirement

	Fixed-Ratio Changeover Requirement									
Response Allocation										
	0		2		6		12		20	
Bird	Slope	SE	Slope	SE	Slope	SE	Slope	SE	Slope	SE
W34	0.55	0.07	1.65	0.23	1.53	0.14	1.81	0.16	1.78	0.13
W35	0.46	0.08	0.96	0.17	1.07	0.10	1.38	0.23	1.18	0.11
W36	0.31	0.16	1.81	0.18	1.75	0.03	1.94	0.14	1.64	0.29
W37	0.76	0.20	1.08	0.16	1.36	0.04	1.44	0.13	1.37	0.09
Median	0.51	0.12	1.37	0.17	1.44	0.07	1.62	0.15	1.50	0.12
										$\text{Median}_{SE} = .14$
Time Allocation										
W34	1.13	0.12	2.15	0.27	1.78	0.11	1.86	0.07	1.83	0.08
W35	1.46	0.24	1.64	0.50	1.49	0.26	1.78	0.29	1.10	0.12
W36	0.76	0.38	1.76	0.13	1.47	0.14	1.59	0.25	1.46	0.22
W37	2.00	0.50	2.32	0.30	1.36	0.13	1.17	0.10	1.06	0.08
Median	1.30	0.31	1.96	0.28	1.48	0.13	1.68	0.18	1.28	0.10
										$\text{Median}_{SE} = .13$

The measure of bias (log b in the bottom panels of Figure 2) remained fairly consistent throughout the experiment, except for two FRCOs (0 & 20) for two Pigeons

(W35 & W36, respectively). Time-allocation bias for W36 gradually shifted toward the left alternative as FRCO increased.

Figure 3 presents logarithmic point estimates of response- and time-allocation sensitivity for most conditions in chronological order. Each pigeon's mean log bias was calculated for each FRCO and then used as a constant to solve Equation 2 for s in each condition that used that FRCO. Conditions with programmed equal reinforcement rates were excluded. The abscissa labels indicate specific conditions. The last digit indicates a particular reinforcer ratio, the first one or two digits indicate the imposed FRCO, and the R indicates a replication condition (see also Table 2). Pigeon number is noted in each panel.

Todorov, Castro, Hanna, Bittencourt, and Barreto (1983) reported that sensitivity decreases as number of conditions increases. Visual inspection of Figure 3 hints at an *increase* in sensitivity across conditions. A trend analysis (Ferguson, 1965) across conditions for individual pigeons found no significant trends, however. Pigeon W35's response-allocation estimates approach a significant positive trend ($z = 1.40, p > .05$) and Pigeon W37's time-allocation estimates approach a significant negative trend ($z = 1.53, p > .05$). Comparison with Todorov et al. must be done with caution, however, because the changeover requirements are also changing across conditions.

Visual inspection indicates that the degree of concordance between response- and time-allocation sensitivities is strong. Generally, the greatest disparity occurs at FRCO 0 and the degree of concordance increases as the FRCO increases.

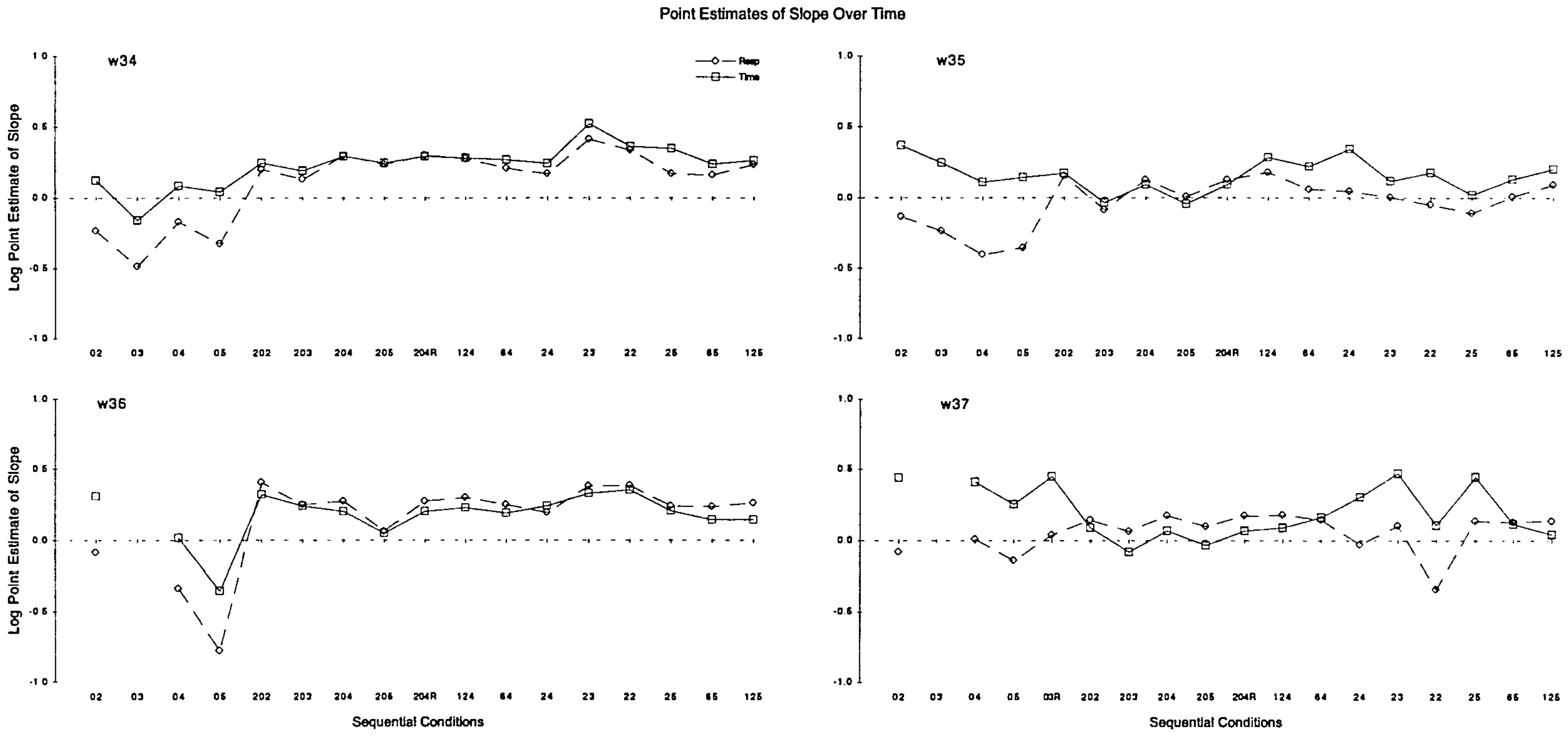

Figure 3. Response- and time-allocation point estimates of slope (base 10 logarithm transform) plotted in order of condition for all pigeons. X-axis labels denote condition. See text for explanation.

Response Rate Analysis. Response rates were calculated by dividing number of pecks on a side by total time on a side for each condition. Then ratios, constant divided by variable, for each category and condition were determined. Figure 4 presents an analysis of response rate ratios for W37. Visits to a side were categorized into those that did (RFT visit) and did not (Non-RFT visit) contain reinforcement. Reinforced visit measures are giving-up measures while non-reinforced visit measures are visit measures (see *Local Results* section, below, for definitions). The left column presents the data as a function of the obtained reinforcer ratio (base 10 logarithm) sorted by changeover requirement. The top panel contains ratios of visits in which no reinforcement was delivered, while the bottom panel's data had one reinforcer delivered. The right column presents the same ratios but plotted as a function of the changeover requirement (base 10 logarithm) sorted by reinforcer ratio. By this analysis, dependent measures of log 1 indicate an equal response rate on both alternatives.

Non-reinforced-visit ratios have less consistency across manipulated variables than the reinforced-visit ratios. Plotted as a function of reinforcer ratio (top-left panel), the smaller two changeover requirements have a negative slope, while the three larger FRCOs produce a relatively constant response rate ratio around equality. Except for FRCO 2, the reinforced visits remain relatively constant, whether plotted as a function of reinforcer ratio or FRCO. Most interesting is the convergence of response rate ratios around equality for non-reinforced visits when plotted as a function of FRCO (top-right panel). Generally, all pigeons show similar results (see Appendix II). An exception: W36 produced a slight positive trend as reinforcer ratio increased for reinforced visits.

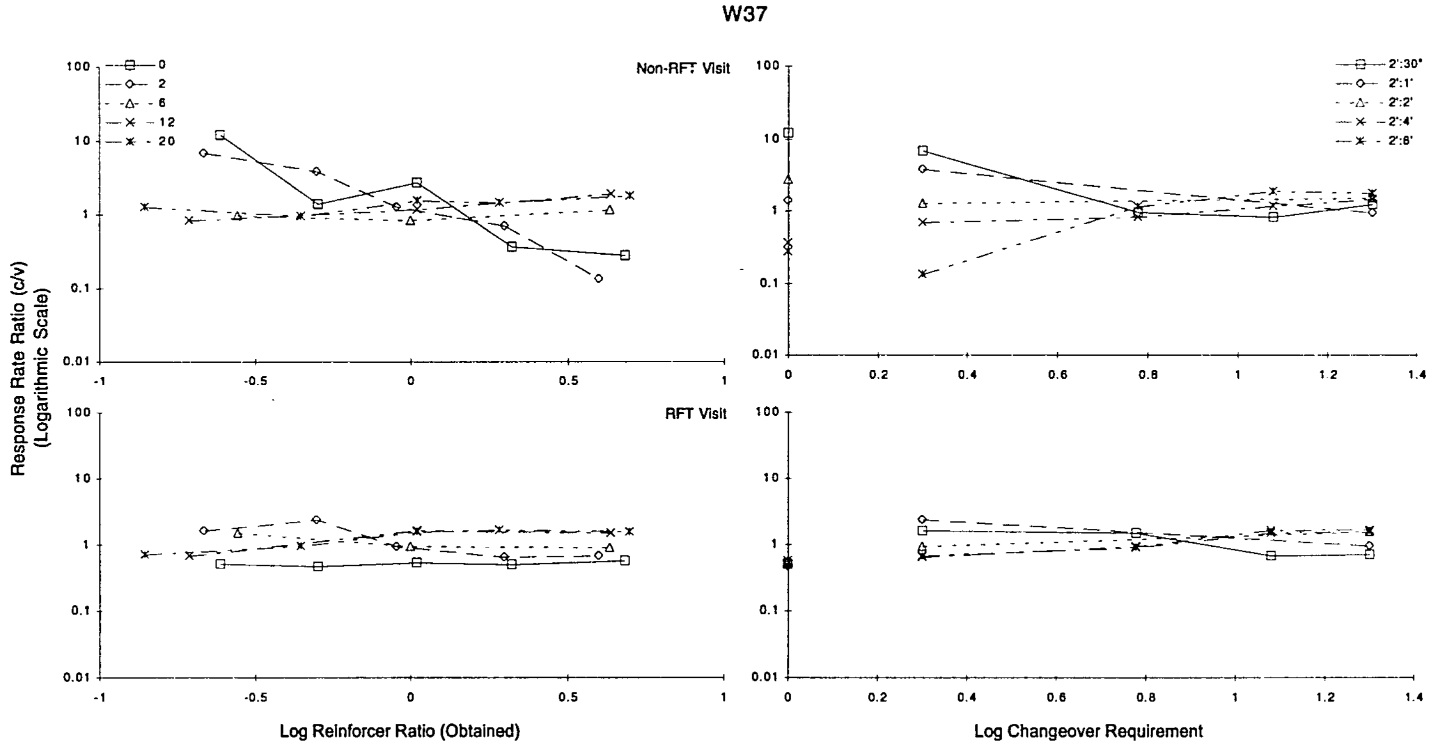

Figure 4. Response rate ratio (c/v; log scale) plotted as a function of log reinforcer ratio (c/v; obtained; left panels), grouped by changeover requirement, and plotted as a function of log changeover requirement (right panels), grouped by reinforcer ratio. Top panels present data from visits in which no reinforcement was received, bottom panels present data from reinforced visits.

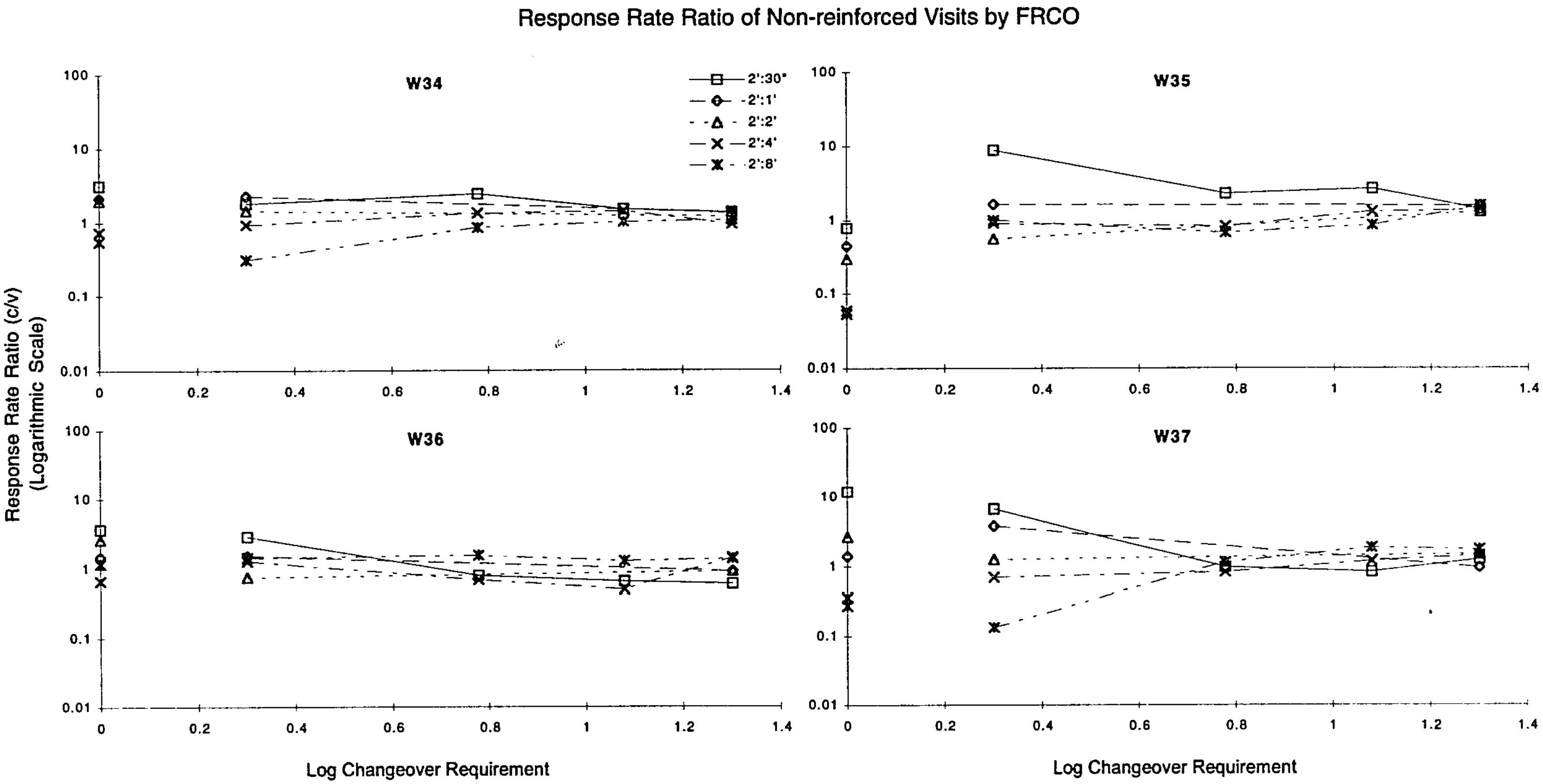

Figure 5. Data from top left panel of Figure 4 (response rate ratio for non-reinforced visits by changeover requirement) for all pigeons are presented.

It is important to note, although difficult to disentangle from relative reinforcer rates in this analysis, that absolute reinforcer rate decreases when moving along the x-axis from left (150 reinforcers per hour) to right (37.5 reinforcers per hour).

Figure 5 presents ratios for the same conditions and category as the top-left panel of Figure 4—as a function of changeover requirement for non-reinforced visits—for all four pigeons. The convergence of response rates to both alternatives as FRCO increased may be seen in all four graphs. The data converge in two ways: first, ratios for different schedule pairs become more similar; and second, ratios approach unity. Also, generally the leaner alternative garners the higher response rate, particularly at FRCO 2. Three of the pigeons consistently show these results, while W36 remains relatively consistent across changeover requirements, except for the VI 2' VI 30" conditions (boxes). These results seem related to the point estimates presented in Figure 3. W36's response and time estimates were similar throughout while the other pigeons had conditions wherein response and time estimates diverged, for smaller FRCOs, and converged, for FRCO 20.

Changeover Rate Analysis. Figure 6 depicts the changeover rates as a function of obtained reinforcer (base 10 logarithm) ratios by changeover requirement. The data support two consistent findings. First, as changeover requirements increase, changeover rate decreases (Baum, 1982; Stubbs et al., 1977; White, 1979). Every pigeon shows this result: Changeover rates are maximal with FRCO 0 and decrease with every increase of FRCO. Second, changeover rates are maximal at equal reinforcer rates and as rates deviate from equality, changeover rate decreases (Alsop & Elliffe, 1988; Catania, 1963; Herrnstein, 1961). This effect is evident from the inverted-U shaped function maintained

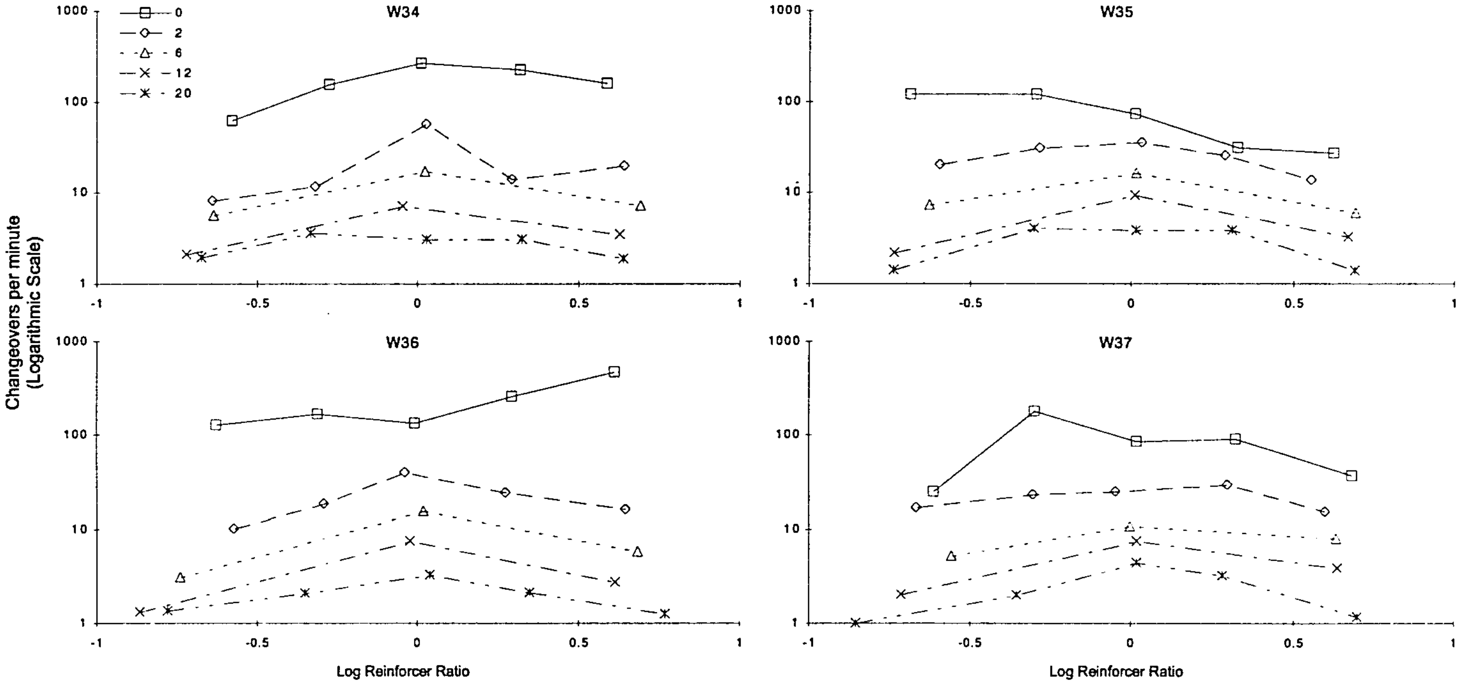

Figure 6. Changeover rate (log scale) grouped by changeover requirement plotted as a function of log reinforcer ratio (c/v) for all four pigeons.

with each FRCO in Figure 6. The peakedness of these functions appears to be less than that shown in Alsop and Elliffe's Figure 4, but their data were plotted on arithmetic scales, had a greater reinforcer ratio range, and changeover time was included in calculations. The lack of any trends across reinforcer ratios, other than the inverted-U, suggests that absolute reinforcer rate had little effect on changeover rates. Pigeons W35 and W36 show the only pronounced deviation from the inverted-U, but only from FRCO 0 conditions. Furthermore, the deviations are inconsistent with each other and thus suggest little about the effect of absolute reinforcer rate.

Local Analyses

These analyses used measures obtained by summing across the stable sessions of each condition. Figures for all pigeons are in Appendix III. The following terms will be used:

- visit: begins with the first peck to a side key and ends with the last peck to the same side key;
- non-reinforced visit: a visit in which the hopper was never presented to the pigeon;
- single-reinforcer visit: a visit in which the hopper was presented once;
- multiple-reinforcer visit: a visit in which the hopper was presented more than once;
- visit pecks (VP): number of pecks made to the active side key during a visit in which no reinforcement was obtained;
- visit time (VT): the time between the first and last pecks in a visit in which no reinforcement was obtained;

- giving-up time (GUT) or pecks (GUP): the time spent on or the number of pecks made to the active side key following the last hopper presentation before switching;
- changeover initiation latency (CO_{int}): duration from last peck to the active side key (also terminates a visit) until the first peck to the changeover key;
- changeover termination latency (CO_{ter}): duration from last peck to the changeover key until the first peck to the new side key (also initiates a visit);
- fixed-ratio response rate (FR Rate): number of pecks made to the changeover key *minus* one divided by the time between first and last pecks.

Giving-up measures rather than entire visit measures were used because reinforcement extends visit duration artifactually (Baum, 1983; Lea, 1985).

Tables and figures of stable data for each pigeon are in Appendix III. Generally, for each analysis one pigeon's data are focused on in the text. Marked differences from the example pigeon are noted.

Changeover Behavior. Figure 7 presents means of changeover behavior pooled across all four pigeons. The left column of panels depicts measures of leaving the constant alternative and going to the variable alternative, and the right column shows measures for going back. The top six panels show measures as a function of programmed reinforcer ratio, constant divided by variable. The bottom six panels depict changeover measures as a function of changeover requirement. The different symbols, identified in the legends, indicate FRCO (top six panels) or programmed reinforcer ratio (bottom six panels). FRCOs 6 and 12 (top six panels) and 1:2 and 2:1 reinforcer ratios (bottom six panels) are not connected by lines because they were not paired with each other.

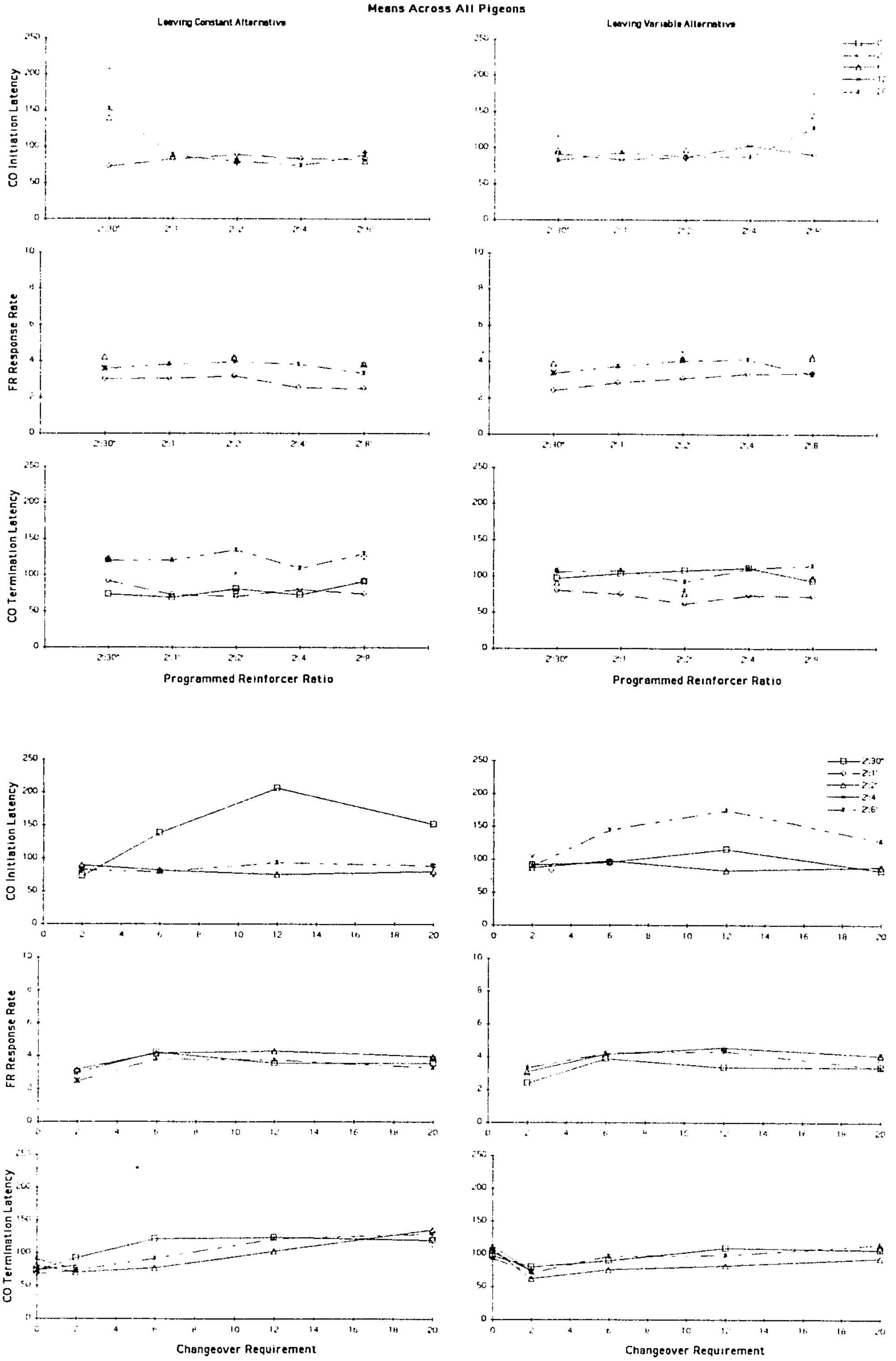

Figure 7. Pooled data for three segments of changeover behavior plotted by programmed reinforcer ratio (top six panels) and changeover requirement (bottom six panels). See text for details.

Changeover latency measures were obtained by summing across stable sessions and dividing by total number of visits (presented in hundredth of a second). The CO_{tcr} panels include mean total changeover time for FRCO 0. The FR rate (presented as responses per second) was obtained by multiplying the number of visits by the changeover requirement minus one, yielding the number of interresponse times, then dividing by the sum of the time between first and last peck on the changeover key.

The top two panels show the CO_{int} measures. The 4:1 and 1:4 conditions had higher latencies when leaving the relatively leaner alternative (VI 2' when paired with VI 30", left most symbols of leaving constant, and VI 8' when paired with VI 2', right most symbols when leaving variable). And the panels depicting CO_{int} as a function of changeover requirement indicate that latency for leaving the leaner alternative remains higher across all changeover requirements, except FRCO 2 (squares in leaving constant panels and asterisks in leaving variable panels). Because the effect is evident for leaving both alternatives, absolute reinforcer rates seem not to affect it (Alsop and Elliffe, 1988; Davison and McCarthy, 1988). This result holds for all pigeons, generally (see Appendix III).

The CO_{tcr} panels show that reinforcer ratio had little effect on the latency to terminate switching while the changeover requirement had a small affect on CO_{tcr}. The pooled data show a small increasing trend in termination latency as FRCO increases. Pigeon W36 accounts for most of the increasing trend (see Appendix III).

Contrary to response rate during COD, which decreases as COD increases (Stubbs et al., 1977), the FR rate shows an increase between FRCO 2 and 6 and little change thereafter as changeover requirement increases. The increase between FRCO 2 and 6 may result from the FRCO 2 having only one interresponse interval per changeover. Nevin (1973) indicated that the relation between average response rate and FR requirement is nonmonotonic. Boren (1953, 1961) reported that for small FRs (i.e., FR-1 to FR-36) response rate negatively accelerates as FR requirement increases. Felton and Lyon (1966), on the other hand, report that for larger FR requirements (i.e., FR-25 to FR-150) response rate tends to decrease as FR requirement increases. Contrary to Boren and Felton and Lyon, the response rates shown here change little across FRCO. Also, there was a small increase in FR response rate across reinforcer ratios when leaving the variable alternative. It was most apparent for W36 (see Appendix III).

Conditional Probability of Switching. To calculate the conditional probability of switching as a function of time, separate frequency distributions (bin size was 3 pecks) were constructed for VPs, GUPs in a single-reinforcer visit (GUP_s), and GUPs in a multiple-reinforcer visit (GUP_m). Prior studies performed separate analyses for reinforced and non-reinforced trials also (see Nevin, 1969, 1979; Silberberg et al., 1978). Then, for each bin, the frequency in a bin was divided by the cumulative frequency of that bin and greater (see Anger, 1956, interresponse time per opportunity analysis). A minimum of 20 opportunities was required for the probability to be calculated. A count in the first bin (labeled 0) indicates that no pecks were made to the active side key following a reinforcer. Except for 0, the x-axis's labels are the upper bounds. This type of analysis asks the question: given that a pigeon has made a number of pecks to the alternative, what is the probability that it will switch alternatives? Appendix III contains figures for all conditions and all pigeons.

Figures 8a-j present 10 conditions selected from the twenty-three possible conditions for Pigeon W37. The left column depicts the constant alternative while the right column shows data from the variable alternative. Programmed reinforcers per hour and FRCO in effect are noted at the top of each figure. Most figures have two rows of charts, however some have three. The top row depicts data from non-reinforced visits; the second row, data from single-reinforcer visits; and the third row, if any, data from multiple-reinforcer visits.

Figures 8a-e are all from FRCO 20 conditions, richest (a) to leanest (e) overall reinforcer rates. Figure 8a indicates that almost all reinforcers from the right side key were obtained during multiple-reinforcer visits (lower right panel) and there were no non-reinforced visits. Conditional probability of switching increased as a function of number of pecks since last reinforcer. The range of GUPs was between 4 and 53. The conditional probability of switching out of the constant alternative rose also, although it was only over two bins.

Progressing through Figures 8b-e suggests similar trends in the conditional probability of switching. As the overall reinforcer rate decreases, the increases in conditional probability of switching become more pronounced.

Comparing Figure 8a with Figure 8e allows evaluation at the two extreme absolute reinforcer rates. Both figures depict data from the same relative reinforcer rate (1:4, a, vs. 4:1, e), but with the richer and leaner schedules reversed and at leaner absolute rates

(150 per hour, a, vs. 37.5 per hour, e). At the leaner absolute reinforcement rate, the richer alternative (Figure 8e, left column) shows the same effect as the rich alternative at the richer absolute rate (Figure 8a, right column). Though the effect is not as steep, it is distributed across more bins with the highest conditional probability of switching in the 96-peck bin for the non-reinforced visit, 72-peck bin for the single-reinforcer visit, and 60-peck bin for the multiple-reinforcer visit. As with the richer absolute reinforcement rate, the sharply increasing conditional probability to exit is evident on the lean alternative in the leaner absolute rate also (Figure 8e, right column), though it occurs across more bins. Comparing down the left column in Figure 8e, the richer alternative, indicates a modest increasing tendency to exit.

Figures 8f-j present the conditional probability of switching as a function of the changeover requirement, FRCO 0 to 20, successively for one pair of schedules. Figure 8j is a duplicate of Figure 8e. Focus, first, on the non-reinforced visits on the richer alternative, top-left panels. At FRCO 0, the highest conditional probability of leaving occurs early in the visit and decreases with longer visits. FRCOs 2 and 6 produce peaked distributions, with the peak in a later bin for FRCO 6 (12-peck bin vs. 24-peck bin). FRCO 12 produces a rise and then a plateau while FRCO 20, as noted above, produces a steady rise.

Scanning down the left column of each figure reveals that the same tendency found in Figure 8e holds for all changeover requirements: the tendency to exit increases. Visits to the lean alternative (right panels) tend to end quickly until FRCO 20 where the conditional probability of switching steadily rises.

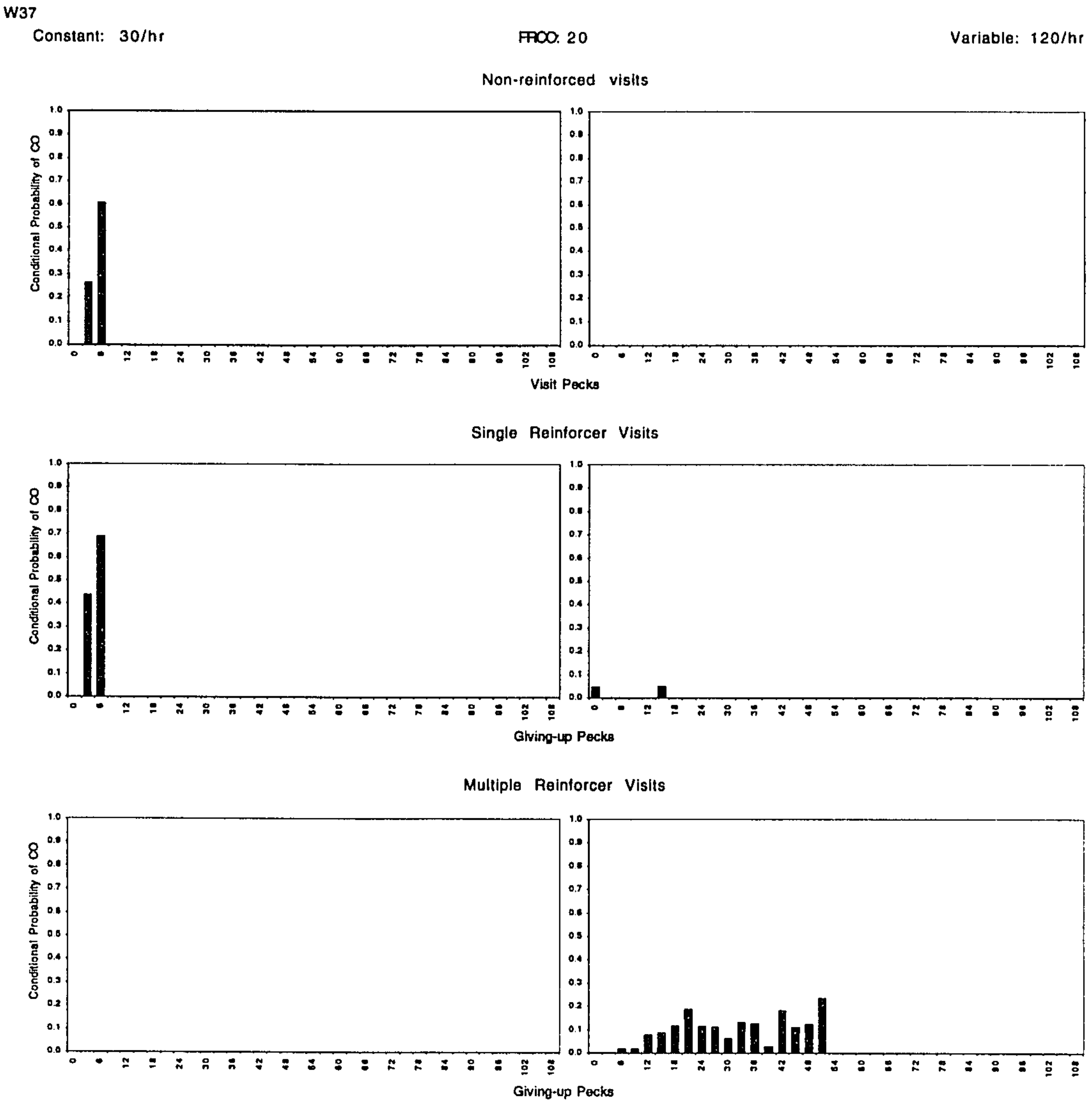

Figure 8a. Conditional probability of switching plotted as a function of visit pecks (bin size = 3, excluding zero bin). Left panels present leaving constant while right panels present leaving variable alternative. Data were separated into non-reinforced visits (top panels), single reinforcer visits (middle panels), and multiple reinforcer visits (bottom panels). Programmed reinforcer rates and changeover requirement noted at top.

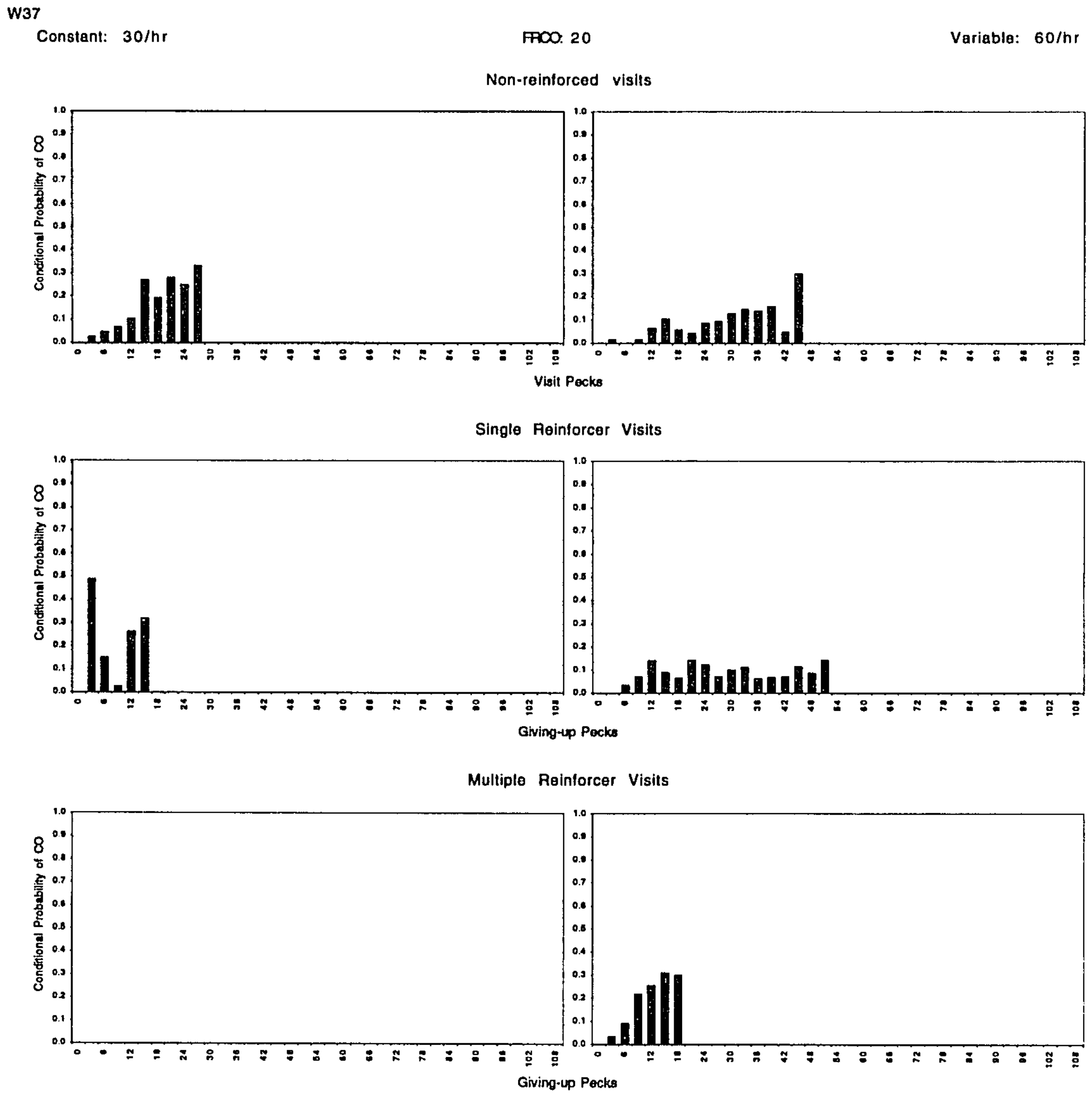

Figure 8b. Conditional probability of switching plotted as a function of visit pecks (bin size = 3, excluding zero bin). Left panels present leaving constant while right panels present leaving variable alternative. Data were separated into non-reinforced visits (top panels), single reinforcer visits (middle panels), and multiple reinforcer visits (bottom panels). Programmed reinforcer rates and changeover requirement noted at top.

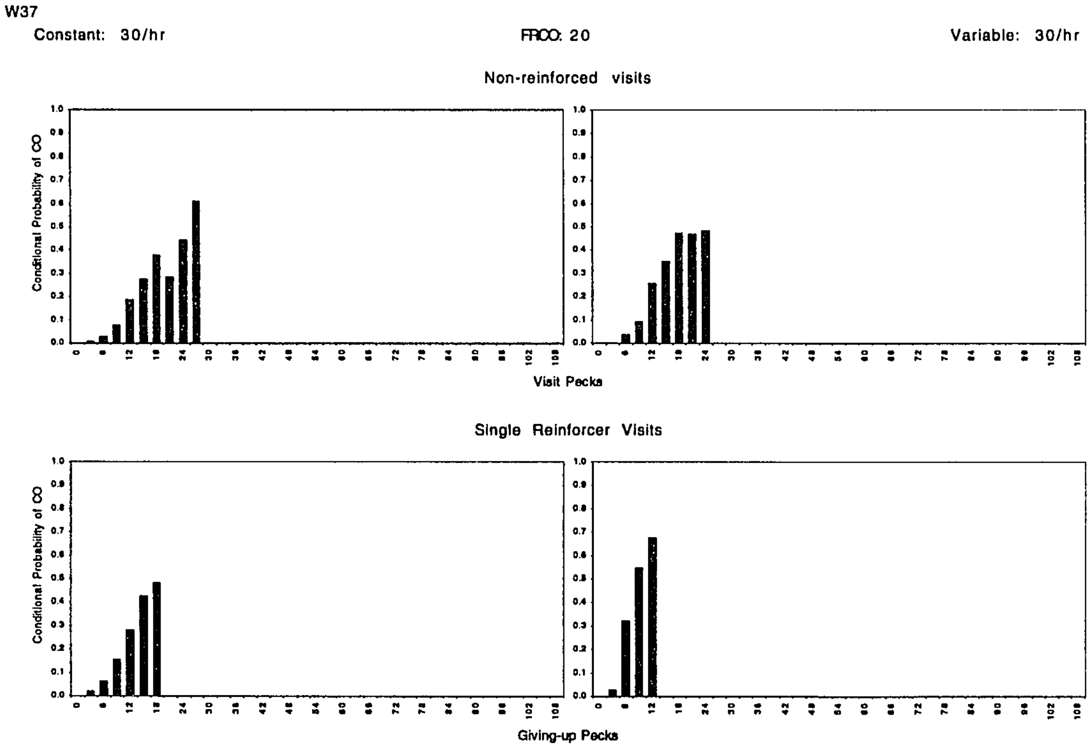

Figure 8c. Conditional probability of switching plotted as a function of visit pecks (bin size = 3, excluding zero bin). Left panels present leaving constant while right panels present leaving variable alternative. Data were separated into non-reinforced visits (top panels), single reinforcer visits (middle panels), and multiple reinforcer visits (bottom panels). Programmed reinforcer rates and changeover requirement noted at top.

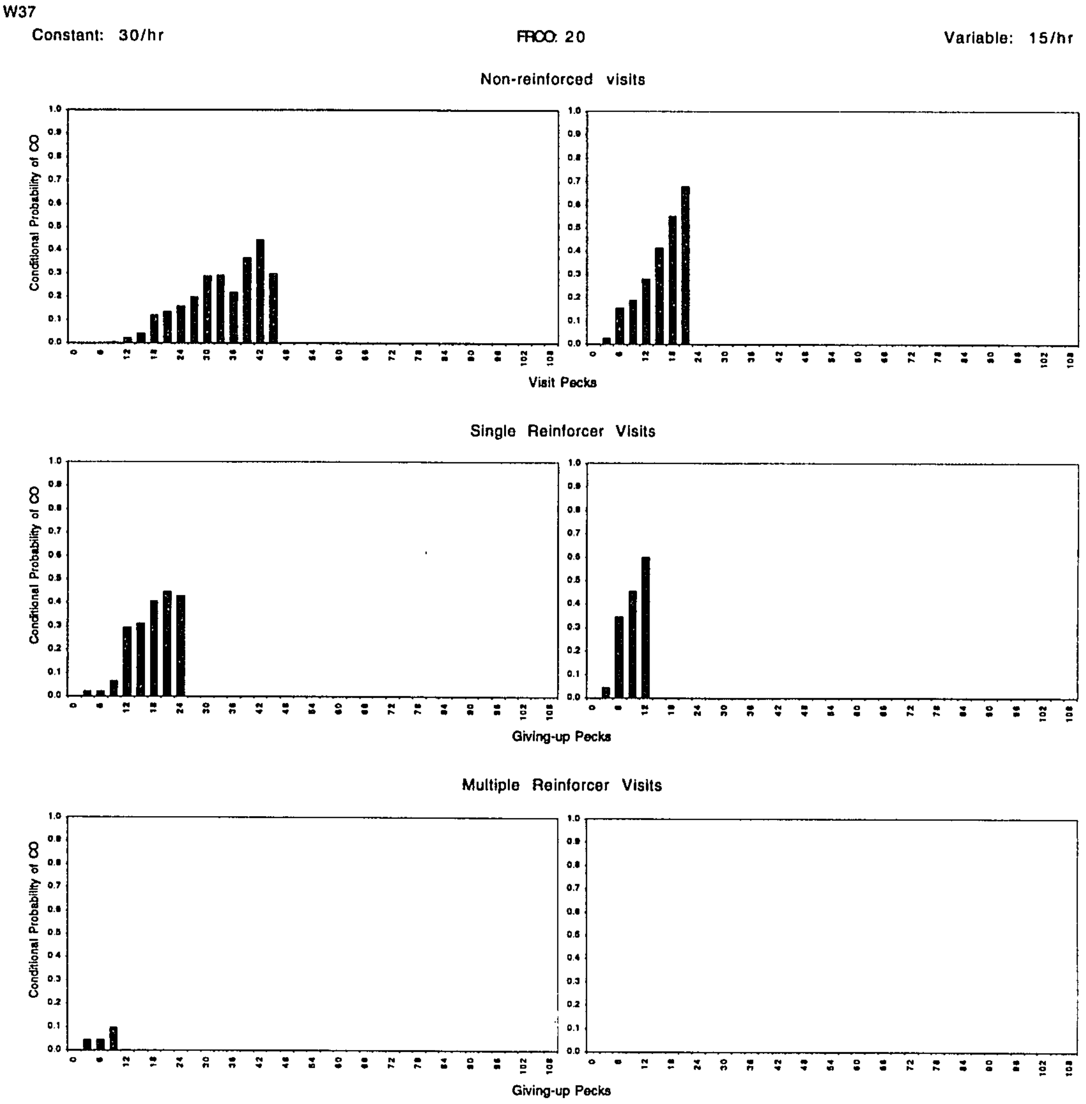

Figure 8d. Conditional probability of switching plotted as a function of visit pecks (bin size = 3, excluding zero bin). Left panels present leaving constant while right panels present leaving variable alternative. Data were separated into non-reinforced visits (top panels), single reinforcer visits (middle panels), and multiple reinforcer visits (bottom panels). Programmed reinforcer rates and changeover requirement noted at top.

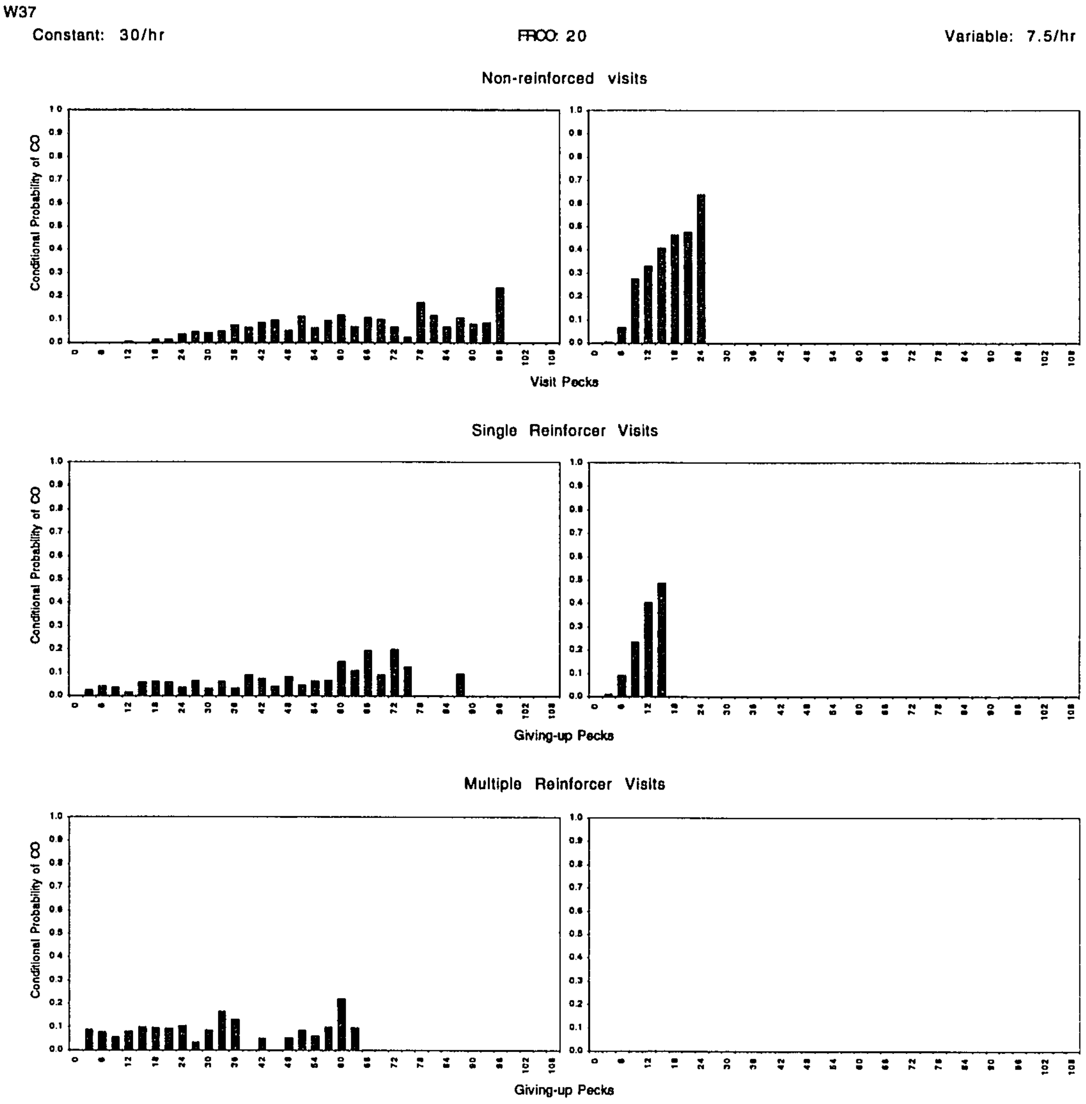

Figure 8e. Conditional probability of switching plotted as a function of visit pecks (bin size = 3, excluding zero bin). Left panels present leaving constant while right panels present leaving variable alternative. Data were separated into non-reinforced visits (top panels), single reinforcer visits (middle panels), and multiple reinforcer visits (bottom panels). Programmed reinforcer rates and changeover requirement noted at top.

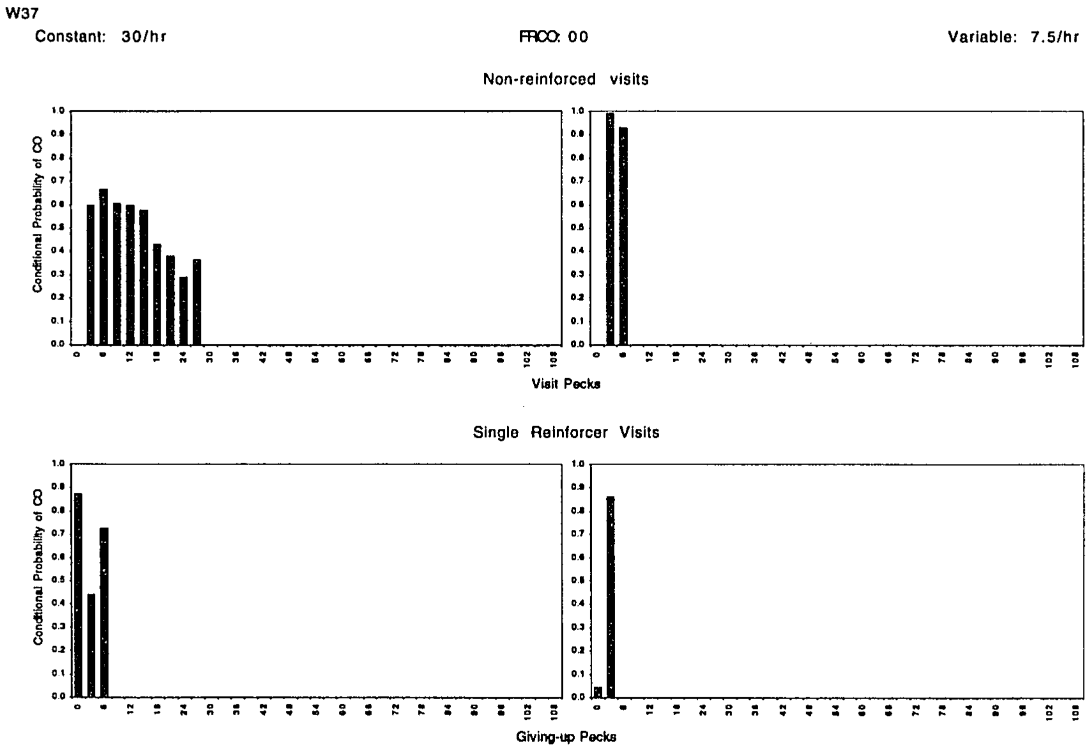

Figure 8f. Conditional probability of switching plotted as a function of visit pecks (bin size = 3, excluding zero bin). Left panels present leaving constant while right panels present leaving variable alternative. Data were separated into non-reinforced visits (top panels), single reinforcer visits (middle panels), and multiple reinforcer visits (bottom panels). Programmed reinforcer rates and changeover requirement noted at top.

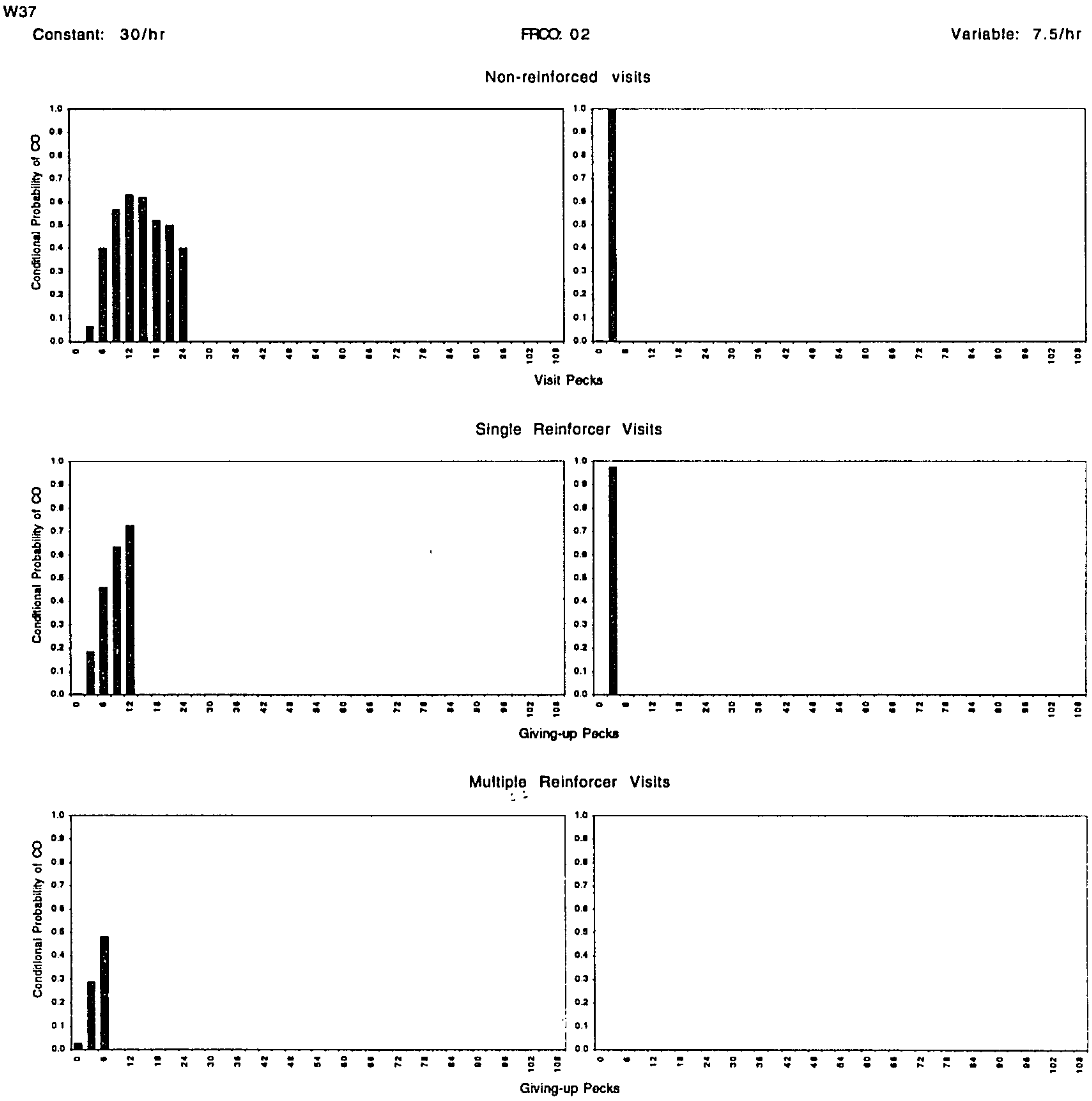

Figure 8g. Conditional probability of switching plotted as a function of visit pecks (bin size = 3, excluding zero bin). Left panels present leaving constant while right panels present leaving variable alternative. Data were separated into non-reinforced visits (top panels), single reinforcer visits (middle panels), and multiple reinforcer visits (bottom panels). Programmed reinforcer rates and changeover requirement noted at top.

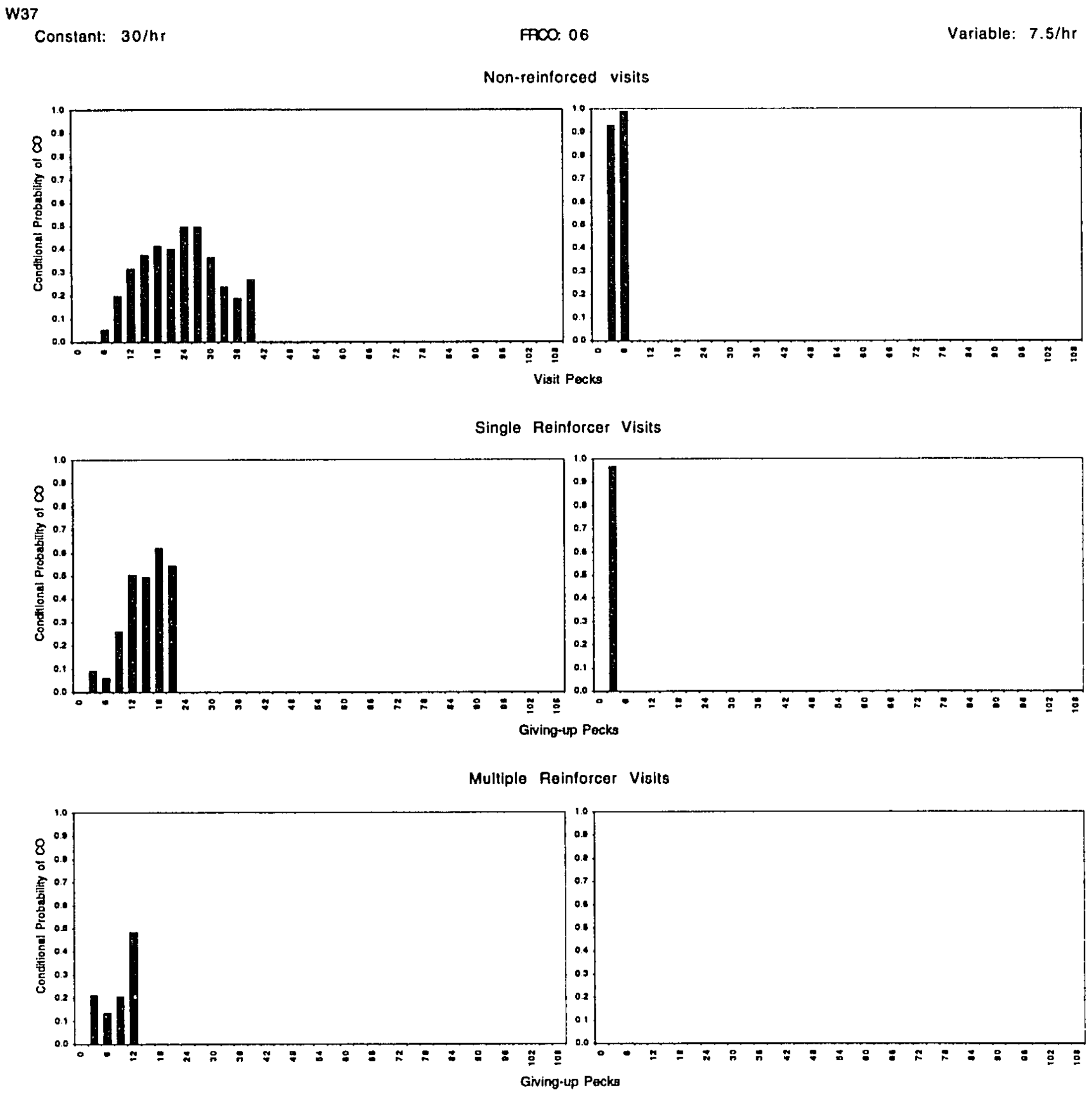

Figure 8h. Conditional probability of switching plotted as a function of visit pecks (bin size = 3, excluding zero bin). Left panels present leaving constant while right panels present leaving variable alternative. Data were separated into non-reinforced visits (top panels), single reinforcer visits (middle panels), and multiple reinforcer visits (bottom panels). Programmed reinforcer rates and changeover requirement noted at top.

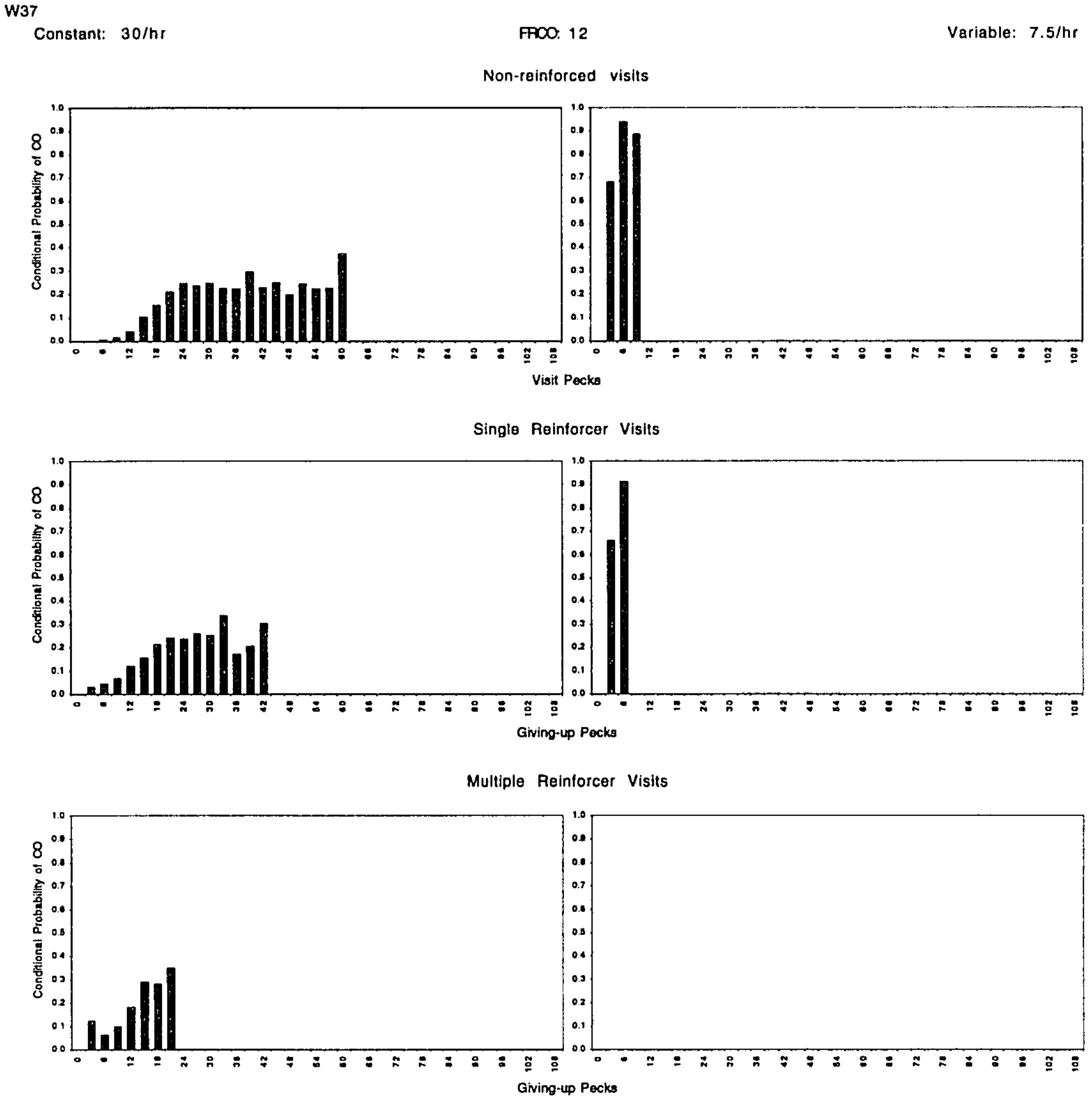

Figure 8i. Conditional probability of switching plotted as a function of visit pecks (bin size = 3, excluding zero bin). Left panels present leaving constant while right panels present leaving variable alternative. Data were separated into non-reinforced visits (top panels), single reinforcer visits (middle panels), and multiple reinforcer visits (bottom panels). Programmed reinforcer rates and changeover requirement noted at top.

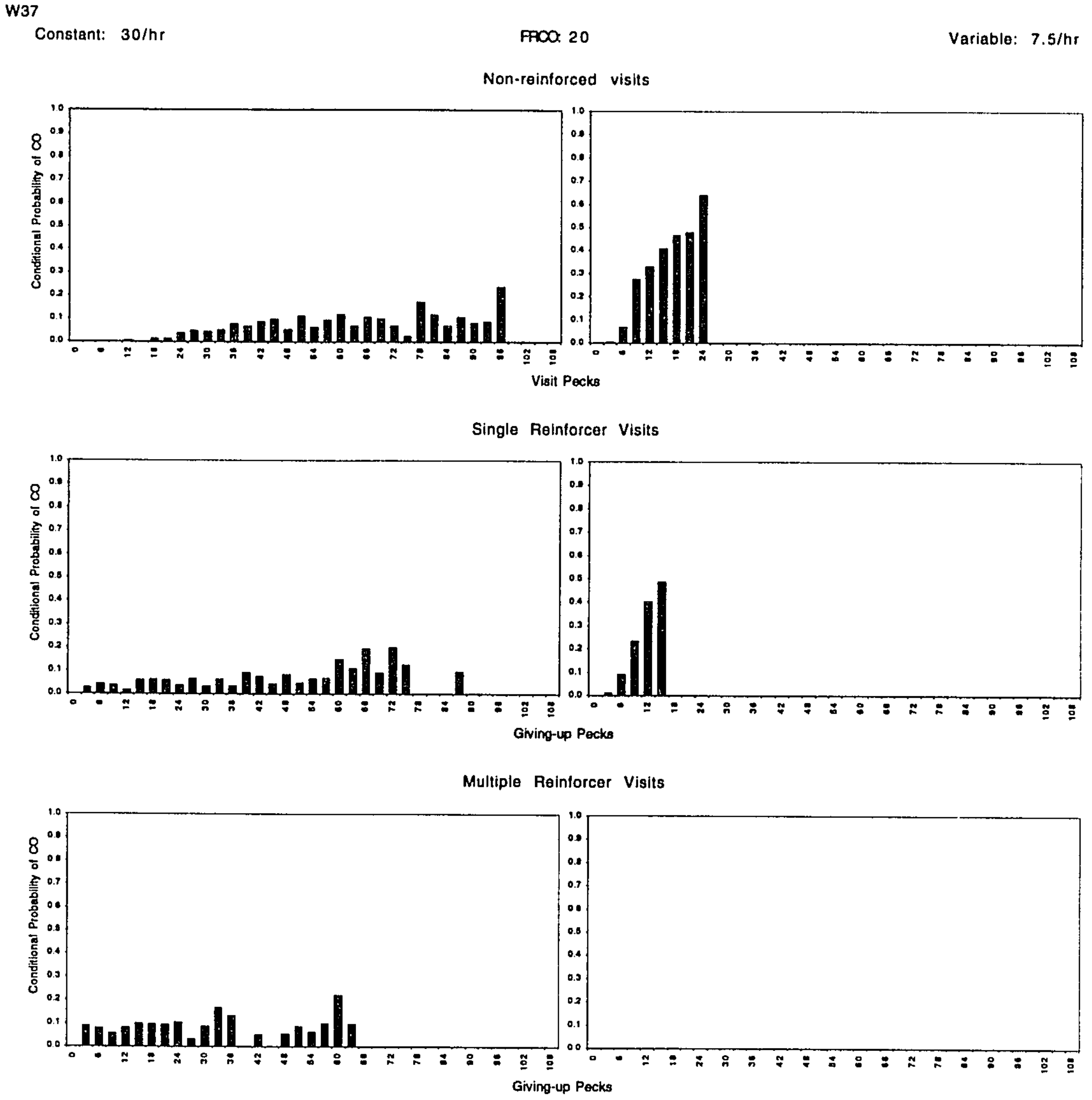

Figure 8j. Conditional probability of switching plotted as a function of visit pecks (bin size = 3, excluding zero bin). Left panels present leaving constant while right panels present leaving variable alternative. Data were separated into non-reinforced visits (top panels), single reinforcer visits (middle panels), and multiple reinforcer visits (bottom panels). Programmed reinforcer rates and changeover requirement noted at top.

Generally, the other pigeons' data show similar results (see Appendix III). Particularly interesting is W36's data from Condition 11 (VI 2' VI 4', see Table 2) which shows an increasing conditional probability of leaving even in extended visits, out to the 237 peck bin. The data from W35 show the effects but not as clearly.

Figures 9 a-b present a summary of the prior analyses. Using least-squares linear regression and excluding the 0-peck bin, slopes were determined for each conditional probability of switching distribution, again separated by visit type (non-reinforced, top panels; single reinforcer, middle panels; and multiple reinforcer, bottom panels) and plotted as a function of log reinforcer rate (obtained; Figure 9a) and log changeover requirement (Figure 9b). The most obvious result was that nearly all slopes were positive thereby supporting the general finding of the analyses presented in Figure 8 of an increasing probability of switching. The most frequent violations of this result occurred when FRCO 0 was in effect. When plotted as a function of log reinforcer rate (Figure 9a), the slopes tended to peak at the equal reinforcer rates, when changeover rates are maximal (see Figure 6). When plotted as a function of FRCO, all slopes tended to remain positive. The absolute value of the slopes should be regarded with some caution, however. The number of bins used to determine each slope was commonly quite different for each changeover requirement and reinforcer ratio. Generally, the larger changeover requirements produced longer visits (see the Foraging Analyses section below) which increases the number of bins. To compensate for this, another analysis would need to be performed constraining the visit pecks and GUPs within a fixed number of bins. These general tendencies hold for all four pigeons, generally (see Appendix III).

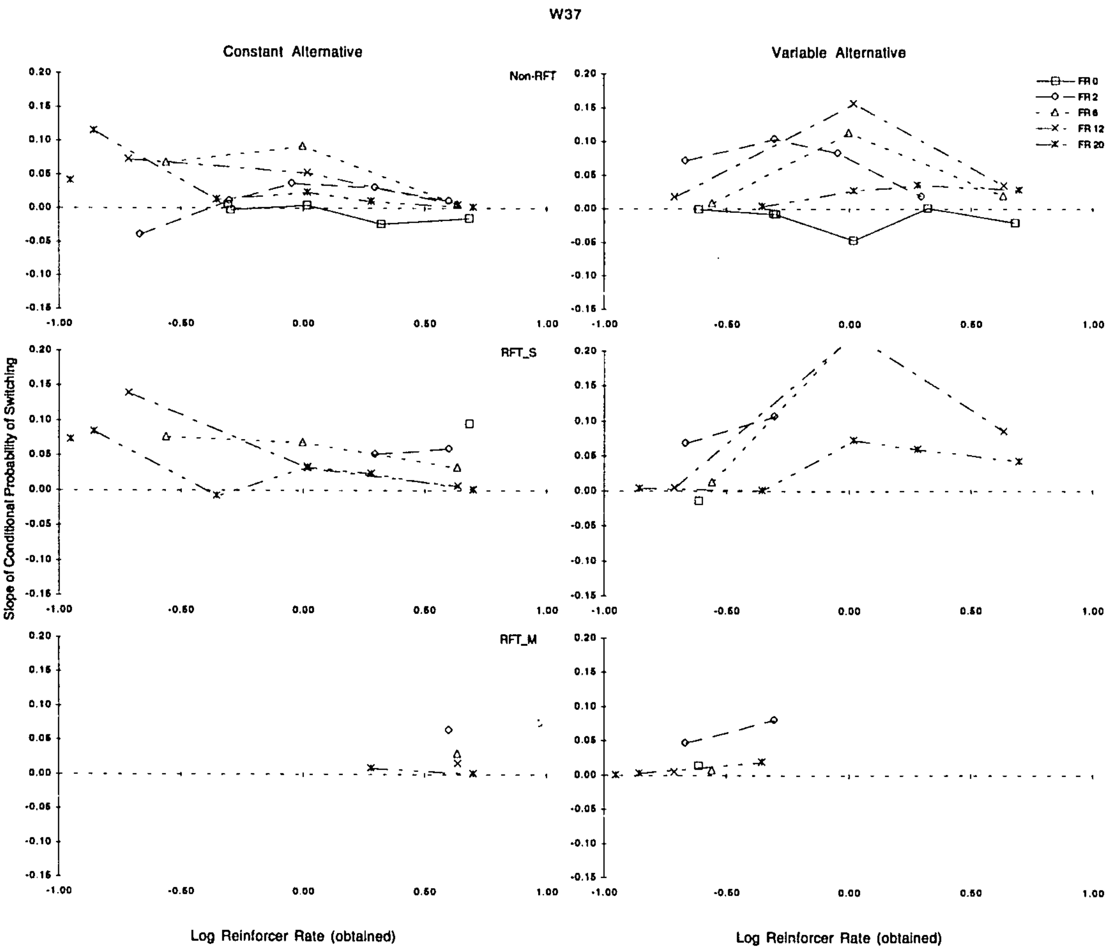

Figure 9a. Slopes of conditional probability of switching for each changeover requirement (see legend) plotted as a function of log reinforcer rate (obtained). Grouped in same manner as Figure 8. One point in the middle-right panel is off the scale.

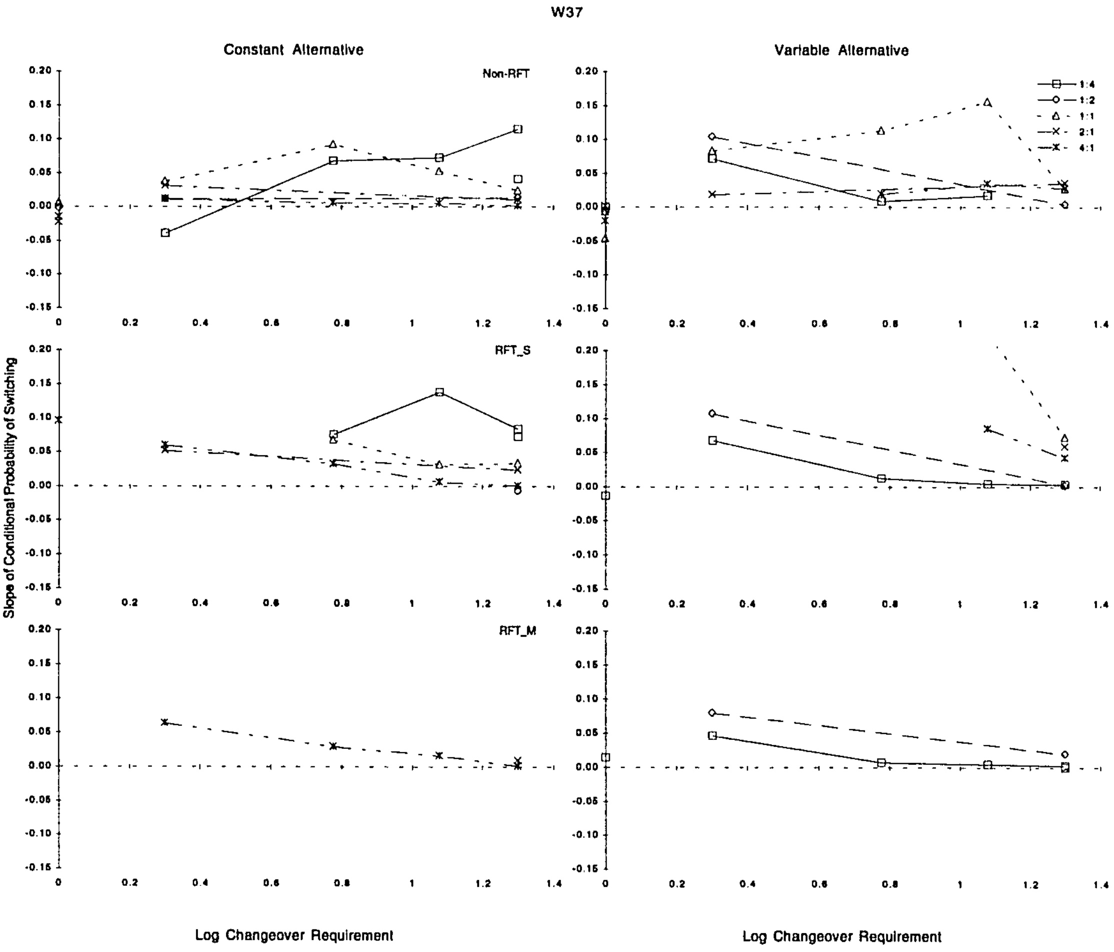

Figure 9b. Slopes of conditional probability of switching for each reinforcer rate (see legend) plotted as a function of log changeover requirement. Grouped in same manner as Figure 8. One point in the middle-right panel is off the scale.

The results portrayed in Figures 8 and 9 indicate that the shape of the conditional probability function is a joint function of absolute reinforcer rate and the changeover requirement.

Foraging Analyses

Representative Statistic. The foraging analyses required determining a statistic that represented the central tendency of the measures. Frequency histograms for data from each pigeon were constructed of the peck and duration measures for non-reinforced, single-reinforcer, and multiple-reinforcer visits for each condition. A minimum sample size of 10 was required to be included in the analyses. GUP_m were affected the most by this requirement. Usually the distributions were symmetrical around a mode. Means and medians were calculated.

Figures 10a-b present the means (left column) and medians (right column) of visit pecks (a) and visit times (b) for Pigeon W36 and are presented to show that there are only little differences between the two statistics. First, consider the relationship between the two columns. Usually the forms have the same shapes: Both means and medians for both visit pecks and visit time show a crossover of performance on the two alternatives. (The slopes are considered in the next figure.) The means, however, tend to be somewhat smoother (see top panels, FRCO 0). Usually the means were smoother for all pigeons and all three categories of visits (non-reinforced, single-reinforcer, and multiple-reinforcer visits; see Appendix IV). For some conditions, the median visit was 0.0 and,

W36

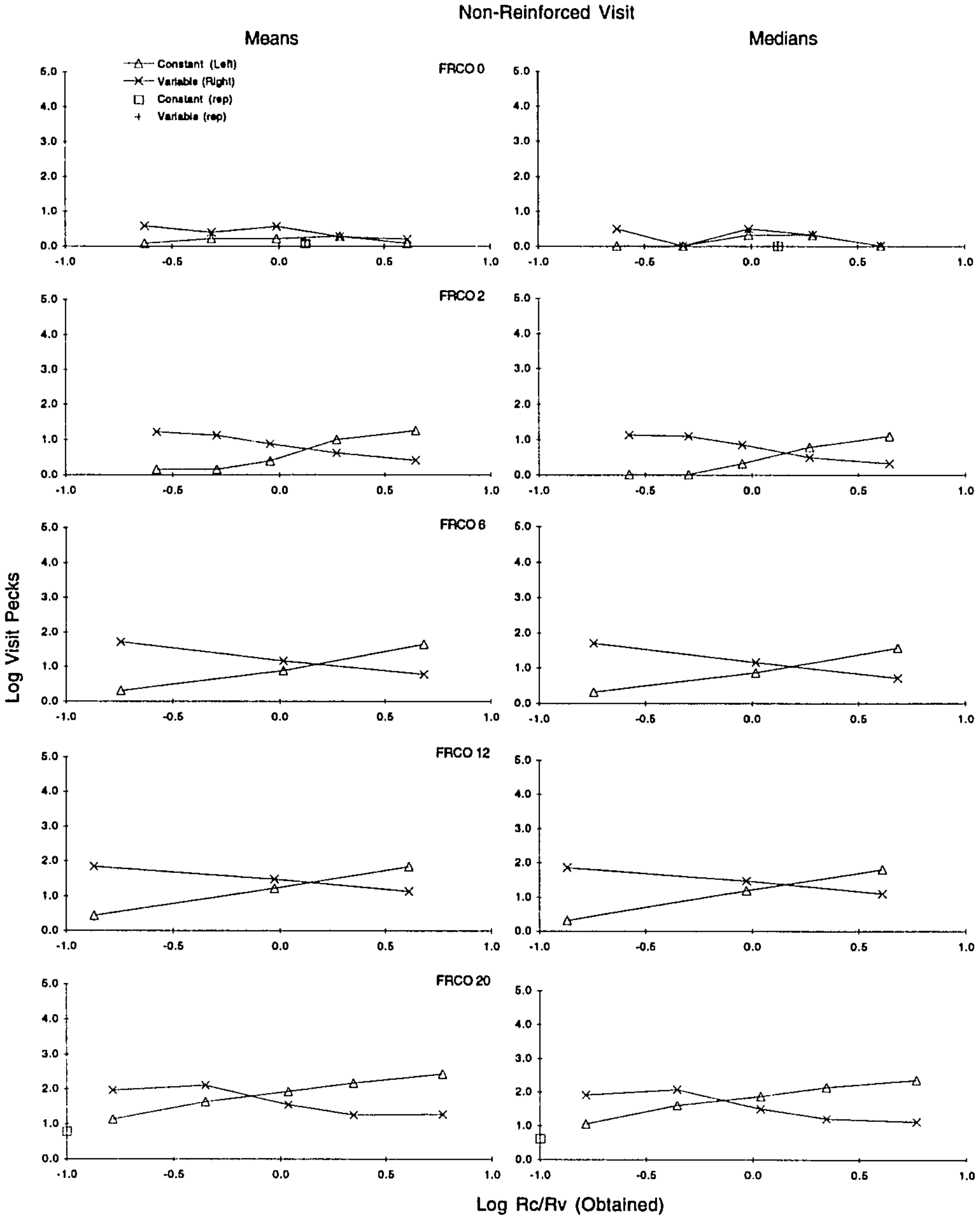

Figure 10a. Mean (left panels) and median (right panels) log visit pecks for constant and variable alternatives (see legend), categorized by travel requirement, plotted as a function of log reinforcer ratio (c/v; obtained).

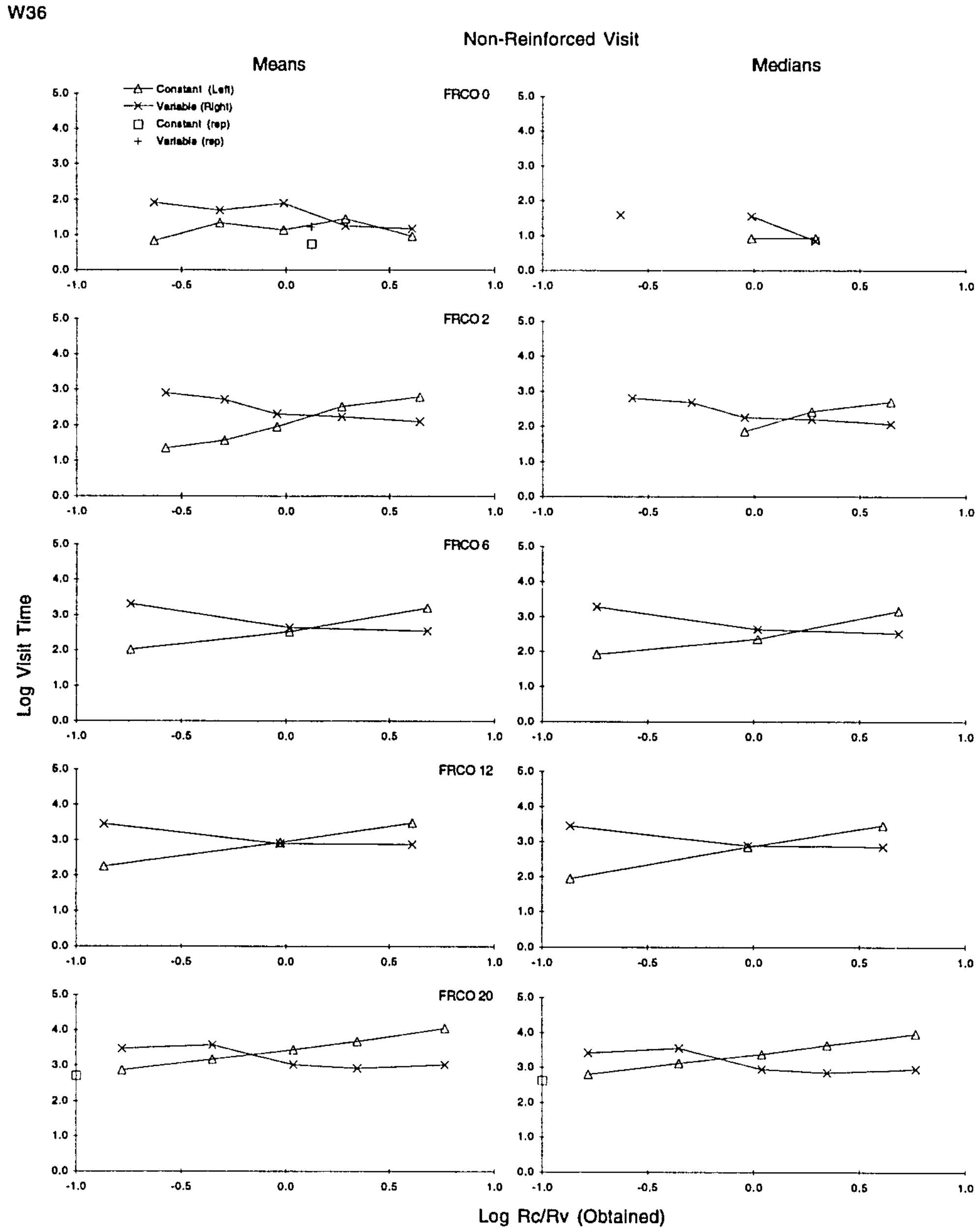

Figure 10b. Mean (left panels) and median (right panels) log visit time for constant and variable alternatives (see legend), categorized by travel requirement, plotted as a function of log reinforcer ratio (c/v; obtained).

since the logarithms are undefined, could not be plotted. The mean is used throughout the remainder of the foraging analyses.

A second feature of Figures 10a-b to note is where along the abscissa the crossovers occur. Both pecks and time show this effect but in slightly different ways. Consider first the pecks. For FRCOs 0, 2, 6, & 12 the point of crossover is consistently to the right of equal reinforcer rates and that point for the higher three changeover requirements is consistent. The crossover point for FRCO 20, however, is to the left of equal reinforcer rates. The same effect holds for the visit times except that as the changeover requirement increases the crossover point progressively shifts to the right on the x-axis. These results are directly correlated with the measures of bias for this pigeon in Figure 2 (triangles in the bottom panels). Response allocation bias was constant for the smaller changeover requirements and switched for FRCO 20. Time allocation bias showed a more gradual shift and then a small jump as changeover requirement increased. The large shift in W35's bias measure when FRCO increased from 0 to 2 (Figure 2) is also evident in the visit pecks and visit time charts (see Appendix IV).

This analysis suggests a slight effect of the absolute reinforcer rate, most evident in Figure 10b. When FRCO 20 was in effect (bottom two panels), the points for the 4:1 reinforcement ratio (far right) are greater than the corresponding points for the 1:4 ratio (far left). Many of the panels for all four pigeons, for non-reinforced visits particularly, support this inverse relation between visit pecks or time and absolute reinforcer rate, consistent with the principle of lost opportunity (see Chapter II & Appendix IV).

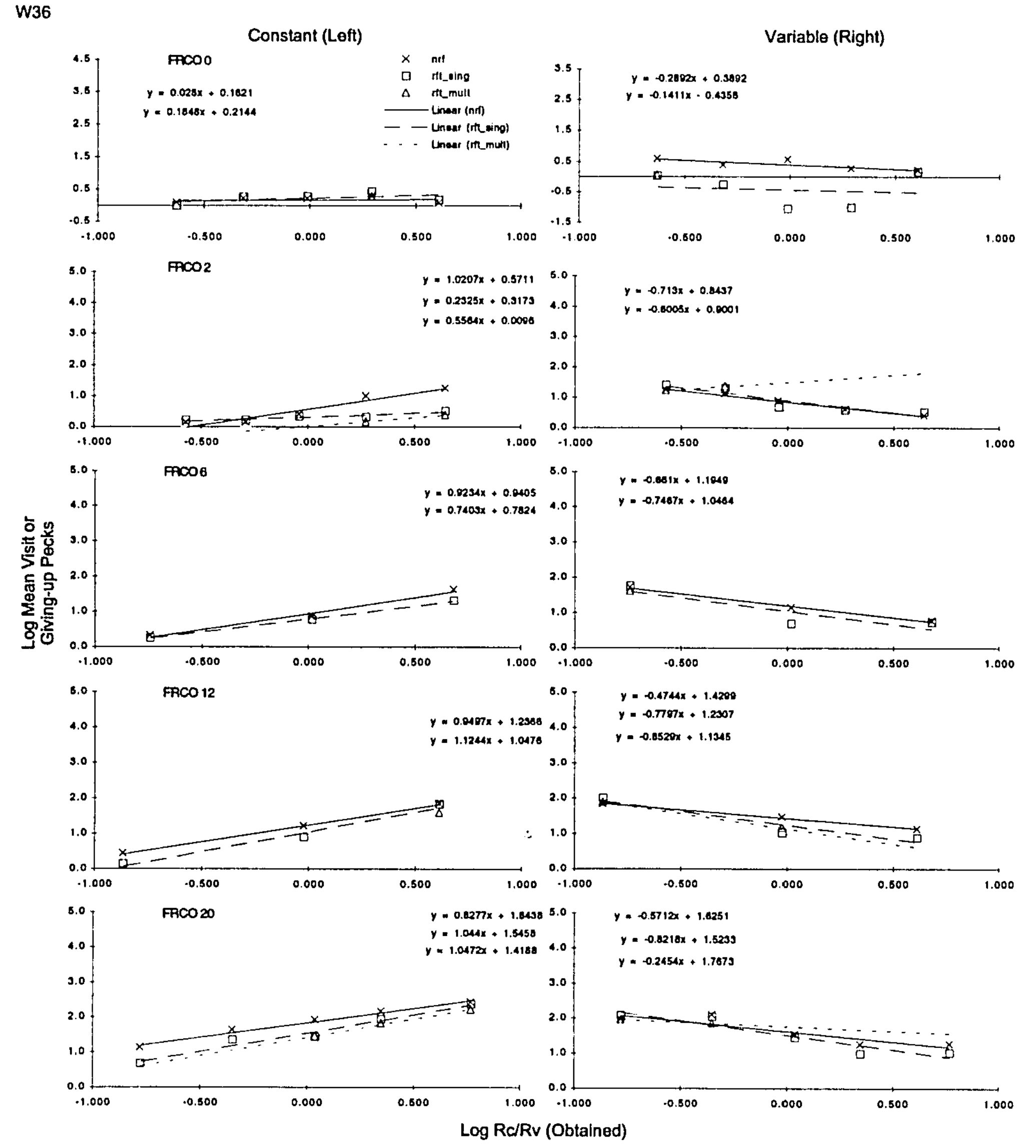

Figure 11a. Log mean visit pecks and giving-up pecks for constant (left panels) and variable (right panels) alternatives, categorized by travel requirement, plotted as a function of log reinforcer ratio (c/v; obtained). Equations are least square linear and are listed in the same order as in the legend.

