THE EVOLUTION OF PROBLEM-SOLVING: AN ASSESSMENT OF PREFERENCE IN CONCURRENT SCHEDULES OF REINFORCEMENT

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ABSTRACT

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In personal problem-solving, an organism emits responses that have been useful in the past to alter its personal contingencies and produce a response that "solves" a problem. In verbal behavior, a human organism emits responses that have previously been useful to alter the contingencies of another human, thus producing a response that "solves a problem." Additionally, in verbal behavior, an organism is controlled by it's current contingencies rather than it's history of reinforcement. It is suggested that personal problem-solving resembles a tandem schedule of reinforcement and that verbal behavior, which has evolved in humans, resembles a multiple schedule of reinforcement. This study attempted to observe the potential for evolution of verbal behavior in a non-human species.

In experiment 1 of the present study, half of the subjects chose the multiple over tandem schedule control across the majority of the sessions. In experiment 2, half the subjects showed a higher maximum FR1 response ratio requirement for the multiple schedule. These findings suggest that, given a choice, rats prefer reinforcement schedules with a prominent discriminative component. Since verbal behavior is defined as behavior controlled by external rather than internal stimuli, these data suggest that the basic requirements for the evolution of verbal behavior may be present in animal species other than Homo Sapiens

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CHAPTER 1

INTRODUCTION

1.1 Problem-Solving and Verbal Behavior

A response an animal emits that manipulates a set of environmental conditions is referred to as operant behavior. Some of these environmental changes are consequences that make it more probable that an animal will repeat the behavior under similar conditions in the future. The probability that an organism will respond similarly under future conditions changes as the contingencies change (Skinner, 1974). Contingencies that govern behaviors favorable to survival are said to occur because they have been reinforced for their effects of increasing chances of survival. Responses essential for survival come in many forms and are occasioned by many environments. Effective problem-solving responses are essential for the survival of any species, thus being able to manipulate a difficult environment is a favorable response. Note that the term "problem" is not defined in terms of response topography, rather it specifies that a response exists in some strength that cannot yet be emitted (Skinner, 1953). In other words, what is difficult about a "problem" is the current lack of availability of the response that is the solution.

Skinner (1953) defined personal problem-solving as "any behavior which, through the manipulation of variables, makes the appearance of a solution more probable." By arranging the stimuli to produce a set of desired conditions, the necessary responses may appear, thus producing the solution to a given problem. Personal problem-solving is defined as the basic relationship between the manipulations of variables in one's environment and the emission of a response appropriate for reinforcement (Skinner, 1953). For example, if someone was looking for a particular destination they would engage in personal problem-solving by "thinking" about potential locations. This "thinking" behavior would have, in the past, been reinforced by leading to the desired location. These privately occasioned behaviors, such as thinking, are blindly emitted with the intention of producing a solution. This sequence of privately occasioned responses have no clear discriminative stimuli between components, rather they are simply the act of "trying".

It has been suggested that an alternative form of problem-solving is seen in verbal behavior. In verbal behavior, one person (the speaker) is deprived and lacks the responses necessary to provide reinforcement. The required responses are provided through the behavior of another person (the listener). For example, a person in the mall who is in need of a water fountain may ask someone where to find it and obtain reinforcement by finding the water fountain. In personal problem-solving, the person may simply wander around looking for the water fountain and may or may not find it and may or may not obtain reinforcement. Thus, verbal behavior and personal problem-solving behavior are functionally the same, except for the way in which the environment is manipulated to produce a response resulting in reinforcement. "Verbal behavior" fits the definition of problem-solving in the sense that the manipulation of variables in one's environment includes the behavior of the second person, which then leads to the emission of a potentially reinforceable response.

In Skinner's analysis, the distinction between verbal and non-verbal operant behavior is not drawn by pointing to formal or "topographical" differences between two behaviors. Although, many have tried to identify verbal behavior as strictly language in structural terms, it is suggested here that, "verbal behavior as behavior reinforced through the mediation of other persons, we do not, and cannot, specify any topographical form, mode or medium" (Skinner, 1959). The difference between verbal and non-verbal problem-solving behavior is defined by its antecedents and consequents, the functional properties of behavior in any environment. Verbal behavior, like other classes of operant behavior, is defined by its placement in time and space, relative to other behaviors and environmental events, and includes the consequences of such placement. For example, the environmental conditions that would occasion a person asking for directions to the water fountain are different from the conditions that would occasion a personal problem-solving approach. More specifically, in verbal behavior, the presence of another person (i.e. audience) occasions problem-solving through public behaviors, whereas in personal problem-solving the external environment lacks the adequate stimuli (i.e. audience) and results in private behaviors of problem-solving. Operant behavior functions to change environmental stimuli and produce the responses required for reinforcement. The example of personal problem-solving used to find a water fountain is demonstrated in this way. Antecedents function to set the occasion for responses, responses function to produce consequences. When antecedents are functionally related to behavior, we have discriminative control.

In verbal behavior, an individual (ie. the "speaker") is under discriminative control of another individual (ie. the "listener"). A verbal episode occurs when the speaker responds in a way that prompts a response from the listener which them prompts a response from the speaker that produces reinforcement for the listener. The listener is reinforced by a response from the speaker (an example is a "thank you") which is often nothing more than an implicit promise to return the favor at a later time. In other words, a verbal episode when a speaker discriminates the availability of an audience, the listener. The listener is animated to response when they discriminate the speaker's behavior. The speaker is "stimulated" by the listener's behavior to emit a response which produces reinforcement for the speaker.

It should be obvious that stimulus control plays a large part in the control and execution of verbal behavior for both the speaker and listener. It also seems obvious that an extensive history of reinforcement would be required for the acquisition of verbal behavior. Of course, not all human behavior is verbal. Individuals acquire many operants without the intervention of a second human being. Personal skills of many kinds can be acquired and refined by an individual acting alone. Feeding, grooming, attending and locomotion are a few of the skills that can be acquired without the assistance of a second human being. As these skills become more refined and as the generalize among situations, we could characterize the individual as becoming more adept at applying them. We then may say that the individual has acquired the more generalizes skill of "problem solving", or being able to discriminate which skill is most appropriate to the situation at hand. Therefore, in some instances an individual may acquire problem solving by interacting with the natural world on their own. In other instances, others may assist the individual in problem solving by virtue of a shared history of verbal behavior.

Skinner (1986) suggested that verbal behavior is the product of a series of small variations and selections, as in all operant behaviors. Specifically, Skinner postulated three *possible* steps in its "ontogenic" evolution: (1) the response of the speaker, becoming strengthened through previous reinforcement, (2) the same response being made on future occasions and 3) the response becoming shaped and maintained by reinforcement in the verbal environment that is present at the time of responding. Note that verbal behavior does not evolve; rather it is the verbal environment (ie. the culture or audience) that evolves. Therefore, verbal behavior is the product of behavior reinforced through the responses of others in the environment, which later set the occasion for responses that will be reinforced (Skinner, 1986). It is this interpersonal occasioning of a response that highlights the role of the public environment in verbal behavior.

Though the basic assumptions behind verbal behavior have been postulated, the current definition of verbal behavior and its possible role as an evolved operant is one that needs clarification. There have been some useful distinctions about the role of the 'speaker' versus the 'listener'. The reinforcement mediator or 'listener' is the person who reinforces, or prompts another person's behavior that is then reinforced (Winokur, 1976). The term 'audience' is given to the 'listener' who becomes a discriminative stimulus (S^D) and, when present before the reinforced responding occurs, becomes a form of antecedent control (Winokur, 1976). The S^D , as usual, will serve to occasion responses that will result in reinforcement. Therefore, the 'audience' serves as the occasion for a response that leads to reinforcement. More importantly, the 'audience' exerts specific discriminative properties that could be assumed to be present in any organism. In other words, the presence of an audience sets the occasion for a response that, in turn, produces reinforcement.

Note that the 'audience' and the 'listener' are in the same temporal position and thus, could be treated as functionally equivalent to "precurrent behaviors" in personal problem-solving. The difference would be that, in verbal behavior, they are public events. By creating a supplementary 'audience', as a discriminative stimulus, it may be possible to observe verbal behavior (public problem-solving) in non-human animals (Winokur, 1976). By simply arranging the primary variables affecting the 'speaker', it is possible to determine at which point the 'audience' is necessary for response selection. This means that, one could assess the preference for precurrent (personal problem-solving) versus interpersonally occasioned (verbal) responses under conditions in which the 'speaker' lacks a necessary response and has a choice between the two forms of problem-solving. The preference for problem-solving through private events versus a public discriminative stimulus could be assessed under a concurrent schedule of reinforcement. Although Winokur's (1976) view of the 'audience 'and 'listener' involves human language behaviors, similar behavior in animals could be simulated by arranging the appropriate reinforcement contingencies. The question is whether, all else being equal, an animal would choose external stimulus control over private events when responding to produce food (solving a problem under conditions of deprivation).

1.2 The Evolution of Verbal Behavior

Currently, Skinner's (1957) definition of verbal behavior extends only to human behavior. However, there must have been times in the phylogenic history of Homo Sapiens when it did not have verbal behavior, but was behaving in ways that could have later been phylogencially selected to produce verbal behavior. For example, a pigeon reinforced for pecking a disk when the disk is red (but to withhold responding when the disk is green) will respond only in the presence of the red stimulus. As the red light becomes increasingly dim the pigeon may strengthen the stimulus (ie. increase the brightness of the light) by pecking another disk and will continue to do so as long as the color of the stimulus is important for reinforcement. In this instance the pigeon can produce a response to additional stimuli in order to produce the favorable discriminative response (Skinner, 1974). Pecking the other disk to brighten the stimulus could be as a rudimentary form of precurrent behavior.

Skinner proposes that verbal behavior is produced by three antecedents; they are (1) a state of deprivation, (2) the lack of an appropriate response, and (3) the presence and availability of another person (the listener). The two consequences that function to strengthen verbal behavior are: (1) the behavior of another person that induces the first person (the speaker) to make a new response, and (2) a reinforcing stimulus produced by the speaker. Basic antecedent conditions of deprivation and a specific environmental condition follow when an animal is faced with a problem and has no precurrent behaviors by which to generate an appropriate solution. In this situation, given the presence of a public stimulus, what is the likelihood that the animal's behavior will be occasioned by that stimulus? It is suggested that under a state of deprivation and in the presence of a public stimulus, the occasioning of a response from a speaker will lead to reinforcement, and this simulates verbal behavior.

One question of interest is the importance of verbal behavior as a major component in the evolution of culture. Culture, by its behavioral definition controls the behaviors of the members of the group (Skinner, 1974). Cooperation and communication are behaviors that depend on the occasioning of responses between two or more people. If humans were able to successfully navigate the environment alone, verbal behavior would not be necessary. Since verbal behavior has evolved and does serve an important function of survival, then under what such conditions did it develop? Early humans must have faced certain ecological pressures to allow for the facilitation of verbal behavior into its present state. Skinner (1974) suggests that verbal behavior has a special character because it is reinforced by its effect on others in our environment. Furthermore, apart from the presence of an audience (the listener) it needs no support from the environment. This suggests that what may have been important for the evolution of verbal behavior is not it's consequences, but can be found in it's antecedent history; namely, the presence of another person. In this way, the other person (the listener) serves as a discriminative stimulus that occasions responding in the speaker.

A discriminative stimulus is any stimulus that serves a discriminative function, and is also referred to as a signal or cue. In other words, discriminative stimuli are associated with a given consequence and serve as the occasion for responding under any environment Furthermore, stimulus discrimination allows an organism to interpret which environmental events will result in reinforcement, given the animal responds accordingly (Domjan, 2003). Organisms that are highly discriminative have fewer incorrect responses and more opportunities for reinforcement. A highly discriminative animal is governed less by trial and error learning and thus behaves in ways that are more efficient. It is suggested here that discrimination is an important feature for social animals that possess a certain level of sensitivity to contingencies. Cooperation and communication, then, is quintessentially social and can emerge only in organisms whose behavior is sensitive to social contingencies (Catania, 2007).

In humans, a sensitivity to the cues in a situation that indicate which behaviors are appropriate is the ability to self-monitor (Snyder, 1974). It has been determined that people who are high self monitors are extremely sensitive to their social environments. They are more aware of their potential for social interaction with others and may alter their own behavior to better fit the situation (Ickes et al, 2006). The research reviewed by Ickes et al (2006) suggests that high self monitors are more concerned with the quality of their interaction, have a greater tendency to follow social scripts, and are more likely to use the cues of a confederates behavior to guide their own. Thus, their sensitivity for social contingencies is greater than moderate or low self monitors. It has also been noted that a high self monitor "enacts a specific behavior because that behavior fulfills an objective" (Douglass, 1983); which mimics the definition of verbal behavior originally set forth by Skinner.

Early studies of verbal behavior were limited but did contribute to the field of the experimental analysis of behavior. In 1955, a study by Greenspoon attempted to devise a methodology to test verbal behavior in the laboratory. In his study, subjects were asked to say words and an experimenter would respond with "mm-hmm" when the subject said a plural noun, which was meant to encourage the subject (speaker) to continue. They found that the relative frequency of plural nouns increased; a finding, which suggested that verbal behavior was, in fact, sensitive to its consequences (Greenspoon, 1955). Several similar studies followed but by the mid 1960's started to become infrequent. However, there were two main contributions of these studies (1) that verbal behavior achieves its effects operating as a sequence of multiple but functionally separate topographies and (2) that verbal behavior is operant behavior and thus, affected by it's consequences (Michael, 1984).

Epstein and Skinner (1980) questioned whether verbal behavior and personal problem-solving are uniquely human. They noted that a pigeon would engage another pigeon in the problem-solving process, when no other means of solving the problem were appropriate. In their experiment, the first pigeon was required to request assistance from the other pigeon in order to obtain reinforcement by pecking one of three colored keys. The request was made by pecking a key that illuminated a "What Color?" key for pigeon 2. Pigeon 2 would then look into a hole to find the correct color and make a response to the key corresponding to that color on an intelligence panel. The first pigeon would receive an illuminated key that occasioned a response on the appropriate colored key, resulting in reinforcement. The experiment required the cooperation of both pigeons in what could be viewed as a process of public problem-solving (verbal behavior), in order to obtain reinforcement. Epstein and Skinner (1980) showed that, under appropriate conditions, an animal may utilize the responses of other animals as public stimuli, setting the occasion for its own responses, which produces reinforcement.

Savage-Rumbaugh (1984) reported behaviors in two chimpanzees that "closely fit the general domain of what Skinner defines as verbal behavior". These two chimpanzee used keyboards to make requests, label items in the environment and communicate with each other as well as humans present in their environment. The animals behaviors did not provide a simple mechanical response, rather triggered responses in other animals in their environment; thus illustrating a form of non-human verbal behavior (Savage-Rumbaugh, 1984). Previous studies of symbolic communication between non-human animals failed to demonstrate an understanding of the governing contingencies (Savage-Rumbaugh, 1984). However, the experiments by Epstein and Skinner (1980) and Savage-Rumbaugh (1984) demonstrated that animals did understand the contingent relations governing their behavior.

1.3 Schedules of Reinforcement and Verbal Behavior

Using reinforcement schedules to test behavioral phenomena and answer psychological questions is a commonly accepted practice. For example, self control is defined as choosing a large delayed reward over an immediate small reward (Domjan, 2003). For example, a study by Rachlin and Green (1972), the basic concurrent schedule was used to arrange for responding in the pigeon to be reinforced by immediate access to a small amount of grain or delayed access to a larger amount of grain. Human self-control is a psychological phenomenon that has very important implications in applied settings, such as juvenile delinquency and drug addiction, thus understanding the contingencies governing such behaviors would be quite beneficial.

The field of neuroscience is primarily interested in the biological basis of behavior. However, the neural basis for learning and behavior is not well understood unless there is an adequate understanding of the behavior we call learning (Catania, 2007). For example, it has been determined that early learning of olfactory cues that are followed by reinforcement (tactile stimulation similar to that naturally occurring in the environment of rat pups) result in both a behavioral odor preference and neural changes in adult rats (Sullivan & Leon, 1986). Similarly, Wilson and Sullivan (1994) found a localized pattern of neural changes in response to early olfactory stimulus conditioning. Therefore, findings suggest that the stimulus conditioning that takes place is important for survival, thus sensitivity to environmental stimuli is an important basis for early learning.

It has been noted that the effects of reinforcement may occur at the neural level. In a study by Stein, Xue, and Belluzzi (1993), in vitro reinforcement of pyramidal cell bursting responses was obtained when the cells responses were contingently reinforced with applications of dopaminergic agents. Importantly, when the applications of dopminergic agents were administered non-contingently, the cell bursting responses failed to show the effects of conditioning (ie. reinforcement effects). These findings highlight the importance of reinforcement schedule methodologies and suggest a crucial role for reinforcement effects in the early learning of species-relevant cues at the behavioral as well as the neural level.

The present experiment was designed to determine the relative preference for personal problem-solving through the acquisition of chain of responses as opposed to problem-solving through the acquisition of behaviors under the control of public discriminative stimuli. Given the complex nature of both personal problem-solving and verbal behavior, it was of interest to clarify the contingencies governing each of these behaviors individually. Once the contingencies are better understood, the analysis of preference for one type of problem-solving over the other will allow for better postulates as to the suggested possible evolution of verbal behavior.

In the analysis of behavior, experimental methodologies for testing preference, or choice, have relied primarily on laboratory experiments utilizing non-human species. The major benefit of using such methods is that they allow for the analysis of the simple events governing any behavior, which will then assist in developing the techniques and vocabulary necessary for testing more complex forms of behavior (Catania, 2007). Using reinforcement schedules to simulate the contingencies thought to resemble personal problem-solving and verbal behavior will allow for an adequate measure of performance under each schedule individually, and asses the preference when given a choice for either.

Previous studies have suggested that the best procedure for examining the preference between two reinforcement schedules is the concurrent "choice" procedure, in which two independent reinforcement schedules are operating at the same time and either of the two is available for selection at any given time. For example, Neuringer (1967) investigated the choice between two concurrent schedules of reinforcement by allowing the subject (a pigeon) to choose the condition by emitting a peck on one of two illuminated keys. He defined choice as the pecking response on one of the two selection keys which would then send the pigeon into one of two reinforcement schedules comprising the concurrent schedule. In the study by Neuringer (1967) each of the concurrent schedule conditions held different reinforcement magnitudes. A relative measure of preference for one of the two reinforcement schedules was obtained by dividing the number of responses per key by the total number of responses throughout a session.

The original formulation of the concurrent choice procedure was first reported by Findley (1958), in which the concurrent schedule was used to assess preference and rates of switching stimulus conditions in pigeons by introducing two or more reinforcement schedules. By allowing the pigeon to peck a white illuminated key, the terminal-link response key would switch colors. The stimulus color was associated with one of two schedule conditions. By pecking the "choice key" the stimulus color would change, thus allowing the subject to perform under a different condition and its associated reinforcement schedule. A clear preference emerged by assessing the time spent in each condition, the rate of responding in each and the rate of switching between initial links. This original formulation of the concurrent choice procedure used a single response key that served as the initial link (or response the initiates the reinforcement schedule) into the respective reinforcement schedules and a separate key that served to determine which schedule would be active on the response keys. Previous work on the possible evolution of verbal behavior used a similar methodology (Roark & Kopp, 2006). However, the present study used the concurrent choice procedure that will make use of two separate choice response keys, a modification of the original formulation which is similar to that described by Neuringer (1967).

It is suggested here that, in evolution, there must have been a point in which the public stimulus control (necessary for verbal behavior thus social behavior and ultimately culture) acquired adaptive value over precurrent response control, the essence of personal problem-solving. It is also suggested that the environment must have been more favorable for responding based on public stimulus control than on behaviors occasioned strictly by the personal environment.

The present study used a concurrent schedule with a fixed ratio schedule to produce reinforcement. No previous studies have been found comparing the preference for multiple (external control) to tandem (internal control) schedules of reinforcement in a concurrent schedule. In the present experiment, a concurrent schedule of reinforcement allowed a subject to choose between a tandem reinforcement schedule component and a multiple schedule component. Subjects were allowed to choose which schedule component by responding to one of two illuminated nose keys in the lower corners of the chamber. The choice of the tandem schedule required a two-response chain (or left lever-right lever sequence). Choice of the multiple schedule required two discriminated responses on one of two randomized levers to produce reinforcement.

The use of tandem and multiple schedule components in the present study stem from the acknowledgement that, as previously noted, private problem-solving consists of both discriminative and manipulative responses (Skinner, 1953). The processes of problem-solving, both personal and verbal, are occasioned by two different events that precede the reinforced behaviors. For personal problem-solving, the preceding events are those included in one's personal history of reinforcement (theoretically epitomized by a tandem schedule performance). In verbal behavior, the preceding events are public (theoretically epitomized by a multiple schedule performance). The discriminative stimuli in the multiple component of the experiment simulate public problem-solving through verbal behavior. Under this condition, subjects are exposed to one of two randomized light illuminations that signal the appropriate lever for responding to produce reinforcement. The responses in the multiple component are occasioned by the presence of an environmental stimulus, simulating verbal behavior. In the tandem component, the emission of the correct two responses in sequence simulates the personal problem-solving (involving private stimuli) condition. Under this condition, subjects are exposed to the presence of both illuminated lights, making discrimination unclear and/or ambiguous.

The responses in the tandem component are occasioned by the subject's previous history of reinforcement, rather than any environmental stimulus.

Because rats have not evolved verbal behavior so far as we know, but could evolve behavior similar to human verbal behavior in the future, any tendency to favor control by multiple schedules in rats could be interpreted as a potential for the development of verbal behavior in the species as phylogenic selection proceeds.

If a preference between the two conditions exists, the next step would be to determine the magnitude of such a preference (Verhave, 1963). An adjusting fixed-ratio schedule adjusts some measured aspect of the organisms behavior after reinforcement (Ferster & Skinner, 1957), which has also been a model for the behavioral effects of drugs (Rodefer & Carroll, 1999). This methodology would give a quantitative index of preference that is thought to have no direct relationship to response rate (Verhave, 1963). This technique investigates the maximal ratio under which an organism will reach and sustain an FR performance (Ferster & Skinner, 1957). Previous work suggests that responding under an adjusting schedule will increase up to a certain point and then settle at an equilibrium point of an unknown value (Verhave, 1963). This equilibration value will be used as a supplementary measure of preference for application in the second part of the present experiment. The equilibration value will be interpreted as the average of the maximum response requirement in each schedule component across sessions. Thus, a new model of choice behavior combines the advantages of choice procedures, such as a concurrent schedule, with those of progressive ratio schedules (Rodefer & Carroll, 1999). Therefore, it was of interest to determine if any other measures of preference can be used to assist in the assessment and interpretation of conditions thought to simulate the two types of problem-solving by using a concurrent adjusting ratio schedule of reinforcement.

Previous research on adjusting FR schedules has used initial pause duration as the variable in which the adjustment is a function rather than the equilibrium value. Others have compared the effects of adjusting FR schedules of punishment contingencies. It is yet to be determined whether any research has been conducted on the effects of a concurrent adjusting FR schedule, under which the variable of interest is the equilibrium value as a function the difference in stimulus conditions between the two schedule components. The proposed experiment sought to identify the equilibrium value, under a concurrent adjusting FR schedule of reinforcement. The purpose was to obtain an organism's preference under such conditions for the use of personal problem-solving behavior or verbal behavior.

Clarifying the contingencies governing personal problem-solving and verbal behavior may allow for better understanding the possible evolution of such behaviors in the human species. The present experiment examined the preference between tandem schedule control and multiple schedule control. It was of interest to determine which of the two schedule components is preferred under normal problem-solving conditions, as in the concurrent condition. Similarly, the allocation of choice responses found was expected to match the concurrent condition. Previous work obtained a clear preference for multiple schedule control, however, the inequality between response requirements may have facilitated such a preference. The present experiment controlled for such inequality by arranging schedule components to have equal response requirements. Namely, a tandem FR1FR1 schedule and a multiple FR2 schedule.

The relative frequency of choice responses per schedule component in the concurrent schedule condition and the maximum fixed ratio response requirement in the adjusting ratio condition was analyzed as a measure of preference. It was expected that all subjects would exhibit a clear preference for one of the two schedule components in the concurrent testing condition and the concurrent adjusting ratio condition. The concurrent testing condition yielded a preference for the multiple schedule in half of the subjects, and the remaining subjects exhibited either no preference or a preference for the tandem condition. Findings in the concurrent adjusting condition were similar to that of the concurrent choice condition.

CHAPTER 2

METHOD

2.1 Subjects and Materials

Eight female albino Sprague-Dawley rats were used in this experiment. However, due to cost of housing and care, only six were used in the data analysis. Subjects numbered 5 and 6 were eliminated from analysis. All subjects were food deprived and maintained at 85% *ad libitum* weight. All subjects were housed according to National Institute of Health rules and regulations for the humane treatment of animals.

A two bar operant chamber, with a grid floor and Plexiglass sides, was used in this experiment. The chamber measures 8 ¼" (height) x 11 ½" (width) x 9 ½" (depth). A fan exhausted isolation chest encloses the testing chamber. The isolation chest contained an observation window measuring 8" x 7 ½". The intelligence panel was configured with a food hopper in the center, at floor level, into which the .045gm food pellet was delivered to the subjects. The two bars were centered 1 ¼" from both sides and 3" above the floor. The nose key (pigeon pecking key) was located on the left side approximately 3" below the bars and 1" above the floor. The two white lights centered 3" above each bar complete the configuration. The light changes and the dispensing of pellets were controlled by a computer, which also collected the data in a MED-PC program. The MED-PC program has sub-programs for each of the reinforcement schedules.

2.2 Procedures

All subjects were pre-trained, using the shaping procedure, that is commonly employed in operant conditioning studies. Subjects were first magazine trained to obtain their food reinforcement. Upon successful magazine training, subjects were trained on FR1 schedule of reinforcement to establish the basic behavior of emitting a right lever press response for reinforcement. Following FR1 right lever press training, subjects acquired a two response chain schedule of behavior using a backward chaining procedure. A backward chaining procedure established the behavior of a single right lever press response to initially produce reinforcement, then added a single left lever response requirement to the right lever response before producing reinforcement. This two response chain was characterized by a left lever press, in the presence of the left light. This response illuminated the right light which occasioned a right lever press response, which then produced reinforcement. After establishing a two response chain schedule of reinforcement, a third component was established where the subjects emitted a response to a nose key. This nose key served as the initial link into one of the two terminal link schedules of the concurrent schedule testing condition.

After establishing the three response chain to a criterion of 90% correct for three consecutive sessions, subjects were placed in the concurrent schedule component pre-training conditions. All subjects received the basic operant performance training and then pre-training of individual concurrent schedule components. After completion of these two pre-training procedures, subjects were placed in the concurrent testing condition of the experimental test.

One of the two concurrent schedule component pre-training conditions, the tandem schedule, consisted of subjects being presented with an illuminated green nose key located in the lower right corner (for half of the subjects) or lower left corner (for the remaining subjects) of the chamber. Upon responding to the steadily illuminated green nose key, both white lights above both response levers were illuminated. Subjects were reinforced after responding to the left lever and right lever chain sequence with no change in the discriminative stimuli (ie. left and right light illuminations) between responses in the tandem performance. Any response errors initiated a 10 second timeout characterized by a blackout of all the stimulus lights. After the 10 sec interval, the green nose key condition resumed. Response errors were defined as any responses to the levers prior to the discriminative stimulus activation, incorrect two response sequence and/or excessive responses to the nose key or levers following stimulus presentation. All errors were collected in a data file in MedPC. This tandem (FR1FR1) schedule of reinforcement will serve as one of the schedule components during the concurrent testing condition (See APPENDIX A1).

The alternative concurrent schedule component pre-training condition, the multiple schedule, consisted of subjects being presented with a flashing green key located in the lower left corner (for half the subjects) or lower right corner (for the remaining subjects) of the chamber. Upon responding once to the flashing green nose key, either the light above the left lever or light above the right lever were illuminated. Two lever press responses to the lever on the side with the illuminated side light resulted in food delivery (ie. reinforcement). The illuminations of the left and right light were randomized to ensure that responding was occasioned by the presence of the light stimulus. Any response errors initiated a 10 second timeout characterized by a blackout of all the stimulus lights. After the reinforcement or 10 second timeout interval, the flashing green nose key light resumed. Response errors were defined as responses to the levers in the absence of the discriminative stimulus and/or any extra responses to the nose key or levers following stimulus presentation. All response errors were collected in a data file of MedPC. This multiple (FR2) schedule of reinforcement will serve as one of the schedule components during the concurrent testing condition (See APPENDIX A2).