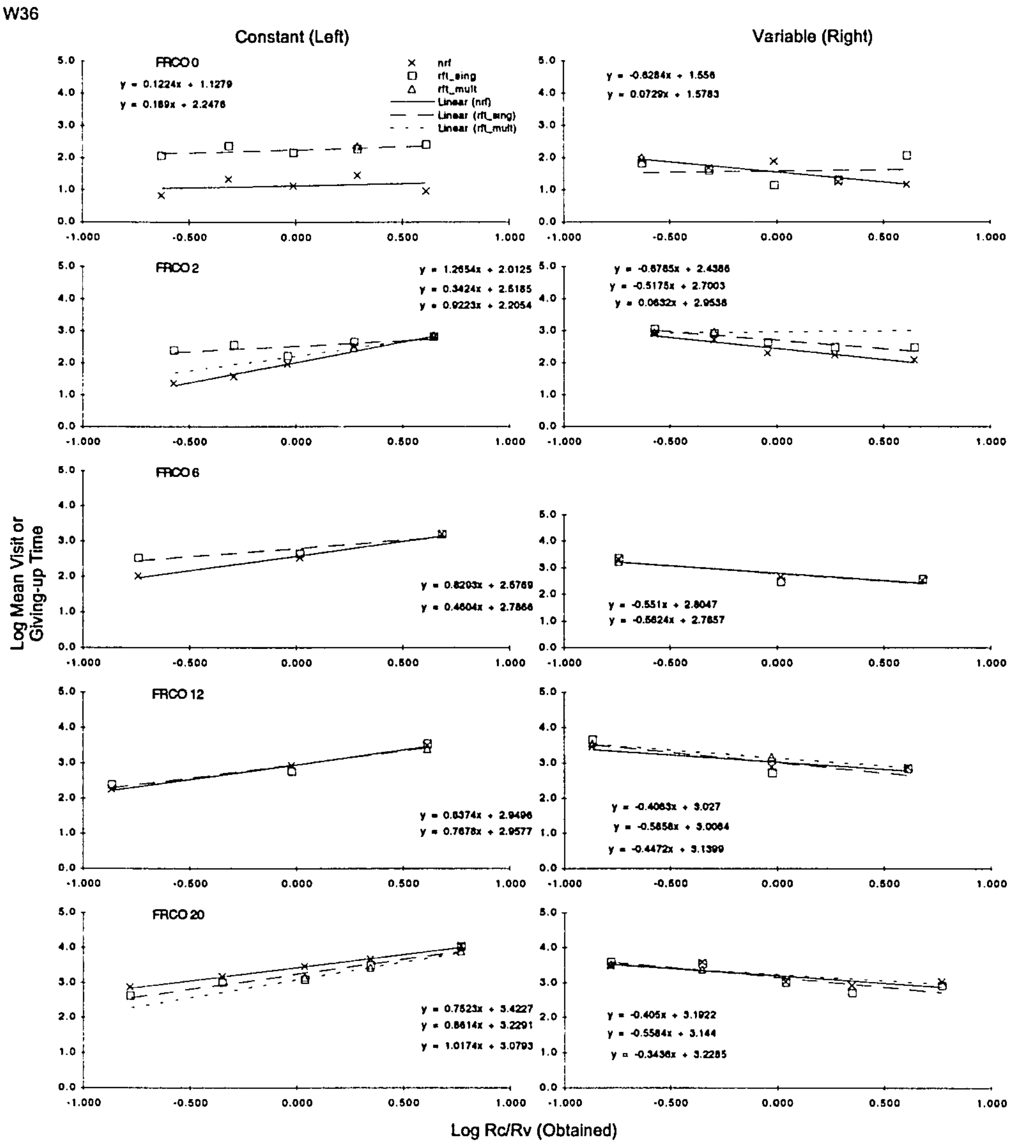

Figure 11b. Log mean visit time and giving-up time for constant (left panels) and variable (right panels) alternatives, categorized by travel requirement, plotted as a function of log reinforcer ratio (c/v; obtained). Equations are least square linear and are listed in the same order as in the legend.

Visit Analyses. Figures 11a (pecks) and 11b (time) depict data similar to Figure 10. (Note that not all y-axis scales are identical, but all are the same length.) The logarithms of the mean visit pecks and giving-up pecks are plotted as a function of the obtained log reinforcer ratio for both the constant (left column) and variable (right column) alternatives by changeover requirement (FRCO 0 on top, increasing changeover requirement downward). The least-squares regression equation for each visit type is included, and these are listed in the same order as the label in the legend. Some GUP_m and GUT_m have fewer than five points due to small sample size.

The most striking observation is the positive slope for the constant alternative and the negative slope for the variable alternative for all FRCOs and for both pecks and times. This result indicates that visit pecks and time and giving-up pecks and time are related to relative reinforcer rate more so than absolute rates. As the constant alternative became richer relative to the variable alternative and absolute reinforcer rates decreased, visits became longer (left panels), consistent with prediction for both relative and absolute reinforcer rates. Conversely, as the variable alternative became leaner relative to the constant alternative and absolute reinforcer rates decreased, visits became shorter (right panels), consistent with prediction for relative reinforcement but inconsistent with prediction for absolute rates. The effect of absolute reinforcement may be evident from the negative slopes being less negative than the positive slopes are positive. Similar results for relative reinforcement rates were reported by Dreyfus et al. (1993). The only exceptions are the positive slope for GUP_m and GUT_m in FRCO 2 on the variable alternative, but those slopes are derived from only two points. And the slopes for the GUT_s when FRCO 0 was in effect are close to zero.

Figures 12a (peck) and 12b (time) are the same points as Figure 11 but the manipulated variables are reversed: that is, pecks and time are plotted as a function of the logarithm (base 10) of the changeover requirement by programmed reinforcer ratio (1:4, top panel, to 4:1, bottom panel). (Note that not all y-axis scales are equal.) With high reliability, as changeover requirement increased so did the measured variable. Baum (1982) and McCarthy, Voss, and Davison (1994) showed the same relationship. All pigeons show similar results (see Appendix IV).

Figure 13 presents a comparison of time measures (visit time, top panels, or GUT_s, bottom panels; y-axis) as a function of response measures (visit pecks, top panels, or GUP_s, bottom panels; x-axis) separated by alternative (constant, left column; variable, right column) with each changeover requirement depicted by different symbols (see legend) for W36. Lines are best fitting lines of each changeover requirement with their equations listed in the same sequence as the sequence of the line's identifier in the legend. The equation at the bottom of each panel is for all points combined, except FRCO 0, with the variance accounted for below it. All y-intercepts are positive and, with the exception of FRCO 0, are fairly consistent at about 2.0. Because time was measured in hundredths, a y-intercept of log 2.0 means a y-intercept of 100, if the slope is close to 1.0, corresponding to a response rate of one peck per second. Excepting FRCO 0, only three slopes approximate 1.0; the remaining are consistently less than one. Furthermore, as FRCO increases the more similar the slopes, generally. These results hold regardless of alternative and for both non-reinforced and single-reinforcer visits.

The slopes for each category of visit for all pigeons are presented in Figure 14. Logs of the slopes, sorted by alternative and reinforced or non-reinforced visits, are plotted as a function of travel requirement. W34 and W35 each have one point for the FRCO 0 condition that is off the scale (constant alternative, single-reinforced visits and variable alternative, non-reinforced visits, respectively). Most prominent is the slopes' convergence as travel increases. W34 and W35 tend to converge around slopes of 1.0 (log 0) while W36 and W37 tend around slopes slightly less than 1.0 (negative logs). In addition, when the slopes are different (i.e., smaller travel requirements), the slopes for the non-reinforced visits tend to be greater than reinforced visits. The convergence of the slopes as travel increased is similar to the convergences depicted in Figures 4 and 5.

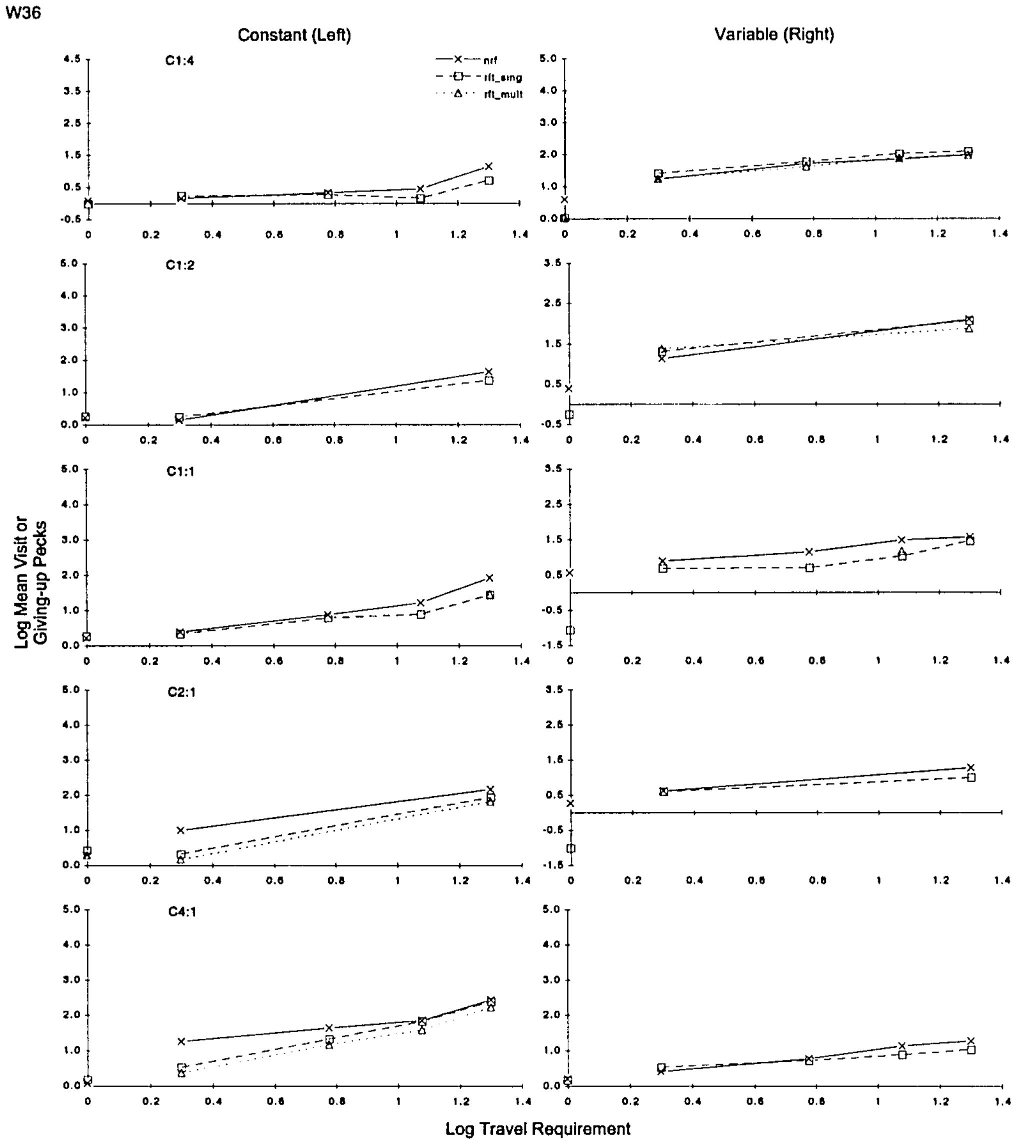

Figure 12a. Log mean visit pecks and giving-up pecks for constant (left panels) and variable (right panels) alternatives, categorized by reinforcer ratio, plotted as a function of log travel requirement.

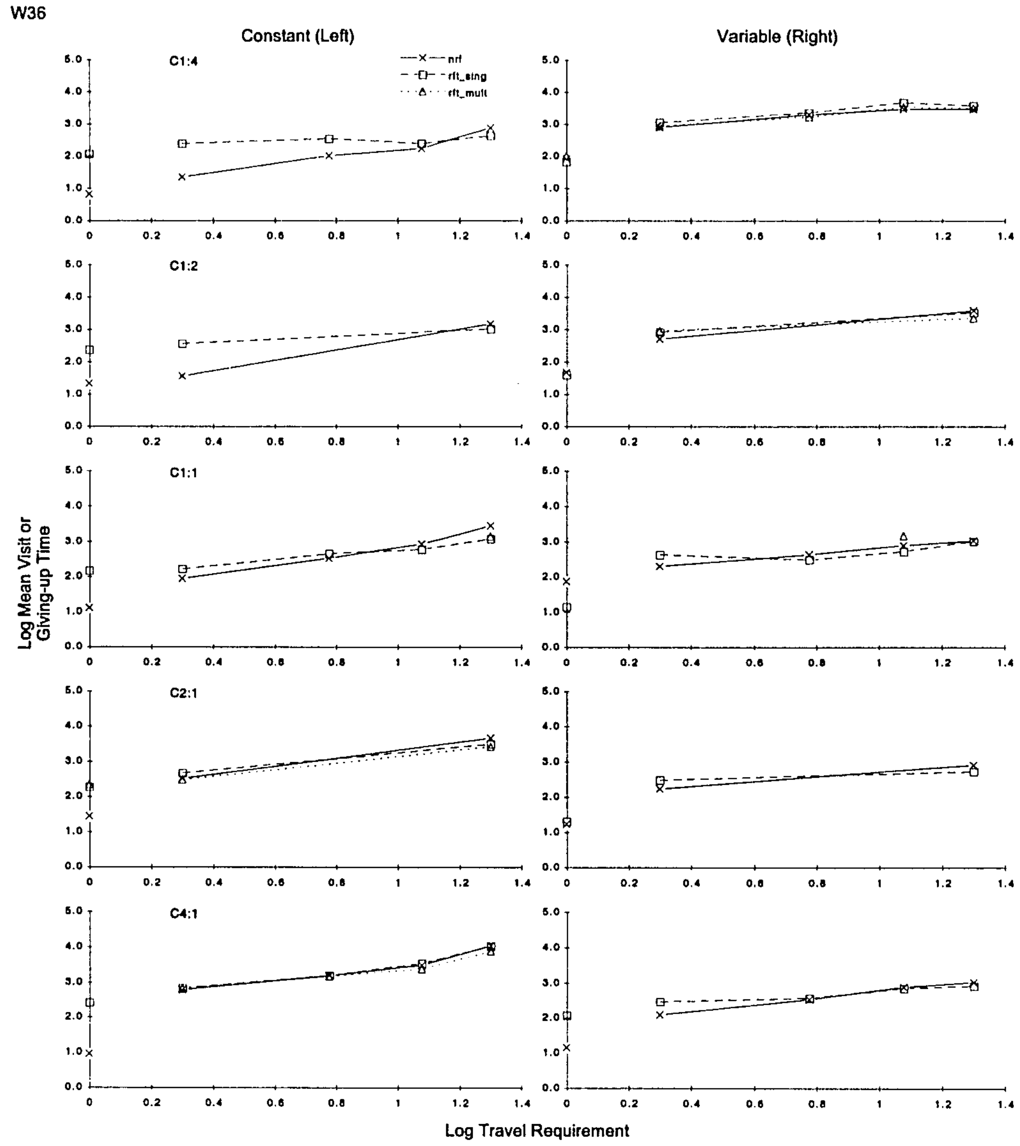

Figure 12b. Log mean visit time and giving-up time for constant (left panels) and variable (right panels) alternatives, categorized by reinforcer ratio, plotted as a function of log travel requirement.

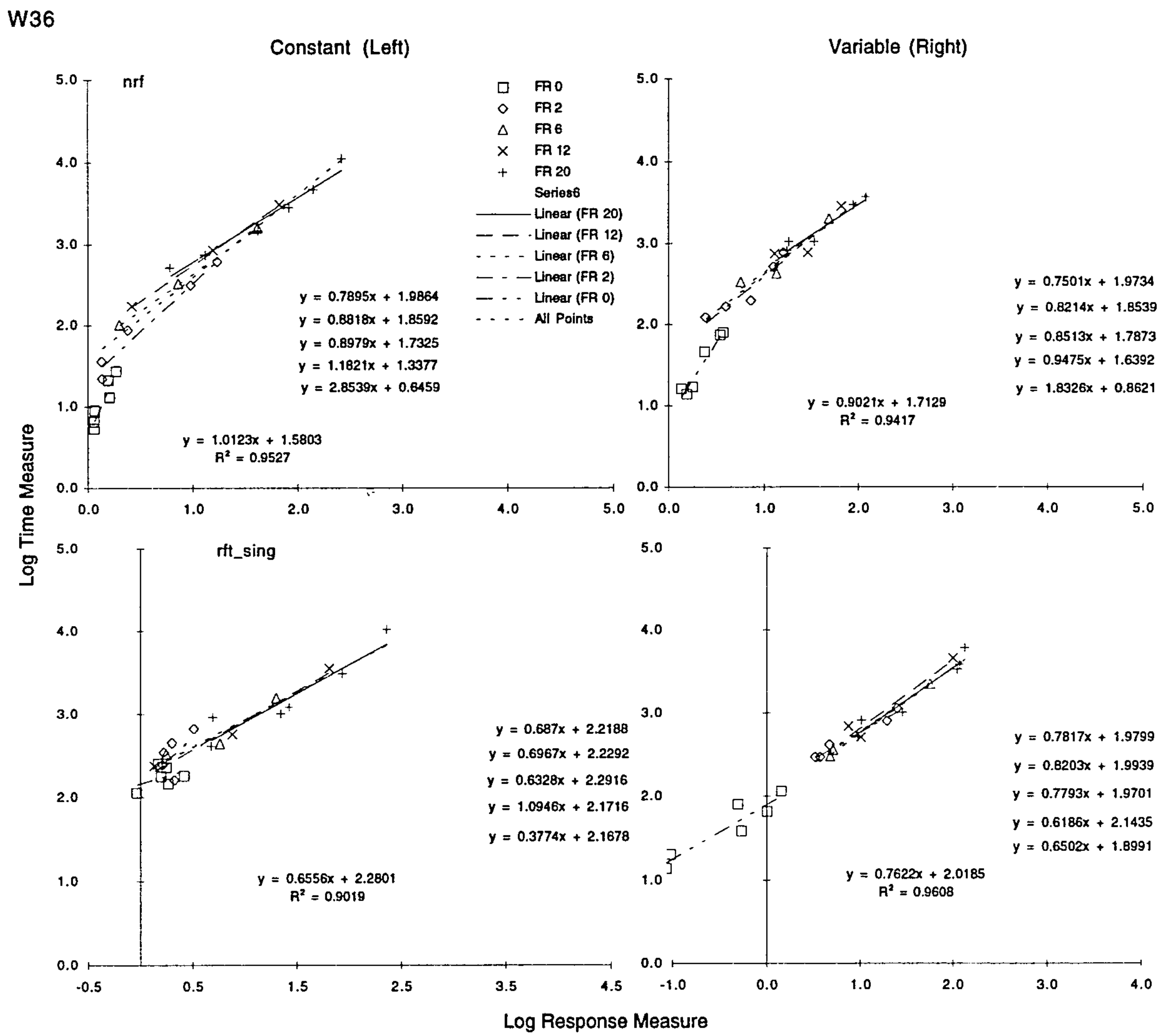

Figure 13. Log time measure, separated by alternative, plotted as a function of log response measure. Top panels depict data from non-reinforced visits while bottom panels present data from reinforced visits.

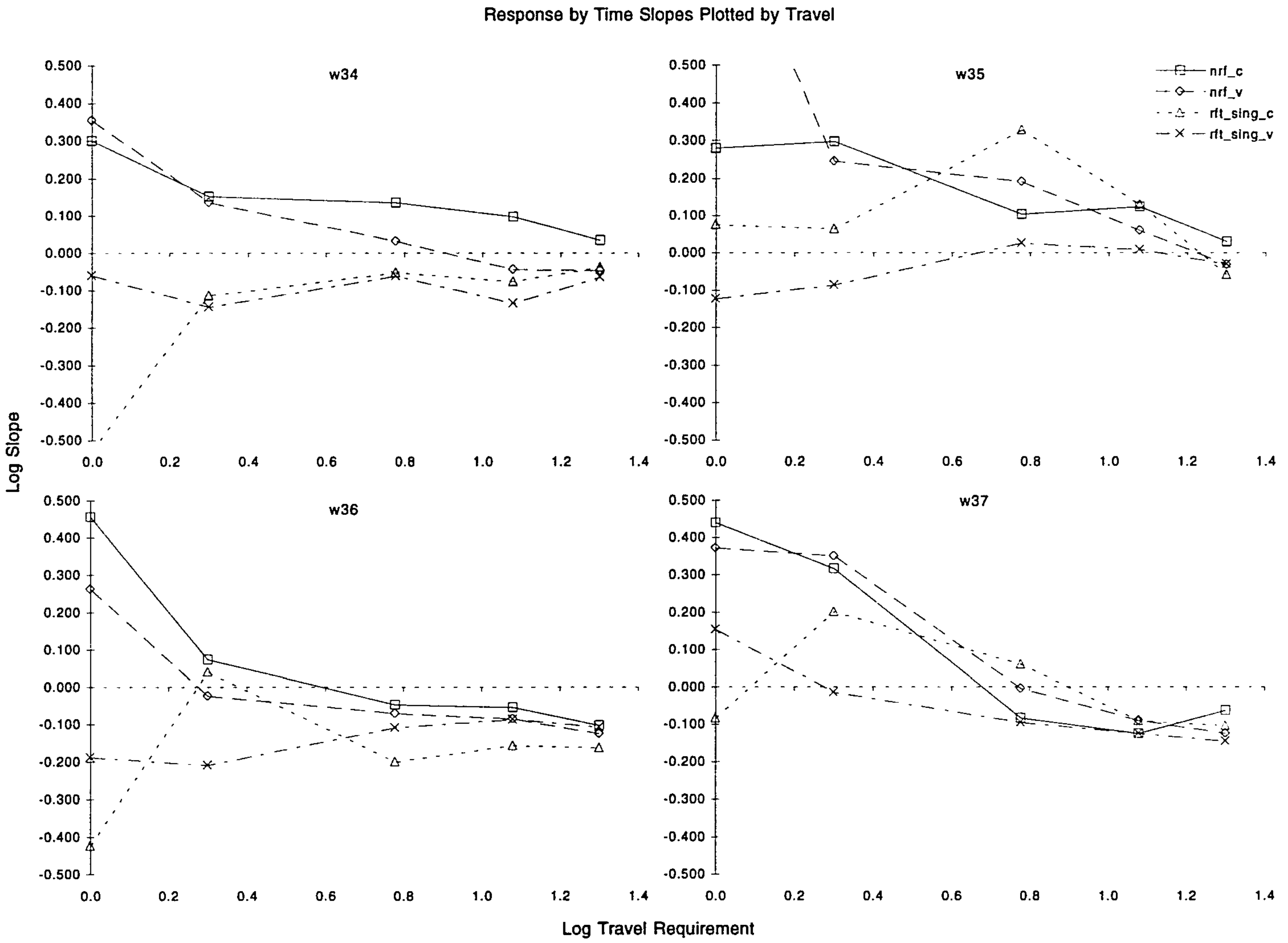

Figure 14. Response by time slopes (from Figure 13) plotted as a function of log travel requirement. Symbols indicate alternative and non-reinforced or reinforced visits (see legend). Pigeon indicated in each panel.

CHAPTER IV

DISCUSSION AND CONCLUSIONS

The motivating issues for this dissertation revolved around the factors that affected choice, generally, and switching, specifically. Research investigating the matching relation has demonstrated that relative reinforcer rates reliably influence behavior. Whether or not reinforcement sensitivity is a constant is currently debated. Research suggests that reinforcement sensitivity is affected by the changeover requirement (Baum, 1974a; 1974b; 1979; Temple, Scown, & Foster; 1995; Wearden & Burgess, 1982; & Williams, 1988), but until recently no parametric examination of its effects had been reported. Temple et. al parametrically manipulated the changeover delay. This present dissertation physically separated the imposed changeover requirement from main-key responding and manipulated it. The results further our understanding about switching. This chapter reviews and discusses the key results.

Molar Findings

The effect of the changeover requirement has been debated since Herrnstein's (1961) report. Research with other than COD changeover requirements (i.e., FR schedules and barriers) suggests that sensitivity increases with changeover requirement and that overmatching becomes the norm. Figure 2 demonstrates that, after some minimal changeover requirement, response-allocation sensitivity remains relatively constant for individual subjects, consistent with Temple, Scown, and Foster's (1995) recent report which varied COD. Pigeons W34 and W36 (see Figure 2) maintained similar response-allocation sensitivity measures for all changeover requirements larger than FRCO 0. Pigeon W37's sensitivity was fairly constant over the larger three FRCOs, while W35 reached a maximum at FRCO 12. Also consistent with Temple et al. and contrary[2] to Herrnstein (1961), behavior is sensitive to reinforcement contingencies even without a COD, although the slope is less than 1.0.

Time allocation sensitivity, on the other hand, has a pronounced negative trend as the changeover requirement increases. This result is contrary to previous findings. All prior reviews and studies reported that time sensitivity deviated less from matching than response sensitivity (Chapter 1, *Why Deviations?*), suggesting that deviations are from some anchor. Figure 15 depicts the sensitivity difference scores for log response sensitivity minus log time sensitivity plotted as a function of changeover requirement. At FRCO 0 time sensitivity was greater than response and, since response sensitivities undermatch, this is in keeping with earlier reports. However at FRCO 2 and larger, all sensitivity measures, except one of W35's response measures, are overmatching; nevertheless, Figure 15 indicates that time sensitivities are more extreme than response sensitivities. Larger FRCOs produced larger difference scores indicating that response sensitivities became relatively greater than time sensitivities as changeover requirement

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[2] "...relative frequency of reinforcement on Key A was about 66%. The relative frequencies of responding on Key A were 50% and 56% for the two pigeons" (Herrnstein, 1961, p. 270).

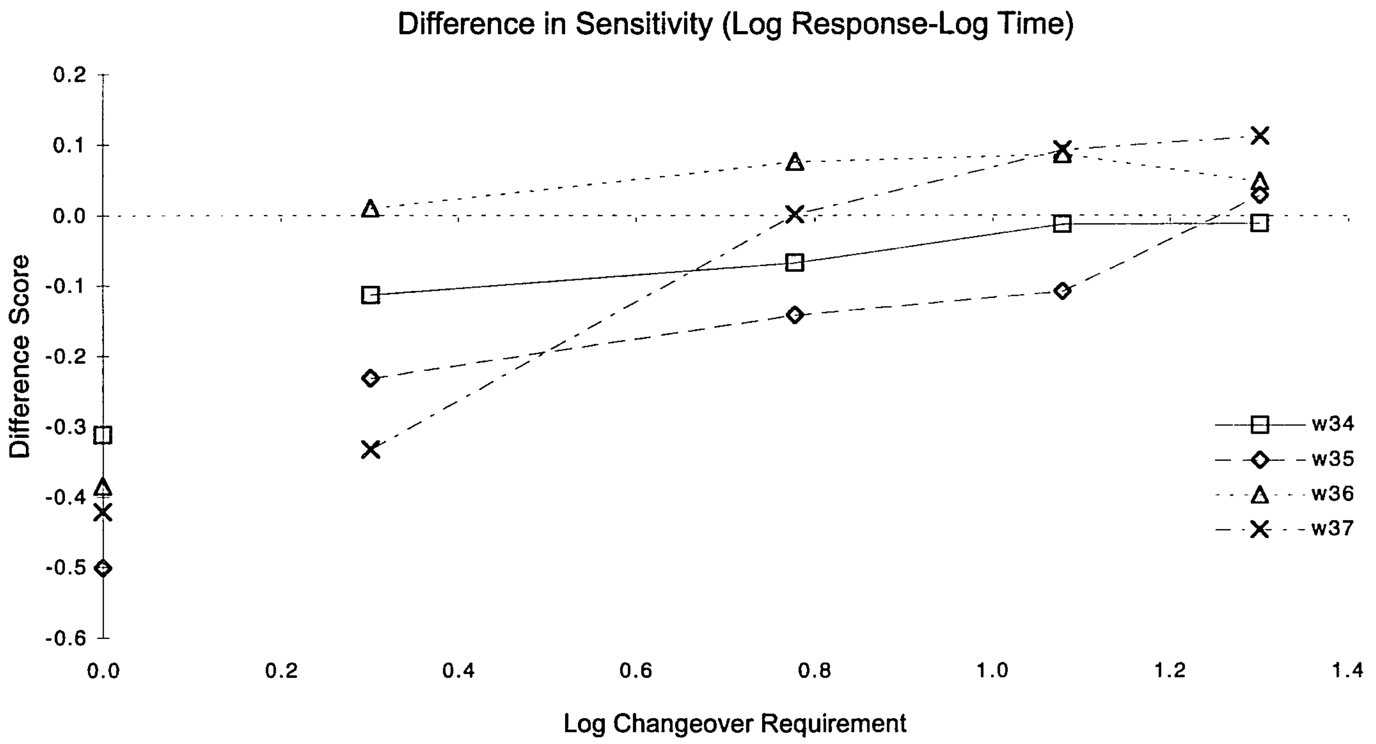

Figure 15. Difference in sensitivity of response and time allocation plotted as a function of log changeover requirement. Symbols denote pigeon (see legend).

increased. This reversal of the sensitivities's deviation from 1.0 as FRCO increased may indicate that time sensitivity is more firmly anchored than response sensitivity (Wearden and Burgess, 1982).

One way to understand the decreasing trend in time sensitivity is to consider what is happening to response rates on each alternative as the changeover requirement increases. Recall the three noted features from Figure 5. First, as changeover requirement increased the response-rate ratios for the different schedule pairs converged, meaning that larger FRCOs produced more similar response rates. Second, almost all ratios converge at 1.0, equal response rates on each alternative regardless of reinforcer rate. And third, at smaller FRCOs the leaner alternative garnered the higher response rate. Baum (1982, p. 42) noted a divergence in response rates to the preferred and non-preferred alternatives. Like Figure 5, Figure 14 suggests similar changes in response rates also. Taken together, these results indicate that response rates on the two alternatives changed reliably with changeover requirement. More specifically, as changeover requirement increased, response rate on the leaner alternative relative to the richer alternative slowed down. This means that the changeover requirement increases the amount of time spent on an alternative more than the number of responses given. Such results reflect the crucial property of VI schedules: quantity of responses is less important than a well placed peck.

The results support the different-response-topography hypothesis proposed by Baum (1979). Clearly, with lower changeover requirements the richer and leaner schedules garnered different response rates. As FRCO increased, the response ratios approached unity. Increasing the time on the lean alternative with responses remaining proportionally constant would produce the negative trend for time-allocation sensitivity while at the same time keeping response sensitivities constant. The changes in response rate may result from changes in the response-to-pause ratio due to the increased visit durations and pecks that occurred as the changeover requirement increased (see Figure 12b). If the richer and leaner alternatives do obtain different response rates, attempts to mathematically model the effects of unequal changeover requirements (Davison, 1991) need to account for changing response rates.

Central to recent investigations of the matching relation is the question of what is the normative value of *s*: matching, undermatching, or overmatching? For other than the lowest changeover requirement, both response and time allocation do not show undermatching here; overmatching is the norm, although matching occurs in a few instances (W35's response allocation and time allocation for W35 and W37 when FRCO 20 was in force). Using chickens as subjects, Temple et al. (1995) reported mostly matching for all but the lowest CODs, when response- and time- allocation measures included changeover behavior. When response-allocation sensitivities excluded changeover responses, they tracked sensitivities that included changeover responses but at higher values, sometimes matching and sometimes overmatching.

The consistency in the FR response rate depicted in Figure 7 indicates that including changeover behavior would add a constant to both alternatives. This would have a proportionally larger effect on the leaner alternative thereby reducing sensitivity. Given that changeover responding occurs on a separate key in this dissertation, including changeover behavior in the calculation seems unwise. Furthermore, supporting Baum

(1982), Temple et al. argue that changeover behavior should be excluded because doing so homogenizes the sensitivity measures derived from different procedures. Perhaps comparing absolute sensitivity values is less important than considering the effects specific procedures have on sensitivity, particularly considering that COD responding is essentially insensitive to reinforcement rates (see Baum, 1974a; 1982; Temple et al.; Figure 1).

Conditional Probability of Switching

The properties of *conc* VI VI schedules (see Chapter I, *Common Procedures*) lead to the intuitive conclusion that the probability of returning to an alternative should increase the longer one is away from that alternative. However, Nevin (1969; 1979), using a discrete-trials procedure, reported that the probability of a changeover response remained constant or decreased slightly as a function of run length; at the same time, the probability of reinforcement for switching increased steadily. Using a two-key changeover procedure (FR 1), Heyman (1979) also reported no increase in the conditional probability of switching. Heyman used a variety of concurrent schedules, both richer (VI 33.3 seconds) and leaner (VI 300 seconds), which allowed run lengths much longer than Nevin obtained. Nevin's (1969) longest run lengths were in the 6-10 bin while Heyman's longest runs were near 50 when a VI 33.3 second schedule was paired with a VI 300 second schedule. Experiment 1 of Silberberg et al. (1978) replicated Nevin and Shimp (1966) and claimed evidence supporting sequential dependencies. Silberberg et al. claimed that their other experiments confirmed this conclusion, although not without theoretical complexity.

Figures 8a-j show an increasing probability of switching the more consecutive pecks on an alternative, particularly when the changeover requirement is large. Why was evidence for an increasing probability of switching so clearly evident in Figures 8 and 9? The most obvious reason is the changeover requirement. When the FRCO 20 was in force (Figures 8a-e), almost every panel shows the increasing trend and Figure 9b indicates that all slopes are positive. When FRCO 0 was in effect (Figure 8f), however, non-reinforced visits show the more typical pattern, constant or decreasing conditional probability of switching. As the changeover requirement increases, the positive trend becomes more pronounced.

The changeover requirements imposed in the reports that tested for momentary control of switching were nothing or minimal. Only three experiments[3] included a changeover requirement: Shimp (1966; Experiment IV) required two pecks, Silberberg et al. (1978; Experiment 2) had a 1.5 second COD, and Heyman (1979) imposed an FR 1. These experiments tended to be the most difficult to fit into the momentary maximizing models. Silberberg et al. admit that "the presence of the COD complicated any attempt to identify the concurrent response rule for free-operant choice allocation" (p. 385). Perseveration on an alternative, fostered by changeover requirements, confounds

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[3] The 6-second intertrial interval that Nevin (1969) included could be considered analogous to a COD, but with a potentially crucial difference: Each peck was separated by the intertrial interval, thereby decreasing the likelihood of prolonged perseveration, opposite the effect of travel here.

momentary maximizing; so much so that Silberberg et al. developed it as a component of their model.

Exactly what momentary maximizing theorists should do with behavior occurring during switching is unclear. It seems that changeover behavior would reduce the momentary probability of reinforcement from the other schedule and, thus, actually decrease the schedule's momentary control; exactly opposite of the results reported here. Perhaps large changeover requirements allow a more clear discrimination of the molar reinforcer rates. Working in conjunction, then, the changeover requirement, by suppressing switching, and the molar reinforcement rates, by exerting more control on behavior the longer the time since last visit, produce the increasing conditional probability of switching observed. An interesting test would be a Nevin-like procedure, but with a changeover requirement.

Foraging

Baum (1982) demonstrated that travel between alternatives in an operant chamber reliably affected not only the matching relation but also "stay time". The data presented in Figures 12a-b confirm Baum's results: as the changeover requirement increased all measures of residence time and pecks increased. These results also support similar findings using different procedures (see McCarthy et al., 1994). Also, the results confirm other reports that residence measures increase as relative reinforcer rates increase (Davison, 1991; Temple et al., 1995). The modestly increasing trends of visit measures (i.e., visit pecks, giving-up pecks) as absolute reinforcer rates decreased supports the principle of lost opportunity: As the richness of overall environment decreases, there is less of a cost for staying in a patch because the probability of obtaining reinforcement from another patch is low (see Chapter II).

Various authors (see Baum, 1983; Lea, 1981; Shettleworth, 1988) have considered the similarities of foraging in the wild and operant behavior. Baum (1983) noted three artificialities of the operant chamber (see *Chapter II*). Baum (1982) addressed the first artificiality. He made the operant chamber more "natural-like" by adding a physical barrier between the two "patches". The results confirmed the previous assumption that the operant chamber is a viable laboratory option to naturalistic research, and that the matching relation can accommodate such data.

This present research progresses the other way, in a sense. Fixed-ratio schedules are commonly used to model work requirements in operant research. And, rather than needing to add an "artificiality" to the operant chamber to make it more natural-like, the tools forged from the operant lab can be considered sufficient to model the natural world. Namely, data that resulted from an FR travel requirement produced results highly similar to Baum's physical travel, and thus an FR schedule sufficiently models the physical distance between patches in the wild. McCarthy et al. (1994) argue that it is not the work associated with traveling, per se, that controls behavior as much as it is the time away from reinforcement. It would be extremely difficult to test such questions in the wild.

My argument merely intends to assert that the tools of operant psychologists need not be rejected because they are contrived. Both operant psychology and behavioral ecology can work cooperatively, confident with their respective tools, to more fully understand the behavior of organisms.

Additional Analyses

The means employed to record these data lend themselves to other analyses. Two come to mind presently. Determining the location during a visit that reinforcement is delivered may help explain the increasing conditional probability of switching as run length increases. One way to investigate this is by determining the proportion of reinforcers received for the first peck following a changeover, categorized by richer and leaner alternatives. Perhaps reinforcement works in different ways depending on whether delivered from the richer or leaner schedule. Leaner schedules may reinforce time away from them by yielding reinforcement upon return, while richer schedules may reinforce active responding. Thus, the longer one is away from the leaner alternative, encouraged by the larger changeover requirements, the more probable switching to it becomes. Also, reinforcement soon after switching to the leaner alternative may contribute to maintaining behavior on it, thereby affecting the exponent of Equation 3.

Perhaps there is some optimal (that is, molar maximizing) time away from the leaner alternative or, more specifically, some optimal time since last reinforcement from the lean side. This time would possibly approximate the mean and depend on travel requirements. The second analysis would seek to answer the following question: What is the function between the probability of switching and time since the last reinforcement from the rich or lean alternative? The method of data recording employed lends itself to such a question; both the time and number of changeovers between reinforcers can be extracted from the data.

Conclusion

The matching relation as a framework for understanding choice is in its fourth decade. Evidence presented in this document supports using the generalized matching relation to understand choice measured at a molar level. Three major conclusions seem warranted. First, once a changeover requirement is implemented, response-allocation sensitivity remains relatively stable in the overmatching range. Time-allocation sensitivity, however, decreases as the changeover requirement increases—a trend that may be related to changing response rates on the richer and leaner alternatives. Second, as changeover requirements increase, the conditional probability of switching increases the longer one remains on an alternative. And third, operant tools of modeling foraging in the wild can be considered functionally similar to foraging in the wild.

In the opening chapter of the book, *The Limits of Rationality*, Jon Elster (1990) asserted that theories fail for two reasons: indeterminacy and inadequacy. The first occurs when a theory fails to make unique predictions, the second, when predictions fail. Elster asserts that inadequacy is a more serious problem. At this point, the matching relation as a theory of choice seems to fail in the first instance: sensitivity depends on procedures and therefore may not have a unique value. But then again, should we be surprised that procedures affect sensitivity? No one would claim that the law of gravity is void if, without accounting for wind resistance, predictions failed. Before we reject matching as a framework for choice we need to unify our procedures; or at least attempt to determine sensitivity values for specific procedures (see Baum, 1979; Taylor & Davison, 1983).

More generally, have we learned anything more about William James' choosing Oxford Street over Divinity Avenue? Just as a physicist would shy away from predicting the path of a particular falling leaf, so too would a psychologist hesitate to predict *a priori* which street James would walk on a particular night. However, allow an operant psychologist to make predictions using multiple observations, the pay-offs associated with each street, and the obstacles (e.g., travel?) that accompany each one and perhaps even James himself might admit that determinism, of a particular kind, is feasible. Perhaps he would have even felt less compulsion to opt for free will.

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APPENDIX I

Tables of Raw Data

The following tables contain data from stable sessions. Pigeon number is indicated on the first page of each table. The first column, labeled FRCO, indicates the fixed-ratio changeover requirement. The second column, labeled VI Vari, indicates the variable-interval reinforcement schedule in seconds for the variable alternative (always the right alternative). The constant alternative maintained a variable-interval 120 second schedule throughout. Responses, times (in seconds), reinforcers, and visits for constant (Const) and variable (Vari) alternatives are included. The Leaving Constant and Leaving Variable columns present mean changeover times in seconds for that session. These times are categorized into changeover initiation (Init), time on the changeover key (FR T), and changeover termination (Term). When FRCO 0 was in effect, all changeover time was recorded in the columns headed *Term.*

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	VI	Responses		Times		Reinforcers		Visits		Leaving Constant			Leaving Variable		
FRCO	Vari	Const	Vari	Const	Vari	Const	Vari	Const	Vari	Init	FRT	Term	Init	FRT	Term
0	120	1953	1769	199	346	20	20	972	972	0	0	.99	0	0	.91
0	120	2044	1699	226	325	19	19	973	973	0	0	.97	0	0	.91
0	120	1974	1800	146	254	18	16	975	975	0	0	.93	0	0	.87
0	120	1993	1551	151	140	16	16	976	976	0	0	.90	0	0	.85
0	120	2168	1780	202	222	17	16	976	975	0	0	.96	0	0	.88
0	120	2061	1864	178	254	20	20	972	972	0	0	.96	0	0	.88
0	240	2227	1500	228	99	16	12	978	978	0	0	.90	0	0	.85
0	240	2293	1690	264	189	19	10	977	978	0	0	.93	0	0	.86
0	240	2256	1605	246	260	17	9	979	979	0	0	.93	0	0	.87
0	240	2482	1443	405	173	21	9	977	977	0	0	.98	0	0	.87
0	240	2379	1494	276	121	17	6	981	980	0	0	.92	0	0	.88
0	240	2331	1465	405	104	18	6	980	980	0	0	.89	0	0	.85
0	240	2528	1516	491	122	18	7	979	980	0	0	.87	0	0	.87
0	240	2530	1381	504	150	22	7	978	977	0	0	.93	0	0	.92
0	240	2583	1359	586	137	20	11	977	976	0	0	.93	0	0	.89
0	240	2283	1452	362	171	17	13	977	977	0	0	.91	0	0	.90
0	240	2235	1582	320	162	18	9	978	979	0	0	.87	0	0	.88
0	240	2425	1520	357	146	18	7	980	979	0	0	.88	0	0	.89
0	60	1413	1541	242	345	17	33	713	713	0	0	1.04	0	0	1.04
0	60	1382	1888	137	425	16	34	750	750	0	0	1.02	0	0	.95
0	60	1357	1797	156	386	17	33	760	760	0	0	.95	0	0	.91
0	60	1196	1421	432	363	21	29	559	558	0	0	1.10	0	0	1.10
0	60	1522	1585	161	299	17	33	863	863	0	0	.97	0	0	.93
0	60	1573	1780	163	370	16	34	826	826	0	0	.97	0	0	.93
0	30	521	1277	58	479	12	38	328	328	0	0	1.00	0	0	.95
0	30	458	1160	52	487	11	40	273	273	0	0	1.06	0	0	1.07
0	30	514	972	72	421	10	40	281	281	0	0	1.09	0	0	1.11

0	30	454	1316	56	563	9	41	295	295	0	0	1.00	0	0	1.05
0	30	509	1212	109	511	12	39	279	279	0	0	1.09	0	0	1.08
0	30	526	1132	278	459	14	36	246	246	0	0	1.06	0	0	1.06
0	30	507	1298	48	585	8	42	315	315	0	0	.98	0	0	1.05
0	30	603	1292	51	458	8	42	402	402	0	0	.92	0	0	.99
0	480	2523	1526	325	147	17	4	982	981	0	0	.90	0	0	.84
0	480	2669	1543	472	137	20	3	981	980	0	0	.89	0	0	.85
0	480	2772	1378	563	91	21	3	980	980	0	0	.90	0	0	.86
0	480	2646	1382	479	98	18	4	981	981	0	0	.89	0	0	.88
0	480	2587	1397	416	108	16	4	982	982	0	0	.89	0	0	.90
0	480	2538	1395	407	133	21	7	978	978	0	0	.91	0	0	.90
0	480	2638	1196	842	132	28	8	974	974	0	0	.96	0	0	1.03
0	480	2368	1406	339	127	18	5	981	980	0	0	.93	0	0	.94
0	480	2556	1477	390	148	19	8	979	978	0	0	.93	0	0	.95
0	480	3524	1392	1395	322	34	6	972	972	0	0	1.28	0	0	1.33
0	480	2835	1273	606	104	23	5	978	978	0	0	.95	0	0	1.08
0	480	3056	1318	793	175	25	6	977	976	0	0	1.00	0	0	1.13
0	480	2767	1383	519	162	23	6	978	977	0	0	.92	0	0	1.03
0	480	2861	1429	741	175	22	10	976	976	0	0	.96	0	0	1.03
0	120	2177	2112	197	381	22	18	972	972	0	0	.92	0	0	.86
0	120	2179	1619	276	243	17	18	975	974	0	0	.93	0	0	.93
0	120	2187	1551	246	212	18	17	975	974	0	0	.91	0	0	.90
0	120	2092	1459	196	167	18	16	975	975	0	0	.89	0	0	.88
0	120	2052	1419	176	175	16	16	976	976	0	0	.90	0	0	.89
0	120	2238	1569	711	358	25	25	915	913	0	0	1.11	0	0	1.17
2	120	2140	1818	592	701	25	25	505	505	.89	.34	.73	.88	.44	.59
2	120	2110	1763	560	672	25	25	533	534	.90	.31	.69	.97	.48	.59
2	120	2264	1810	558	619	24	24	596	596	.84	.32	.66	.90	.45	.55
2	120	2142	1776	458	585	27	23	566	566	.84	.31	.72	.84	.46	.53
2	120	2068	1679	542	577	27	23	551	550	.78	.31	.74	.77	.45	.54

2	240	4412	955	2107	426	33	17	312	313	.96	.50	.74	.99	.63	.77
2	240	3360	2015	1753	1001	33	17	257	258	1.05	.47	.74	1.01	.65	.89
2	240	3861	1470	1974	674	34	16	303	303	1.04	.47	.76	.92	.53	.79
2	240	4325	964	2032	396	32	18	334	334	1.06	.48	.83	.90	.57	.72
2	240	4341	985	2120	474	34	16	293	294	1.06	.44	.78	.94	.60	.77
2	240	4538	1010	2111	518	33	17	315	316	1.05	.51	.84	.90	.58	.74
2	60	343	2560	121	1432	16	35	123	123	.92	.41	.73	1.16	.50	1.09
2	60	244	2633	66	1449	16	34	115	114	.98	.48	.70	1.04	.48	1.21
2	60	317	2380	104	1339	17	33	134	135	.93	.41	.83	1.07	.52	1.04
2	60	291	2330	69	1243	16	34	165	165	.93	.41	.66	1.11	.50	1.01
2	60	291	2187	78	1180	17	33	157	157	.86	.46	.77	1.03	.56	1.25
2	60	233	2606	76	1390	16	34	125	125	1.03	.44	.99	1.06	.65	1.41
2	60	315	2835	84	1388	16	34	142	143	.91	.41	.88	.97	.54	1.29
2	30	113	1647	29	844	11	39	56	57	.83	.38	1.13	.98	.49	.73
2	30	126	2020	26	1034	10	42	72	72	.95	.37	.86	.91	.39	1.05
2	30	168	1844	49	999	10	43	75	76	.98	.37	1.09	.97	.44	1.03
2	30	165	1948	52	984	9	42	69	70	.91	.38	1.00	1.05	.44	1.15
2	30	192	1797	71	930	10	40	63	64	.93	.41	.97	1.02	.47	1.08
2	30	156	1857	57	869	12	38	66	67	.86	.39	.83	1.14	.46	1.17
2	30	155	1711	55	811	10	40	48	48	.88	.40	.88	1.24	.54	1.09
2	30	163	1743	60	978	9	41	63	62	.94	.37	.87	1.24	.47	.94
2	30	122	1653	44	878	8	43	61	60	.88	.38	.93	1.05	.50	1.04
2	30	173	1709	63	942	8	42	82	82	.94	.37	.97	1.53	.55	.89
2	30	188	1783	67	946	7	43	67	68	.84	.37	.80	1.35	.48	.81
2	480	4616	612	2431	180	40	10	379	378	.97	.40	.84	.82	.70	.73
2	480	5184	723	2943	143	44	6	507	507	1.07	.39	.82	.75	.47	.73
2	480	4798	652	2868	143	42	8	445	444	1.00	.38	.75	.73	.51	.87
2	480	3635	812	2198	270	39	11	437	437	1.05	.35	.81	.78	.52	.90
2	480	5016	777	2955	162	42	8	531	531	1.14	.39	.73	.78	.46	.80
2	480	3993	701	2558	165	42	8	453	453	1.02	.44	.62	.86	.57	.79

2	480	3962	745	2493	124	39	11	494	494	.96	.37	.71	.79	.46	.74
2	480	4953	635	2787	97	38	12	440	439	.93	.43	.67	.84	.54	.64
2	480	4891	645	3064	71	44	6	490	489	1.09	.41	.73	.79	.44	.69
2	480	5153	550	2846	57	39	11	462	462	.95	.43	.84	.76	.51	.78
2	480	4682	583	2516	82	39	11	447	446	.91	.43	.68	.78	.48	.74
6	120	1577	1796	634	922	25	25	237	238	.97	1.59	.89	1.09	1.76	.87
6	120	1795	2045	673	1011	26	25	230	230	.97	1.58	.78	.98	1.76	.80
6	120	1524	1946	576	1025	27	23	233	233	.98	1.59	.82	.92	1.80	.79
6	120	1723	1678	678	867	26	24	208	208	1.04	1.53	.77	1.03	1.79	.76
6	120	1516	1637	610	869	25	25	210	209	1.05	1.54	1.05	1.08	1.72	.80
6	30	110	1753	23	919	9	43	50	51	.87	1.30	.76	.84	1.64	.59
6	30	107	1973	25	1067	7	44	45	46	.89	1.27	.79	.82	1.56	.60
6	30	108	1798	27	968	10	40	42	43	.95	1.37	.70	.81	1.61	.63
6	30	108	1753	31	939	10	40	44	45	.84	1.30	.60	.88	1.57	.67
6	30	133	1698	42	919	13	38	47	48	.88	1.23	.75	.82	1.52	.63
6	30	136	1815	47	1039	8	42	50	50	.99	1.30	.84	.82	1.52	.59
6	30	140	1768	49	940	13	37	45	46	.91	1.28	.87	.74	1.49	.61
6	30	104	1619	50	872	11	40	40	41	1.20	1.32	.72	.80	1.90	.67
6	30	104	2001	17	1029	7	46	52	53	.85	1.41	.79	.92	1.80	.61
6	30	97	1986	27	1064	9	41	49	50	1.17	1.29	.87	.93	1.52	.56
6	30	78	1706	21	917	8	42	44	45	1.03	1.31	1.00	.98	1.52	.60
6	480	5387	534	2234	175	40	10	182	181	1.03	1.84	.81	1.06	1.67	.89
6	480	5633	653	2960	310	42	8	227	226	1.12	1.92	.81	1.00	1.68	.90
6	480	5707	717	3005	346	42	8	245	244	1.04	1.86	.85	1.05	1.68	.93
6	480	5593	790	3088	370	43	7	222	221	.99	1.97	1.03	1.01	1.76	.96
6	480	5002	966	2509	484	39	11	173	173	.87	2.00	.82	1.05	1.82	.96
6	480	4823	1680	2376	708	39	11	193	192	.95	1.85	.70	.84	1.56	.87
6	480	6554	901	3659	402	43	7	193	192	1.09	1.94	.83	.89	1.59	.90
6	480	6569	829	3683	403	44	6	227	227	.90	1.74	.63	1.01	1.52	.81
6	480	5559	727	3281	352	43	7	187	186	.97	1.73	.80	1.02	1.38	1.10

6	480	5210	892	2876	392	41	9	203	202	.98	1.76	.69	.86	1.63	1.02
6	480	5730	1031	3519	475	42	9	199	198	1.15	1.91	.89	.94	1.54	1.19
6	480	5686	902	3082	354	42	8	209	209	1.15	1.77	.74	.89	1.59	.95
6	480	6165	643	3353	293	42	9	212	212	1.02	1.85	1.33	1.03	1.60	1.10
12	120	1722	1807	694	979	23	27	109	110	.70	3.71	.76	.81	3.96	.91
12	120	2000	1844	764	1046	22	28	97	97	.74	3.86	1.44	.83	4.06	.89
12	120	1877	2016	746	1086	25	25	112	111	.71	3.70	.82	.77	3.97	.68
12	120	2093	2170	860	1234	24	26	116	115	.80	3.59	1.47	.80	3.83	.72
12	120	2101	1800	878	1148	25	26	118	117	.89	3.53	1.80	.79	3.82	.69
12	30	119	2320	45	1233	9	47	22	23	1.28	2.89	.86	1.62	3.63	.80
12	30	132	2327	43	1177	9	47	25	25	1.18	2.97	.72	1.58	3.14	.69
12	30	103	2041	45	1095	10	40	18	17	1.13	2.72	.86	.95	3.03	.72
12	30	82	2177	28	1162	9	43	21	21	1.43	2.75	.87	1.06	3.50	.90
12	30	67	2365	25	1196	7	47	16	17	1.25	2.77	1.00	.95	3.13	.66
12	30	89	2163	40	1094	13	41	20	20	1.24	2.65	.69	.87	3.15	.64
12	30	113	2202	40	1184	7	44	20	20	1.32	2.91	.81	1.01	2.98	.66
12	30	58	2299	27	598	5	46	16	15	1.73	2.78	.92	1.40	2.86	.74
12	30	57	2448	23	1326	8	48	17	17	1.32	2.80	.74	1.06	3.15	.68
12	30	77	2086	45	1173	6	45	17	17	1.32	2.77	.77	1.06	3.20	.73
12	30	70	1895	29	1001	10	40	23	22	1.28	2.79	.62	1.10	3.07	.61
12	30	105	2131	51	1192	9	46	24	24	1.18	2.94	.75	1.03	3.15	.63
12	480	4525	534	3303	366	37	13	105	105	1.44	3.47	1.33	1.44	3.09	.87
12	480	4108	288	2984	223	39	11	97	97	1.42	4.17	2.81	1.85	3.24	1.39
12	480	4692	146	3610	96	40	10	72	71	2.10	4.24	7.06	1.97	3.24	1.61
12	480	5266	776	3309	469	41	10	93	92	1.31	3.65	1.47	1.16	2.66	.93
12	480	6390	740	3809	462	40	10	95	94	1.18	3.36	1.12	.95	2.75	.95
12	480	5597	583	3217	300	42	8	124	124	1.12	3.39	1.30	1.08	2.53	1.18
12	480	5541	374	3446	212	42	8	120	119	1.40	3.39	1.33	1.27	2.46	1.05
12	480	5114	320	3175	206	42	8	92	92	1.45	4.32	1.91	1.56	2.79	1.35
12	480	5509	696	3097	444	39	11	123	122	1.23	3.99	1.67	1.12	3.06	.72

12	480	6492	580	3295	379	40	10	123	123	.95	3.81	1.13	.91	3.23	.65
12	480	7097	434	3803	316	44	6	120	119	1.02	3.55	1.14	1.24	3.12	.67
20	120	2376	2421	1187	1449	26	24	65	65	.96	6.34	.83	.89	6.34	.84
20	120	2604	1957	1226	1151	27	25	59	60	.94	6.38	.90	1.09	6.42	.81
20	120	2552	2009	1279	1154	26	25	63	63	.99	6.00	.85	.95	5.84	.74
20	120	2179	2004	1210	1197	25	25	72	72	.88	5.87	.80	.98	5.65	.81
20	120	2161	1611	1348	1223	27	23	59	58	.88	5.91	1.84	1.46	5.09	.71
20	240	3517	1161	2532	800	34	16	61	61	.81	6.44	.77	1.58	6.37	.67
20	240	2854	1630	1894	1027	34	16	87	87	.91	6.70	.89	1.02	6.21	.77
20	240	3388	1271	2094	822	34	16	84	83	.84	6.77	.82	1.20	6.25	.69
20	240	3172	1022	2167	712	35	16	74	75	.86	7.15	1.02	1.38	6.19	.77
20	240	3431	1062	2384	628	34	16	86	85	.79	6.45	.79	1.09	6.10	.80
20	240	3748	1246	2680	768	34	17	82	82	.91	6.35	.82	1.16	5.91	.71
20	240	3637	1227	2284	815	34	16	76	75	.91	6.54	.99	1.18	6.12	.76
20	60	663	2039	289	1223	16	35	50	51	.94	5.43	.88	1.13	4.94	.72
20	60	561	2058	274	1216	18	33	54	54	.94	4.99	.64	1.05	4.91	.79
20	60	641	2219	275	1330	16	34	50	51	.91	5.13	.98	.99	5.05	.66
20	60	841	2354	366	1371	16	36	51	52	.88	5.51	.90	1.07	5.24	.66
20	60	758	2108	346	1219	15	35	40	39	.85	5.40	.81	.95	5.48	.69
20	60	513	2500	247	1394	16	34	39	38	.96	5.31	.73	1.19	5.43	.76
20	60	772	2372	326	1240	16	35	45	46	.87	5.55	.73	1.26	5.47	.71
20	30	98	1541	58	960	13	41	19	19	1.09	5.67	1.58	1.00	5.69	.71
20	30	66	1717	38	1036	8	43	15	15	1.31	5.68	1.42	1.14	5.31	.71
20	30	54	1672	31	1014	9	41	12	13	1.33	5.75	1.71	1.13	6.01	.68
20	30	59	1945	33	1265	5	46	11	12	1.60	5.58	2.57	.95	5.17	.65
20	30	65	1848	30	1046	9	42	18	18	1.61	5.33	.77	1.06	5.51	.64
20	30	88	1579	46	1008	9	41	18	18	1.48	6.14	2.69	1.15	5.38	.59
20	30	71	1720	33	942	9	41	19	19	1.39	4.80	.91	1.15	4.91	.70
20	30	54	1678	28	995	10	40	16	15	1.18	4.73	.81	1.60	5.60	.76
20	30	51	1829	26	1157	7	43	14	13	1.16	5.43	.97	1.21	5.20	.86

20	30	107	1755	56	967	10	41	21	21	1.09	4.80	.90	1.12	4.96	.76
20	30	58	2054	26	583	10	47	17	18	1.42	4.51	1.11	1.04	4.51	.61
20	480	7731	514	3821	291	40	10	70	69	.98	5.63	.84	1.19	5.19	.75
20	480	6770	623	3682	391	38	12	66	65	.92	5.89	.71	1.24	5.41	.80
20	480	6735	653	3599	423	40	10	75	75	.98	6.03	.79	1.32	5.41	.80
20	480	5923	596	3594	396	41	9	59	59	1.06	5.90	.82	1.92	5.75	.88
20	480	5608	958	3867	582	42	9	79	79	1.17	5.95	.75	1.07	5.98	.73
20	480	5922	844	3608	483	40	10	65	64	.97	6.24	.86	.93	6.25	.74
20	480	5033	475	3122	294	38	12	57	56	1.03	6.25	.89	1.04	6.15	.75
20	480	6673	400	4267	265	42	8	67	66	1.27	5.94	.85	1.26	5.25	.84
20	480	6331	379	4325	267	44	6	63	62	1.23	5.79	.84	1.15	5.67	.76
20	480	5524	331	4225	269	41	10	56	56	1.24	5.88	1.82	1.18	5.39	1.12
20	480	4915	489	3749	401	44	7	60	60	1.06	6.16	1.22	1.26	5.97	1.06
20	30	43	1963	21	1198	6	44	13	14	1.72	5.20	1.03	1.45	5.24	.75
20	30	40	1936	27	1139	8	42	10	10	1.28	5.22	.90	1.46	5.78	.72
20	30	46	1983	20	1174	6	44	13	13	1.53	5.22	.67	1.23	5.15	.62
20	30	59	2122	29	1275	7	46	15	15	1.37	4.90	.75	1.52	4.99	.69
20	30	45	2278	21	774	7	54	13	13	1.50	4.53	.91	1.51	5.64	1.10
20	30	72	1515	45	1338	7	48	14	14	1.21	4.71	1.55	1.69	4.95	.74
20	30	72	1925	73	1263	4	52	14	14	1.00	5.30	.74	1.43	4.91	.73
20	30	60	1997	30	584	11	44	13	14	1.07	5.21	.70	1.50	5.28	.73
20	30	124	1805	48	980	6	45	22	21	.98	4.96	.72	1.04	5.13	.69
20	30	70	2023	40	1138	5	45	17	16	1.59	6.42	.72	1.02	5.46	.60
20	30	57	2231	23	1288	8	50	17	17	1.89	5.26	.65	1.26	5.09	.73
20	30	61	1672	33	1068	7	43	15	16	1.29	4.95	1.75	1.21	5.15	.77
20	30	55	2064	31	1256	7	47	14	14	1.74	4.91	.86	1.28	4.98	.70
20	30	68	1779	46	1054	8	43	15	14	1.41	4.61	.68	1.05	7.80	.77
20	30	44	1960	27	1214	5	45	11	12	1.56	5.26	1.09	1.58	7.25	.69

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	VI	Responses		Times		Reinforcers		Visits		Leaving Constant			Leaving Variable		
FRCO	Vari	Const	Vari	Const	Vari	Const	Vari	Const	Vari	Init	FRT	Term	Init	FRT	Term
0	120	1385	1005	709	246	25	25	823	823	0	0	0.93	0	0	1.39
0	120	1234	754	970	184	24	26	637	637	0	0	0.96	0	0	1.55
0	120	1551	982	1055	211	24	26	838	837	0	0	0.93	0	0	1.65
0	120	1307	743	992	108	27	23	656	656	0	0	0.91	0	0	2.05
0	120	1533	665	1246	98	27	23	584	583	0	0	1.01	0	0	2.05
0	240	2093	596	2416	15	34	16	574	574	0	0	0.90	0	0	1.87
0	240	2441	625	2493	57	34	16	575	574	0	0	0.86	0	0	1.95
0	240	2770	681	2582	36	34	16	641	640	0	0	0.87	0	0	1.60
0	240	2216	739	2055	51	34	16	693	692	0	0	0.89	0	0	1.70
0	240	2371	802	2195	62	34	16	733	732	0	0	0.99	0	0	1.40
0	240	2823	767	2817	19	34	16	732	732	0	0	0.88	0	0	1.27
0	240	2378	626	2548	42	34	16	582	582	0	0	0.84	0	0	1.57
0	60	1103	776	479	117	17	33	693	692	0	0	0.77	0	0	1.24
0	60	1073	849	411	181	16	34	724	724	0	0	0.76	0	0	1.21
0	60	1079	783	506	172	16	34	660	661	0	0	0.86	0	0	1.13
0	60	1097	758	532	148	17	33	648	648	0	0	0.80	0	0	1.30
0	60	943	717	476	165	18	32	595	595	0	0	0.76	0	0	1.51
0	60	1032	717	569	152	17	33	607	607	0	0	0.82	0	0	1.37
0	30	510	518	250	238	9	41	353	353	0	0	0.85	0	0	1.27
0	30	714	591	320	187	11	39	461	462	0	0	0.77	0	0	1.07
0	30	612	528	353	179	7	43	399	399	0	0	0.79	0	0	1.30
0	30	553	543	229	192	8	42	401	401	0	0	0.71	0	0	1.14
0	30	574	606	179	231	8	42	445	445	0	0	0.70	0	0	1.14
0	30	582	499	291	157	8	42	391	391	0	0	0.79	0	0	1.17
0	30	612	668	163	261	9	41	470	470	0	0	0.69	0	0	1.15
0	30	721	631	243	140	9	41	524	523	0	0	0.72	0	0	0.99
0	30	846	675	327	117	8	42	582	582	0	0	0.68	0	0	0.87

0	480	3213	720	3402	25	42	8	701	700	0	0	0.94	0	0	1.57
0	480	2600	891	3013	68	42	8	813	812	0	0	0.94	0	0	1.73
0	480	2883	847	3024	103	41	9	754	757	0	0	1.00	0	0	1.15
0	480	2846	728	3237	72	41	9	691	690	0	0	1.11	0	0	1.04
0	480	3349	619	3831	6	41	9	605	605	0	0	0.97	0	0	0.82
0	480	2290	631	2788	30	37	13	610	609	0	0	0.94	0	0	1.26
0	480	2883	792	3053	22	38	12	775	774	0	0	0.93	0	0	1.00
0	480	3055	791	3371	17	41	9	774	773	0	0	0.94	0	0	0.86
0	480	2967	783	3061	69	42	8	744	744	0	0	1.07	0	0	1.03
0	480	3480	895	3465	8	39	11	876	875	0	0	0.86	0	0	1.00
0	120	1750	785	1299	85	27	23	741	740	0	0	0.90	0	0	1.02
0	120	1894	891	1367	110	28	22	821	820	0	0	0.94	0	0	0.94
0	120	2067	1021	1331	79	24	25	968	967	0	0	0.89	0	0	0.82
0	120	1971	904	1647	98	25	25	844	843	0	0	0.97	0	0	0.91
0	120	1797	943	1207	107	26	24	869	870	0	0	0.83	0	0	0.94
2	120	1215	599	1075	299	26	24	368	367	.63	.27	1.44	1.28	.22	0.50
2	120	1451	670	1207	278	25	25	418	419	.59	.26	1.12	1.12	.22	0.49
2	120	1395	737	1059	357	26	24	481	482	.61	.27	1.12	1.39	.22	0.49
2	120	1650	821	1251	326	26	24	512	513	.52	.27	.99	1.29	.19	0.47
2	120	1547	684	1370	248	27	23	415	414	.59	.31	1.12	1.24	.19	0.50
2	240	1701	806	1393	493	34	16	496	495	.57	.36	1.14	1.55	.19	0.79
2	240	2094	958	1647	599	33	17	513	512	.59	.35	1.17	1.18	.19	0.66
2	240	1920	883	1598	571	33	17	439	438	.56	.32	1.30	1.16	.20	0.64
2	240	1906	927	1611	697	34	16	438	438	.56	.32	.76	1.40	.19	0.77
2	240	1699	863	1432	791	33	18	465	465	.66	.37	.71	2.06	.20	0.89
2	240	1551	800	1365	793	32	18	417	417	.62	.37	.73	1.71	.20	0.77
2	60	543	976	274	816	18	32	294	293	.61	.24	.71	.84	.20	0.59
2	60	556	1131	285	952	18	32	260	259	.69	.25	.65	.82	.21	0.50
2	60	571	854	295	789	17	33	299	299	.65	.28	.81	.89	.22	0.64
2	60	596	698	324	649	17	33	292	292	.66	.26	.82	1.16	.18	0.54

2	60	540	845	310	798	16	34	269	269	.60	.27	.72	1.03	.20	0.54
2	60	449	959	245	839	17	33	263	263	.91	.26	.70	.74	.19	0.71
2	30	195	715	50	737	10	40	136	135	.55	.27	.68	.80	.36	0.54
2	30	223	490	31	578	11	40	165	165	.59	.30	1.21	1.14	.33	0.56
2	30	212	669	30	668	11	39	172	172	.58	.30	.88	.84	.36	0.57
2	30	155	760	24	799	9	41	121	121	.59	.32	1.07	.85	.44	0.53
2	30	172	771	39	806	10	40	118	118	.62	.32	.94	.87	.37	0.51
2	30	202	861	30	778	11	39	155	155	.63	.29	.85	.78	.39	0.51
2	30	155	736	22	865	8	43	129	128	.58	.25	1.21	.92	.33	0.54
2	30	153	946	31	1065	7	47	116	117	.59	.22	.94	.89	.33	0.49
2	30	142	521	22	710	12	38	110	111	.61	.25	1.36	1.65	.34	0.51
2	30	185	632	37	697	14	36	137	136	.62	.27	1.05	1.08	.35	0.57
2	480	2708	1044	1989	892	38	12	440	439	.48	.34	.63	1.34	.19	0.61
2	480	2864	1137	2287	868	38	12	458	457	.51	.40	.65	1.00	.19	0.56
2	480	3616	1019	2862	794	41	9	394	394	.54	.38	.66	1.09	.21	0.60
2	480	3087	875	2782	823	42	8	311	310	.55	.36	.63	1.16	.21	0.63
2	480	2753	1011	2730	975	40	10	354	353	.59	.36	.82	1.24	.19	0.81
2	480	3090	940	3015	931	39	11	336	335	.58	.34	.79	1.68	.23	0.70
2	480	3001	1071	2629	861	37	13	423	423	.54	.34	.86	1.22	.20	0.63
2	480	2459	590	2219	424	39	11	342	342	.60	.40	1.40	1.63	.22	0.63
2	480	2781	851	2370	621	38	12	368	367	.60	.41	1.03	1.26	.21	0.62
6	120	1251	703	1142	440	25	25	280	280	.71	1.00	.94	1.08	.88	0.62
6	120	1472	748	1359	576	27	24	263	264	.58	1.05	.96	1.71	.79	0.70
6	120	1293	638	1484	529	29	21	217	216	.68	1.04	.85	1.55	.87	0.66
6	120	1236	692	1198	559	23	27	239	239	.59	1.09	.87	1.91	.88	0.79
6	120	1154	606	1116	699	24	26	225	226	.65	1.11	.87	1.82	.93	0.75
6	30	164	531	115	866	9	42	54	54	1.13	.79	1.56	1.67	1.02	0.76
6	30	143	576	107	850	8	42	45	45	1.08	.88	2.24	1.06	.89	0.73
6	30	182	643	123	945	7	43	55	54	1.06	.87	1.48	1.27	.87	0.76
6	30	200	520	146	848	10	40	56	56	1.29	.92	1.51	1.47	.98	0.71

6	30	159	489	111	714	12	38	49	49	1.25	.91	1.47	1.42	.99	0.83
6	30	175	593	109	860	8	42	64	63	1.06	.87	1.65	1.51	.91	0.77
6	30	155	577	93	798	13	38	53	53	1.02	.90	1.46	1.39	.97	0.75
6	30	160	693	71	958	8	44	67	68	1.30	.91	1.32	1.32	.96	0.76
6	30	140	474	63	709	12	39	61	60	.90	.89	1.32	1.29	.93	0.94
6	30	162	616	81	870	10	41	72	72	.93	.88	1.78	.96	.89	0.75
6	30	116	261	109	695	10	42	43	43	1.61	1.07	5.68	4.44	1.10	1.86
6	480	2560	288	2844	166	39	11	175	174	.89	1.02	1.04	2.04	.80	1.07
6	480	2921	351	3232	302	42	8	172	172	.85	1.02	.85	1.74	.81	1.00
6	480	2488	260	3029	139	41	9	174	174	.84	1.03	1.17	2.15	.82	1.26
6	480	2888	249	3572	143	44	6	167	166	.88	1.01	1.19	2.80	.87	1.16
6	480	3248	416	3133	336	41	9	200	199	.72	.98	.82	2.71	.79	1.08
6	480	3245	596	3432	465	41	9	218	217	.85	1.06	.88	1.74	.76	1.06
6	480	3560	445	3647	358	43	8	192	192	.78	1.06	1.06	1.45	.79	0.95
6	480	2591	334	3070	266	39	11	161	160	.74	1.08	1.19	2.02	.78	1.05
6	480	3008	663	3447	472	43	7	202	201	.86	1.10	.95	1.73	.80	1.08
6	480	2560	396	2863	376	38	12	169	169	.85	1.12	1.46	2.06	.82	1.23
6	480	3710	348	3809	228	43	7	209	208	.59	1.05	1.77	2.29	.80	0.93
6	480	3062	409	4001	304	45	6	172	171	.73	1.06	.84	2.20	.84	1.13
6	480	3173	371	3863	294	43	7	147	146	.75	.99	1.07	2.31	.82	1.06
12	120	1313	484	1188	796	24	26	149	149	.86	2.20	1.11	1.39	2.07	0.84
12	120	1274	476	1345	723	27	23	143	143	.81	1.93	1.08	1.29	1.80	0.86
12	120	1383	530	1376	616	25	25	166	166	.87	1.87	1.06	1.33	1.76	0.83
12	120	1338	571	1464	618	26	24	165	165	.85	2.01	1.04	1.00	1.85	0.84
12	120	1626	667	1514	740	25	25	179	179	.75	2.01	.90	.96	1.72	0.80
12	30	53	685	19	1205	8	43	17	18	1.84	2.94	2.80	1.88	2.86	1.12
12	30	82	651	36	1206	7	44	24	24	1.57	2.58	.91	1.75	2.63	1.11
12	30	64	653	29	1108	12	38	19	19	1.67	2.42	1.40	1.54	2.72	1.21
12	30	85	546	44	1135	8	43	21	21	1.77	2.68	2.82	1.56	2.66	1.09
12	30	65	785	53	1069	7	45	22	22	1.51	2.48	1.22	1.85	2.68	1.35

12	30	68	588	38	1148	8	44	21	21	1.61	2.64	2.31	2.36	2.76	1.09
12	30	86	528	59	949	8	42	19	18	1.68	2.51	1.23	1.62	2.69	0.98
12	30	90	670	58	1135	8	45	18	18	1.31	2.41	2.00	.94	2.74	1.14
12	30	118	592	54	1103	6	44	21	21	1.40	2.51	1.42	1.33	2.61	0.89
12	30	103	654	55	943	10	40	22	22	1.46	2.82	.82	1.13	2.79	0.90
12	30	120	709	56	1127	5	45	26	25	1.35	2.76	.82	1.38	3.06	0.87
12	30	82	804	47	1172	7	43	24	24	1.41	2.82	1.18	1.12	2.77	1.06
12	30	73	902	52	1155	9	44	20	20	1.76	2.80	1.40	1.42	3.19	1.26
12	480	3056	253	4102	277	41	10	88	87	.79	2.53	.95	3.42	2.21	1.21
12	480	3299	321	3925	275	43	7	110	109	.69	2.47	.85	4.00	2.26	1.06
12	480	2527	243	3596	209	42	8	86	85	.61	2.46	.85	4.56	2.24	1.12
12	480	2891	312	3415	200	41	9	95	94	.69	2.37	.85	3.92	2.25	1.05
12	480	3624	221	4266	181	43	8	101	100	.77	2.50	.91	3.72	2.48	1.19
12	480	2905	214	3254	173	41	9	104	104	.87	2.49	1.01	4.38	2.27	0.97
12	480	2999	347	3462	350	39	11	99	99	.65	2.40	1.12	2.53	2.41	1.16
12	480	3822	349	3972	312	43	7	119	118	.68	2.23	.93	3.02	2.13	1.08
12	480	3134	329	3073	455	37	13	122	122	.71	2.44	1.01	2.69	2.09	1.13
12	480	3231	444	3497	504	41	9	140	140	.66	2.35	.81	2.65	2.13	1.05
12	480	3056	282	3851	356	43	7	112	111	.77	2.50	.86	3.60	2.28	1.39
12	480	2800	221	3726	237	42	8	108	108	.86	2.68	.90	4.63	2.21	1.36
20	120	1386	745	1416	944	24	26	78	78	.77	3.46	1.15	1.25	3.57	0.92
20	120	1115	652	1236	891	27	24	67	67	1.01	3.42	1.17	1.32	4.01	0.96
20	120	1396	905	1371	1299	26	25	74	74	.81	3.52	1.10	.99	3.98	0.90
20	120	1439	911	1322	1258	27	23	81	80	1.01	3.65	1.18	1.04	4.47	0.87
20	120	1563	869	1635	986	25	26	94	94	.88	3.50	.94	.92	3.56	0.90
20	240	2243	662	2220	890	33	17	105	105	.69	3.72	.86	.82	3.32	1.01
20	240	2314	633	2311	922	34	16	98	98	.81	3.60	.83	.82	3.64	1.03
20	240	2457	546	2622	708	34	16	97	96	.71	3.80	.83	.70	3.64	0.94
20	240	2394	473	2454	677	34	16	108	107	.71	3.57	.85	.83	3.22	1.00
20	240	2403	569	2541	701	34	18	105	106	.66	3.76	.83	.76	3.17	1.19

20	240	2222	549	2342	766	34	16	100	99	.74	3.62	.84	.90	3.16	1.14
20	60	535	842	559	1152	16	35	52	51	.76	3.54	.99	.70	3.48	0.98
20	60	650	715	564	1044	18	32	54	54	.65	3.70	.88	1.19	3.87	0.97
20	60	702	739	662	896	16	35	64	64	.90	3.88	.86	1.67	3.82	0.90
20	60	599	674	568	1103	17	33	54	54	.62	3.95	1.53	1.57	3.65	0.99
20	60	541	705	558	1037	17	33	49	48	.70	4.16	1.04	.82	3.79	1.06
20	60	596	664	622	976	17	33	57	57	1.07	4.19	.98	.85	3.79	0.97
20	30	130	861	125	1131	7	43	14	15	.73	4.24	1.18	.98	4.01	1.18
20	30	180	849	157	1085	9	41	17	17	.84	4.50	1.32	.48	4.13	1.05
20	30	194	1079	164	1274	6	48	17	17	.85	4.59	.88	.57	4.10	0.88
20	30	135	1048	111	1235	5	46	15	14	.79	4.22	.94	.85	4.26	0.94
20	30	98	883	91	1000	11	42	11	12	.61	4.41	.92	.63	4.05	0.89
20	30	161	1017	160	1124	6	44	14	14	.69	4.72	1.03	.56	4.45	1.14
20	30	144	1203	157	1175	6	44	13	13	.82	4.23	.94	.69	4.42	1.28
20	30	154	973	168	1200	10	45	17	18	.96	4.33	1.13	.92	4.19	1.23
20	30	136	1028	126	1118	7	43	15	15	1.10	4.34	1.01	.63	4.42	1.43
20	30	133	987	148	1120	10	42	12	13	.85	4.12	.94	.97	4.84	1.40
20	30	146	767	139	1090	10	40	14	14	.82	5.00	.92	.81	5.14	1.51
20	30	190	936	172	1121	9	43	14	15	.79	4.63	1.03	.76	4.84	1.52
20	30	102	822	125	418	8	45	13	13	1.83	4.13	.96	.76	4.79	1.25
20	480	2737	370	3148	556	41	9	42	43	.78	4.18	.99	1.57	5.24	1.42
20	480	3113	633	2903	844	41	9	34	34	.77	4.15	1.05	.95	4.54	1.41
20	480	3462	541	4049	904	43	8	42	42	.68	4.55	1.36	1.36	4.48	1.32
20	480	4031	757	4027	1041	44	7	45	44	.80	4.59	.96	.74	4.36	1.18
20	480	4277	461	3826	630	46	10	46	46	.67	4.57	.96	1.86	4.49	1.40
20	480	3087	559	1558	836	38	12	41	41	.67	4.82	1.35	1.10	4.20	1.16
20	480	3787	422	3948	726	42	9	58	57	.68	4.09	1.44	2.25	4.46	1.10
20	480	3906	478	2889	703	44	7	48	49	.84	4.39	.94	1.10	4.51	1.13
20	480	3979	494	3568	910	43	8	55	55	.83	4.28	.95	1.72	4.65	1.18
20	480	3902	379	3820	786	43	9	54	54	.81	3.72	1.11	3.43	4.03	1.31

20	480	4130	554	4073	770	42	8	67	67	.85	4.19	.95	1.70	4.11	1.34
20	480	4338	398	4158	605	44	8	56	56	.71	3.84	.91	2.54	4.76	1.27
20	30	150	714	135	1144	6	44	15	16	1.85	4.63	2.56	.73	4.47	0.97
20	30	126	672	106	1124	9	44	16	16	1.61	5.40	6.87	2.67	4.73	0.98
20	30	51	740	52	495	7	44	9	8	2.54	5.52	7.65	1.44	5.01	1.13
20	30	119	781	136	529	6	45	11	11	2.65	6.80	7.42	.84	5.20	1.24
20	30	71	717	109	1080	7	43	9	10	1.98	6.96	3.48	1.05	4.61	1.41
20	30	54	732	60	1006	9	41	10	10	3.36	5.51	3.81	.65	4.87	1.20
20	30	100	733	86	1279	9	45	13	14	2.25	5.38	3.16	1.47	5.66	0.96
20	30	86	719	102	1226	9	45	12	13	3.64	3.83	4.27	1.04	4.85	1.36
20	30	175	709	213	1138	7	43	15	15	2.93	4.14	2.30	1.01	3.92	1.05
20	30	89	810	95	1129	8	43	17	17	3.26	4.12	1.88	.72	4.85	1.01
20	30	76	771	83	994	9	42	17	17	2.51	3.60	1.35	.84	4.56	1.23
20	30	59	778	24	1103	9	43	16	17	2.67	4.67	.86	1.19	4.59	1.07
20	30	50	904	28	1270	7	46	13	13	3.04	4.11	1.41	.80	5.15	1.24

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	VI	Responses		Times		Reinforcers		Visits		Leaving Constant			Leaving Variable		
FRCO	Vari	Const	Vari	Const	Vari	Const	Vari	Const	Vari	Init	FRT	Term	Init	FRT	Term
0	120	1712	3718	174	754	19	18	974	973	0	0	0.57	0	0	0.77
0	120	1645	3596	161	720	17	17	975	975	0	0	0.53	0	0	0.73
0	120	1584	4084	145	938	17	17	975	975	0	0	0.55	0	0	0.71
0	120	1489	3698	114	806	16	18	975	975	0	0	0.51	0	0	0.71
0	120	1644	2850	154	544	14	15	977	978	0	0	0.47	0	0	0.69
0	120	1549	3101	147	705	16	16	976	976	0	0	0.47	0	0	0.77
0	120	1518	2933	143	594	16	16	976	976	0	0	0.48	0	0	0.79
0	240	1283	1735	145	197	14	5	982	983	0	0	0.52	0	0	0.93
0	240	1373	2104	69	213	11	11	981	981	0	0	0.50	0	0	0.93
0	240	1595	1635	234	116	15	5	982	982	0	0	0.49	0	0	0.95
0	240	2348	1675	845	125	18	6	980	980	0	0	0.51	0	0	0.83
0	240	2060	1594	331	115	15	6	981	982	0	0	0.45	0	0	0.89
0	240	1986	1563	350	119	15	10	980	979	0	0	0.48	0	0	0.89
0	240	1934	1742	284	174	14	11	979	980	0	0	0.47	0	0	0.77
0	240	1881	1915	260	223	11	5	984	984	0	0	0.51	0	0	0.78
0	240	1862	1831	192	169	15	8	981	980	0	0	0.47	0	0	0.75
0	240	2101	1809	250	185	14	4	983	983	0	0	0.49	0	0	0.69
0	240	1935	1924	241	204	11	5	984	984	0	0	0.49	0	0	0.71
0	240	1979	1821	274	178	12	8	982	982	0	0	0.52	0	0	0.72
0	60	1608	3399	180	718	16	32	968	968	0	0	0.48	0	0	0.62
0	60	1424	2195	166	379	12	29	971	972	0	0	0.49	0	0	0.67
0	60	1629	2060	304	418	16	31	969	968	0	0	0.55	0	0	0.72
0	60	1532	1939	227	344	11	27	973	973	0	0	0.49	0	0	0.68
0	60	1379	1996	196	380	13	27	972	972	0	0	0.50	0	0	0.70
0	60	1604	2075	320	405	16	31	968	969	0	0	0.53	0	0	0.72
0	60	1660	2583	246	549	18	32	937	937	0	0	0.50	0	0	0.74
0	30	685	2087	45	468	11	39	612	613	0	0	0.56	0	0	0.69

0	30	546	1996	42	428	12	38	488	489	0	0	0.55	0	0	0.67
0	30	714	2511	29	516	12	38	682	683	0	0	0.51	0	0	0.62
0	30	736	2292	29	501	7	43	671	672	0	0	0.48	0	0	0.60
0	30	660	2044	17	482	10	40	640	640	0	0	0.48	0	0	0.63
0	30	800	2685	83	590	7	43	587	587	0	0	0.51	0	0	0.68
0	30	639	2140	54	532	8	42	486	486	0	0	0.51	0	0	0.63
0	30	645	1854	62	456	11	39	519	520	0	0	0.53	0	0	0.66
0	30	696	2059	76	500	8	42	565	566	0	0	0.52	0	0	0.66
0	480	1078	2398	106	319	12	3	985	984	0	0	0.49	0	0	0.48
0	480	1120	1906	96	231	12	2	985	985	0	0	0.47	0	0	0.51
0	480	1100	1540	98	114	13	3	984	984	0	0	0.45	0	0	0.49
0	480	1339	1445	211	108	10	2	986	986	0	0	0.43	0	0	0.45
0	480	1292	1326	167	98	12	2	985	985	0	0	0.49	0	0	0.50
0	480	1122	1187	68	67	5	4	988	987	0	0	0.43	0	0	0.52
0	480	1155	1338	59	104	5	2	988	989	0	0	0.42	0	0	0.47
0	480	1165	1160	97	73	13	2	985	984	0	0	0.42	0	0	0.42
0	120	1217	1367	73	153	7	8	984	985	0	0	0.42	0	0	0.49
0	120	1159	1438	74	200	9	8	983	984	0	0	0.42	0	0	0.52
0	120	1267	1323	94	151	9	4	985	986	0	0	0.42	0	0	0.48
0	120	1102	1359	56	201	12	11	980	981	0	0	0.43	0	0	0.47
0	120	1088	1452	47	192	12	9	981	982	0	0	0.44	0	0	0.50
0	120	1050	1305	45	134	7	3	987	987	0	0	0.44	0	0	0.44
0	120	1170	1226	102	122	11	7	983	983	0	0	0.46	0	0	0.47
2	120	1041	3207	491	1092	26	24	539	540	.76	.29	.48	.62	.33	0.47
2	120	1372	3968	473	1190	21	27	596	596	.61	.29	.51	.53	.32	0.42
2	120	1164	4109	365	1079	25	26	487	488	.59	.27	.53	.52	.29	0.40
2	120	1506	4341	571	1149	24	26	572	572	.54	.27	.54	.54	.30	0.40
2	120	1720	4876	642	1234	23	27	553	553	.54	.33	.51	.52	.34	0.39
2	240	4766	2244	1547	942	32	18	466	467	.69	.31	.88	.62	.23	0.54
2	240	3792	2385	1348	1019	33	17	495	494	.68	.34	.86	.67	.28	0.62

2	240	4032	1634	1568	645	32	18	473	474	.86	.38	1.02	.70	.30	0.59
2	240	4291	1782	1475	772	33	17	485	485	.73	.38	1.16	.69	.22	0.57
2	240	4928	1707	1680	685	34	16	459	458	.74	.33	1.06	.62	.21	0.56
2	240	4963	1904	1750	832	32	18	483	483	.75	.35	1.12	.61	.23	0.56
2	60	272	2904	99	1234	16	34	211	213	.71	.28	.91	.73	.34	0.56
2	60	263	2917	88	1242	17	34	201	202	.87	.33	.96	.73	.42	0.60
2	60	266	2843	71	1101	17	34	175	174	.76	.31	.97	.80	.51	0.65
2	60	283	3127	90	1247	18	33	193	193	.77	.42	.88	.72	.38	0.68
2	60	341	3180	176	1140	18	33	202	202	.91	.28	.95	.65	.34	0.60
2	60	348	3045	226	1023	17	33	203	204	.92	.29	.95	.65	.36	0.66
2	30	129	1824	36	839	13	38	83	84	.72	.25	1.34	.95	.37	0.94
2	30	164	2011	67	844	13	38	85	86	.75	.24	1.16	.74	.31	0.77
2	30	115	1726	53	789	11	39	64	65	.75	.31	1.40	.84	.33	0.91
2	30	124	2146	32	922	10	40	81	82	.78	.29	1.17	.81	.34	0.96
2	30	140	1945	55	815	12	38	90	90	.63	.33	1.17	.78	.30	0.84
2	30	136	2080	36	933	9	41	96	97	.80	.28	1.37	.74	.31	0.74
2	30	114	2005	46	965	9	42	74	75	.89	.31	1.33	.75	.39	0.99
2	30	90	2084	28	957	10	41	67	68	.79	.31	1.45	.79	.45	0.87
2	30	103	1916	29	1047	8	43	69	70	.71	.27	1.08	1.03	.52	0.70
2	30	116	1887	26	899	12	38	80	81	.66	.33	1.17	.79	.51	0.86
2	480	5786	1282	2485	568	37	13	417	416	.75	.31	.91	.67	.20	0.62
2	480	6306	1208	2586	569	42	8	445	444	.83	.32	1.00	.72	.20	0.57
2	480	7731	1263	3159	526	44	6	497	496	.78	.31	.93	.70	.19	0.55
2	480	7490	1223	2744	620	42	8	434	433	.81	.35	.88	.65	.20	0.67
2	480	8336	1196	2989	638	42	8	448	447	.79	.33	.87	.70	.21	0.66
2	480	9214	1271	3238	645	43	7	484	484	.67	.29	.93	.78	.20	0.66
2	480	8687	1060	2888	629	37	13	359	359	.64	.29	1.02	.74	.19	0.68
2	480	9287	966	3214	493	40	10	442	441	.68	.28	.90	.84	.21	0.69
2	480	8233	960	2859	482	41	9	458	457	.85	.30	.98	.92	.21	0.85
2	480	6550	1073	2405	487	41	9	496	496	.79	.29	.97	.79	.20	0.69

2	480	5987	1043	2359	517	40	10	479	478	.81	.29	1.07	.85	.21	0.82
6	120	1867	3271	897	1034	24	26	294	295	.51	.94	.69	.61	1.10	0.62
6	120	1995	3430	892	1136	25	25	312	313	.50	.92	.72	.63	1.03	0.62
6	120	1870	3533	840	1176	27	23	218	219	.53	.96	.68	.51	1.11	0.56
6	120	2105	4261	880	1245	26	24	245	245	.52	1.00	.75	.48	1.09	0.62
6	120	1749	3001	1012	984	26	24	232	232	.47	.99	.87	.53	1.07	0.63
6	30	78	2865	35	1164	7	45	32	33	.92	1.27	2.20	.87	2.01	1.26
6	30	83	2314	61	981	11	39	33	34	1.07	1.30	1.93	.67	1.23	1.60
6	30	79	2481	48	1041	5	45	30	31	1.38	1.24	1.78	.80	1.21	1.21
6	30	56	2975	53	1108	7	43	23	24	1.49	1.30	1.59	.71	1.24	1.05
6	30	61	2986	74	1091	8	42	25	26	1.33	1.38	1.32	.69	1.29	1.12
6	30	53	3063	45	1124	8	42	27	28	1.69	1.21	1.29	.68	1.21	1.61
6	30	68	3167	48	1182	8	42	30	31	1.54	1.25	1.75	.73	1.20	1.03
6	30	80	3168	48	1205	7	48	34	35	1.10	1.27	1.81	.87	1.18	0.90
6	30	42	2541	34	975	9	42	22	23	1.35	1.23	1.56	1.00	1.18	1.00
6	30	56	2204	72	981	12	39	26	26	1.89	1.27	1.67	.93	1.22	1.85
6	30	67	2792	32	1156	5	46	36	37	1.57	1.28	1.06	1.01	1.11	0.79
6	30	52	2637	19	1132	7	43	28	29	1.15	1.23	1.35	.75	1.19	1.09
6	30	61	2345	31	993	8	42	27	28	.99	1.32	1.62	1.05	1.78	0.94
6	480	7490	937	2871	575	38	12	192	192	.67	1.09	1.07	.80	1.23	1.05
6	480	6752	1422	2668	723	40	10	241	240	.64	1.04	1.26	.67	1.19	0.87
6	480	8518	1294	3435	736	43	7	221	221	.67	1.06	1.17	.70	1.23	0.87
6	480	7102	1274	3196	705	43	7	218	218	.75	1.26	1.23	.67	1.31	1.01
6	480	8161	819	3557	490	43	7	166	165	.76	1.21	1.24	.86	1.39	1.04
6	480	7178	1025	2936	579	39	11	186	186	.86	1.14	1.30	.65	1.30	0.84
6	480	8775	1203	3638	705	45	5	222	221	.80	1.16	1.15	.77	1.30	0.90
6	480	8351	1054	3415	581	39	11	170	171	.83	1.46	1.11	.70	1.35	0.78
6	480	7929	1116	3111	631	44	6	173	173	1.05	1.28	1.04	.76	1.34	0.78
6	480	8648	879	3159	547	39	11	162	162	.75	1.21	1.06	.77	1.33	0.73
6	480	9092	1260	3727	760	44	6	197	196	.77	1.16	1.03	.69	1.37	0.71

6	480	7283	858	3054	466	41	9	143	142	.78	1.17	1.23	.67	1.27	0.81
6	480	9107	1120	3728	662	41	9	169	168	.74	1.21	1.31	.74	1.30	0.84
12	120	2543	4778	1136	1225	24	26	136	136	.53	2.23	.99	.73	2.06	0.86
12	120	1676	3316	1154	1082	22	28	128	129	.59	2.40	1.50	.70	2.17	0.89
12	120	1911	3805	1146	1046	23	27	146	147	.70	2.43	1.35	.65	1.96	0.88
12	120	2270	3759	1125	1068	28	22	136	136	.58	2.35	1.10	.66	1.89	0.88
12	120	2022	3457	1111	987	25	25	148	149	.58	2.25	.99	.62	1.92	0.90
12	30	25	2711	24	1277	7	46	9	10	2.22	3.34	2.18	.85	3.18	1.53
12	30	40	3211	51	779	12	56	12	13	3.01	4.73	2.99	1.18	3.24	1.45
12	30	38	2675	48	1172	8	44	13	14	2.82	3.40	2.10	1.39	5.40	1.46
12	30	25	2766	14	1199	7	45	10	11	3.09	3.17	1.96	1.07	3.21	1.36
12	30	25	2904	12	581	5	45	12	12	2.95	3.07	2.36	1.21	3.07	1.27
12	30	15	3125	12	671	3	47	8	9	4.48	3.50	3.05	2.34	3.32	1.29
12	30	23	3487	38	920	7	57	9	10	2.99	3.73	2.03	1.07	3.48	1.43
12	30	21	2729	14	1232	6	45	9	10	3.75	3.64	2.29	1.07	3.41	1.38
12	30	32	2737	21	1295	6	45	9	10	2.84	3.62	1.71	1.05	3.40	1.12
12	30	20	2776	8	595	5	46	8	9	4.22	3.51	1.77	1.98	5.76	1.28
12	30	18	3097	7	673	5	47	8	9	4.14	3.64	.99	2.12	6.00	1.24
12	30	20	2903	10	607	6	45	9	10	4.47	3.34	1.36	1.97	3.06	1.43
12	30	32	3182	23	801	5	55	11	12	2.94	3.25	1.44	1.35	3.41	1.30
12	30	16	2849	14	584	8	43	7	8	3.30	3.25	1.20	1.62	3.37	1.76
12	30	21	2900	29	575	7	44	8	8	3.92	3.27	2.88	1.31	3.14	1.62
12	30	26	3063	11	1298	6	45	10	10	4.19	3.30	1.56	1.53	6.07	1.13
12	480	8388	1690	3620	840	42	8	113	113	.81	2.59	1.42	.80	2.23	0.83
12	480	7389	1467	3352	815	40	10	96	95	.87	2.54	1.72	.74	2.22	0.89
12	480	7437	1063	3570	703	39	11	88	87	.93	2.62	1.59	.99	2.25	0.90
12	480	6901	1433	3156	850	40	10	118	117	.78	2.65	1.65	.91	2.25	0.93
12	480	7510	1239	3566	810	43	9	130	129	.72	2.70	1.71	.95	2.24	0.86
12	480	7863	1116	3783	698	42	9	118	117	.77	2.66	1.39	.96	2.27	0.85
12	480	7603	779	3670	547	42	8	95	94	.87	2.58	1.33	1.06	2.22	0.94