Both of the individual concurrent schedule pre-training components were presented in a counterbalanced fashion during training to prevent any schedule bias. The amount of reinforcement in each of the individual schedule components was also measured and used in the interpretation for preference.

2.2.1 Experimental Test 1 Procedures

The concurrent schedule testing condition was designed to begin with both the multiple schedule (flashing green key) and the tandem schedule (steady green key) components presented, each corresponding to their location in one of the lower corners of the experimental chamber during pre-training. The independent schedules (multiple and tandem) were combined into a concurrent schedule of reinforcement in which the subjects were free to emit a response on either of the two schedules. The purpose of using the concurrent schedules was to measure the animal's preference, or 'choice', for either the multiple or tandem components of the concurrent schedule testing condition. A concurrent choice procedure permits the subjects to switch schedule components by emitting a response to the nose key of their choice in its respective location. Once a response had been made to one of the two nose keys, (ie. Initial links) the subjects were reinforced for emitting the terminal link performance respective of that reinforcement schedule. After reinforcement the concurrent choice condition was again presented. Any extraneous responses to the nose keys or levers following a ‘choice’ response on the selected nose key, resulted in a 10 second time out in which all stimulus illuminations are terminated. Upon completion of a 10 second timeout the concurrently presented nose key stimuli were again presented.

The location of each nose key served as the necessary discriminative stimulus that corresponds to its appropriate reinforcement schedule, in the event that nose key responding was not well occasioned by a colored light stimulus. The nose key producing the tandem schedule (steady green) was located in the lower left corner and the multiple schedule (flashing green) was in the lower right corner for half subjects, termed configuration “J” (See APPENDIX B2). The remaining subjects were presented with the nose key producing the tandem schedule (steady green) in the lower right corner and multiple schedule (flashing green) in the lower left corner, termed configuration “M” (See APPENDIX B1). This was done to ensure that the measure of preference was not confounded with any position bias. Accordingly, any preference for the multiple schedule located in the lower left corner for half the subjects would be seen in the remaining subjects as a preference for the multiple located in the lower right corner.

It is important to note that due to a loss of two subjects the counterbalanced configurations were unequal in sample size. Originally, subjects 1 through 4 were assigned to configuration J and subjects 5 through 8 to configuration M. Subjects 5 and 6 were lost due to time and financial constraints, which left the configurations unbalanced. However, the nature of a single subject design does not require these two groups to be equal in sample size for the results to be significant.

The subjects were placed in an A-B-A design where the configuration alternated across blocks of sessions. All subjects were given the configuration they were exposed to during pretraining (J for subjects 1-4 and M for subjects 7-8) for ten sessions, the opposing configuration for ten, original for two, opposing for two; and so on for a total of 30 sessions (See Table 1). On occasion the design block and configurations were confused with little effect on the outcome (See Table 2.) All sessions were approximately 50 minutes in duration.

The measures of schedule choice were assessed in two ways: (a) by the number of 'choice' responses per schedule component and (b) the number of reinforcements obtained per schedule component. The number of responses to either of the two nose keys during the concurrent schedule served as a "choice" response. These initial link responses conceptually represent the number of times a "choice" is made for a particular schedule component over the other. The number of reinforcements obtained in either of the schedule components is equivalent to terminal link responses; the responses that bring forth primary reinforcement. The relative frequency of terminal link responses was used as the basis for inferences about choice behavior regarding the two terminal schedule components (multiple vs tandem). Note that the amount of reinforcement obtained per schedule was proportional to the amount of choices to that schedule during any given session.

2.2.2 Experimental Test 2 Procedures

Following preference assessment in the concurrent schedule testing condition, subjects were placed in a testing condition that simulated "problem-solving" under increasingly difficult conditions. An adjusting fixed-ratio schedule component was added to the already acquired topography of both the tandemFR1FR1 and the mulitpleFR2 schedules. Each time a subject responds within one condition, the ratio requirement incremented by one unit for the terminal link in that condition. For example, in the tandem condition, a subject began at tandemFR1FR1 and upon successful completion, a tandemFR1FR2 was presented. At this point, if the subject chooses to switch to the multiple schedule by emitting a response to the flashing green nose key, it began at a multiple FR2 schedule of reinforcement. After completing the mulitpleFR2, the next response requirement was a multiple FR3. After each reinforcement, the terminal link responses incremented by one until the subject emitted a response on the opposing nose key, switching the subject over to the opposing schedule component. When performing under either condition, subsequent reinforcements increased the ratio required to obtain reinforcement in the current schedule and concurrently decreasde the ratio requirement in the opposing schedule condition. However, this decrement only occurred until the requirement in the opposing schedule reached its minimum value (ie. tandemFR1FR1 or mulitple FR2). There were no timeouts for errors in this procedure, rather all stimuli would remain until the correct sequence and response requirement was reached. The nose key locations were counterbalanced and the blocks were ten sessions each (See Table 2). All sessions were approximately 45 minutes.

Using a "forced trials" procedure ensured that all subjects have completed their "choice" performance before making a switch to the opposing schedule. This procedure was used to ensure that subjects were exposed to the contingencies of their choice, therefore allowing a more pure assessment of preference based on the contingent relations governing each of the two concurrent performances. The gradual increment in response requirement, during either of the concurrent schedule components, served as an assessment of the degree to which a subject preferred one of the two components. Measurement of the maximum response served to highlight the theoretical implication that the point at which the problem becomes too difficult to solve, and the opposing strategy is solicited, served as a basis for understanding the contingencies that govern problem-solving responses and verbal behavior.

CHAPTER 3

RESULTS AND DISCUSSION

3.1 Experimental Test 1 Findings

Experiment 1 assessed the basic schedule preference between a tandem FR1FR1 and multiple FR2 concurrent schedule. Half of the subjects showed a reliable preference for the multiple schedule. Subject D2 chose the multiple schedule across all 30 sessions (See Fig 2). Subject D8 showed a preference for multiple in 26 of the 30 sessions (See Fig 6). Subject D3 showed a preference for multiple over tandem in 22 of the 30 sessions (See Fig 3). However, when rapid counterbalancing of the configurations began at session 20, responding became more of a side preference than schedule preference for subject D3.

A dependent sample T test was conducted on individual subject's performances of the number of choice responses between schedules across all 30 sessions. There was a significant difference of multiple schedule preference for subject D2 with $t(29) = 21.197$, $p < .01$. Subject D3 showed a preference for multiple over tandem schedule $t(29) = -2.71$, $p<.05$. Subject D8 also showed a significant difference in choosing multiple over tandem $t(29) =-5.268$, $p<.01$. The other half of the subjects showed no significant differences in the number of choice responses between the multiple and tandem schedules.

One subject, D4, simply responded to whichever schedule was produced by a response on the lower left nose key (See Fig 4). This subject obtained a higher choice value under whichever schedule was present on the left nose key. A similar position preference emerged in the remaining two subjects. Subject D1, although showing an initial preference for multiple, began exhibiting a position preference and continually choosing the schedule located on the left nose key as counterbalancing began (See Fig. 1). Subject D7 always chose the schedule on the left nose key (See Fig 5). These three subjects obtained approximately equal rates of reinforcement across the two kinds of schedules.

Due to the block sizes of counterbalancing in the last 10 sessions, more variability and less stability was observed in five of the six subjects. Subjects who showed moderately stable choice performance in the first 2 blocks (ten sessions each) began to exhibit more of a side preference in the latter blocks (1 to 5 sessions each). When the counterbalancing was placed after one session, the performance of most subjects began to choose whichever schedule key was on the left side. The quick counterbalancing of blocks induced a performance based less on the contingencies and more on an innate location preference. Thus, it was decided that Experiment 2 would have longer blocks during counterbalancing.

Time-outs were programmed throughout experiment 1 to discourage inattentive behaviors or incorrect responses. There were approximately equal time-outs for all subjects across all sessions. However, there was a difference in where the tim-out occurred in either of the two schedule components (see Fig 13). The time-outs for the multiple schedule tended to occur during initial link responding, whereas the time-outs for the tandem schedule were associated with the terminal link chain performance. The greatest numbers of errors, for all subjects and across all sessions, were seen for the right lever in the tandem performance. The correct tandem performance was a left lever followed by a right lever press, and most subjects were timed out by making a right lever press first. The second highest response error was found for a double response on the left lever during the tandem performance. Most errors during the multiple schedule were produced by too many responses to the initial link, or choice key (the flashing green nose key). There were some errors in the terminal link performances during the multiple schedule performance, but there were significantly lower than that found in the tandem schedule. The least number of errors occurred to the right lever during a multiple schedule performance.

3.1.2 Experimental Test 2 Findings

Experiment 2 assessed the basic preference between tandem FR1FR1 and multiple FR2 using an adjusting concurrent schedule method. Here the number of choice responses for each schedule and the maximum response ratio obtained per schedule were proportional so the latter was used as a more quantitative measure in the following analyses. Four of the six the subjects exhibited a higher maximum response ratio requirement for the multiple schedule over the tandem. Subject D1, D3, D4 and D8 obtained a higher maximum response requirement across the 40 session for multiple over tandem (See Fig 7, 9, 10 & 12). The preference for these subjects was the same irrespective of the location of the multiple schedule nose key. It should be noted that only two subjects (D3 and D8) showed significance in both experiment 1 and 2.

A dependent samples T test was conducted on individual subject's performances on the maximum response ratio requirement across all 40 sessions. Significant differences in obtaining a higher maximum response ratio requirement in multiple over tandem was found for subject D1 $t(39)=2.547$, $p<.05$.; subject D3 $t(39)=2.448$, $p<.05$; subject D4 $t(39) = 3.478$, $p<.05$ and for subject D8 $t(39)=5.195$, $p<.05$. The remaining subjects showed no significant differences in maximum response ratio requirement between the multiple and tandem schedules. Subject D2 obtained nearly equal maximum response requirements for both schedules in any given session (See Fig 8). Subject D7 obtained a higher maximum response requirement in some sessions with the tandem schedule. However, the differences between the schedules across all sessions were not significant (See Fig 11).

Experiment 2 used ten session blocks of counterbalancing with the goal of eliminating the emergence of a side preference, such as that observed in experiment 1. There weren't many indications that any preference observed in experiment 2 was based on a location preference; rather, the performance in this experiment appeared to be strongly attributable to the contingencies. Most subjects showed a moderately stable preference across counterbalanced blocks with little disruption in performance. Any variability in preference across sessions seemed to be attrobutable to individual differences in the reinforcement histories of the subjects.

There were no stimulus time-outs in experiment 2; however, the numbers of errors for each lever within each schedule component were measured. The pattern of lever press errors resembled that of experiment 1 (see Fig 14). Again, the most errors were for too many responses produced on the right lever during a tandem schedule performance. The second highest error rate was for multiple responses to the left lever during the tandem schedule performance.. The right lever produced more errors than the left lever during the multiple schedule performance. However, a significant decrease in error rates for all subjects was observed as sessions progressed.

Most often, any switching between schedules in experiment 2 occurred within the first few minutes of the session. The highest maximum response requirement values usually were obtained as the last data points, illustrating an increasing response requirement pattern as the session progressed. The ratio was often driven up to its maximum as the session ended. Often the maximum value in the non-preferred schedule stayed near its minimum value, suggesting that the schedule was seldom preferred. This finding shows that once a preference was established, the subject would continue to choose a particular condition and tolerate its increasing response requirement.

3.2 Discussion of Experimental Findings

The purpose of this study was to measure preferences, if any, between two response schedules of reinforcement which were taken as requiring personal problem-solving versus problem-solving based upon external cues. It was anticipated that the results would assist in clarifying the characteristics governing the suggested evolution of verbal behavior. In the present study, the majority of subjects showed a reliable preference for the multiple schedule. It is suggested that rats prefer multiple over tandem in a ConcurrentMulitpleFR2TandemFR1FR1. Although not all subjects demonstrated a clear preference for multiple over tandem, it is suggested that the ability to demonstrated by some of the subjects gives support to the idea that the potential for multiple schedule control does exist in the rat.

Some possible comments regarding these experiments might be as follows. Although one of the subjects did demonstrate a preference for the personal problem-solving condition (tandem schedule) in both experiments; it could be suggested that there may be, in some cases, an inherited tendency to favor privately occasioned responding over externally cued responding. Because subject D7 preferred to rely on it's previous training of a two response sequence to discriminate environmental contingencies and produce a chain of responses, it may said they preferred a more direct means of obtaining reinforcement.

Some of Skinner's thoughts regarding problems and solutions suggest that although responses made the tandem condition may produce a solution, the mere appearance of a solution does not guarantee that problem-solving has taken place (Skinner, 1957). Skinner argued that trial and error learning is not really the process of problem-solving, but rather the reinforcement of responses for "trying" (Skinner, 1957).These responses are sometimes preferred by the problem solver because of the previous success and therefore, an association has been formed between the situation and the emitted response. A similar phenomenon is that of accidental reinforcement. Accidental reinforcement can produce reliable and stringent behaviors depending upon its frequency and its placement among otherwise unrelated responses. The preference for tandem performance by one of the six subjects in the present experiment may reflect contingencies of this kind.

During a trial-and-error performance, one can experimentally account for the emergence of each response in terms of the situation and history of reinforcement (Skinner, 1957). However, this behavioral momentum performance is of no real theoretical interest in the sense that it is not a characteristic performance of problem-solving, whereby one manipulates and arranges stimuli in order to obtain a response leading to reinforcement. Performance in more discriminative based learning displays understanding of the contingencies governing the interaction, whereby arranging stimuli to produce a source of information sets the occasion for the reinforced response. This type of learning is a process in which one is controlling the contingencies, by increasing the chances of finding the solution to the problem and thus, improving performance along the way.

According to Verhave (1963) "if an animal can be made to produce one of two alternative conditions via a switching or choice key, a preference in demonstrated for the condition produced by the choice key". In the present study, the majority of subjects demonstrated a preference for the multiple schedule in both experiments, which suggests that some of the subjects *may* have exhibited a preference for a condition with more environmentally produced and fewer privately produced responses. These findings suggest that, some species *may* have the potential to demonstrate a preference for a publicly based over a privately controlled process of problem-solving.

The adjusting ratio schedule used in this experiment was different from those used in traditional studies. The present experiment imposed the adjusting schedule on the terminal link performances of the condition, as opposed to the choice key (initial link).