12	480	7164	805	3568	497	39	12	83	82	.90	2.94	1.33	1.07	2.38	0.93
12	480	7005	1444	3463	722	40	11	98	97	.82	3.11	1.25	.97	2.32	0.74
12	480	7161	1378	3338	709	40	10	89	89	.72	2.72	1.48	.99	2.25	0.78
12	480	7998	1261	3770	651	40	10	74	73	.79	2.83	1.41	1.30	2.50	0.87
12	480	7265	1175	3426	664	40	10	68	67	.80	2.92	1.42	1.35	2.55	0.88
20	120	4685	2025	1594	596	28	23	57	58	.66	4.55	2.68	.67	3.57	1.03
20	120	5646	2518	1848	704	24	26	81	82	.59	4.19	2.37	.73	3.66	1.02
20	120	5920	2850	1891	798	29	22	64	64	.65	4.39	2.79	.66	3.70	1.15
20	120	4718	2192	1616	752	25	26	57	57	.68	4.19	2.43	.64	3.85	0.92
20	120	4647	1945	1772	706	27	24	75	76	.73	4.65	2.66	.66	4.10	1.08
20	240	8540	1087	2807	501	35	16	78	78	.74	4.15	1.89	.87	3.65	1.30
20	240	9829	746	3142	372	35	16	51	51	.67	4.80	2.06	.92	3.88	1.12
20	240	9839	1119	3047	501	36	14	55	55	.64	3.91	1.69	.76	3.47	0.82
20	240	9318	983	3051	493	34	16	64	65	.77	4.24	1.66	.87	3.53	1.09
20	240	8643	951	2779	495	35	15	71	71	.73	4.22	2.14	.83	3.51	0.91
20	240	9263	1145	3169	455	33	17	60	61	.76	3.94	1.89	.90	3.66	1.10
20	240	88	1155	3321	459	36	15	56	55	.92	4.12	2.27	.83	3.78	0.96
20	60	1146	4607	404	1378	15	35	33	33	.89	4.56	2.30	.65	5.12	1.84
20	60	681	4932	311	1542	15	35	31	32	.89	4.03	2.01	.70	4.73	1.66
20	60	1002	4674	407	1411	16	35	33	34	1.12	4.34	2.99	.72	4.64	1.65
20	60	1403	4735	432	1453	16	34	31	32	.96	4.70	2.74	.67	5.19	1.34
20	60	1320	5084	479	1504	15	35	30	31	.74	4.41	2.13	.70	5.04	1.35
20	60	1363	4785	518	1391	16	35	34	34	.72	4.13	1.53	.69	4.89	1.01
20	60	1013	4895	423	1364	16	34	33	34	1.15	4.40	2.26	.80	5.05	1.59
20	30	51	2806	35	1069	9	41	10	10	1.88	4.76	1.88	.66	6.00	1.64
20	30	135	2924	51	1096	7	44	12	13	1.65	4.91	2.22	.67	6.30	0.88
20	30	89	3453	38	1257	4	47	12	13	1.34	4.87	1.63	.75	5.77	0.90
20	30	31	3619	18	622	11	47	10	11	2.19	4.63	1.70	.75	5.80	1.07
20	30	100	3246	49	1176	9	45	11	12	1.33	4.83	1.60	.70	6.47	1.08
20	30	108	3375	54	1146	9	44	14	15	1.71	7.58	2.06	.67	6.22	1.11

20	30	158	3696	146	1219	10	47	14	15	1.16	5.62	1.52	.66	5.63	1.20
20	30	154	3538	107	1142	5	46	12	13	2.24	4.82	2.17	.75	5.34	1.11
20	30	237	3468	97	1032	5	45	13	14	1.19	4.91	1.50	.71	8.03	1.04
20	30	105	4467	60	1380	6	50	13	14	1.03	5.24	1.84	.67	5.91	1.75
20	30	183	3284	132	1026	11	40	18	18	1.20	5.06	1.81	.77	5.69	2.09
20	30	115	3353	110	1054	6	44	14	14	.88	5.27	1.87	.85	5.63	1.36
20	30	54	4077	29	744	8	48	9	10	.88	5.52	1.93	.85	7.16	1.71
20	30	128	3785	111	1250	6	48	14	15	1.02	5.07	1.82	.76	6.18	1.93
20	480	1237	183	625	180	41	10	17	17	.78	7.92	2.66	1.65	5.52	1.01
20	480	2603	389	2496	208	45	6	21	21	.78	4.93	1.43	1.33	5.16	0.87
20	480	3087	237	1190	230	45	10	21	20	.73	5.48	2.56	1.11	5.98	1.15
20	480	1442	268	2701	194	44	7	22	21	.70	7.06	1.96	1.46	5.73	1.26
20	480	224	501	2977	280	40	11	26	26	.72	5.20	1.65	1.64	5.13	1.09
20	480	9828	455	2174	256	44	8	29	29	.77	4.86	1.80	1.09	5.72	1.11
20	480	9625	567	2541	317	42	8	26	26	.93	5.24	3.27	.80	5.62	1.35
20	480	976	505	3024	256	44	8	24	23	1.03	4.75	2.39	1.00	4.74	1.16
20	480	755	199	654	137	45	5	16	16	.99	5.13	2.37	1.49	5.18	1.25
20	480	2354	657	2169	277	50	8	20	20	1.22	7.29	3.46	1.37	5.34	1.05
20	480	1747	208	886	99	48	3	16	16	1.19	6.05	1.83	1.34	5.54	1.29
20	480	1212	232	-204	145	45	5	14	15	1.02	4.87	2.45	1.22	5.13	1.19
20	480	1210	261	2197	163	41	9	24	24	1.04	5.68	3.33	1.37	4.51	0.97
20	480	934	302	2157	192	45	7	25	24	1.07	5.71	2.58	1.08	5.65	1.14
20	30	47	2928	70	1243	8	46	9	9	1.53	5.57	1.65	.91	9.13	1.33
20	30	28	2809	54	1261	5	47	8	9	2.80	6.68	1.78	1.03	5.22	1.26
20	30	19	2978	24	683	5	47	7	8	4.16	6.70	3.16	.65	5.73	1.35
20	30	33	2982	54	576	6	45	8	8	1.74	6.21	2.30	.89	5.65	1.45
20	30	40	3127	60	735	8	50	8	8	1.48	8.20	1.69	1.64	5.68	1.22
20	30	77	3332	94	1436	5	53	8	8	1.13	6.69	1.79	2.09	8.65	0.96
20	30	59	2791	89	604	8	44	8	9	1.75	6.64	1.27	1.01	6.15	1.35
20	30	116	3057	134	1375	7	49	8	9	.93	7.01	1.46	1.07	6.08	0.98

20	30	74	3778	70	1029	6	62	8	9	.78	5.78	1.32	.94	4.91	1.55
20	30	25	3435	23	782	3	48	3	4	1.05	5.71	2.03	1.21	6.85	2.68
20	30	73	4003	96	944	7	58	9	10	1.19	5.66	1.19	.85	5.33	1.21
20	30	28	3242	48	616	5	45	6	6	1.45	6.16	1.52	1.42	11.82	1.32
20	30	26	3534	35	232	6	53	5	6	1.13	5.93	2.01	1.04	7.36	2.14
20	30	32	3467	39	201	5	49	5	6	1.69	5.63	1.24	.87	5.87	1.77
20	30	4	4475	6	-54	2	62	1	2	1.58	5.77	2.02	1.06	6.20	2.09
20	30	16	3712	19	380	4	58	4	4	2.43	7.06	1.52	1.00	5.35	0.88
20	30	3	3517	1	189	2	51	1	2	8.61	6.87	.83	.75	6.09	3.69
20	30	15	2773	26	681	3	47	4	5	1.65	7.80	2.87	1.27	7.50	1.43
20	30	11	3302	30	-446	2	51	2	3	1.12	12.32	2.47	1.68	7.80	1.18

W37

	VI	Responses		Times		Reinforcers		Visits		Leaving Constant			Leaving Variable		
FRCO	Vari	Const	Vari	Const	Vari	Const	Vari	Const	Vari	Init	FRT	Term	Init	FRT	Term
0	120	1388	1538	480	841	24	23	968	969	0	0	0.89	0	0	1.05
0	120	1292	1722	294	1098	24	23	968	969	0	0	0.88	0	0	1.00
0	120	1136	1908	159	1389	25	25	902	903	0	0	0.85	0	0	0.95
0	120	1301	1743	241	1205	25	23	968	968	0	0	0.77	0	0	0.95
0	120	1332	1392	272	721	20	19	972	973	0	0	0.73	0	0	0.93
0	240	1541	1171	532	274	16	10	979	979	0	0	0.60	0	0	0.96
0	240	1608	1137	652	213	21	8	978	977	0	0	0.56	0	0	0.86
0	240	2186	1094	1215	174	29	9	973	973	0	0	0.65	0	0	1.00
0	240	2228	1072	1375	211	28	14	971	971	0	0	0.67	0	0	1.19
0	240	2150	1067	1196	132	22	13	975	974	0	0	0.57	0	0	1.11
0	240	2086	1096	1091	180	23	13	974	974	0	0	0.58	0	0	1.14
0	240	2451	1080	1568	238	30	15	970	969	0	0	0.71	0	0	1.31
0	240	2168	1095	1143	270	26	14	972	972	0	0	0.74	0	0	1.43
0	240	1993	1090	904	228	28	10	973	973	0	0	0.56	0	0	1.41
0	60	1274	1075	290	360	17	33	863	864	0	0	0.48	0	0	1.20
0	60	1262	1107	232	357	17	33	869	869	0	0	0.46	0	0	1.15
0	60	1383	1195	244	314	17	33	956	956	0	0	0.44	0	0	1.10
0	60	1455	1193	292	303	16	33	968	967	0	0	0.43	0	0	1.08
0	60	1086	1034	226	385	17	34	787	787	0	0	0.46	0	0	1.28
0	60	1218	1064	201	311	17	34	881	880	0	0	0.44	0	0	1.27
0	30	253	887	15	884	10	41	216	217	0	0	0.70	0	0	1.10
0	30	287	920	24	907	10	40	244	245	0	0	0.66	0	0	1.09
0	30	233	902	15	859	11	39	209	210	0	0	0.67	0	0	1.09
0	30	184	1013	6	976	7	43	171	171	0	0	0.57	0	0	1.04
0	30	174	1036	8	1009	7	43	163	164	0	0	0.59	0	0	1.08
0	30	260	917	15	869	11	39	231	232	0	0	0.65	0	0	1.13
0	30	226	814	27	862	10	42	194	195	0	0	0.75	0	0	0.98

0	30	203	911	14	976	9	41	188	188	0	0	0.65	0	0	1.11
0	30	186	809	23	932	13	37	166	166	0	0	0.77	0	0	1.24
0	30	152	758	11	930	11	40	144	145	0	0	0.68	0	0	1.19
0	480	2449	1257	1687	414	33	10	970	971	0	0	0.98	0	0	1.07
0	480	2947	1147	2497	297	39	8	968	969	0	0	1.19	0	0	1.11
0	480	3458	1057	2987	221	45	5	916	916	0	0	1.56	0	0	1.00
0	480	3000	1162	2413	424	43	7	933	933	0	0	1.58	0	0	1.20
0	480	3402	1060	2553	301	39	11	882	883	0	0	1.46	0	0	1.08
0	480	3441	778	3319	181	43	8	677	677	0	0	1.73	0	0	1.20
0	480	2857	752	2318	112	39	11	683	683	0	0	1.69	0	0	1.27
0	480	3260	941	2697	169	39	11	829	829	0	0	1.24	0	0	1.28
0	480	3047	1140	2164	238	36	8	970	970	0	0	1.08	0	0	1.17
0	480	3407	1168	2486	216	36	5	971	972	0	0	0.84	0	0	1.05
0	480	4030	967	3264	123	43	7	811	811	0	0	0.88	0	0	0.97
0	480	3178	904	2729	132	42	8	761	761	0	0	1.34	0	0	1.09
0	60	420	1245	49	1269	18	33	341	342	0	0	1.28	0	0	0.90
0	60	511	1126	96	1096	16	34	381	382	0	0	1.37	0	0	0.82
0	60	537	1048	98	993	17	34	402	402	0	0	1.50	0	0	0.87
0	60	524	1044	122	1026	16	34	376	376	0	0	1.42	0	0	0.86
0	60	505	957	111	973	16	34	377	378	0	0	1.62	0	0	0.87
0	60	542	1099	100	1032	17	33	416	416	0	0	1.36	0	0	0.88
2	120	646	769	466	647	25	25	306	307	2.08	.46	.47	.79	.44	1.10
2	120	847	914	681	935	24	26	317	318	.90	.37	.44	.72	.44	0.93
2	120	1038	1123	978	1042	23	27	338	339	1.01	.41	.42	.74	.51	0.81
2	120	670	900	514	1024	22	28	305	306	1.74	.44	.45	.79	.47	1.22
2	120	683	890	431	856	25	26	294	294	1.91	.41	.43	.91	.50	0.97
2	240	1416	1218	1369	889	34	16	436	436	.94	.46	.41	.74	.41	1.01
2	240	1613	1135	1430	674	34	16	494	494	.87	.46	.44	1.09	.43	0.82
2	240	1576	1276	1217	863	33	17	541	541	1.08	.44	.42	1.07	.40	0.89
2	240	1687	1096	1392	561	33	17	518	518	.96	.43	.41	1.08	.37	0.79

2	240	1672	1012	1459	428	33	18	493	494	.92	.48	.42	1.18	.38	0.78
2	240	1559	1140	1244	636	34	17	490	490	1.02	.52	.43	1.10	.46	0.71
2	60	468	1109	191	1039	17	33	234	233	.90	.34	.44	.61	.45	0.60
2	60	469	1194	75	1159	17	34	246	248	.77	.34	.44	.58	.50	0.61
2	60	489	1155	122	1146	17	34	242	242	.78	.34	.45	.61	.52	0.58
2	60	431	1025	115	1113	17	34	234	236	.96	.39	.47	.78	.57	0.64
2	60	495	1089	91	1171	17	33	242	242	.89	.36	.44	.75	.56	0.56
2	60	472	1117	135	1082	16	34	236	237	.87	.37	.45	.61	.51	0.57
2	30	234	933	34	854	9	41	107	108	.79	.33	.47	.71	.45	0.68
2	30	224	913	22	824	9	41	131	132	.74	.43	.47	.70	.50	0.99
2	30	143	895	6	859	9	42	121	122	.69	.40	.48	.75	.47	1.01
2	30	153	833	11	899	5	45	113	114	.59	.38	.48	.69	.50	0.80
2	30	170	889	25	846	12	39	108	109	.78	.38	.48	.69	.50	0.85
2	30	303	930	63	821	10	40	119	119	.67	.36	.47	.81	.47	0.72
2	30	269	945	44	833	10	41	128	129	.63	.39	.47	.70	.48	0.67
2	30	255	890	58	819	12	41	123	124	.65	.37	.51	.72	.46	0.76
2	30	224	873	37	771	7	43	122	122	.60	.42	.47	.76	.46	0.78
2	30	248	914	33	798	8	42	130	131	.63	.45	.47	.72	.49	0.73
2	30	174	812	15	800	8	42	125	126	.59	.54	.48	.77	.55	1.06
2	480	3304	401	3019	39	39	11	351	350	.70	.85	.42	.68	.54	0.71
2	480	3914	435	3319	63	39	12	380	379	.68	.77	.44	.68	.53	0.77
2	480	2946	526	2953	72	42	8	438	437	.96	.71	.42	.73	.74	0.78
2	480	3488	449	3426	40	39	11	400	400	.75	.64	.42	.63	.60	0.65
2	480	3191	558	3139	133	39	11	422	421	.91	.75	.40	.60	.53	0.83
2	480	3003	413	3308	47	39	11	357	358	1.24	.71	.45	.59	.63	0.74
2	480	3089	562	2888	74	40	10	496	495	1.30	.60	.45	.62	.59	0.82
2	480	2757	488	2950	77	38	12	423	423	1.17	.61	.47	1.01	.60	0.80
2	480	3022	473	3058	97	44	7	393	393	1.05	.67	.43	1.09	.68	0.87
2	480	3227	478	3203	136	43	8	373	373	.89	.67	.44	1.32	.73	0.72
6	120	766	836	1092	989	25	25	193	193	1.09	1.44	.57	.61	1.46	0.84

6	120	709	878	1031	1018	24	26	178	179	1.26	1.46	.58	.70	1.51	1.07
6	120	896	860	1300	886	24	26	201	201	1.30	1.50	.58	.72	1.52	0.83
6	120	990	854	1252	871	26	24	194	194	1.01	1.52	.56	.76	1.50	0.92
6	120	1082	988	1091	1139	27	25	192	193	.82	1.47	.59	.77	1.51	0.79
6	30	129	973	121	890	8	42	39	40	2.51	1.33	.64	.60	1.56	0.87
6	30	131	1055	90	938	11	42	44	45	2.79	1.34	.66	.53	1.35	0.75
6	30	108	807	89	753	13	39	37	38	2.90	1.33	.61	.59	1.31	0.94
6	30	126	817	114	775	12	38	49	50	2.62	1.34	.62	.62	1.47	1.21
6	30	182	909	130	841	11	41	45	46	1.38	1.51	.65	.61	1.60	0.75
6	30	139	911	109	789	11	40	33	34	1.97	1.58	.61	.62	1.55	0.93
6	30	173	797	163	725	12	39	41	41	2.06	1.53	.62	.59	1.49	0.94
6	30	173	1013	156	827	12	38	40	41	1.51	1.36	.60	.66	1.59	1.26
6	30	137	936	139	819	10	41	39	39	1.44	1.58	.60	.63	1.47	0.93
6	480	3766	446	3486	186	42	9	256	255	.65	1.38	.54	1.69	1.35	0.83
6	480	3257	462	3472	311	45	6	225	224	.61	1.30	.56	1.87	1.33	1.00
6	480	3047	518	2776	526	39	11	209	208	.57	1.35	.55	1.23	1.37	0.97
6	480	3794	491	3386	479	41	9	212	211	.56	1.36	.55	1.43	1.40	0.95
6	480	3535	543	3177	595	44	7	226	225	.57	1.31	.55	1.58	1.38	1.13
6	480	2799	491	2336	638	38	12	199	198	.54	1.41	.56	1.55	1.42	0.98
6	480	3071	472	2826	642	42	10	246	245	.61	1.37	.56	2.76	1.44	1.19
6	480	2675	558	2583	607	38	12	234	234	.62	1.46	.58	2.18	1.40	0.87
6	480	3366	544	2938	607	43	7	234	234	.56	1.59	.57	1.61	1.36	0.84
6	480	2972	450	2682	272	39	11	216	215	.58	1.51	.58	2.21	1.37	0.81
6	480	3377	423	2932	332	38	12	213	213	.60	1.49	.55	2.70	1.31	0.88
6	480	3493	466	2912	353	42	8	238	237	.63	1.54	.57	3.06	1.28	0.90
12	120	1113	732	989	848	27	23	130	131	.76	2.83	.61	.61	2.88	0.76
12	120	1259	837	1329	988	24	26	142	143	.88	2.83	.61	.59	2.81	0.74
12	120	1026	672	1223	930	25	25	124	124	.83	2.94	.61	.62	2.88	0.78
12	120	859	604	989	856	27	23	109	109	.78	2.83	.62	.66	2.87	0.86
12	120	888	561	963	886	25	25	116	117	.76	2.75	.61	.77	2.85	0.75

12	30	78	971	97	1106	7	44	18	19	2.26	3.33	.71	.49	3.71	1.18
12	30	62	1069	75	1085	10	42	20	20	3.90	3.53	.76	.54	3.63	1.44
12	30	63	935	65	949	9	42	18	18	2.74	3.54	.59	.51	3.11	1.08
12	30	85	867	129	896	10	41	21	21	2.61	3.58	.63	.50	3.15	1.27
12	30	65	958	78	1098	10	43	19	20	2.67	3.74	.59	.55	3.06	0.96
12	30	98	801	155	861	9	43	23	24	2.97	3.85	.60	.50	3.68	1.38
12	30	102	909	176	991	9	41	23	23	1.55	3.53	.65	.52	3.05	1.33
12	30	127	1014	166	1038	6	45	18	19	1.22	3.52	.61	.54	3.10	0.99
12	30	138	1156	202	1204	10	50	18	19	1.07	3.79	.64	.52	3.65	1.27
12	30	118	962	189	1002	7	43	19	20	.69	3.90	.63	.52	3.81	1.27
12	30	76	982	118	1115	7	46	15	16	.76	3.86	.68	.62	2.94	1.14
12	30	93	924	162	1037	8	45	19	20	1.20	3.71	.65	.52	3.09	1.10
12	480	3831	356	3008	618	38	12	121	120	.67	2.91	.62	1.34	2.72	0.88
12	480	4231	341	3839	544	44	8	124	123	.90	3.07	.62	1.74	2.58	0.85
12	480	3101	455	3466	598	40	10	134	133	1.20	3.07	.63	.69	2.81	1.00
12	480	2966	378	3355	604	43	7	145	145	1.53	2.95	.63	1.21	2.69	0.85
12	480	3632	425	3556	655	44	6	140	139	1.37	3.05	.64	1.13	2.83	0.90
12	480	3373	302	3111	529	41	9	115	115	.81	3.02	.62	1.78	2.84	0.82
12	480	2817	306	2590	616	38	12	125	124	.62	2.74	.62	2.09	2.63	0.83
12	480	3122	454	3278	795	42	9	164	163	.66	3.02	.63	1.03	2.76	0.89
12	480	2722	322	2709	646	40	11	127	126	.66	3.47	.67	1.36	2.91	0.84
12	480	3163	476	3114	793	42	8	109	108	.77	3.18	.67	.62	2.90	1.04
12	480	3506	547	3432	912	42	8	106	106	.87	3.18	.68	.50	3.10	0.94
12	480	3525	481	3413	794	37	13	106	105	.76	3.39	.70	.68	3.35	0.98
20	120	1378	1056	1195	1070	24	26	80	80	.73	6.39	.69	.63	6.11	0.90
20	120	1187	982	997	830	26	24	65	65	.63	6.36	.72	.70	6.12	1.06
20	120	1427	1278	897	1260	27	23	89	89	.64	6.16	.70	.70	6.52	0.91
20	120	1446	1092	896	1318	25	25	81	82	.71	6.61	.68	.70	5.90	0.94
20	120	1236	1206	825	1390	26	24	78	78	.79	6.98	.70	.68	6.43	1.00
20	240	2080	862	1976	1021	33	18	76	76	.63	6.74	.73	.58	7.89	1.25

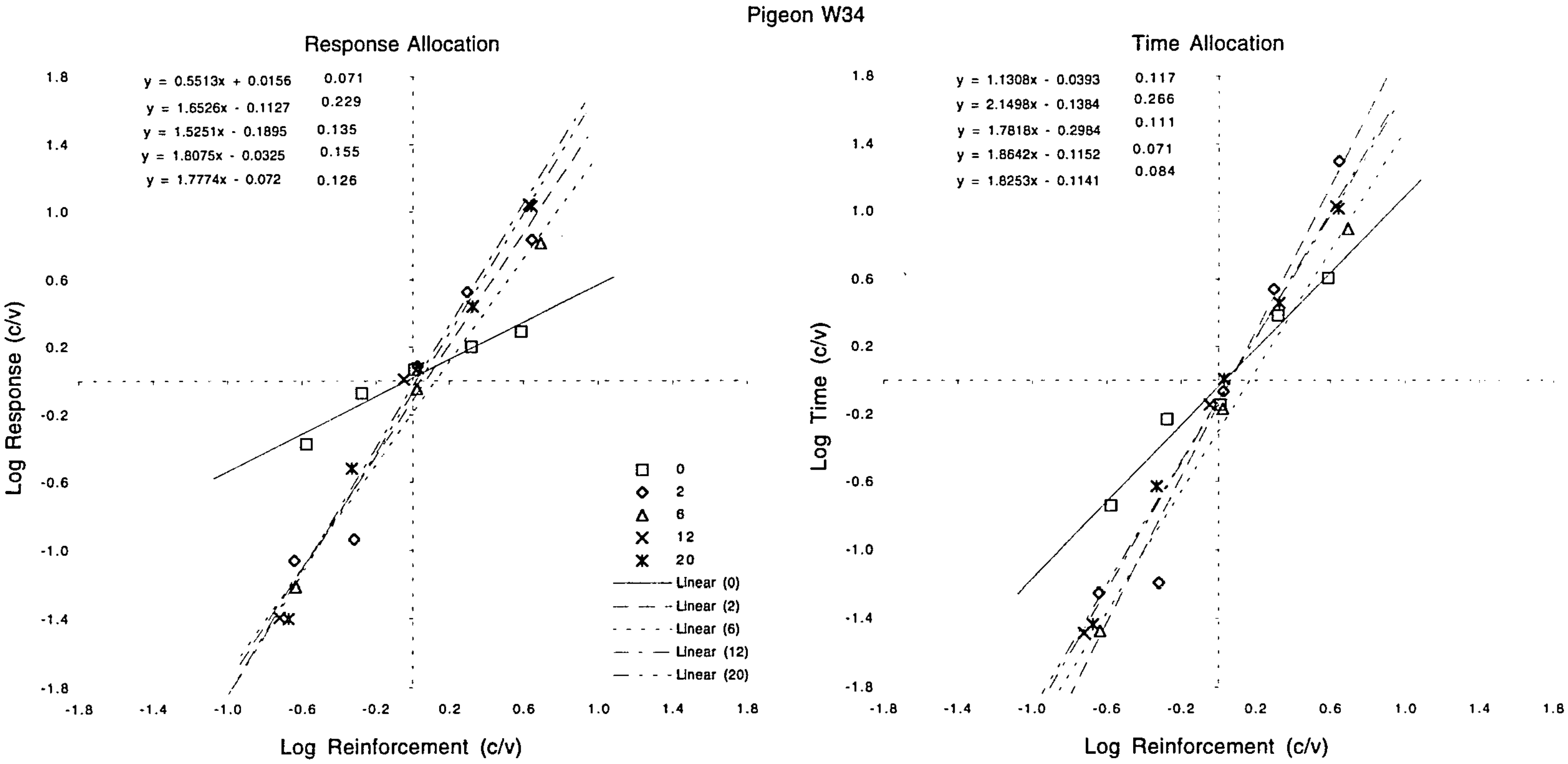
20	240	2118	1081	1858	1232	34	16	80	79	.61	7.53	.74	.60	7.30	1.49
20	240	2027	916	1707	1180	33	17	83	82	.62	6.97	.74	.68	7.00	1.78
20	240	1963	971	1600	1275	32	18	76	77	.64	7.15	.75	.66	7.60	1.61
20	240	1909	956	1730	1251	33	17	72	72	.67	6.93	.74	.67	7.01	1.75
20	240	2126	893	1771	1064	33	17	86	85	.62	6.88	.70	.70	8.00	1.65
20	60	370	1490	354	1427	13	38	20	19	.72	9.28	.72	.75	8.95	1.20
20	60	417	1533	459	1470	16	35	22	23	1.22	8.35	.73	.95	8.20	1.11
20	60	578	1255	469	1310	16	35	27	28	.81	8.60	.74	.75	9.09	1.30
20	60	531	1175	626	1181	16	37	29	29	.72	7.42	.68	.74	8.14	1.19
20	60	450	1285	491	1290	17	33	35	34	.91	6.64	.71	.83	7.77	1.17
20	60	484	1223	468	1203	16	35	38	38	.80	6.68	.68	.78	6.60	1.11
20	60	388	1434	385	1400	16	34	37	37	1.21	6.38	.66	.72	6.93	0.94
20	30	43	1051	58	1325	7	48	8	9	3.47	6.15	.60	.59	6.49	1.47
20	30	47	1160	49	1299	7	46	9	10	2.95	6.82	.66	.57	6.98	1.21
20	30	77	1742	106	1385	5	75	9	10	1.65	7.87	.60	.62	7.97	1.42
20	30	94	1164	95	714	5	48	6	7	2.00	6.64	.63	.76	7.16	0.87
20	30	26	1005	35	86	5	45	4	5	2.30	7.72	.56	.57	6.06	0.93
20	30	27	1043	24	571	6	44	6	6	2.44	6.73	.61	.70	7.32	1.01
20	30	65	896	64	1044	9	42	11	12	3.36	7.60	.58	.71	8.53	0.82
20	30	35	1020	47	1350	7	48	8	9	2.33	6.75	.60	.83	7.43	0.93
20	30	44	1094	65	518	9	42	9	9	2.77	6.30	.62	.62	8.35	0.86
20	30	57	1152	78	1239	8	46	10	11	2.80	5.88	.58	.62	6.41	0.65
20	30	43	1176	55	1403	8	48	9	10	2.34	6.19	.61	.59	6.40	0.80
20	30	35	1047	32	1235	5	46	8	9	2.54	7.11	.57	.58	6.66	1.08
20	30	74	1088	67	1252	8	46	12	13	2.30	7.41	.63	.68	7.46	0.90
20	30	53	1240	79	1291	5	46	10	11	1.87	6.56	.57	.65	7.56	0.89
20	30	70	928	161	-35	6	44	6	7	1.80	6.36	.62	1.56	15.89	0.81
20	480	3491	567	4045	856	45	6	38	38	.70	9.31	.76	.70	9.82	1.20
20	480	3037	494	2789	893	42	8	39	39	.79	8.39	.75	.74	8.76	1.19
20	480	3824	472	3145	818	47	8	37	36	.87	10.51	.78	.78	9.44	1.53

20	480	3394	402	2729	762	40	10	39	38	.81	8.95	.76	.83	8.15	1.58
20	480	2091	552	2580	928	40	10	42	41	.91	7.45	.80	.84	7.92	1.80
20	480	3133	507	2285	912	40	10	34	33	.83	8.39	.72	.79	9.80	1.18
20	480	2465	679	2403	1168	42	8	43	42	.85	7.37	.74	.73	8.58	1.33
20	480	2971	391	3128	818	43	7	42	41	.93	10.12	.74	1.00	8.54	1.17
20	480	2805	346	2287	898	43	10	27	27	.67	7.96	.98	.87	9.01	1.11
20	480	3602	401	2143	963	45	8	33	32	.62	8.71	.81	.95	10.70	1.28
20	480	2814	403	3347	963	40	10	31	30	.91	8.30	.84	.86	9.16	1.20
20	480	3532	548	3038	1252	44	7	36	36	.64	8.17	.77	1.25	8.58	1.56
20	30	15	1361	29	993	8	60	7	8	3.72	6.97	.58	.60	8.05	1.42
20	30	16	1187	14	658	6	45	7	7	5.07	6.69	.71	.61	7.32	1.20
20	30	34	1442	38	890	6	59	10	11	4.33	7.22	.76	.62	7.55	1.12
20	30	20	1163	36	17	6	47	5	6	2.31	7.97	.63	.59	7.68	0.88
20	30	23	1148	20	1346	9	43	8	9	6.78	7.57	.59	.58	7.71	1.00
20	30	13	1127	29	670	6	47	4	5	5.80	7.46	.62	.55	6.11	1.04
20	30	23	1214	39	249	5	54	6	7	3.31	7.77	.93	.60	6.46	0.92
20	30	24	1252	41	120	5	48	5	6	4.25	7.00	.59	.82	6.84	0.95
20	30	14	1557	28	-210	5	59	4	5	4.87	7.02	.62	.61	6.92	1.07
20	30	16	1460	35	863	4	54	6	7	5.45	8.23	.60	.57	7.33	1.17
20	30	19	1255	40	249	3	51	6	7	3.26	8.69	.69	.78	7.47	0.91
20	30	23	1930	29	481	6	58	5	6	4.37	9.26	.63	.60	8.32	0.94
20	30	34	1685	48	234	9	54	8	9	4.62	7.77	.60	.58	7.68	0.88
20	30	47	1563	57	269	6	57	9	9	2.05	7.04	.66	.58	6.70	1.16
20	30	16	1326	16	754	3	48	5	6	4.32	8.03	.71	.55	6.86	1.35
20	30	8	1241	9	-549	4	47	3	4	10.00	6.61	.51	.56	7.50	0.91
20	30	14	1207	21	55	4	46	4	4	3.82	7.55	.63	.59	7.17	1.15
20	30	23	1178	48	556	8	42	9	9	3.39	7.07	.62	.60	7.72	1.46

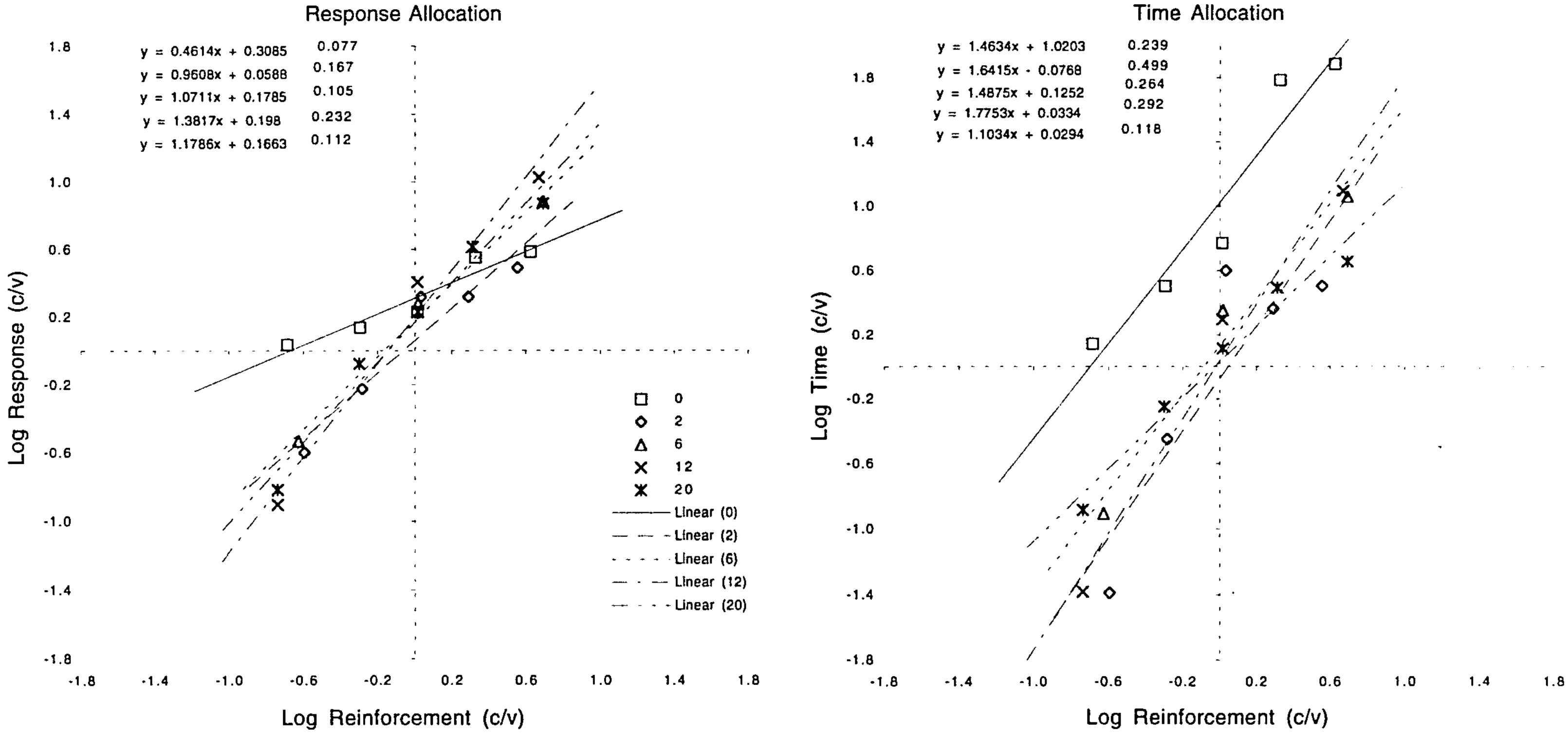
APPENDIX II

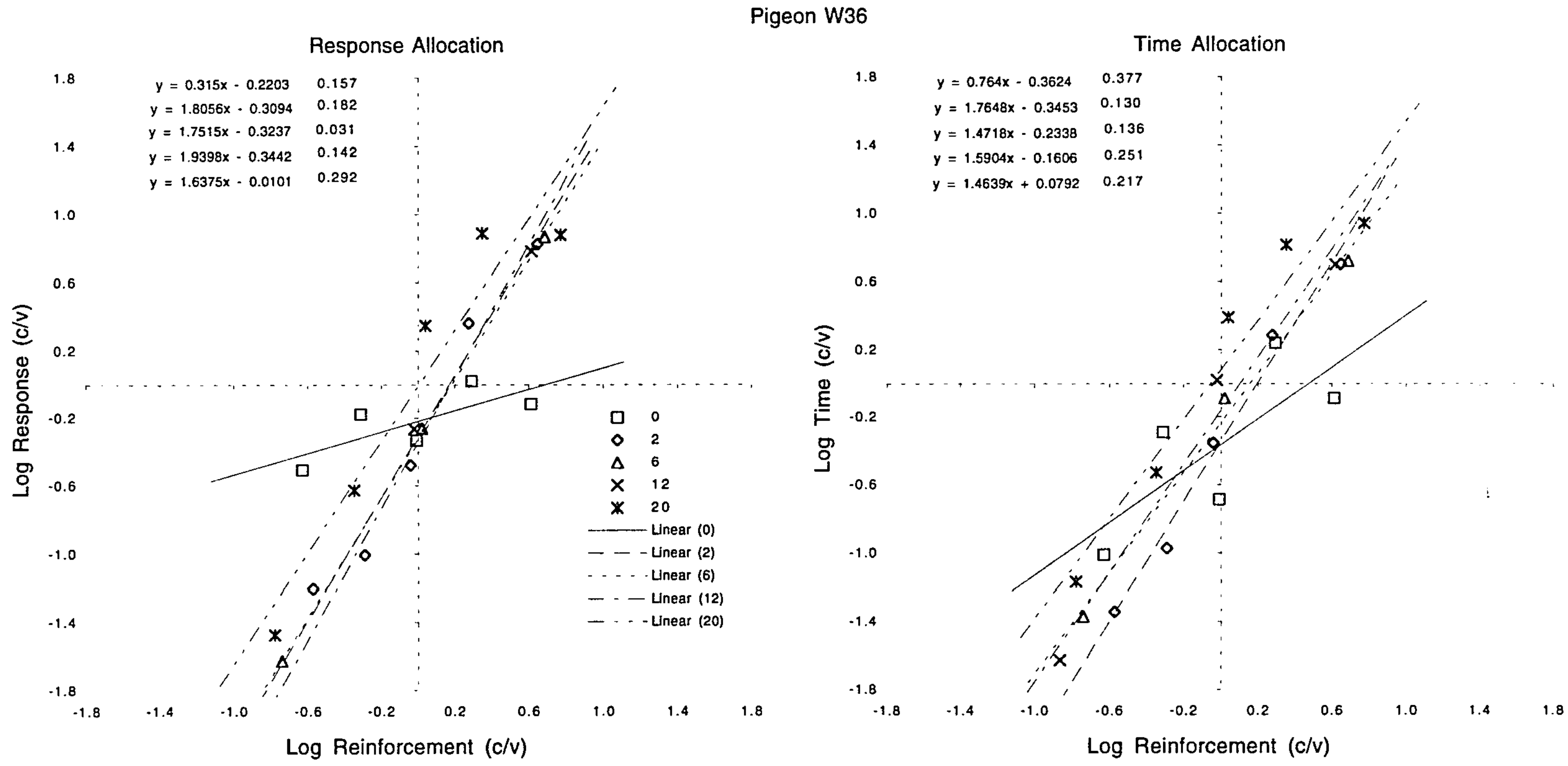
Molar Analyses

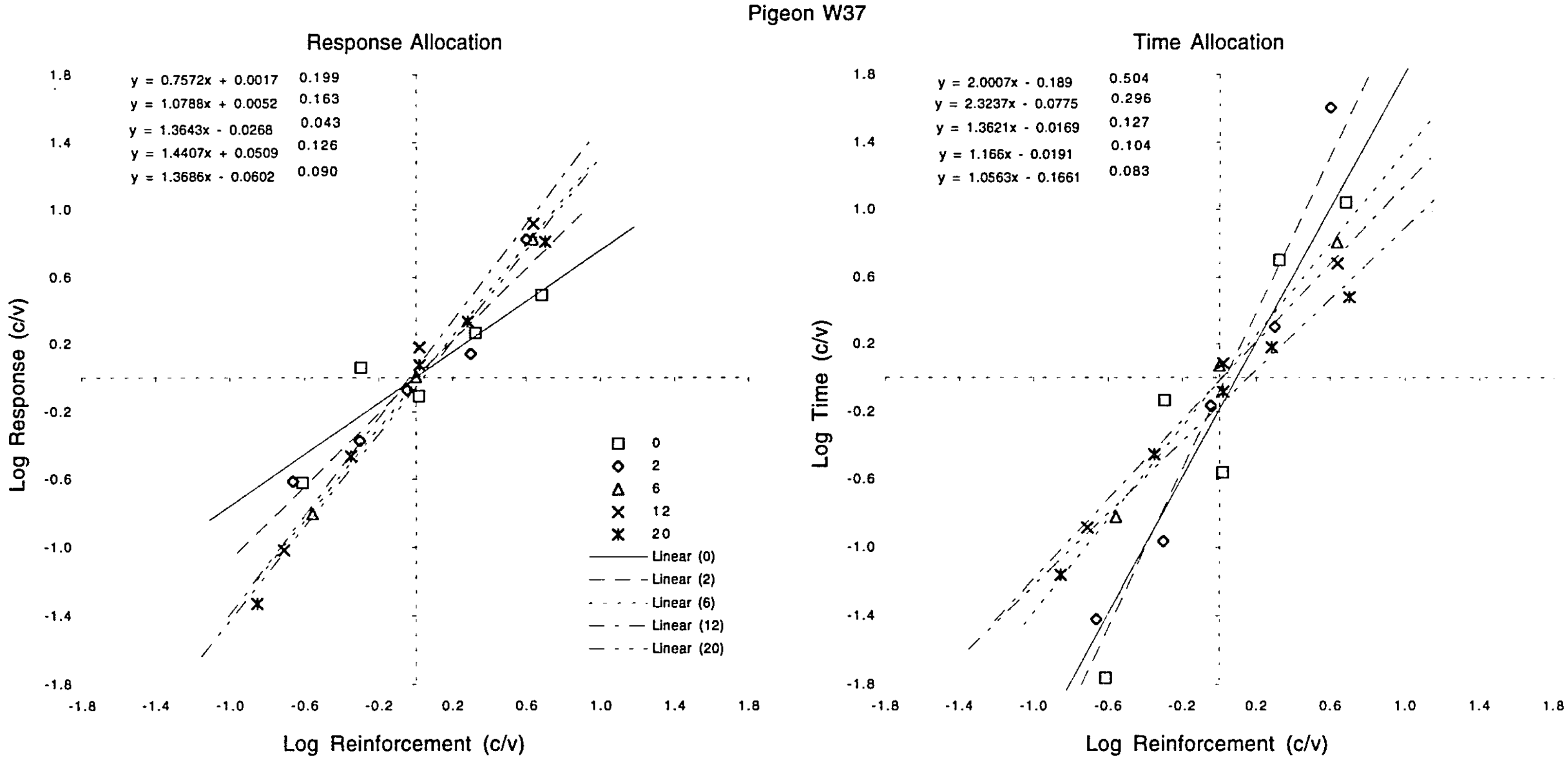
The following four figures present log response (c/v) by log reinforcer (c/v) and log time. Pigeon number is noted on each figure. Linear equations and standard errors of the slope estimate are listed in the same order as their legend labels.


Pigeon W34
Response Allocation
y = 0.5513x + 0.0156 0.071
y = 1.6526x - 0.1127 0.229
y = 1.5251x - 0.1895 0.135
y = 1.8075x - 0.0325 0.155
y = 1.7774x - 0.072 0.126
Log Response (c/v)
Log Reinforcement (c/v)
1.8
1.4
1.0
0.6
0.2
-0.2
-0.6
-1.0
-1.4
-1.8
□ 0
◇ 2
△ 6
✕ 12
✱ 20
Linear (0)
Linear (2)
Linear (6)
Linear (12)
Linear (20)
Time Allocation
y = 1.1308x - 0.0393 0.117
y = 2.1498x - 0.1384 0.266
y = 1.7818x - 0.2984 0.111
y = 1.8642x - 0.1152 0.071
y = 1.8253x - 0.1141 0.084
Log Time (c/v)
Log Reinforcement (c/v)

Pigeon W35


Response Allocation
y = 0.4614x + 0.3085 0.077
y = 0.9608x + 0.0588 0.167
y = 1.0711x + 0.1785 0.105
y = 1.3817x + 0.198 0.232
y = 1.1786x + 0.1663 0.112
Log Response (c/v)
1.8
1.4
1.0
0.6
0.2
-0.2
-0.6
-1.0
-1.4
-1.8
-1.8
-1.4
-1.0
-0.6
-0.2
0.2
0.6
1.0
1.4
1.8
Log Reinforcement (c/v)
□ 0
◇ 2
△ 6
✕ 12
✱ 20
Linear (0)
Linear (2)
Linear (6)
Linear (12)
Linear (20)
Time Allocation
y = 1.4634x + 1.0203 0.239
y = 1.6415x - 0.0768 0.499
y = 1.4875x + 0.1252 0.264
y = 1.7753x + 0.0334 0.292
y = 1.1034x + 0.0294 0.118
Log Time (c/v)
1.8
1.4
1.0
0.6
0.2
-0.2
-0.6
-1.0
-1.4
-1.8
-1.8
-1.4
-1.0
-0.6
-0.2
0.2
0.6
1.0
1.4
1.8
Log Reinforcement (c/v)


Pigeon W36
Response Allocation
y = 0.315x - 0.2203 0.157
y = 1.8056x - 0.3094 0.182
y = 1.7515x - 0.3237 0.031
y = 1.9398x - 0.3442 0.142
y = 1.6375x - 0.0101 0.292
Log Response (c/v)
1.8
1.4
1.0
0.6
0.2
-0.2
-0.6
-1.0
-1.4
-1.8
-1.8
-1.4
-1.0
-0.6
-0.2
0.2
0.6
1.0
1.4
1.8
Log Reinforcement (c/v)
□ 0
◇ 2
△ 6
× 12
✱ 20
Linear (0)
Linear (2)
Linear (6)
Linear (12)
Linear (20)
Time Allocation
y = 0.764x - 0.3624 0.377
y = 1.7648x - 0.3453 0.130
y = 1.4718x - 0.2338 0.136
y = 1.5904x - 0.1606 0.251
y = 1.4639x + 0.0792 0.217
Log Time (c/v)
1.8
1.4
1.0
0.6
0.2
-0.2
-0.6
-1.0
-1.4
-1.8
-1.8
-1.4
-1.0
-0.6
-0.2
0.2
0.6
1.0
1.4
1.8
Log Reinforcement (c/v)



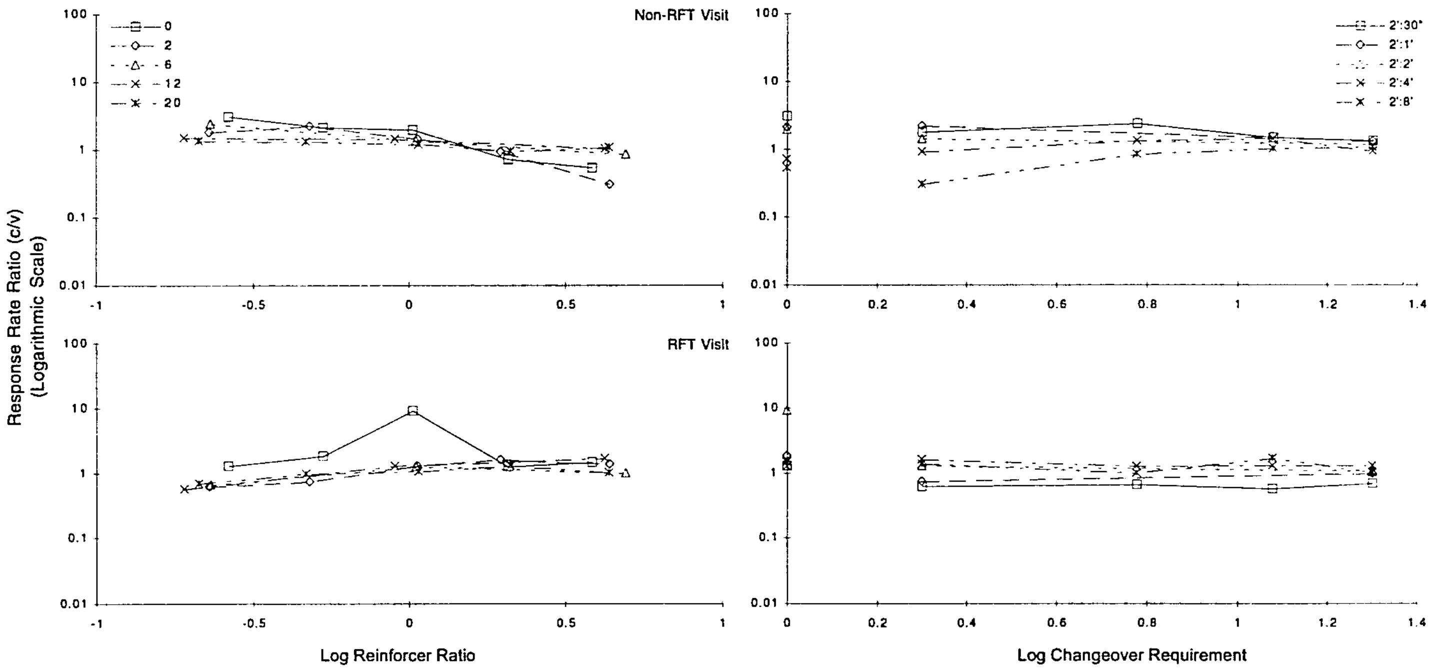
Pigeon W37

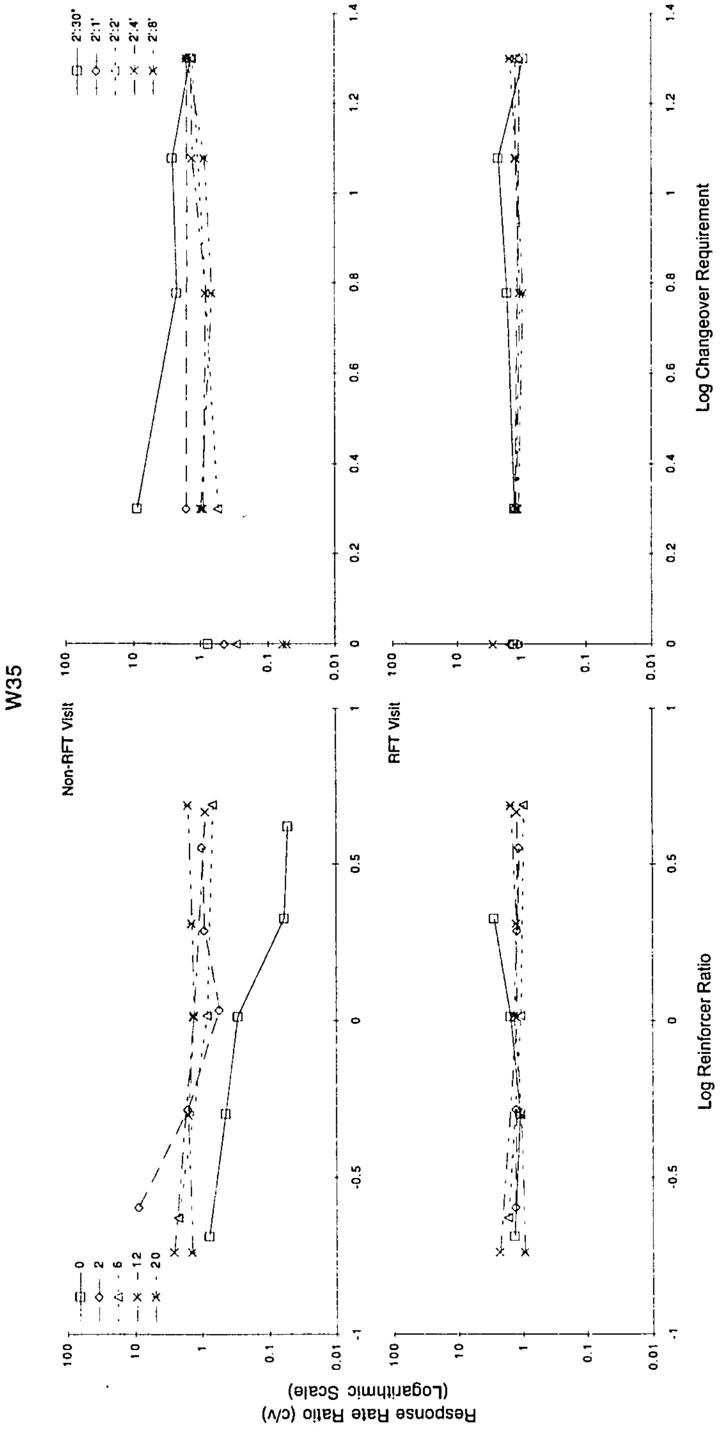
Response Allocation

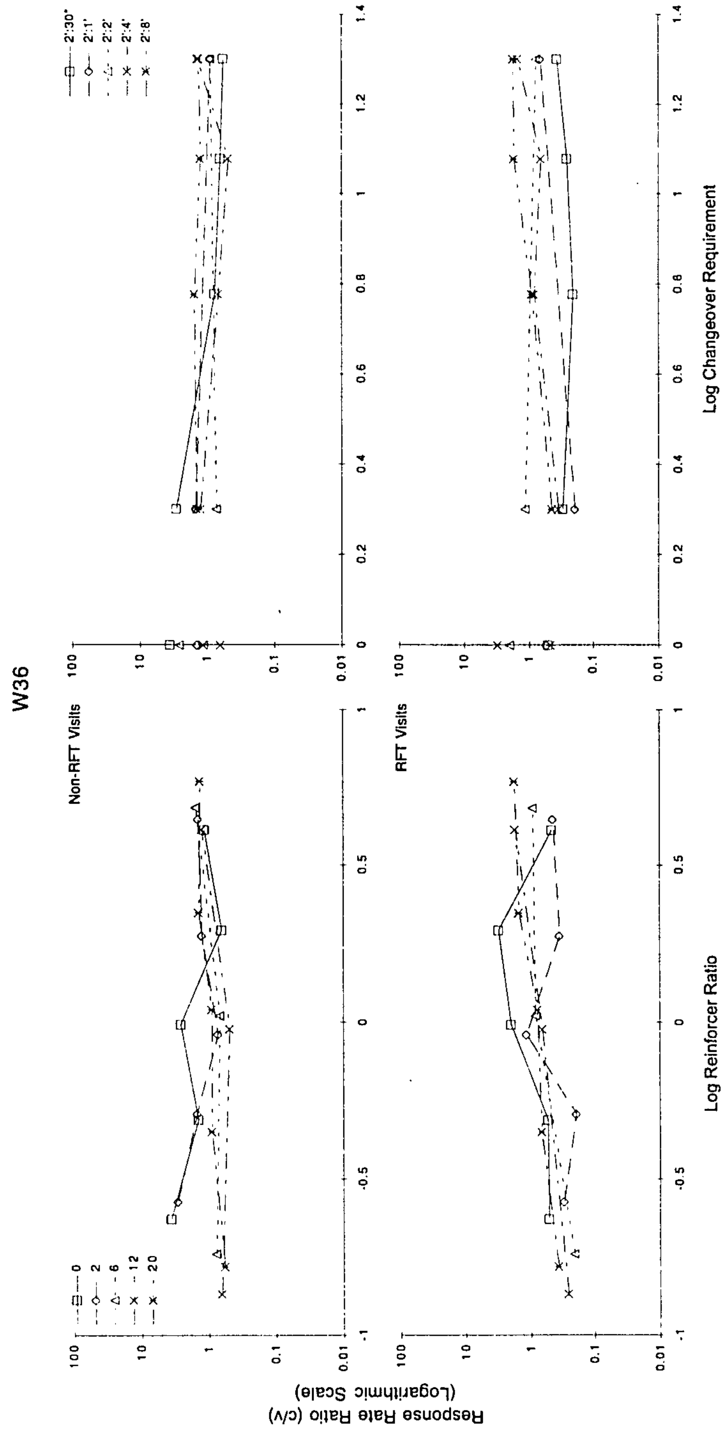
Time Allocation

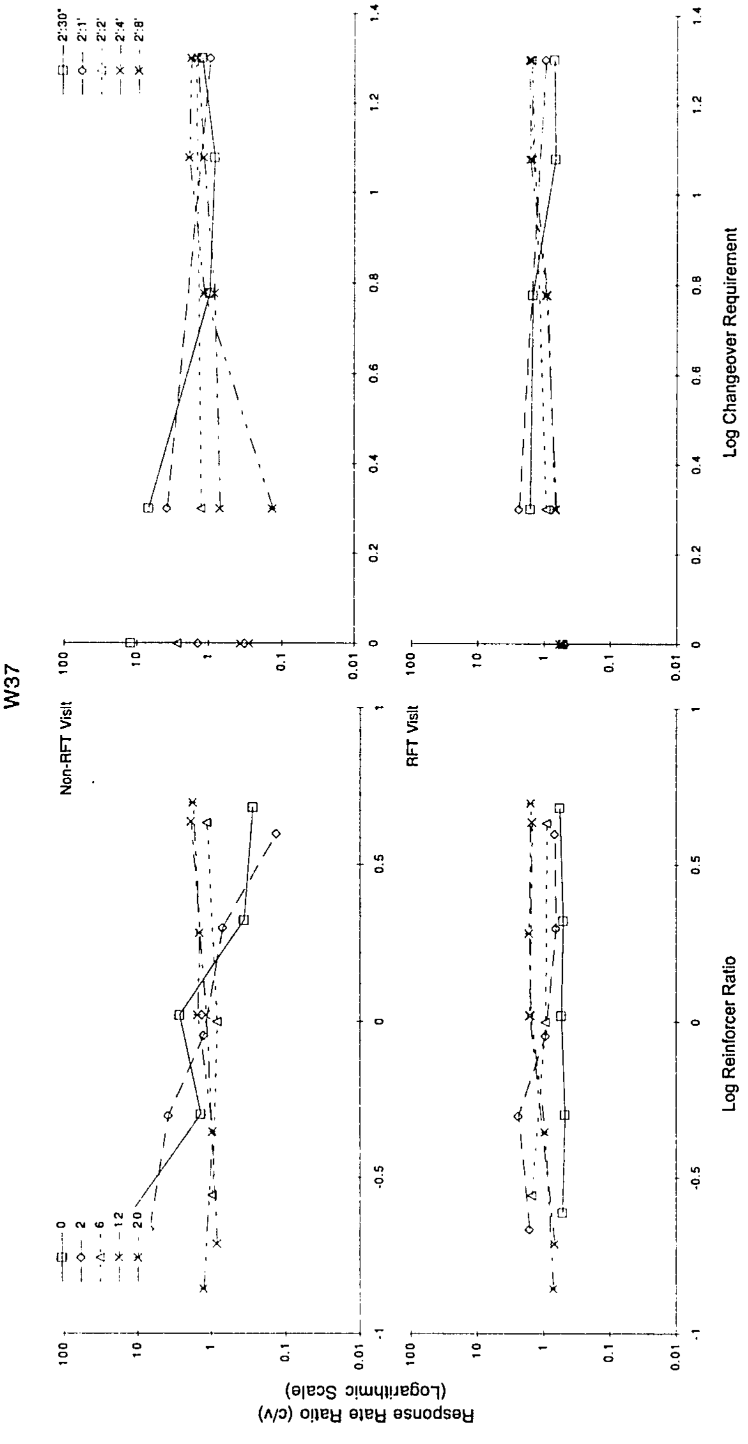
The following four figures present response rate ratio (c/v) as a function of log reinforcer ratio (c/v; left panels) and log changeover requirement (right panels). The top row of panels are measures from non-reinforced visits, while the bottom row are from reinforced visits. Legends indicate symbols for the other manipulated variable. Note logarithmic scale on y-axis.

W34


Non-RFT Visit
RFT Visit
0
2
6
12
20
2':30"
2':1'
2':2'
2':4'
2':8'
Response Rate Ratio (c/v)
(Logarithmic Scale)
100
10
1
0.1
0.01
-1
-0.5
0
0.5
1
0.2
0.4
0.6
0.8
1.2
1.4
Log Reinforcer Ratio
Log Changeover Requirement


W35
Non-RFT Visit
RFT Visit
Response Rate Ratio (c/v)
(Logarithmic Scale)
100
10
1
0.1
0.01
-1
-0.5
0
0.5
1
0
0.2
0.4
0.6
0.8
1
1.2
1.4
0
2
6
-12
-20
2:30"
2:1'
2:2'
2:4'
2:8'
Log Reinforcer Ratio
Log Changeover Requirement

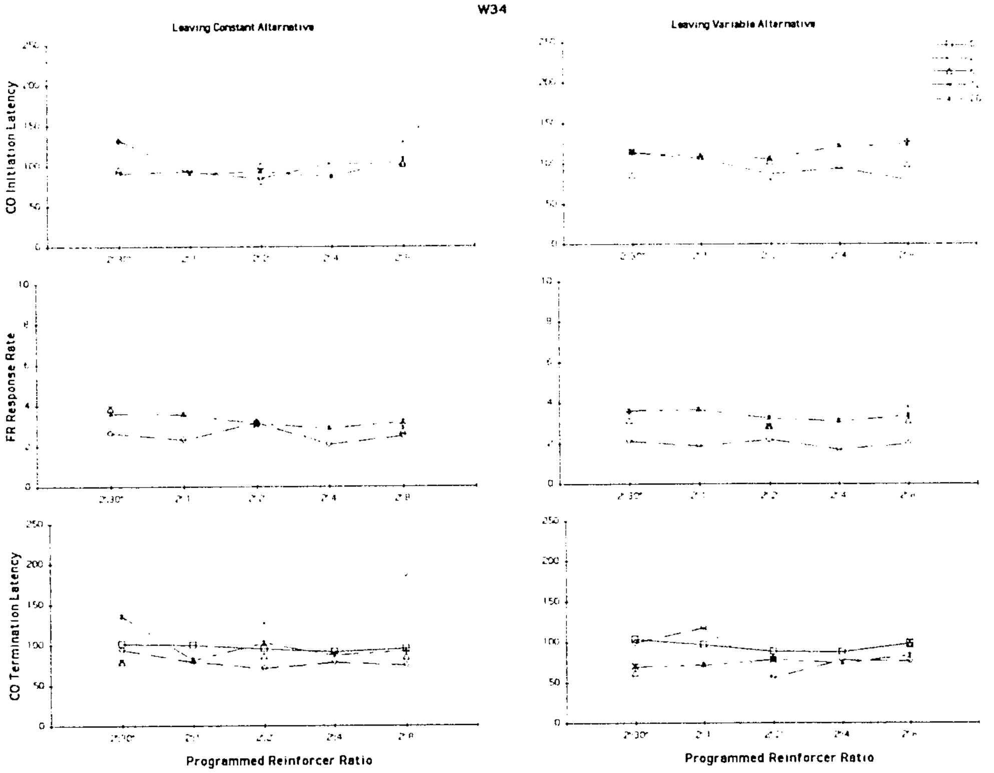

W36
Non-RFT Visits
RFT Visits
Response Rate Ratio (c/v)
(Logarithmic Scale)
Log Reinforcer Ratio
Log Changeover Requirement
0
2
6
12
20
2:30"
2:1"
2:2"
2:4"
2:8"
100
10
1
0.1
0.01
-1
-0.5
0
0.5
1
0.2
0.4
0.6
0.8
1.2
1.4

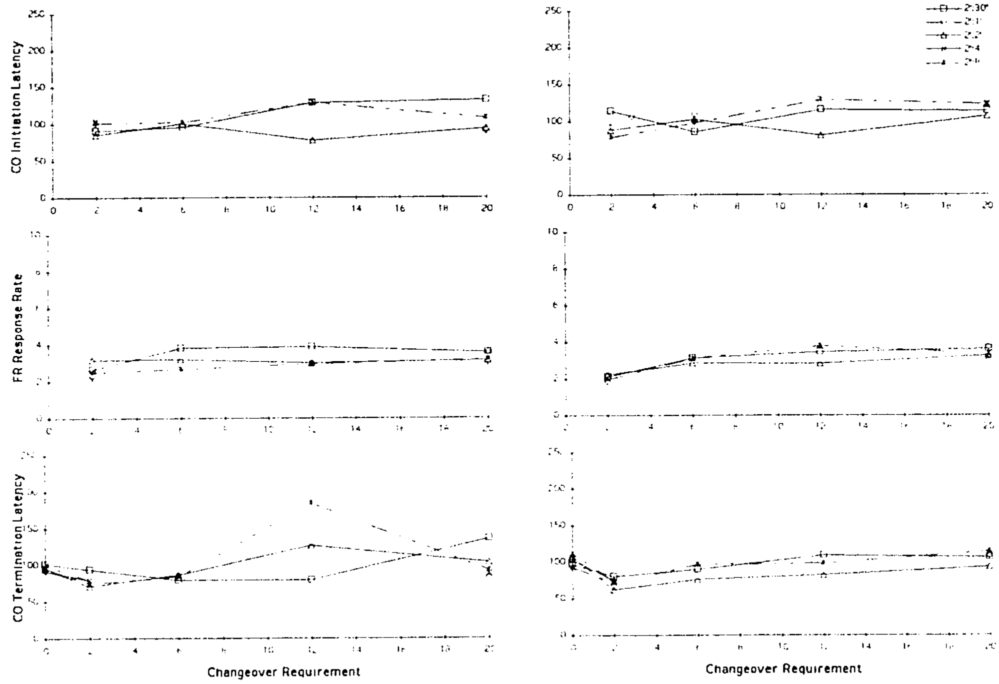

W37
Non-RFT Visit
RFT Visit
Response Rate Ratio (c/v)
(Logarithmic Scale)
100
10
1
0.1
0.01
-1
-0.5
0
0.5
1
0
0.2
0.4
0.6
0.8
1
1.2
1.4
0
2
6
12
20
2':30"
2':1'
2':2'
2':4'
2':8'
Log Reinforcer Ratio
Log Changeover Requirement

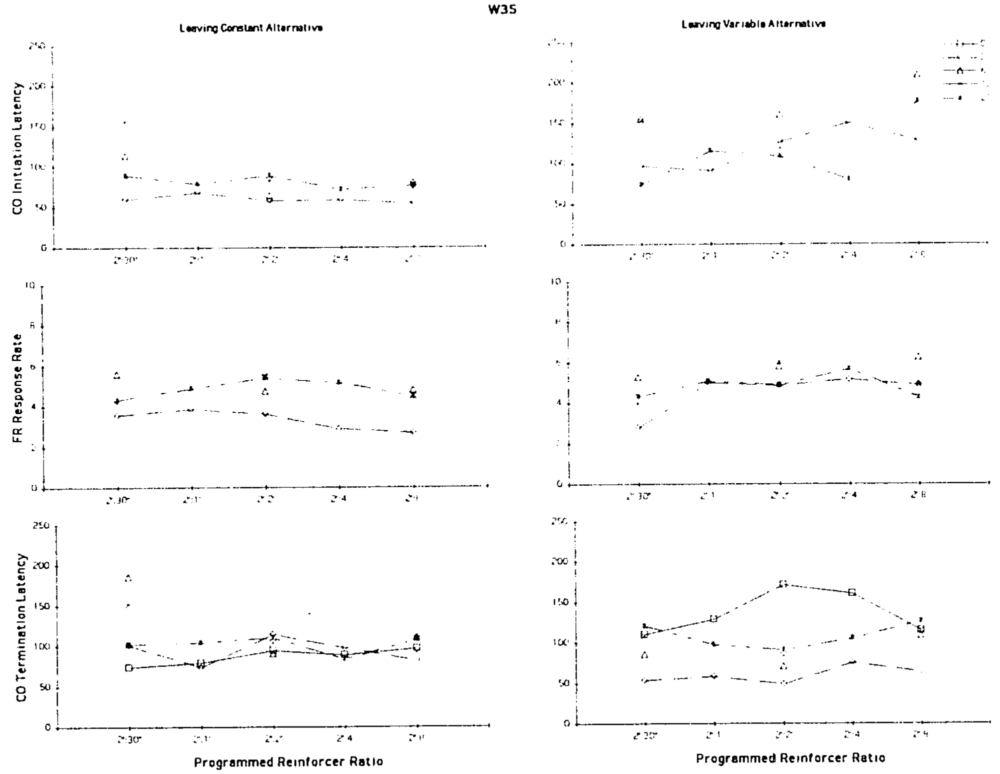
APPENDIX III

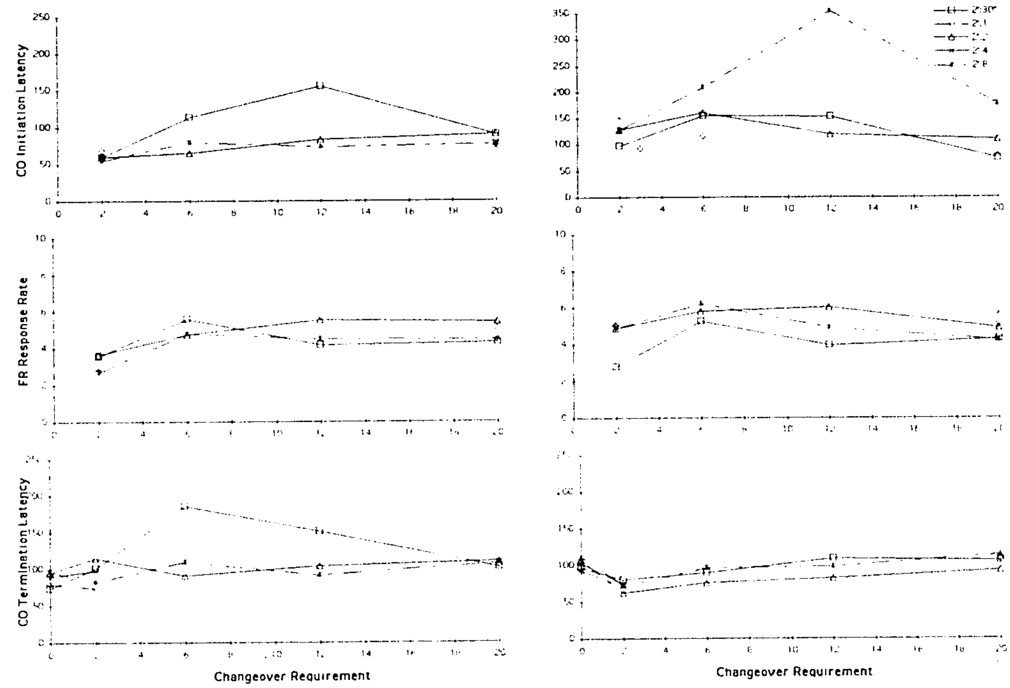
Local Analyses

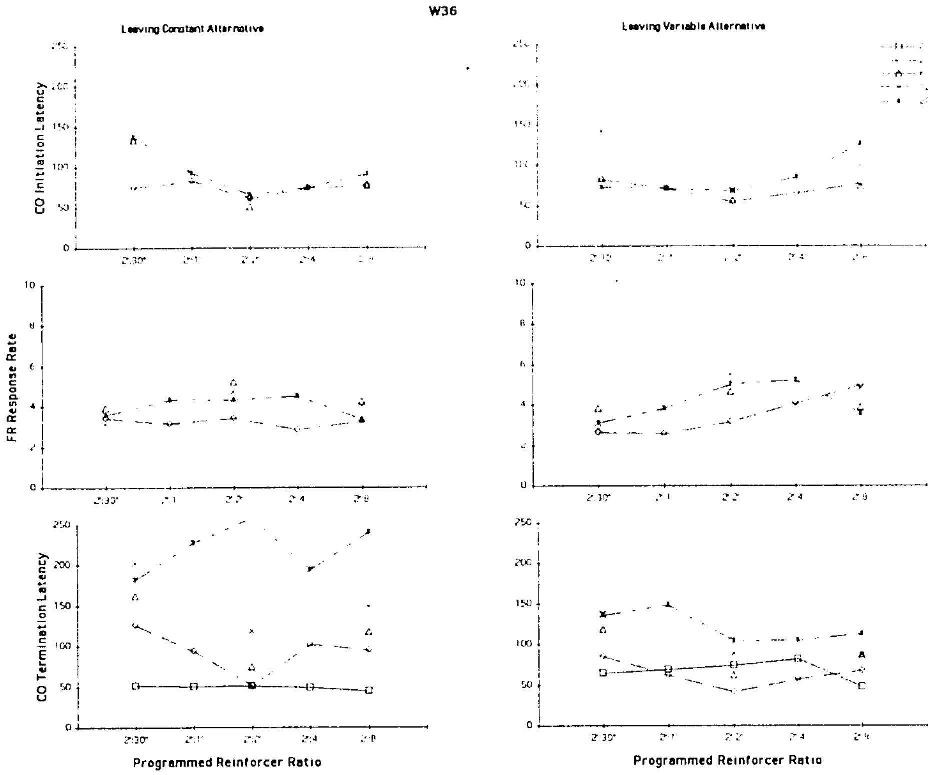
The following four figures present means of changeover measures as a function of programmed reinforcer ratio (top six panels) and changeover requirement (bottom six panels). Symbols of the other manipulated variable are noted in the legends. Left panels depict measures of leaving the constant alternative and going to the variable alternative, and right panels show measures for going back. The top row of each set of panels present changeover initiation latency (last peck active key to first peck changeover key), middle-row panels of each set present response rate on the changeover key, and bottom-row panels of each set present changeover termination latency (last peck changeover key to first peck new alternative). Pigeon number is noted on each figure.

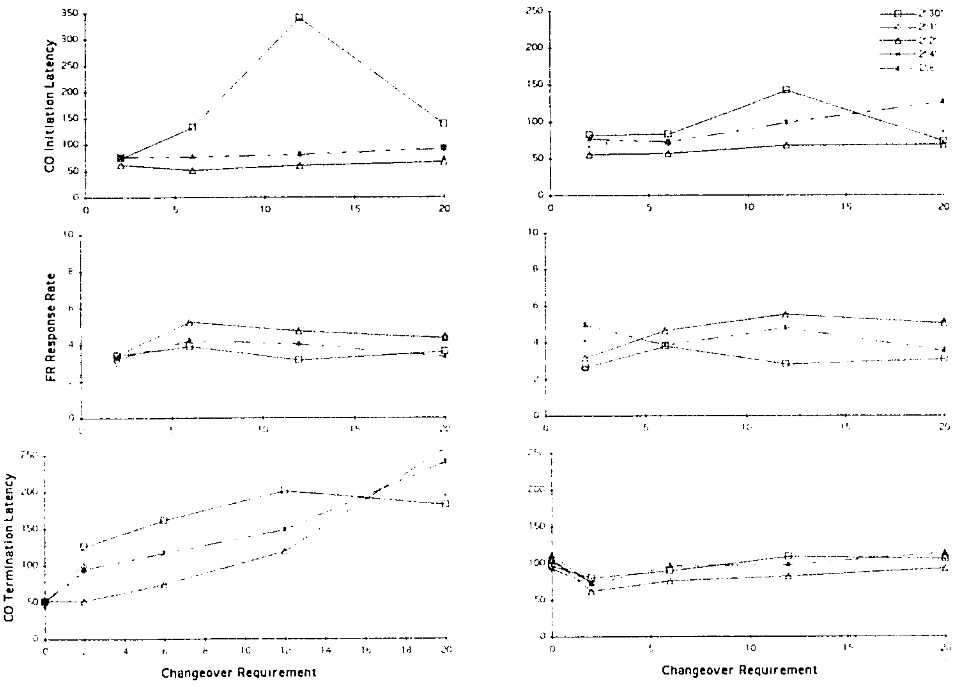

W34
Leaving Constant Alternative
Leaving Variable Alternative
CO Initiation Latency
FR Response Rate
CO Termination Latency
Programmed Reinforcer Ratio
Programmed Reinforcer Ratio
0
50
100
150
200
250
0
2
4
6
8
10
2:30"
2:1
2:2
2:4
2:8

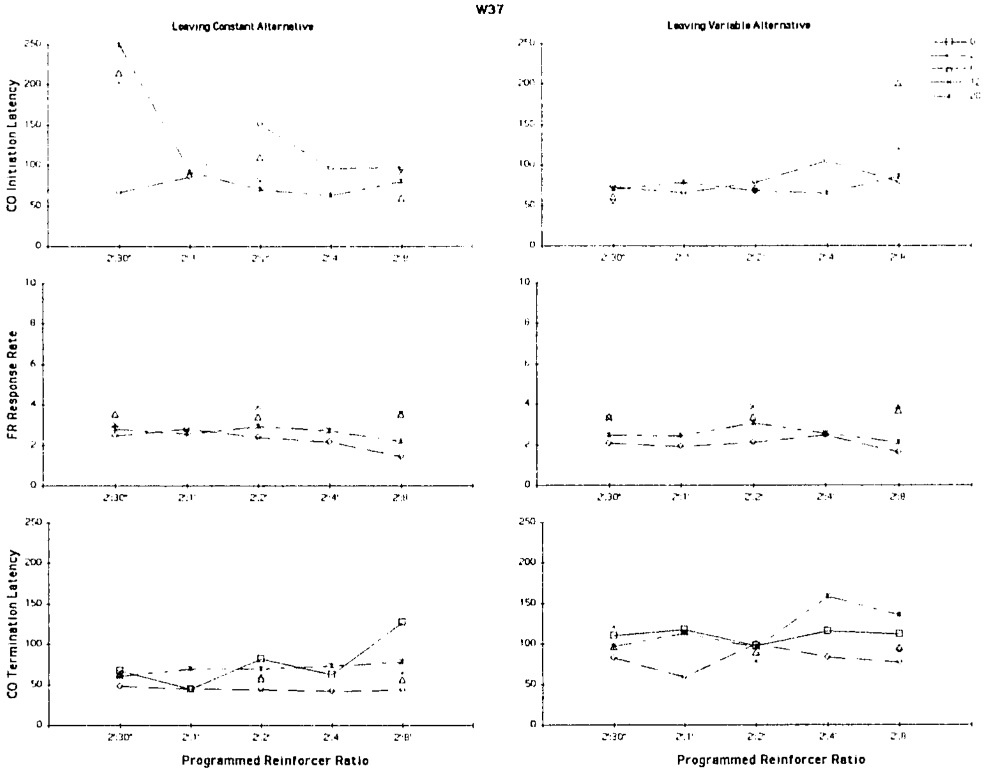

CO Initiation Latency
FR Response Rate
CO Termination Latency
Changeover Requirement
Changeover Requirement
2:30"
2:1
2:2
2:4
2:8
0
2
4
6
8
10
12
14
16
18
20
0
50
100
150
200
250

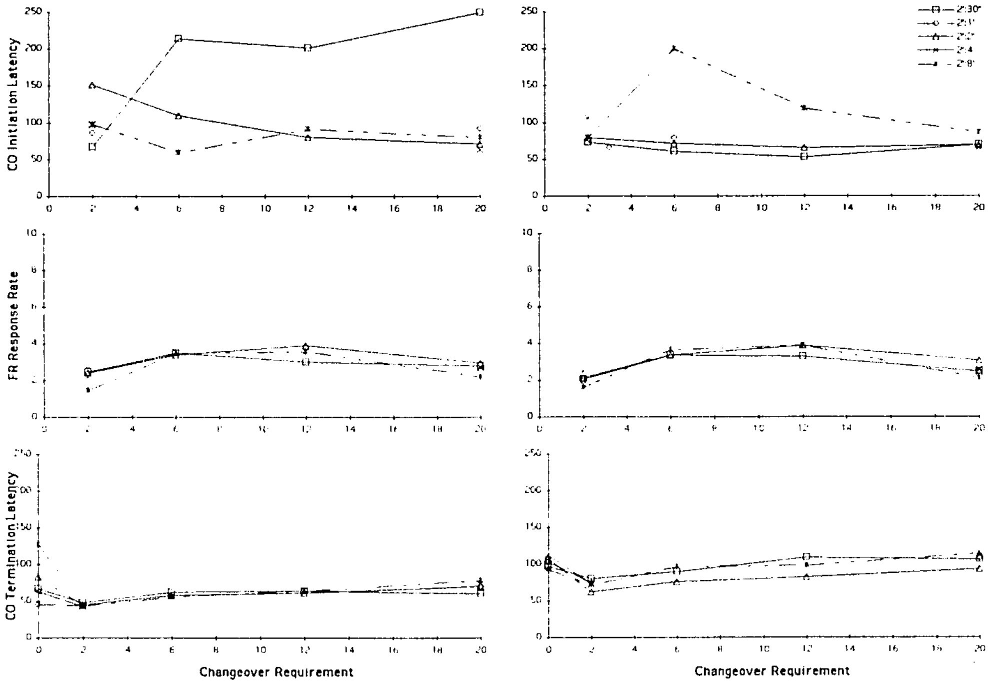

W35
Leaving Constant Alternative
Leaving Variable Alternative
CO Initiation Latency
FR Response Rate
CO Termination Latency
250
200
150
100
50
0
10
8
6
4
2
2:30*
2:1
2:2
2:4
2:8
Programmed Reinforcer Ratio
Programmed Reinforcer Ratio


2:30*
2:1
2:2
2:4
2:8
CO Initiation Latency
FR Response Rate
CO Termination Latency
350
300
250
200
150
100
50
0
10
8
6
4
2
0
2
4
6
8
10
12
14
16
18
20
Changeover Requirement
Changeover Requirement


W36
Leaving Constant Alternative
Leaving Variable Alternative
CO Initiation Latency
FR Response Rate
CO Termination Latency
0
50
100
150
200
250
2
4
6
8
10
2:30"
2:1
2:2
2:4
2:8
Programmed Reinforcer Ratio


2:30"
2:1
2:2
2:4
2:8
CO Initiation Latency
FR Response Rate
CO Termination Latency
0
50
100
150
200
250
300
350
2
4
6
8
10
0
5
10
15
20
12
14
16
18
Changeover Requirement


W37
Leaving Constant Alternative
Leaving Variable Alternative
0
2
6
12
20
CO Initiation Latency
FR Response Rate
CO Termination Latency
0
50
100
150
200
250
0
2
4
6
8
10
2:30"
2:1"
2:2"
2:4"
2:8"
Programmed Reinforcer Ratio
Programmed Reinforcer Ratio

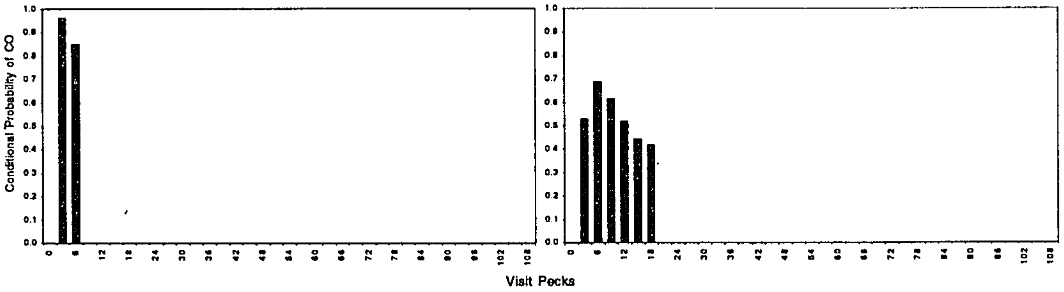

2:30"
2:1"
2:2"
2:4
2:8"
CO Initiation Latency
FR Response Rate
CO Termination Latency
0
50
100
150
200
250
0
2
4
6
8
10
0
2
4
6
8
10
12
14
16
18
20
Changeover Requirement
Changeover Requirement

The following 92 figures present the conditional probability of switching as a function of run length categorized by non-reinforced, single reinforcer, or multiple reinforcer (on some figures) visits (rows) and left (left panels) and right (right panels) alternatives. Pigeon number, changeover requirement (FRCOR) and reinforcement schedules are noted at the top of each figure. Figures are grouped by pigeon, then by changeover requirement and, within each changeover group, proceed from richer to learner overall reinforcer rate.