Verhave (1963) imposed the adjusting schedule on the choice key so that each subsequent "choice" to switch stimulus conditions required an increasing response requirement, which essentially places the burden on the choice aspect of the performance. The present experiment sought to identify performance under increasing difficulty within each stimulus condition, after a choice had been made. Accordingly, the decision was made to place the adjusting schedule after the choice response, in order to identify at what response value an animal would then choose the non-preferred condition

Four of the six subjects demonstrated a preference for externally signaled responses in the multiple schedule. Verbal behavior in humans is the manipulation of other's behavior in order to produce a solution, which is more like the behavioral control seen in a multiple schedule. Since some subjects showed this sensitivity, it is suggested that other non-human animals may have the potential to evolve a behavior functionally equivalent to that of humans; if not now, then during phases in its future evoltion. Epstein and Skinner (1980) and Savage-Rumbaugh (1984) have already demonstrated these behaviors in two species; namely, the pigeon and chimpanzee. It is of interest for future experiments to determine any biological, cognitive or methodological differences that may account for a more robust demonstration of such behaviors.

Presumably, there must have been a phase in early human evolution during which environmental sensitivity was not high and problem-solving through verbal behavior did not exist. Under these conditions, human problem-solving behavior must have been controlled primarily through personal reinforcement histories and less through the behavior of others. Some might argue that humans were the first species to evolve sensitivity to environmental determinants of behavior seen in the speaker and listener in a verbal episode, characterized by a stimulus-response sequence. Unfortunately, the present experiment was unsuccessful in yielding the deeper understanding of how and why such tendencies evolved in the human species as anticipated.

In the applied sense, a preference for multiple schedule control would be important for treating prompt dependency in the performance of people with developmental disabilities. Prompt dependency is defined as either (a) the tendency for rote responding, following reinforcement, under similar stimulus conditions or (b) the inability to respond in the absence of a stimulus. What makes prompt dependency possible is the requirement built into a contingency that requires attending, discriminating and learning in order for the correct response to be emitted (http://www.christinaburkaba.com/Procedures.htm.). If verbal behavior, or discriminative problem-solving, is important for the evolution of problem-solving behavior under conditions that favor stimulus control, prompt dependency may be the result of an over-reliance on such stimulus control. For example, spoken language is a behavior that is often difficult for people with certain developmental disabilities to acquire, at least in a time frame appropriate for socialization. The result is often the reliance on techniques that involve the use of textual or symbolic cues, such as the Picture Exchange Communication system, or PECS (Bondy & Frost, 2001).

Futhermore, the definition of language, or functional communication, has been modified to state that "language is the behavior of an individual directed toward another person who in turn provides related direct or social rewards" (Bondy & Sulzer-Azaroff, 2001). This definition is important for continued study of verbal behavior in that it is suggested that these textual and symbolic communication tools are also verbal behavior. Lacking the necessary precurrent responses (ie. those already in one's repertoire that create the opportunity for reinforcement), the use of discriminative cues allows an individual to successfully acquire the reinforcement for responding under such conditions. Thus, using PECS may be the more adaptive behavior for responding under situations that require communication. This idea supports the previous idea that verbal behavior may have evolved as a necessary component to responding in situations in which an organism lacks the necessary perquisite behaviors for responding.

In applied settings, verbal behavior is often understood and best described by the use of terms, derived from Skinner's theory of Verbal Behavior, such as tacts, mands, echolics, and so on. Although the use of these terms is helpful when instructing a non verbal person in language acquisition, these terms are often difficult to define and observe in the natural world. For example, language acquisition is often a process studied in more structuralistic terms. However, in the case of verbal behavior, language acquisition can be thought of as the process of generalization (Skinner 1957). In this way, sensitivity to discriminate environmental events is a prerequisite for generalization to occur; which recounts the importance of the postulated steps in the evolution of verbal behavior set forth earlier. Without an understanding of the basic evolutionary steps, and conditions under which such steps occurred in evolution, the present state of problem-solving and human language use is difficult to study and apply most efficiently.

Therefore, it is important that the evolution of verbal behavior continue to be studied experimentally.

There were some problems with the present experiment, namely, that the choice behavior was being governed by relations other than the environmental contingencies. According to the Matching Law, an organism distributes its responses in the initial links in proportion to the amount of reinforcement in the terminal links (Hernstein 1964a). This model is generally concerned with steady state relations between the allocation of behavior to alternatives and the variables governing choice. However, the present experiment used equal response requirements for both schedules, with only the stimulus conditions differing. This difference suggests that the matching law is not a potential explanation for the variability found in the present experiment. An alternative model might suggest that the critical variable for determining choice is the amount of reduction in expected time to primary reinforcement occasioned by entry into one of the terminal links relative to the expected time occasioned by entry into the other terminal link (Fantino 1969). In other words, the transition into one of the terminal links serves as the conditioned reinforcer for responding to that particular initial link because its terminal link occasions a shorter wait time for obtaining primary reinforcement. The present experiment used approximately equal times to primary reinforcement. The only potential difference would be the fractions of a second less time to make two responses to the same lever in the multiple schedule rather than to make two responses to two different response levers in the tandem schedule.

Another point of contention is whether certain inherent tendencies bias choice behavior. Spontaneous alternation suggests that under certain choice situations, organisms may choose to explore a non-reinforced choice option. For example, in the T-maze a mouse is placed into the maze and allowed to choose one of the two arms of the maze. The animal gets reinforced on the first trial for it's choice and is then brought back to the start. The animal tends to choose the alternate arm on the next trial, and given that it was not reinforced for this choice in the previous trial, it's choice is described as spontaneous. However, this bias is often not the case when using concurrent reinforcement schedules; whereby each schedule component performance is trained to a mastery criterion. Additionally, each subject is given large numbers of trials per session, under the free operant procedure, as well as several sessions in which all behavior is measured. Similarly, the idea that learning occurs as a result of evolutionary pressures for adapatation reflects the notion of bioilogical preparedness. Again, training to criterion ensures that an animal is not simply responding in random ways; rather it is a product of the contingencies. Neither Pavlov nor Skinner were troubled by such classic problems of learning because they believed that controlling your conditions ensured prediction and order.

Most scientists would agree that prediction and control are the most important components to any experiment. Skinner argued that there are two ways to maximize prediction and control in any experiment. One is to use large numbers of subjects averaged to produce a single data point. Statistical controls eliminate bias and other sources of extraneous variance in this fashion. However, the problem with statistical controls is that the average of multiple observations may not represent any single instance in the real world. Another way to achieve good prediction and control is to instrument the experiment so that natural variance is minimized and errors due to human judgment and verbal report are eliminated.

Because experiment 1 yielded increasingly mixed preferences across the smaller counterbalancing blocks, the issue of whether a true preference was demonstrated may be questioned. However, research has shown that choice behavior adjusts to changing environments, and that these adjustments may occur more rapidly when environmental changes occur frequently across sessions (Schofield & Davison, 1997). These findings suggests that the use of smaller counterbalancing blocks could have resulted in the change from a true preference into one with more variability. Less variability across all sessions, in terms of preference, was observed in experiment 2. Previous findings suggest that continued exposure to randomly changing reinforcer ratios leads to a progressive enhancement of control by the reinforcement contingencies in that session (Schofield & Davison, 1997). Therefore, the adjusting response requirements in experiment 2 may have resulted in control governed more by the contingencies.

Similarly, the use of animal subjects to investigate human operant behaviors has also been a point of contention. The comparative relevance of using animal studies to make inferences about human behavior is often criticized. In studies investigating schedule performance between humans and non-human animals, performances were similar when the humans less than 5 years of age (Bentall et al., as cited in Bentall & Lowe, 1987). The suggestion is that "the verbal repertoires greatly alter human operant performance and that this accounts for the many differences found between animal and human learning" (Bentall & Lowe, 1987). However, the nature of the Bentall & Lowe (1987) project was to model the capacities of early human, possibly before the evolution of such repertoires. It was concluded that the acquisition of verbal behavior is the variable that transitions an organism from animal-like operant behavior to adult human-like operant behavior (Bentall & Lowe, 1987). Perhaps the theoretical premise examined in the present experiment has already been empirically supported in the laboratory. Future experiments, might aim to manipulate the schedules used for each condition. Also, by experimenting with different response requirements and criteria for switching, it would be of interest to determine any effects on preference under different situations. Similarly, it would be of interest to determine any differences in performance in each schedule component alone, rather than under a concurrent choice procedure. Perhaps, comparing individual schedule performances could give more insight into the contingencies governing verbal behavior in a non-human animal. Another possibility is to examine the preference in human subjects, which could better highlight the environmental conditions and consequences that may be contributing to human verbal behavior.

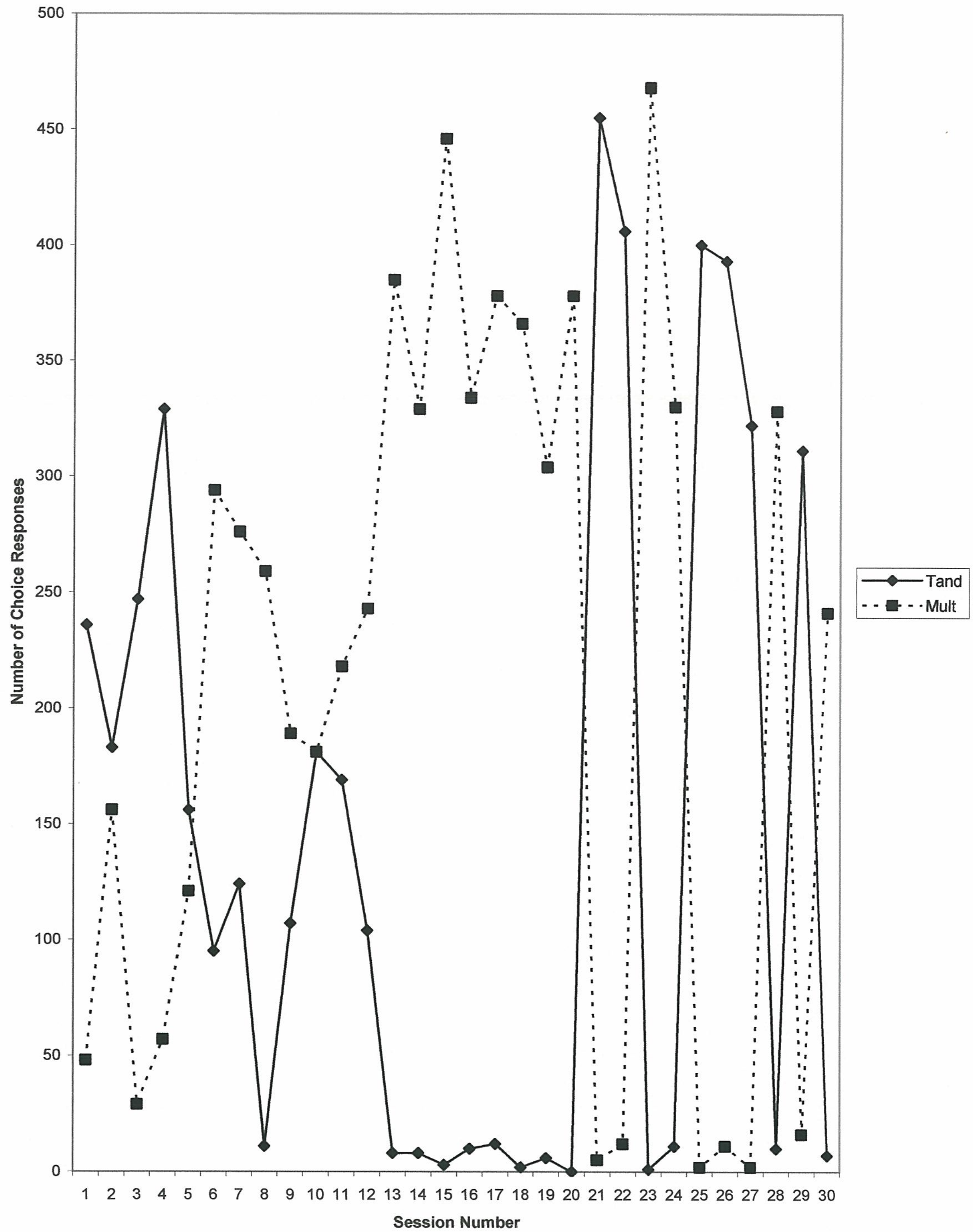


Figure 1. Number choice responses in Experiment 1 for subject D1

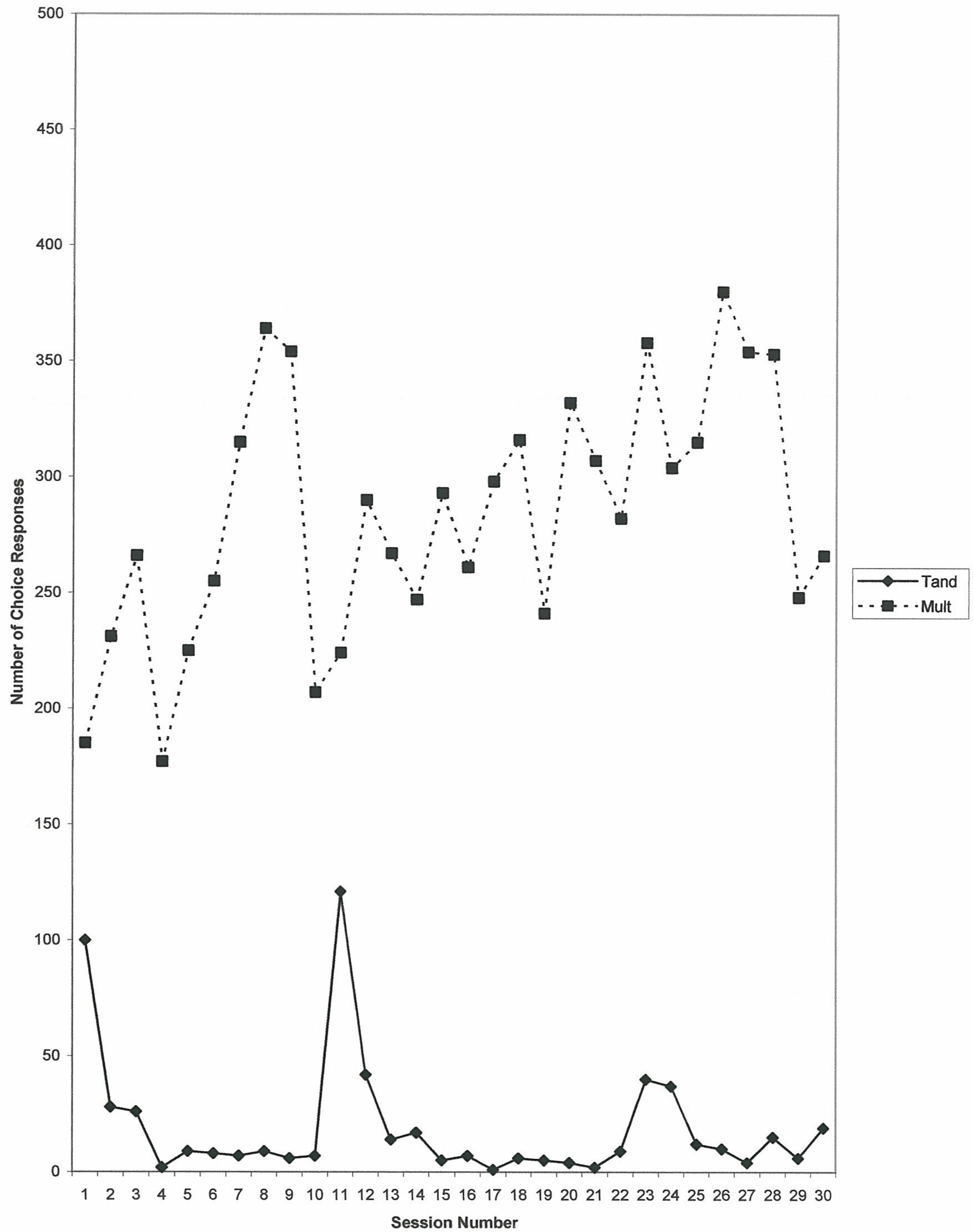


Figure 2. Number choice responses in Experiment 1 for subject D2

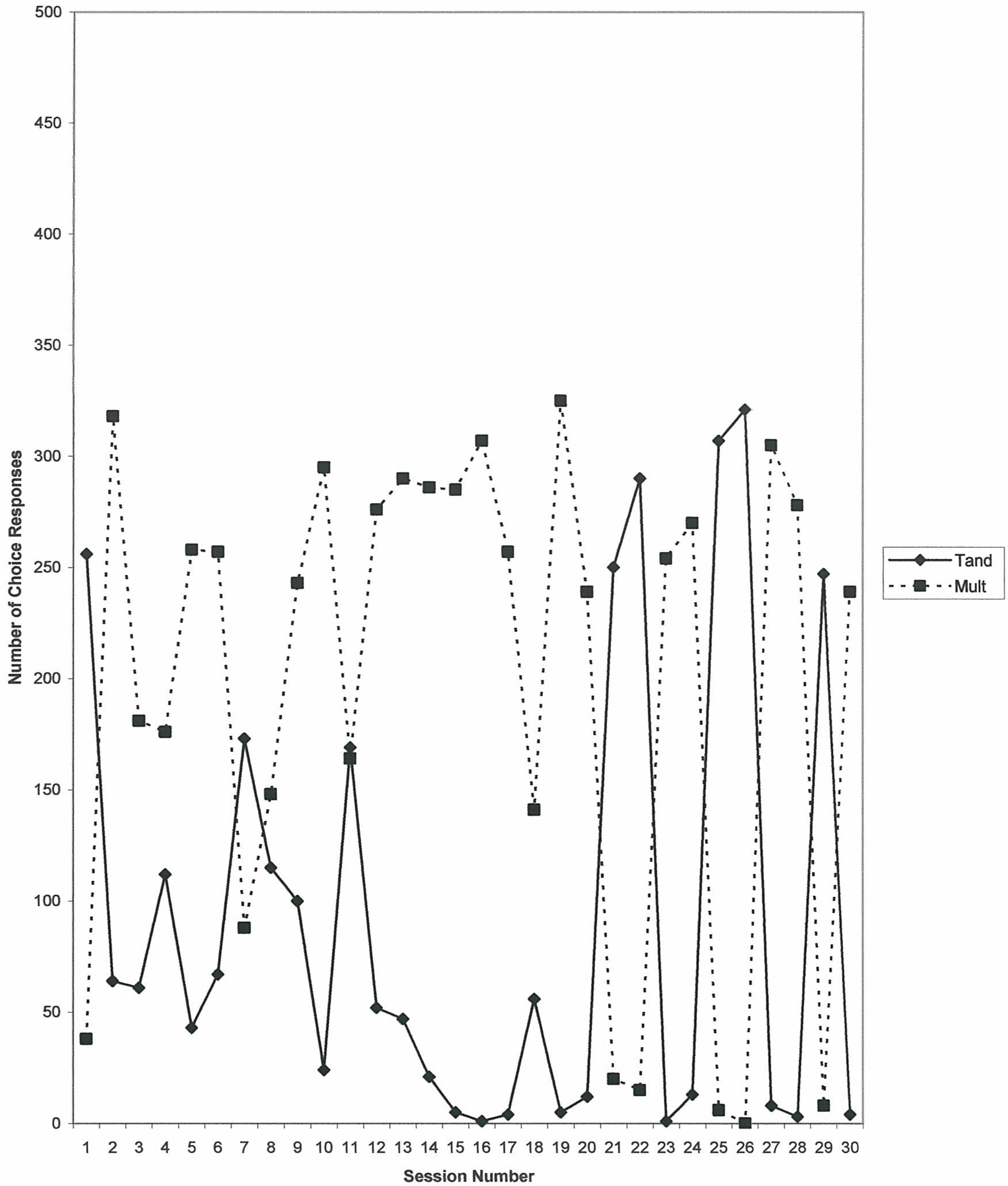


Figure 3. Number choice responses in Experiment 1 for subject D3

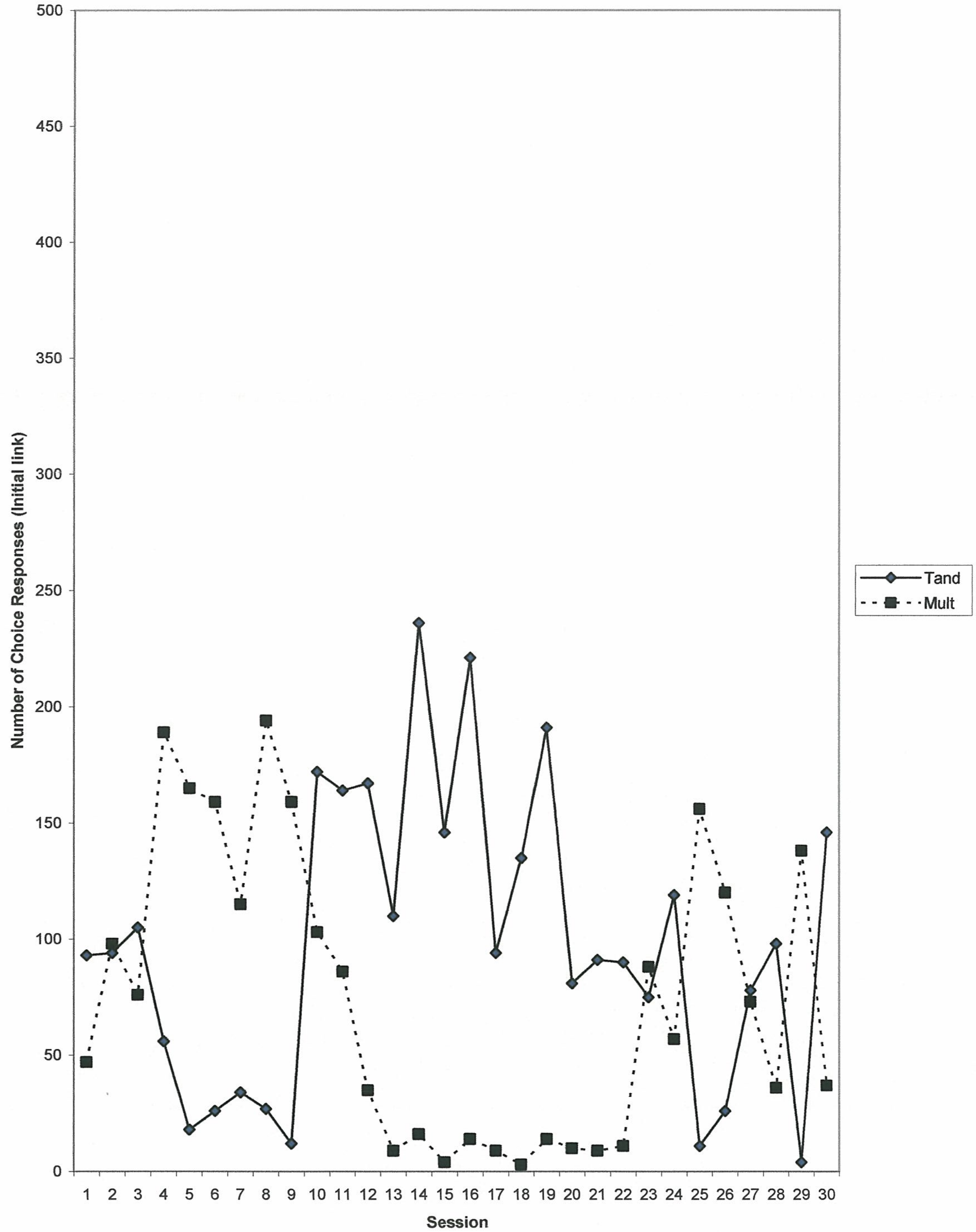


Figure 4. Number choice responses in Experiment 1 for subject D4

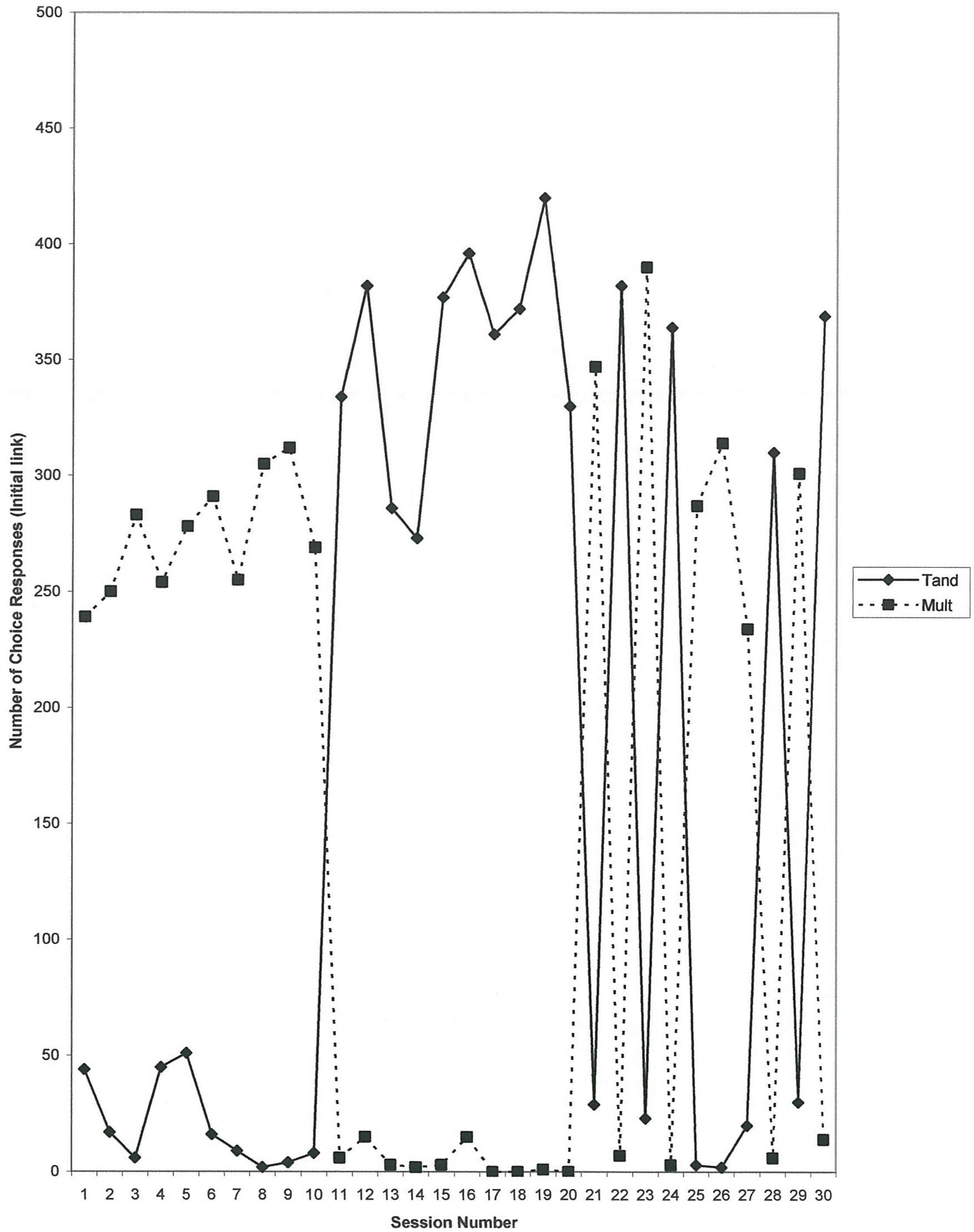