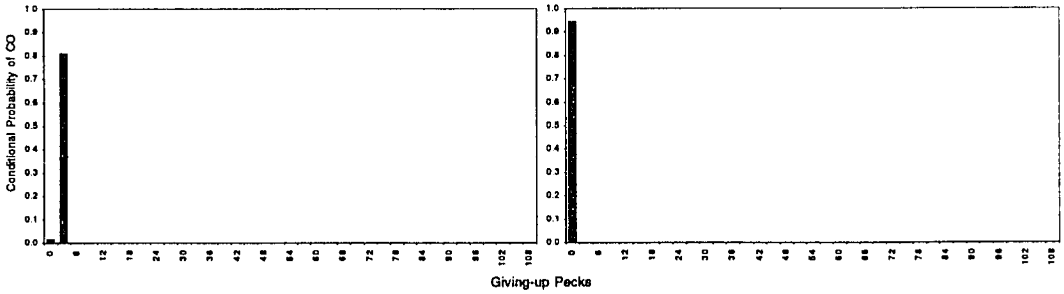
W34

Constant: 30/hr FRCO: 00 Variable: 120/hr

Non-reinforced visits

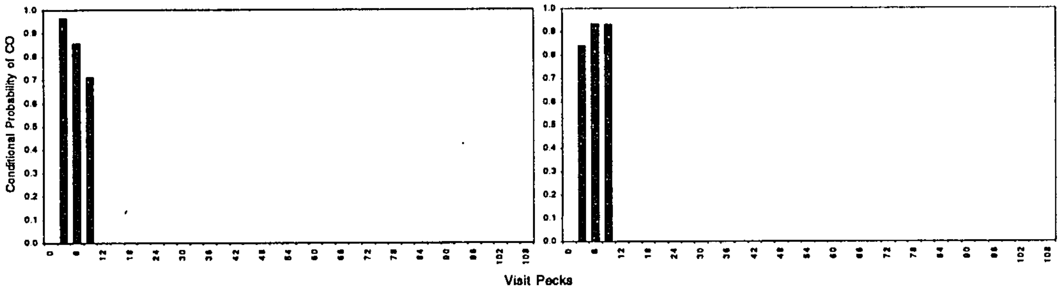


Single Reinforcer Visits

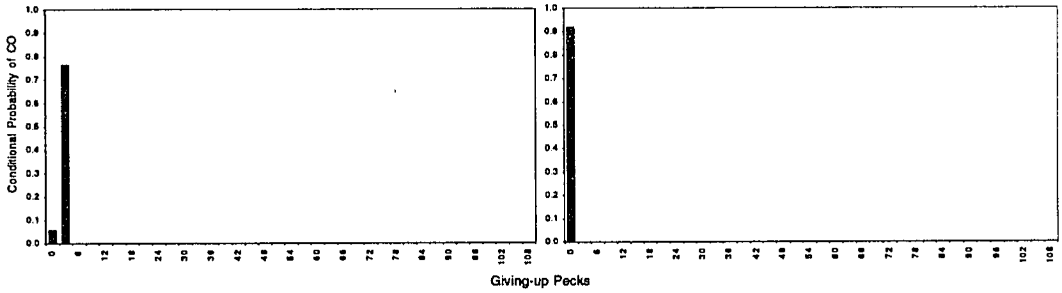


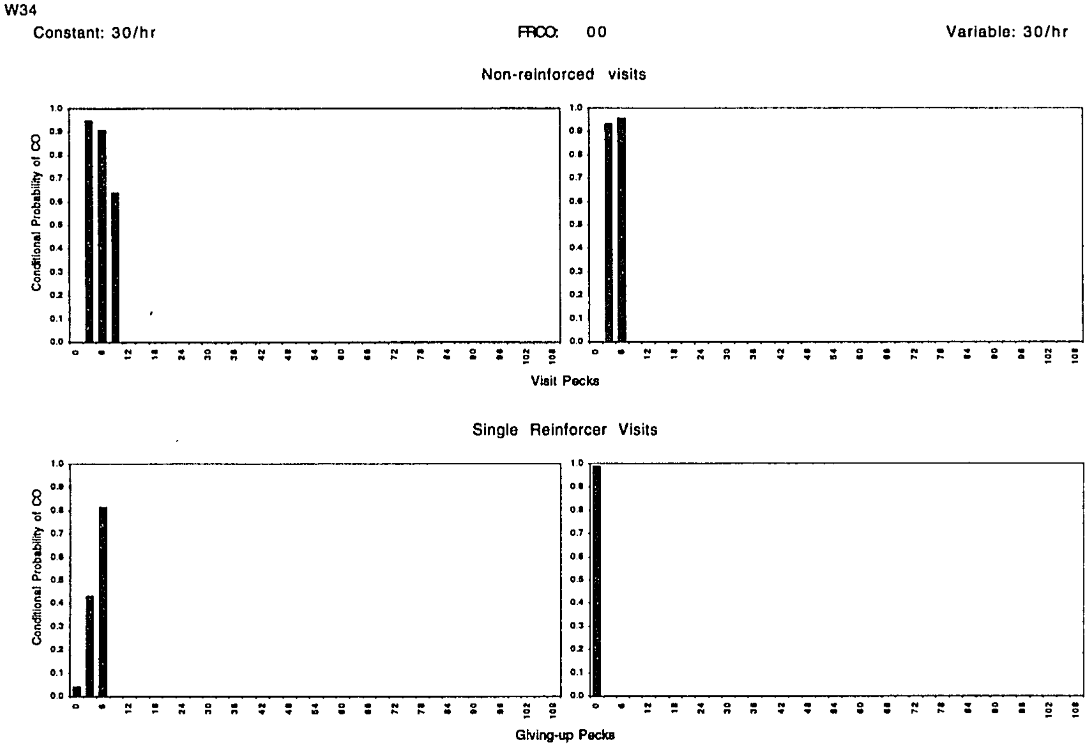
W34
Constant: 30/hr FRCO: 00 Variable: 60/hr

Non-reinforced visits



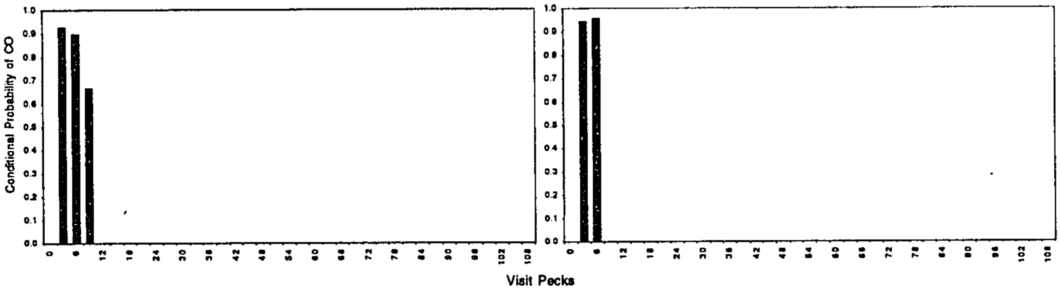
Single Reinforcer Visits



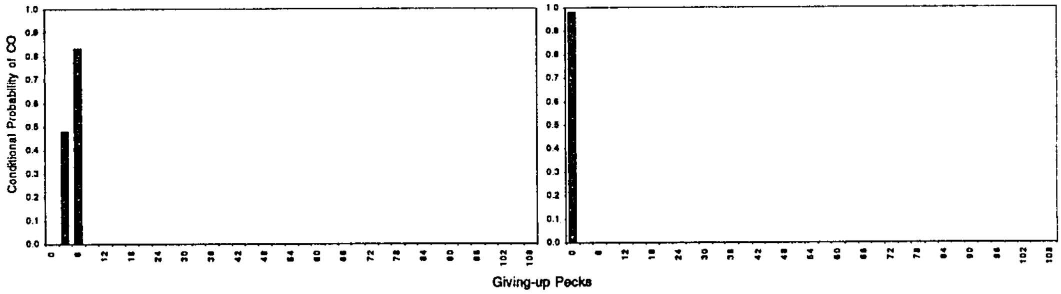

W34
Constant: 30/hr
FROO: 00
Variable: 30/hr
Non-reinforced visits
Conditional Probability of CO
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
6
12
18
24
30
36
42
48
54
60
66
72
78
84
90
96
102
108
Visit Pecks
Single Reinforcer Visits
Giving-up Pecks

W34
Constant: 30/hr FRCO: 00 R Variable: 30/hr

Non-reinforced visits

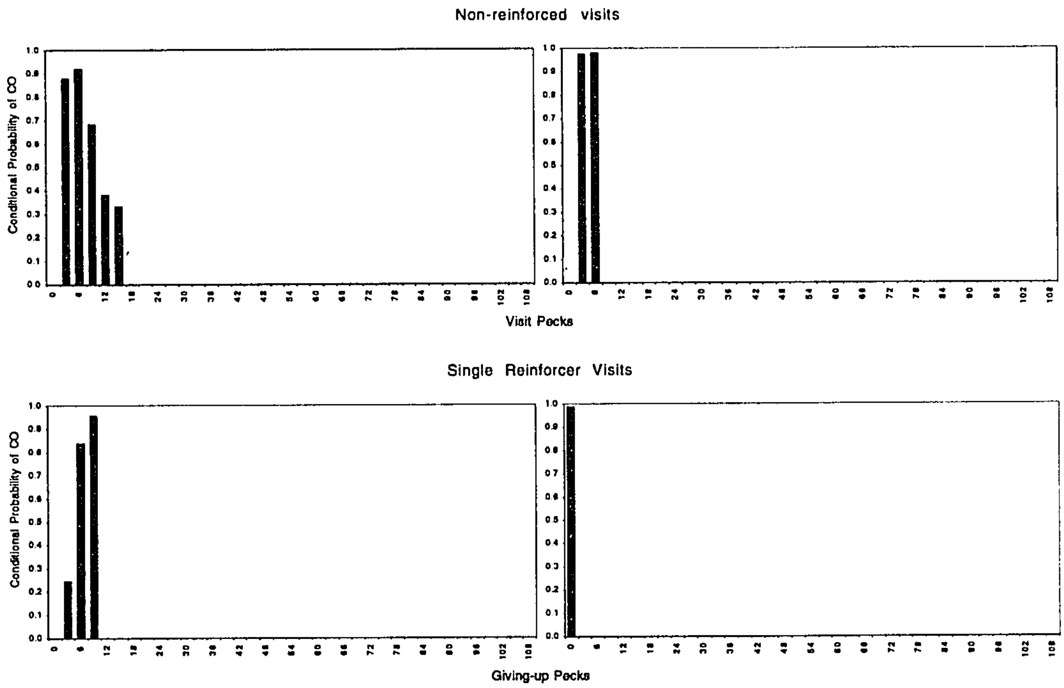


Single Reinforcer Visits



W34

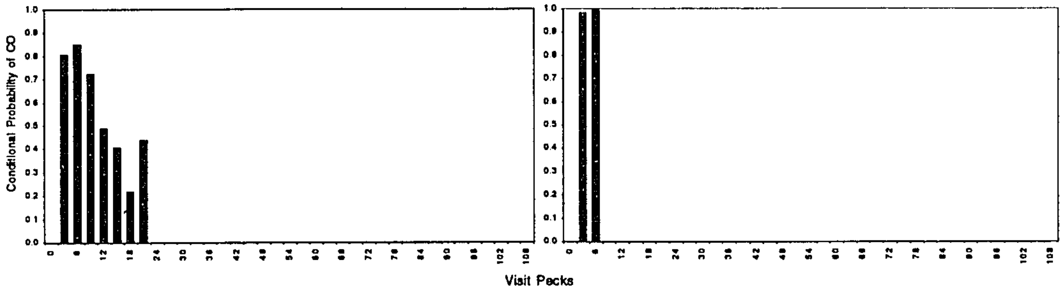
Constant: 30/hr FRCO: 00 Variable: 15/hr



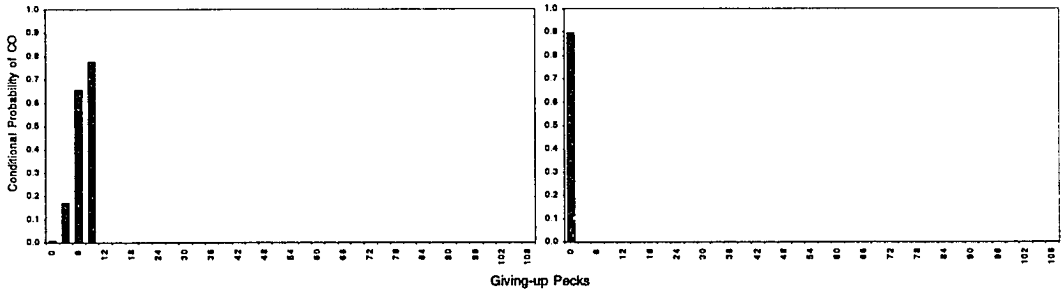
W34

Constant: 30/hr FRCO: 00 Variable: 7.5/hr

Non-reinforced visits

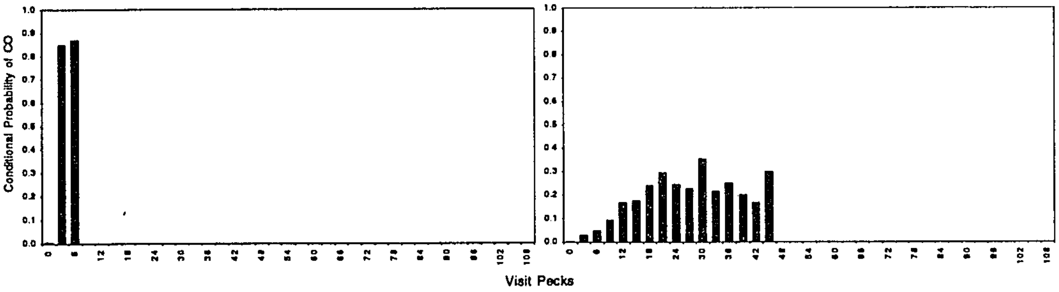


Single Reinforcer Visits

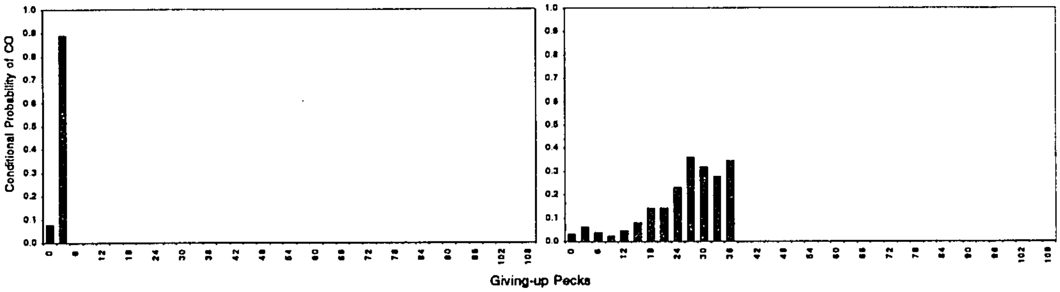


W34
Constant: 30/hr FROO: 02 Variable: 120/hr

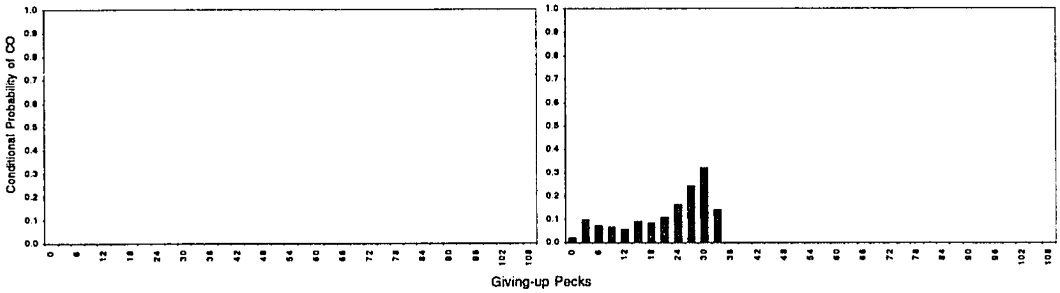
Non-reinforced visits



Single Reinforcer Visits

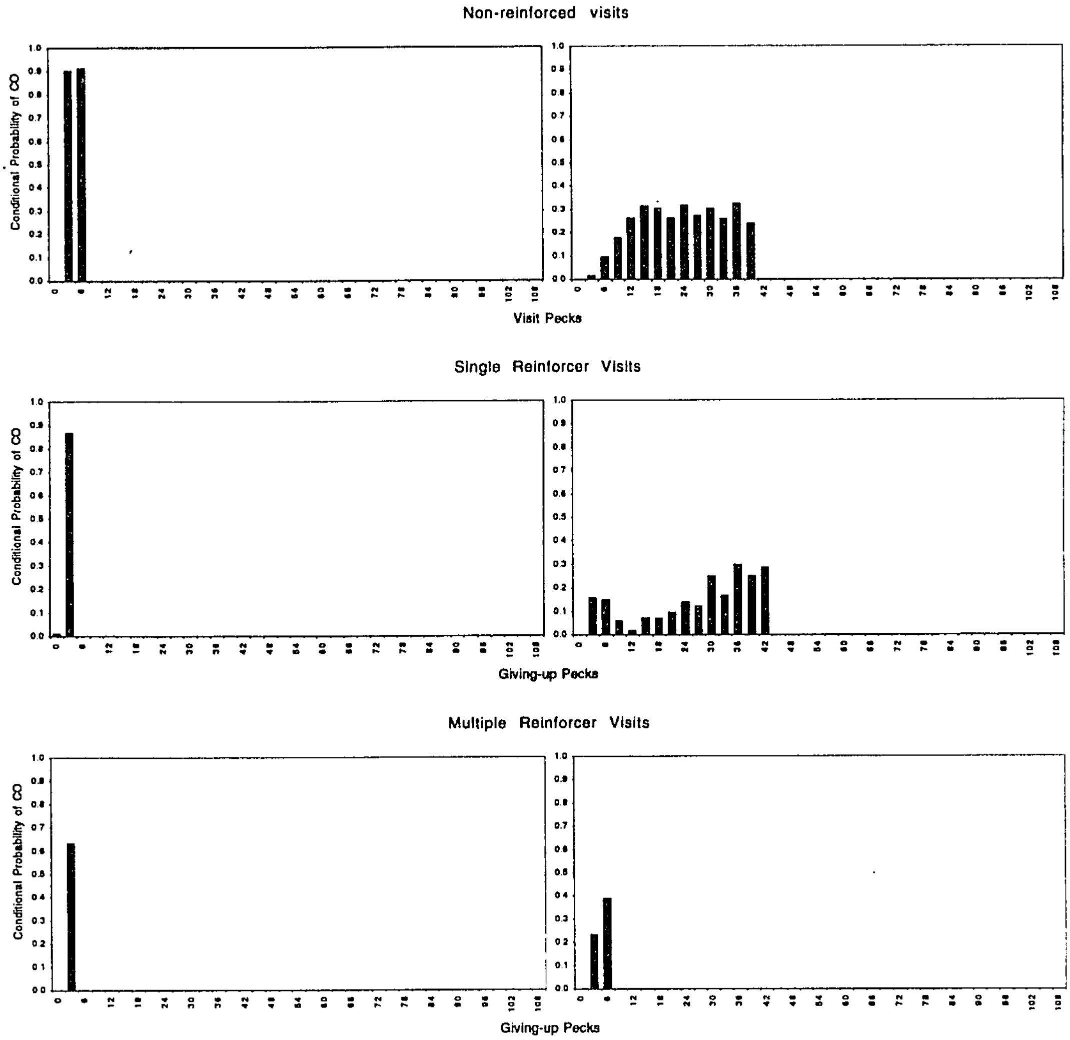


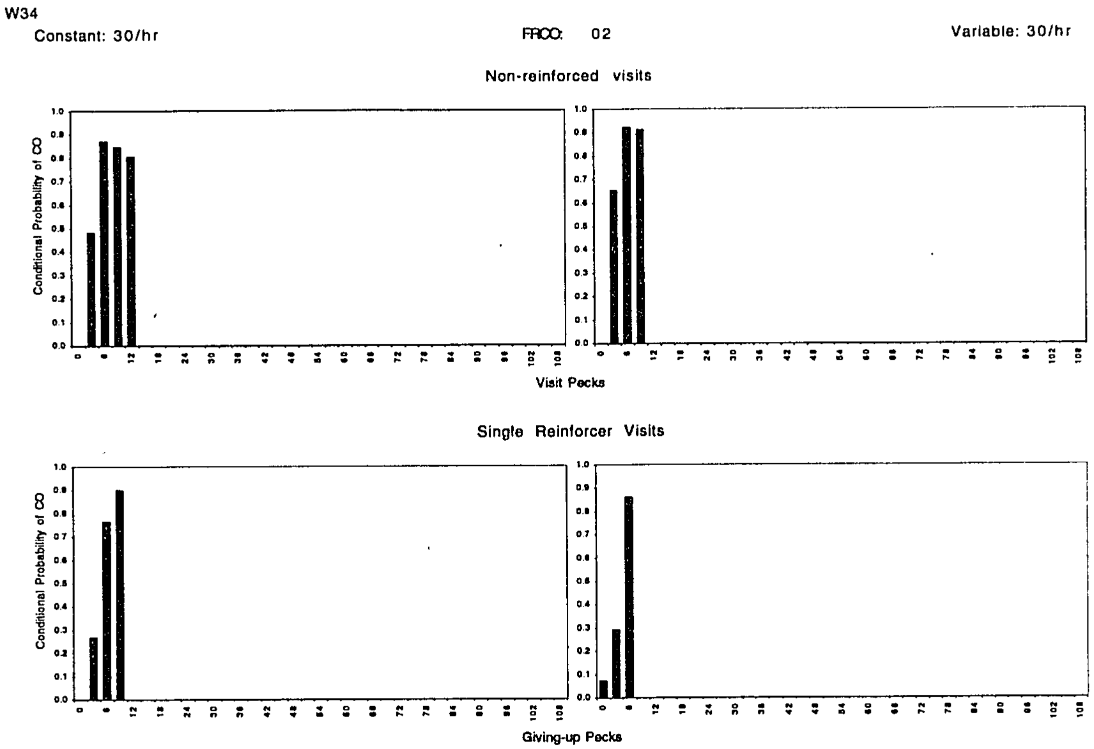
Multiple Reinforcer Visits

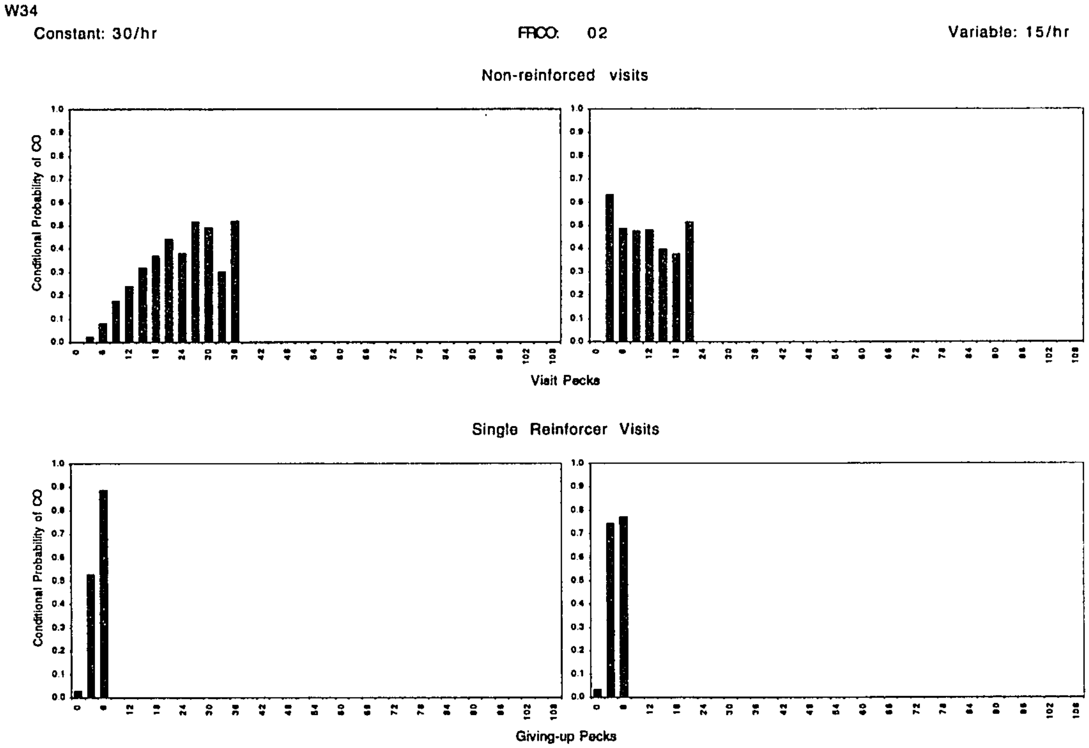


W34

Constant: 30/hr FRCO: 02 Variable: 60/hr



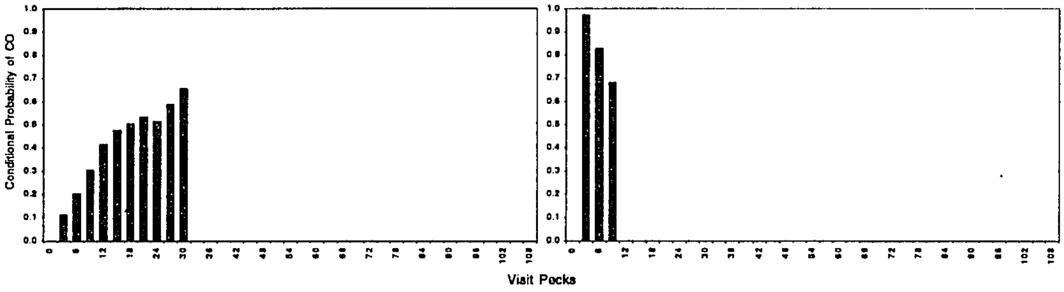

W34
Constant: 30/hr
FROO: 02
Variable: 30/hr
Non-reinforced visits
Conditional Probability of CO
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0 6 12 18 24 30 36 42 48 54 60 66 72 78 84 90 96 102 108
Visit Pecks
Single Reinforcer Visits
Conditional Probability of CO
Giving-up Pecks


W34
Constant: 30/hr
FRCO: 02
Variable: 15/hr
Non-reinforced visits
Conditional Probability of CO
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
6
12
18
24
30
36
42
48
54
60
66
72
78
84
90
96
102
108
Visit Pecks
Single Reinforcer Visits
Giving-up Pecks

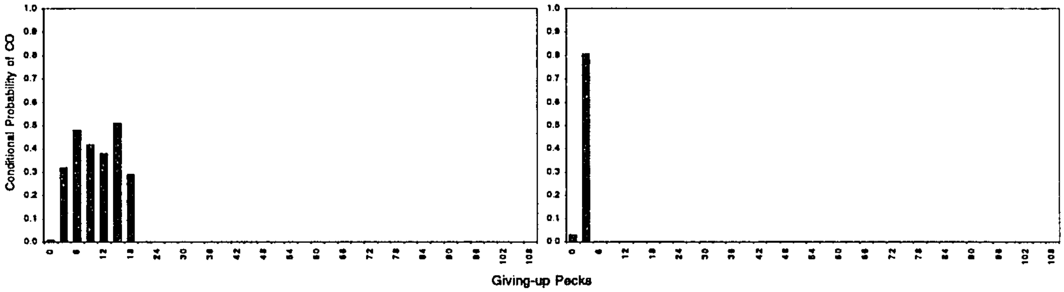
W34

Constant: 30/hr PROC: 02 Variable: 7.5/hr

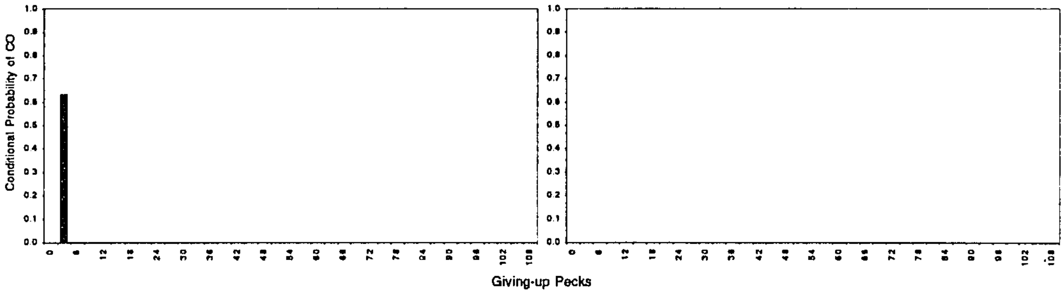
Non-reinforced visits



Single Reinforcer Visits



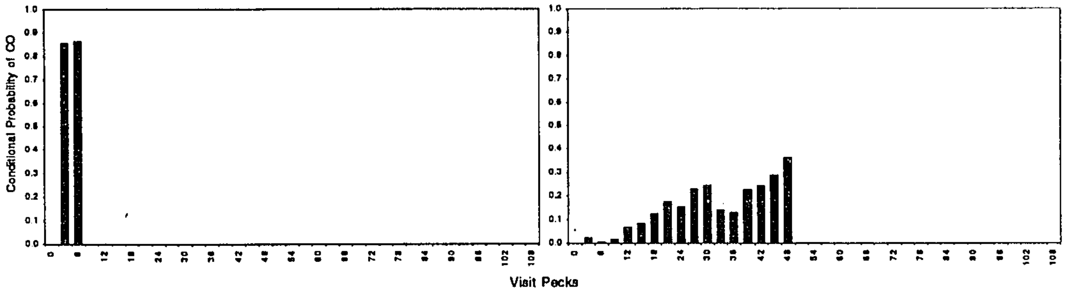
Multiple Reinforcer Visits



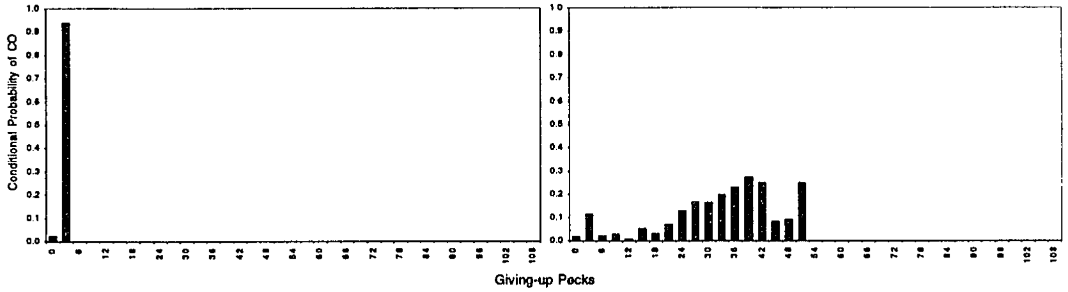
W34

Constant: 30/hr FRCO: 06 Variable: 120/hr

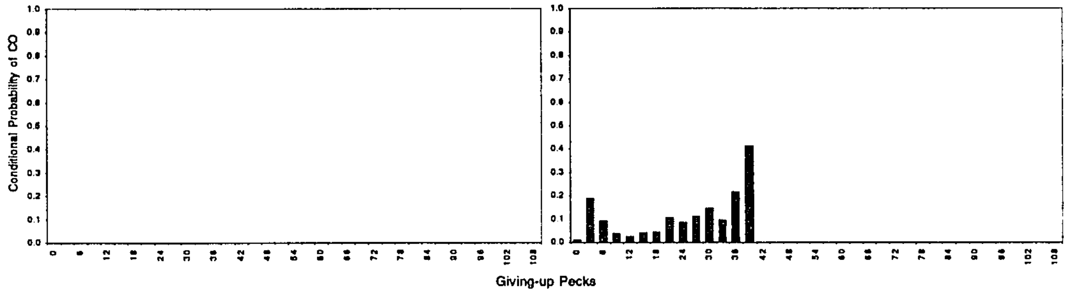
Non-reinforced visits



Single Reinforcer Visits



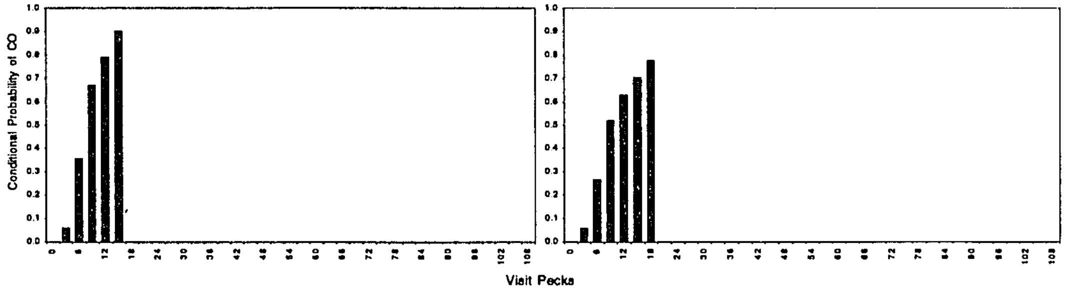
Multiple Reinforcer Visits



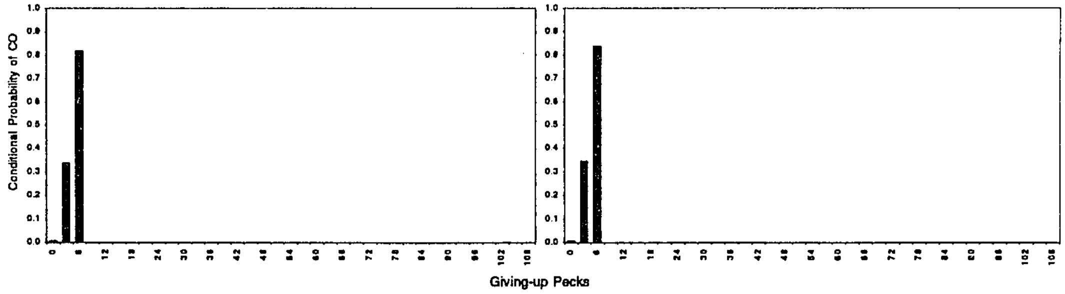
W34

Constant: 30/hr FROO: 06 Variable: 30/hr

Non-reinforced visits



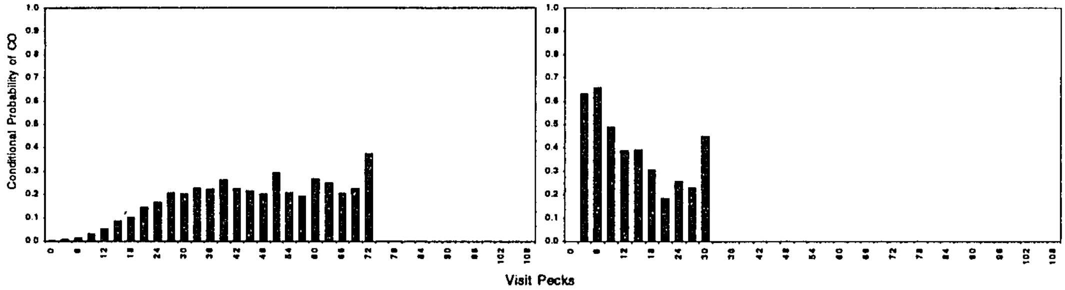
Single Reinforcer Visits



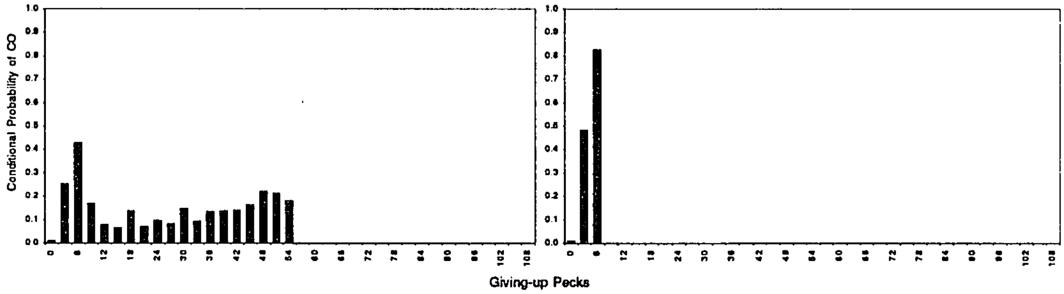
W34

Constant: 30/hr FRCO: 06 Variable: 7.5/hr

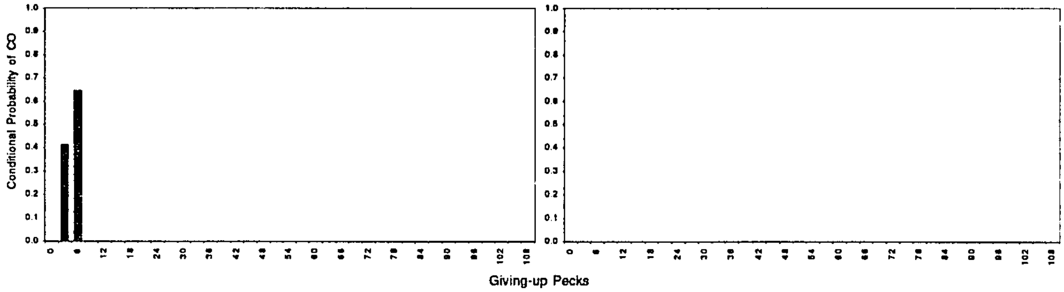
Non-reinforced visits



Single Reinforcer Visits



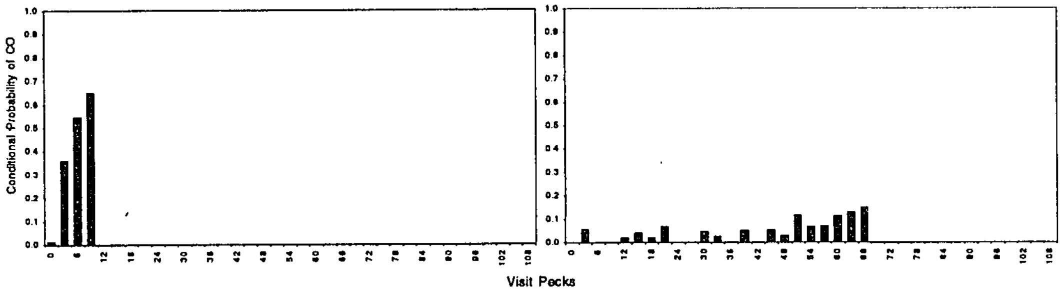
Multiple Reinforcer Visits



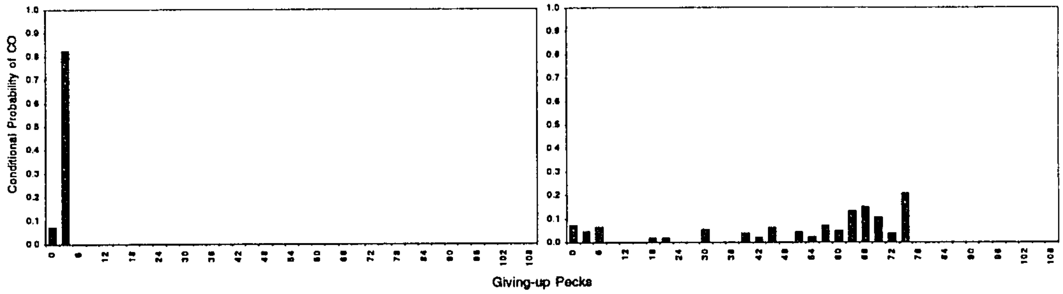
W34

Constant: 30/hr FRCO: 12 Variable: 120/hr

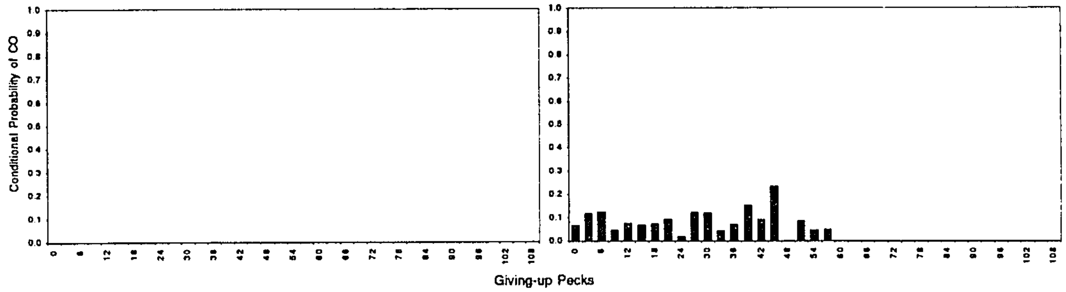
Non-reinforced visits



Single Reinforcer Visits

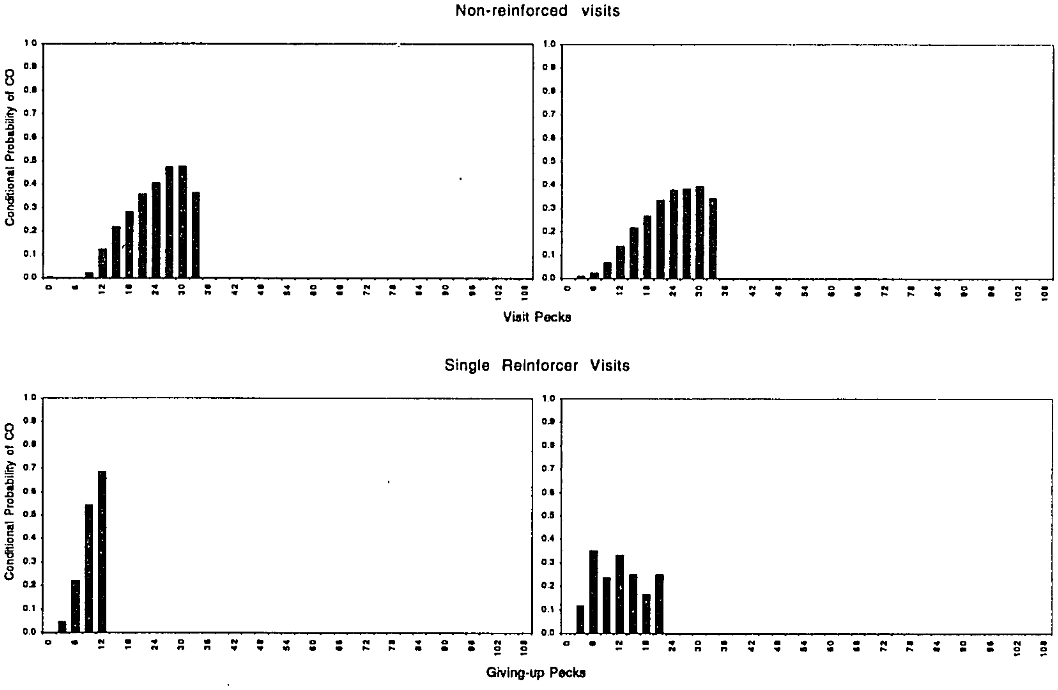


Multiple Reinforcer Visits



W34

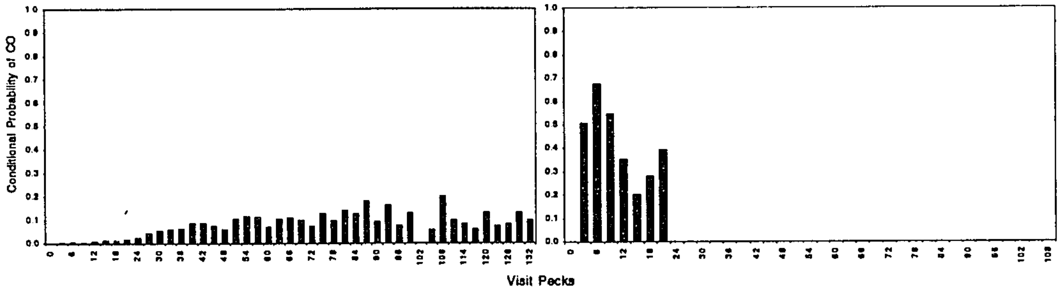
Constant: 30/hr FRCO: 12 Variable: 30/hr



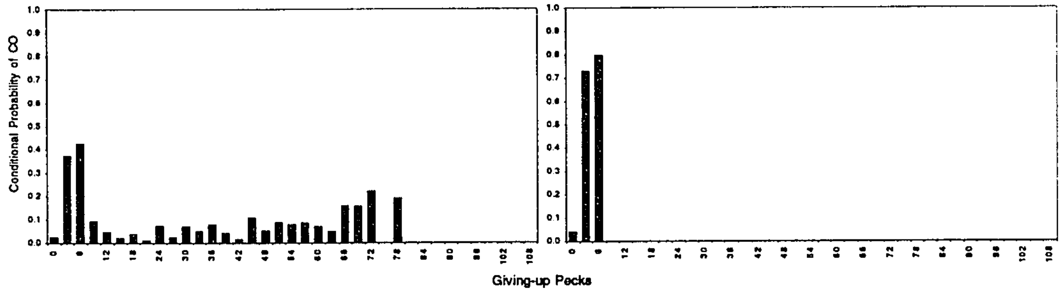
W34

Constant: 30/hr FRCO: 12 Variable: 7.5/hr

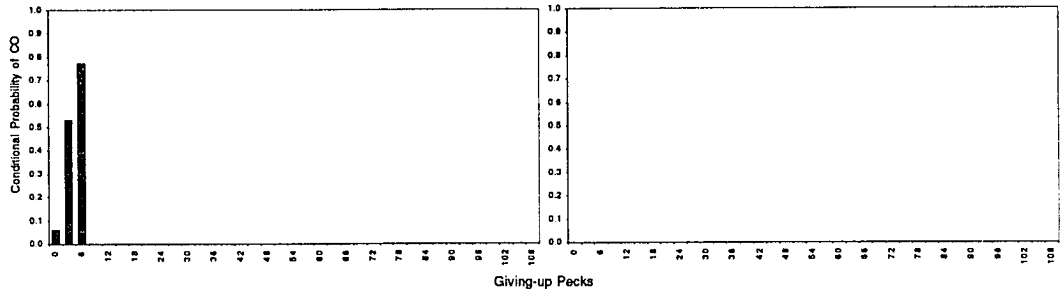
Non-reinforced visits



Single Reinforcer Visits

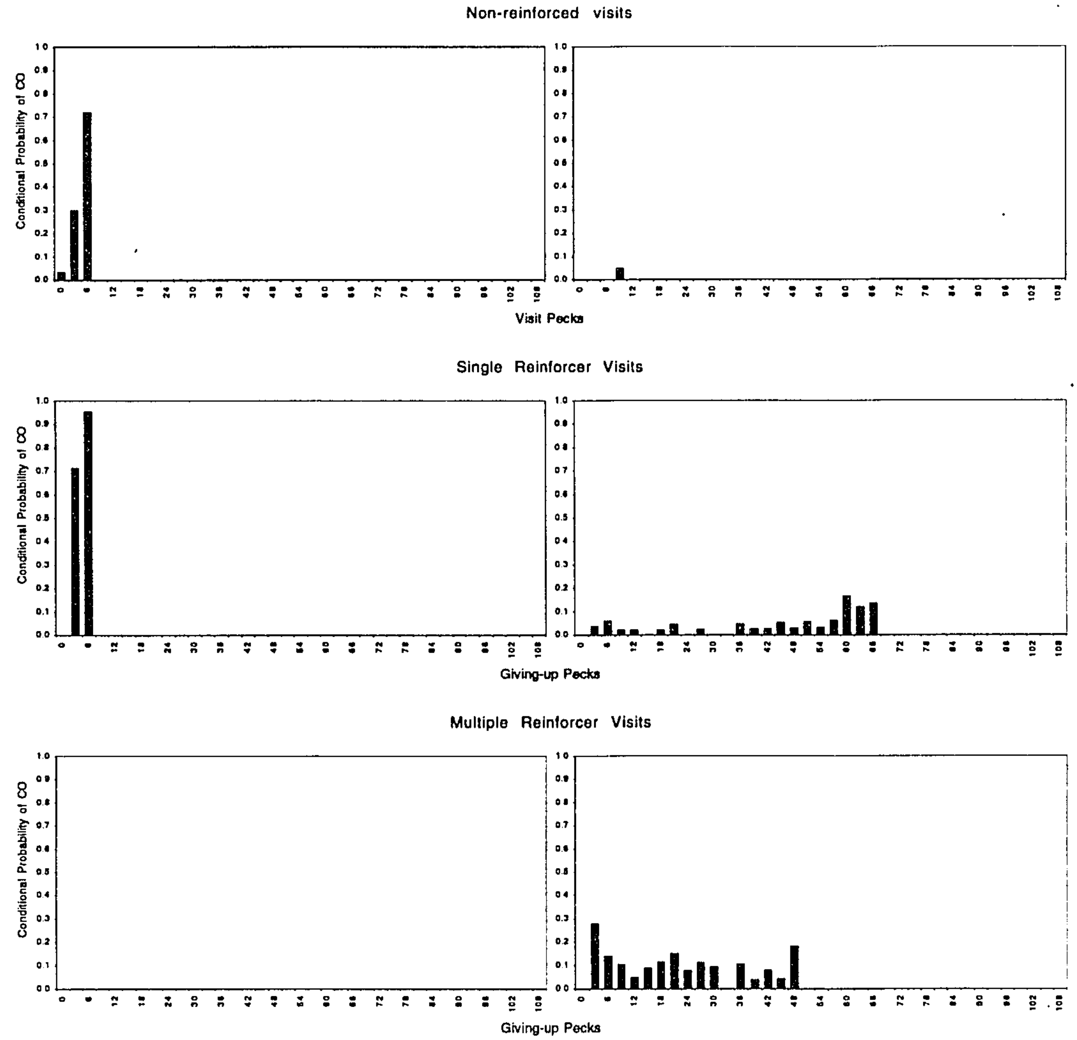


Multiple Reinforcer Visits



W34

Constant: 30/hr FRCO: 20 Variable: 120/hr

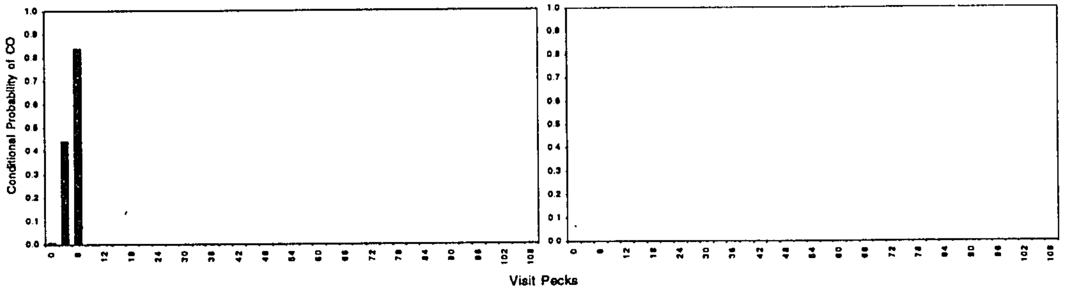


W34
Constant: 30/hr

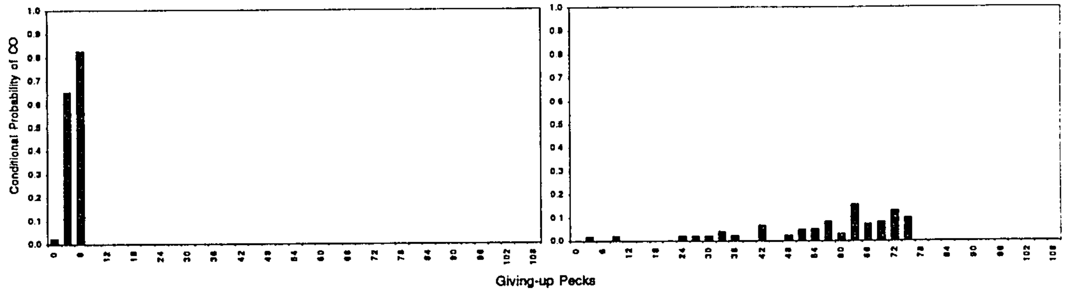
FRCO: 20 R

Variable: 120/hr

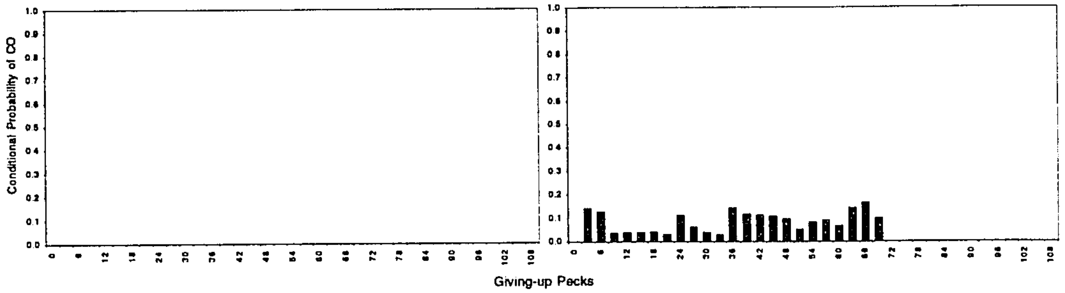
Non-reinforced visits



Single Reinforcer Visits



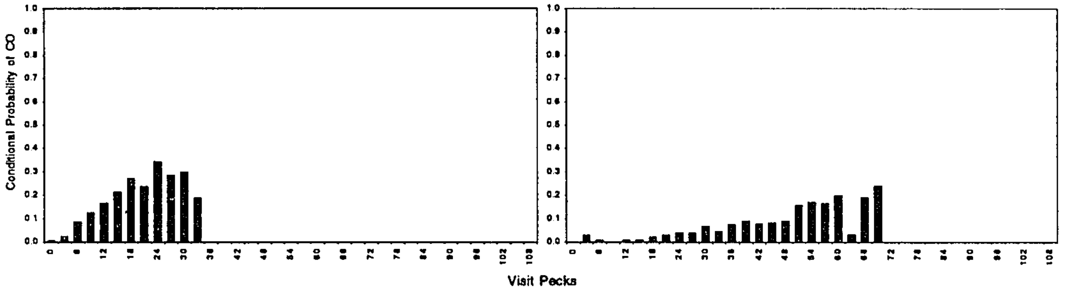
Multiple Reinforcer Visits



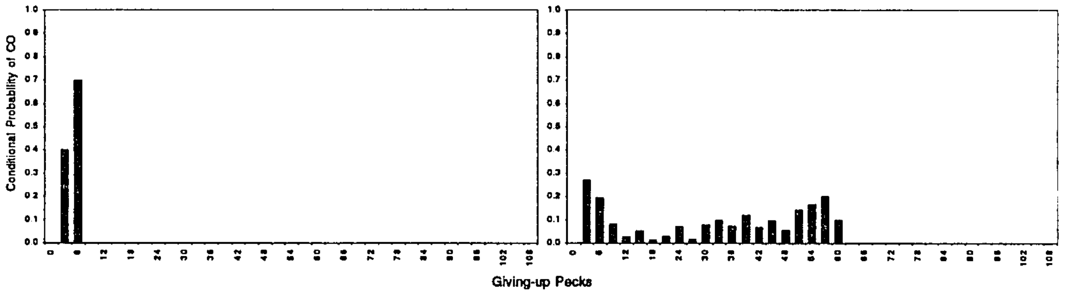
W34

Constant: 30/hr FRCO: 20 Variable: 60/hr

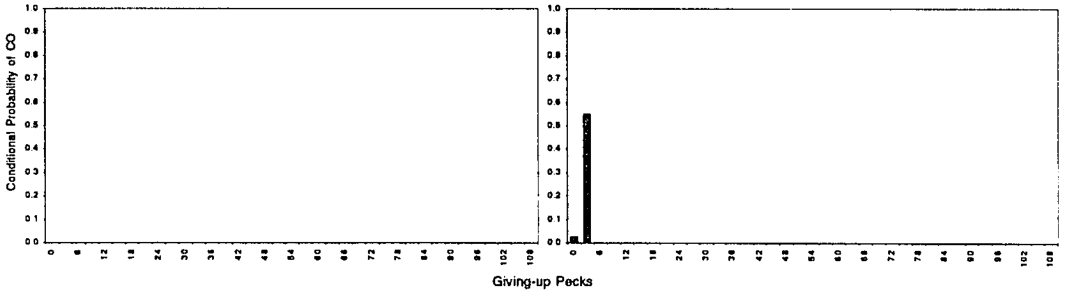
Non-reinforced visits

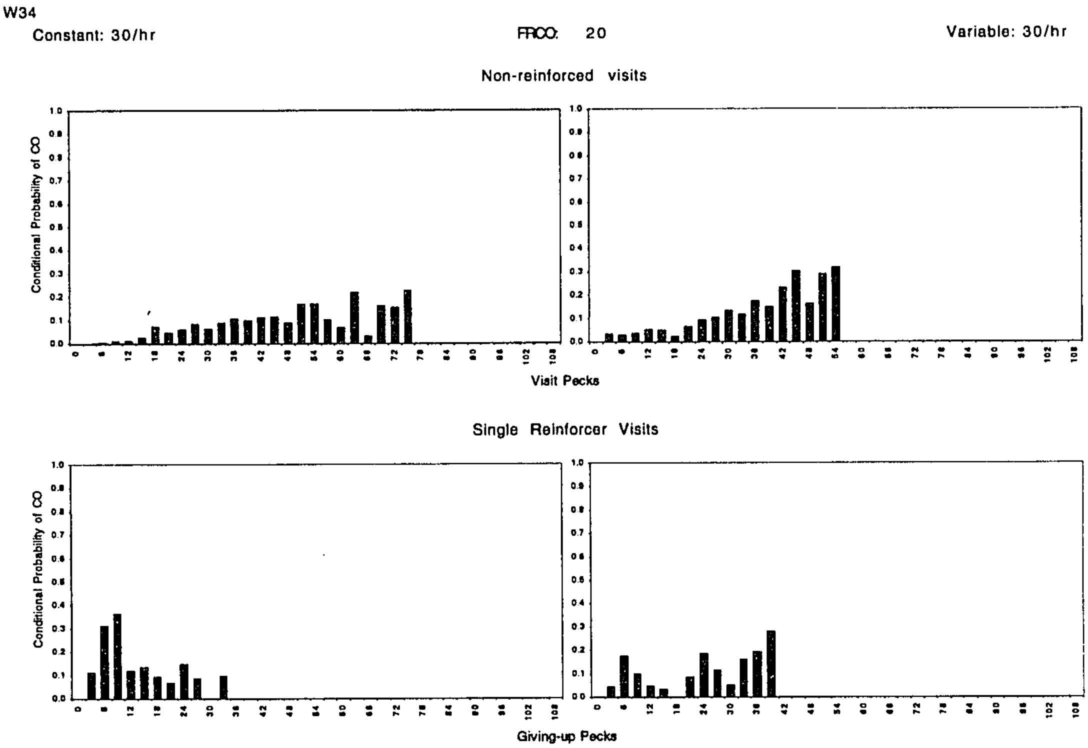


Single Reinforcer Visits



Multiple Reinforcer Visits

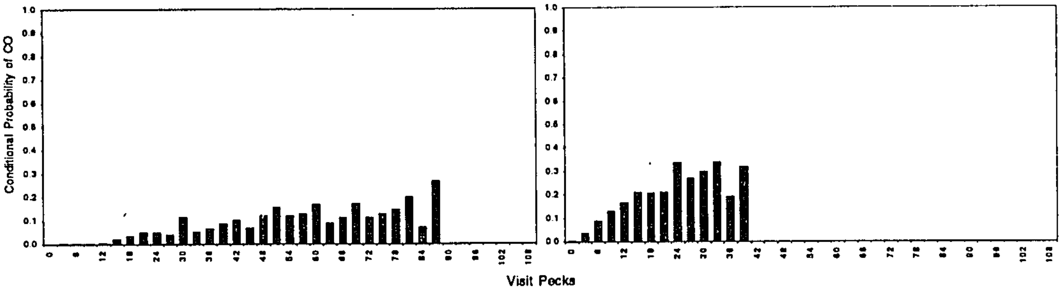



W34
Constant: 30/hr
FRCO: 20
Variable: 30/hr
Non-reinforced visits
Conditional Probability of CO
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
6
12
18
24
30
36
42
48
54
60
66
72
78
84
90
96
102
108
Visit Pecks
Single Reinforcer Visits
Conditional Probability of CO
Giving-up Pecks

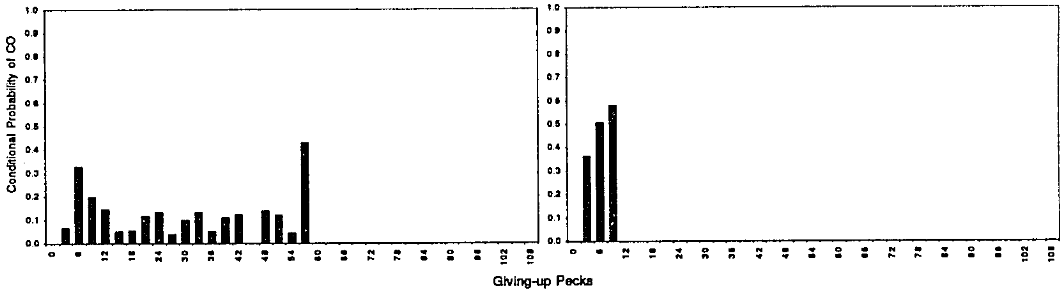
W34

Constant: 30/hr FRCO: 20 Variable: 15/hr

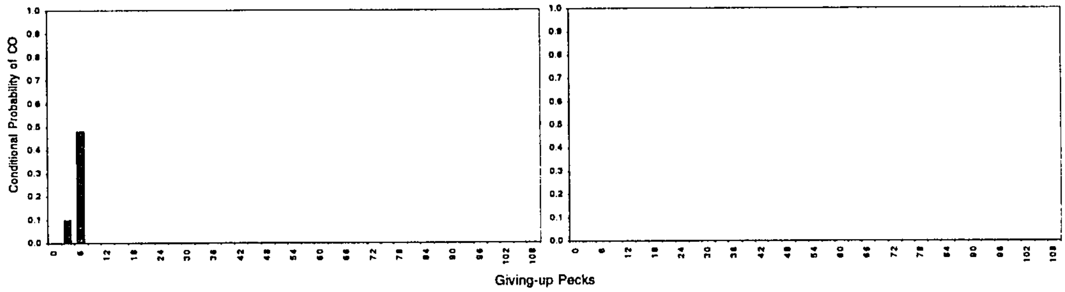
Non-reinforced visits



Single Reinforcer Visits



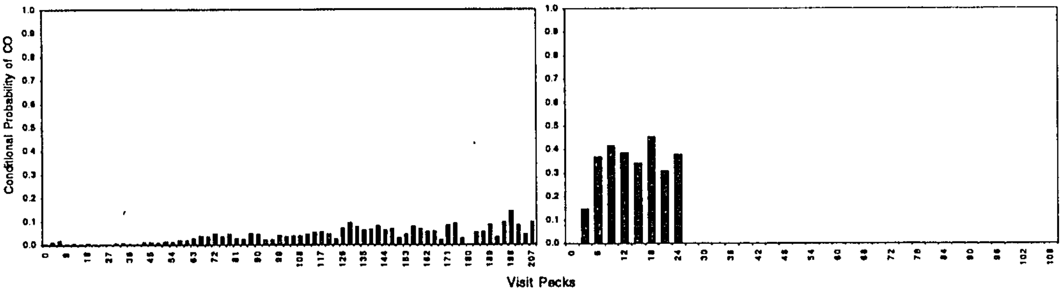
Multiple Reinforcer Visits



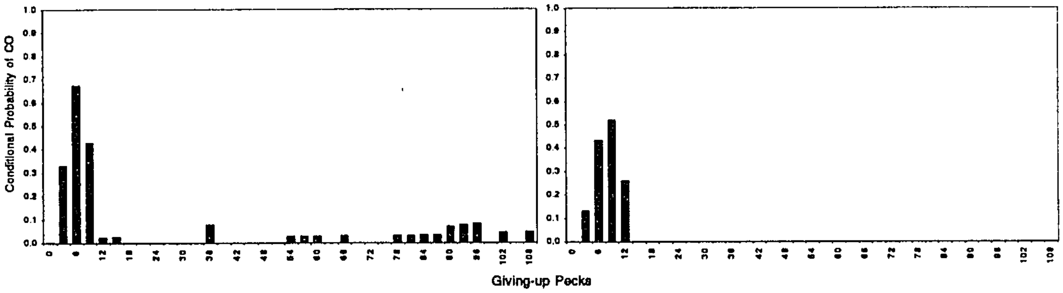
W34

Constant: 30/hr FRCO: 20 Variable: 7.5/hr

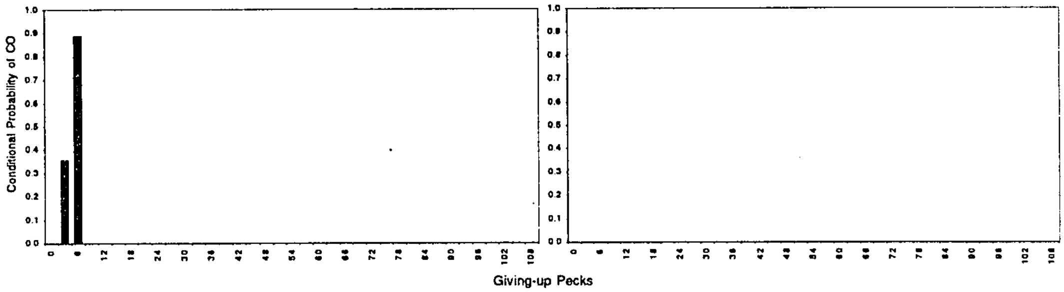
Non-reinforced visits



Single Reinforcer Visits

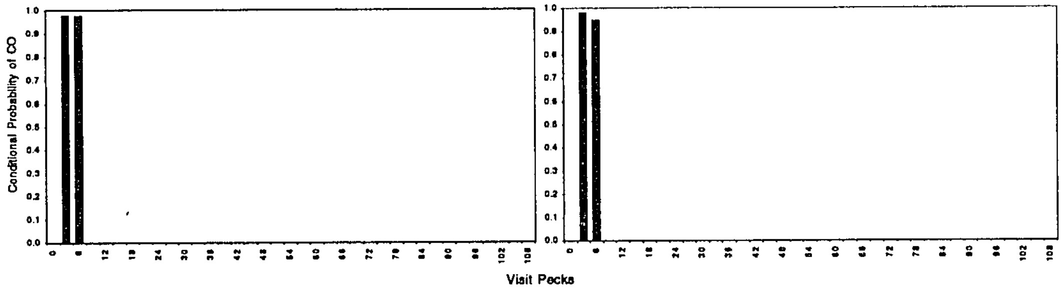


Multiple Reinforcer Visits

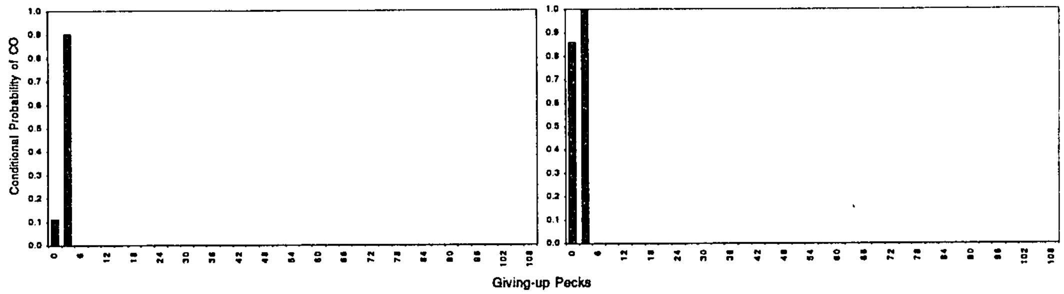


W35
Constant: 30/hr FRCO: 00 Variable: 120/hr

Non-reinforced visits



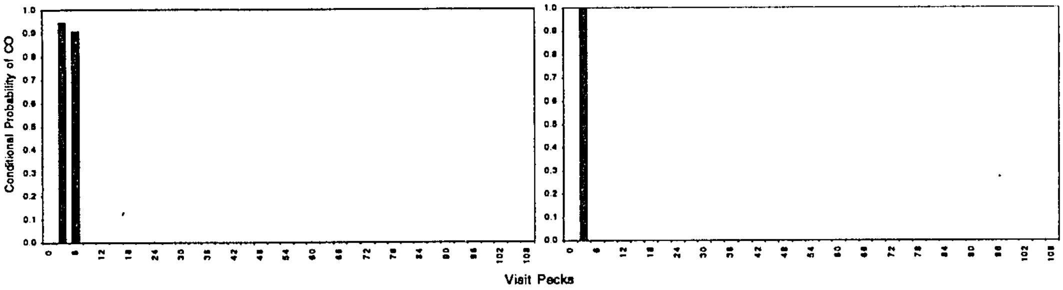
Single Reinforcer Visits



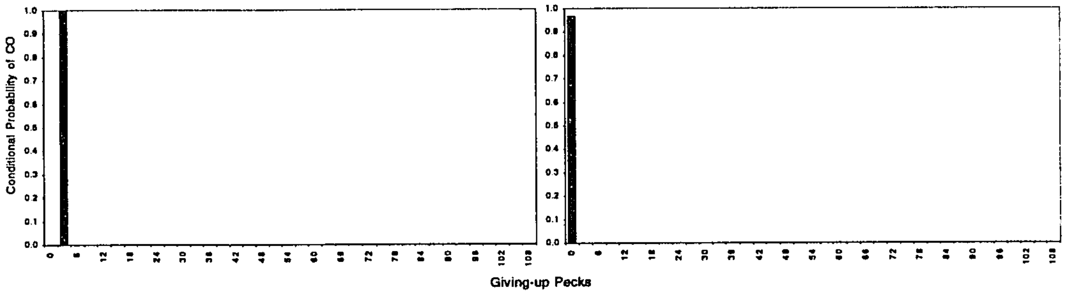
W35

Constant: 30/hr FRCO: 00 Variable: 60/hr

Non-reinforced visits



Single Reinforcer Visits



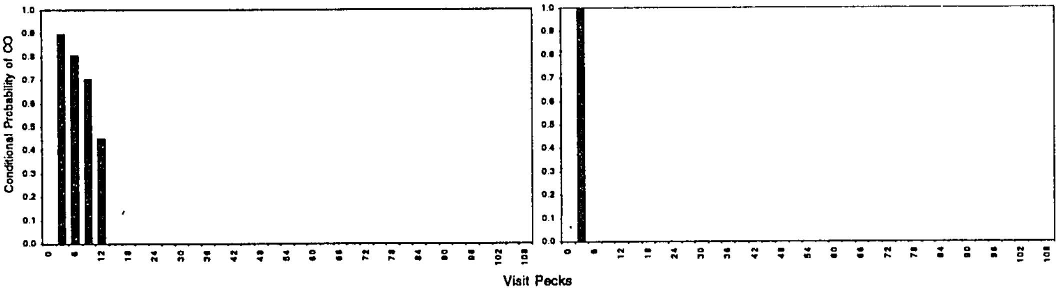
W35

Constant: 30/hr

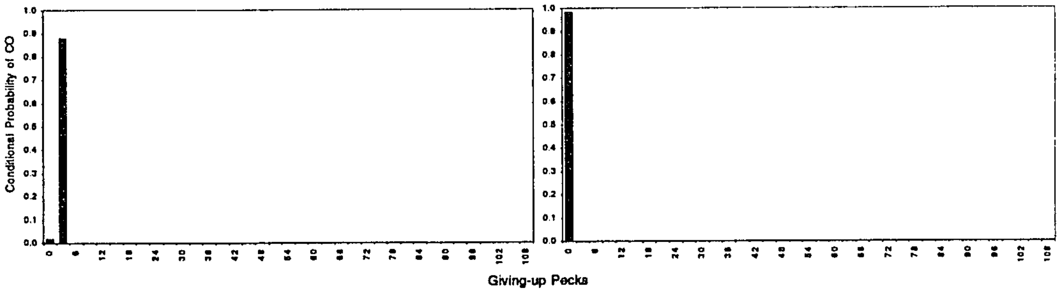
FRCO: 00

Variable: 30/hr

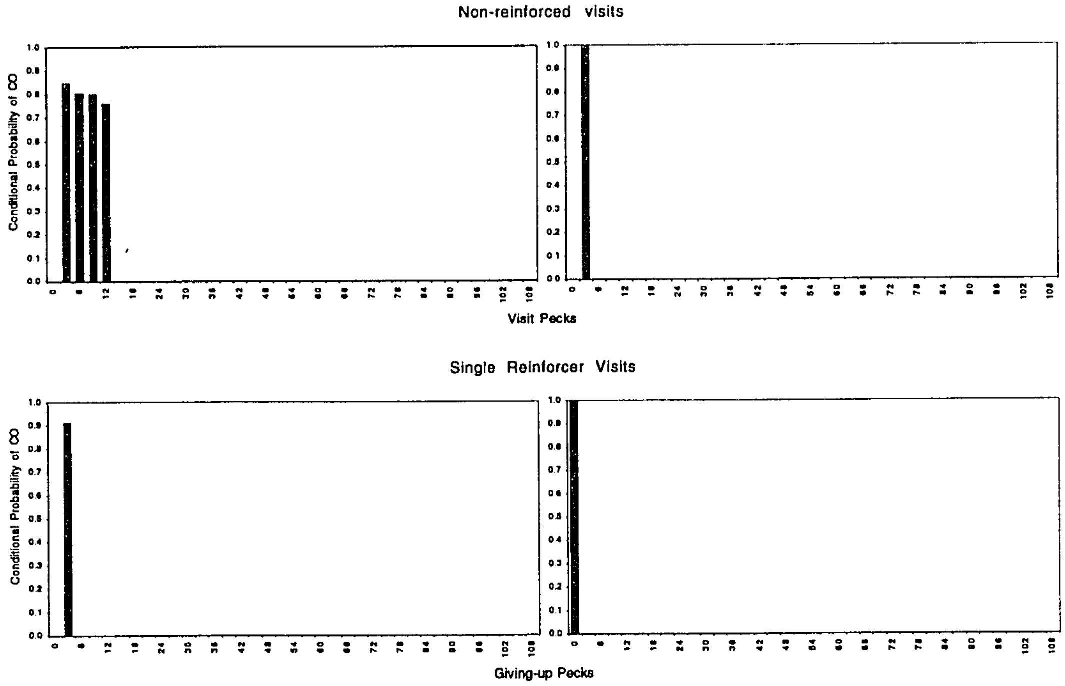
Non-reinforced visits



Single Reinforcer Visits



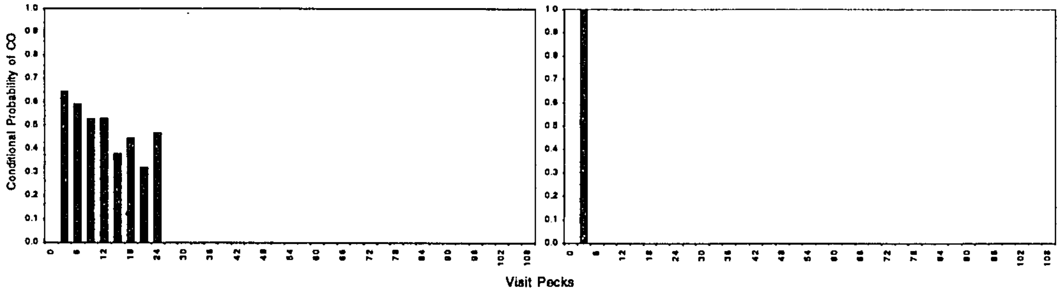
W35
Constant: 30/hr FRCO: 00 R Variable: 30/hr



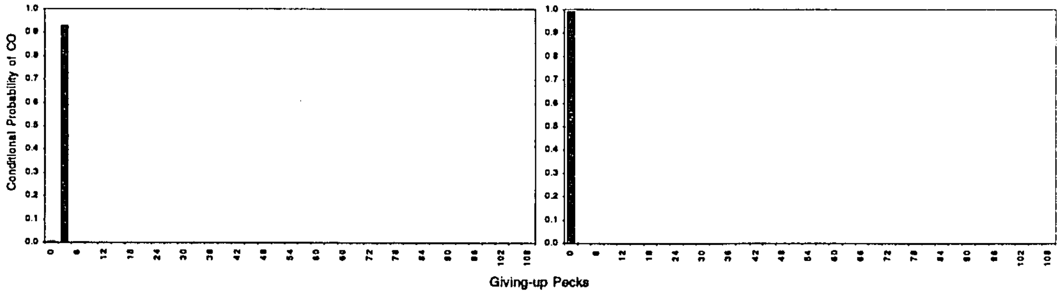
W35

Constant: 30/hr FRCO: 00 Variable: 15/hr

Non-reinforced visits



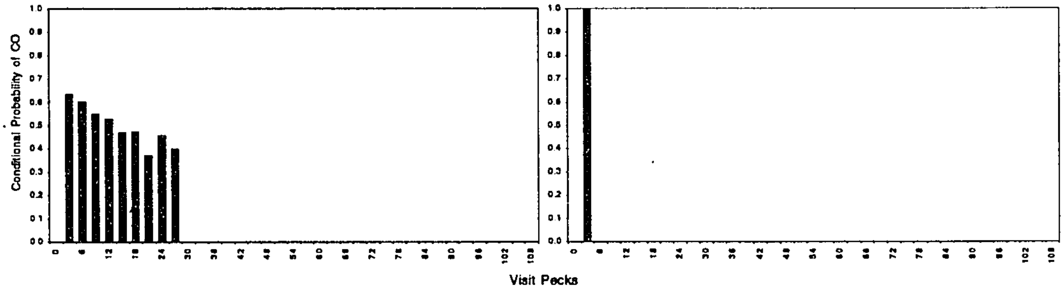
Single Reinforcer Visits



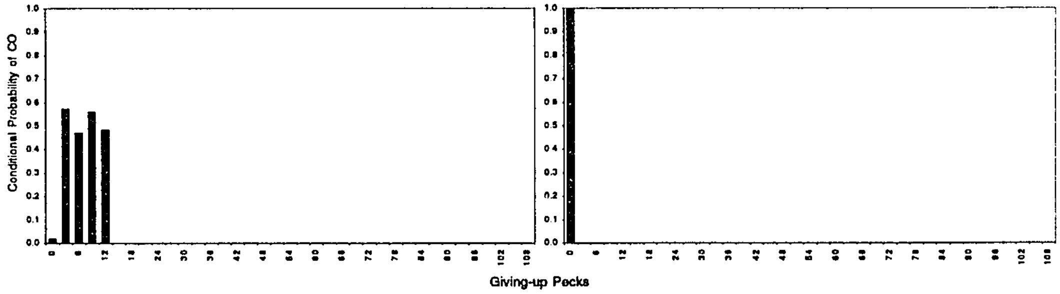
W35

Constant: 30/hr FRCO: 00 Variable: 7.5/hr

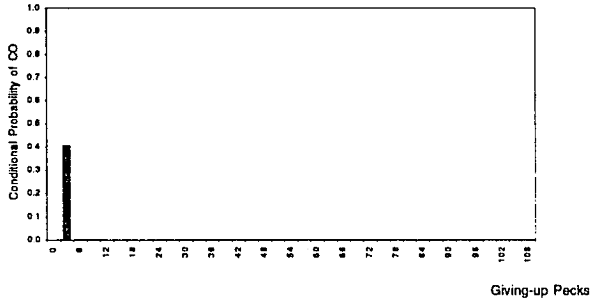
Non-reinforced visits



Single Reinforcer Visits



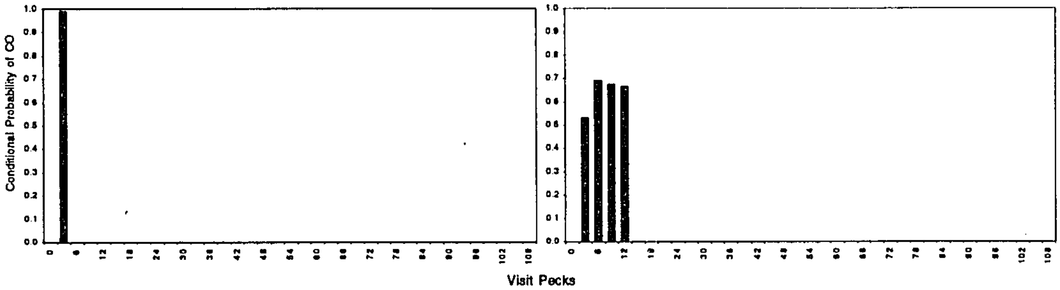
Multiple Reinforcer Visits



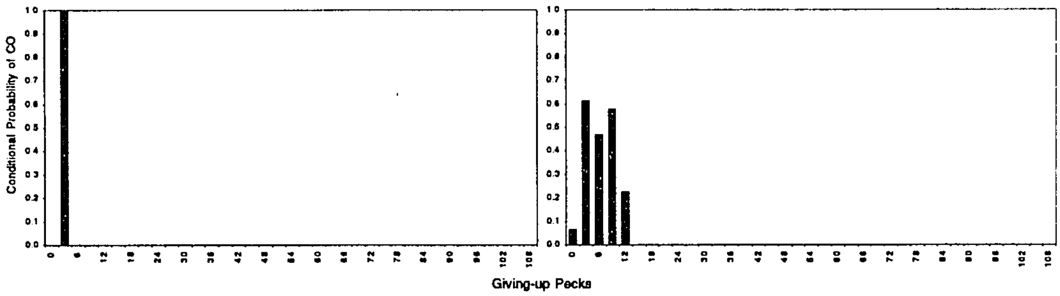
W35

Constant: 30/hr FROO: 02 Variable: 120/hr

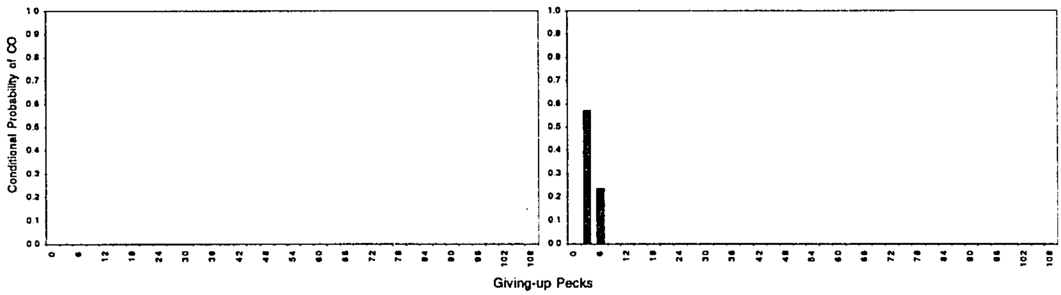
Non-reinforced visits



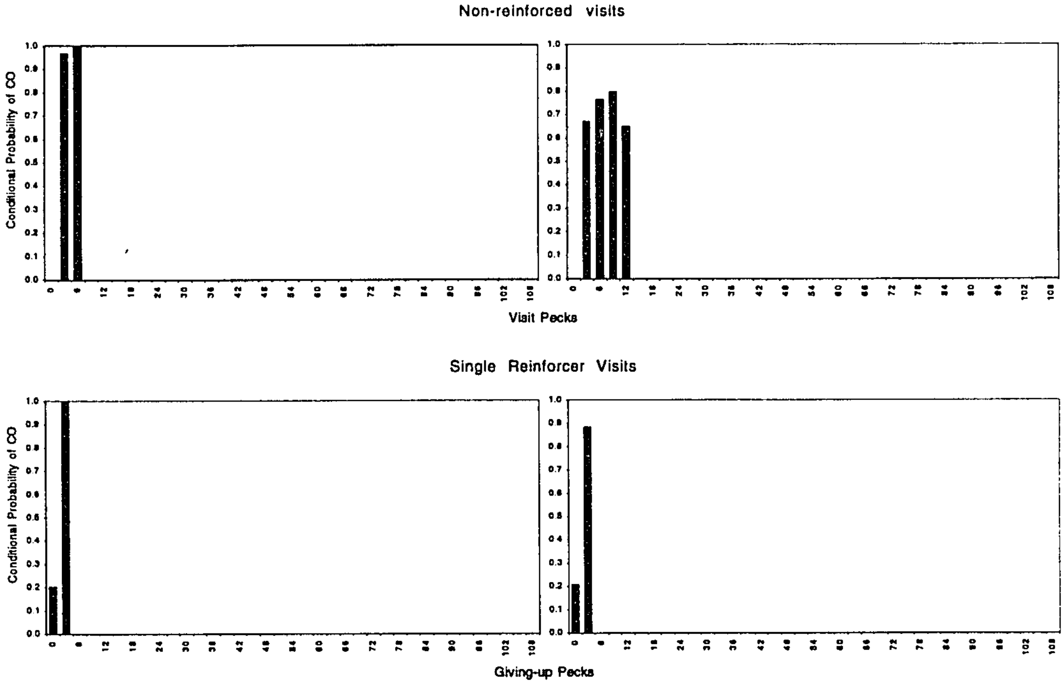
Single Reinforcer Visits



Multiple Reinforcer Visits

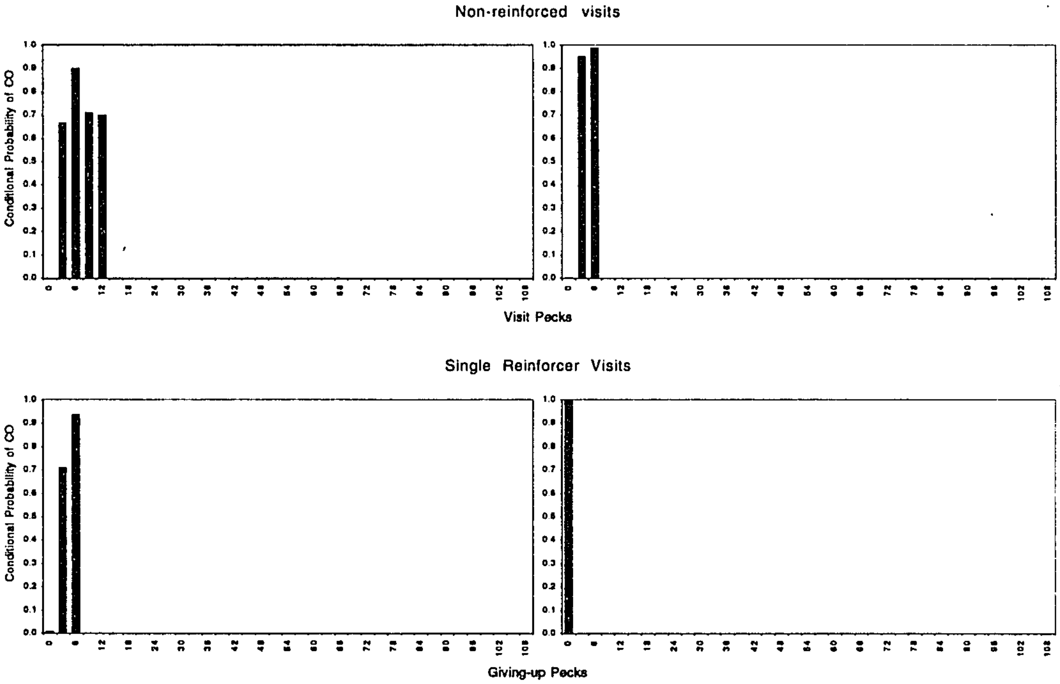


W35
Constant: 30/hr FRCO: 02 Variable: 60/hr



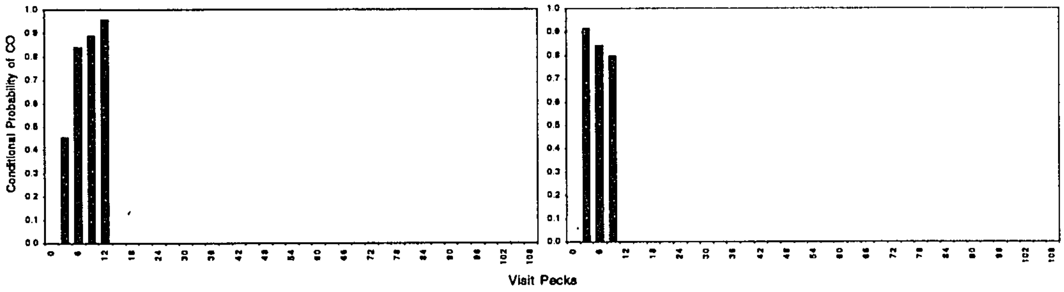
W35

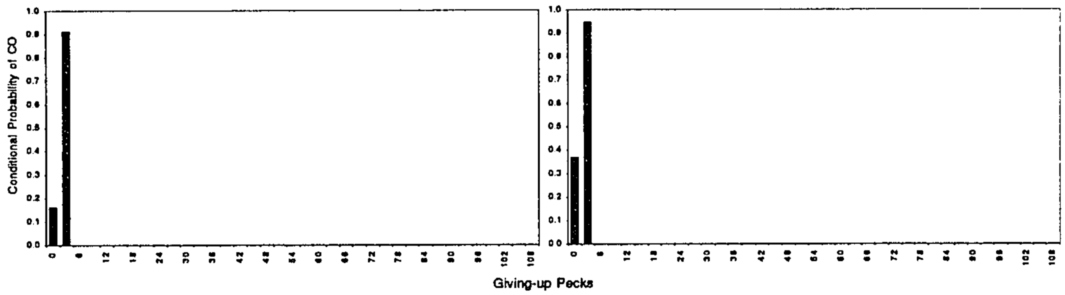
Constant: 30/hr FRCO: 02 Variable: 30/hr



W35

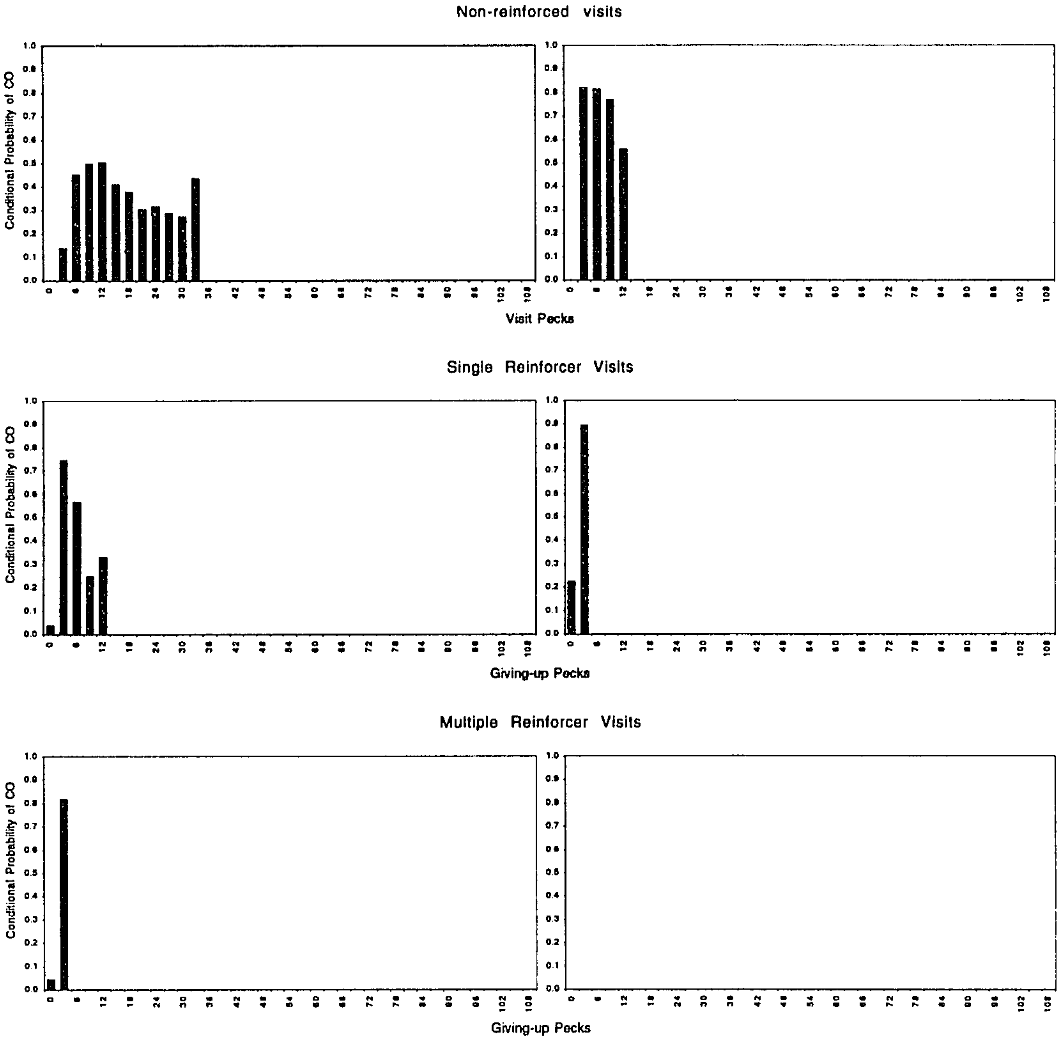
Constant: 30/hr FROO: 02 Variable: 15/hr


Non-reinforced visits


Single Reinforcer Visits

W35

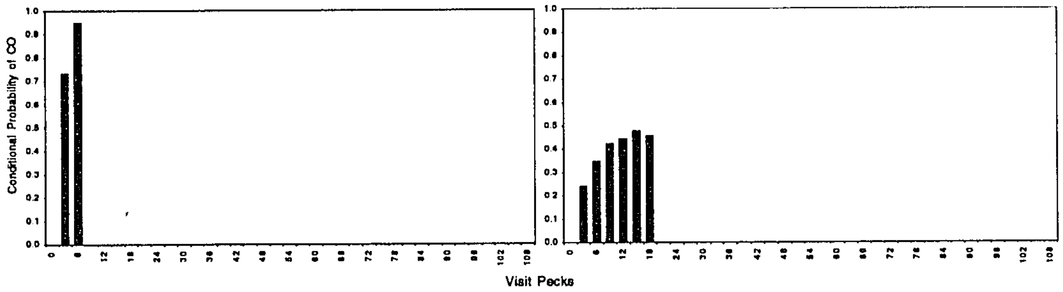
Constant: 30/hr FRCO: 02 Variable: 7.5/hr



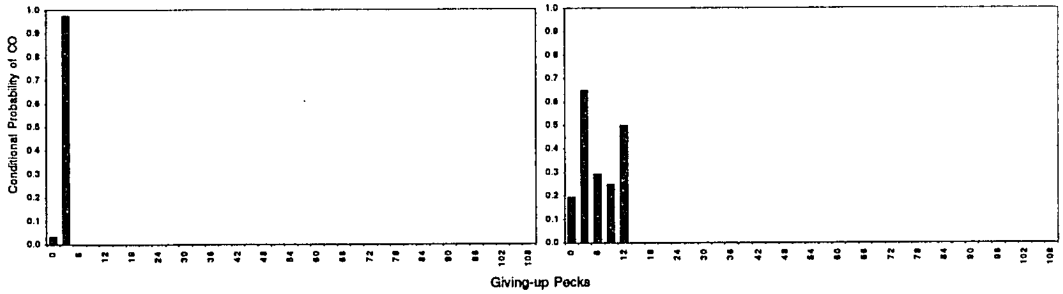
W35

Constant: 30/hr FRCO: 06 Variable: 120/hr

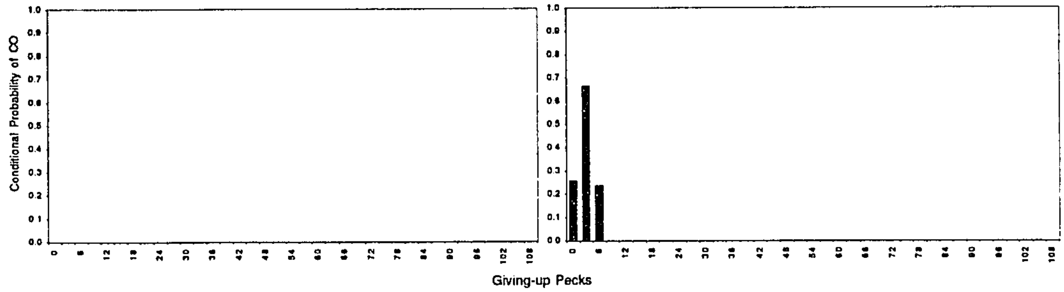
Non-reinforced visits

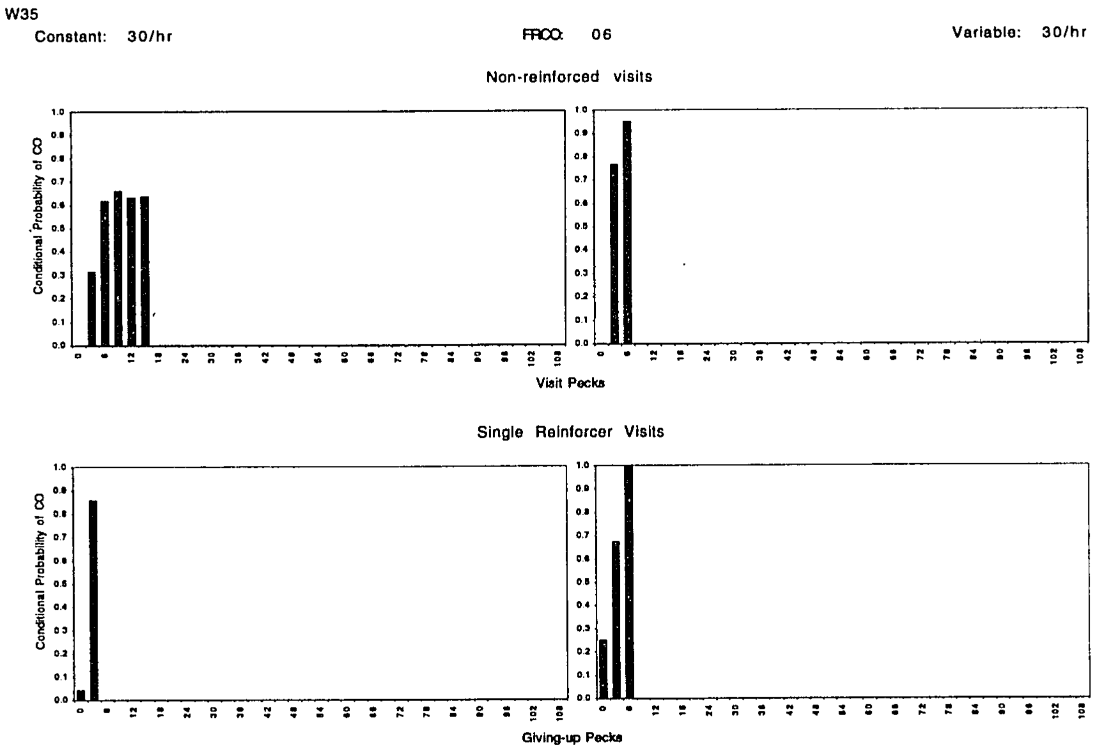


Single Reinforcer Visits



Multiple Reinforcer Visits




W35
Constant: 30/hr
FROO: 06
Variable: 30/hr
Non-reinforced visits
Conditional Probability of CO
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
0
6
12
18
24
30
36
42
48
54
60
66
72
78
84
90
96
102
108
Visit Pecks
Single Reinforcer Visits
Giving-up Pecks