Figure 5. Number choice responses in Experiment 1 for subject D7

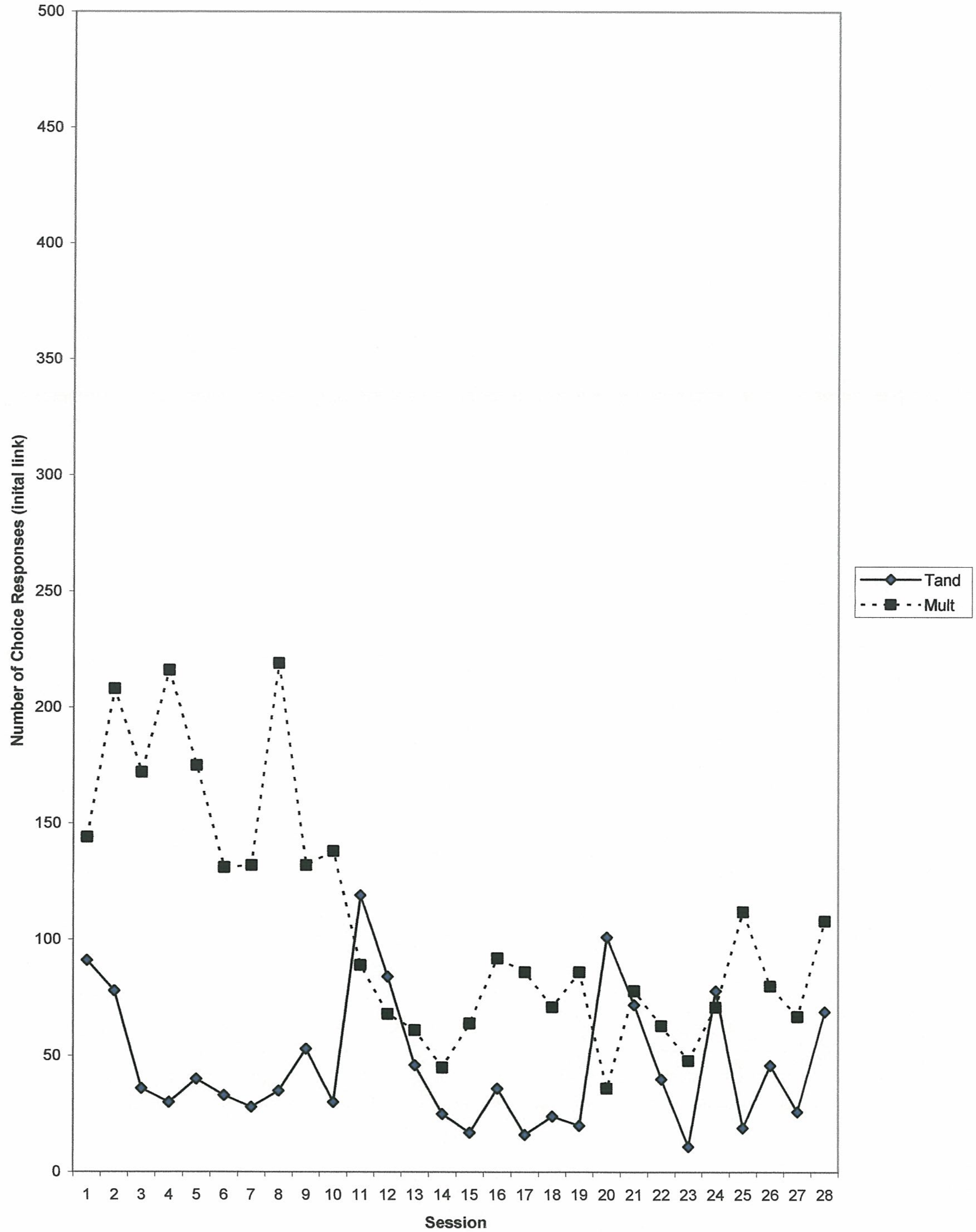


Figure 6. Number choice responses in Experiment 1 for subject D8

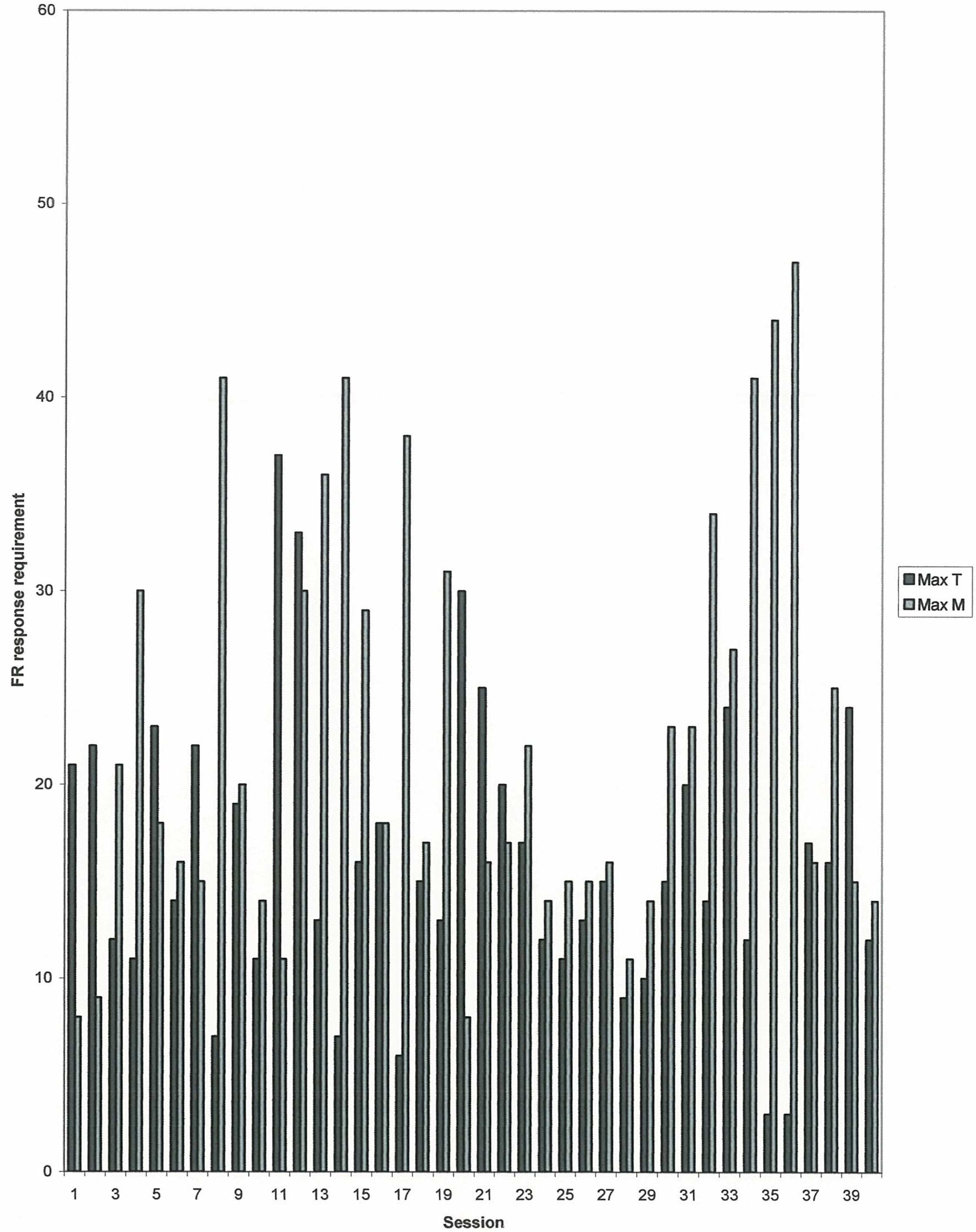


Figure 7. Maximum FR response value in Experiment 2 for subject D1

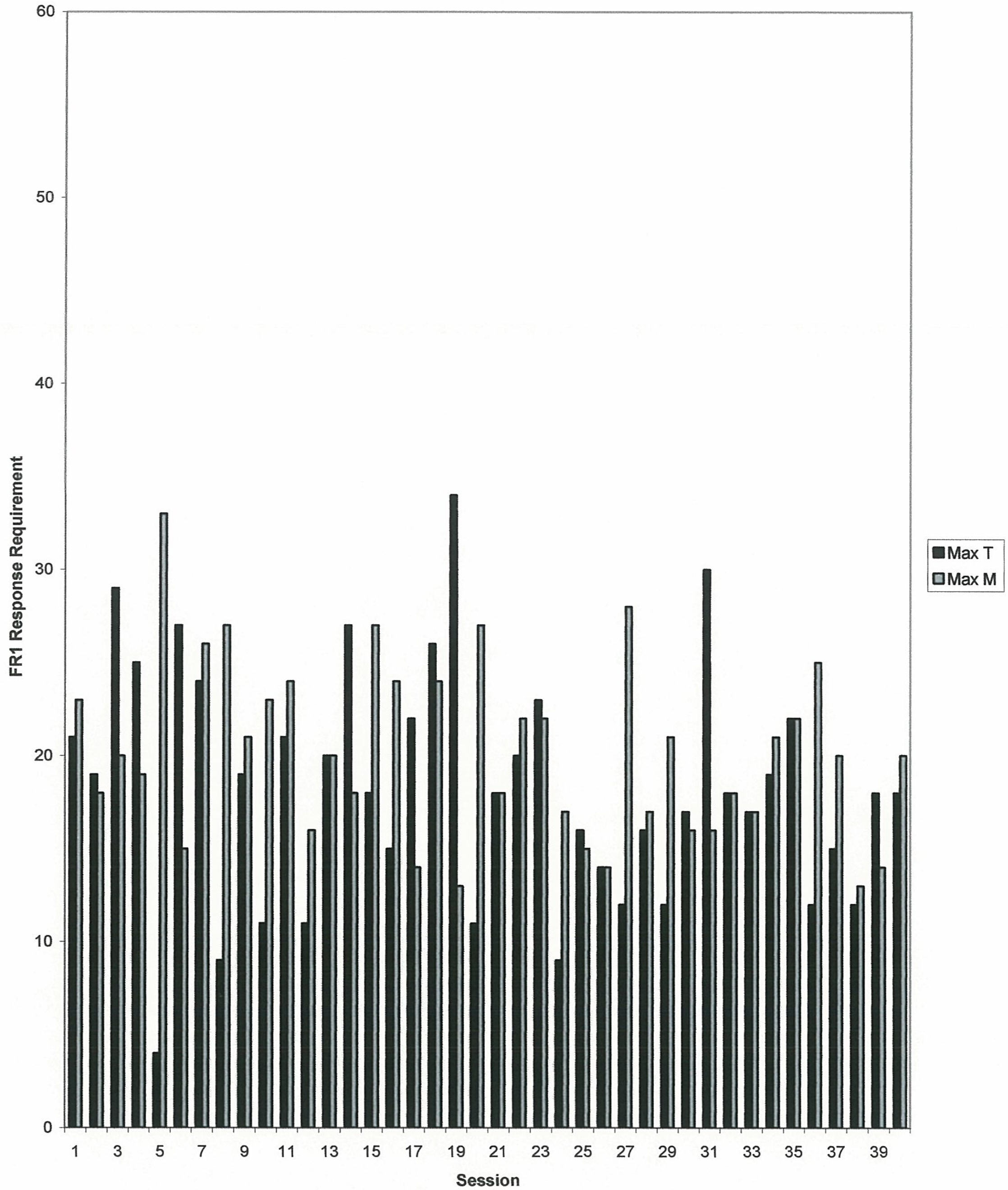


Figure 8. Maximum FR response value in Experiment 2 for subject D2

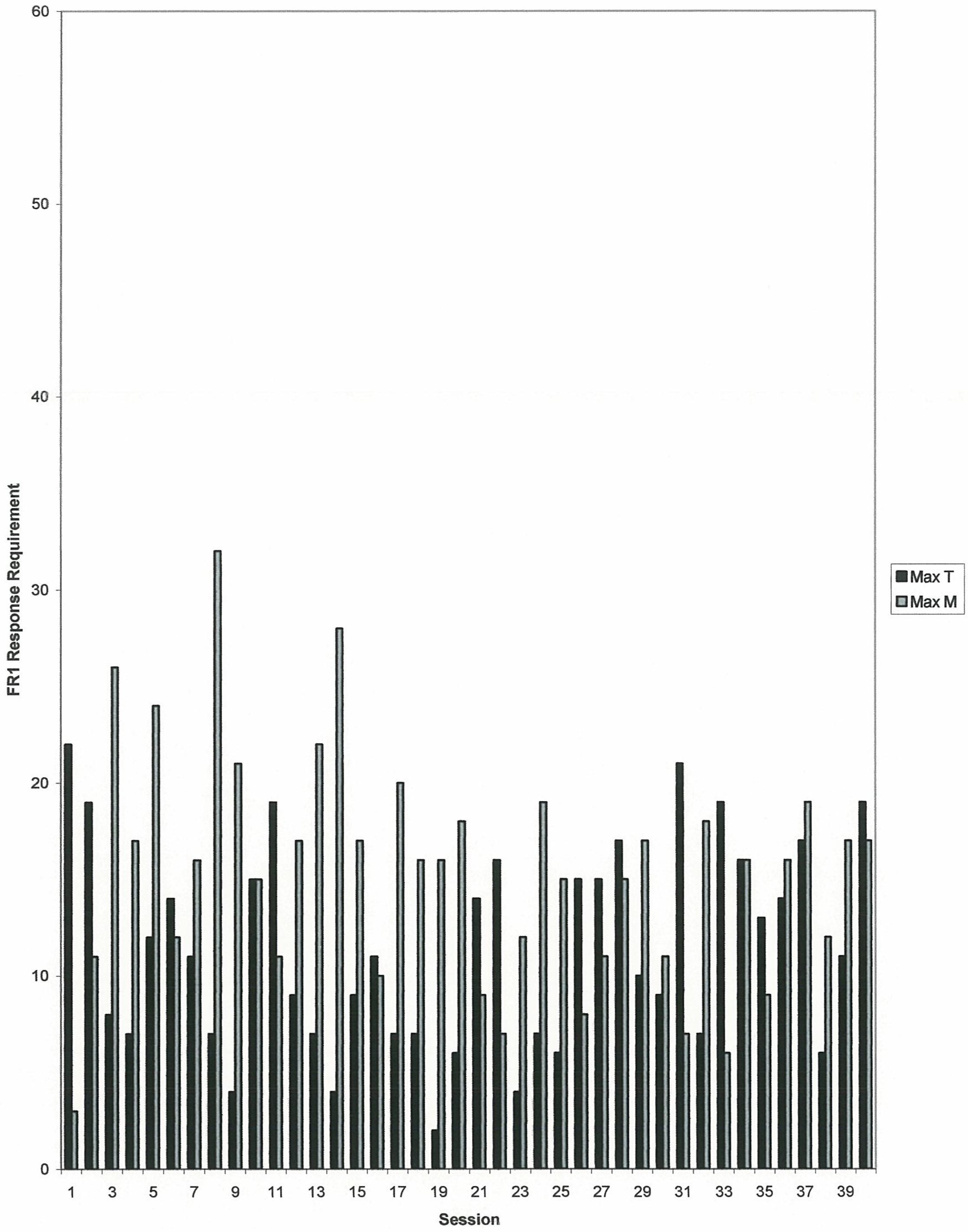


Figure 9. Maximum FR response value in Experiment 2 for subject D3