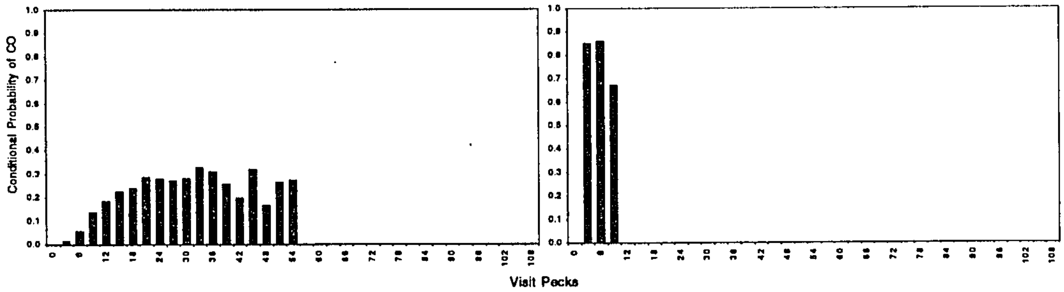
W35

Constant: 30/hr

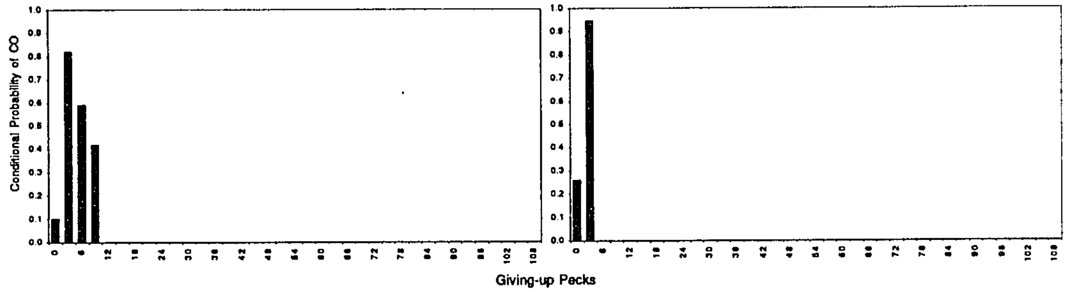
FRCO: 06

Variable: 7.5/hr

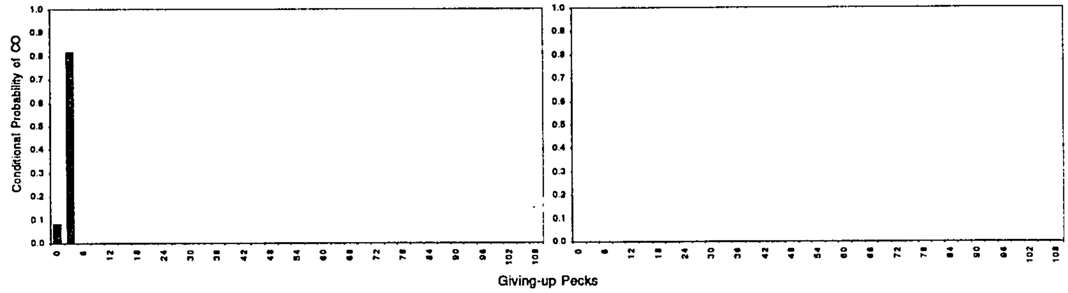
Non-reinforced visits



Single Reinforcer Visits



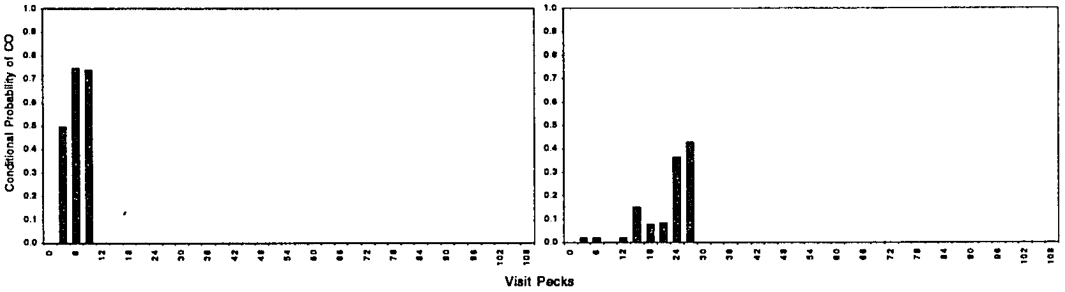
Multiple Reinforcer Visits



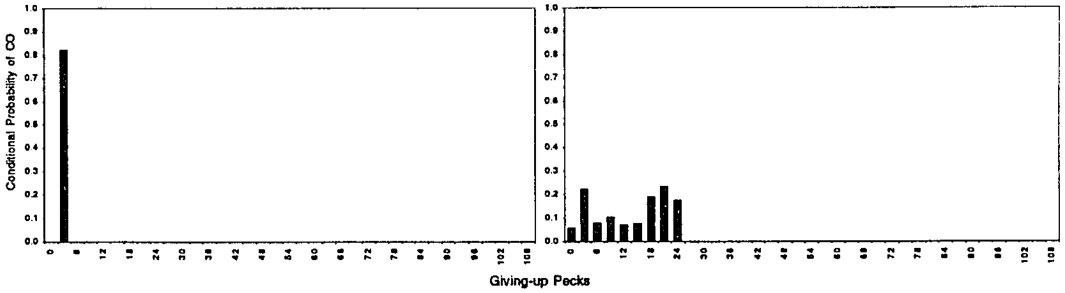
W35

Constant: 30/hr FRCO: 12 Variable: 120/hr

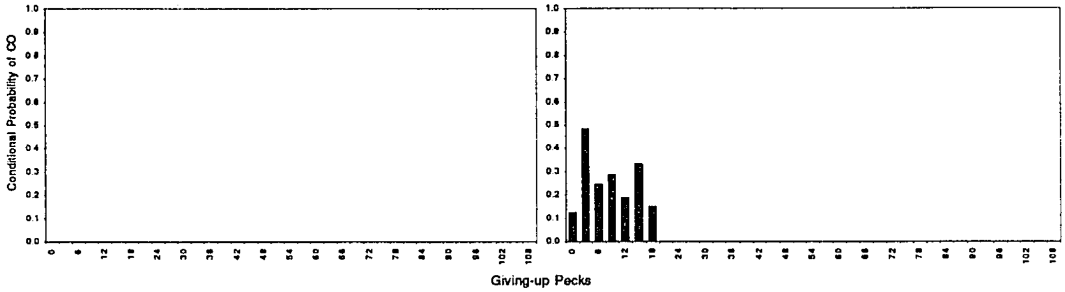
Non-reinforced visits



Single Reinforcer Visits



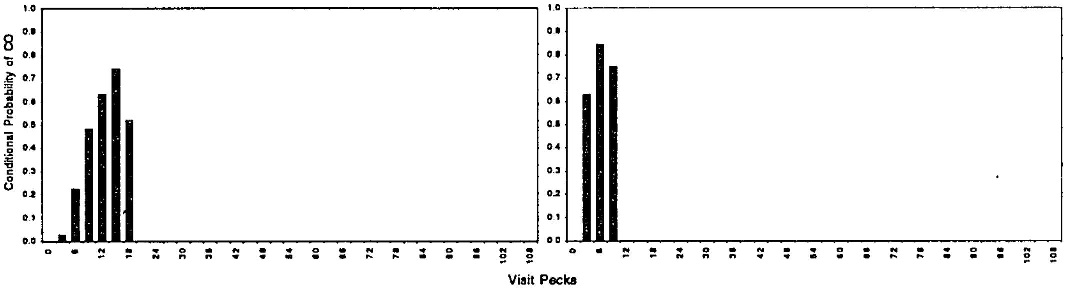
Multiple Reinforcer Visits



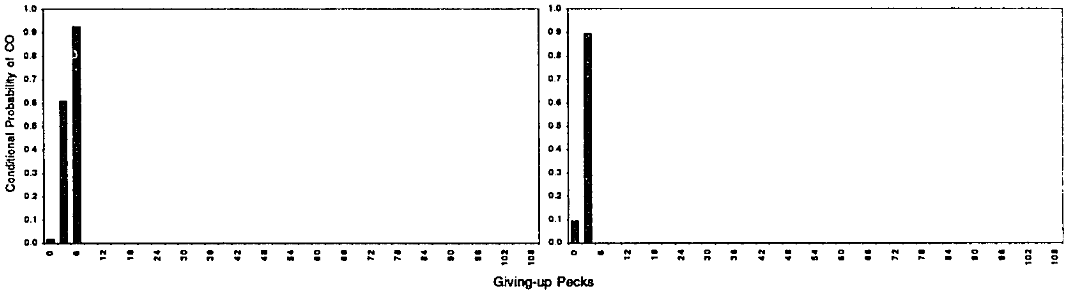
W35

Constant: 30/hr FRCO: 12 Variable: 30/hr

Non-reinforced visits

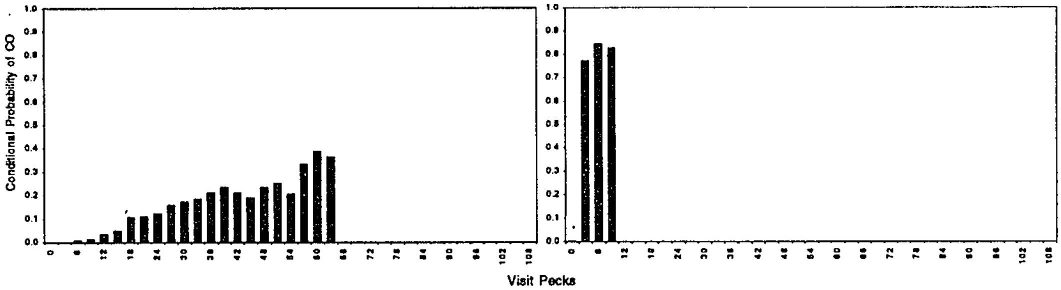


Single Reinforcer Visits

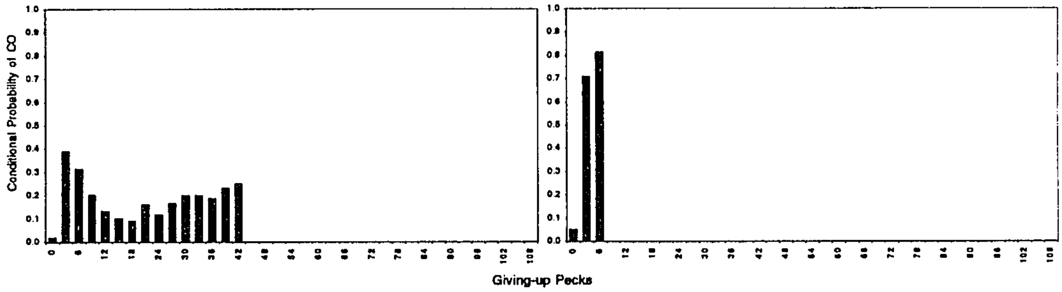


W35
Constant: 30/hr FRCO: 12 Variable: 7.5/hr

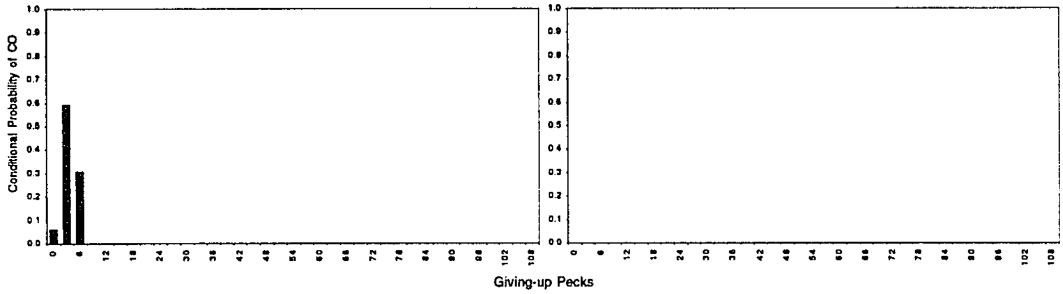
Non-reinforced visits



Single Reinforcer Visits



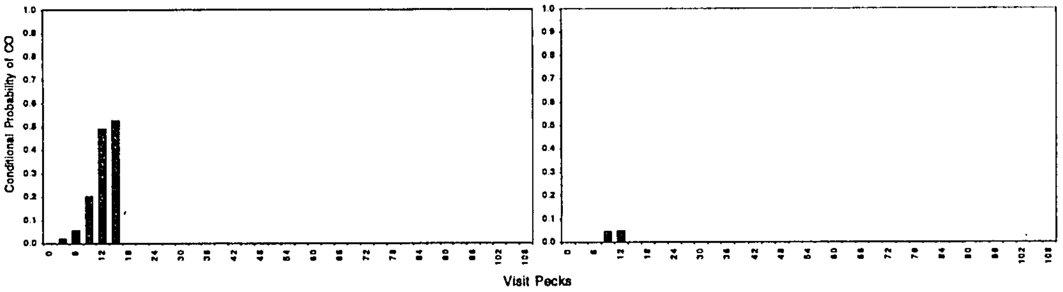
Multiple Reinforcer Visits



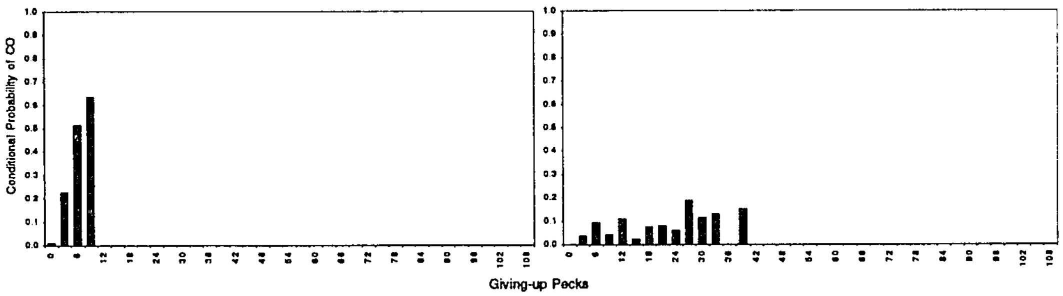
W35

Constant: 30/hr FRCO: 20 Variable: 120/hr

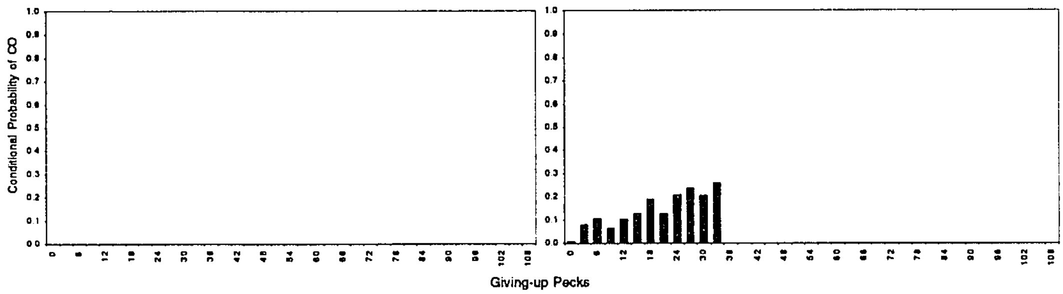
Non-reinforced visits



Single Reinforcer Visits

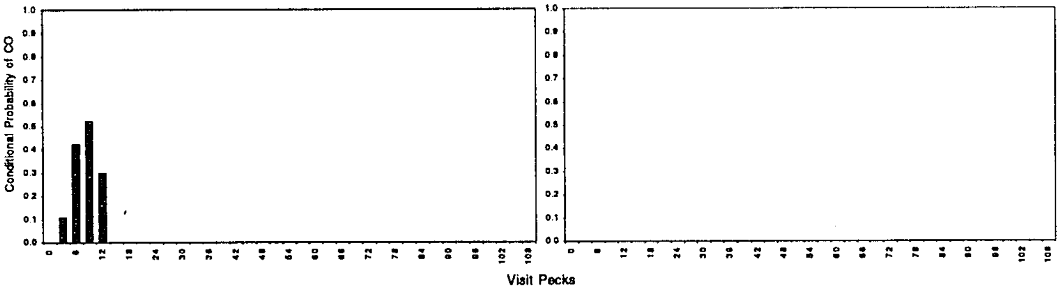


Multiple Reinforcer Visits

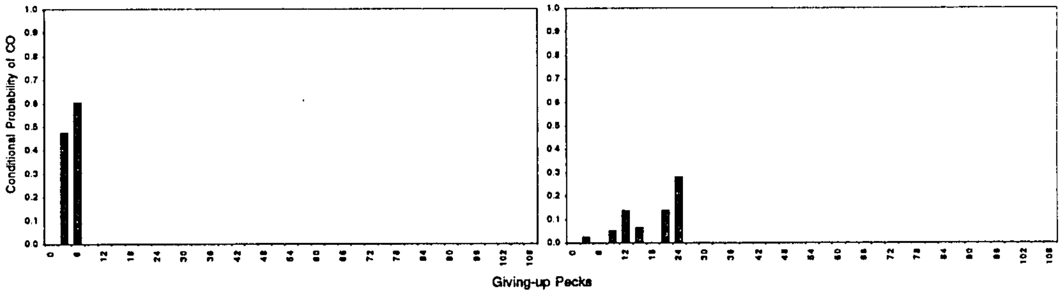


W35
Constant: 30/hr FRCO: 20 R Variable: 120/hr

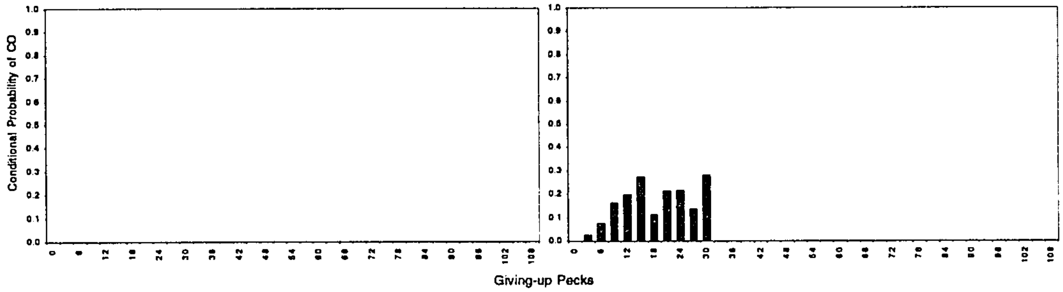
Non-reinforced visits



Single Reinforcer Visits



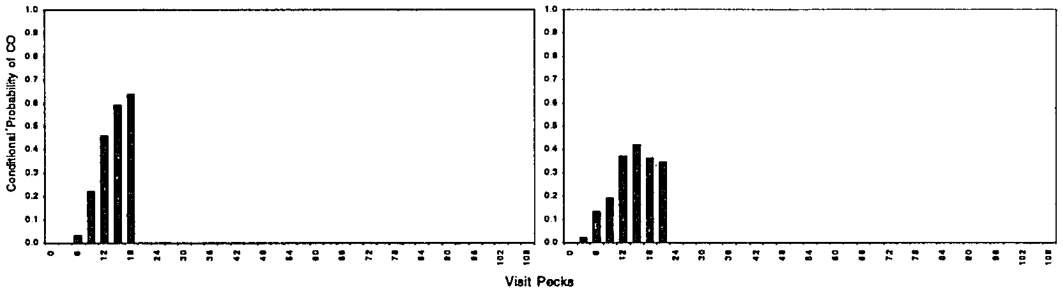
Multiple Reinforcer Visits



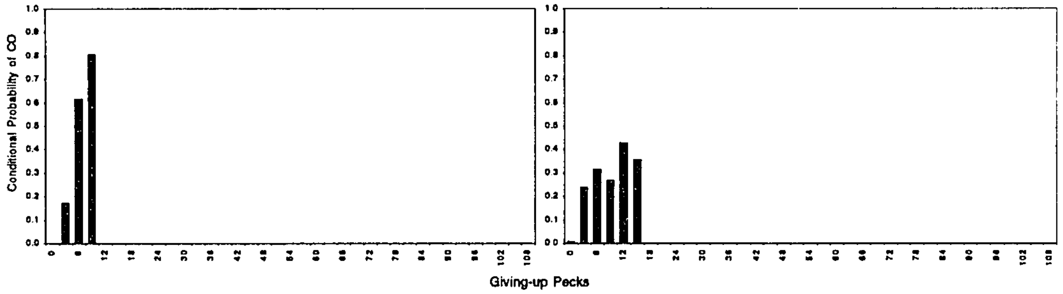
W35

Constant: 30/hr FRCO: 20 Variable: 60/hr

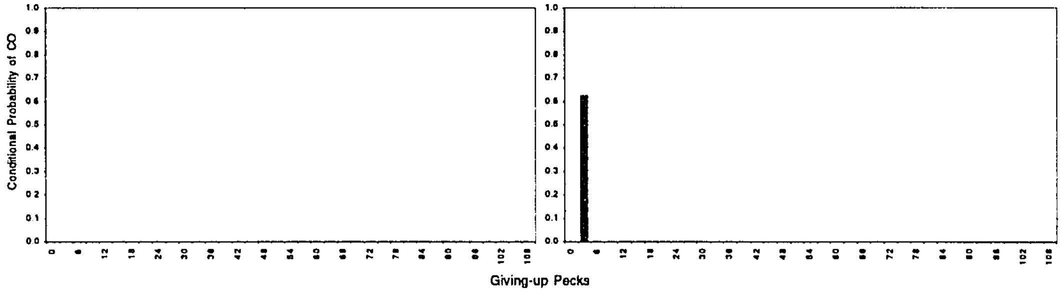
Non-reinforced visits



Single Reinforcer Visits



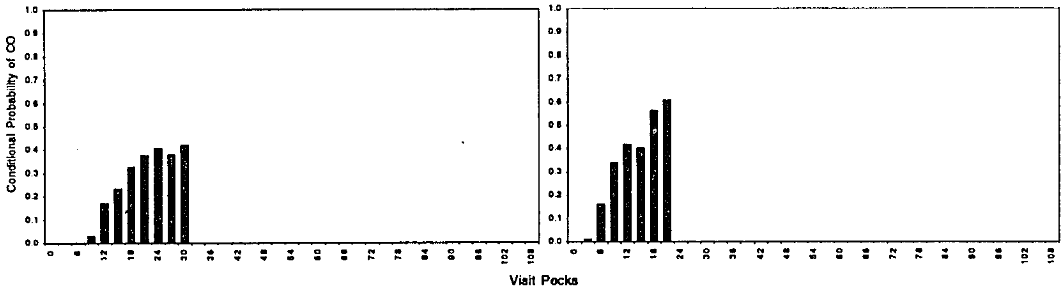
Multiple Reinforcer Visits



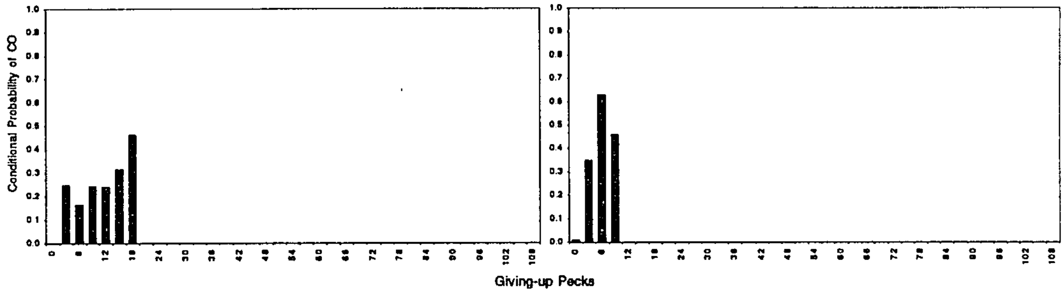
W35

Constant: 30/hr FRCO: 20 Variable: 30/hr

Non-reinforced visits



Single Reinforcer Visits

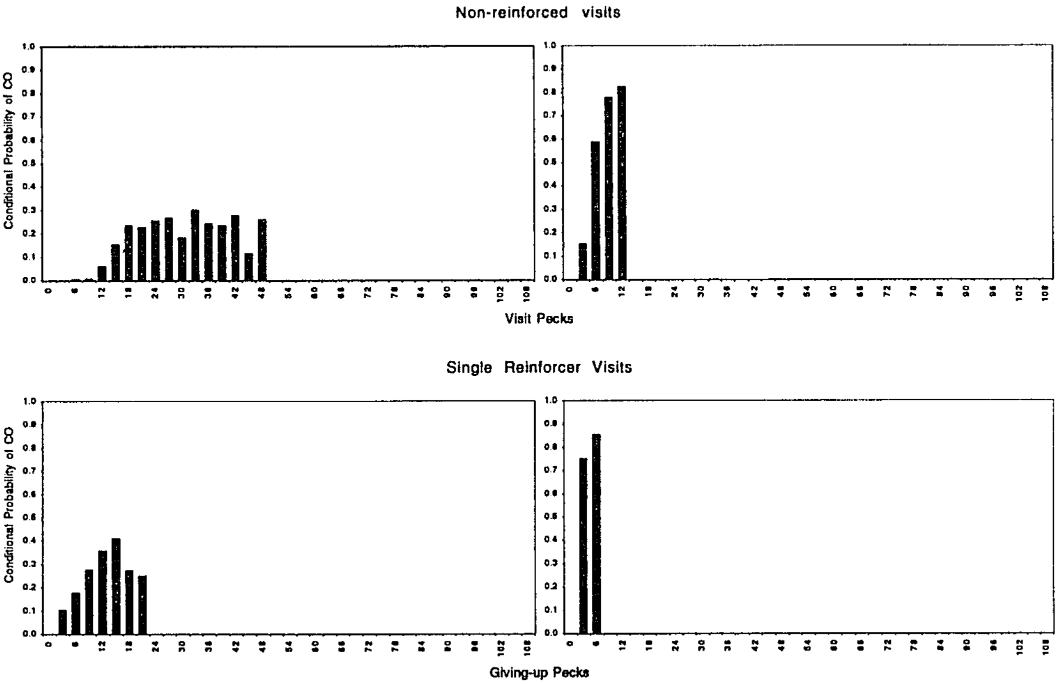


W35

Constant: 30/hr

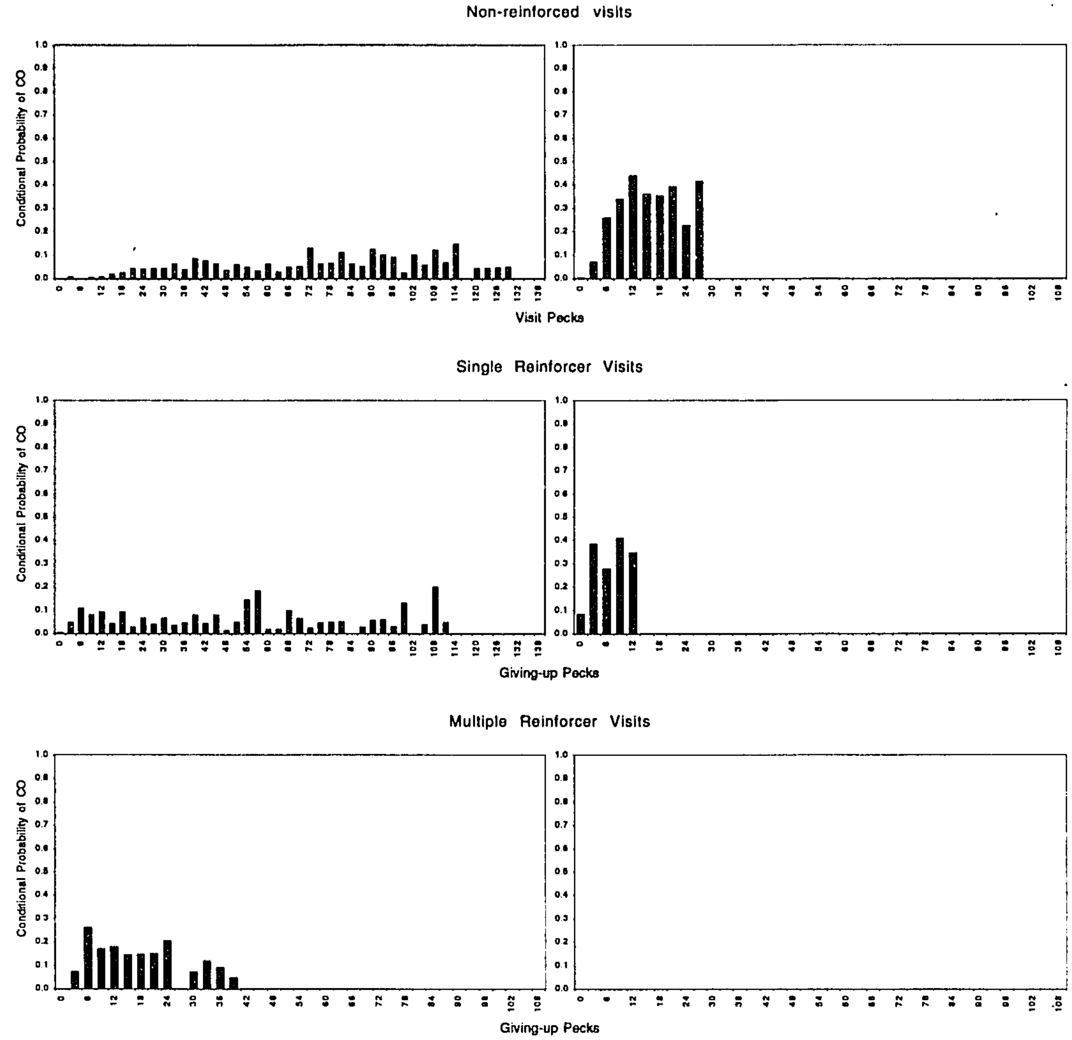
FRCO: 20

Variable: 15/hr

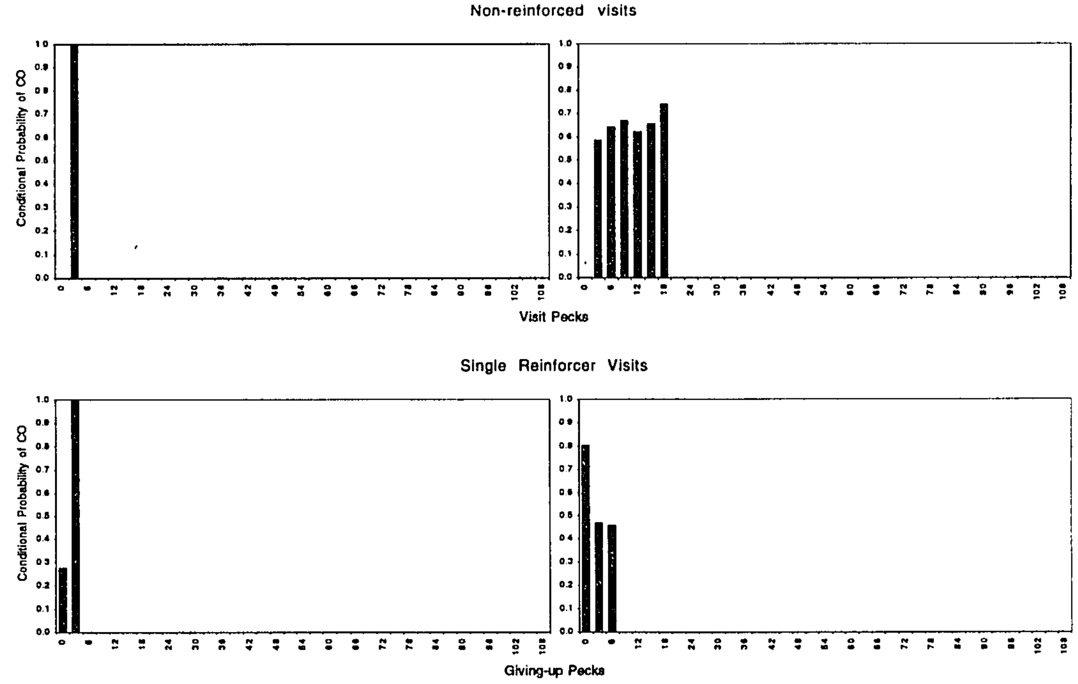


W35

Constant: 30/hr FRCO: 20 Variable: 7.5/hr

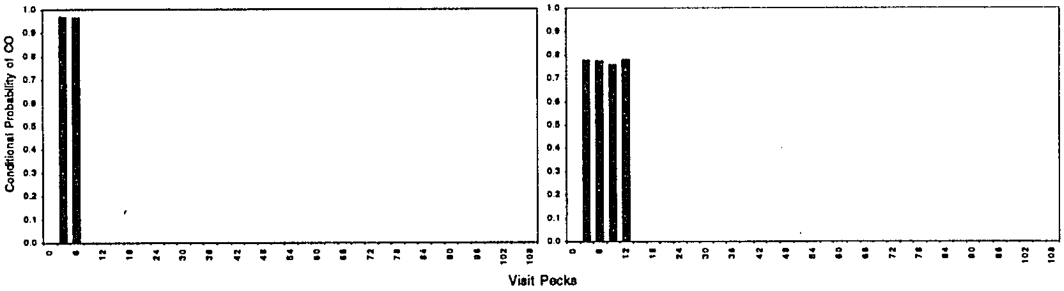


W36
Constant: 30/hr FRCO: 00 Variable: 120/hr

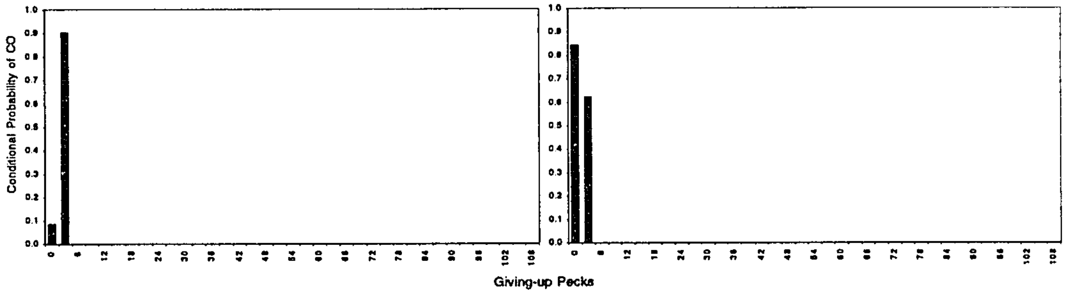


W36
Constant: 30/hr FRCO: 00 Variable: 60/hr

Non-reinforced visits



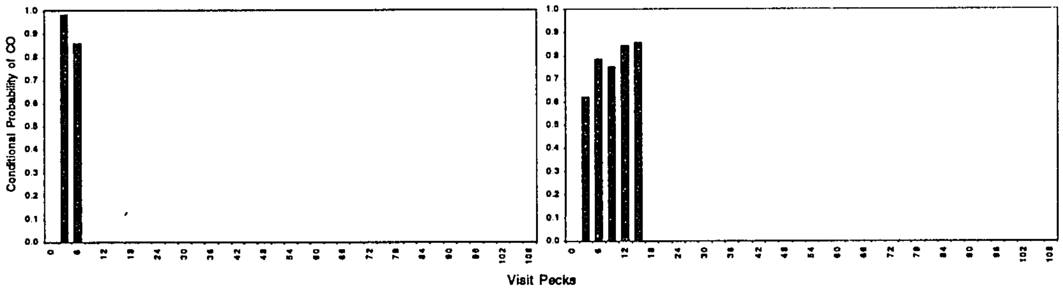
Single Reinforcer Visits



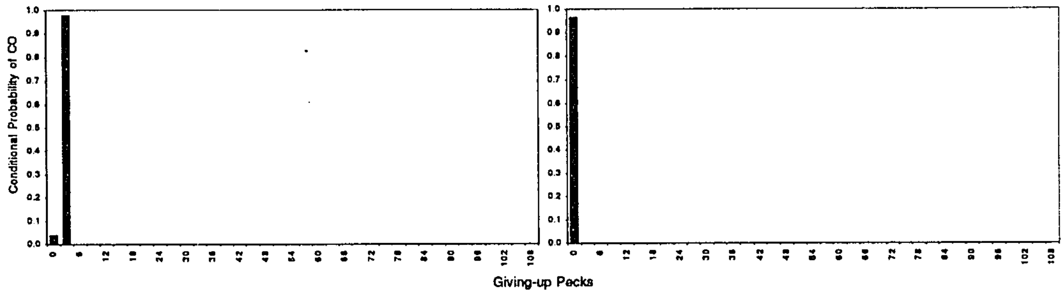
W36

Constant: 30/hr FRCO: 00 Variable: 30/hr

Non-reinforced visits



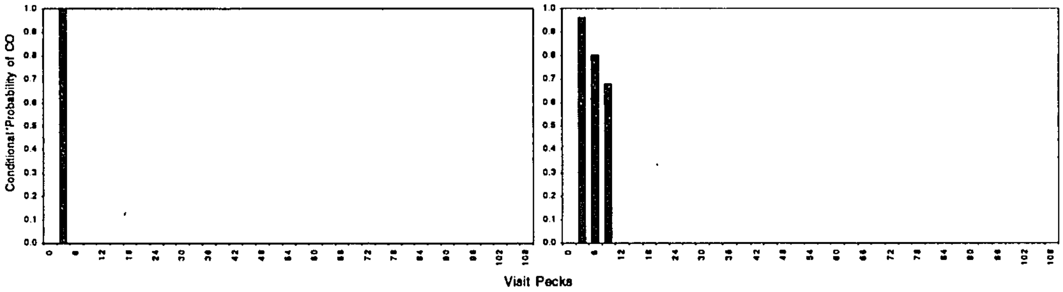
Single Reinforcer Visits



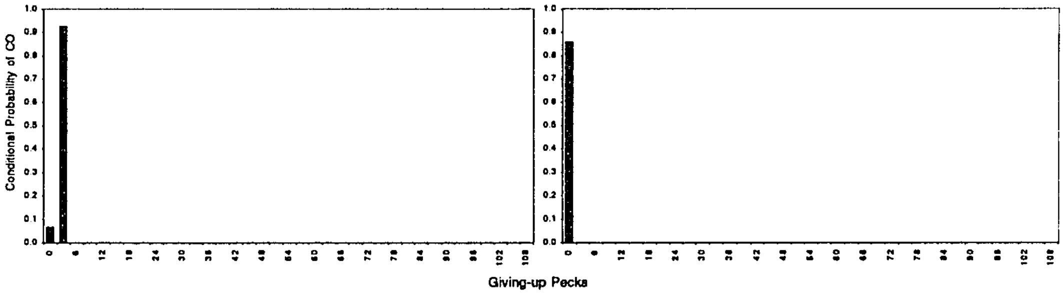
W36

Constant: 30/hr FRCO: 00 R Variable: 30/hr

Non-reinforced visits



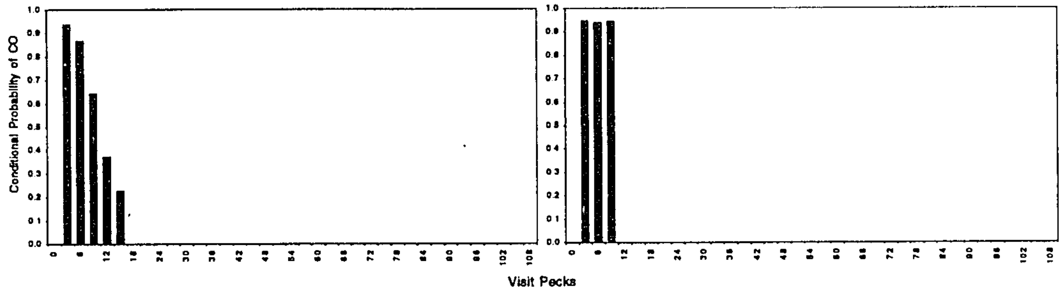
Single Reinforcer Visits



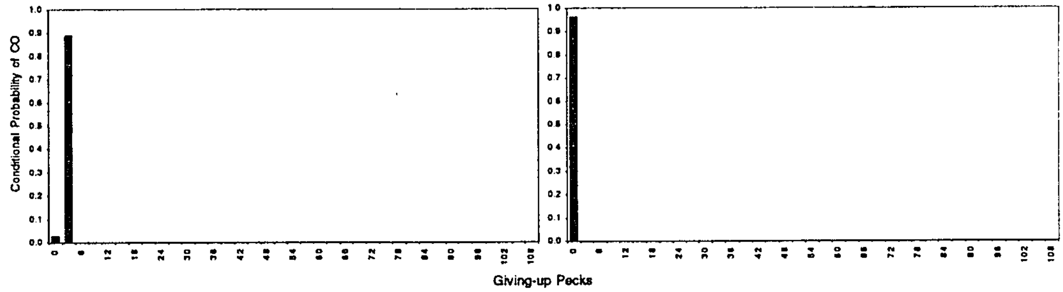
W36

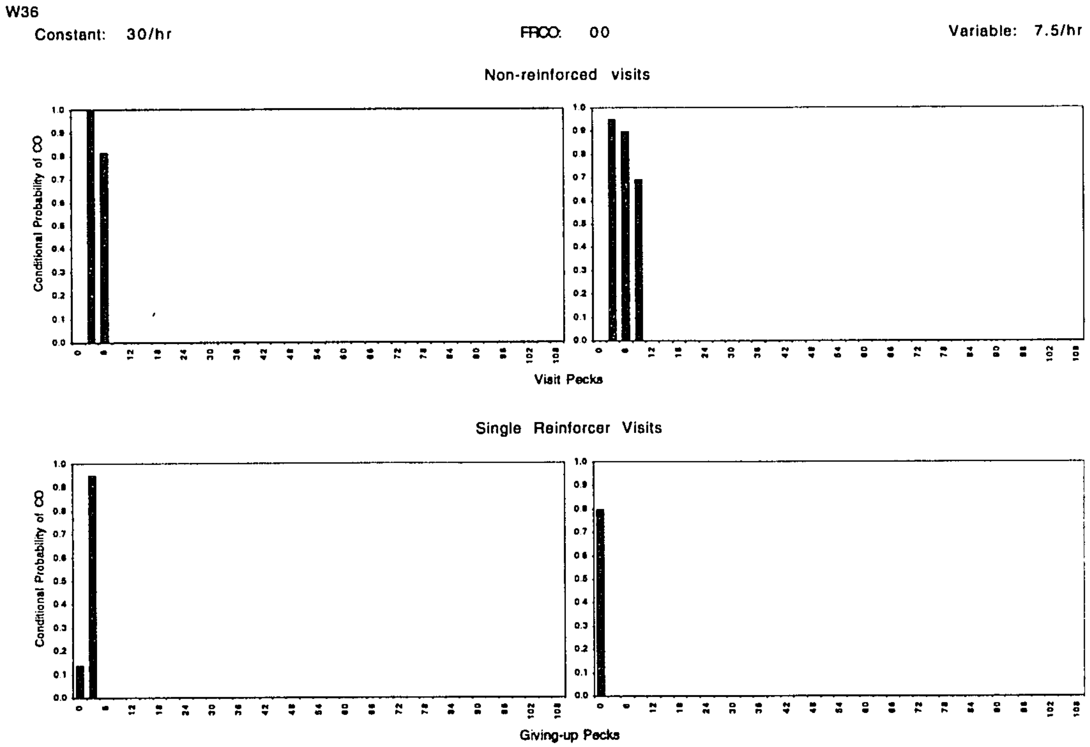
Constant: 30/hr FRCO: 00 Variable: 15/hr

Non-reinforced visits

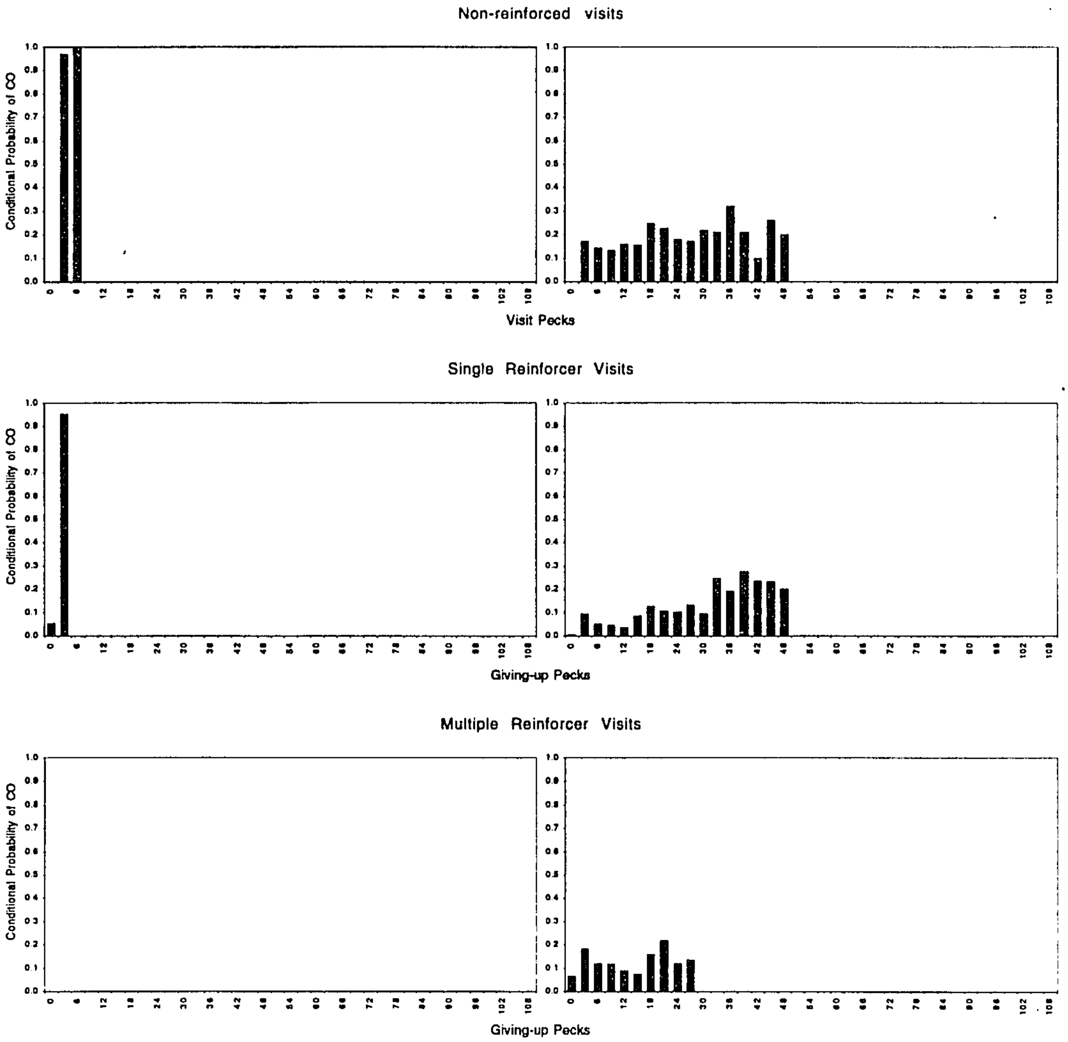


Single Reinforcer Visits

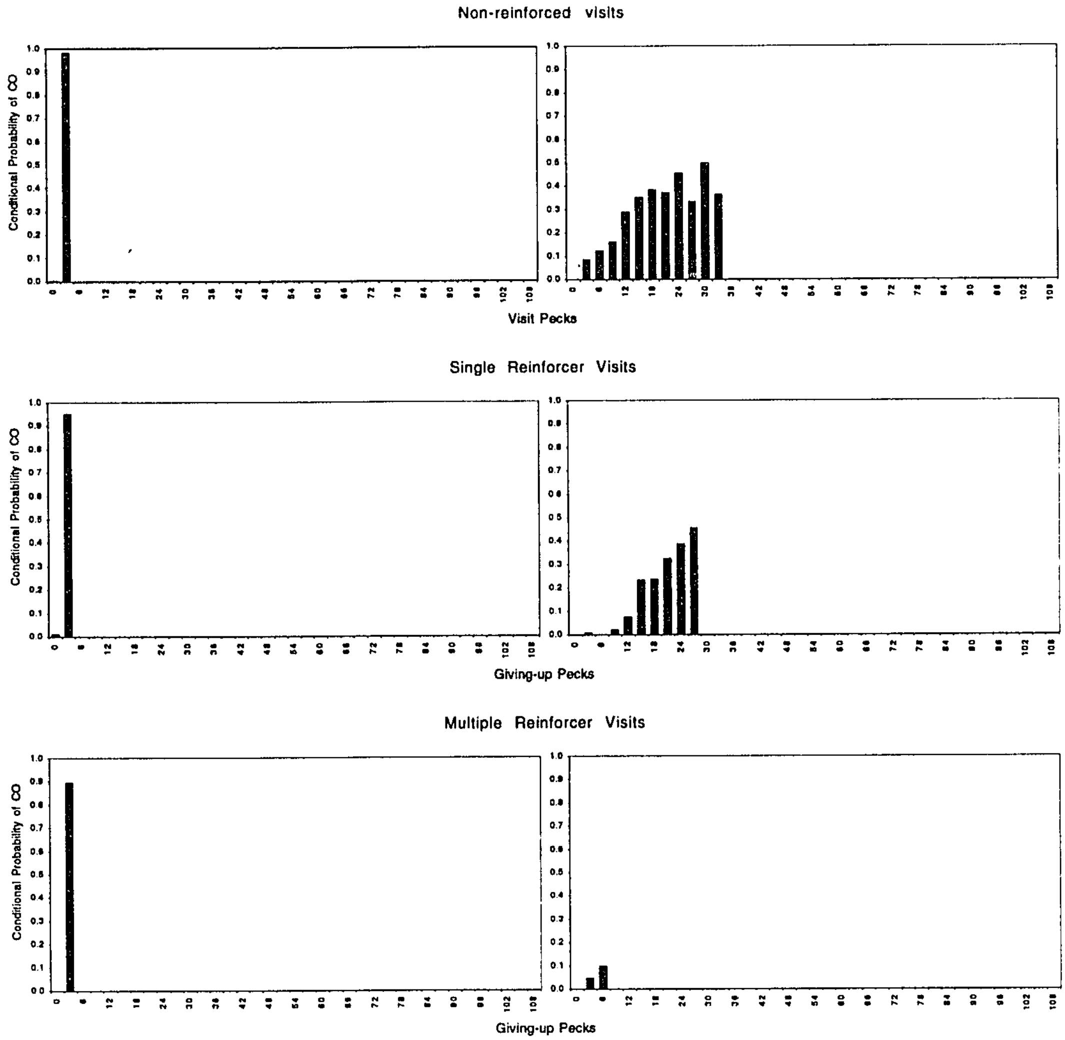



W36
Constant: 30/hr
FRCO: 00
Variable: 7.5/hr
Non-reinforced visits
Conditional Probability of CO
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
6
12
18
24
30
36
42
48
54
60
66
72
78
84
90
96
102
108
Visit Pecks
Single Reinforcer Visits
Giving-up Pecks

W36
Constant: 30/hr PROC: 02 Variable: 120/hr

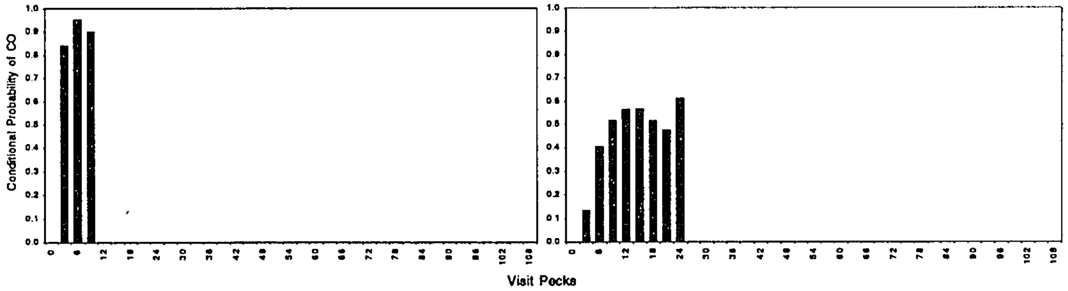


W36
Constant: 30/hr FROO: 02 Variable: 60/hr

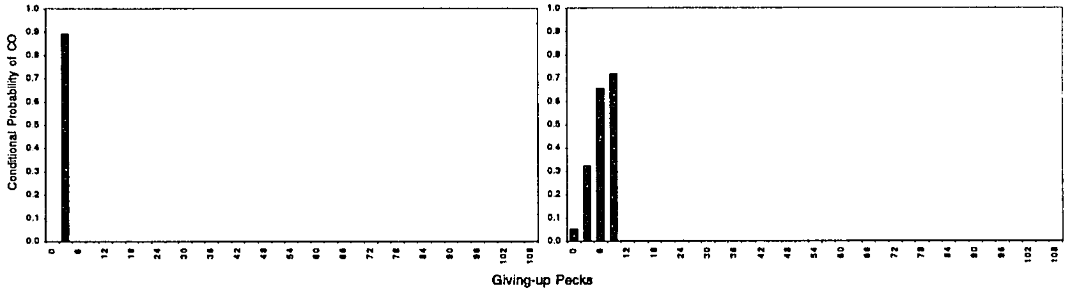


W36
Constant: 30/hr PROC: 02 Variable: 30/hr

Non-reinforced visits



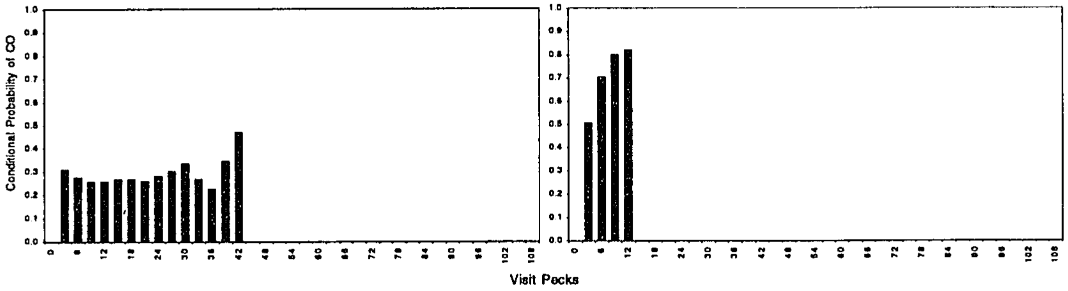
Single Reinforcer Visits



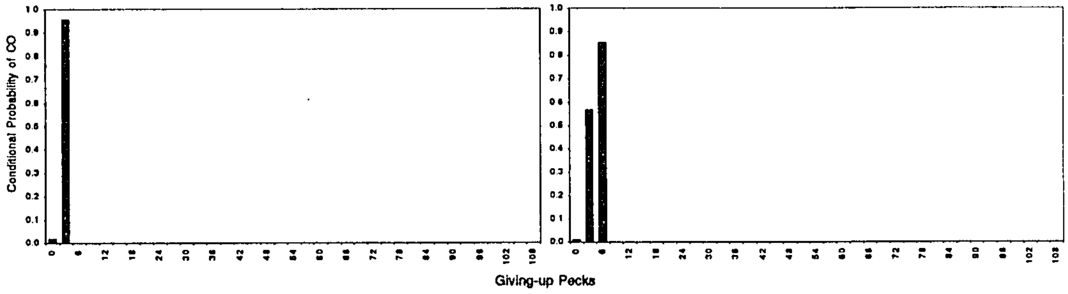
W36

Constant: 30/hr FRCO: 02 Variable: 15/hr

Non-reinforced visits



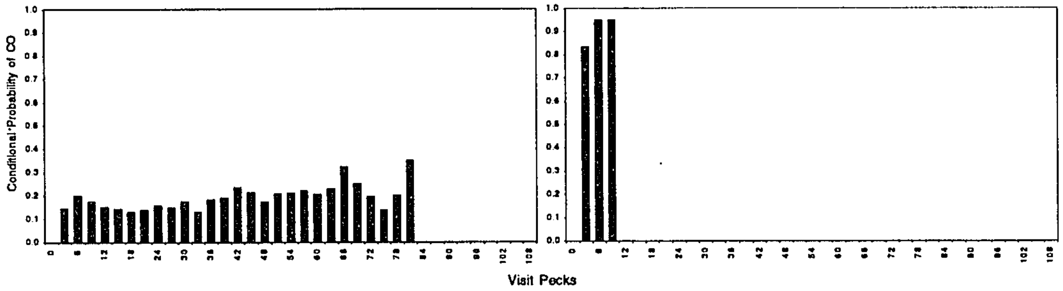
Single Reinforcer Visits



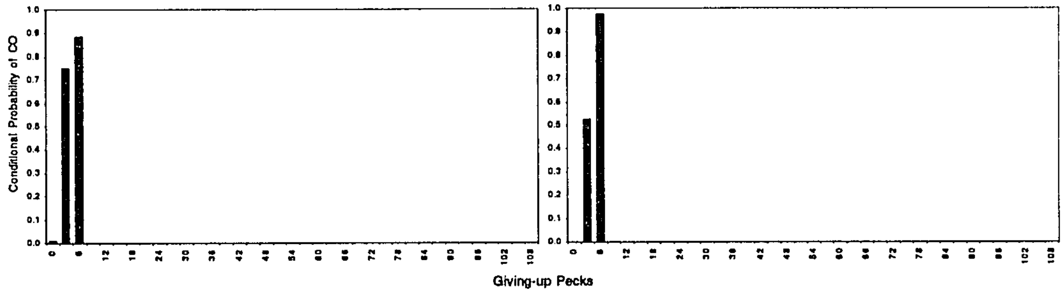
W36

Constant: 30/hr FRCO: 02 Variable: 7.5/hr

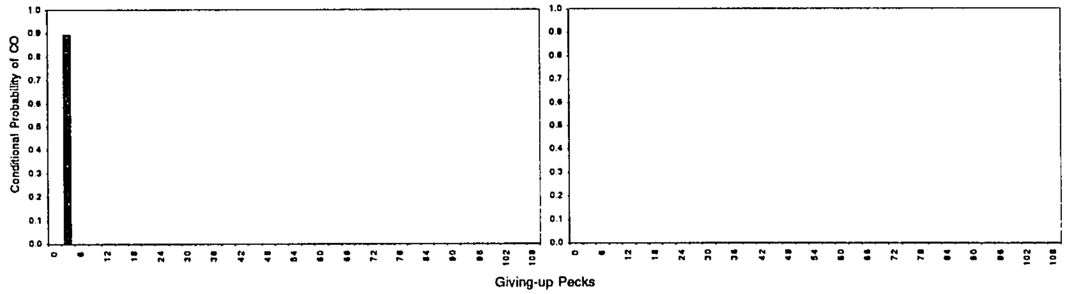
Non-reinforced visits



Single Reinforcer Visits



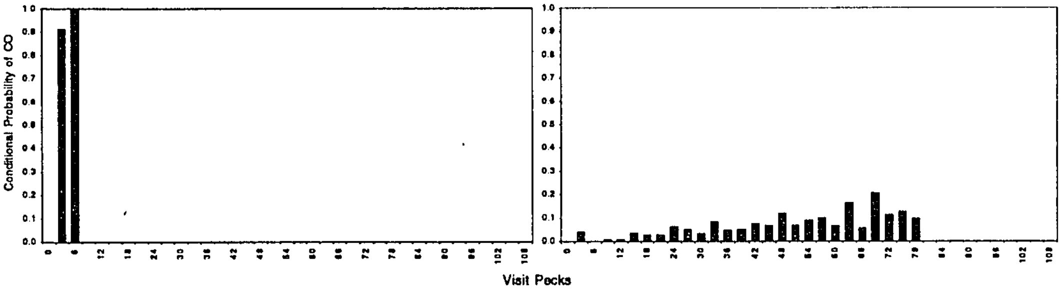
Multiple Reinforcer Visits



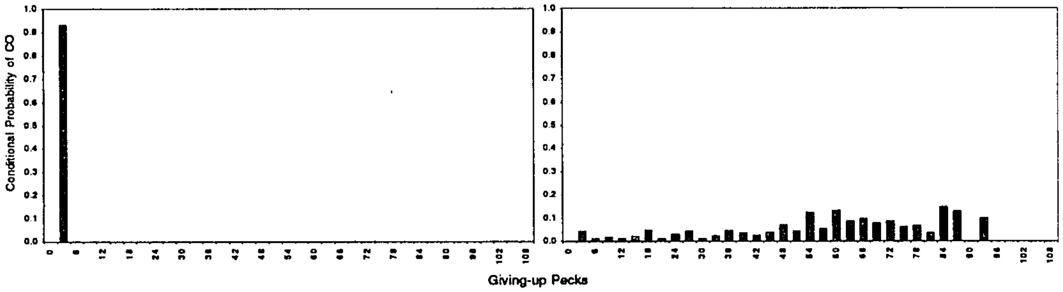
W36

Constant: 30/hr FROO: 06 Variable: 120/hr

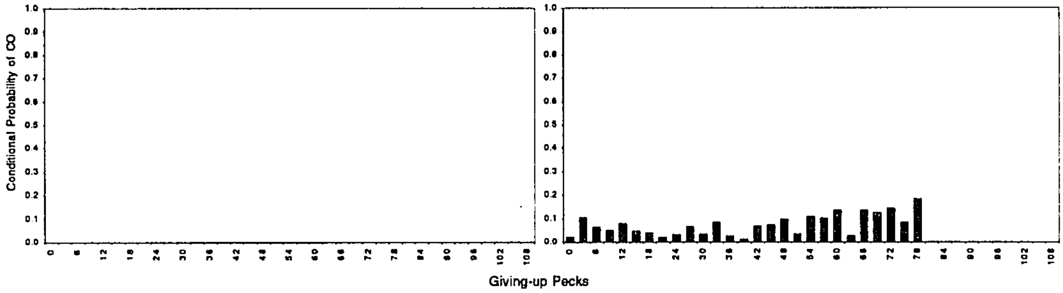
Non-reinforced visits



Single Reinforcer Visits



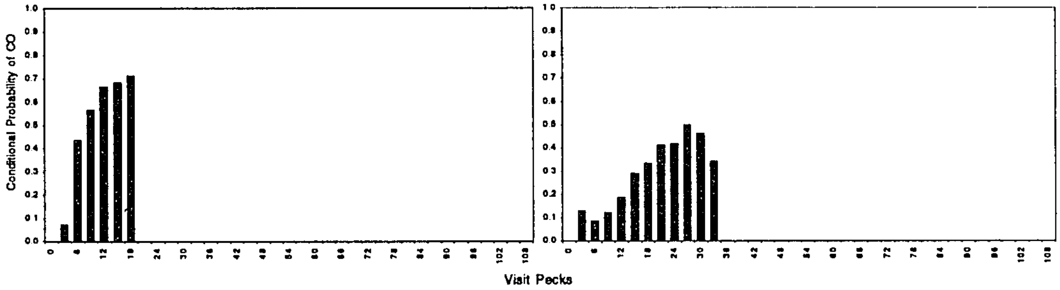
Multiple Reinforcer Visits



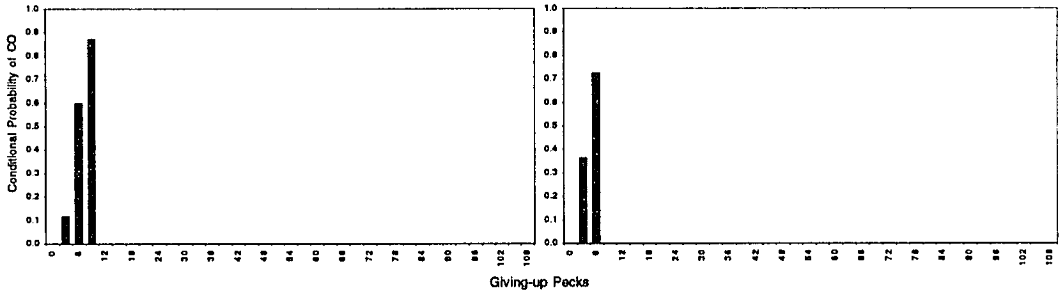
W36

Constant: 30/hr FRCO: 06 Variable: 30/hr

Non-reinforced visits



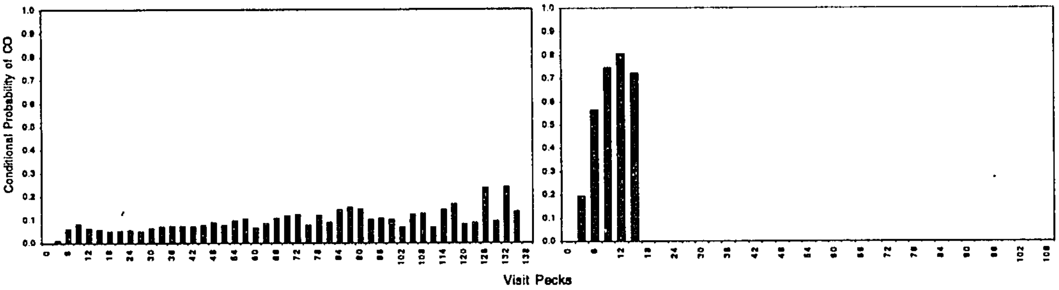
Single Reinforcer Visits



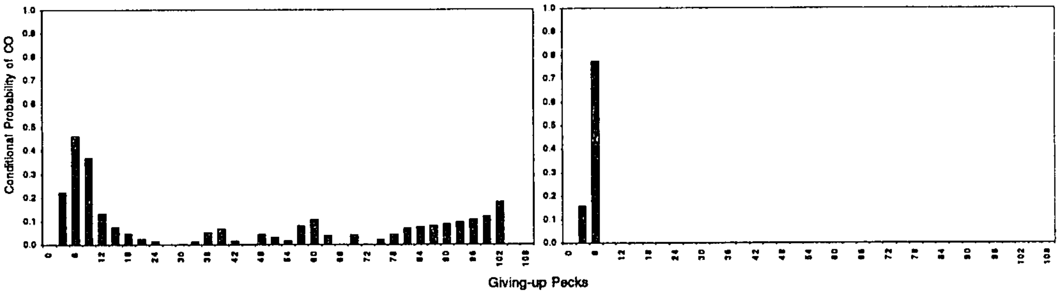
W36

Constant: 30/hr FROO: 06 Variable: 7.5/hr

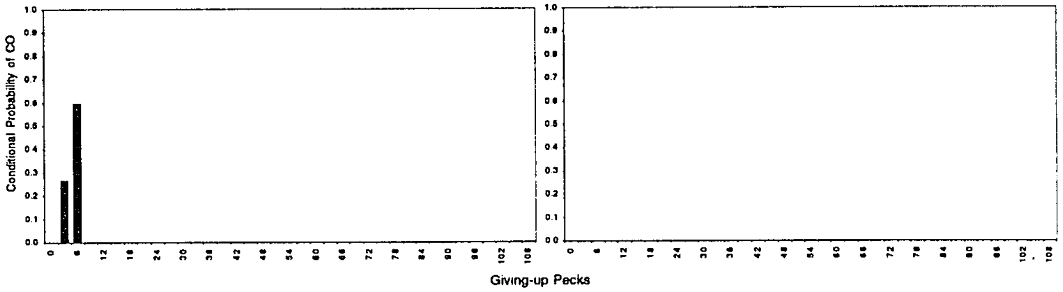
Non-reinforced visits



Single Reinforcer Visits



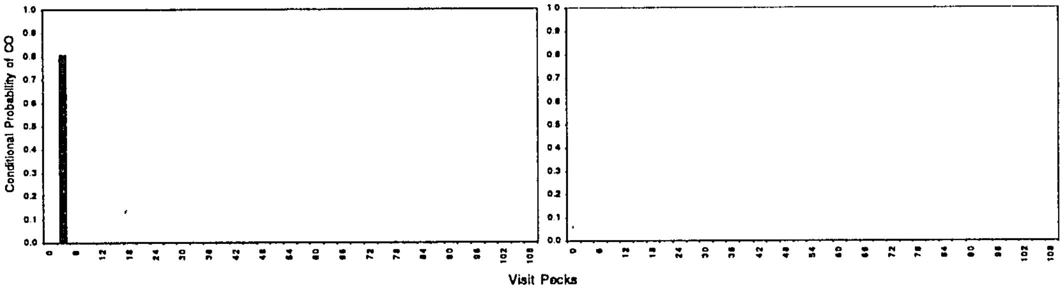
Multiple Reinforcer Visits



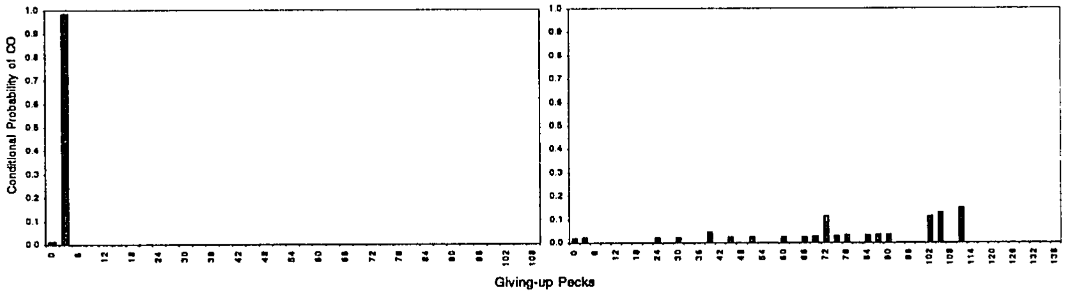
W36

Constant: 30/hr FRCO: 12 Variable: 120/hr

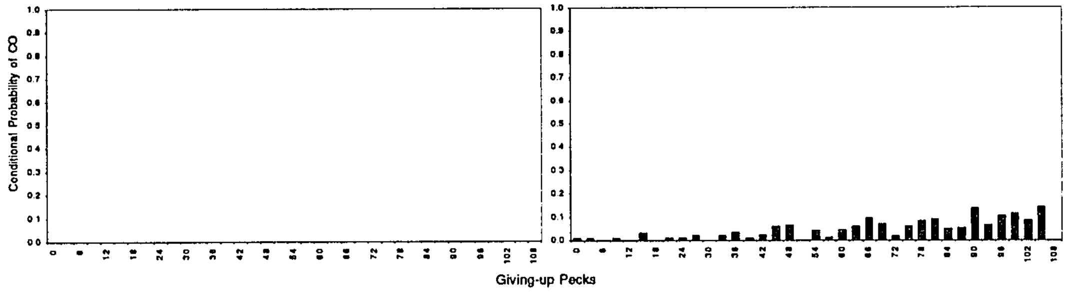
Non-reinforced visits



Single Reinforcer Visits



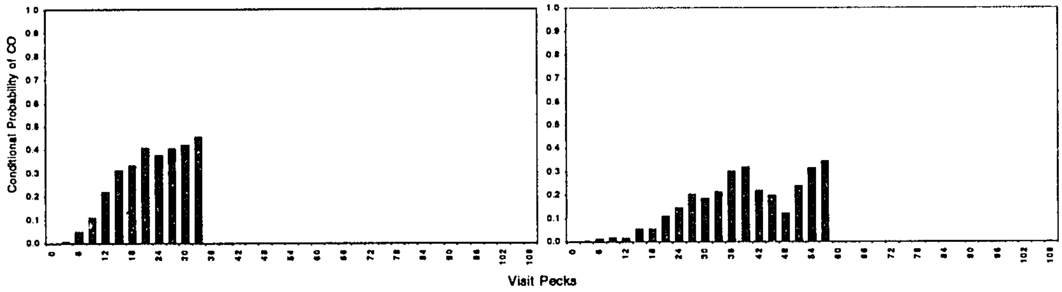
Multiple Reinforcer Visits



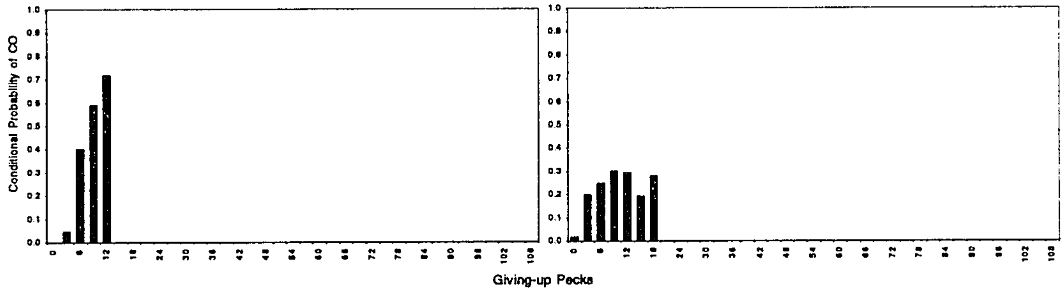
W36

Constant: 30/hr FRCO: 12 Variable: 30/hr

Non-reinforced visits

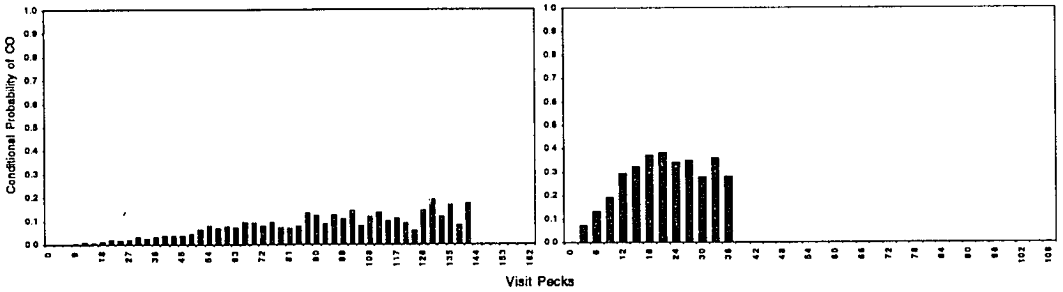


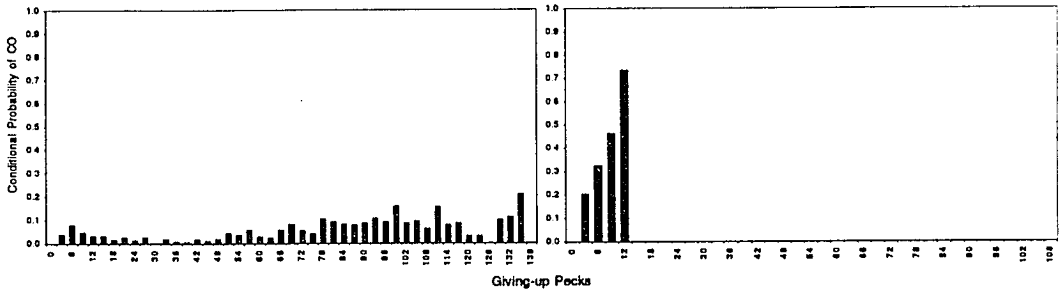
Single Reinforcer Visits

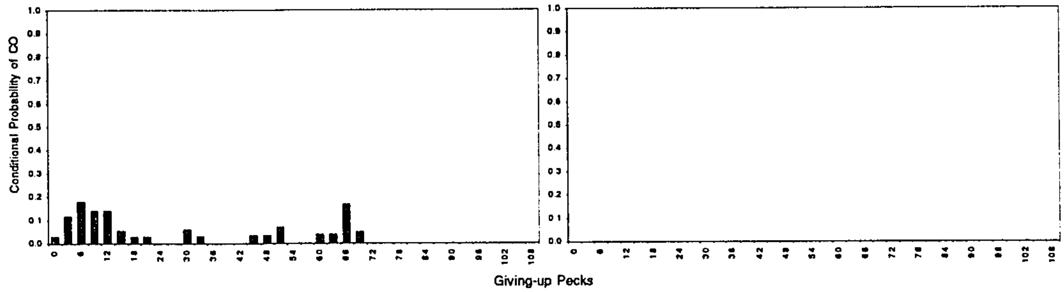


W36

Constant: 30/hr FRCO: 12 Variable: 7.5/hr


Non-reinforced visits

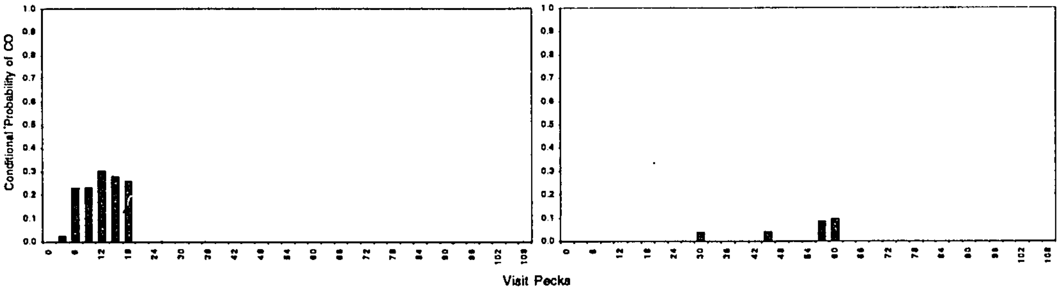

Single Reinforcer Visits


Multiple Reinforcer Visits

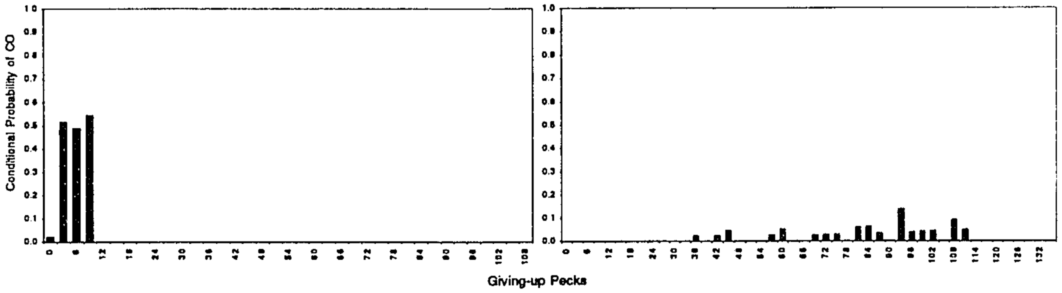
W36

Constant: 30/hr FRCO: 20 Variable: 120/hr

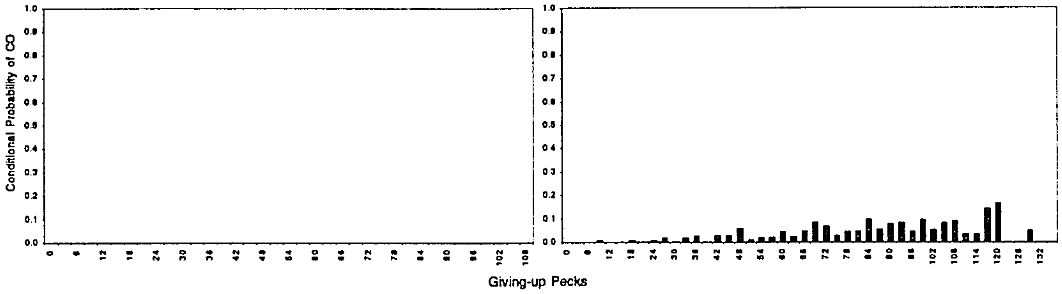
Non-reinforced visits



Single Reinforcer Visits

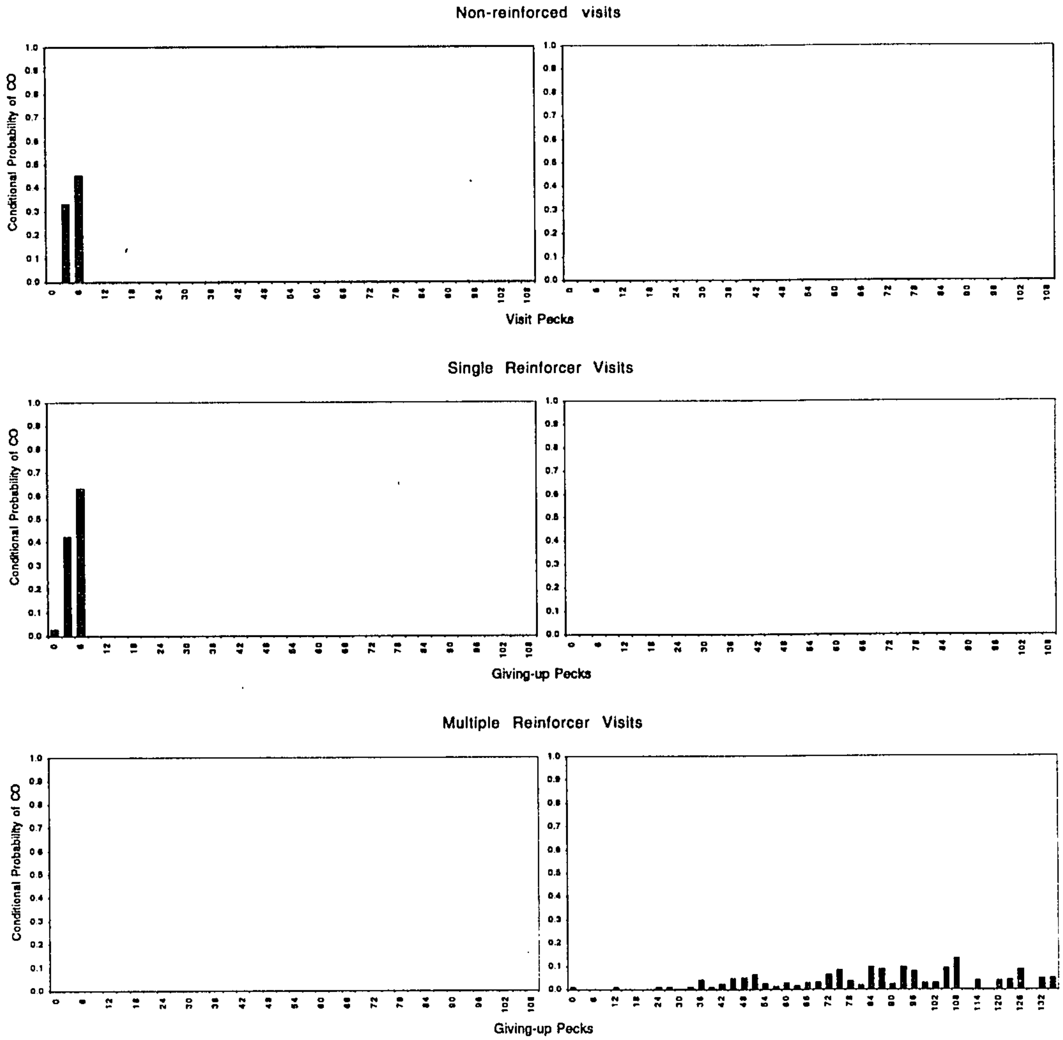


Multiple Reinforcer Visits

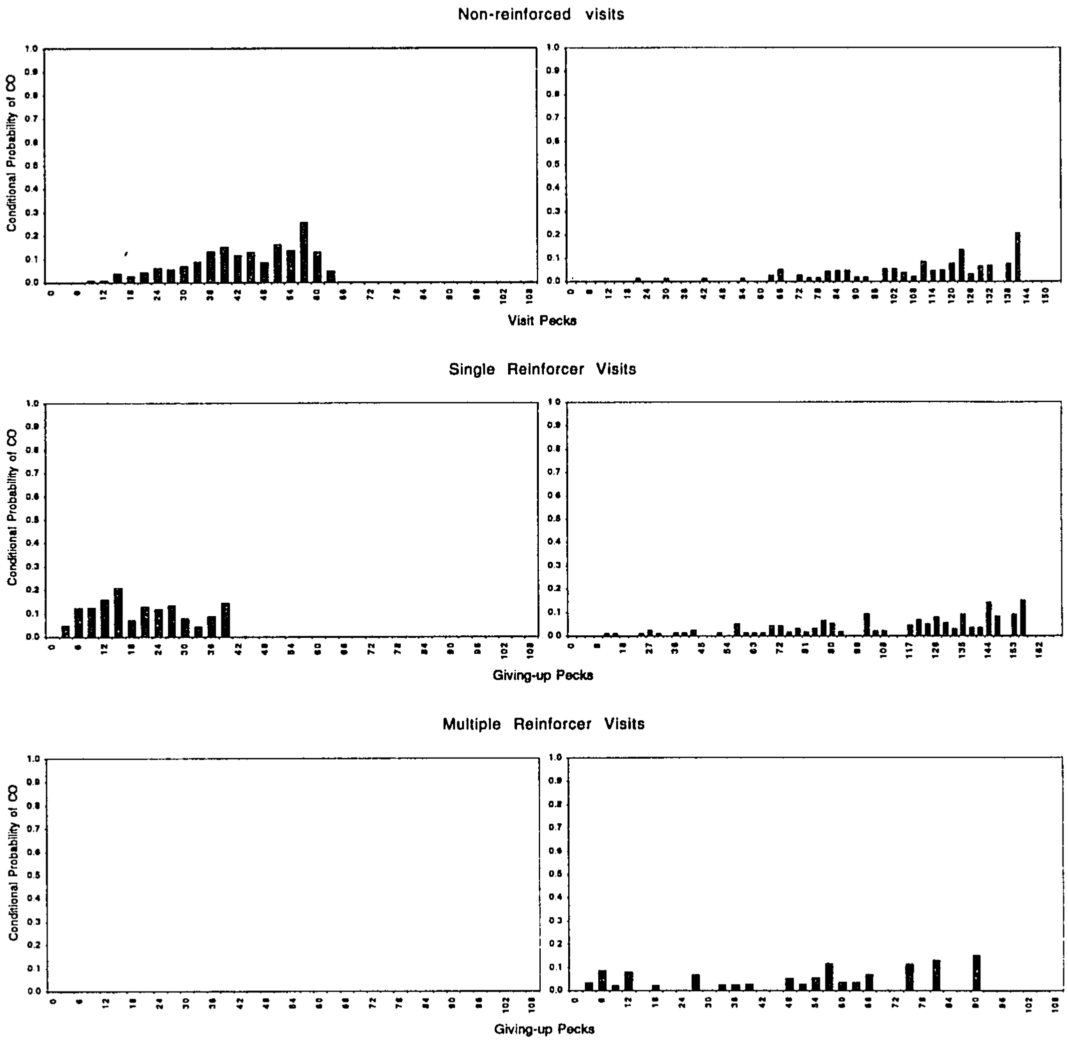


W36

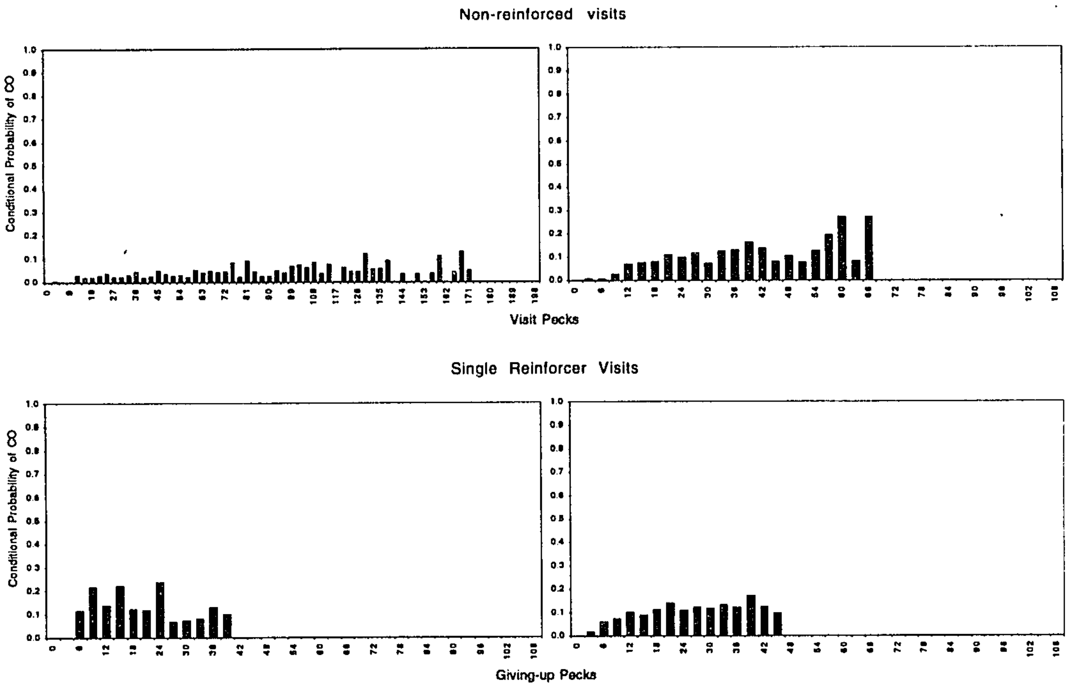
Constant: 30/hr FRCO: 20 R Variable: 120/hr



W36
Constant: 30/hr FRCO: 20 Variable: 60/hr

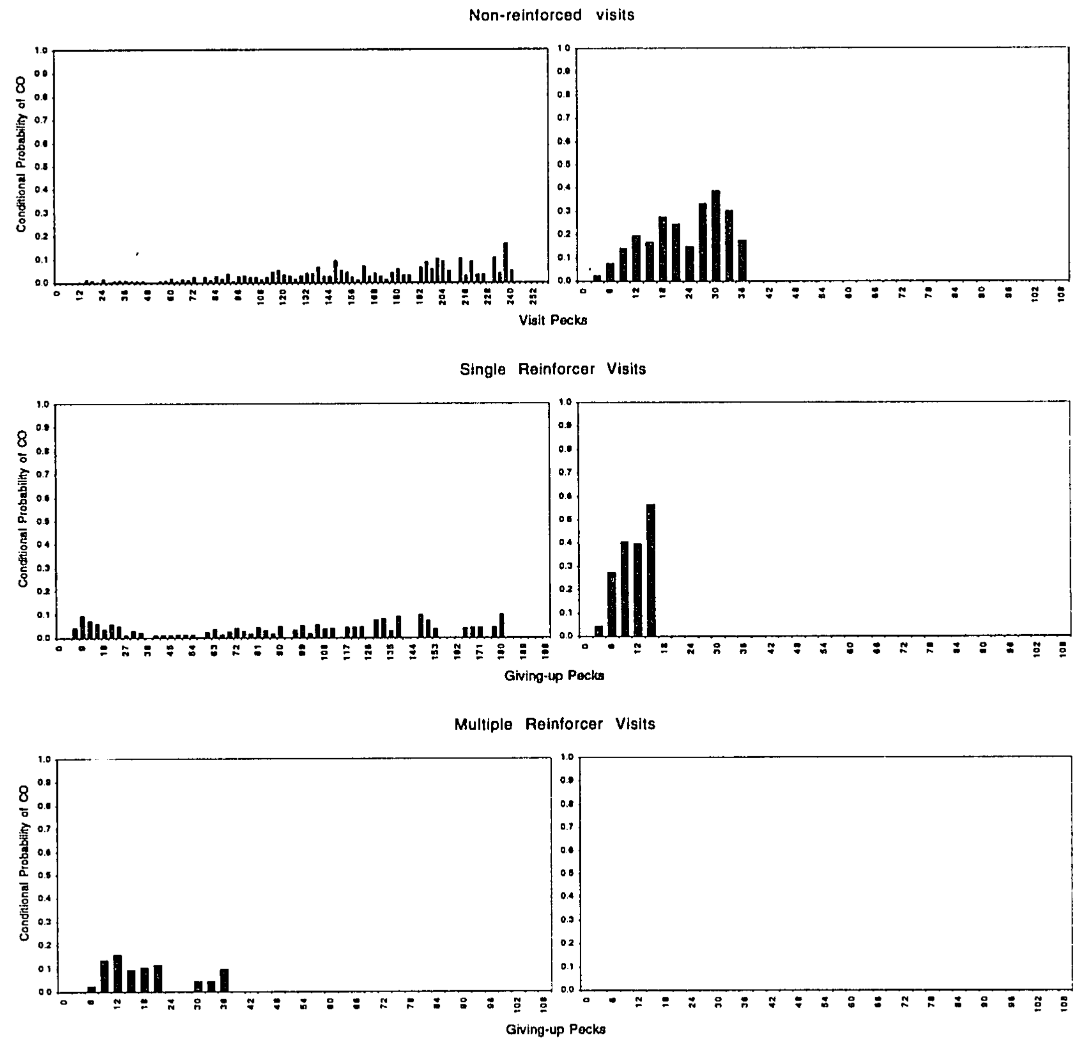


W36
Constant: 30/hr FRCO: 20 Variable: 30/hr



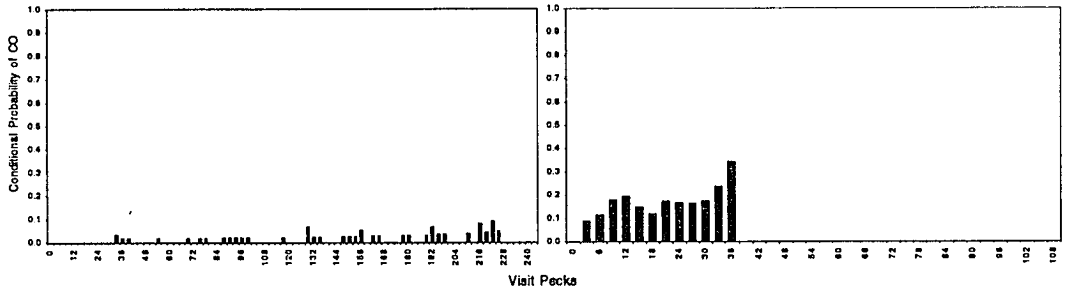
W36

Constant: 30/hr FRCO: 20 Variable: 15/hr

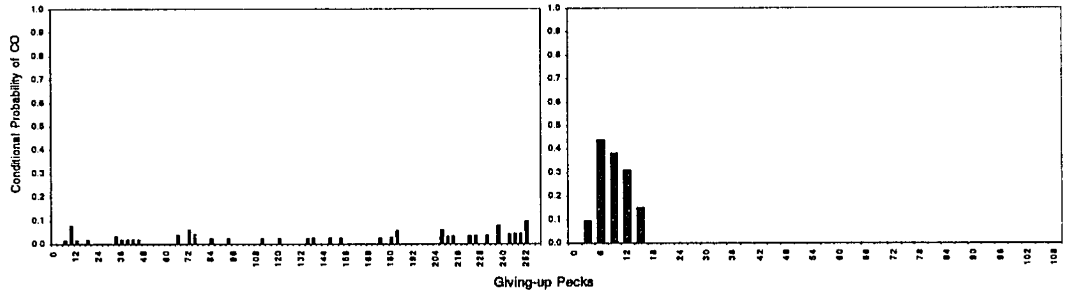


W36
Constant: 30/hr FROO: 20 Variable: 7.5/hr

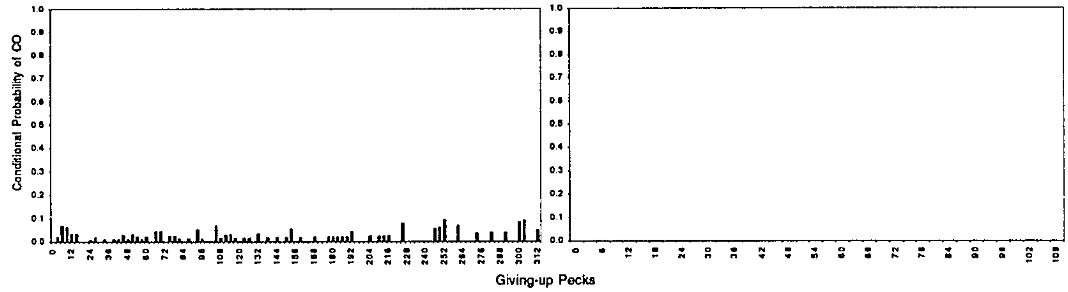
Non-reinforced visits



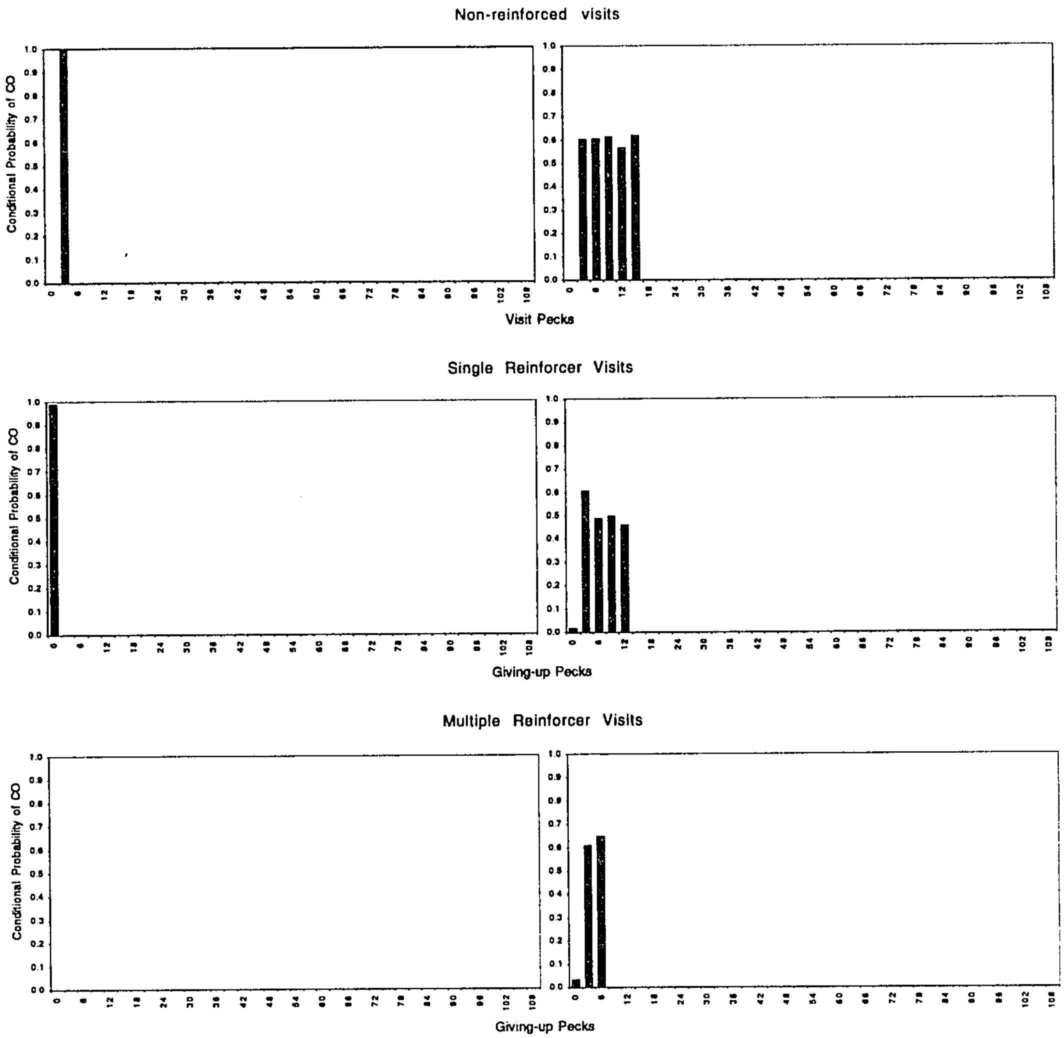
Single Reinforcer Visits



Multiple Reinforcer Visits



W37
Constant: 30/hr FRCO: 00 Variable: 120/hr


Non-reinforced visits

Single Reinforcer Visits

Multiple Reinforcer Visits

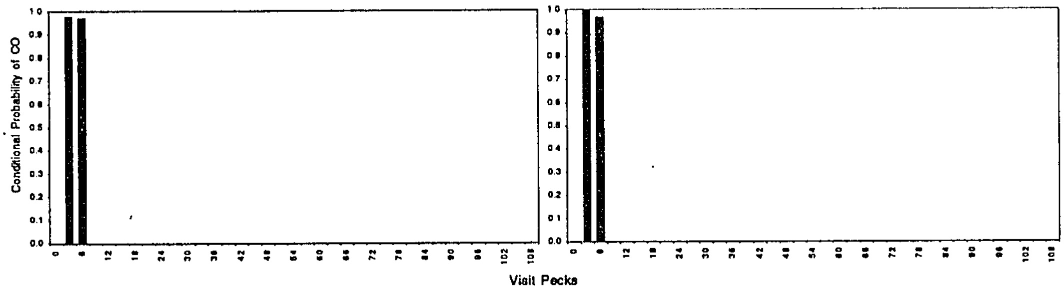
W37

Constant: 30/hr

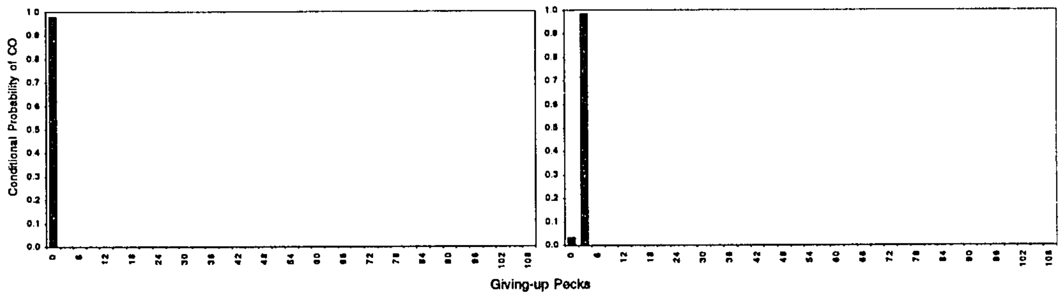
FRCO: 00

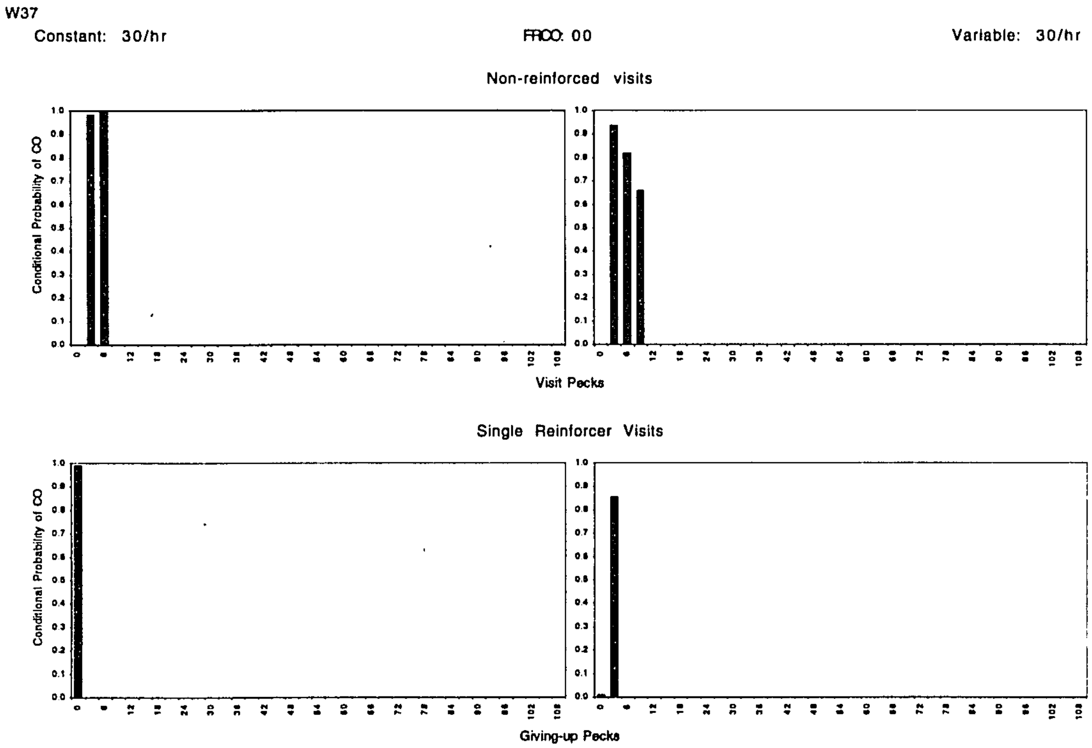
Variable: 60/hr

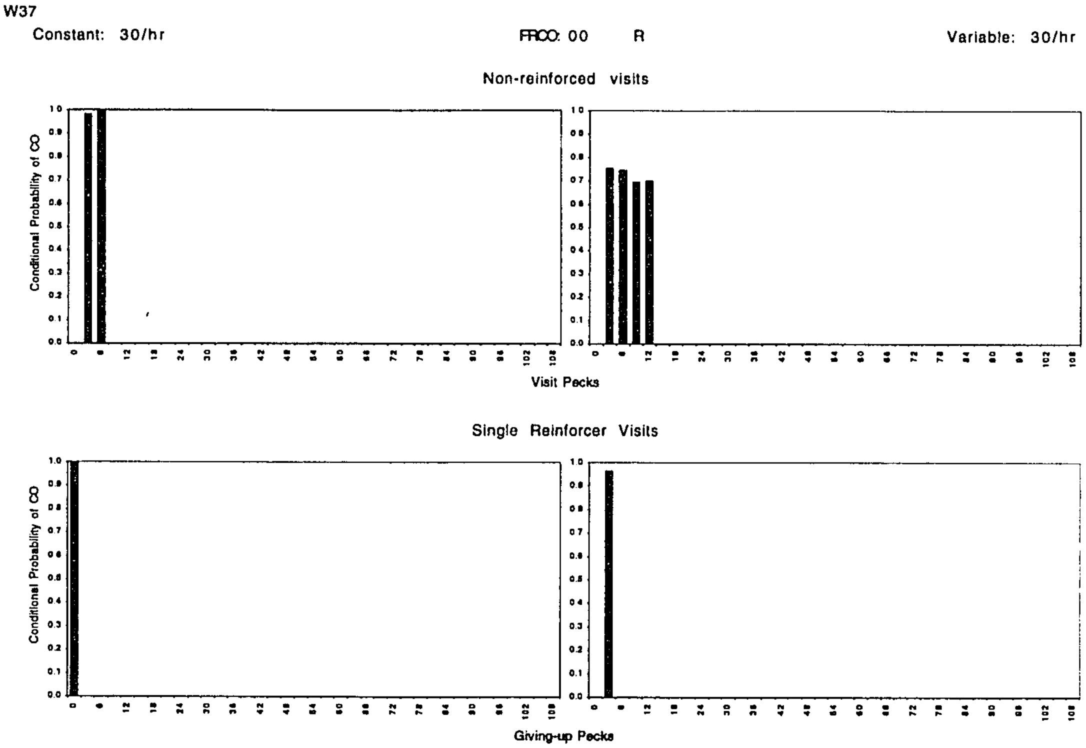
Non-reinforced visits



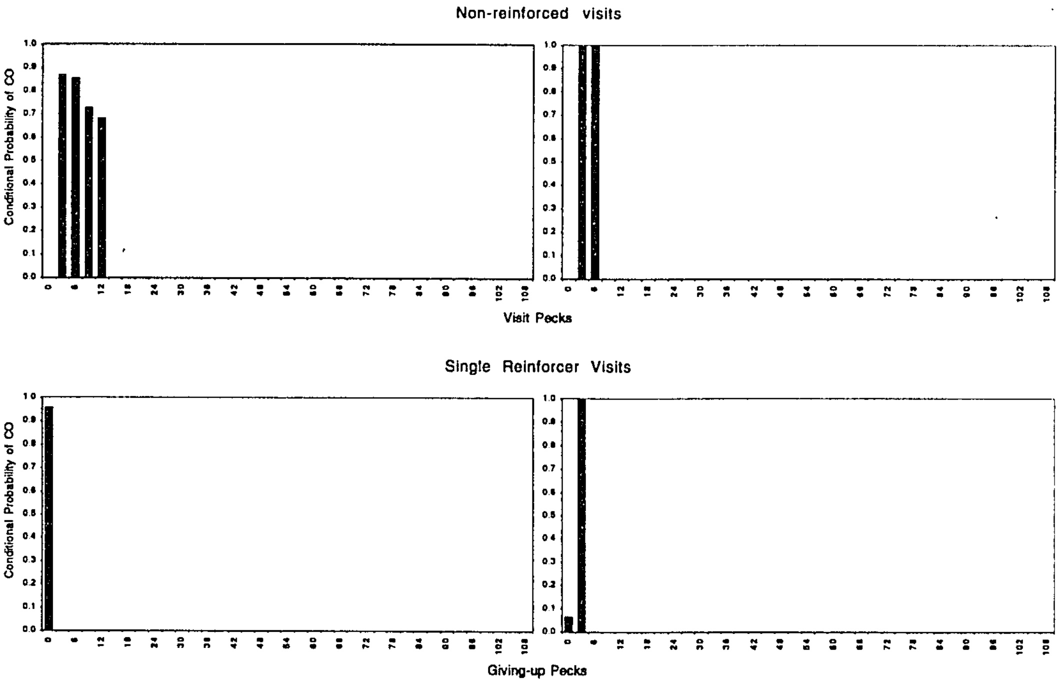
Single Reinforcer Visits

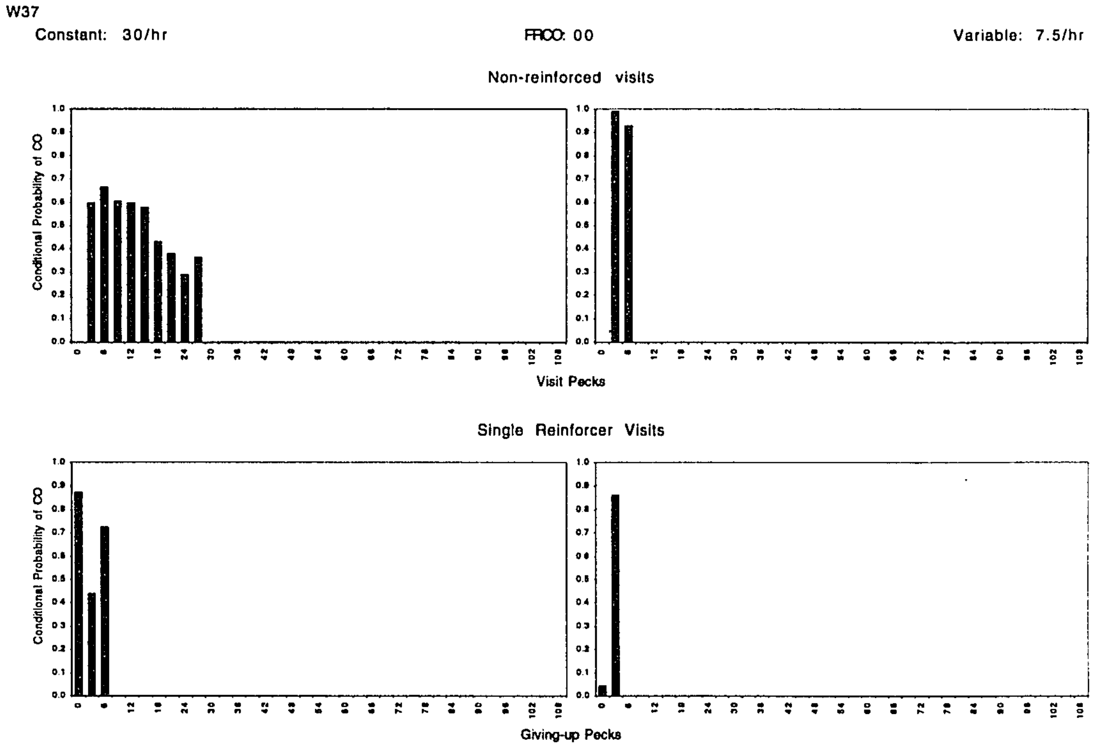



W37
Constant: 30/hr
FRCO: 00
Variable: 30/hr
Non-reinforced visits
Conditional Probability of CO
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
6
12
18
24
30
36
42
48
54
60
66
72
78
84
90
96
102
108
Visit Pecks
Single Reinforcer Visits
Giving-up Pecks


W37
Constant: 30/hr
FRCO: 00 R
Variable: 30/hr
Non-reinforced visits
Conditional Probability of CO
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
6
12
18
24
30
36
42
48
54
60
66
72
78
84
90
96
102
108
Visit Pecks
Single Reinforcer Visits
Giving-up Pecks

W37
Constant: 30/hr FRCO: 00 Variable: 15/hr

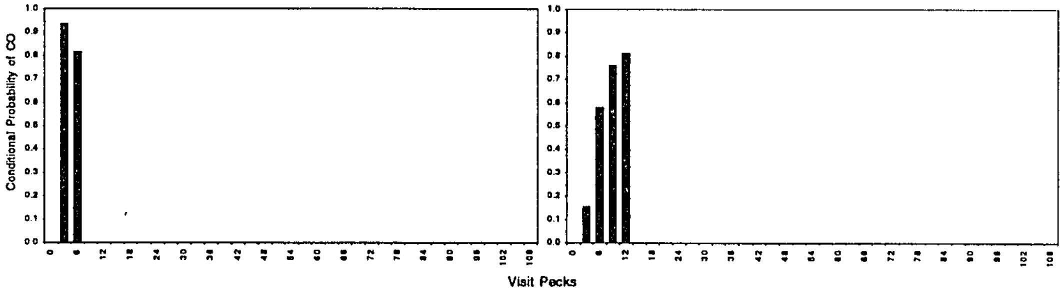



W37
Constant: 30/hr
FRCO: 00
Variable: 7.5/hr
Non-reinforced visits
Conditional Probability of CO
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
6
12
18
24
30
36
42
48
54
60
66
72
78
84
90
96
102
108
Visit Pecks
Single Reinforcer Visits
Giving-up Pecks

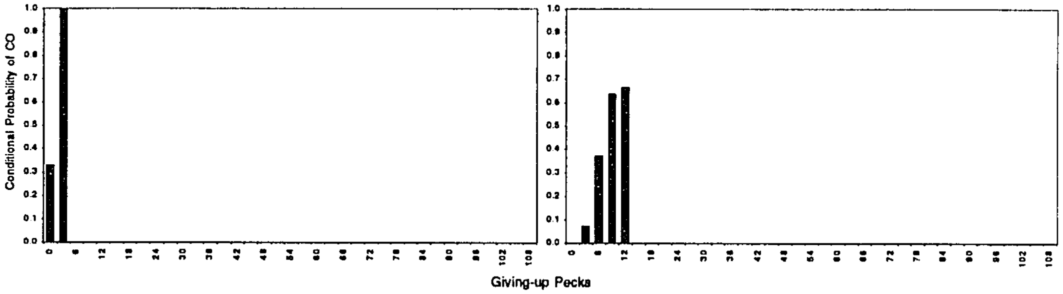
W37

Constant: 30/hr FRCO: 02 Variable: 120/hr

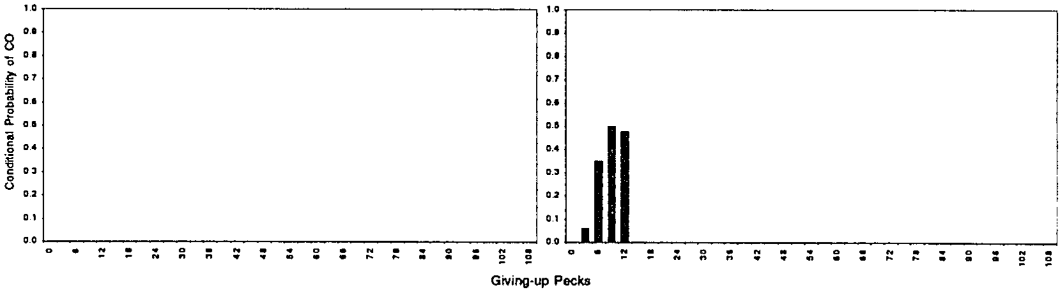
Non-reinforced visits



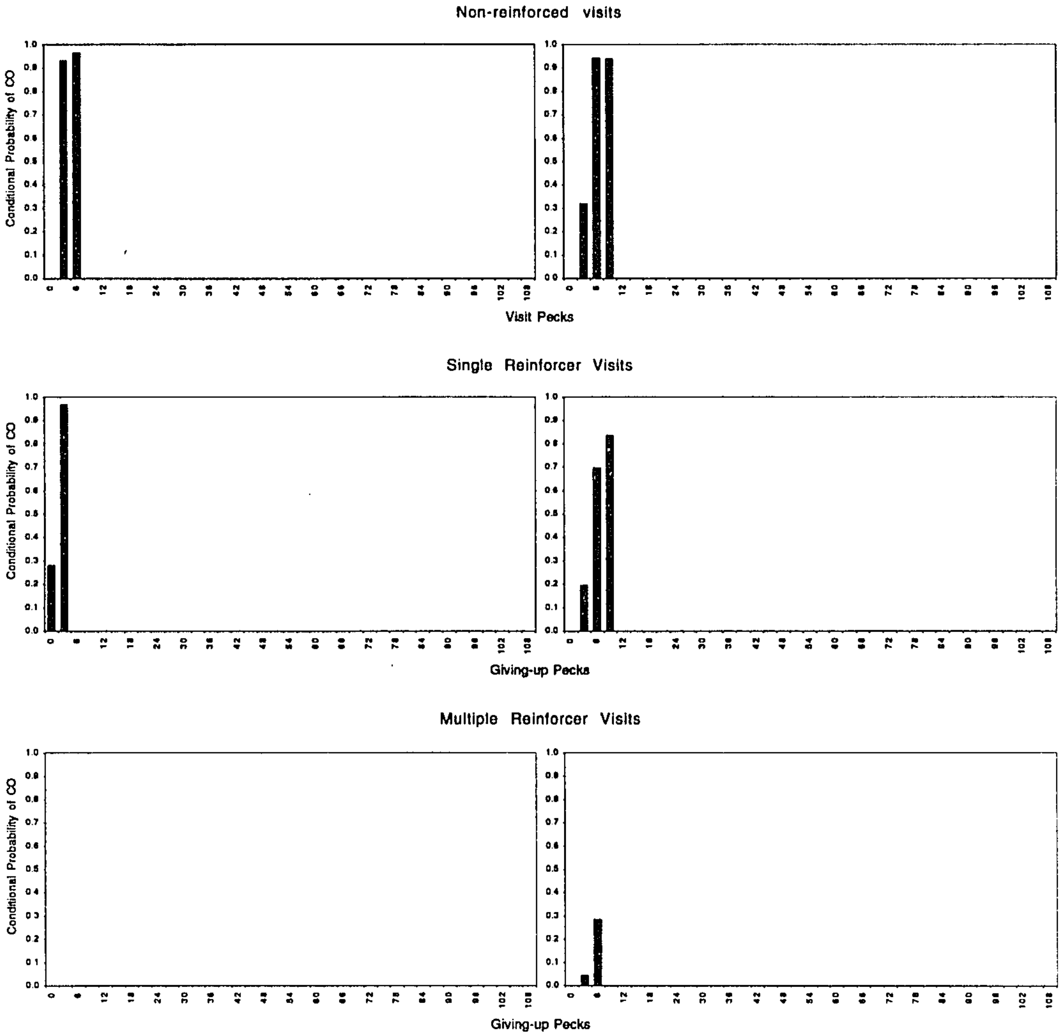
Single Reinforcer Visits



Multiple Reinforcer Visits



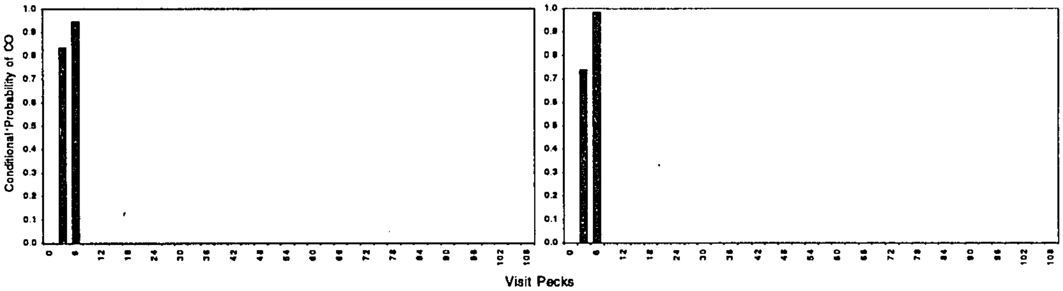
W37
Constant: 30/hr FRCO: 02 Variable: 60/hr



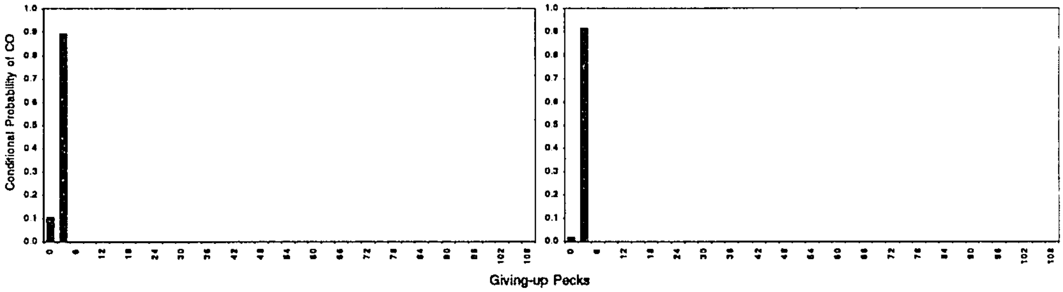
W37

Constant: 30/hr FRCO: 02 Variable: 30/hr

Non-reinforced visits



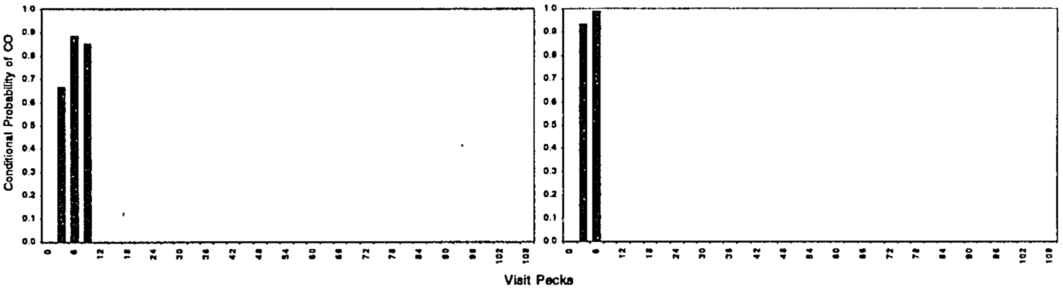
Single Reinforcer Visits



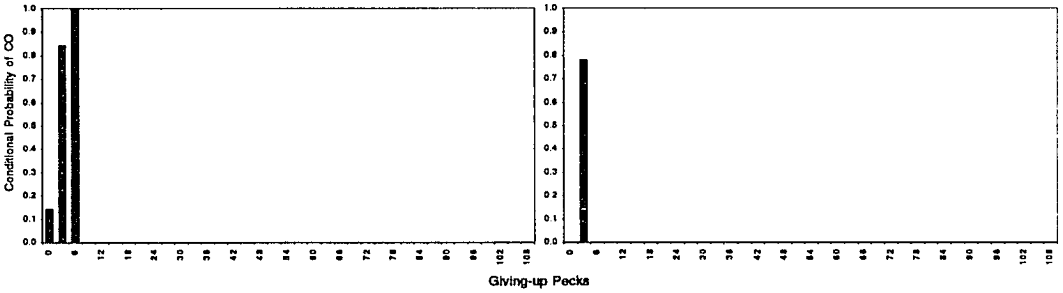
W37

Constant: 30/hr FRCO: 02 Variable: 15/hr

Non-reinforced visits



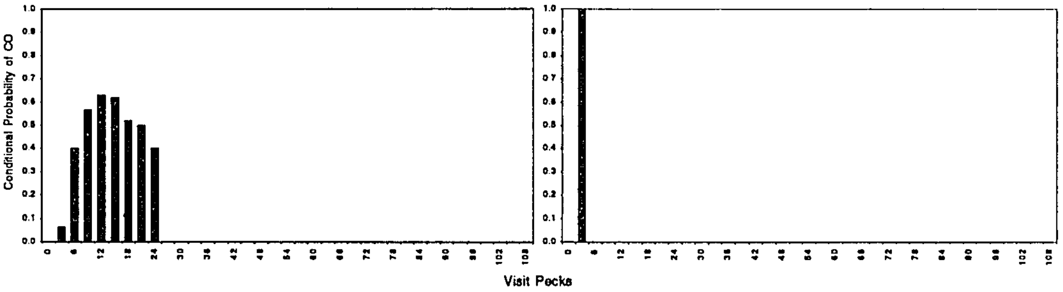
Single Reinforcer Visits



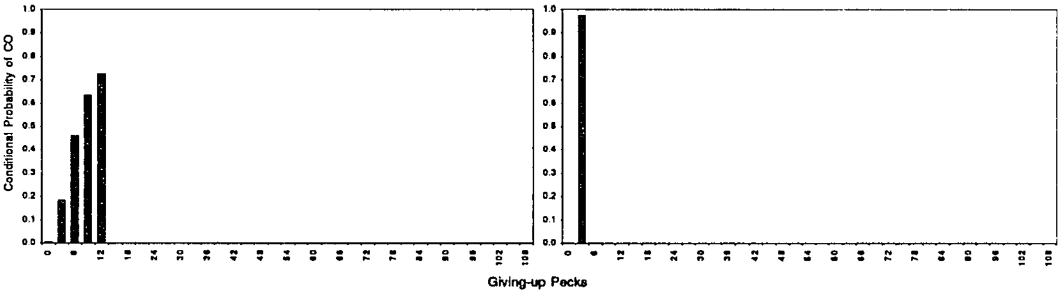
W37

Constant: 30/hr FRCO: 02 Variable: 7.5/hr

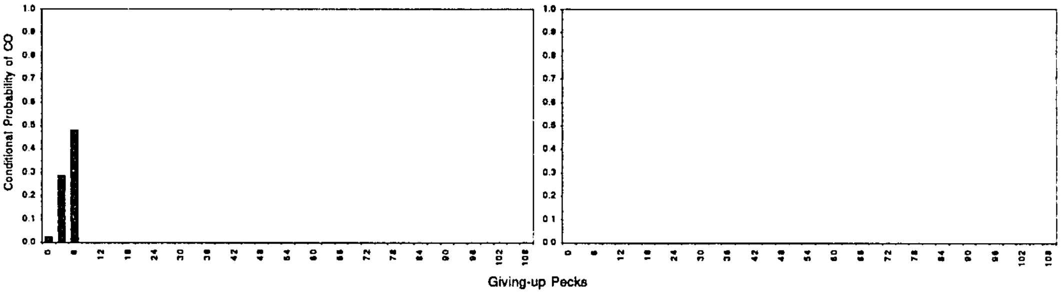
Non-reinforced visits



Single Reinforcer Visits



Multiple Reinforcer Visits



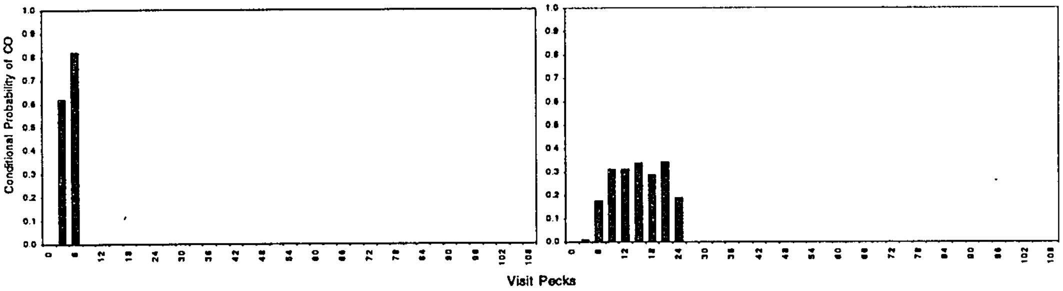
W37

Constant: 30/hr

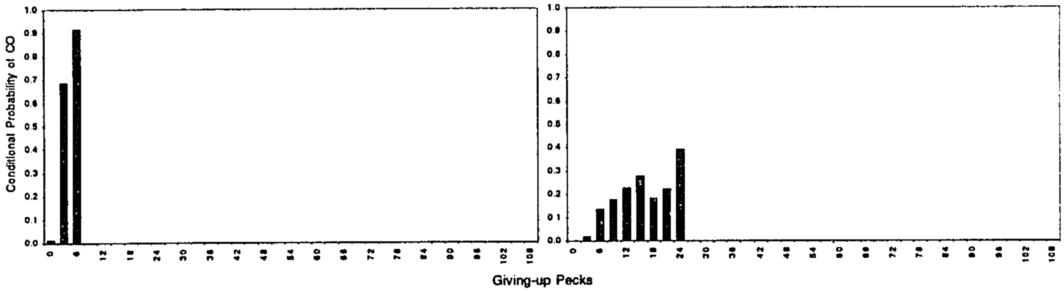
FRCO: 06

Variable: 120/hr

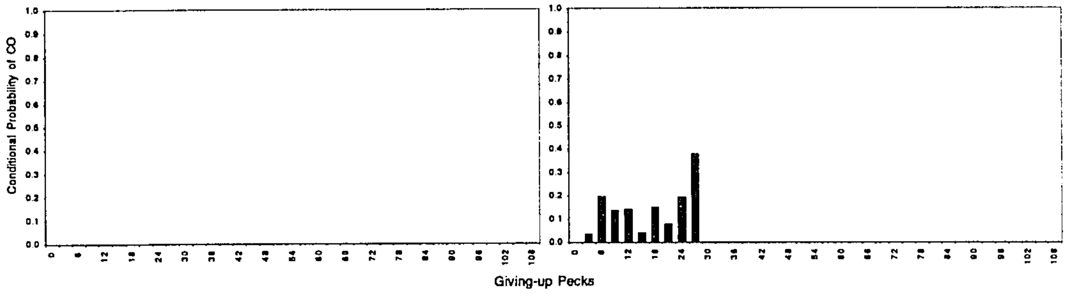
Non-reinforced visits



Single Reinforcer Visits

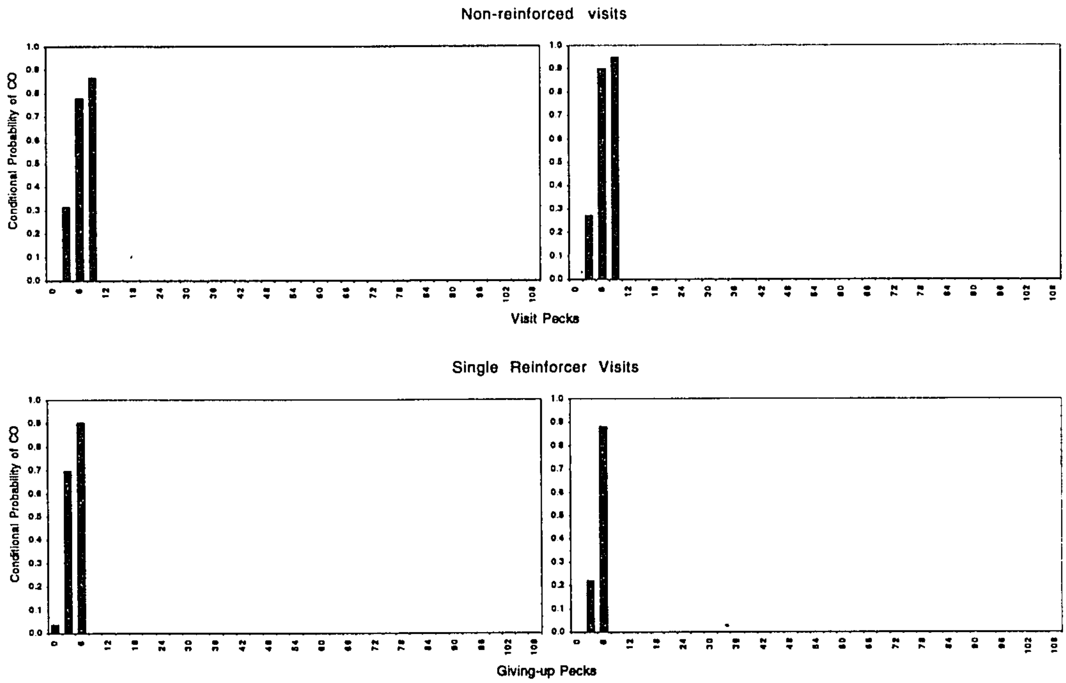


Multiple Reinforcer Visits

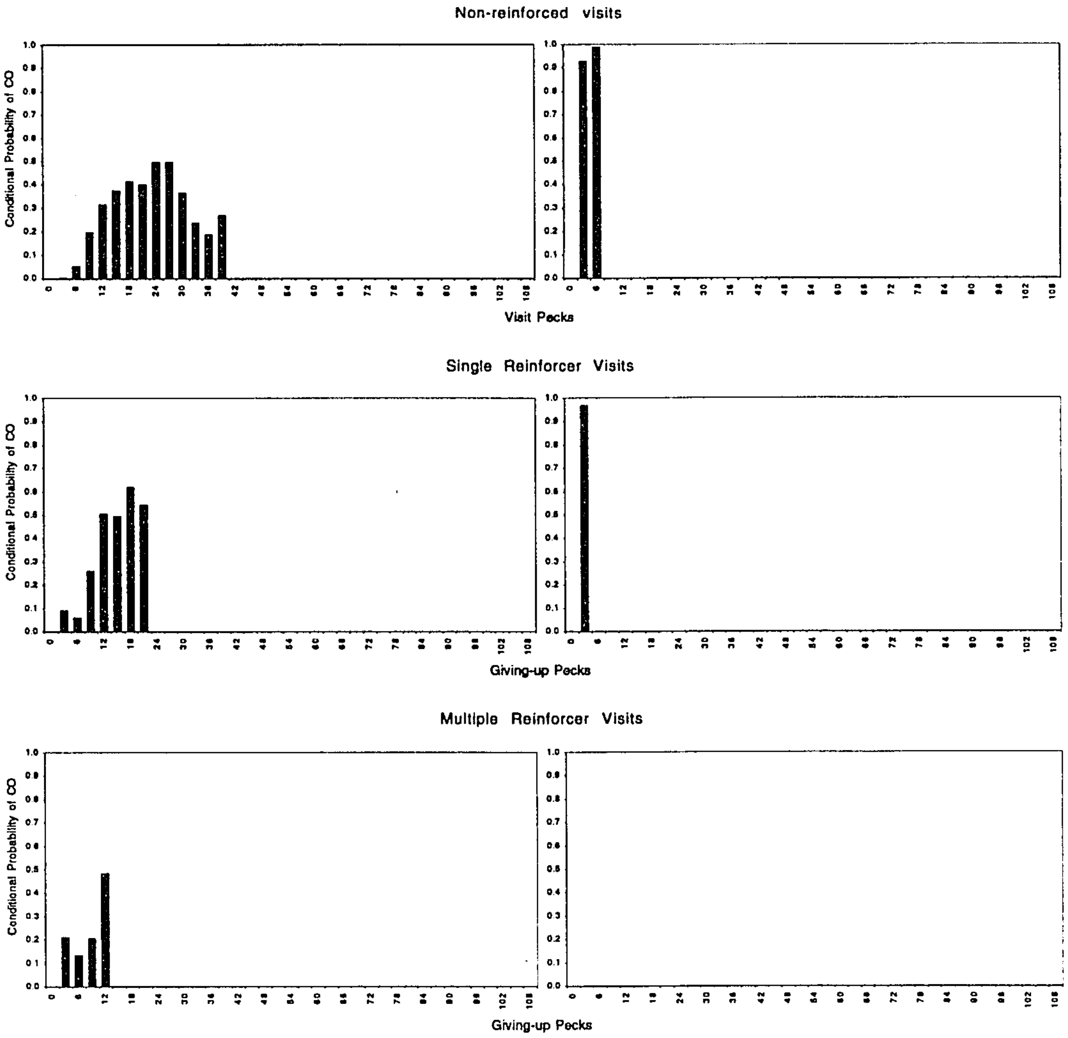


W37

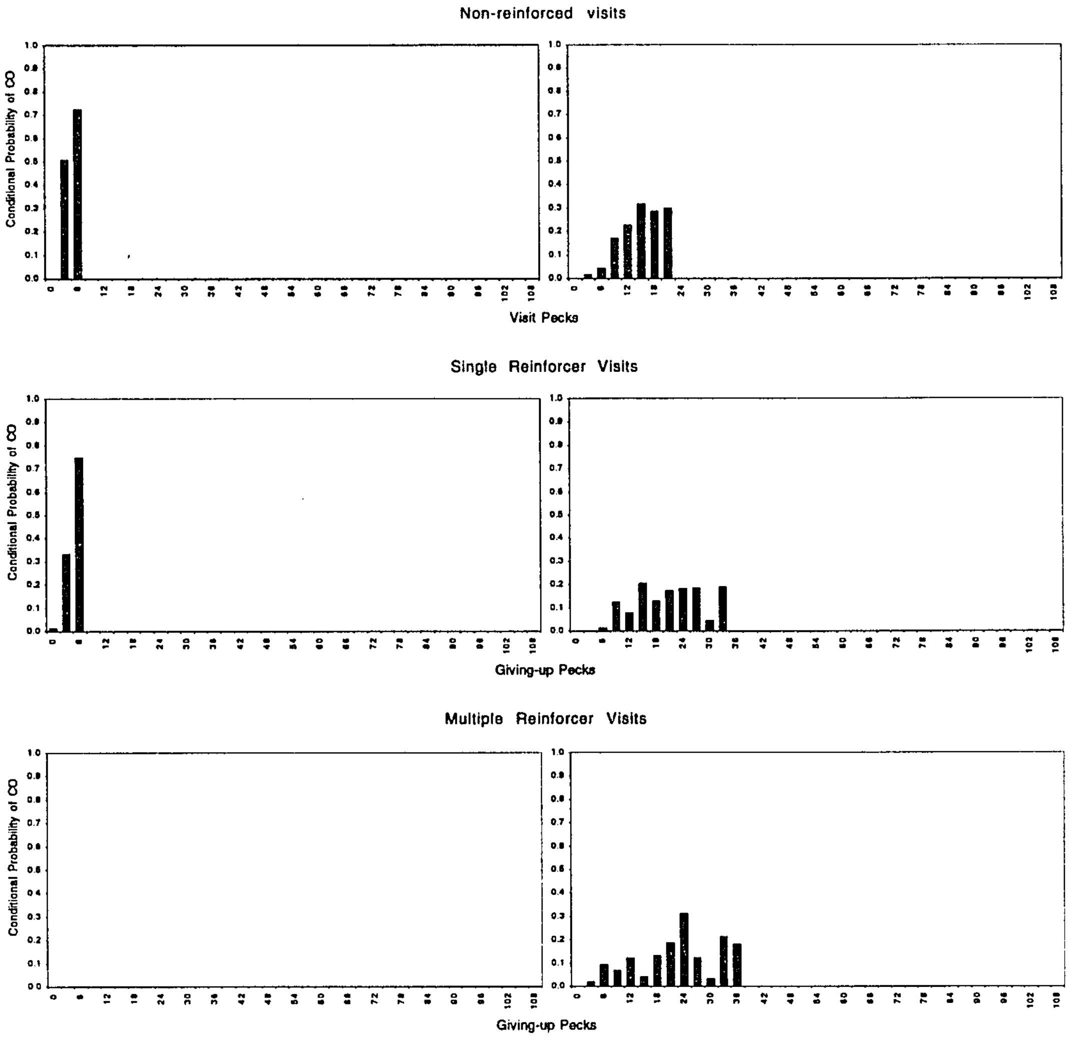
Constant: 30/hr FRCO: 06 Variable: 30/hr



W37
Constant: 30/hr FRCO: 06 Variable: 7.5/hr

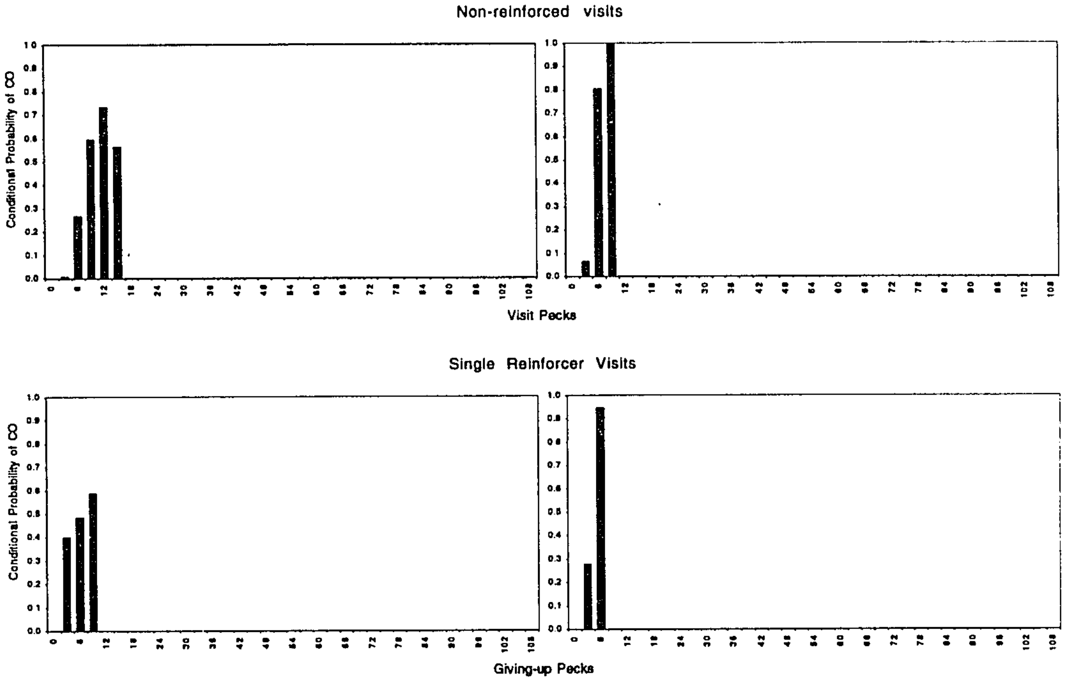


W37
Constant: 30/hr FRCO: 12 Variable: 120/hr



W37

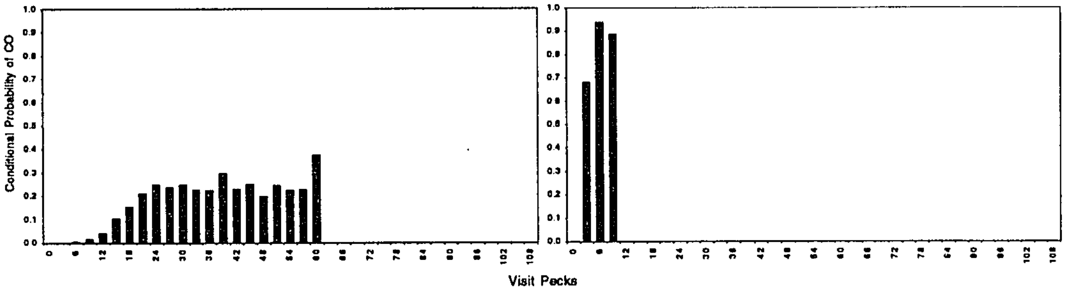
Constant: 30/hr FRCO: 12 Variable: 30/hr



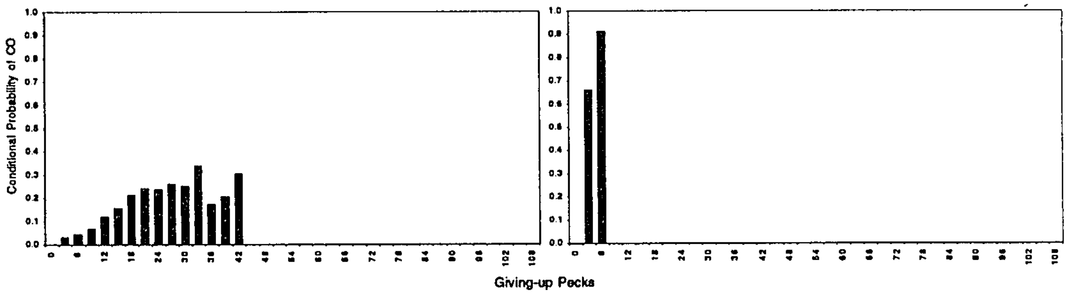
W37

Constant: 30/hr FRCO: 12 Variable: 7.5/hr

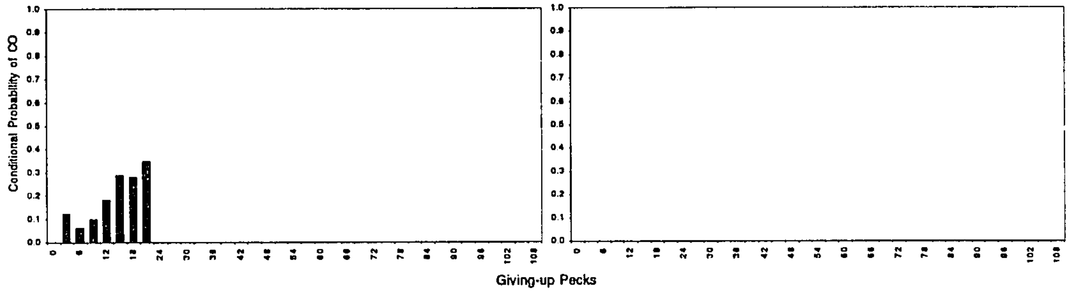
Non-reinforced visits



Single Reinforcer Visits



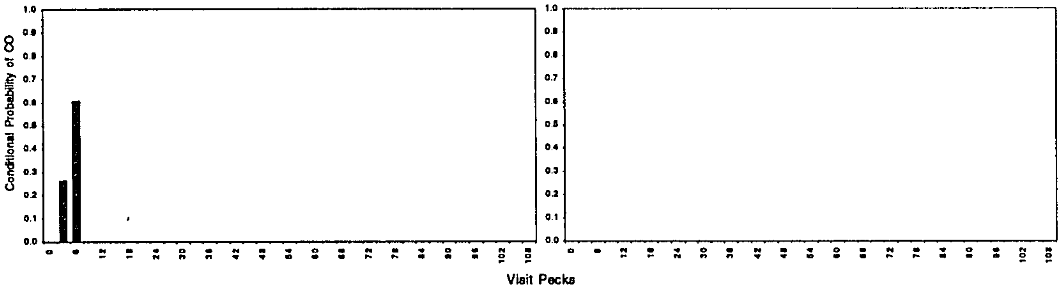
Multiple Reinforcer Visits



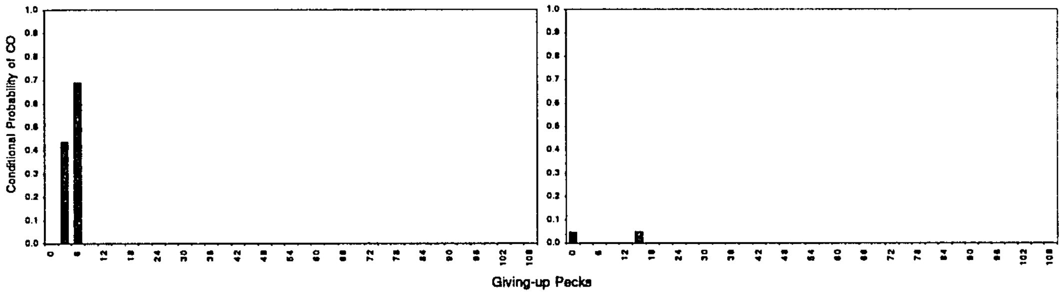
W37

Constant: 30/hr FROO: 20 Variable: 120/hr

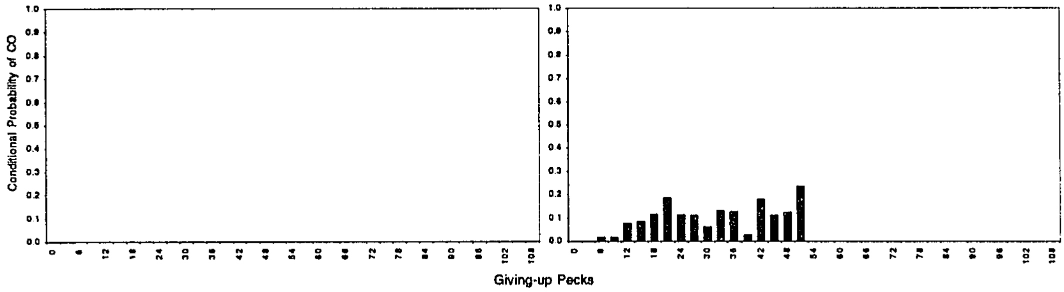
Non-reinforced visits



Single Reinforcer Visits



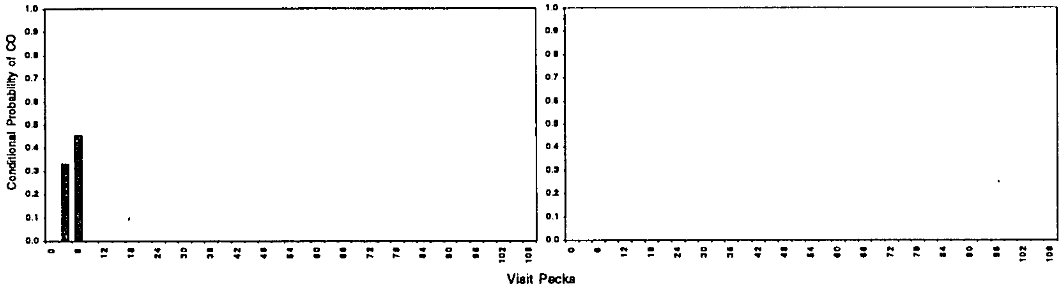
Multiple Reinforcer Visits



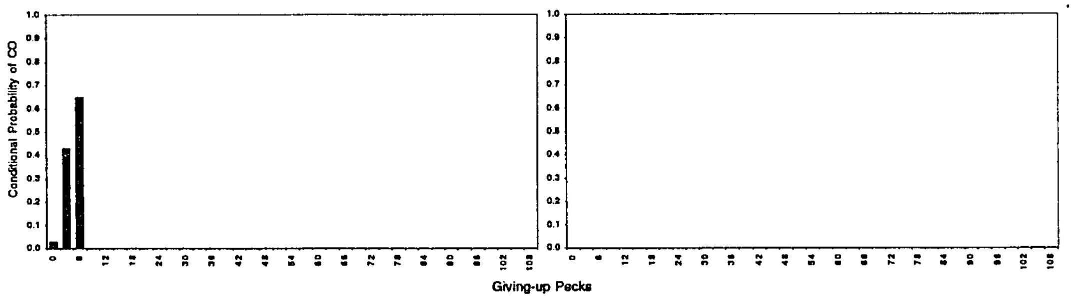
W37

Constant: 30/hr FRCO: 20 R Variable: 120/hr

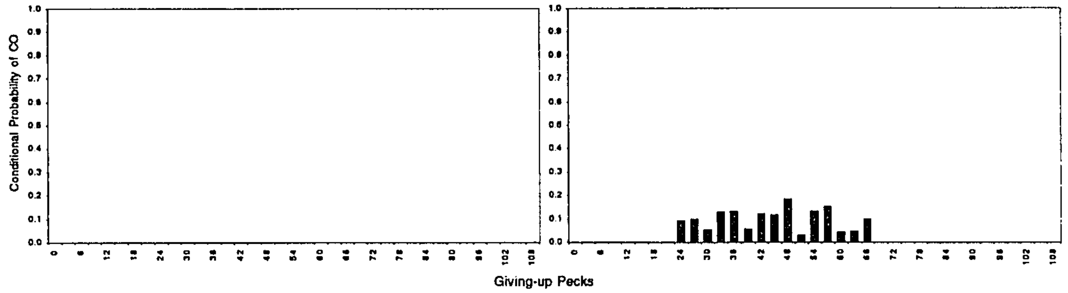
Non-reinforced visits



Single Reinforcer Visits



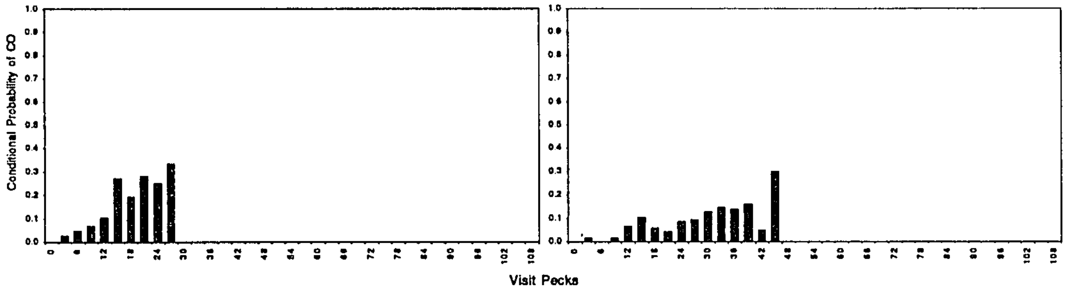
Multiple Reinforcer Visits



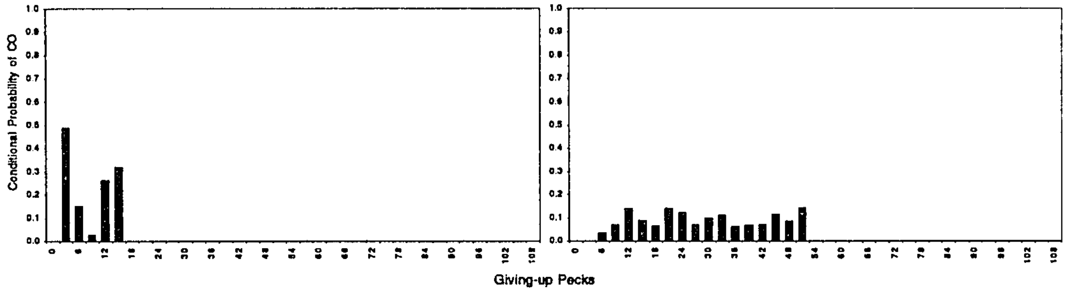
W37

Constant: 30/hr FRCO: 20 Variable: 60/hr

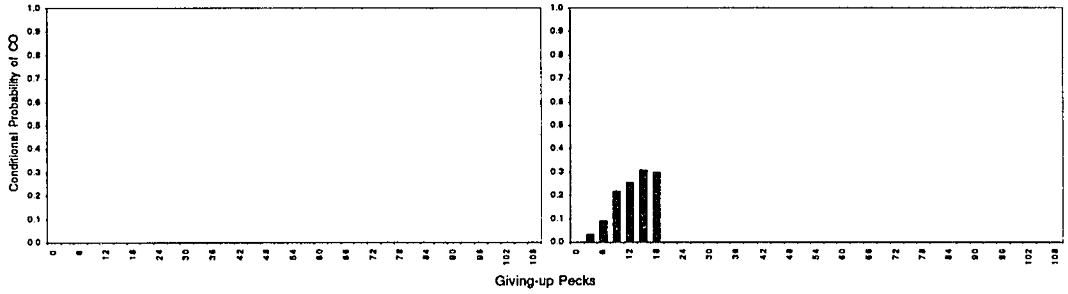
Non-reinforced visits



Single Reinforcer Visits



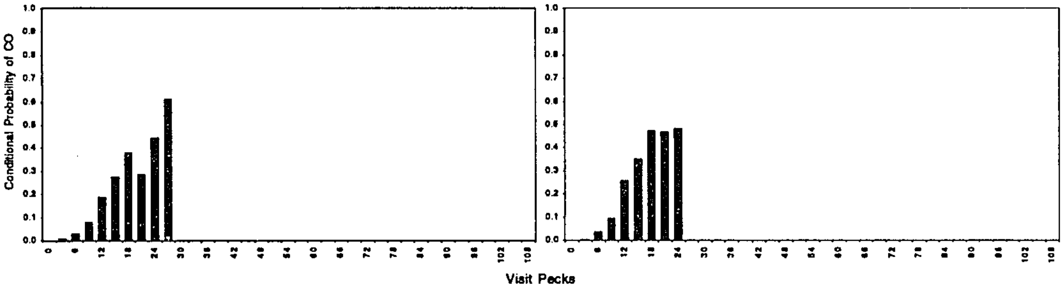
Multiple Reinforcer Visits



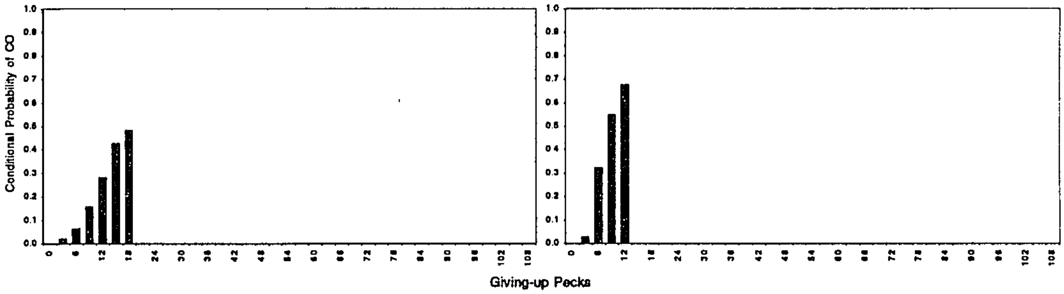
W37

Constant: 30/hr FRCO: 20 Variable: 30/hr

Non-reinforced visits



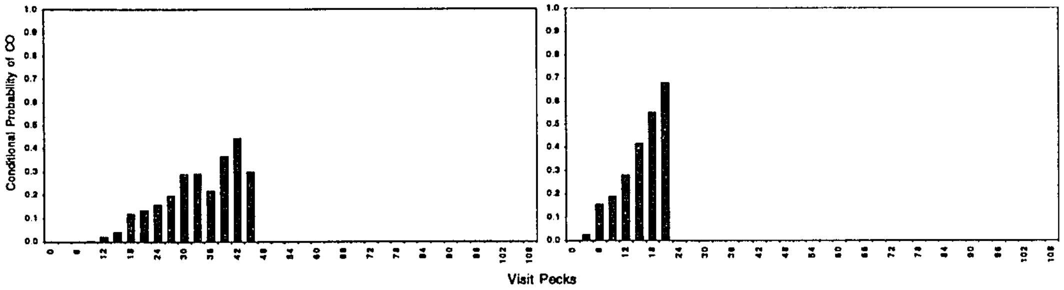
Single Reinforcer Visits



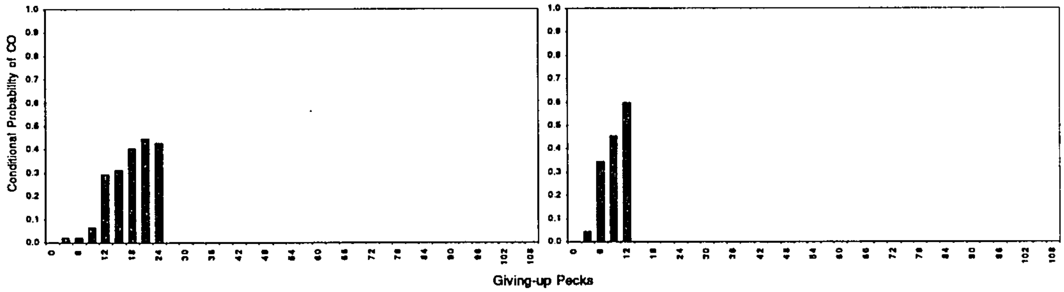
W37

Constant: 30/hr FRCO: 20 Variable: 15/hr

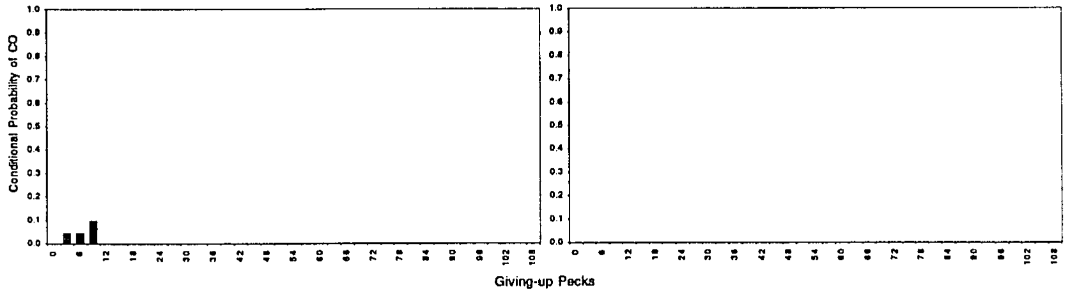
Non-reinforced visits

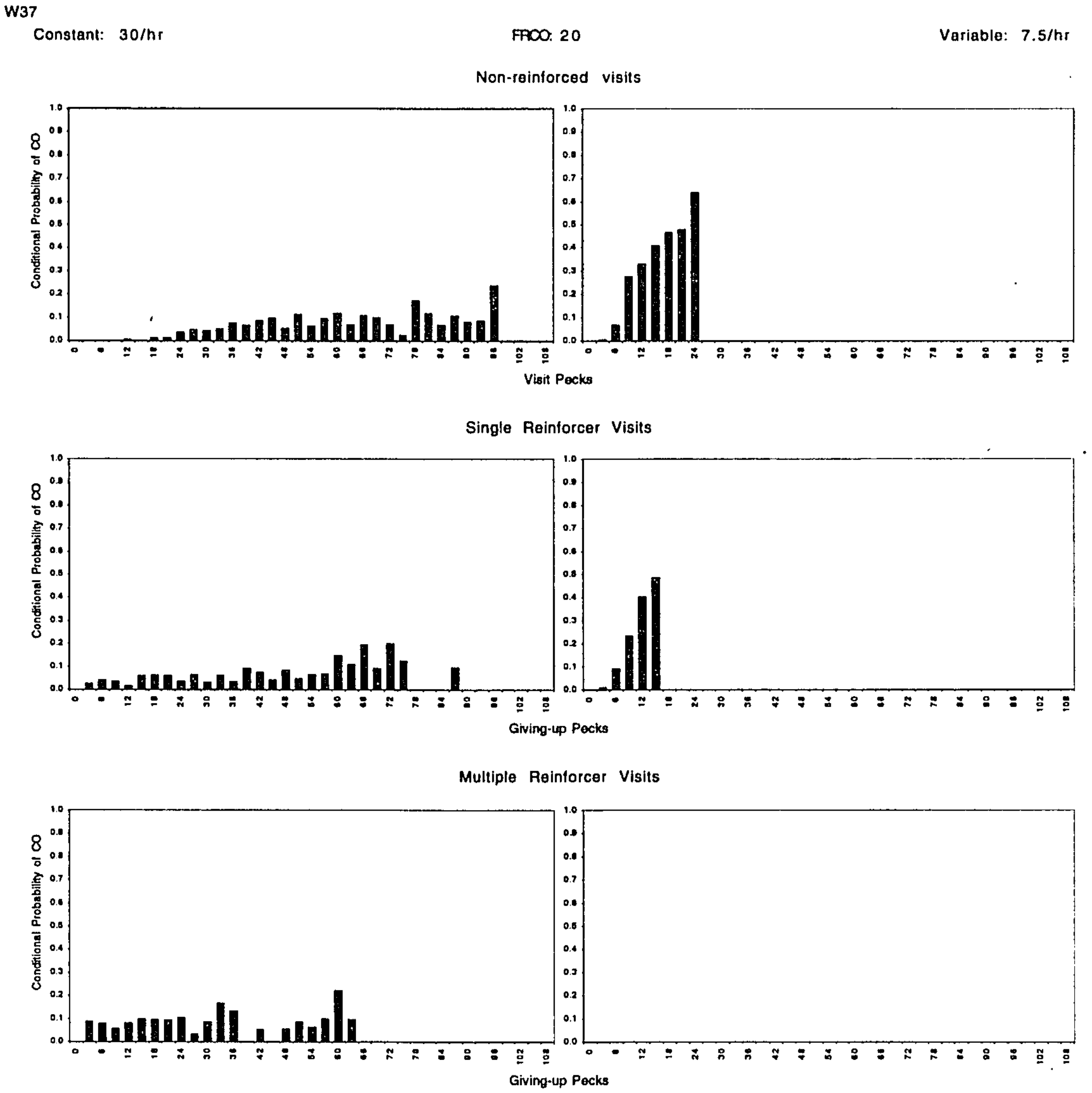


Single Reinforcer Visits

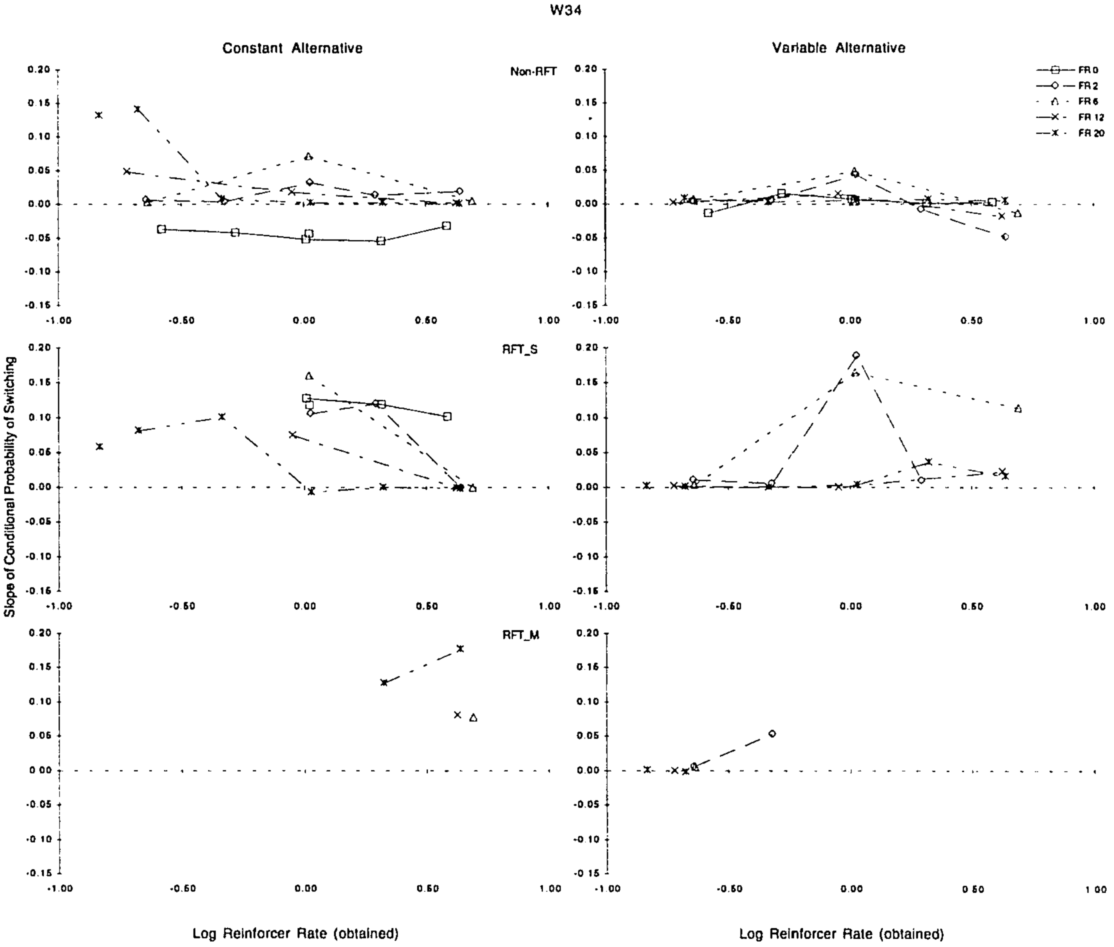


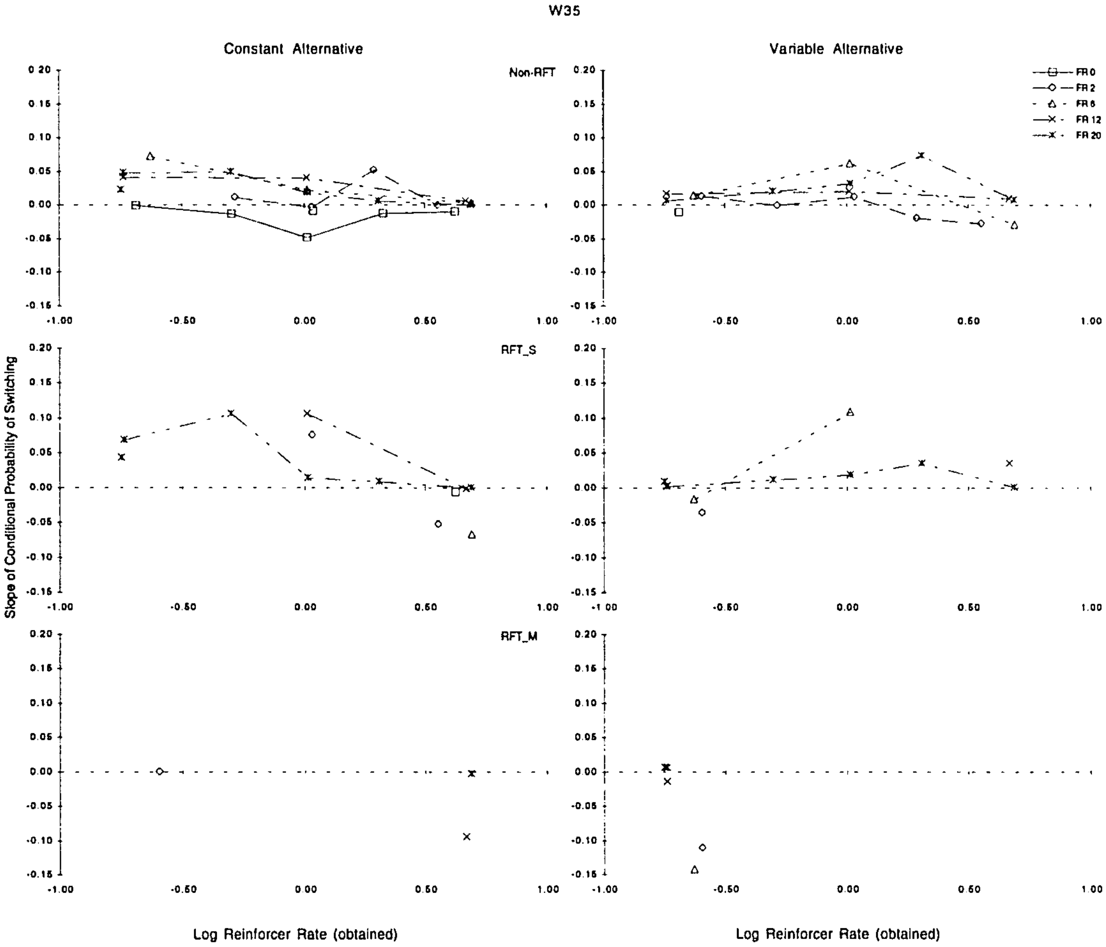
Multiple Reinforcer Visits

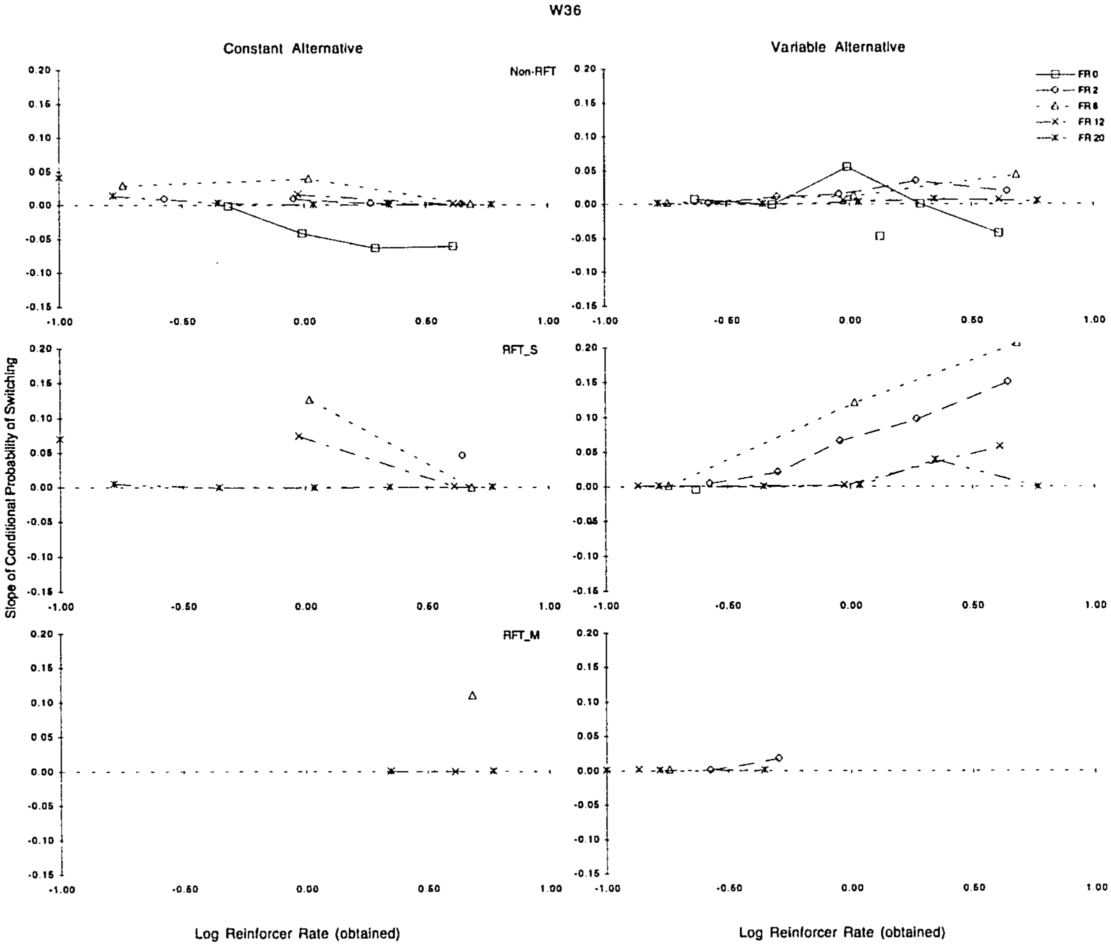


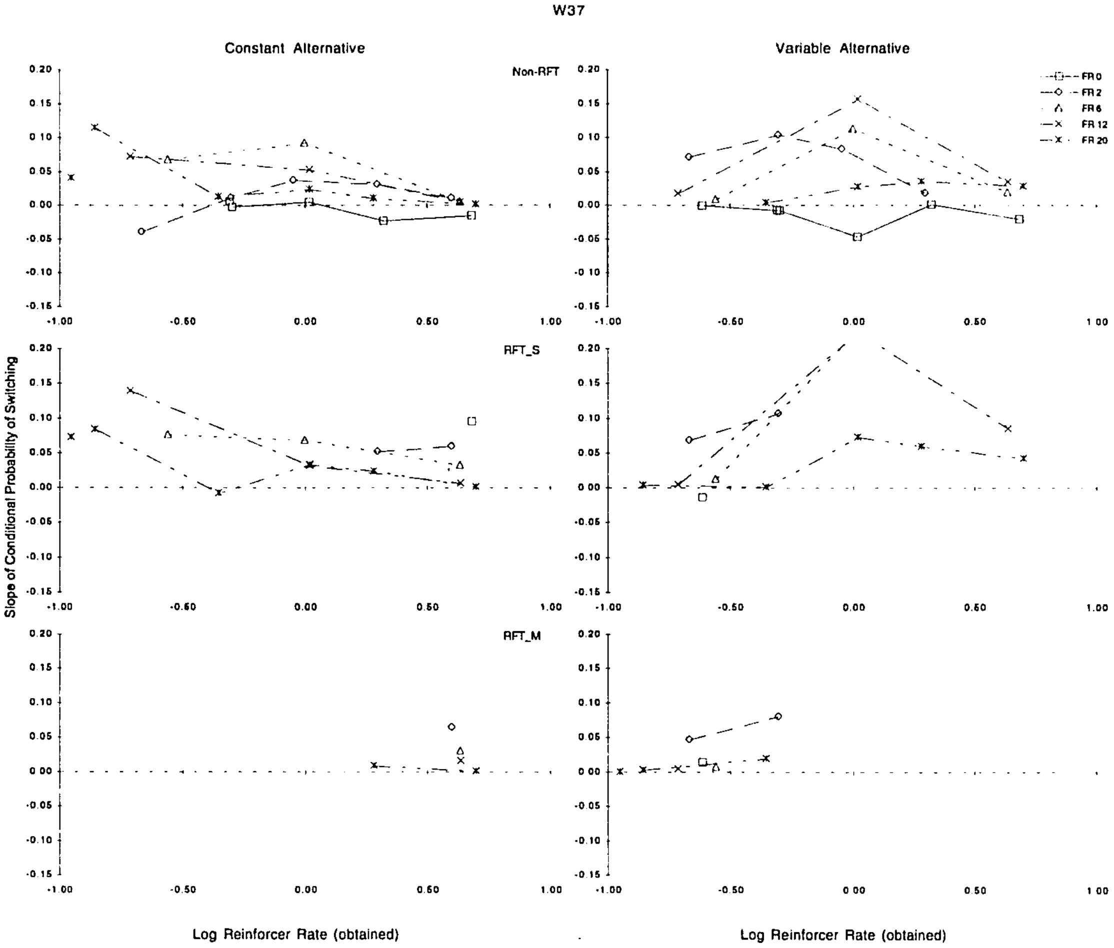

W37
Constant: 30/hr
FRCO: 20
Variable: 7.5/hr
Non-reinforced visits
Conditional Probability of CO
Visit Pecks
Single Reinforcer Visits
Conditional Probability of CO
Giving-up Pecks
Multiple Reinforcer Visits
Conditional Probability of CO
Giving-up Pecks
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
0
6
12
18
24
30
36
42
48
54
60
66
72
78
84
90
96
102
108

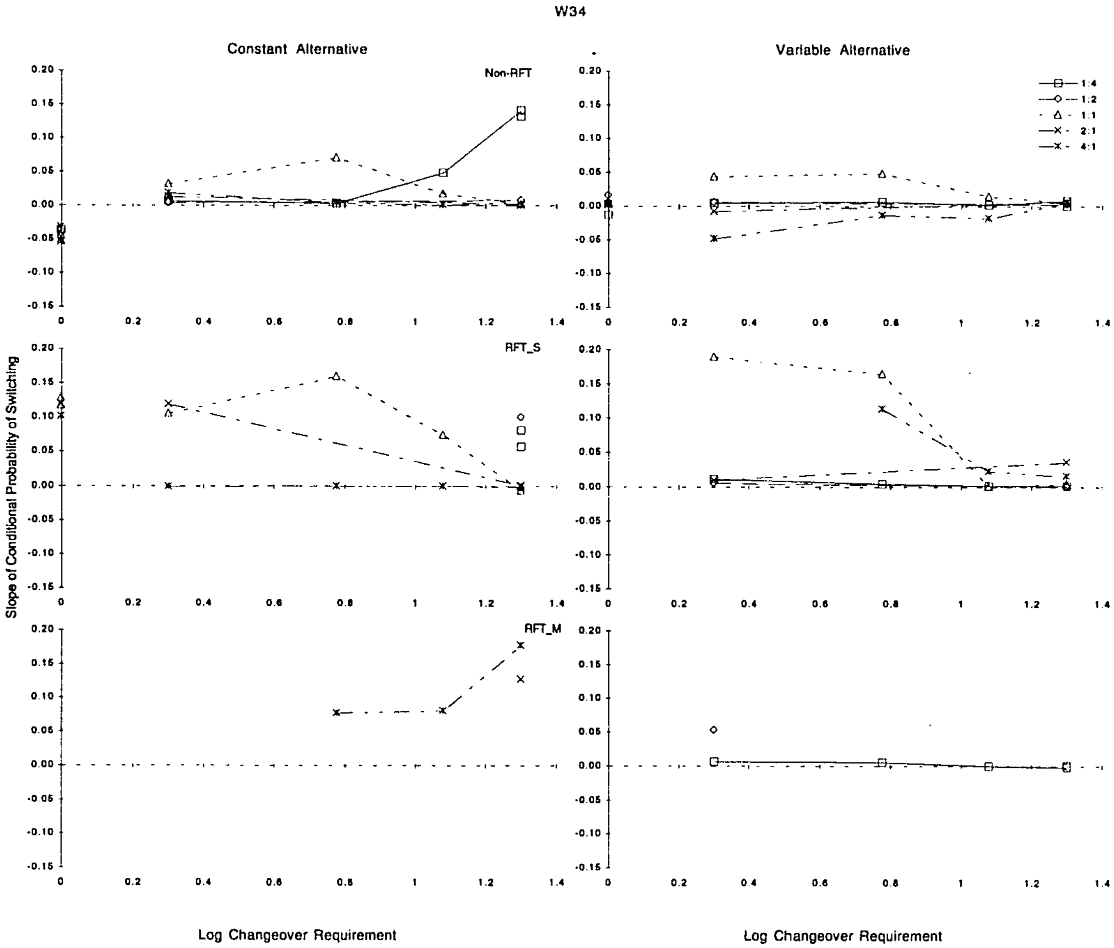
The following eight figures present summaries of data presented in the immediately prior figures. Slopes, derived using least-squares linear regression and excluding the 0-peck bin, for each conditional probability of switching distribution are plotted as a function of log reinforcer rate (obtained; first four figures) and log changeover requirement (last four figures). As in the prior analysis, slopes were categorized by non-reinforced, single reinforcer, or multiple reinforcer (on some figures) visits (rows) and left (left panels) and right (right panels) alternatives.