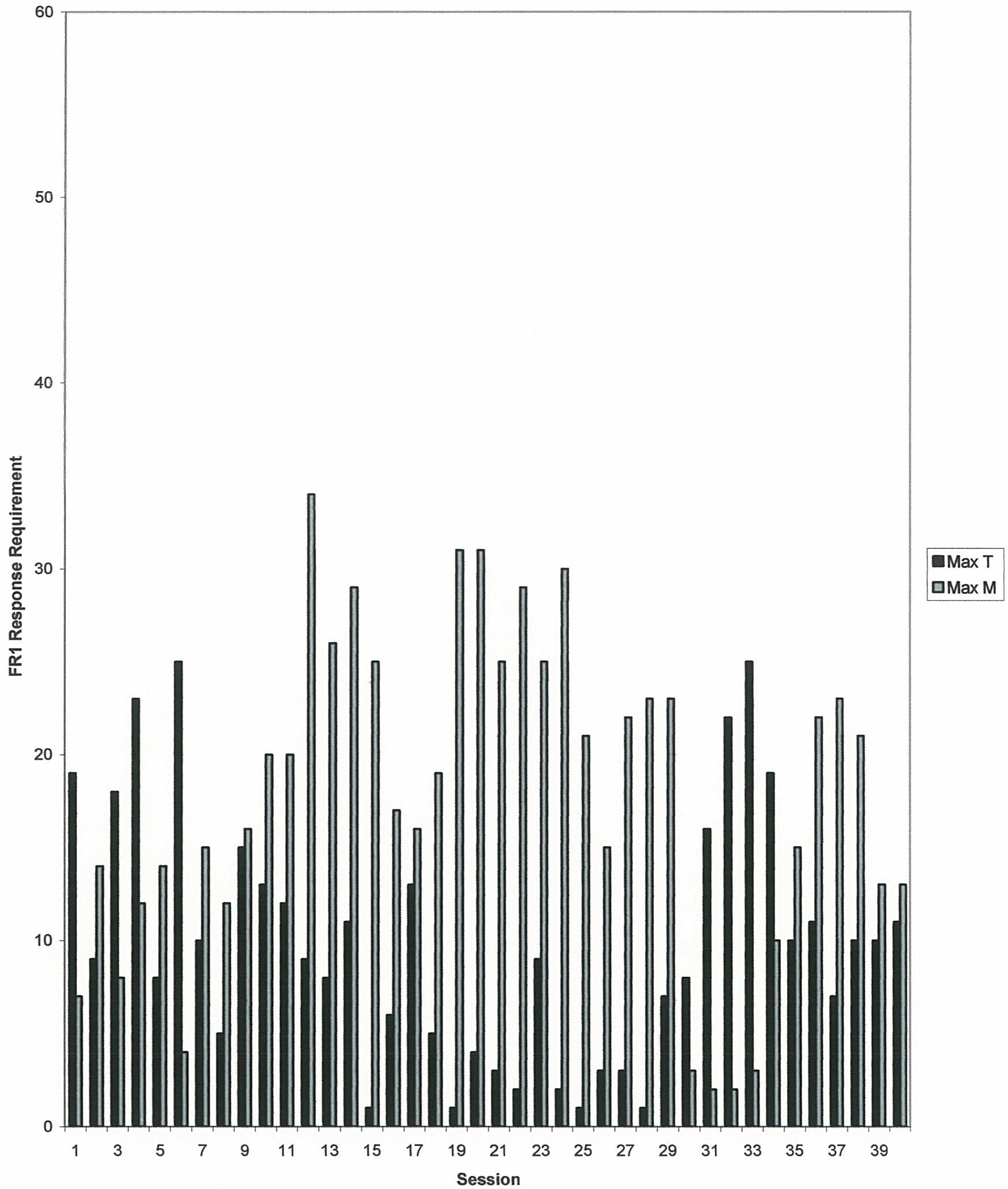


Figure 10. Maximum FR response value in Experiment 2 for subject D4

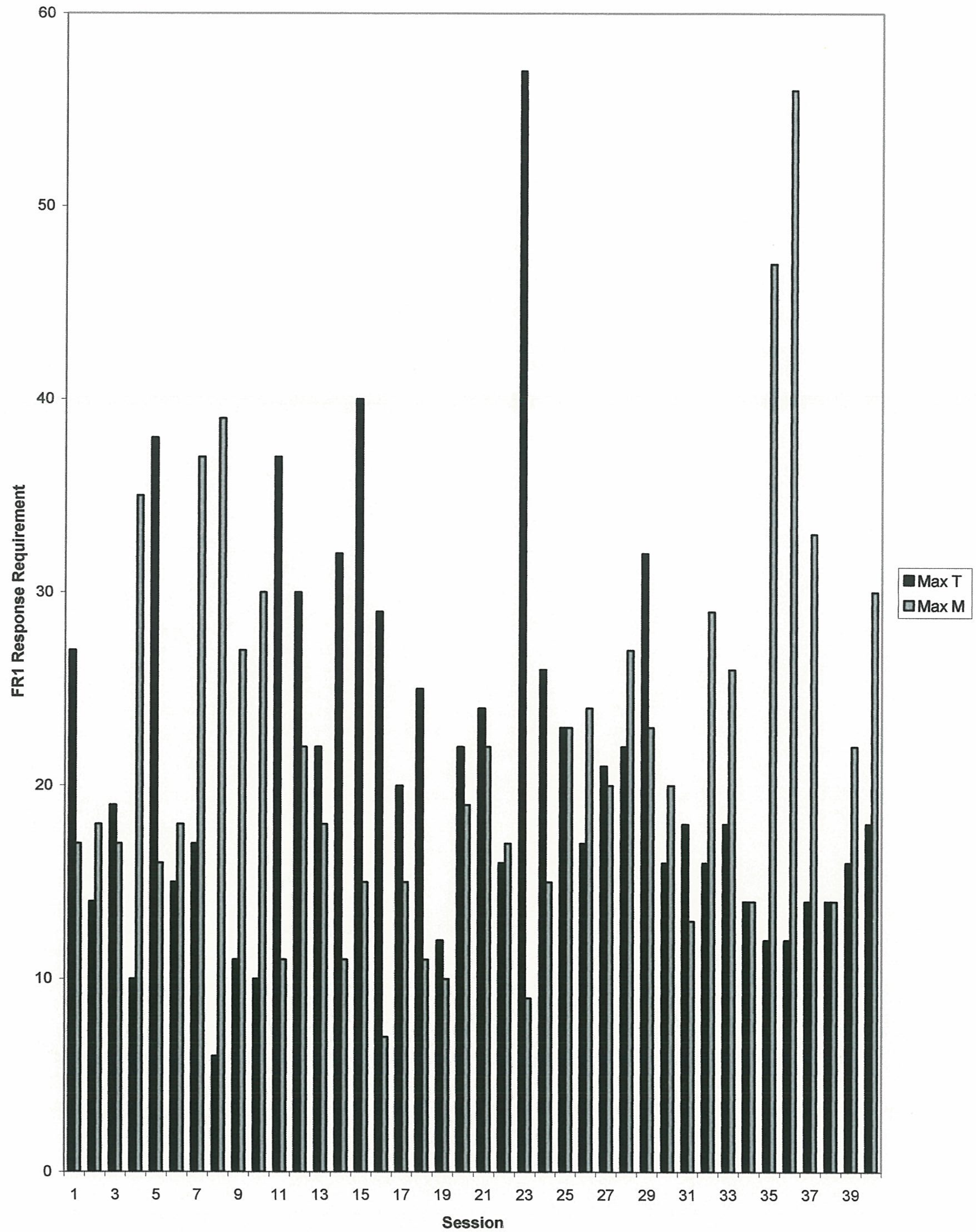


Figure 11. Maximum FR response value in Experiment 2 for subject D7

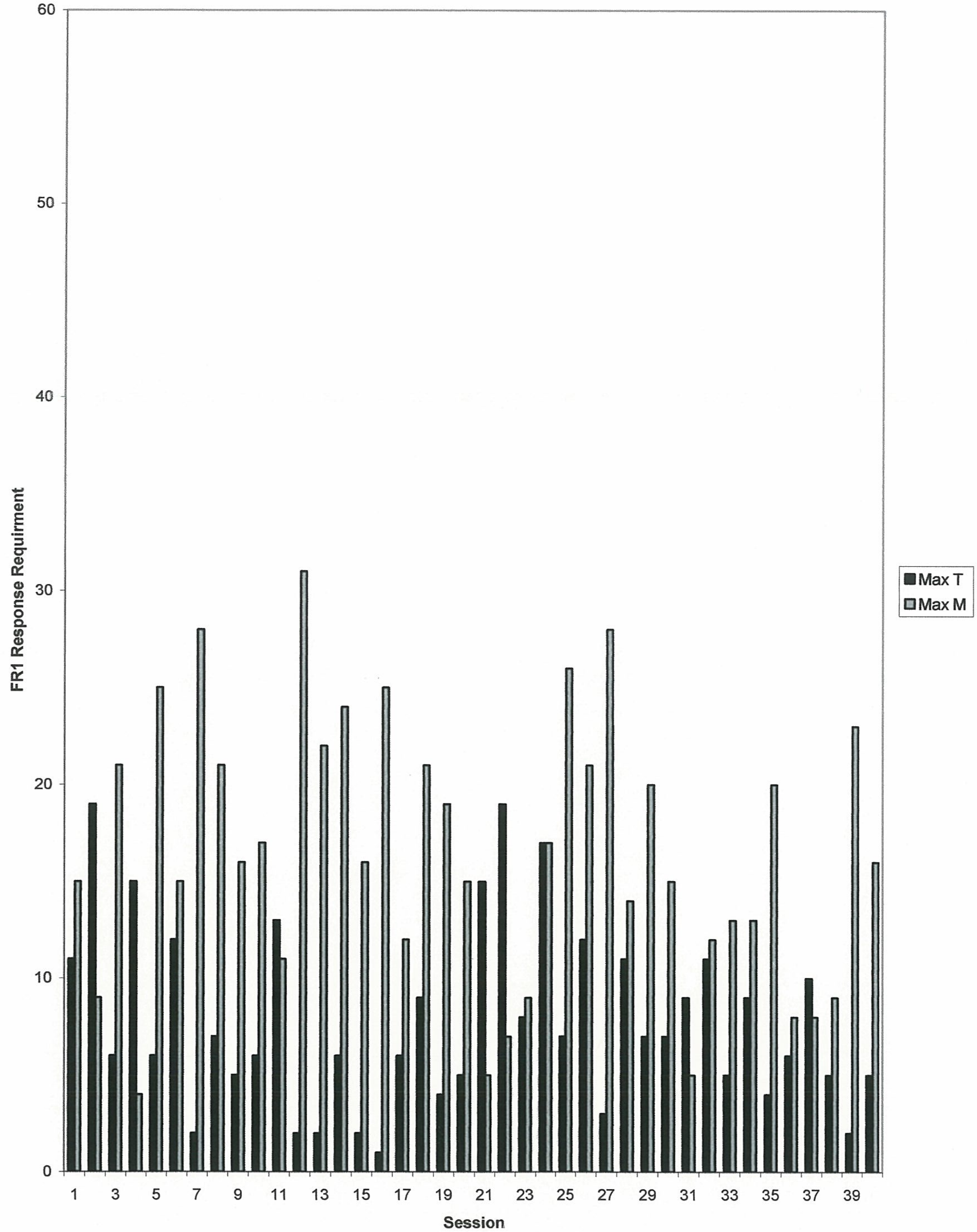


Figure 12. Maximum FR response value in Experiment 2 for subject D8

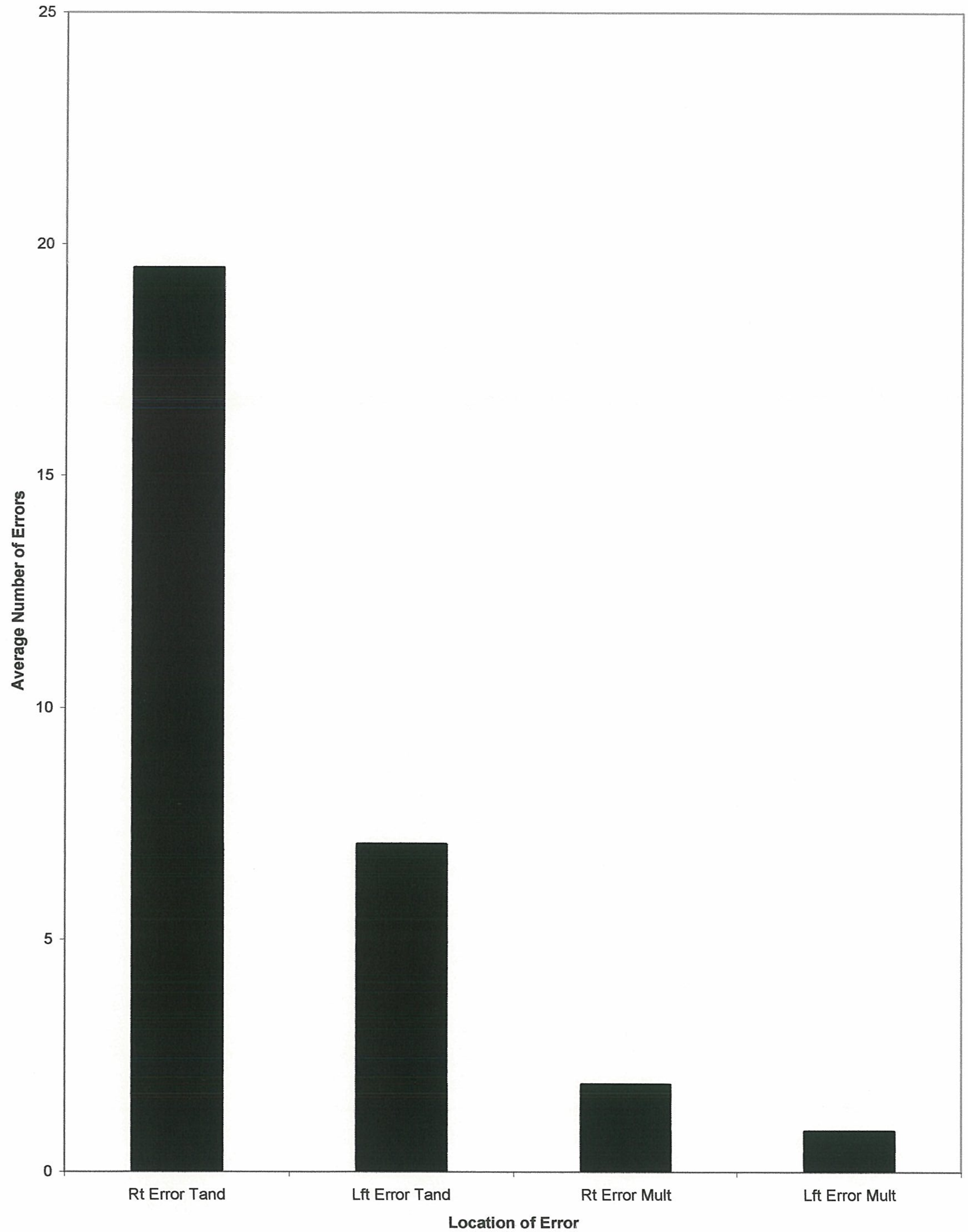


Figure 13. Average number of errors per schedule in Experiment 1 for all subjects