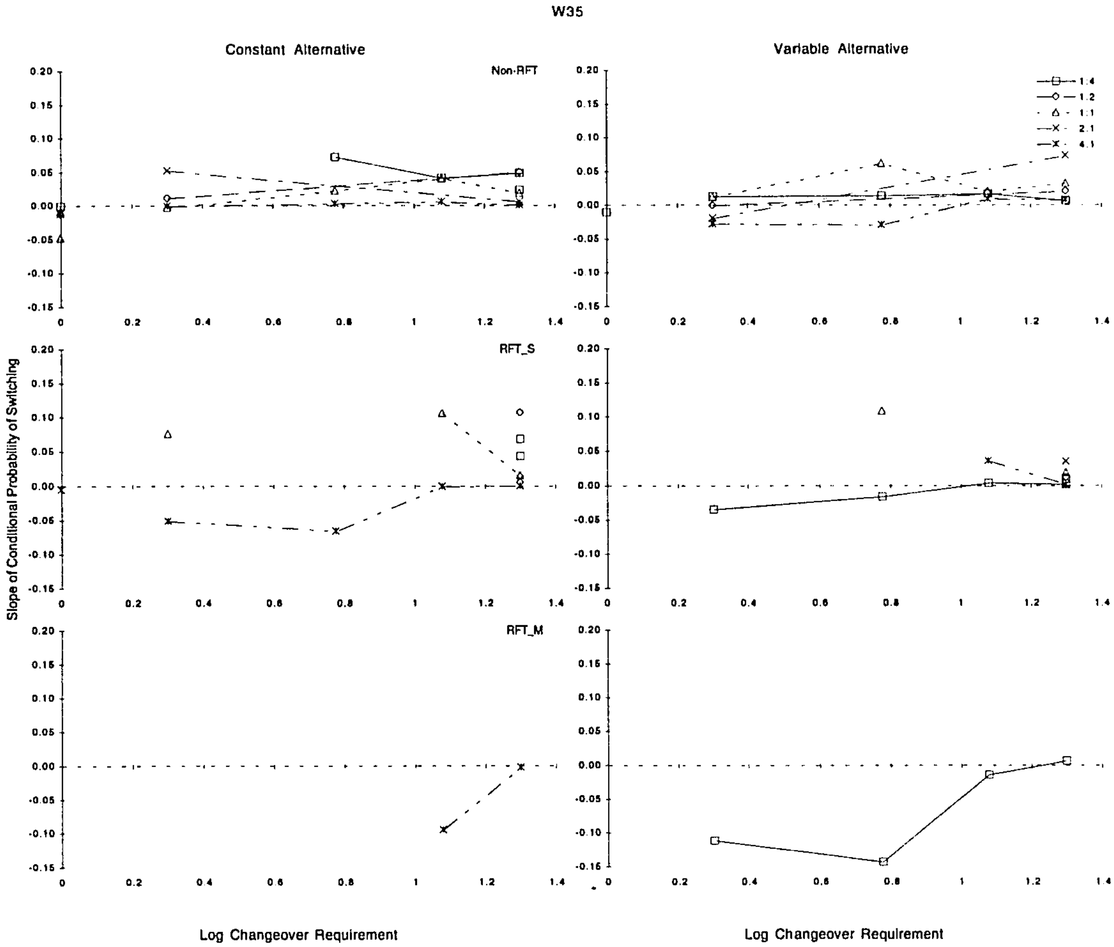

W34
Constant Alternative
Variable Alternative
Non-RFT
RFT_S
RFT_M
FR 0
FR 2
FR 6
FR 12
FR 20
Slope of Conditional Probability of Switching
0.20
0.15
0.10
0.05
0.00
-0.05
-0.10
-0.15
-1.00
-0.50
0.00
0.50
1.00
Log Reinforcer Rate (obtained)
Log Reinforcer Rate (obtained)

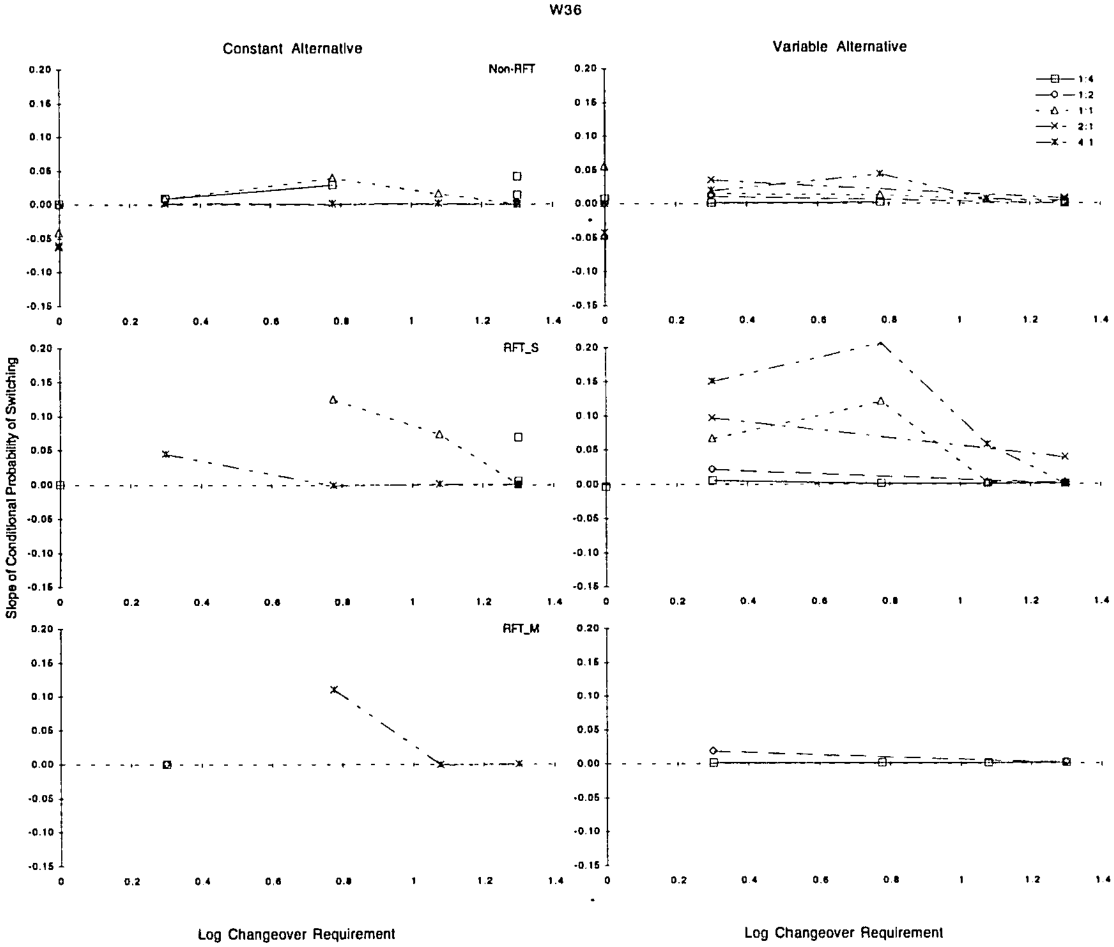

W35
Constant Alternative
Variable Alternative
Non-RFT
RFT_S
RFT_M
FR 0
FR 2
FR 6
FR 12
FR 20
Slope of Conditional Probability of Switching
Log Reinforcer Rate (obtained)
Log Reinforcer Rate (obtained)
0.20
0.15
0.10
0.05
0.00
-0.05
-0.10
-0.15
-1.00
-0.50
0.00
0.50
1.00

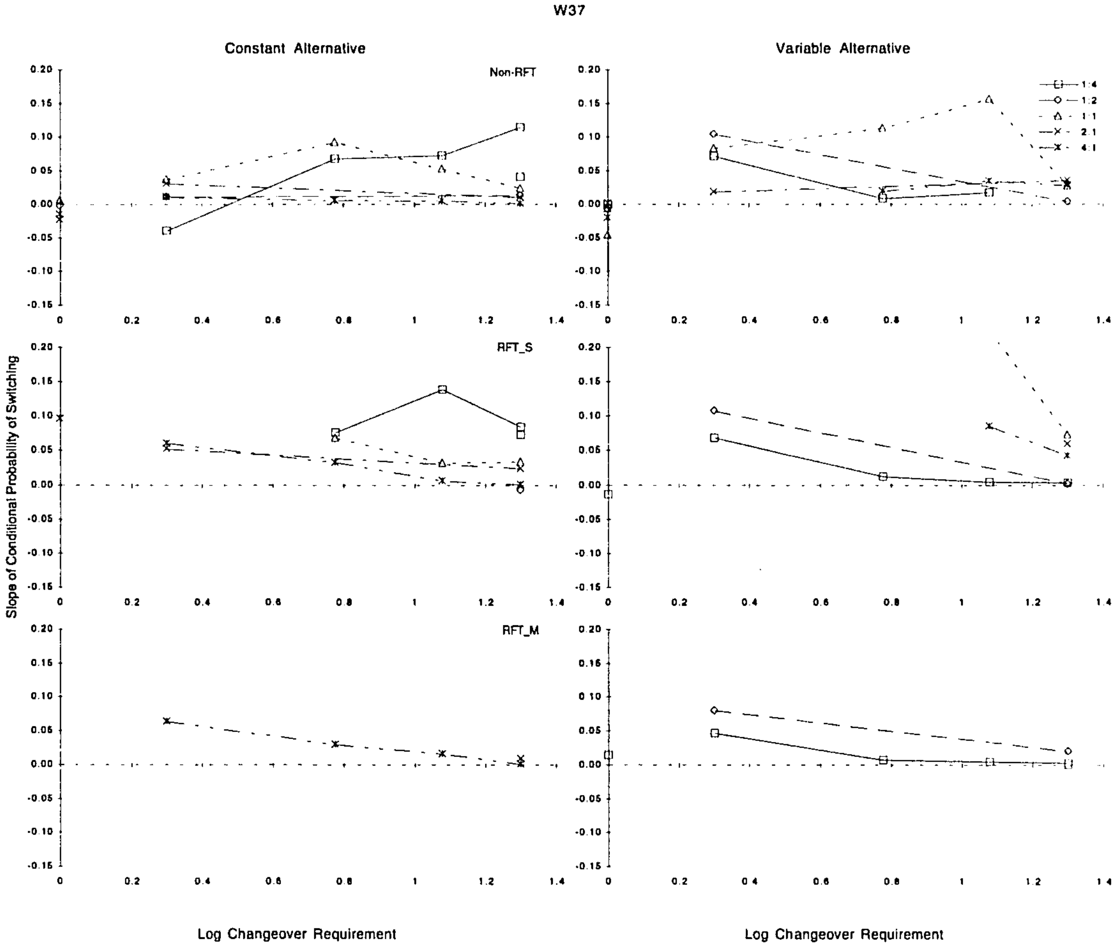

W36
Constant Alternative
Variable Alternative
Non-RFT
RFT_S
RFT_M
FR 0
FR 2
FR 6
FR 12
FR 20
Slope of Conditional Probability of Switching
0.20
0.15
0.10
0.05
0.00
-0.05
-0.10
-0.15
-1.00
-0.50
0.00
0.50
1.00
Log Reinforcer Rate (obtained)
Log Reinforcer Rate (obtained)


W37
Constant Alternative
Variable Alternative
Non-RFT
RFT_S
RFT_M
FR 0
FR 2
FR 6
FR 12
FR 20
Slope of Conditional Probability of Switching
0.20
0.15
0.10
0.05
0.00
-0.05
-0.10
-0.15
-1.00
-0.50
0.00
0.50
1.00
Log Reinforcer Rate (obtained)
Log Reinforcer Rate (obtained)


W34
Constant Alternative
Variable Alternative
Non-RFT
RFT_S
RFT_M
1:4
1:2
1:1
2:1
4:1
Slope of Conditional Probability of Switching
0.20
0.15
0.10
0.05
0.00
-0.05
-0.10
-0.15
0
0.2
0.4
0.6
0.8
1
1.2
1.4
Log Changeover Requirement
Log Changeover Requirement


W35
Constant Alternative
Variable Alternative
Non-RFT
RFT_S
RFT_M
1:4
1:2
1:1
2:1
4:1
Slope of Conditional Probability of Switching
0.20
0.15
0.10
0.05
0.00
-0.05
-0.10
-0.15
0
0.2
0.4
0.6
0.8
1
1.2
1.4
Log Changeover Requirement
Log Changeover Requirement

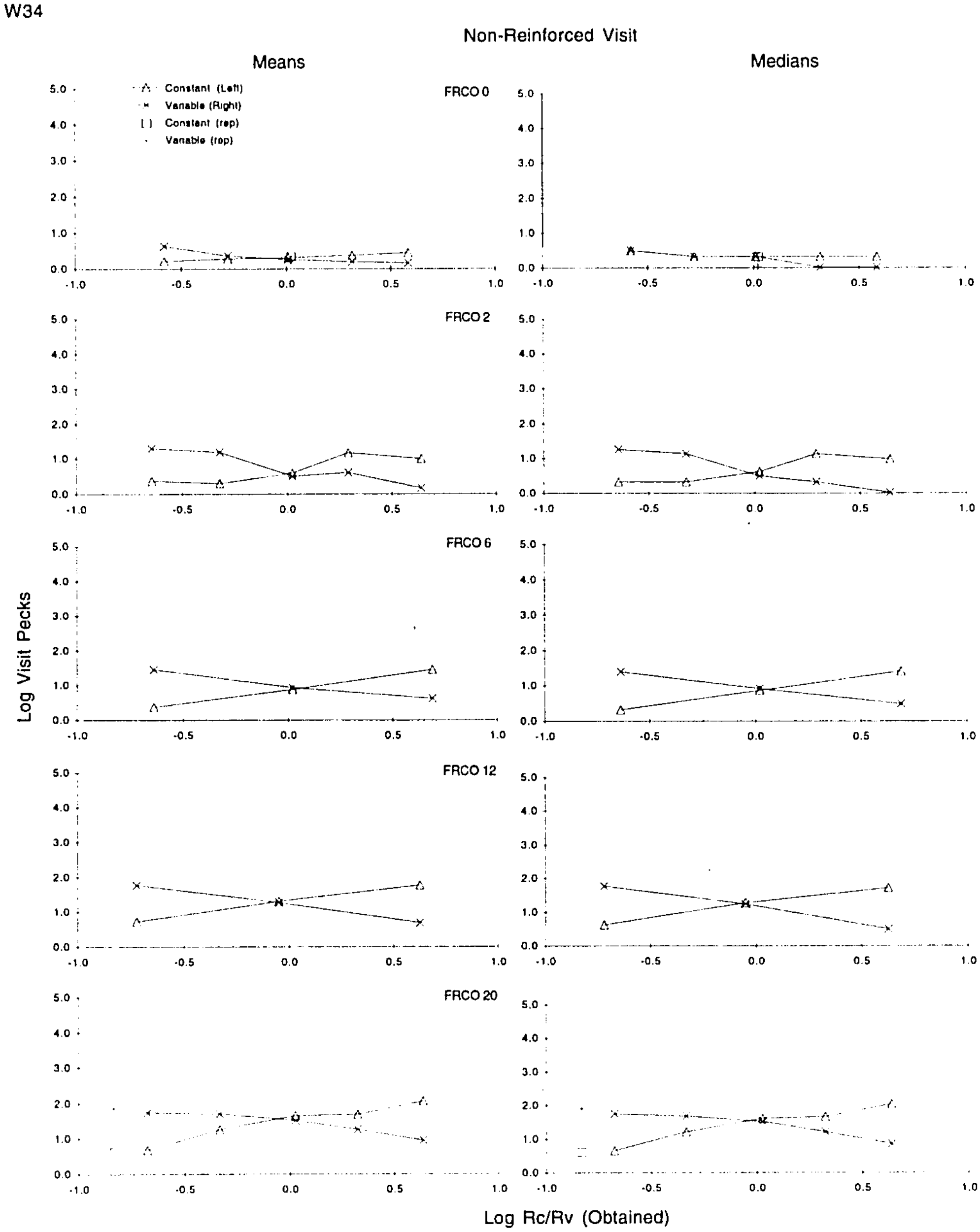

W36
Constant Alternative
Variable Alternative
Non-RFT
RFT_S
RFT_M
1:4
1:2
1:1
2:1
4:1
0.20
0.15
0.10
0.05
0.00
-0.05
-0.10
-0.15
0
0.2
0.4
0.6
0.8
1
1.2
1.4
Slope of Conditional Probability of Switching
Log Changeover Requirement
Log Changeover Requirement


W37
Constant Alternative
Variable Alternative
Non-RFT
RFT_S
RFT_M
1:4
1:2
1:1
2:1
4:1
Slope of Conditional Probability of Switching
Log Changeover Requirement
Log Changeover Requirement
0.20
0.15
0.10
0.05
0.00
-0.05
-0.10
-0.15
0
0.2
0.4
0.6
0.8
1
1.2
1.4

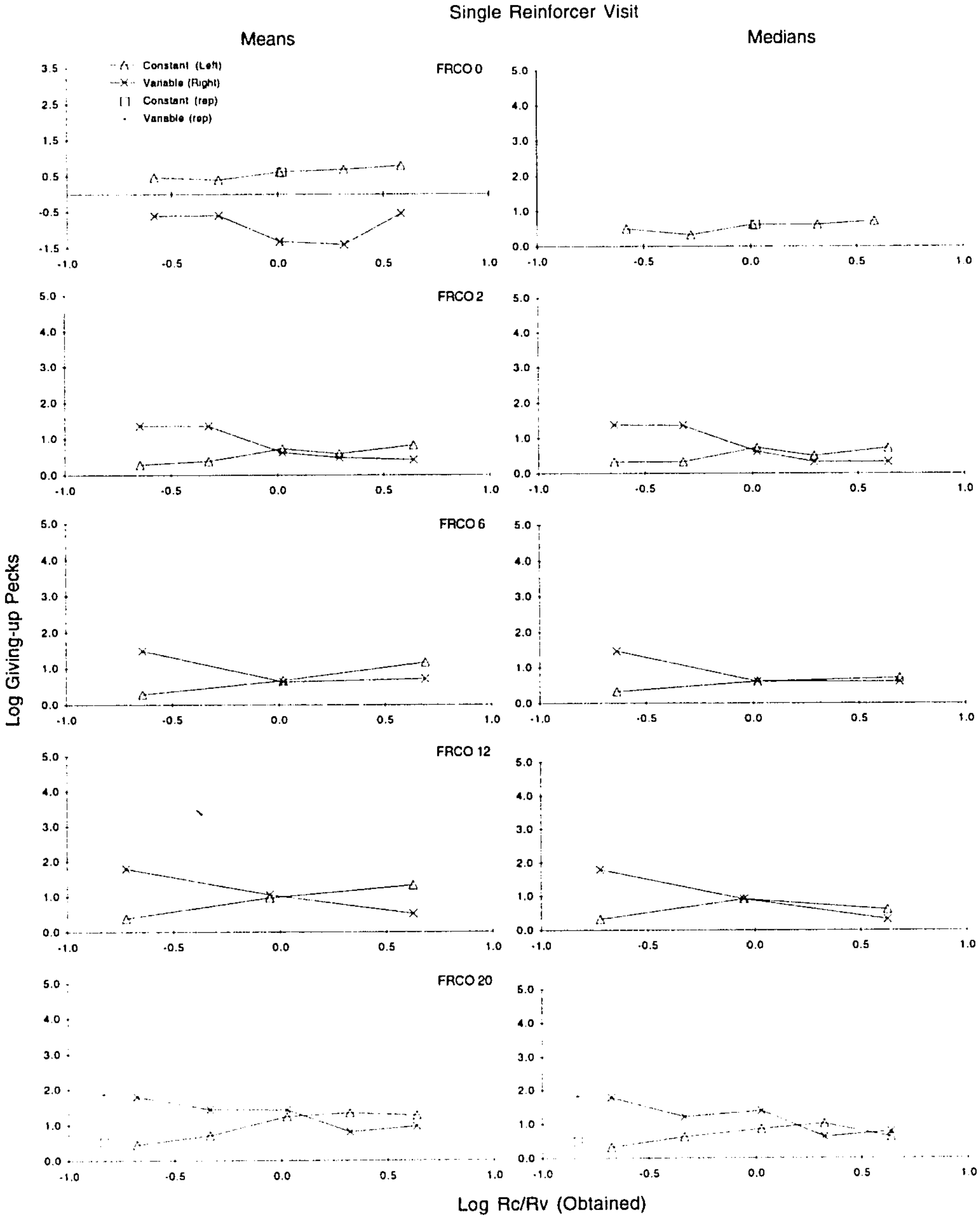
APPENDIX IV

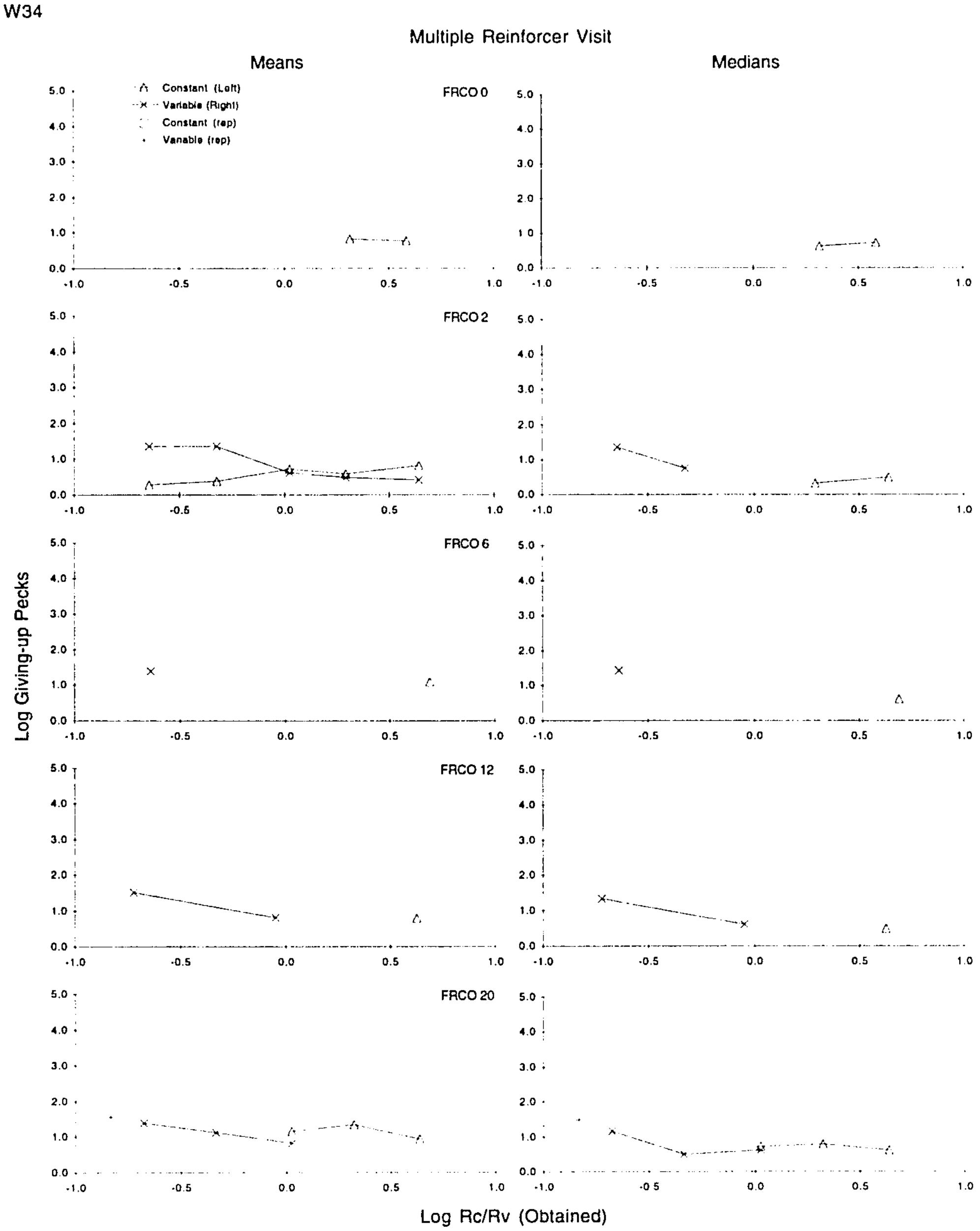
Foraging Analyses

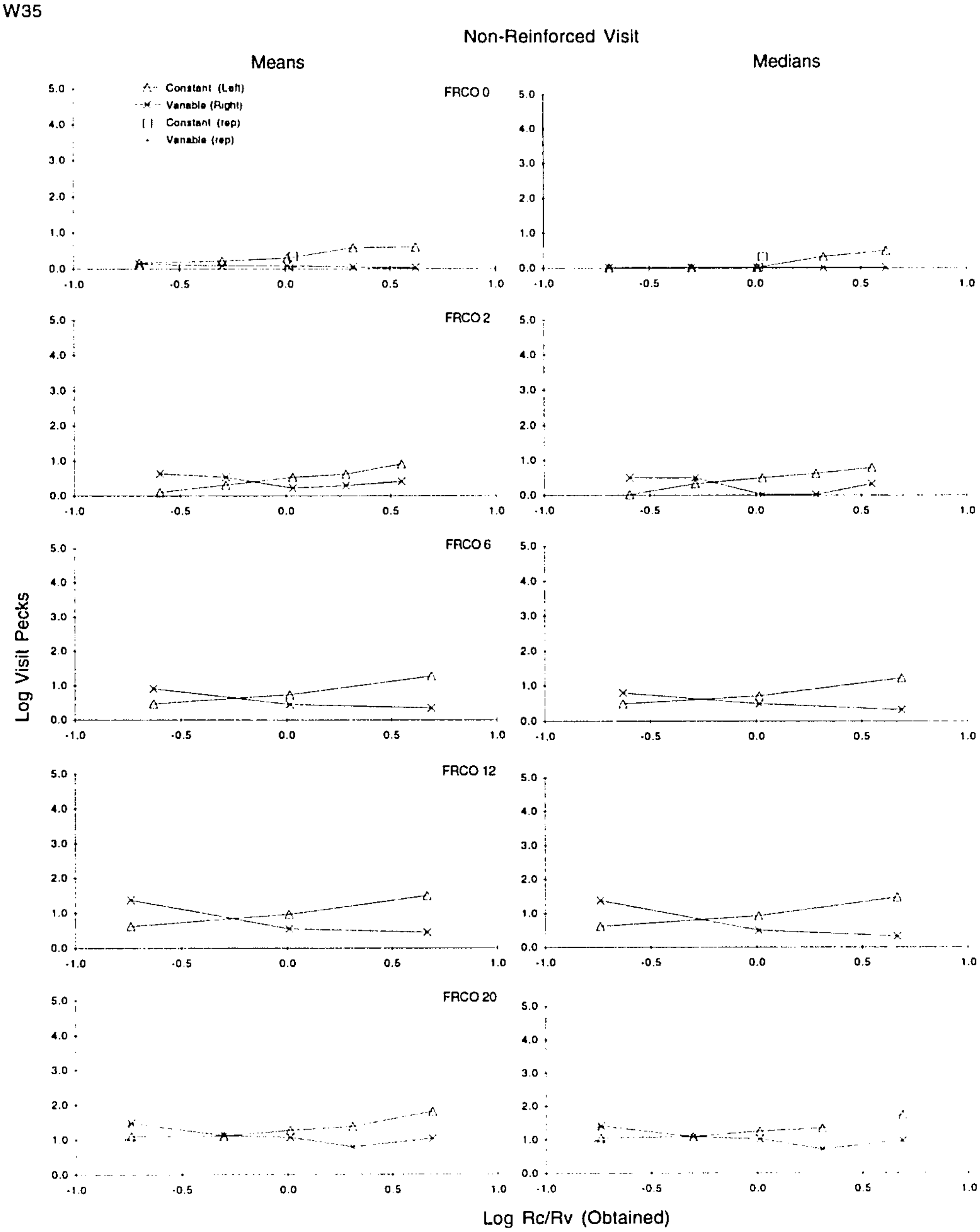
The following 24 figures present log mean (left panels) and median (right panels) peck measures (visit pecks or giving-up pecks; first 12 figures) and duration measures (visit time or giving-up time; last 12 figures) as a function of log obtained reinforcer ratio. Ordered by pigeon (number is noted on each figure), measures are categorized by non-reinforced (first figure), single reinforcer (second figure), and multiple reinforcer visits (third figure) as noted at the top of each figure. Changeover requirement increases from top to bottom panels. Within each panel, measures present both constant and variable alternatives (see legends for symbols).


W34
Non-Reinforced Visit
Means
Medians
Constant (Left)
Variable (Right)
[ ] Constant (rep)
· Variable (rep)
FRCO 0
FRCO 2
FRCO 6
FRCO 12
FRCO 20
Log Visit Pecks
Log Rc/Rv (Obtained)
0.0
1.0
2.0
3.0
4.0
5.0
-1.0
-0.5
0.0
0.5
1.0

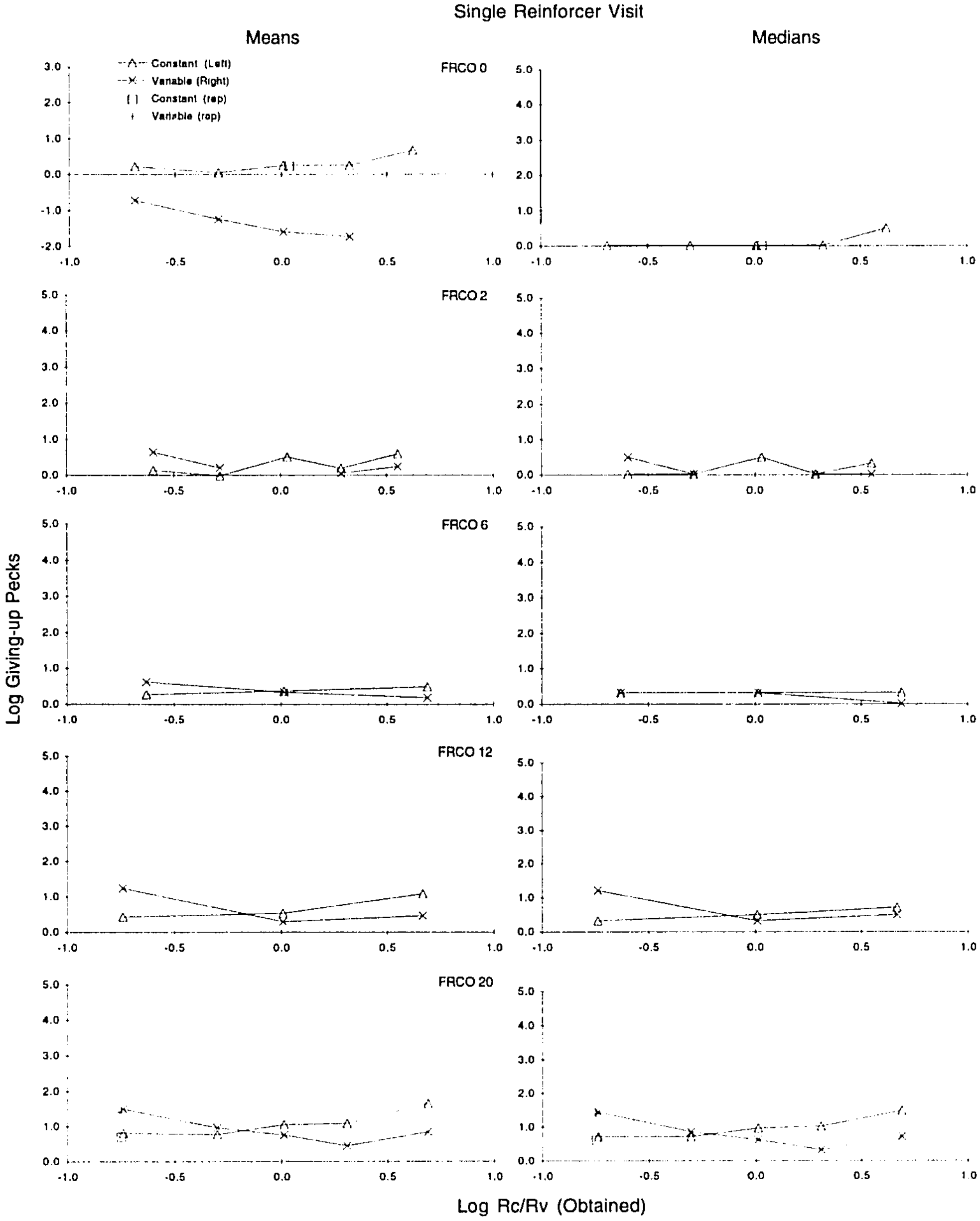
W34


Single Reinforcer Visit
Means
Medians
Constant (Left)
Variable (Right)
Constant (rep)
Variable (rep)
FRCO 0
FRCO 2
FRCO 6
FRCO 12
FRCO 20
3.5
2.5
1.5
0.5
-0.5
-1.5
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-0.5
0.0
0.5
1.0
Log Giving-up Pecks
Log Rc/Rv (Obtained)


W34
Multiple Reinforcer Visit
Means
Medians
Constant (Left)
Variable (Right)
Constant (rep)
Variable (rep)
FRCO 0
FRCO 2
FRCO 6
FRCO 12
FRCO 20
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-0.5
0.0
0.5
1.0
Log Giving-up Pecks
Log Rc/Rv (Obtained)

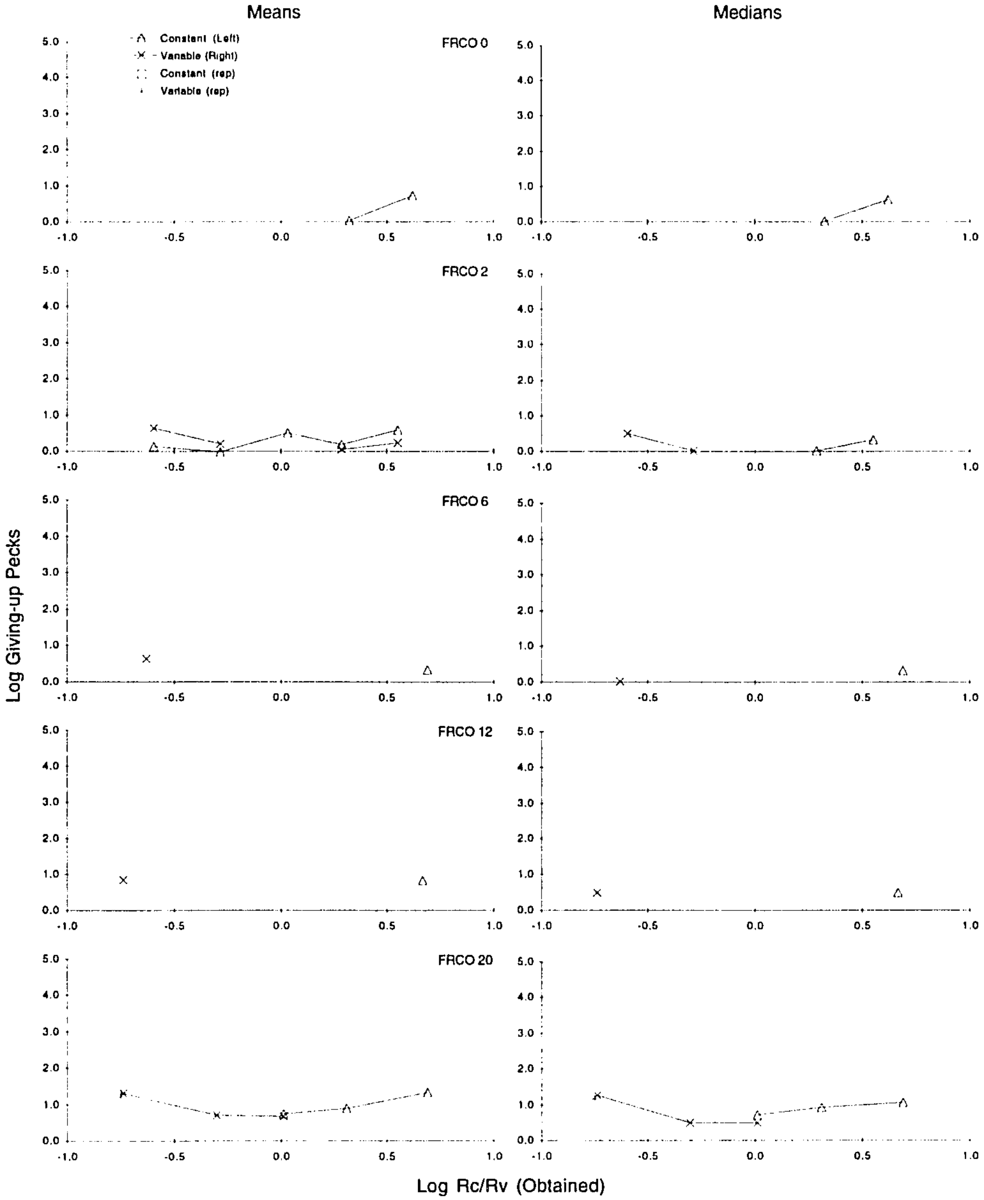

W35
Non-Reinforced Visit
Means
Medians
Constant (Left)
Variable (Right)
Constant (rep)
Variable (rep)
FRCO 0
FRCO 2
FRCO 6
FRCO 12
FRCO 20
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-0.5
0.0
0.5
1.0
Log Visit Pecks
Log Rc/Rv (Obtained)

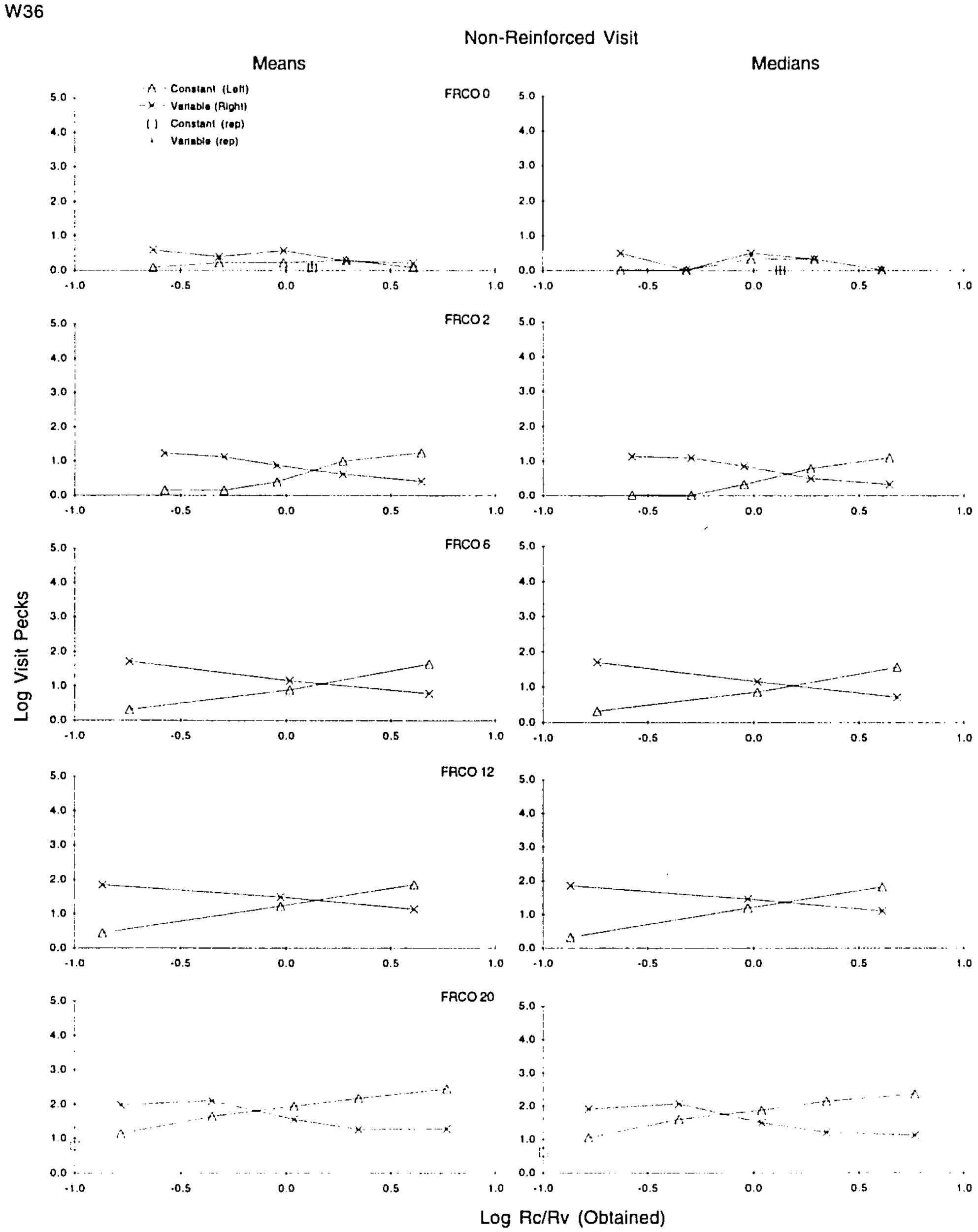
W35


Single Reinforcer Visit
Means
Medians
Constant (Left)
Variable (Right)
Constant (rep)
Variable (rep)
FRCO 0
FRCO 2
FRCO 6
FRCO 12
FRCO 20
Log Giving-up Pecks
Log Rc/Rv (Obtained)
-2.0
-1.0
0.0
1.0
2.0
3.0
4.0
5.0
-1.0
-0.5
0.0
0.5
1.0

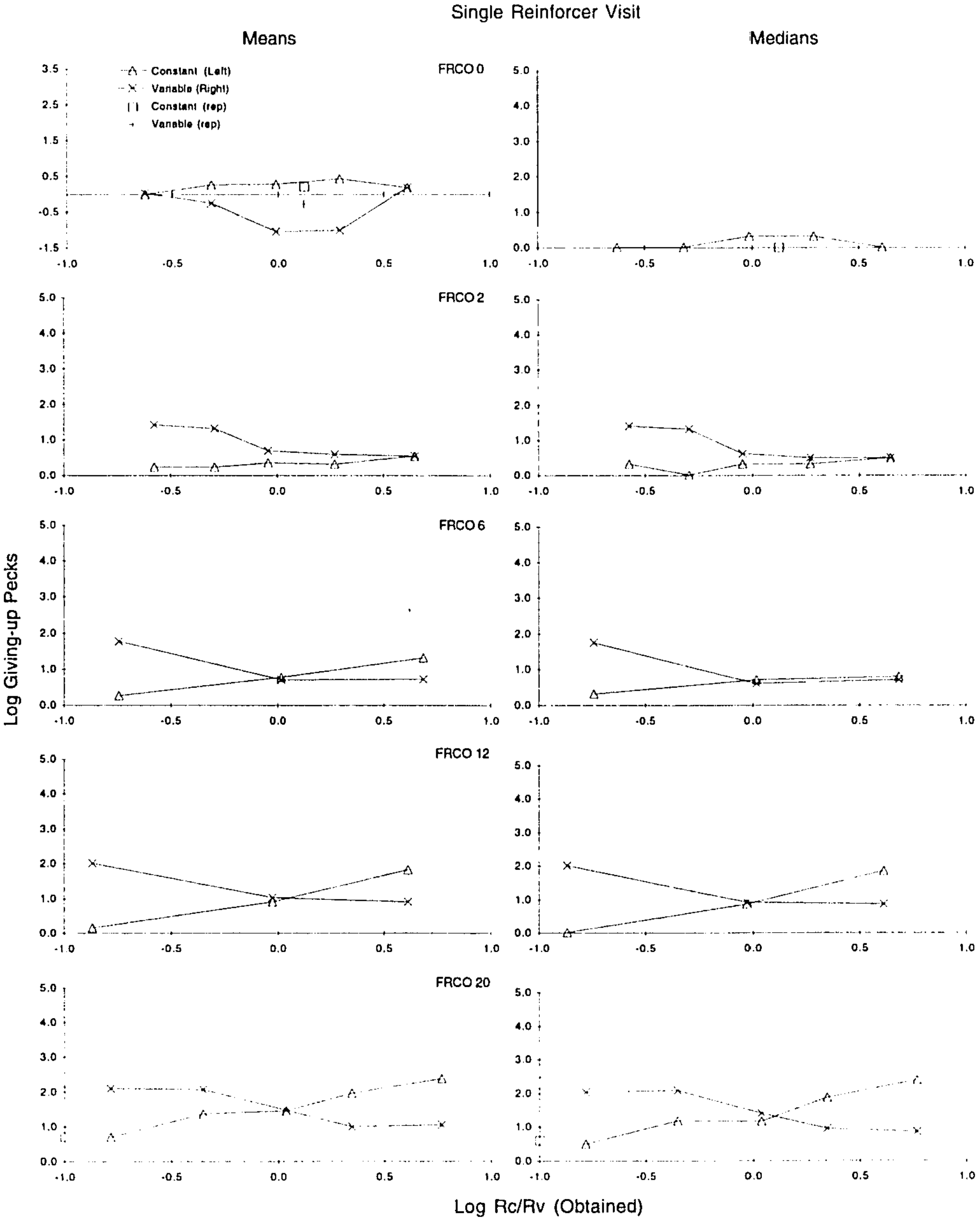
W35

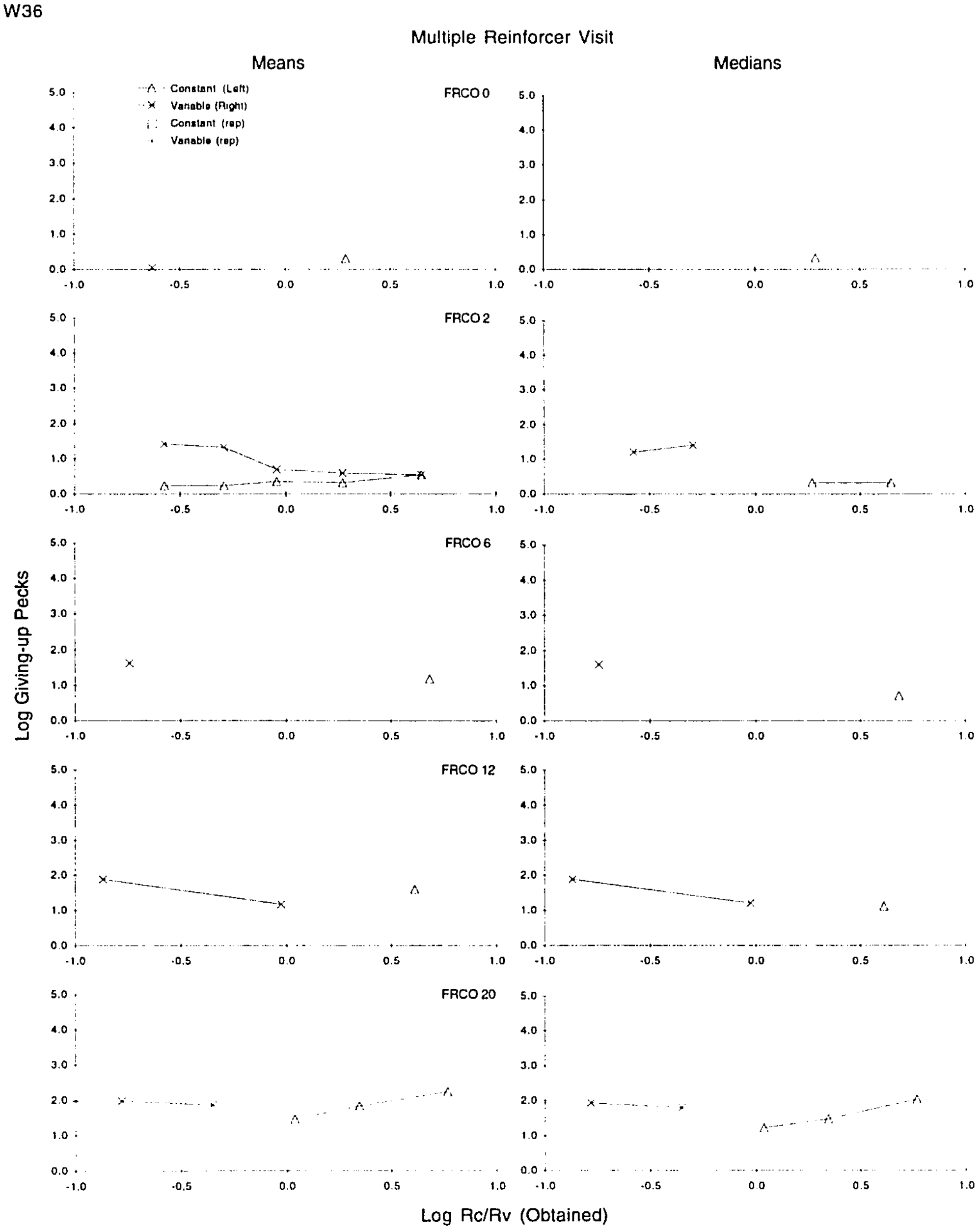
Multiple Reinforcer Visit

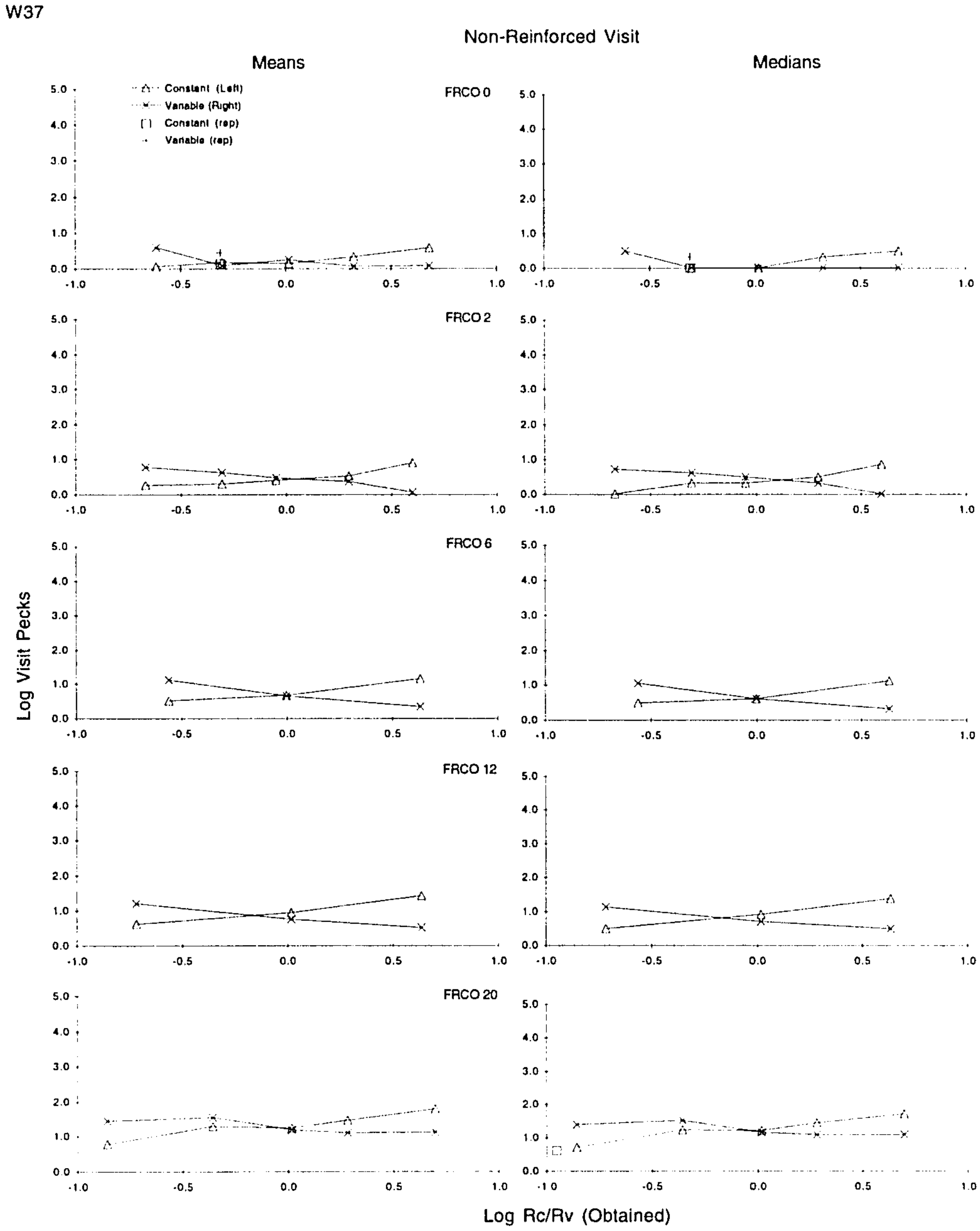



W36
Non-Reinforced Visit
Means
Medians
Δ Constant (Left)
× Variable (Right)
[ ] Constant (rep)
+ Variable (rep)
FRCO 0
FRCO 2
FRCO 6
FRCO 12
FRCO 20
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-0.5
0.0
0.5
1.0
Log Visit Pecks
Log Rc/Rv (Obtained)

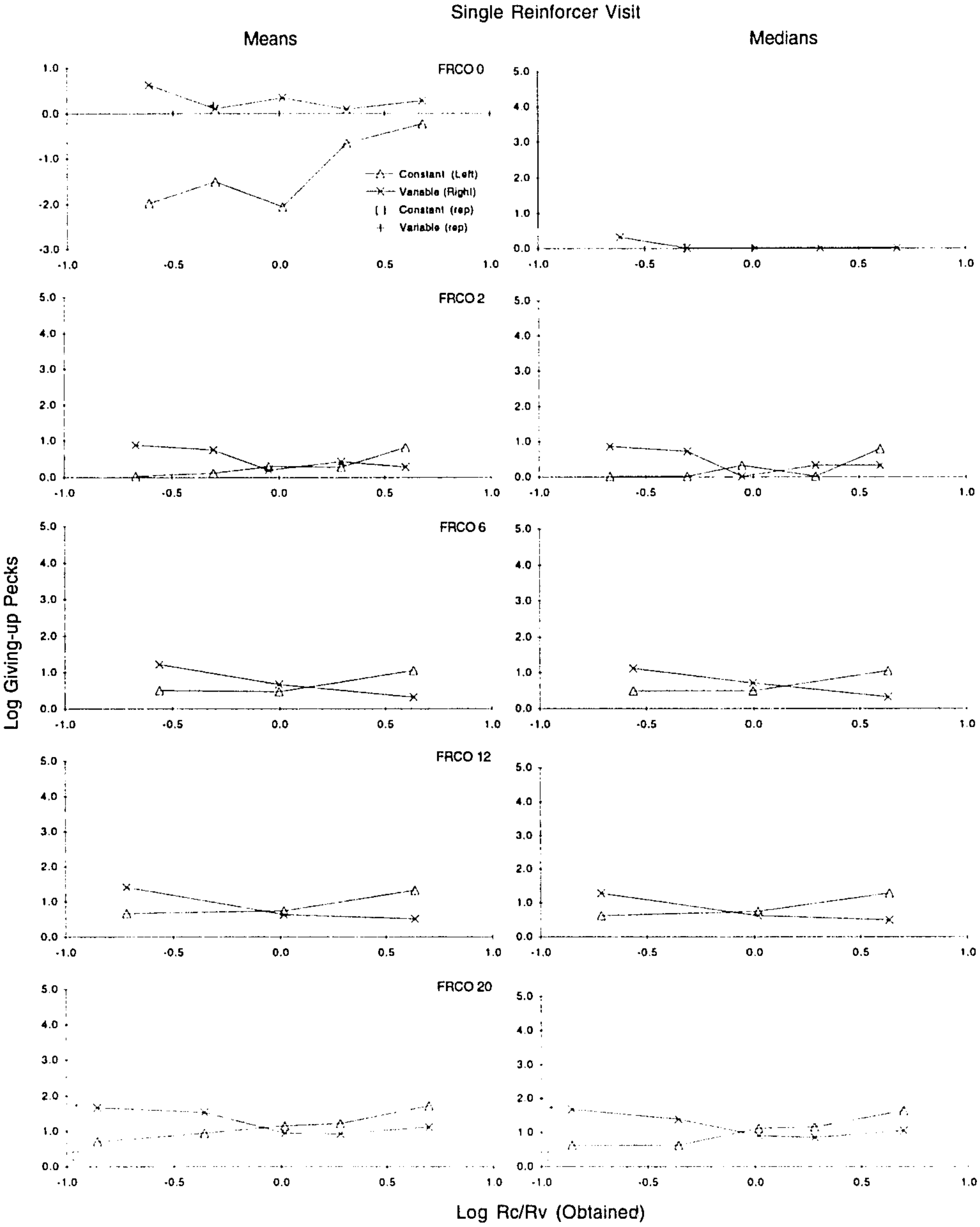
W36


Single Reinforcer Visit
Means
Medians
Constant (Left)
Variable (Right)
Constant (rep)
Variable (rep)
FRCO 0
FRCO 2
FRCO 6
FRCO 12
FRCO 20
Log Giving-up Pecks
Log Rc/Rv (Obtained)
3.5
2.5
1.5
0.5
-0.5
-1.5
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-0.5
0.0
0.5
1.0

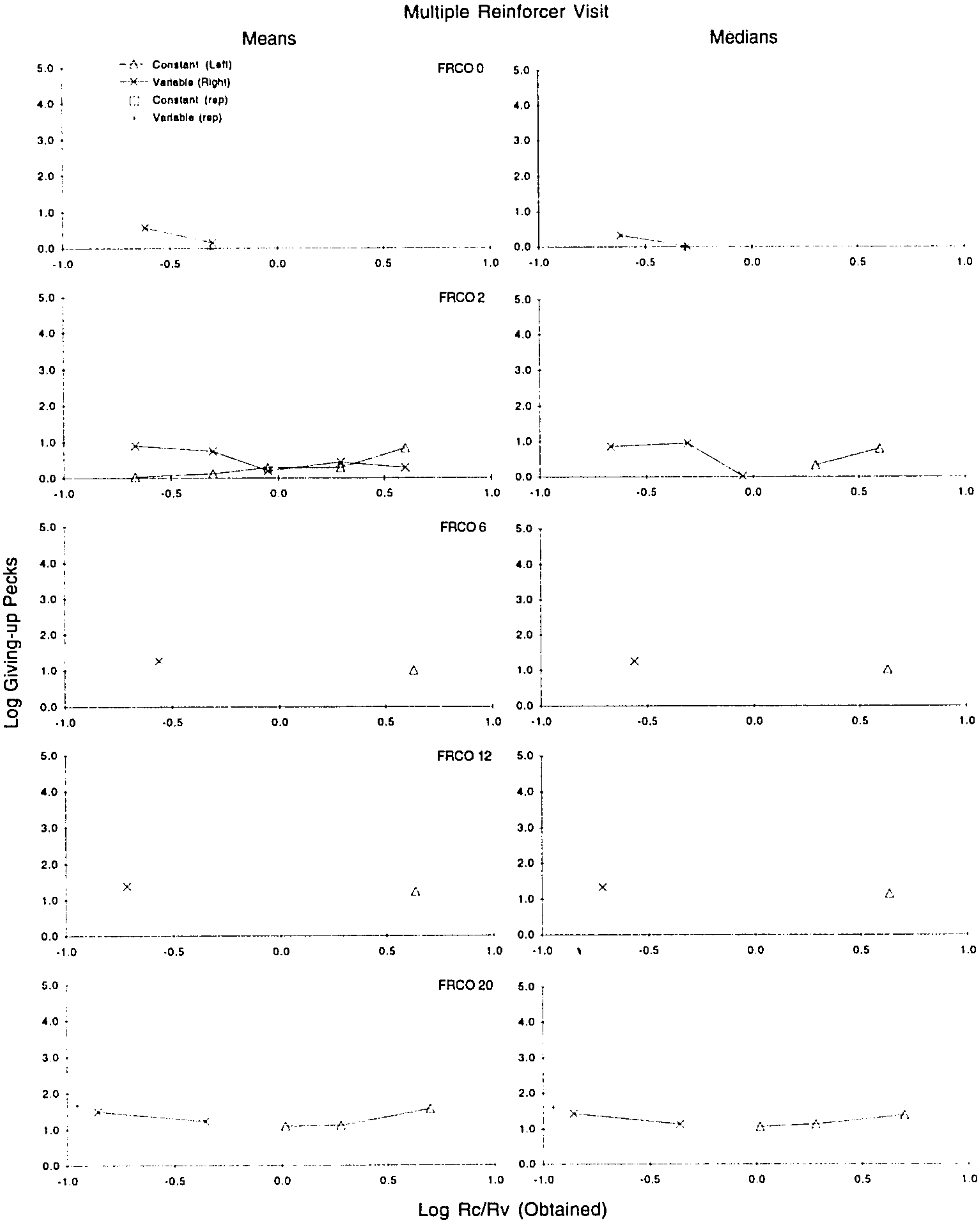

W36
Multiple Reinforcer Visit
Means
Medians
Constant (Left)
Variable (Right)
Constant (rep)
Variable (rep)
FRCO 0
FRCO 2
FRCO 6
FRCO 12
FRCO 20
Log Giving-up Pecks
Log Rc/Rv (Obtained)
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-0.5
0.0
0.5
1.0


W37
Non-Reinforced Visit
Means
Medians
Constant (Left)
Variable (Right)
Constant (rep)
Variable (rep)
FRCO 0
FRCO 2
FRCO 6
FRCO 12
FRCO 20
Log Visit Pecks
Log Rc/Rv (Obtained)
0.0
1.0
2.0
3.0
4.0
5.0
-1.0
-0.5
0.0
0.5
1.0

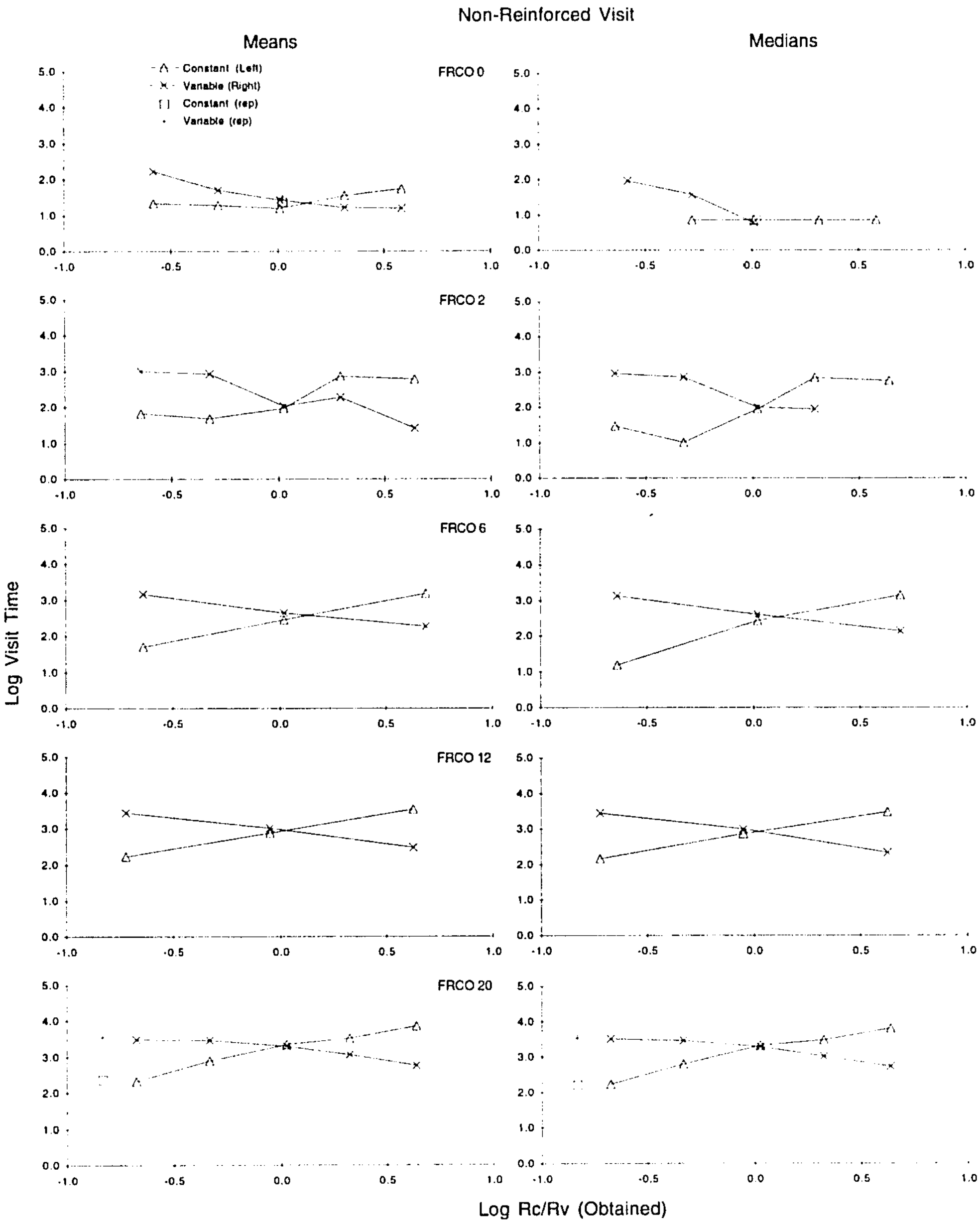
W37


Single Reinforcer Visit
Means
Medians
FRCO 0
FRCO 2
FRCO 6
FRCO 12
FRCO 20
Constant (Left)
Variable (Right)
Constant (rep)
Variable (rep)
Log Giving-up Pecks
Log Rc/Rv (Obtained)
-3.0
-2.0
-1.0
0.0
1.0
2.0
3.0
4.0
5.0
-1.0
-0.5
0.0
0.5
1.0

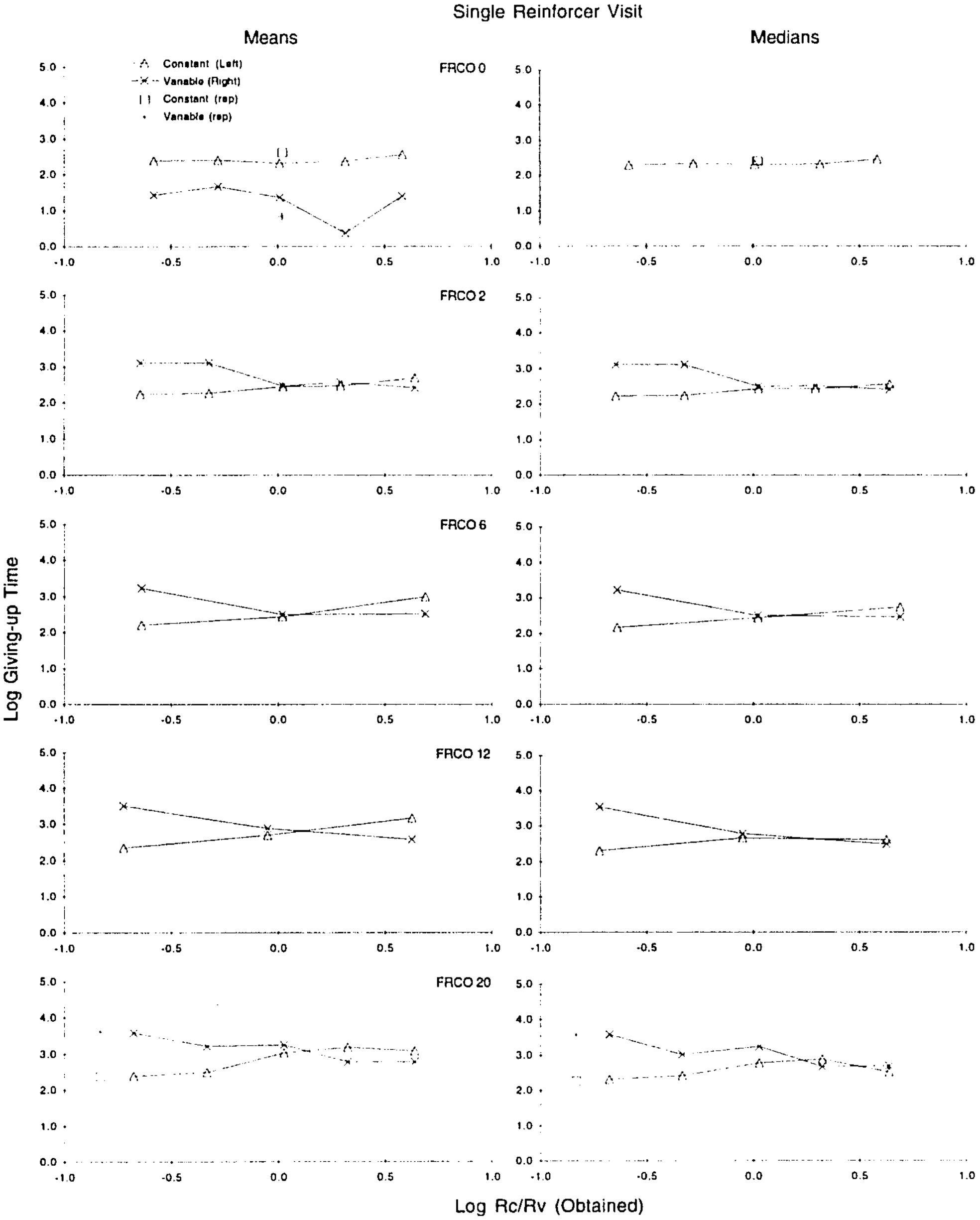
W37


Multiple Reinforcer Visit
Means
Medians
Constant (Left)
Variable (Right)
Constant (rep)
Variable (rep)
FRCO 0
FRCO 2
FRCO 6
FRCO 12
FRCO 20
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-0.5
0.0
0.5
1.0
Log Giving-up Pecks
Log Rc/Rv (Obtained)

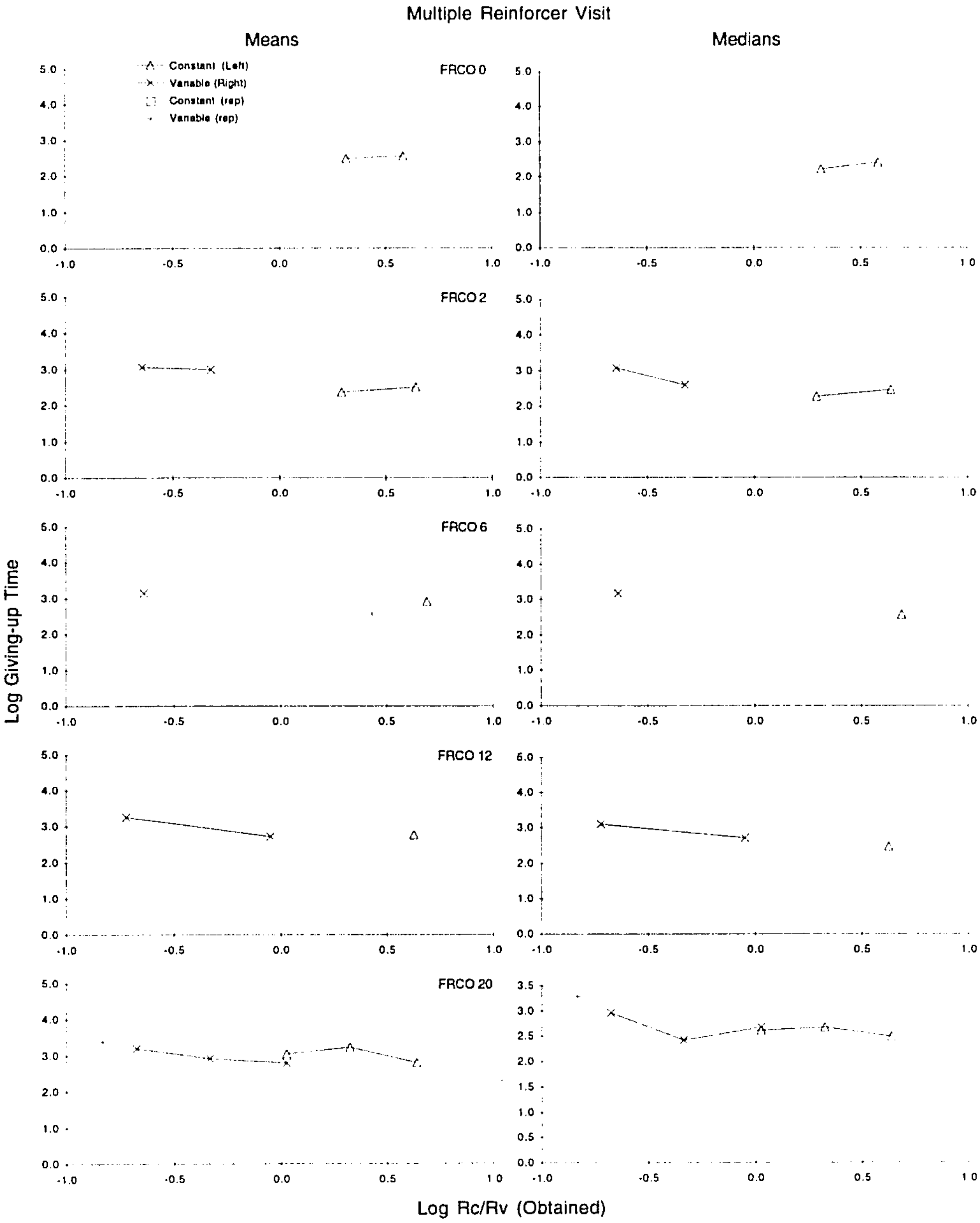
W34

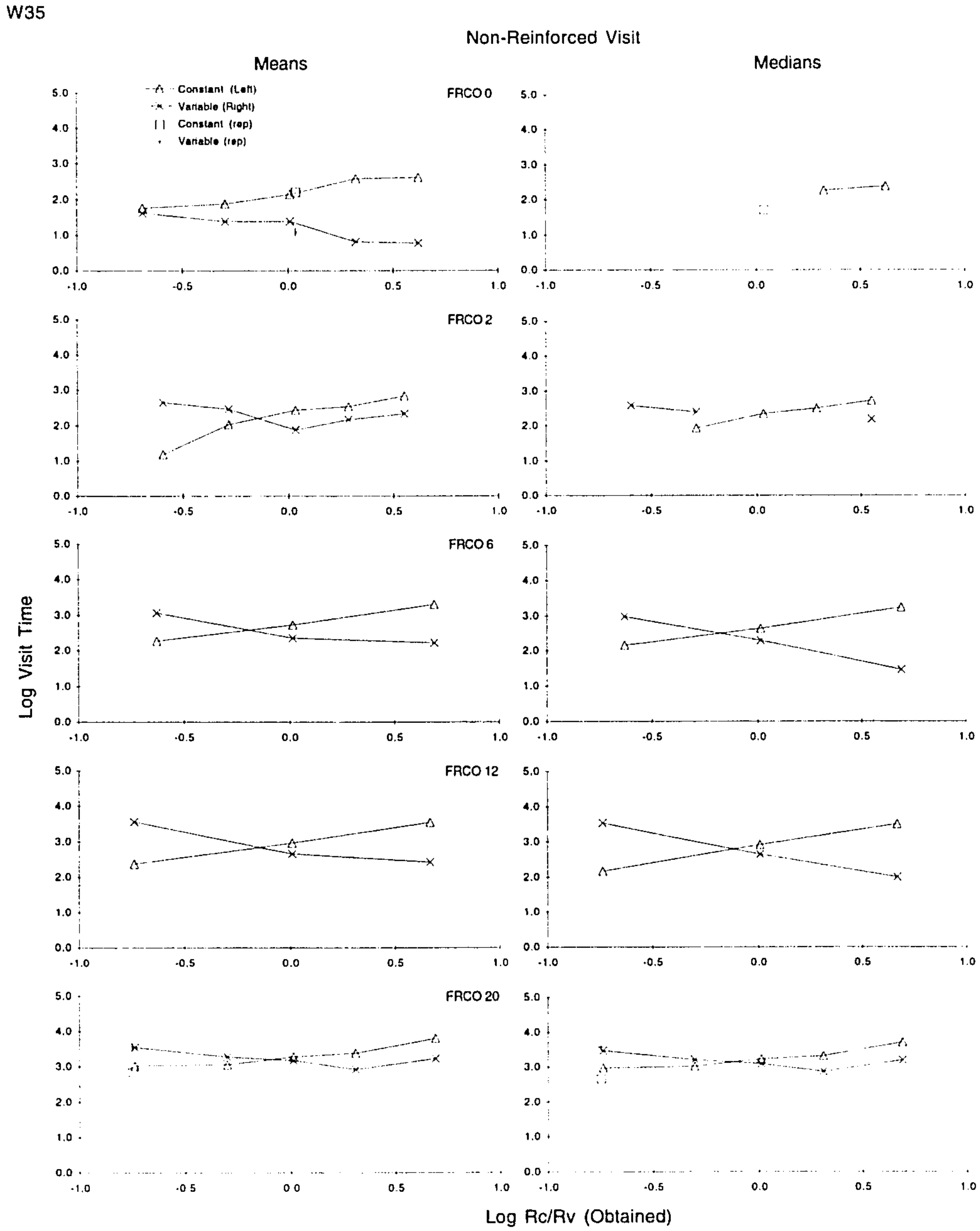

Non-Reinforced Visit
Means
Medians
Constant (Left)
Variable (Right)
Constant (rep)
Variable (rep)
FRCO 0
FRCO 2
FRCO 6
FRCO 12
FRCO 20
Log Visit Time
Log Rc/Rv (Obtained)
0.0
1.0
2.0
3.0
4.0
5.0
-1.0
-0.5
0.0
0.5
1.0

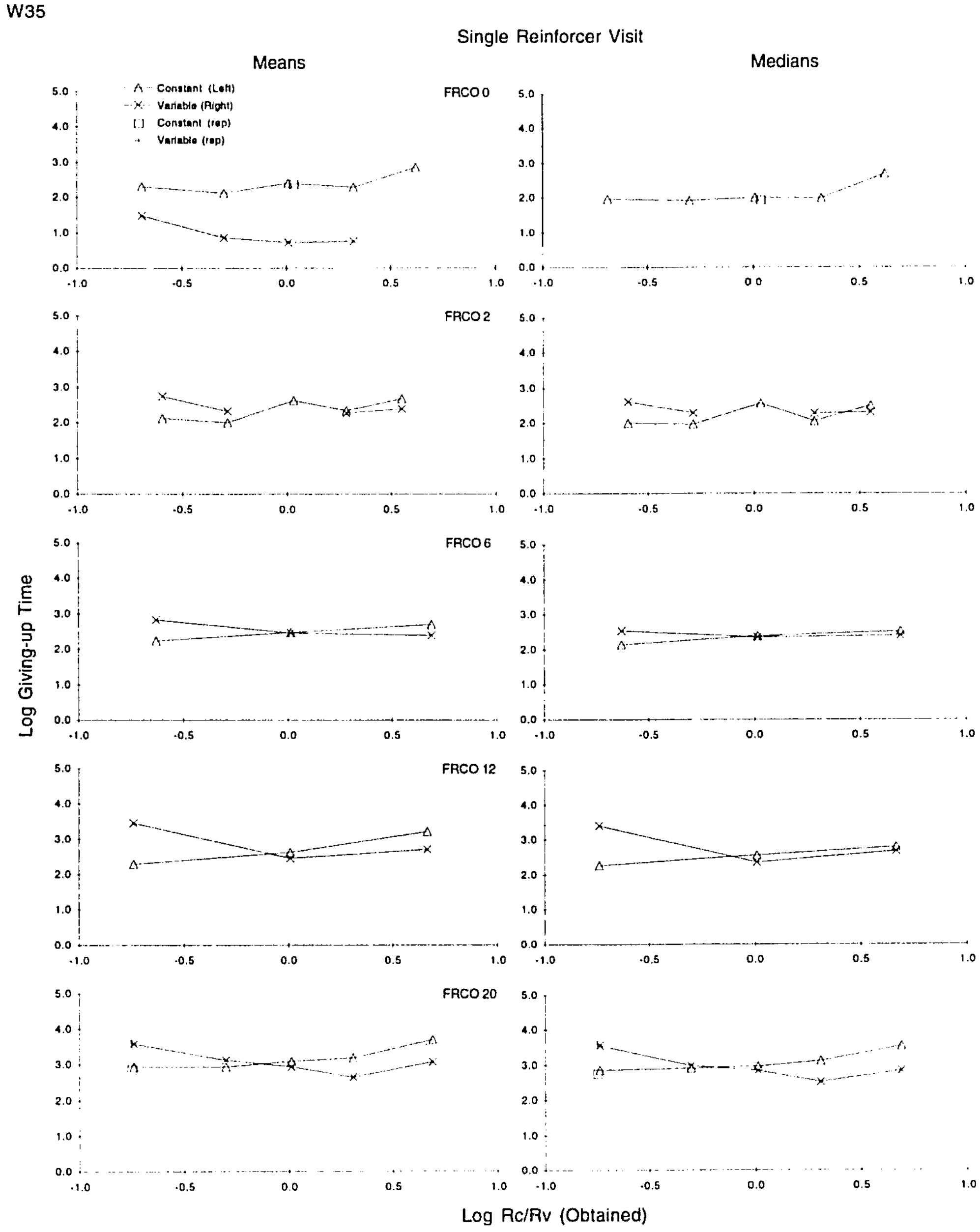
W34


Single Reinforcer Visit
Means
Medians
Constant (Left)
Variable (Right)
Constant (rep)
Variable (rep)
FRCO 0
FRCO 2
FRCO 6
FRCO 12
FRCO 20
Log Giving-up Time
Log Rc/Rv (Obtained)
0.0
1.0
2.0
3.0
4.0
5.0
-1.0
-0.5
0.0
0.5
1.0

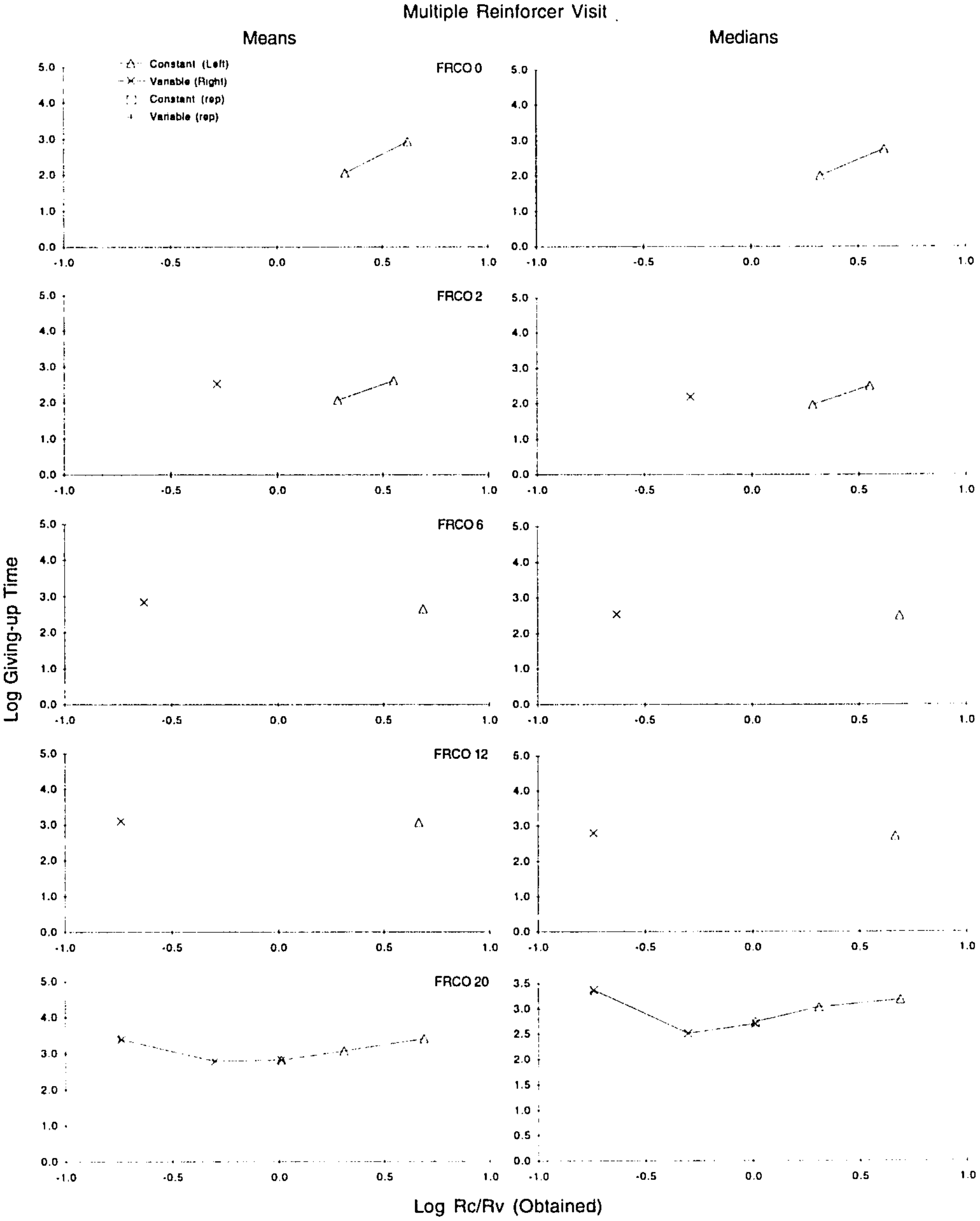
W34

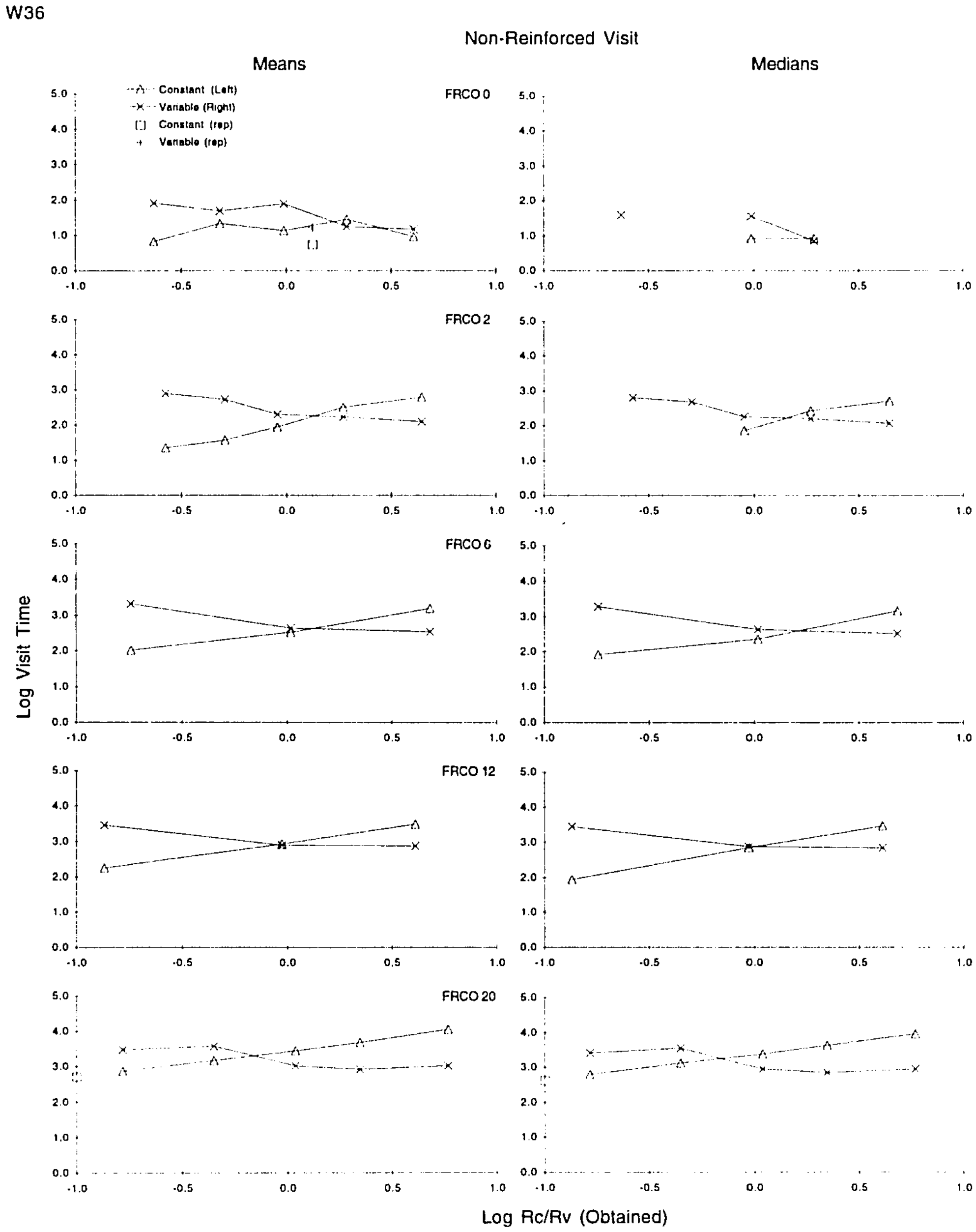

Multiple Reinforcer Visit
Means
Medians
Constant (Left)
Variable (Right)
Constant (rep)
Variable (rep)
FRCO 0
FRCO 2
FRCO 6
FRCO 12
FRCO 20
Log Giving-up Time
Log Rc/Rv (Obtained)
0.0
1.0
2.0
3.0
4.0
5.0
-1.0
-0.5
0.0
0.5
1.0

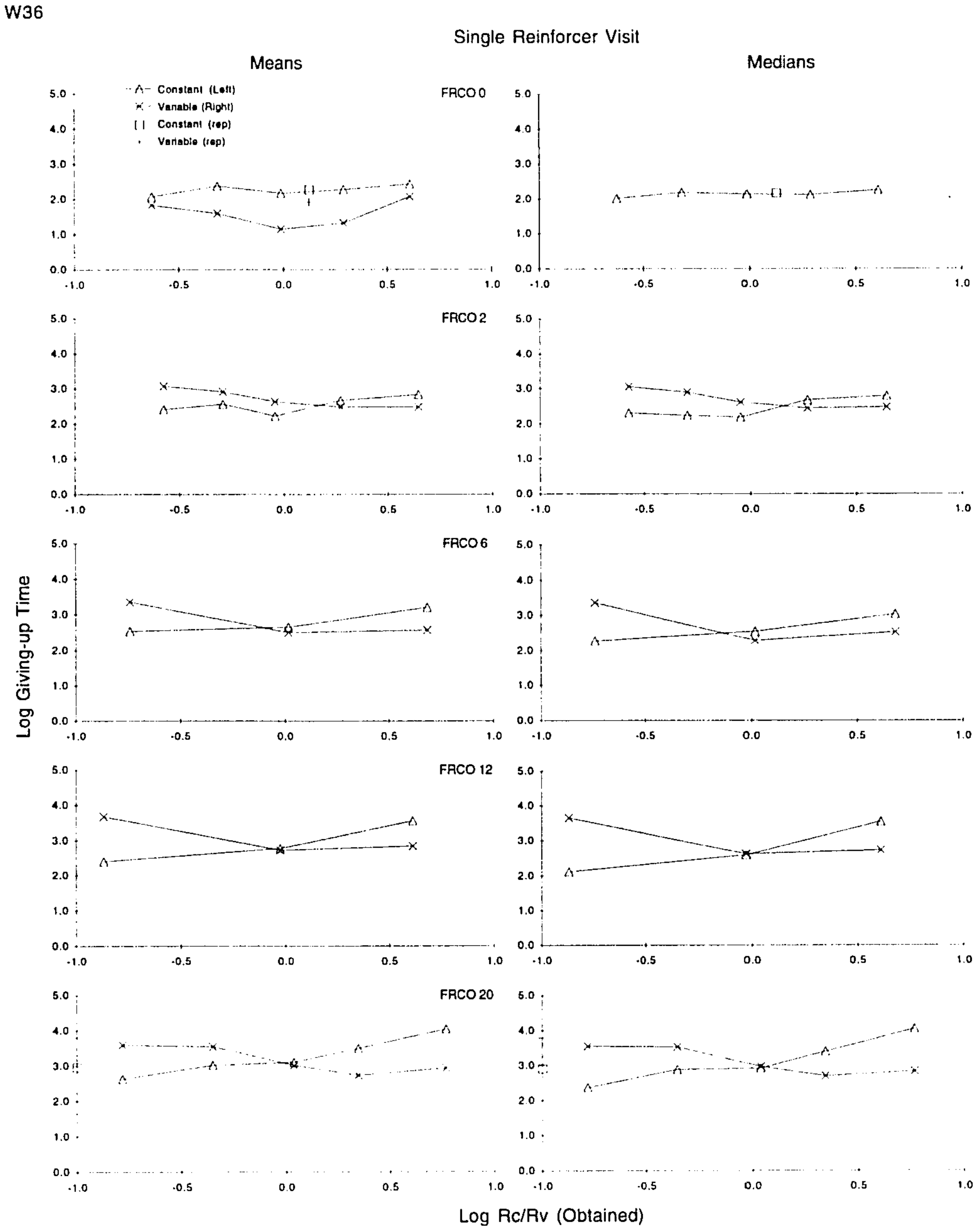

W35
Non-Reinforced Visit
Means
Medians
Constant (Left)
Variable (Right)
Constant (rep)
Variable (rep)
FRCO 0
FRCO 2
FRCO 6
FRCO 12
FRCO 20
Log Visit Time
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-0.5
0.0
0.5
1.0
Log Rc/Rv (Obtained)


W35
Single Reinforcer Visit
Means
Medians
Constant (Left)
Variable (Right)
Constant (rep)
Variable (rep)
FRCO 0
FRCO 2
FRCO 6
FRCO 12
FRCO 20
0.0
1.0
2.0
3.0
4.0
5.0
-1.0
-0.5
0.0
0.5
1.0
Log Giving-up Time
Log Rc/Rv (Obtained)

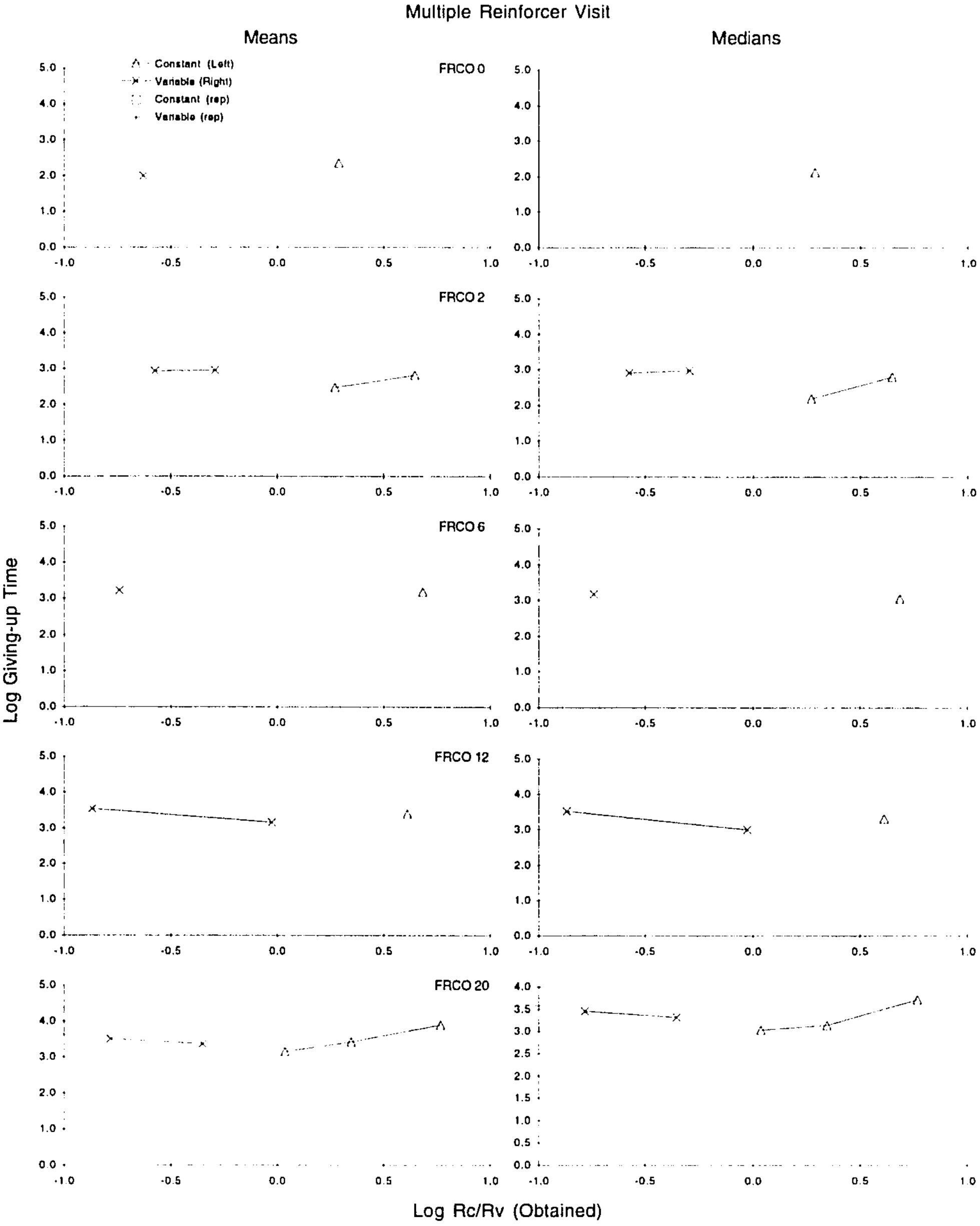
W35

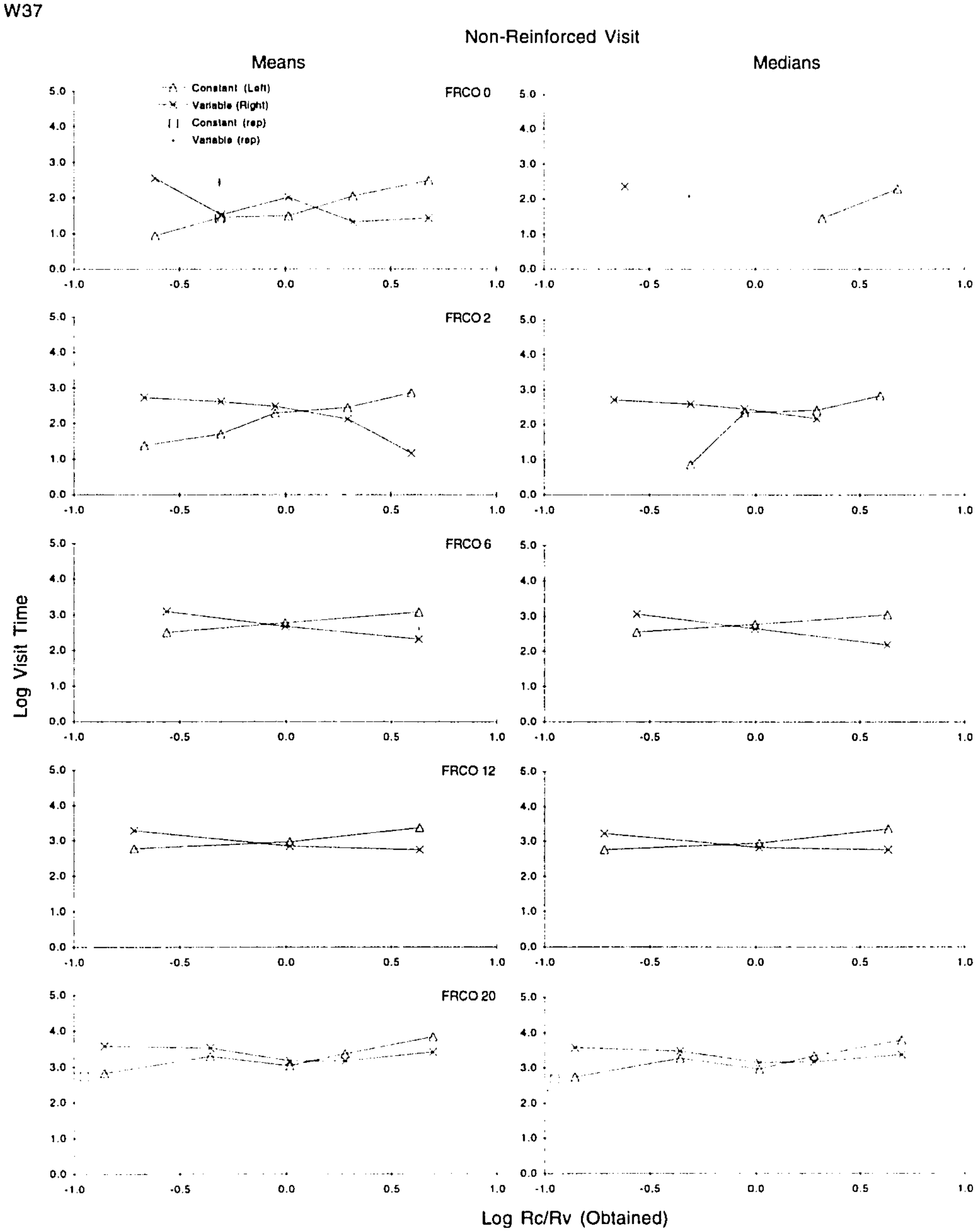

Multiple Reinforcer Visit
Means
Medians
Constant (Left)
Variable (Right)
Constant (rep)
Variable (rep)
FRCO 0
FRCO 2
FRCO 6
FRCO 12
FRCO 20
Log Giving-up Time
Log Rc/Rv (Obtained)
0.0
1.0
2.0
3.0
4.0
5.0
0.5
1.5
2.5
3.5
-1.0
-0.5
0.0
0.5
1.0


W36
Non-Reinforced Visit
Means
Medians
Constant (Left)
Variable (Right)
Constant (rep)
Variable (rep)
FRCO 0
FRCO 2
FRCO 6
FRCO 12
FRCO 20
Log Visit Time
Log Rc/Rv (Obtained)
0.0
1.0
2.0
3.0
4.0
5.0
-1.0
-0.5
0.0
0.5
1.0

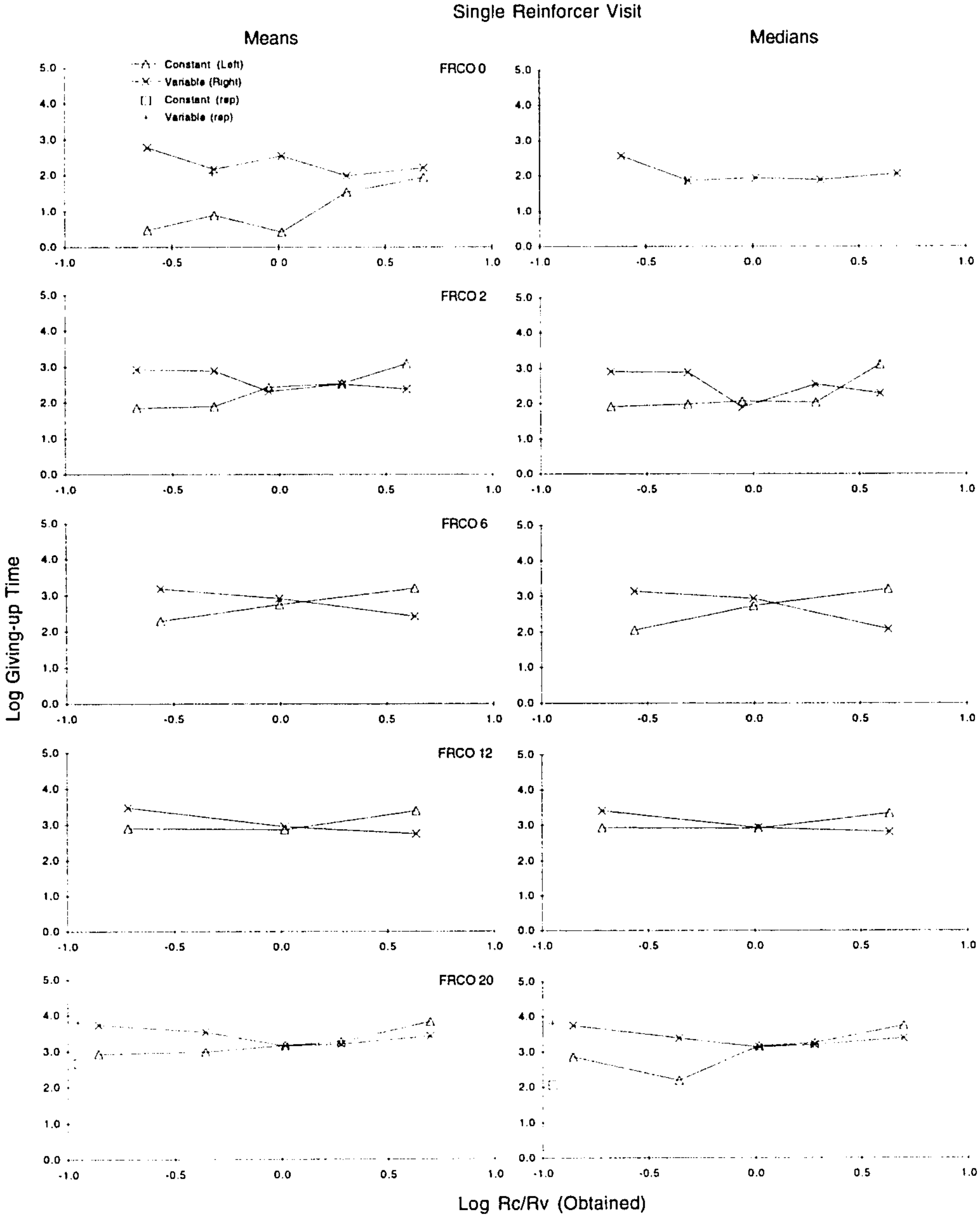

W36
Single Reinforcer Visit
Means
Medians
Constant (Left)
Variable (Right)
Constant (rep)
Variable (rep)
FRCO 0
FRCO 2
FRCO 6
FRCO 12
FRCO 20
Log Giving-up Time
Log Rc/Rv (Obtained)
0.0
1.0
2.0
3.0
4.0
5.0
-1.0
-0.5
0.0
0.5
1.0

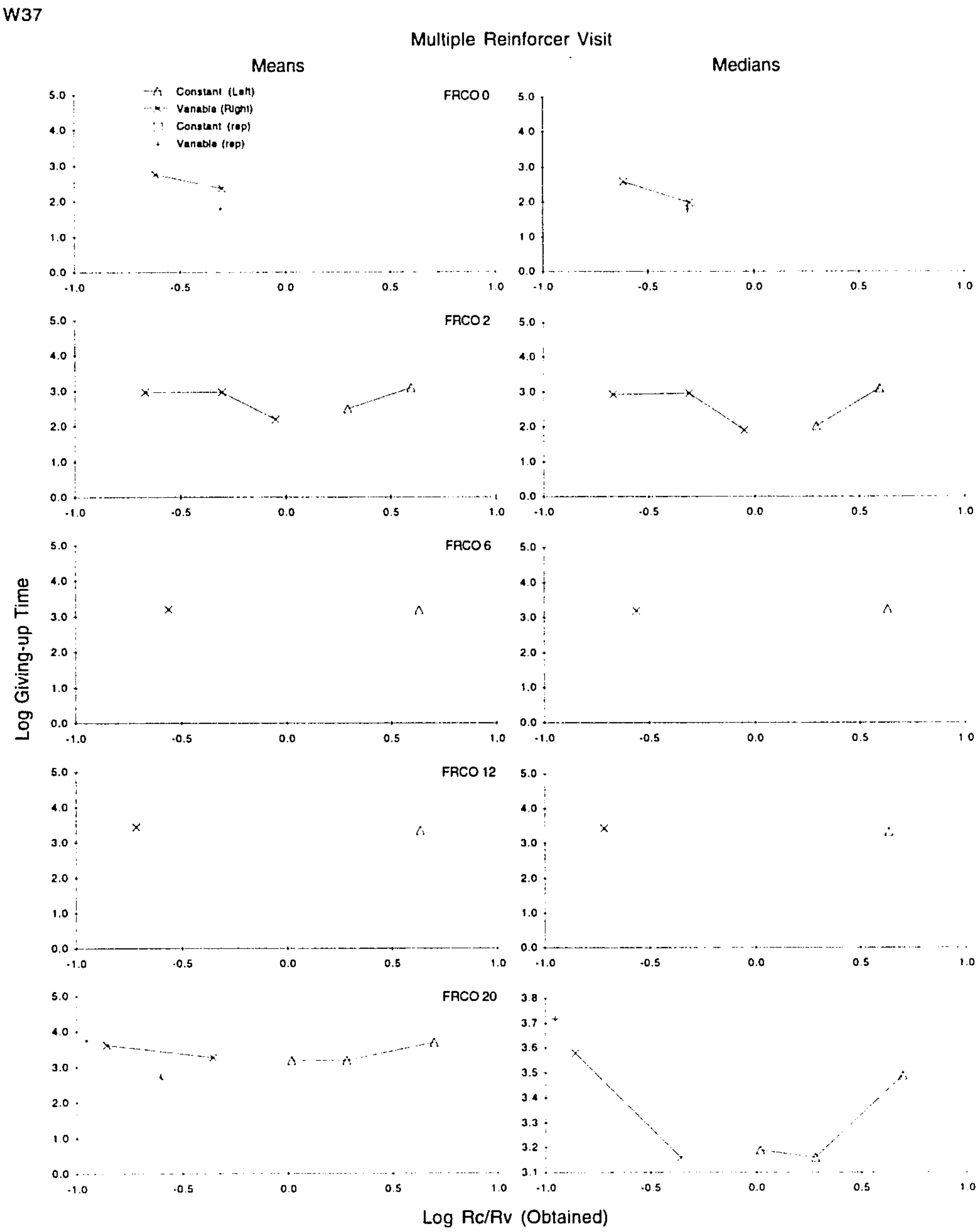
W36


Multiple Reinforcer Visit
Means
Medians
Constant (Left)
Variable (Right)
Constant (rep)
Variable (rep)
FRCO 0
FRCO 2
FRCO 6
FRCO 12
FRCO 20
Log Giving-up Time
Log Rc/Rv (Obtained)
0.0
1.0
2.0
3.0
4.0
5.0
-1.0
-0.5
0.0
0.5
1.0

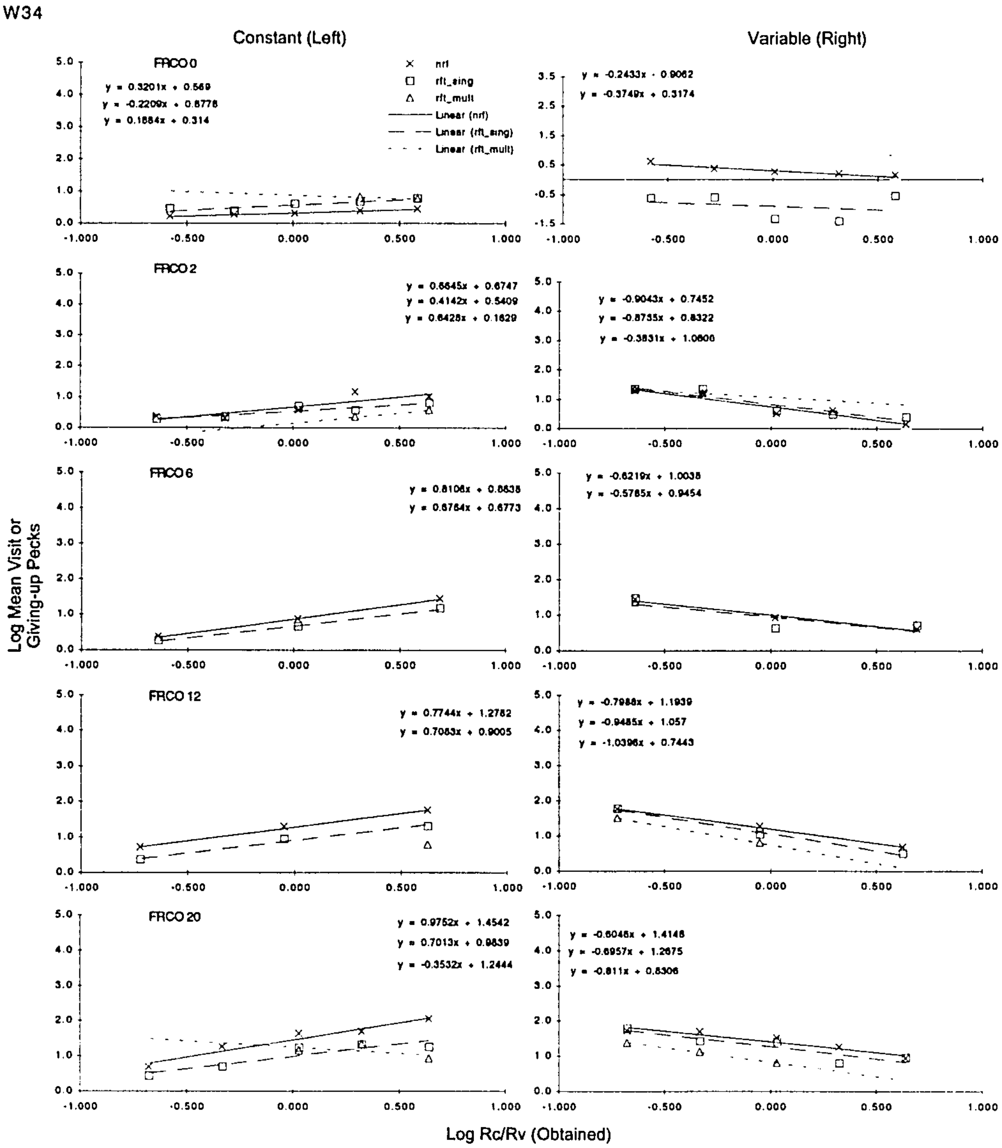

W37
Non-Reinforced Visit
Means
Medians
Constant (Left)
Variable (Right)
Constant (rep)
Variable (rep)
FRCO 0
FRCO 2
FRCO 6
FRCO 12
FRCO 20
Log Visit Time
Log Rc/Rv (Obtained)
0.0
1.0
2.0
3.0
4.0
5.0
-1.0
-0.5
0.0
0.5
1.0

W37

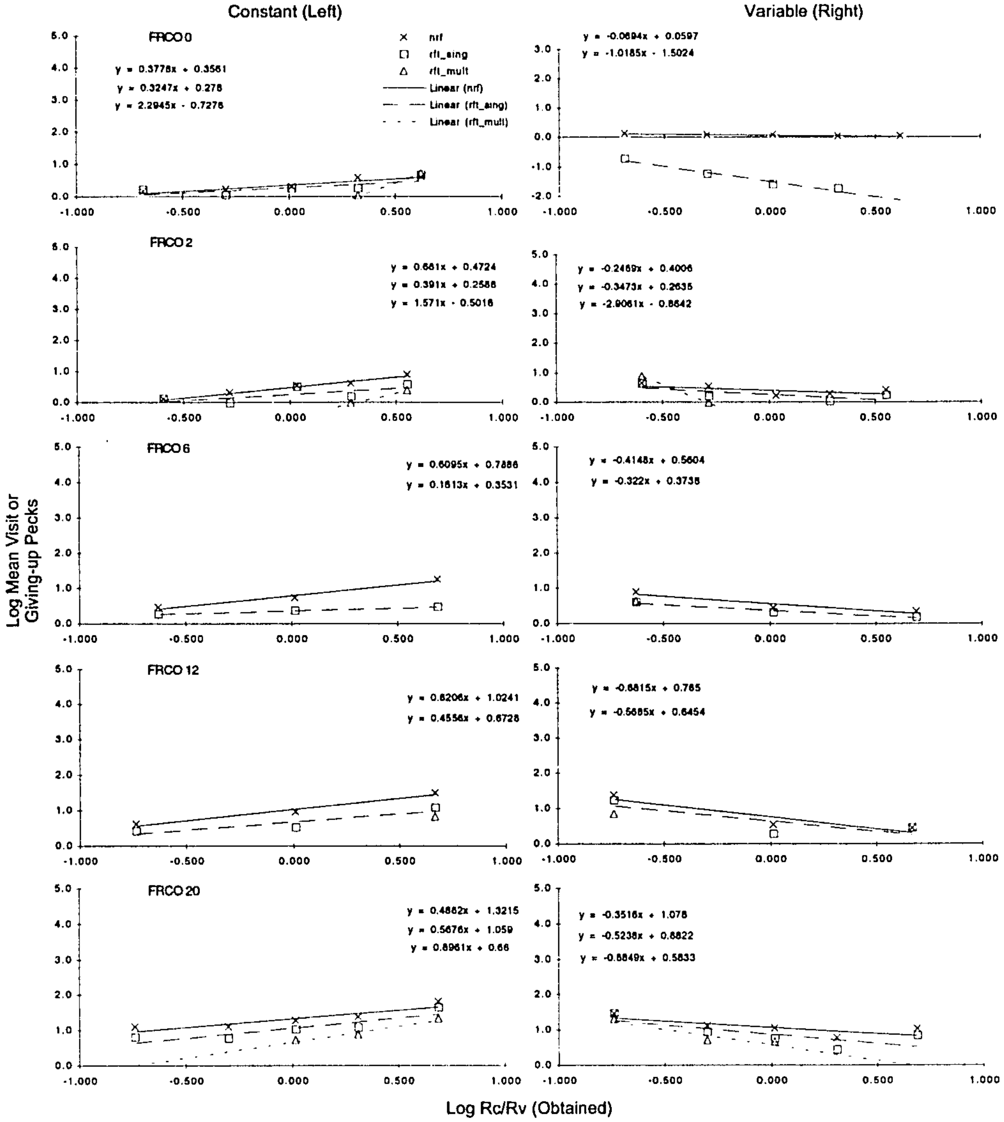

Single Reinforcer Visit
Means
Medians
Constant (Left)
Variable (Right)
Constant (rep)
Variable (rep)
FRCO 0
FRCO 2
FRCO 6
FRCO 12
FRCO 20
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-0.5
0.0
0.5
1.0
Log Giving-up Time
Log Rc/Rv (Obtained)


W37
Multiple Reinforcer Visit
Means
Medians
Constant (Left)
Variable (Right)
Constant (rep)
Variable (rep)
FRCO 0
FRCO 2
FRCO 6
FRCO 12
FRCO 20
Log Giving-up Time
Log Rc/Rv (Obtained)
0.0
1.0
2.0
3.0
4.0
5.0
3.1
3.2
3.3
3.4
3.5
3.6
3.7
3.8
-1.0
-0.5
0.0
0.5
1.0

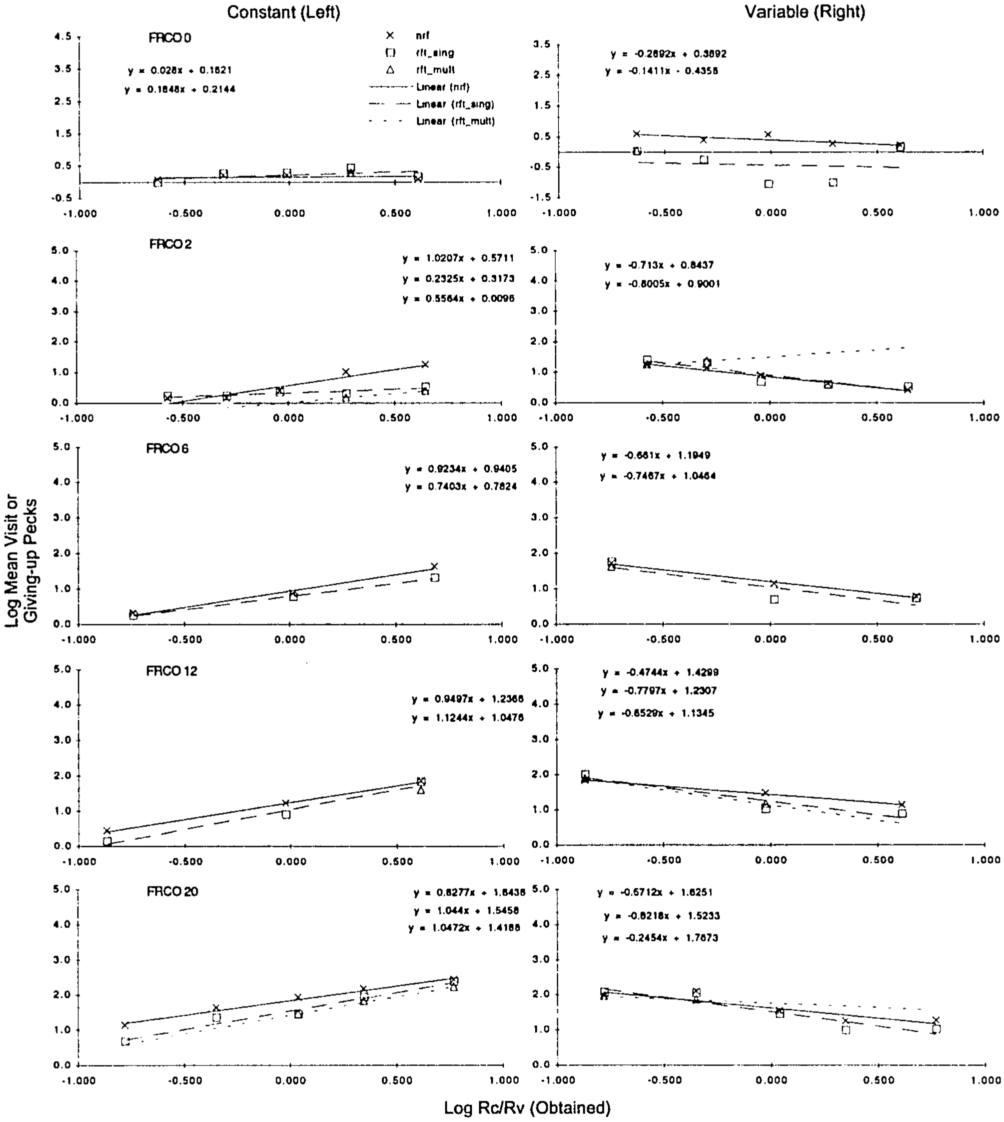
The following 16 figures present the means presented in the prior figures separated into constant (left panels) and variable (right panels) alternatives. The first eight figures plot peck measures (first four figures) and time measures (last four figures) as a function of obtained log reinforcer ratio. The least-squares regression equations for each category of visit are given in each panel in the order listed in the legend. The last eight figures plot peck measures (first four figures) and time measures (last four figures) as a function of log travel requirement.


W34
Constant (Left)
Variable (Right)
FRCO 0
y = 0.3201x + 0.569
y = -0.2209x + 0.8778
y = 0.1884x + 0.314
nrf
rft_sing
rft_mult
Linear (nrf)
Linear (rft_sing)
Linear (rft_mult)
y = -0.2433x - 0.9062
y = -0.3749x + 0.3174
3.5
2.5
1.5
0.5
-0.5
-1.5
FRCO 2
y = 0.6645x + 0.6747
y = 0.4142x + 0.5409
y = 0.6428x + 0.1629
y = -0.9043x + 0.7452
y = -0.8735x + 0.8322
y = -0.3831x + 1.0600
FRCO 6
y = 0.8106x + 0.8638
y = 0.6764x + 0.6773
y = -0.6219x + 1.0038
y = -0.5785x + 0.9454
FRCO 12
y = 0.7744x + 1.2782
y = 0.7063x + 0.9005
y = -0.7988x + 1.1939
y = -0.9485x + 1.057
y = -1.0396x + 0.7443
FRCO 20
y = 0.9752x + 1.4542
y = 0.7013x + 0.9839
y = -0.3532x + 1.2444
y = -0.6046x + 1.4148
y = -0.6957x + 1.2675
y = -0.811x + 0.8306
5.0
4.0
3.0
2.0
1.0
0.0
-1.000
-0.500
0.000
0.500
1.000
Log Mean Visit or Giving-up Pecks
Log Rc/Rv (Obtained)

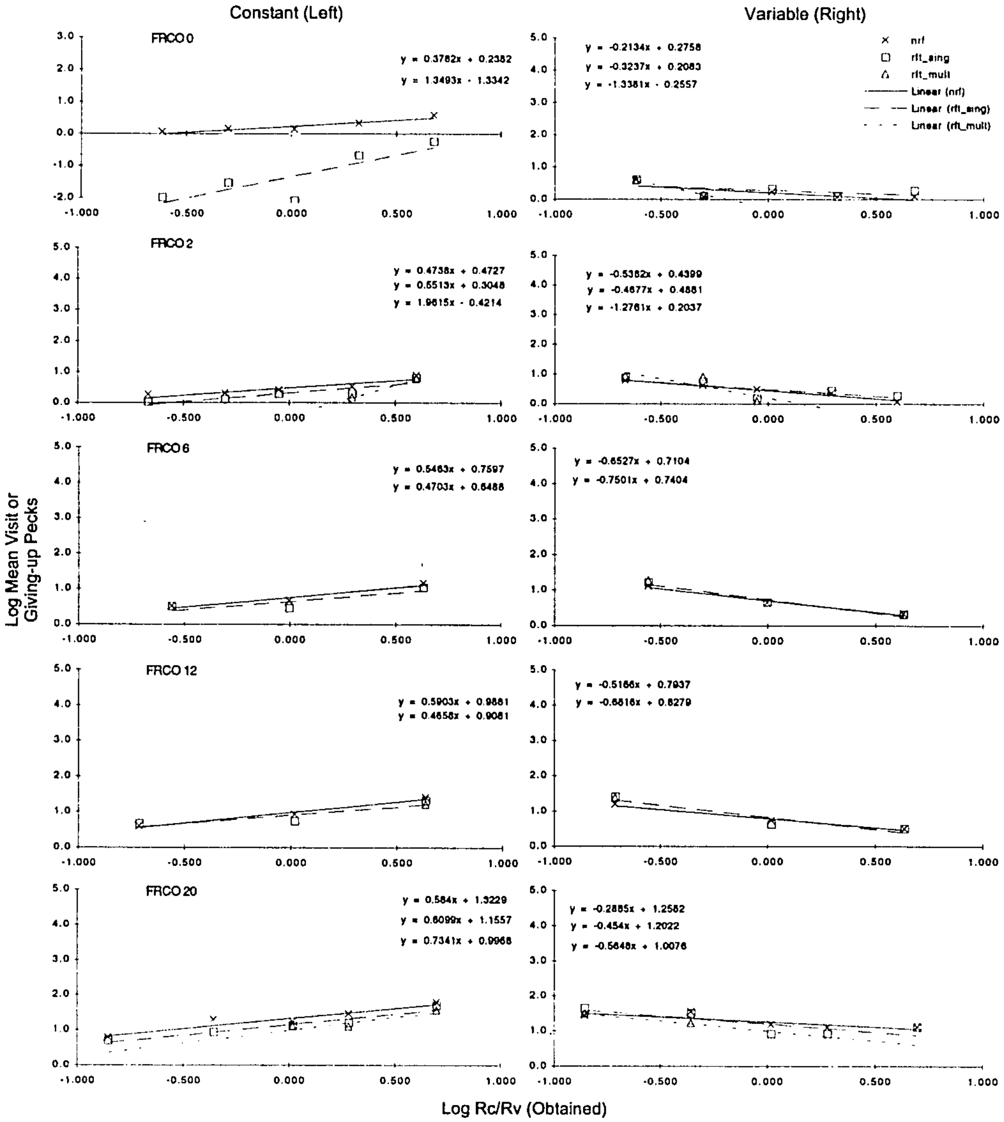
W35


Constant (Left)
Variable (Right)
FRCO 0
× nrf
□ rft_sing
Δ rft_mult
Linear (nrf)
Linear (rft_sing)
Linear (rft_mult)
y = 0.3778x + 0.3561
y = 0.3247x + 0.278
y = 2.2945x - 0.7276
y = -0.0694x + 0.0597
y = -1.0185x - 1.5024
FRCO 2
y = 0.661x + 0.4724
y = 0.391x + 0.2588
y = 1.571x - 0.5016
y = -0.2469x + 0.4006
y = -0.3473x + 0.2635
y = -2.9061x - 0.8642
FRCO 6
y = 0.6095x + 0.7886
y = 0.1613x + 0.3531
y = -0.4148x + 0.5604
y = -0.322x + 0.3738
FRCO 12
y = 0.8206x + 1.0241
y = 0.4556x + 0.6728
y = -0.6815x + 0.765
y = -0.5685x + 0.6454
FRCO 20
y = 0.4882x + 1.3215
y = 0.5676x + 1.059
y = 0.8961x + 0.66
y = -0.3516x + 1.078
y = -0.5238x + 0.6822
y = -0.8849x + 0.5833
Log Mean Visit or Giving-up Pecks
Log Rc/Rv (Obtained)
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-1.000
-0.500
0.000
0.500
1.000

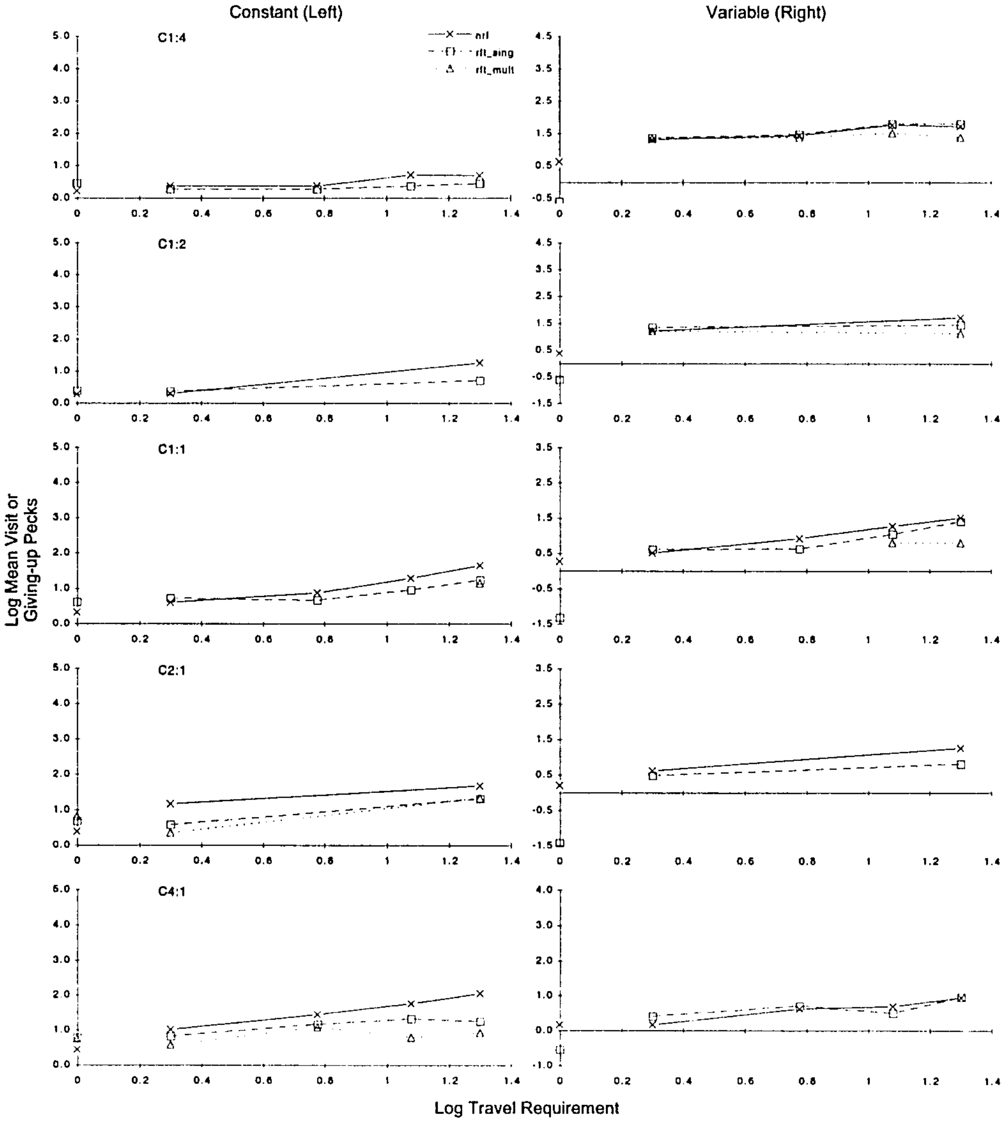
W36


Constant (Left)
Variable (Right)
FRCO 0
× nrf
□ rft_sing
△ rft_mult
Linear (nrf)
Linear (rft_sing)
Linear (rft_mult)
y = 0.028x + 0.1621
y = 0.1848x + 0.2144
y = -0.2892x + 0.3892
y = -0.1411x - 0.4358
FRCO 2
y = 1.0207x + 0.5711
y = 0.2325x + 0.3173
y = 0.5564x + 0.0096
y = -0.713x + 0.8437
y = -0.8005x + 0.9001
FRCO 6
y = 0.9234x + 0.9405
y = 0.7403x + 0.7824
y = -0.681x + 1.1949
y = -0.7467x + 1.0464
FRCO 12
y = 0.9497x + 1.2368
y = 1.1244x + 1.0476
y = -0.4744x + 1.4299
y = -0.7797x + 1.2307
y = -0.8529x + 1.1345
FRCO 20
y = 0.8277x + 1.8438
y = 1.044x + 1.5458
y = 1.0472x + 1.4188
y = -0.5712x + 1.8251
y = -0.8218x + 1.5233
y = -0.2454x + 1.7873
4.5
3.5
2.5
1.5
0.5
-0.5
-1.5
5.0
4.0
3.0
2.0
1.0
0.0
-1.000
-0.500
0.000
0.500
1.000
Log Mean Visit or Giving-up Pecks
Log Rc/Rv (Obtained)

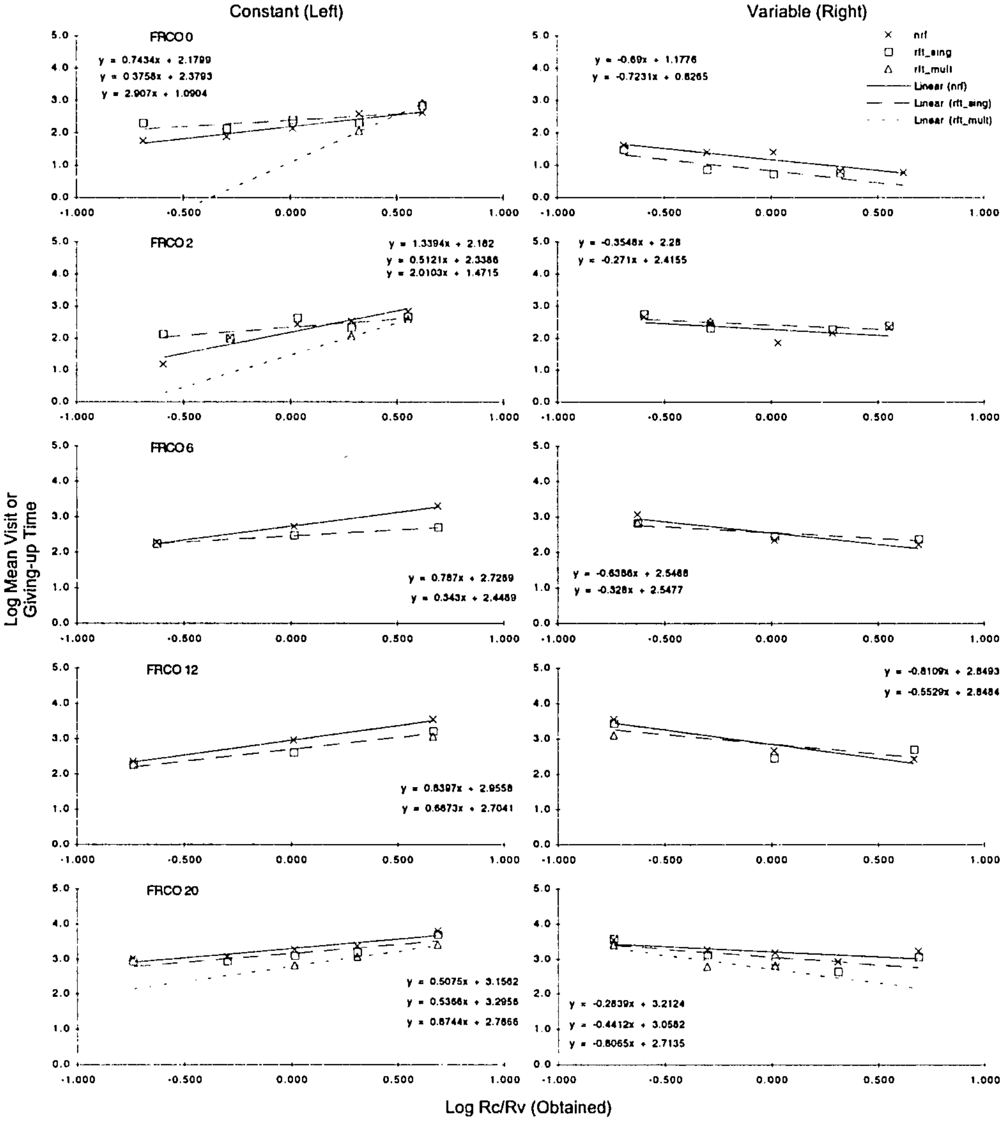
W37


Constant (Left)
Variable (Right)
× nrf
□ rft_sing
△ rft_mult
Linear (nrf)
Linear (rft_sing)
Linear (rft_mult)
FRCO 0
y = 0.3782x + 0.2382
y = 1.3493x - 1.3342
y = -0.2134x + 0.2758
y = -0.3237x + 0.2083
y = -1.3381x - 0.2557
FRCO 2
y = 0.4738x + 0.4727
y = 0.5513x + 0.3048
y = 1.9615x - 0.4214
y = -0.5382x + 0.4399
y = -0.4677x + 0.4881
y = -1.2761x + 0.2037
FRCO 6
y = 0.5463x + 0.7597
y = 0.4703x + 0.6488
y = -0.6527x + 0.7104
y = -0.7501x + 0.7404
FRCO 12
y = 0.5903x + 0.9881
y = 0.4656x + 0.9081
y = -0.5166x + 0.7937
y = -0.6616x + 0.8279
FRCO 20
y = 0.584x + 1.3229
y = 0.6099x + 1.1557
y = 0.7341x + 0.9968
y = -0.2885x + 1.2582
y = -0.454x + 1.2022
y = -0.5648x + 1.0076
3.0
2.0
1.0
0.0
-1.0
-2.0
5.0
4.0
-1.000
-0.500
0.000
0.500
1.000
Log Mean Visit or Giving-up Pecks
Log Rc/Rv (Obtained)

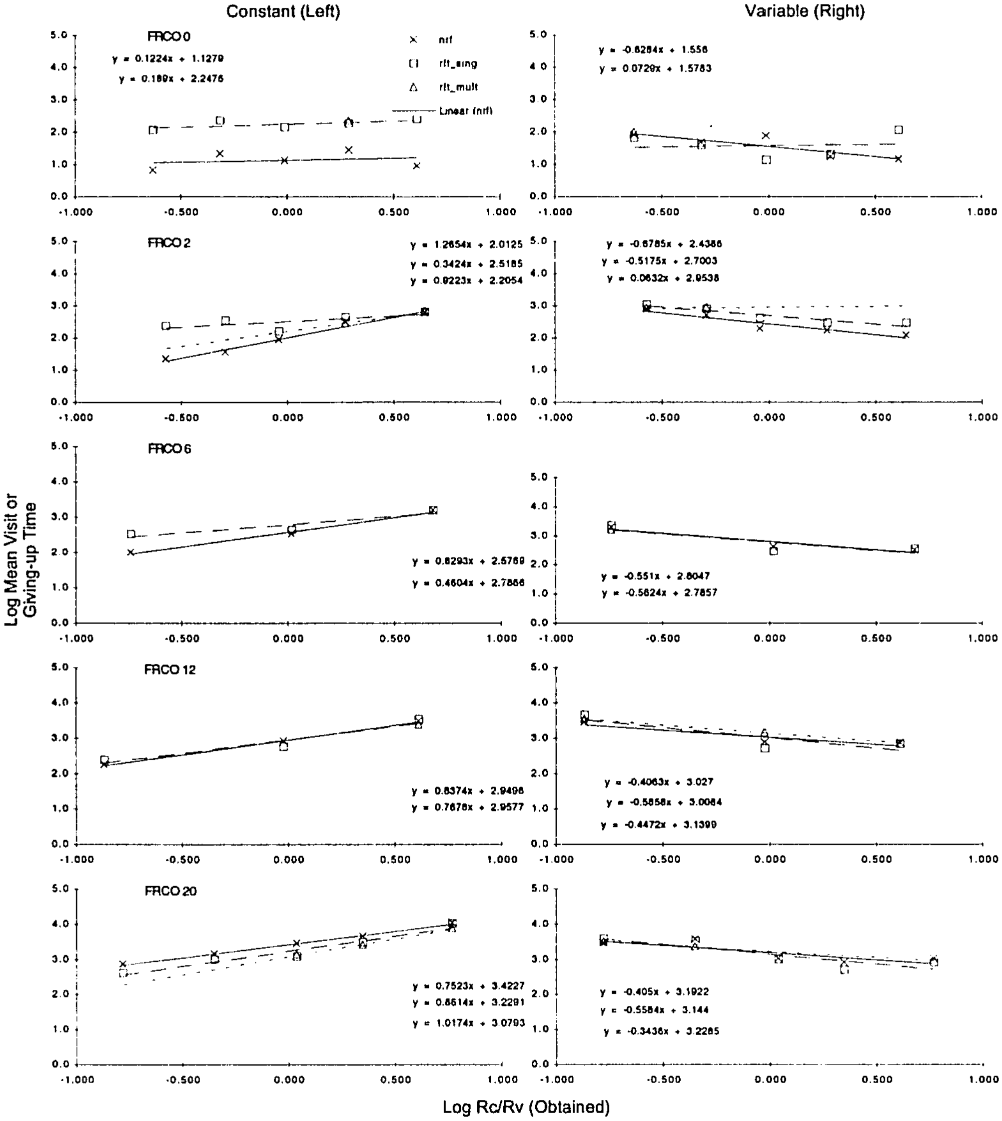
W34


Constant (Left)
Variable (Right)
C1:4
C1:2
C1:1
C2:1
C4:1
rfl
rfl_sing
rfl_mult
Log Mean Visit or Giving-up Pecks
Log Travel Requirement
0
0.2
0.4
0.6
0.8
1
1.2
1.4

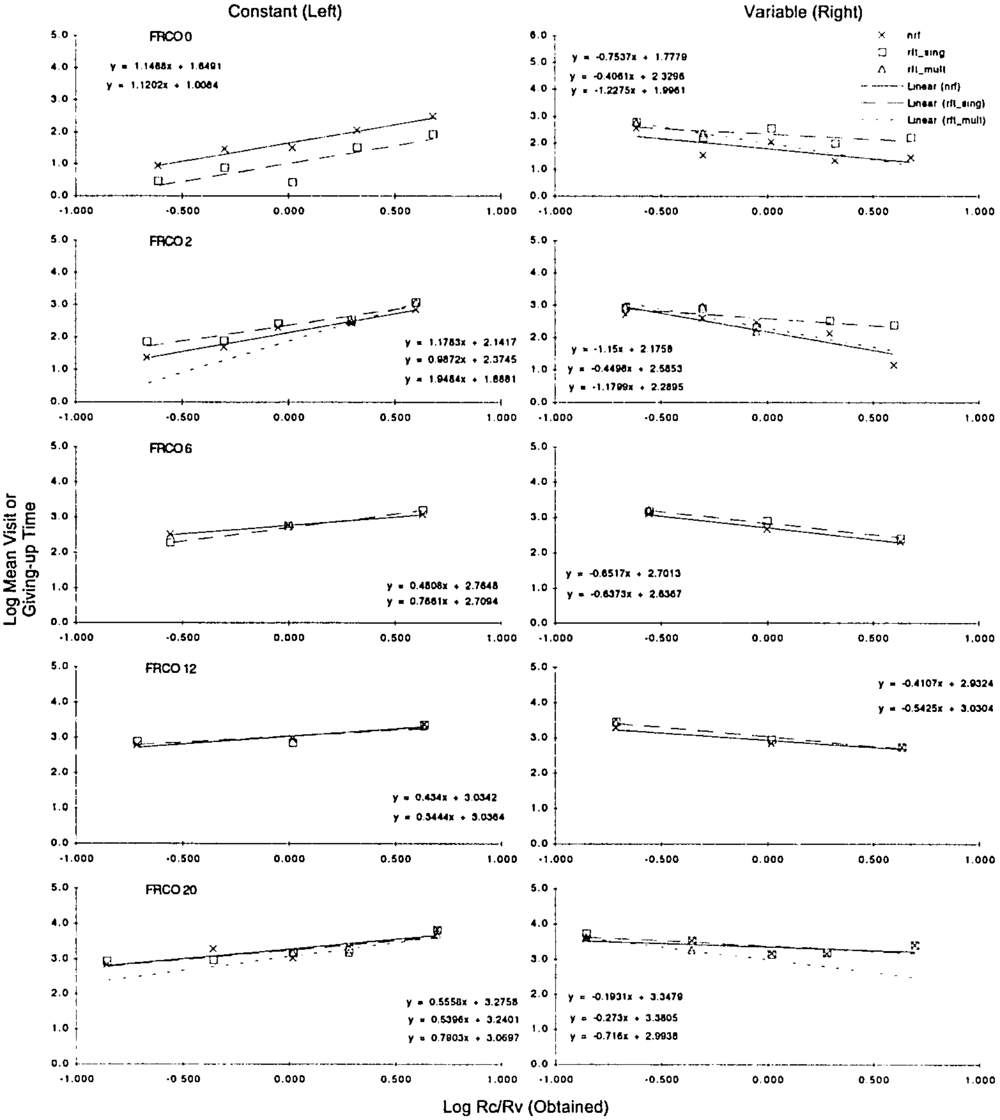
W35


Constant (Left)
Variable (Right)
Log Mean Visit or Giving-up Time
Log Rc/Rv (Obtained)
× nrf
☐ rft_sing
△ rft_mult
Linear (nrf)
Linear (rft_sing)
Linear (rft_mult)
FRCO 0
y = 0.7434x + 2.1799
y = 0.3758x + 2.3793
y = 2.907x + 1.0904
y = -0.69x + 1.1776
y = -0.7231x + 0.8265
FRCO 2
y = 1.3394x + 2.182
y = 0.5121x + 2.3386
y = 2.0103x + 1.4715
y = -0.3548x + 2.28
y = -0.271x + 2.4155
FRCO 6
y = 0.787x + 2.7269
y = 0.343x + 2.4489
y = -0.6386x + 2.5488
y = -0.328x + 2.5477
FRCO 12
y = 0.8397x + 2.9558
y = 0.6873x + 2.7041
y = -0.8109x + 2.8493
y = -0.5529x + 2.8484
FRCO 20
y = 0.5075x + 3.1562
y = 0.5366x + 3.2956
y = 0.8744x + 2.7866
y = -0.2839x + 3.2124
y = -0.4412x + 3.0582
y = -0.8065x + 2.7135
0.0
1.0
2.0
3.0
4.0
5.0
-1.000
-0.500
0.000
0.500
1.000

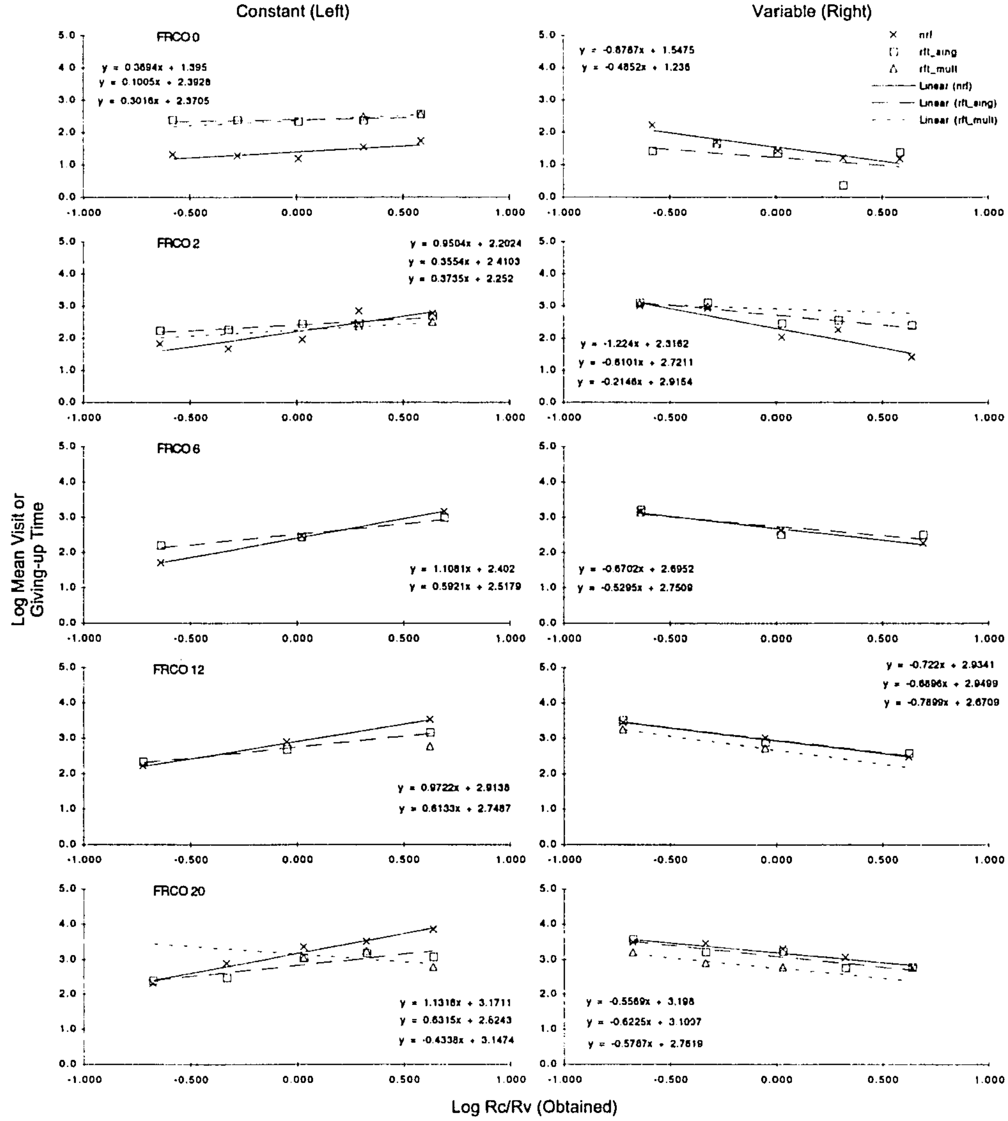
W36


Constant (Left)
Variable (Right)
FRCO 0
y = 0.1224x + 1.1279
y = 0.189x + 2.2476
× nrf
□ rlt_sing
Δ rlt_mult
Linear (nrf)
y = -0.6284x + 1.556
y = 0.0729x + 1.5783
FRCO 2
y = 1.2654x + 2.0125
y = 0.3424x + 2.5185
y = 0.9223x + 2.2054
y = -0.6785x + 2.4386
y = -0.5175x + 2.7003
y = 0.0632x + 2.9538
FRCO 6
y = 0.8293x + 2.5769
y = 0.4604x + 2.7866
y = -0.551x + 2.8047
y = -0.5624x + 2.7857
FRCO 12
y = 0.8374x + 2.9496
y = 0.7678x + 2.9577
y = -0.4063x + 3.027
y = -0.5858x + 3.0084
y = -0.4472x + 3.1399
FRCO 20
y = 0.7523x + 3.4227
y = 0.8614x + 3.2291
y = 1.0174x + 3.0793
y = -0.405x + 3.1922
y = -0.5584x + 3.144
y = -0.3436x + 3.2285
5.0
4.0
3.0
2.0
1.0
0.0
-1.000
-0.500
0.000
0.500
1.000
Log Mean Visit or Giving-up Time
Log Rc/Rv (Obtained)

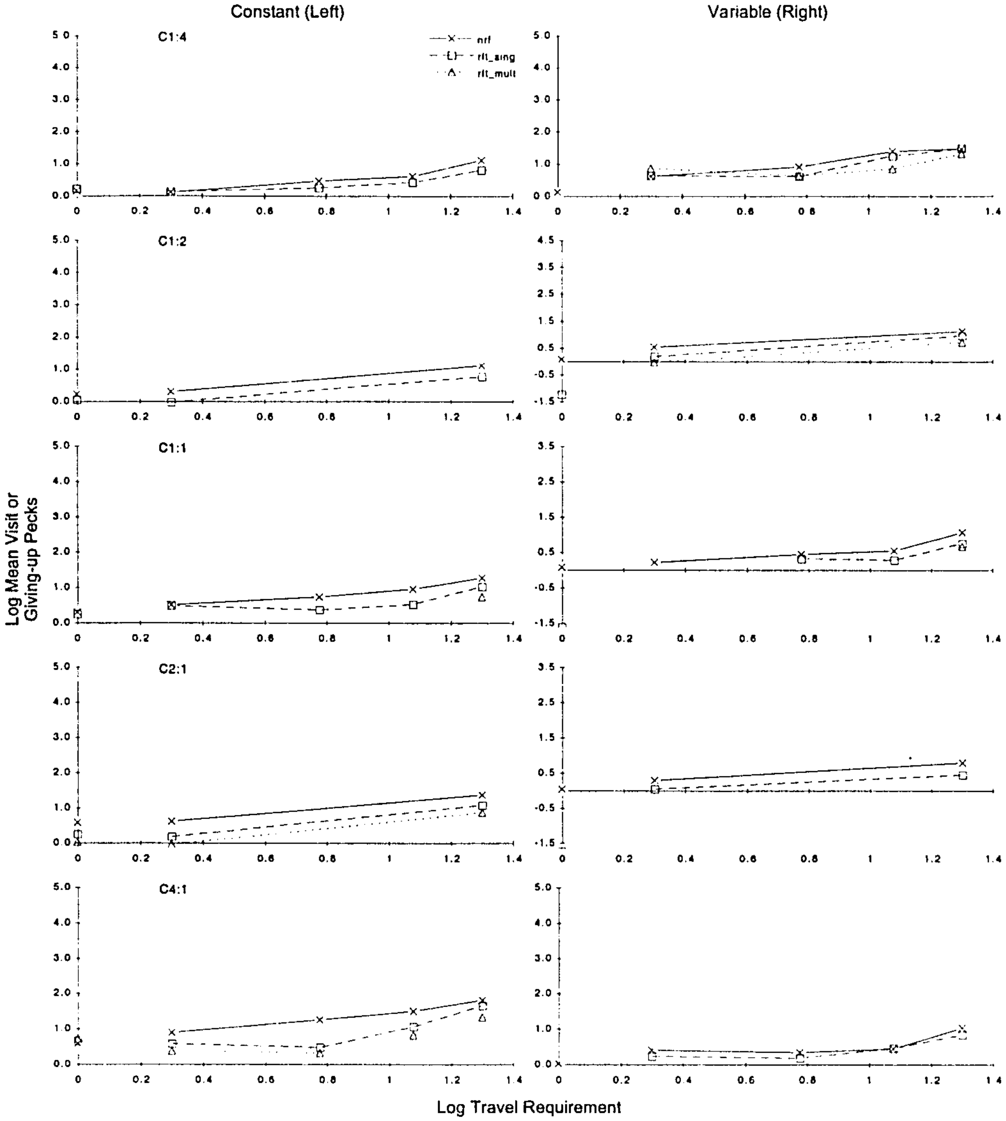
W37

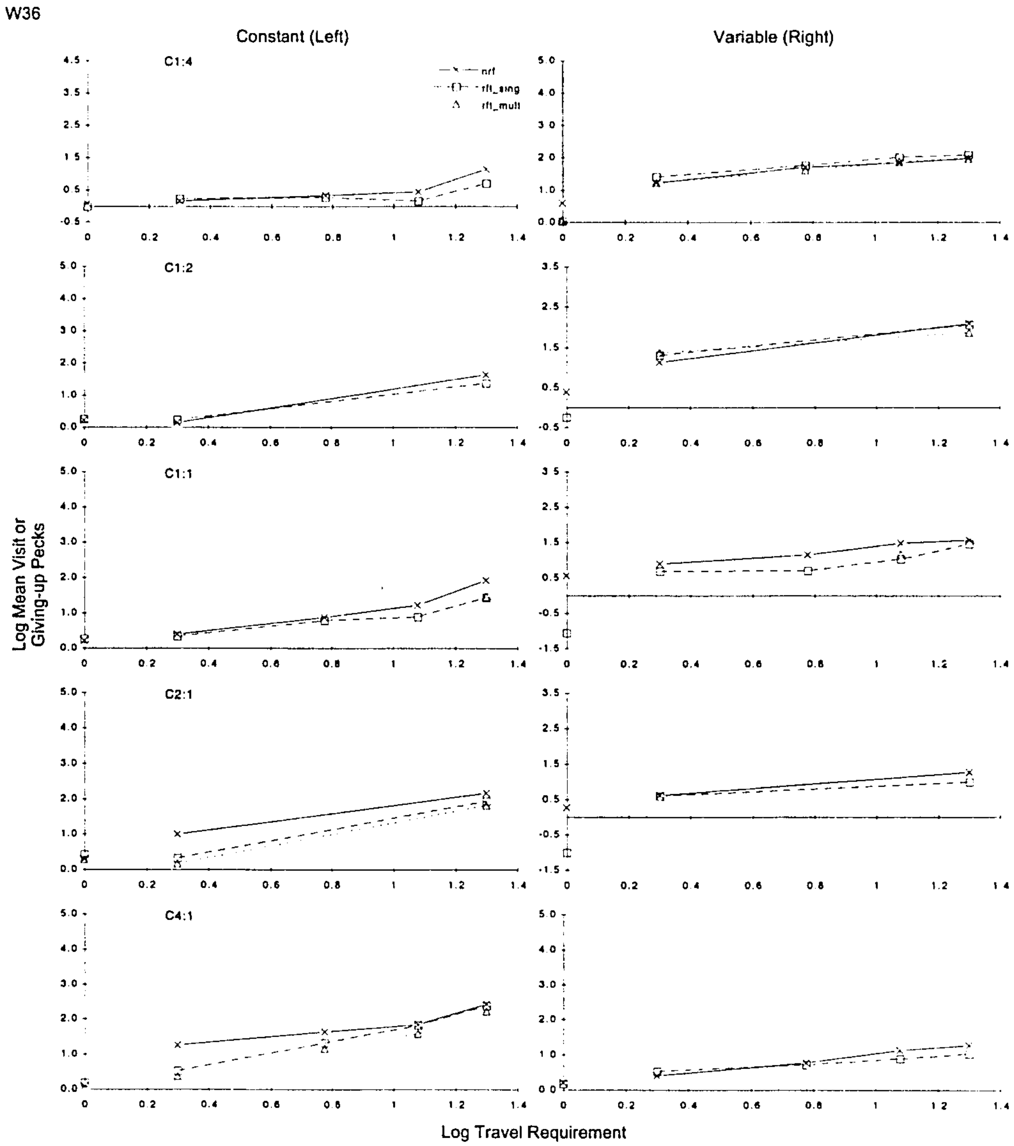

Constant (Left)
Variable (Right)
Log Mean Visit or Giving-up Time
Log Rc/Rv (Obtained)
FRCO 0
y = 1.1488x + 1.6491
y = 1.1202x + 1.0084
y = -0.7537x + 1.7779
y = -0.4061x + 2.3296
y = -1.2275x + 1.9961
× nrf
□ rft_sing
Δ rft_mult
Linear (nrf)
Linear (rft_sing)
Linear (rft_mult)
FRCO 2
y = 1.1783x + 2.1417
y = 0.9872x + 2.3745
y = 1.9484x + 1.6881
y = -1.15x + 2.1758
y = -0.4498x + 2.5853
y = -1.1799x + 2.2895
FRCO 6
y = 0.4808x + 2.7648
y = 0.7661x + 2.7094
y = -0.6517x + 2.7013
y = -0.6373x + 2.8367
FRCO 12
y = 0.434x + 3.0342
y = 0.3444x + 3.0364
y = -0.4107x + 2.9324
y = -0.5425x + 3.0304
FRCO 20
y = 0.5558x + 3.2758
y = 0.5396x + 3.2401
y = 0.7803x + 3.0697
y = -0.1931x + 3.3479
y = -0.273x + 3.3805
y = -0.716x + 2.9938
0.0
1.0
2.0
3.0
4.0
5.0
6.0
-1.000
-0.500
0.000
0.500
1.000

W34

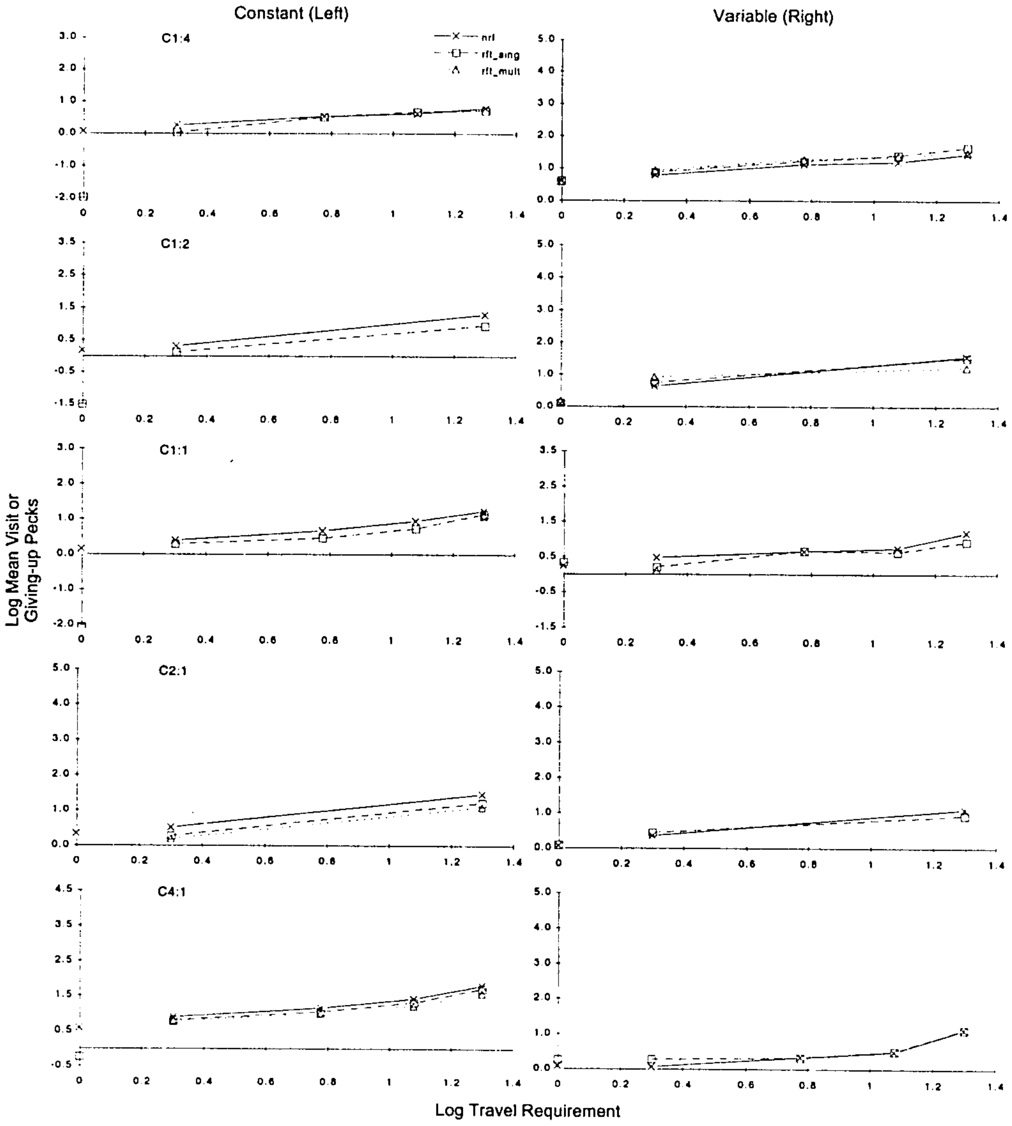

Constant (Left)
Variable (Right)
FRCO 0
y = 0.3694x + 1.395
y = 0.1005x + 2.3928
y = 0.3016x + 2.3705
y = -0.8787x + 1.5475
y = -0.4852x + 1.236
× nrf
□ rft_sing
△ rft_mult
Linear (nrf)
Linear (rft_sing)
Linear (rft_mult)
FRCO 2
y = 0.9504x + 2.2024
y = 0.3554x + 2.4103
y = 0.3735x + 2.252
y = -1.224x + 2.3162
y = -0.6101x + 2.7211
y = -0.2146x + 2.9154
FRCO 6
y = 1.1081x + 2.402
y = 0.5921x + 2.5179
y = -0.6702x + 2.6952
y = -0.5295x + 2.7509
FRCO 12
y = 0.9722x + 2.9138
y = 0.6133x + 2.7487
y = -0.722x + 2.9341
y = -0.6896x + 2.9499
y = -0.7899x + 2.6709
FRCO 20
y = 1.1316x + 3.1711
y = 0.6315x + 2.6243
y = -0.4338x + 3.1474
y = -0.5569x + 3.198
y = -0.6225x + 3.1007
y = -0.5787x + 2.7619
Log Mean Visit or Giving-up Time
Log Rc/Rv (Obtained)
5.0
4.0
3.0
2.0
1.0
0.0
-1.000
-0.500
0.000
0.500
1.000

W35

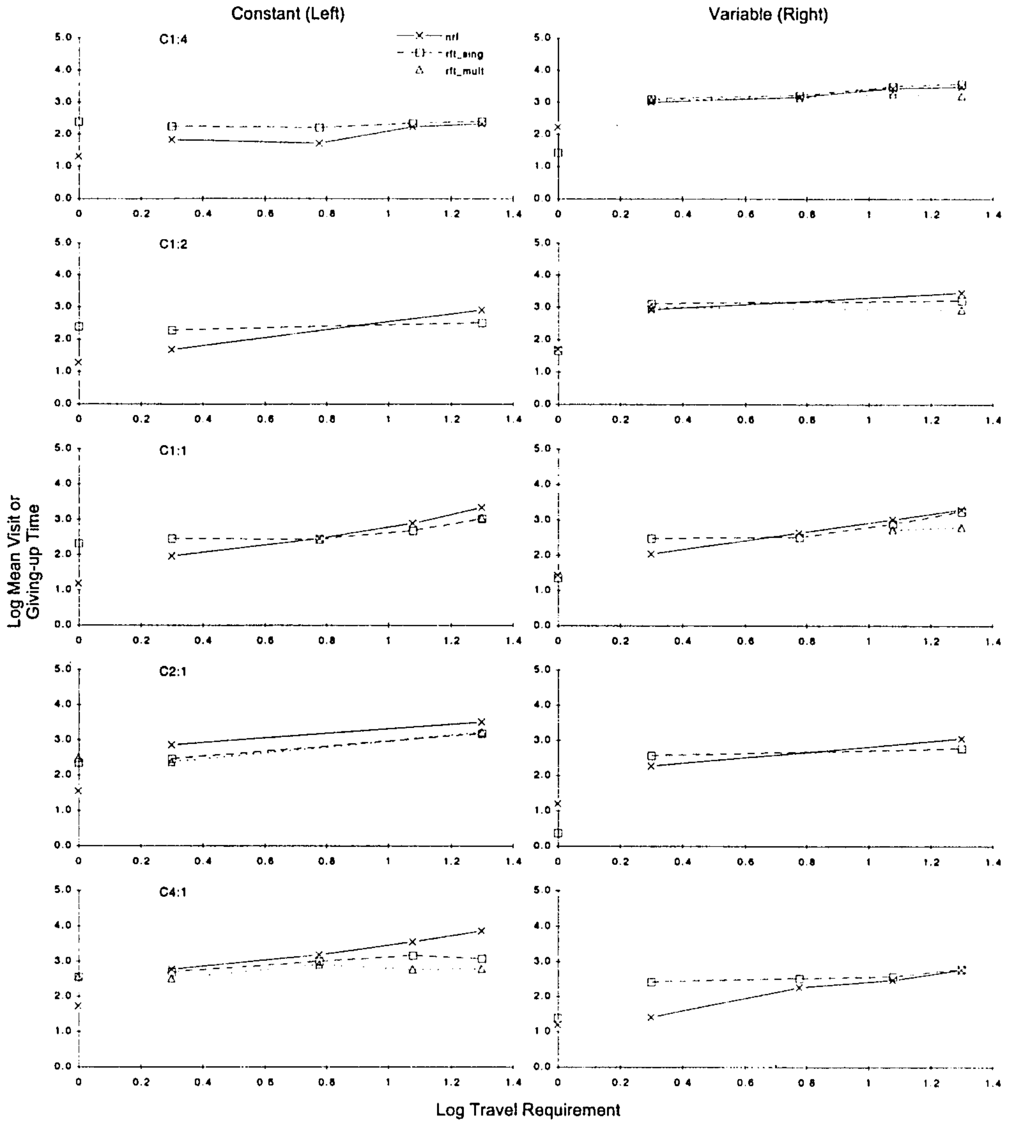

Constant (Left)
Variable (Right)
C1:4
C1:2
C1:1
C2:1
C4:1
nrf
rlt_sing
rlt_mult
Log Mean Visit or Giving-up Pecks
Log Travel Requirement
0
0.2
0.4
0.6
0.8
1
1.2
1.4
0.0
1.0
2.0
3.0
4.0
5.0
-1.5
-0.5
0.5
1.5
2.5
3.5
4.5

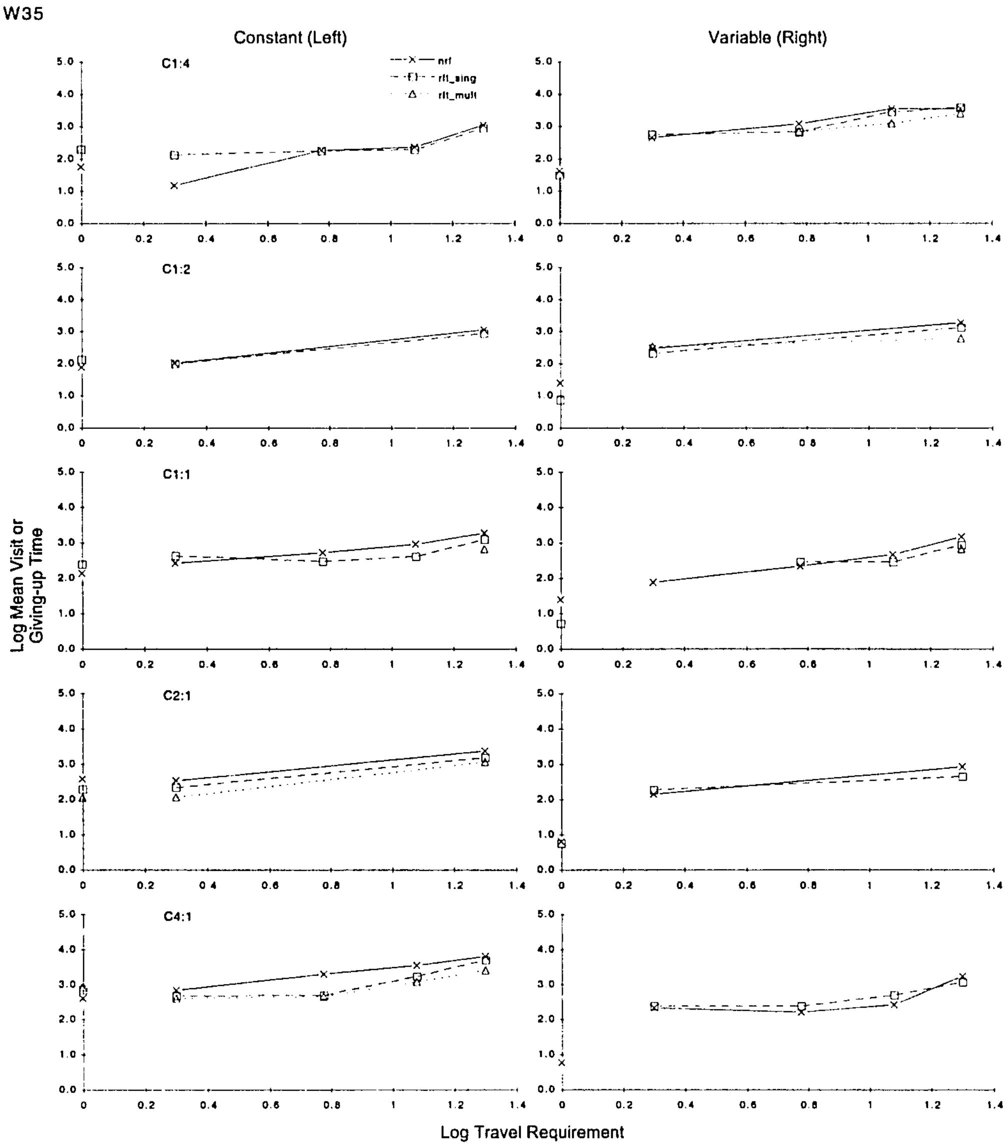

W36
Constant (Left)
Variable (Right)
C1:4
C1:2
C1:1
C2:1
C4:1
nrf
rfl_sing
rfl_mult
Log Mean Visit or Giving-up Pecks
Log Travel Requirement
0
0.2
0.4
0.6
0.8
1
1.2
1.4

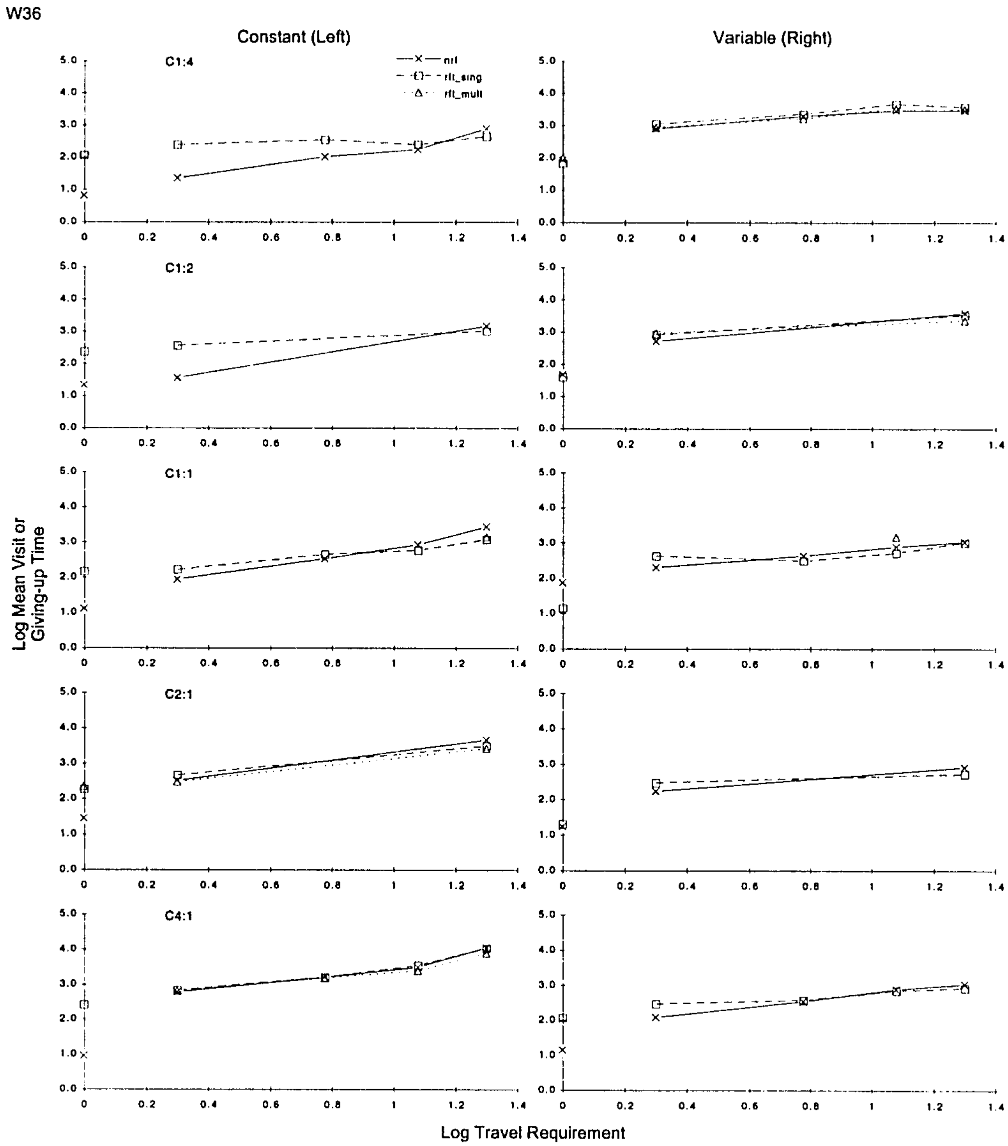
W37


Constant (Left)
Variable (Right)
C1:4
C1:2
C1:1
C2:1
C4:1
—X— nrl
- -□- - rft_sing
Δ rft_mult
Log Mean Visit or Giving-up Pecks
Log Travel Requirement
0
0.2
0.4
0.6
0.8
1
1.2
1.4

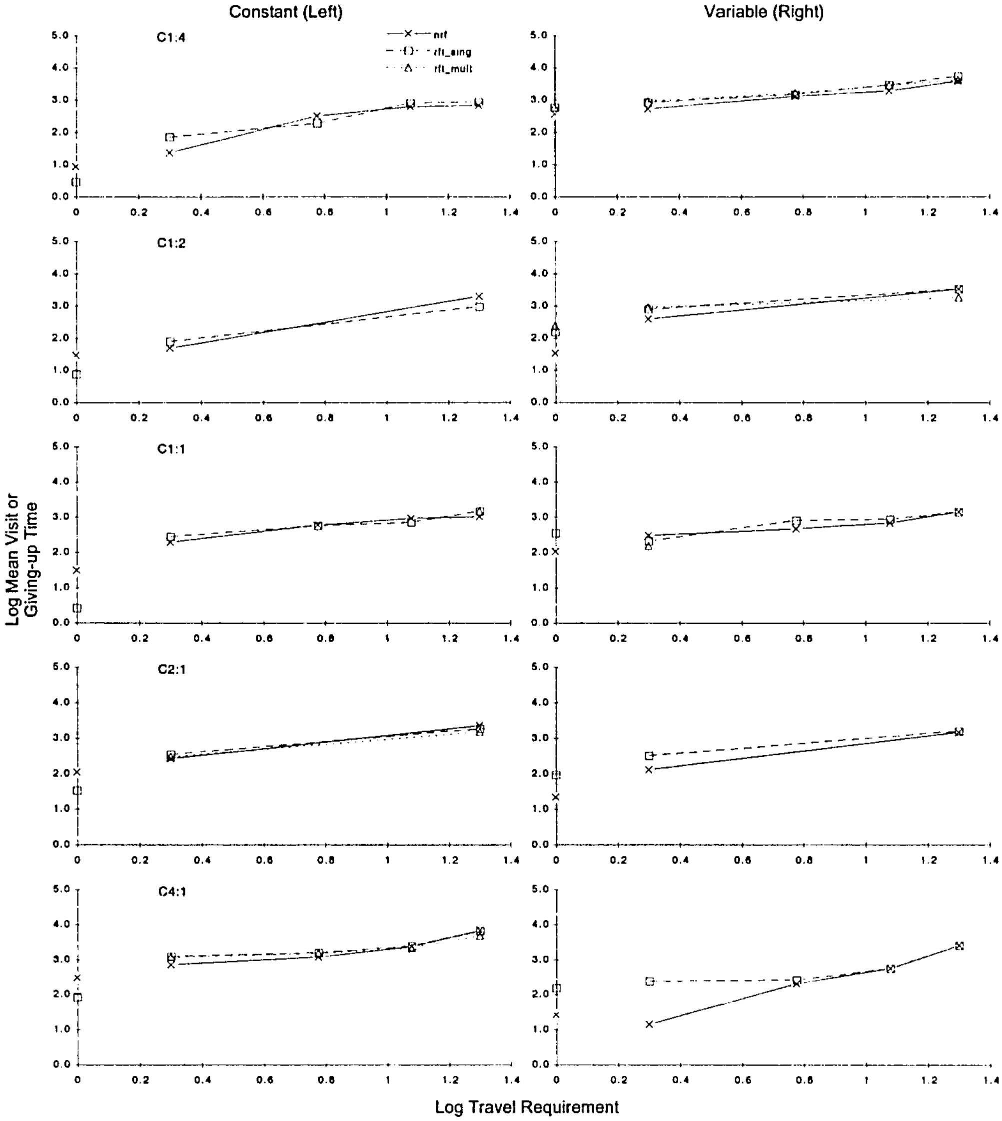
W34


Constant (Left)
Variable (Right)
C1:4
C1:2
C1:1
C2:1
C4:1
nrl
rft_sing
rft_mult
5.0
4.0
3.0
2.0
1.0
0.0
0
0.2
0.4
0.6
0.8
1
1.2
1.4
Log Mean Visit or Giving-up Time
Log Travel Requirement

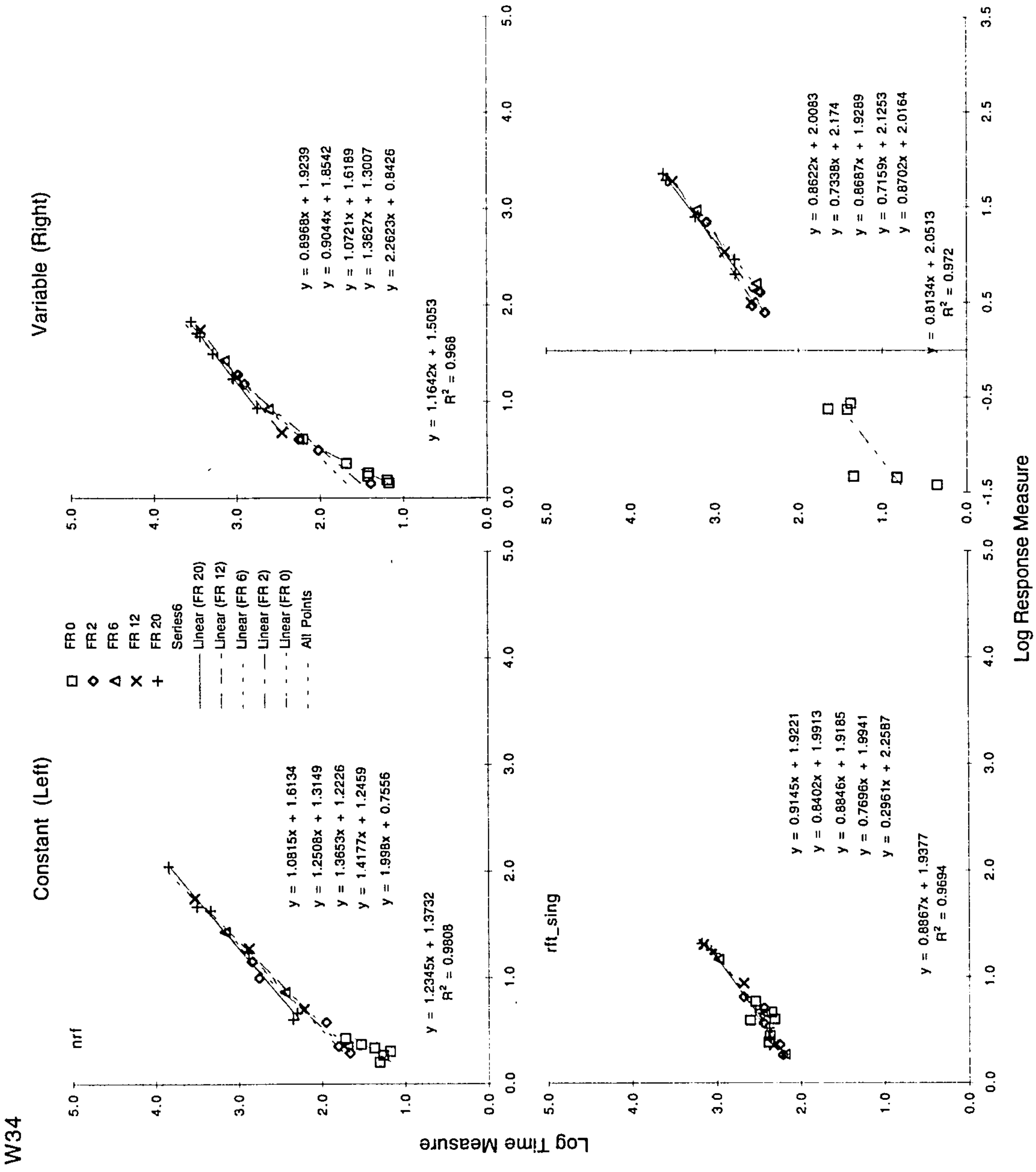

W35
Constant (Left)
Variable (Right)
nrf
rft_sing
rft_mult
C1:4
C1:2
C1:1
C2:1
C4:1
Log Mean Visit or Giving-up Time
Log Travel Requirement
0.0
1.0
2.0
3.0
4.0
5.0
0
0.2
0.4
0.6
0.8
1
1.2
1.4

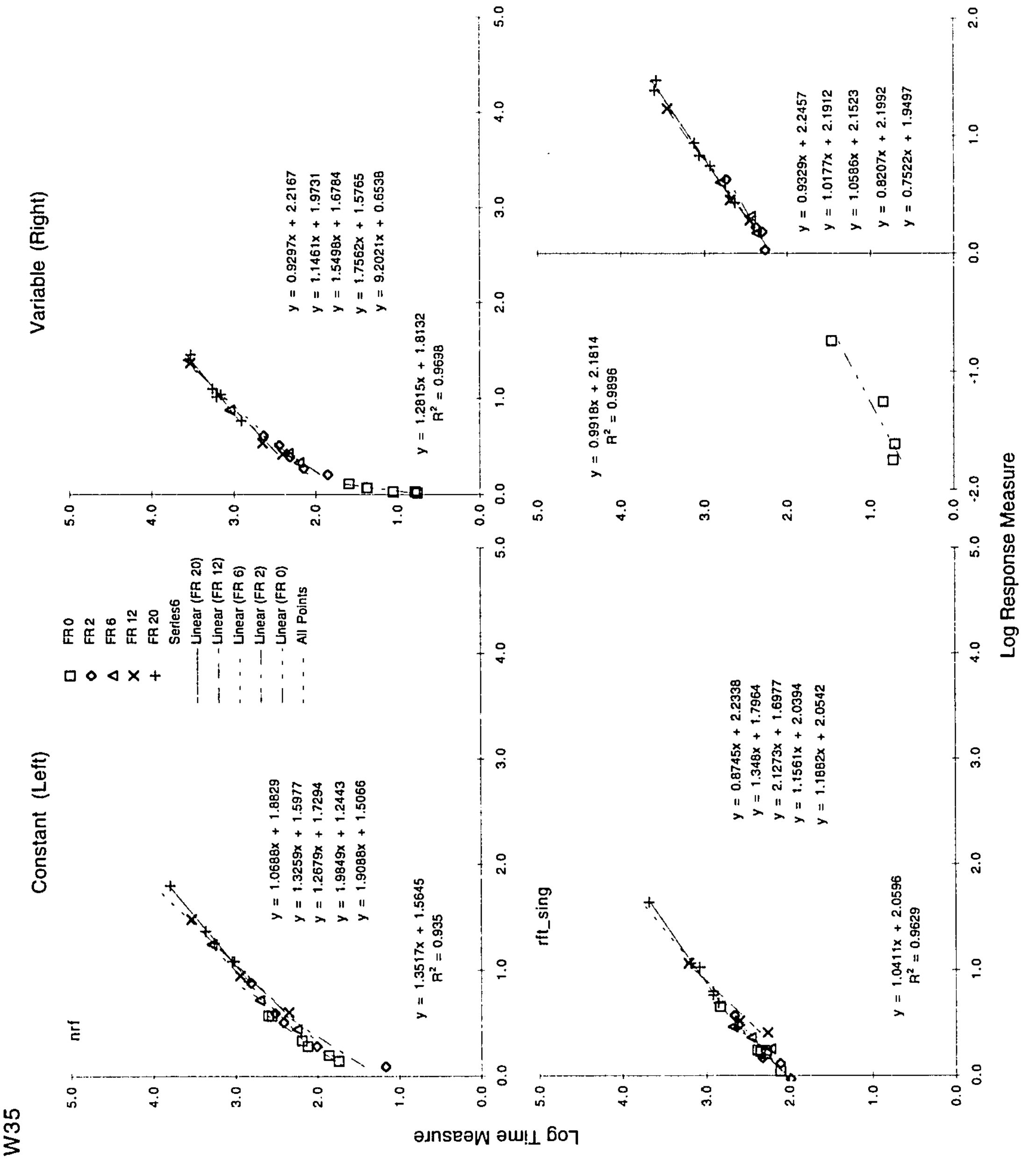

W36
Constant (Left)
Variable (Right)
C1:4
C1:2
C1:1
C2:1
C4:1
nrl
rft_sing
rft_mult
Log Mean Visit or Giving-up Time
Log Travel Requirement
0.0
1.0
2.0
3.0
4.0
5.0
0
0.2
0.4
0.6
0.8
1
1.2
1.4

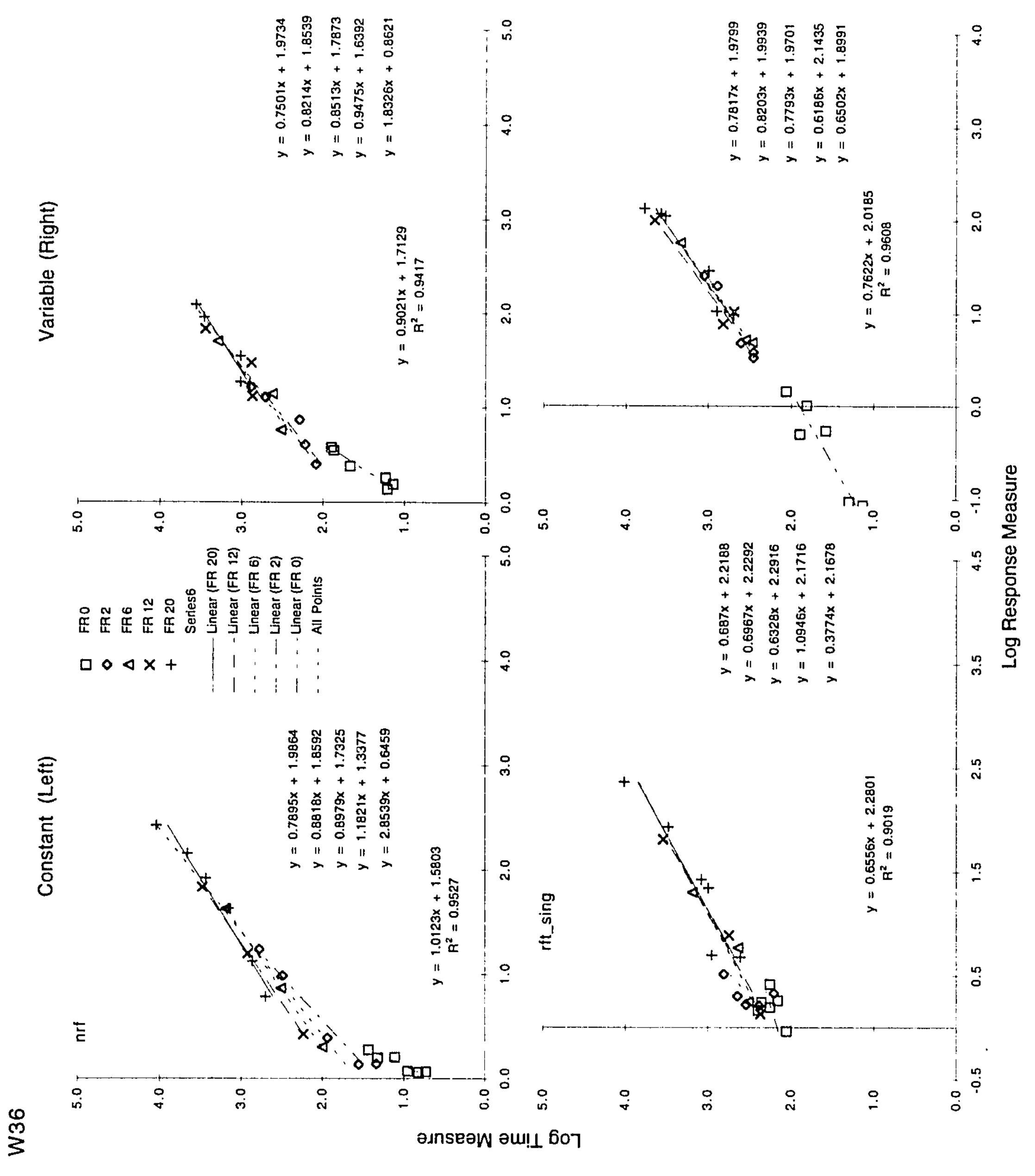
W37


Constant (Left)
Variable (Right)
C1:4
nrt
rft_sing
rft_mult
C1:2
C1:1
C2:1
C4:1
Log Mean Visit or Giving-up Time
Log Travel Requirement
0.0
1.0
2.0
3.0
4.0
5.0
0
0.2
0.4
0.6
0.8
1
1.2
1.4

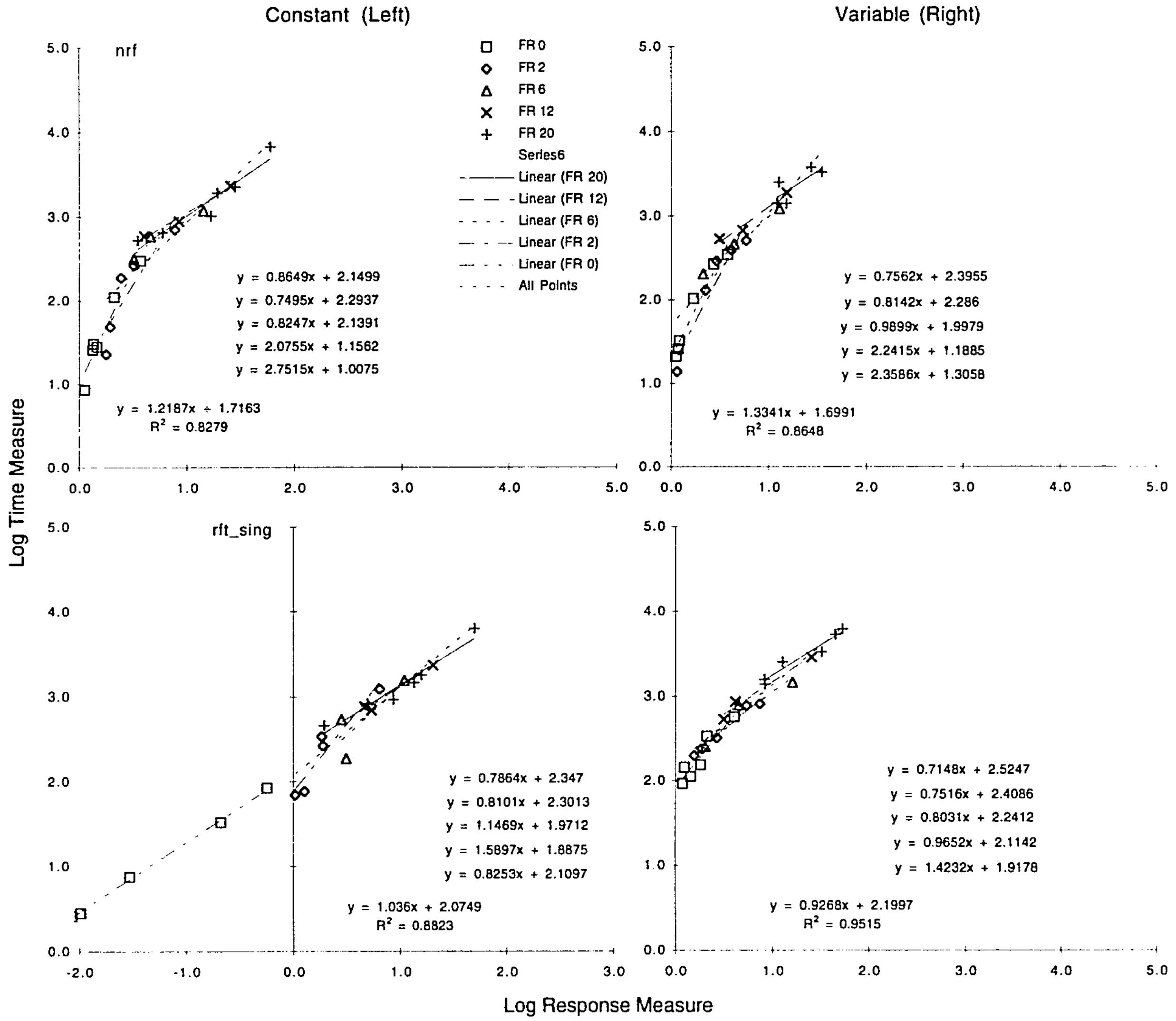
The following four figures present the relation between the time measures (y-axis) and the response measures (x-axis) presented in the immediately prior figures. Left panels present constant alternative measures and right panels present variable alternative measures. Top panels are data from non-reinforced visits and bottom panels are data from single reinforcer visits. Lines are best fitting lines of each changeover requirement with their equations listed in the same sequence as identified in the legend. The equation with the variance accounted for below it is for all points combined, except FRCO 0.


W34
Constant (Left)
Variable (Right)
Log Time Measure
Log Response Measure
nrf
rft_sing
□ FR 0
◇ FR 2
△ FR 6
X FR 12
+ FR 20
Series6
Linear (FR 20)
Linear (FR 12)
Linear (FR 6)
Linear (FR 2)
Linear (FR 0)
All Points
y = 1.0815x + 1.6134
y = 1.2508x + 1.3149
y = 1.3653x + 1.2226
y = 1.4177x + 1.2459
y = 1.998x + 0.7556
y = 1.2345x + 1.3732
R² = 0.9808
y = 0.8968x + 1.9239
y = 0.9044x + 1.8542
y = 1.0721x + 1.6189
y = 1.3627x + 1.3007
y = 2.2623x + 0.8426
y = 1.1642x + 1.5053
R² = 0.968
y = 0.9145x + 1.9221
y = 0.8402x + 1.9913
y = 0.8846x + 1.9185
y = 0.7696x + 1.9941
y = 0.2961x + 2.2587
y = 0.8867x + 1.9377
R² = 0.9694
y = 0.8622x + 2.0083
y = 0.7338x + 2.174
y = 0.8687x + 1.9289
y = 0.7159x + 2.1253
y = 0.8702x + 2.0164
y = 0.8134x + 2.0513
R² = 0.972
0.0
1.0
2.0
3.0
4.0
5.0
-1.5
-0.5
0.5
1.5
2.5
3.5


W35
Constant (Left)
Variable (Right)
nrf
rft_sing
Log Time Measure
Log Response Measure
0.0
1.0
2.0
3.0
4.0
5.0
-2.0
-1.0
FR 0
FR 2
FR 6
FR 12
FR 20
Series6
Linear (FR 20)
Linear (FR 12)
Linear (FR 6)
Linear (FR 2)
Linear (FR 0)
All Points
y = 1.0688x + 1.8829
y = 1.3259x + 1.5977
y = 1.2679x + 1.7294
y = 1.9849x + 1.2443
y = 1.9088x + 1.5066
y = 1.3517x + 1.5645
R² = 0.935
y = 0.9297x + 2.2167
y = 1.1461x + 1.9731
y = 1.5498x + 1.6784
y = 1.7562x + 1.5765
y = 9.2021x + 0.6538
y = 1.2815x + 1.8132
R² = 0.9698
y = 0.8745x + 2.2338
y = 1.348x + 1.7964
y = 2.1273x + 1.6977
y = 1.1561x + 2.0394
y = 1.1882x + 2.0542
y = 1.0411x + 2.0596
R² = 0.9629
y = 0.9329x + 2.2457
y = 1.0177x + 2.1912
y = 1.0586x + 2.1523
y = 0.8207x + 2.1992
y = 0.7522x + 1.9497
y = 0.9918x + 2.1814
R² = 0.9896


W36
Constant (Left)
Variable (Right)
nrf
rft_sing
Log Time Measure
Log Response Measure
□ FR0
◇ FR2
△ FR6
X FR12
+ FR20
Series6
Linear (FR 20)
Linear (FR 12)
Linear (FR 6)
Linear (FR 2)
Linear (FR 0)
All Points
y = 0.7895x + 1.9864
y = 0.8818x + 1.8592
y = 0.8979x + 1.7325
y = 1.1821x + 1.3377
y = 2.8539x + 0.6459
y = 1.0123x + 1.5803
R² = 0.9527
y = 0.7501x + 1.9734
y = 0.8214x + 1.8539
y = 0.8513x + 1.7873
y = 0.9475x + 1.6392
y = 1.8326x + 0.8621
y = 0.9021x + 1.7129
R² = 0.9417
y = 0.687x + 2.2188
y = 0.6967x + 2.2292
y = 0.6328x + 2.2916
y = 1.0946x + 2.1716
y = 0.3774x + 2.1678
y = 0.6556x + 2.2801
R² = 0.9019
y = 0.7817x + 1.9799
y = 0.8203x + 1.9939
y = 0.7793x + 1.9701
y = 0.6186x + 2.1435
y = 0.6502x + 1.8991
y = 0.7622x + 2.0185
R² = 0.9608
0.0
1.0
2.0
3.0
4.0
5.0
-0.5
0.5
1.5
2.5
3.5
4.5
-1.0

W37


Constant (Left)
Variable (Right)
nrf
rft_sing
FR 0
FR 2
FR 6
FR 12
FR 20
Series6
Linear (FR 20)
Linear (FR 12)
Linear (FR 6)
Linear (FR 2)
Linear (FR 0)
All Points
y = 0.8649x + 2.1499
y = 0.7495x + 2.2937
y = 0.8247x + 2.1391
y = 2.0755x + 1.1562
y = 2.7515x + 1.0075
y = 1.2187x + 1.7163
R² = 0.8279
y = 0.7562x + 2.3955
y = 0.8142x + 2.286
y = 0.9899x + 1.9979
y = 2.2415x + 1.1885
y = 2.3586x + 1.3058
y = 1.3341x + 1.6991
R² = 0.8648
y = 0.7864x + 2.347
y = 0.8101x + 2.3013
y = 1.1469x + 1.9712
y = 1.5897x + 1.8875
y = 0.8253x + 2.1097
y = 1.036x + 2.0749
R² = 0.8823
y = 0.7148x + 2.5247
y = 0.7516x + 2.4086
y = 0.8031x + 2.2412
y = 0.9652x + 2.1142
y = 1.4232x + 1.9178
y = 0.9268x + 2.1997
R² = 0.9515
Log Time Measure
Log Response Measure
5.0
4.0
3.0
2.0
1.0
0.0
-2.0
-1.0
0.0
1.0
2.0
3.0
4.0
5.0