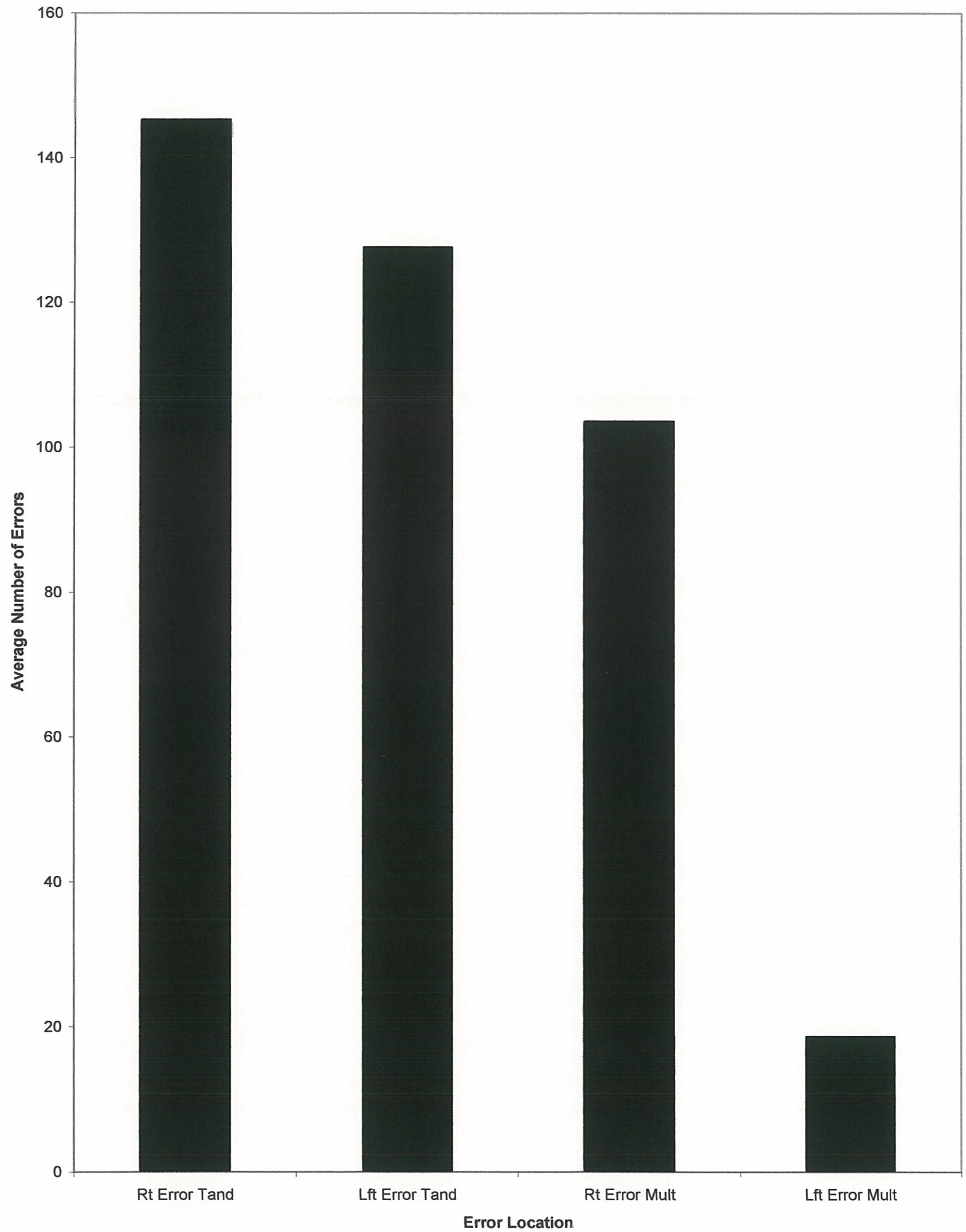


Figure 14. Average number of errors per schedule in Experiment 2 for all subjects

Table 1. ConcurrentTandemFR1FR1MultipleFR2 configuration across sessions

Subjects D1 – D4		Subjects D7 – D8	
Session	Configuration	Session	Configuration
1 -10	J	1 - 10	M
11 - 20	M	11 - 20	J
21 - 22	J	21 - 22	M
23 - 24	M	23 - 24	J
25 - 26	J	25 - 26	M
27 - 28	M	27 - 28	J
29	J	29	M
30	M	30	J

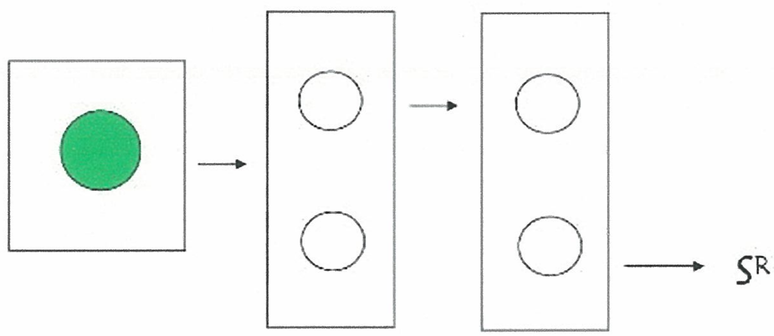
Table 2. ConcurrentAdjustingTandemFR1FR1MultipleFR2 configuration across sessions

Subjects D1 – D4		Subjects D7 – D8	
Session	Configuration	Session	Configuration
1 – 10	J	1 – 10	M
11 – 20	M	11 – 20	J
21 – 30	J	21 – 20	M
31 – 40	M	31 – 40	J

APPENDIX A

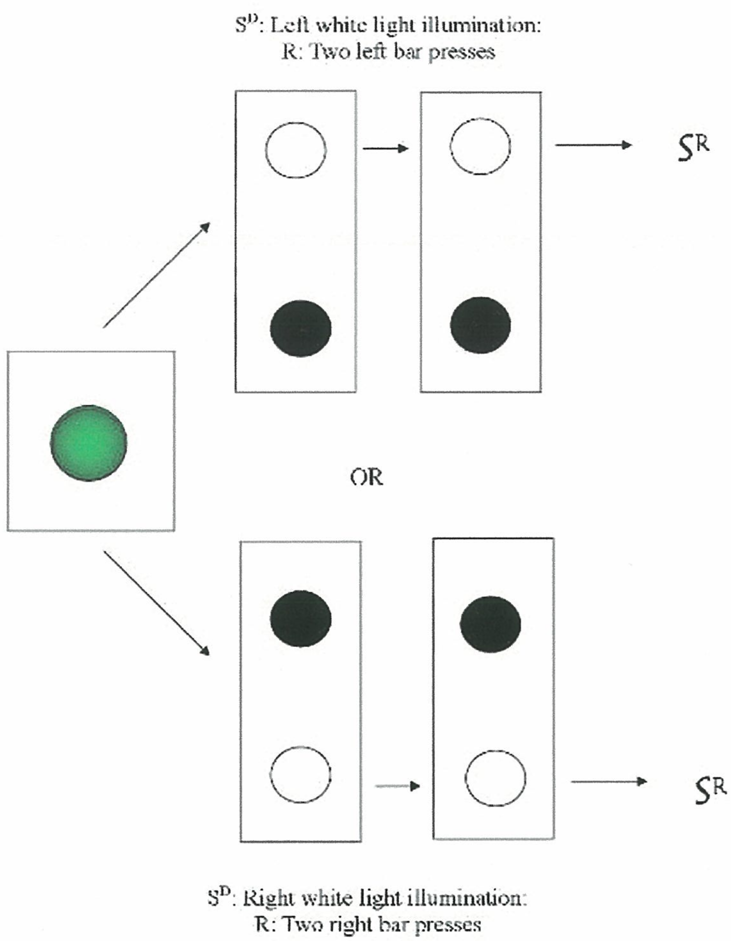
DIAGRAMS OF REINFORCEMENT SCHEDULES

Tandem Schedule



S^D: Both white lights:
R: Left   Right bar press

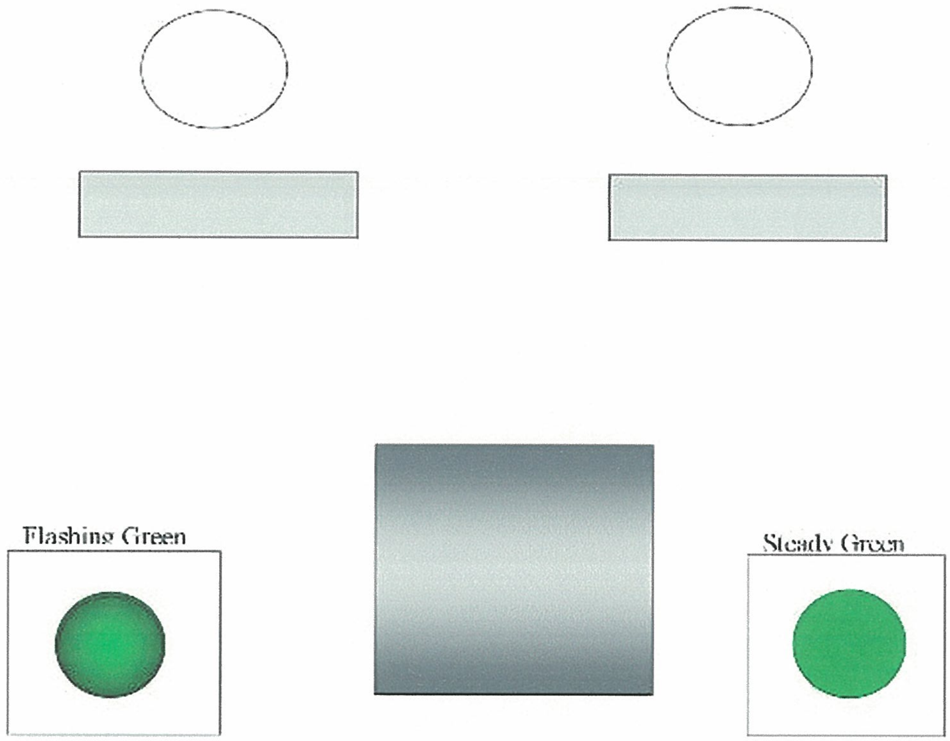
Multiple Schedule



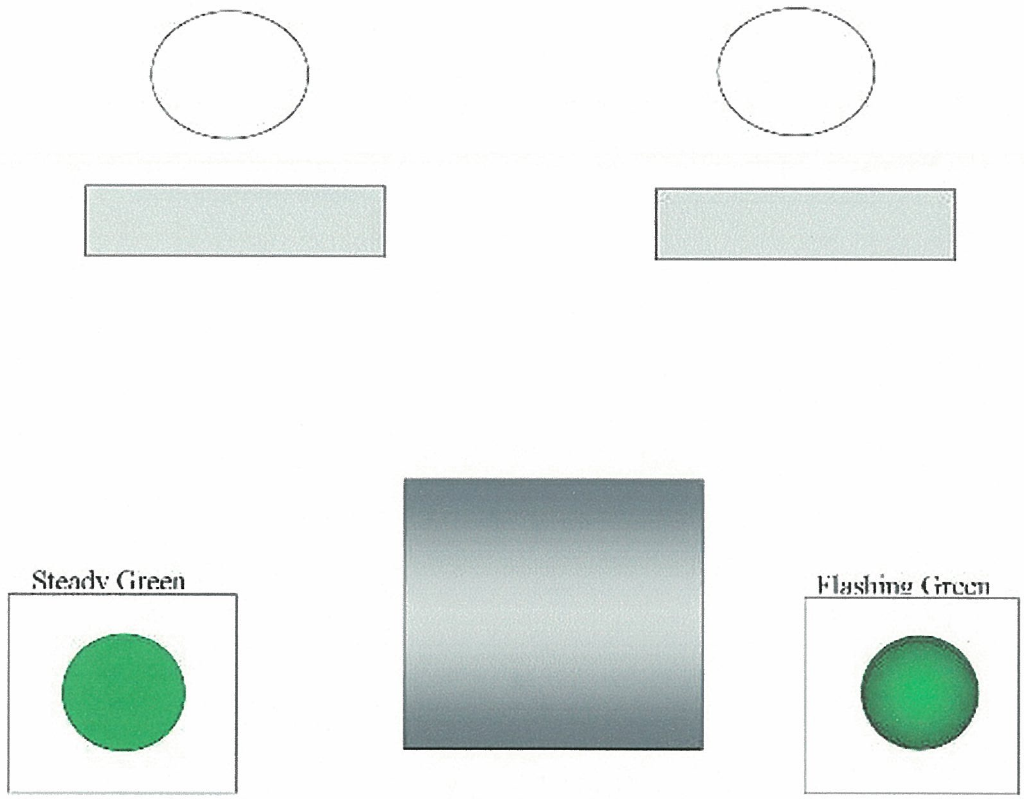
APPENDIX B

DIAGRAMS OF OPERANT CHAMBER CONFIGURATION

Concurrent Configuration "M"



Concurrent Configuration "J"



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BIOGRAPHICAL INFORMATION

Melissa Roark has developed an interest in Experimental Psychology, specifically The Experimental Analysis of Behavior throughout her academic career. She is a Board Certified Associate Behavior Analyst and plans to sit for the full exam by 2010. Research interests include Operant Conditioning and the applied aspects of Positive Reinforcement for people with mental disabilities/mental illness. She is currently employed as an Associate Psychologist/Behavior Analyst at the Denton State School. She develops positive behavioral interventions for people with mental retardation and mental illness. She plans to advance her career as a Behavior Analyst and continue to work with people with mental disabilities.